RIVER FLOW ALTERATIONS AND ENVIRONMENTAL FLOW STANDARDS IN TEXAS

A Dissertation

by

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Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

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May 2019

Major Subject: Water Management and Hydrological Science

ABSTRACT

River basin hydrology in Texas is characterized by extreme variability both spatially and temporally. Rapid population growth and declining groundwater supplies intensify demands on surface water resources. With enactment of the 2007 Senate Bill 3, the Texas Legislature mandated establishment of a process for creating and implementing environmental flow standards. The Texas Commission on Environmental Quality (TCEQ) is working with the water management community to establish environmental flow standards with subsistence, base, in-bank pulse and over-bank flow components for incorporation into the statewide water availability modeling system to protect environmental instream flows from intense water appropriation for human uses.

The two objectives of this dissertation are (1) quantitative analyses and improved understanding of streamflow modifications, especially alterations of flow regimes that produce ecological change and (2) exploration of environmental flow standards via the water availability modeling (WAM) system. The Indicators of Hydrologic Alteration (IHA) statistical methods developed by the Nature Conservancy were employed to characterize streamflow hydrographs for the Sabine, Neches, Guadalupe-San Antonio, Trinity, Brazos, Colorado Rivers and their major tributaries. The TCEQ WAM System was applied to investigate various aspects of environmental flow standards in two case study river basins, the Brazos, Trinity, and Neches.

The IHA software was used to summarize long periods of daily hydrologic data into much more manageable series of ecologically relevant hydrologic parameters and was demonstrated to be a feasible approach for calculating the characteristics of natural and altered hydrologic regimes. The results show that long-term changes in observed flows are very different between river basins and sites, but changes appear to be relatively more evident downstream of major dams. The WAM simulation results as to reliability, frequency, and duration metrics related to SB3 environmental flow standards at selected sites in the Trinity, Neches, and Brazos River Basins test and illustrate strategies for modeling flow standards which are applicable in other basins as well. Different scenarios are simulated to assess potential capabilities for satisfying instream flow targets. Research results have been evaluated and summarized to assist scientists and decision-makers in establishing new flow standards and improving existing standards to avoid or mitigate impacts of water development on natural environmental resources.

ACKNOWLEDGEMENTS

I would like to express a great amount of thanks and appreciation to the Water Management and Hydrological Science program especially Dr. Ralph Wurbs, my advising professor and chair of my advisory committee. Without his unlimited and invaluable guidance, support, and motivation it would have been impossible to complete this research. Thanks for water program providing all the academic-related resources and scholarship, which allowed me to focus on my academic career. Thanks for their dedication and hardwork.

I also owe gratitude to my committee members: Dr. Hongbin Zhan, Dr. Huilin Gao and Dr. Raghavan Srinivasan for agreeing to serve on my committee and their encouragement, and professional instructions regarding my research topic.

I deeply appreciate the China Scholarship Council (CSC), who gave me the opportunity to pursue a doctor degree at Texas A&M University and has provided financial support over four years.

I am cordially thankful my parents, for their support and encouragement, as well as other professors I have had along the way. I would also like to thank all my friends, colleagues and the department faculty for assisting, supporting and caring both about my study and life at Texas A&M University.

CONTRIBUTORS AND FUNDING SOURCES

Contributors

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The data analyzed for Chapter 4 was provided from the USGS National Water Information System. The data analyzed for Chapters 5 and 6 was provided by Professor Dr. Ralph Wurbs. All other work conducted for the dissertation was completed by the student independently.

Funding Sources

Graduate study was supported by a fellowship from the China Scholarship Council (CSC) and a WMHS Academic Scholarship from Water Management and Hydrological Science program.

NOMENCLATURE

BBASC	Basin and Bay Area Stakeholder Committee
BBEST	Basin and Bay Expert Science Team
DSSVue	Data Storage System Visual Utility Engine
EFCs	Environmental Flow Components
HEC	Hydrologic Engineering Center
IHA	Indicators of Hydrological Alteration
NAT	Naturalized Flow
NWIS	National Water Information System
REG	Regulated Flow
RVA	Range of Variability Approach
SB3	Senate Bill 3 of the 80th Texas Legislature enacted in 2007
TAMU	Texas A&M University
TCEQ	Texas Commission on Environmental Quality
TWDB	Texas Water Development Board
USACE	U.S. Army Corps of Engineers
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WAM	Water Availability Model
WRAP	Water Rights Analysis Package Begin

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1. INTRODUCTION

1.1. Background

Population and economic growth, and accompanying water resource development projects, such as reservoirs, diversions to supply agricultural, municipal and industrial needs, and return flows from surface and groundwater sources have substantially impacted river flows characteristics. Texas is characterized by extreme hydrologic variability both spatially and temporally. Rapid population growth and declining groundwater supplies will probably intensify the demands on surface water resources. The population in Texas is projected to be 51 million by 2070, which is nearly twice its population in 2010 (25.4 million people). This increase inevitably means water resource challenges (Texas Water Development Board, 2017). Long-term alteration of streamflow characteristics can produce large changes in aquatic ecosystem structures and functions. The impacts of climate change on hydrology and water management have been investigated extensively by the hydrological and water management communities. However, quantifying long-term changes is difficult due to the great natural variations in flows that shallow the long-term trends. The impacts of reservoir storage for water use on daily flows versus monthly or annual flows may also be significantly different. Human-activity effects on low flows may be very different than those on high flows. For example, regulation of rivers by dams reduces peak flood flows but may increase low flows at downstream locations. These changes could influence ecosystems by altering aquatic conditions for long stretches of the river and connected wetland.

This dissertation addresses two related issues: (1) alterations in river flow characteristics that have occurred in Texas over the past 75 or more years; (2) recently established environmental instream flow requirements. Flow characteristics and long-term changes thereto have been investigated through statistical analyses of observed flows at U.S. Geological Survey (USGS) gauging stations and Water Availability Model (WAM) simulated, naturalized, and regulated flows. The WAM simulations have also been employed to assess the capabilities of the river systems to satisfy the environmental flow standards and the impacts of the standards on unappropriated flows available for municipal, agricultural, and other water needs. The analyses employ long sequences of daily, monthly, and annual flow volumes representing actual historical flows, simulated natural conditions without development, and simulated regulated flows based on combining natural historical hydrology with present conditions of water resource development and use.

1.2. Hydrology and Water Management in Texas

Climate, hydrology, geography, economic development, and water management vary dramatically across the 15 major river basins and 8 coastal basins of Texas as shown in Figures 1.1 and 1.2. Flows in Texas rivers are highly variable, with daily, seasonal, and multiple-year fluctuations reflecting the extremes of floods and droughts, as well as less severe variations. The hydrologically most severe drought on record for most of the state began in 1950 and gradually ended in April 1957 with one of the largest floods on record.

In 2011, more than half of Texas experienced the lowest annual precipitation since the beginning of official precipitation records in 1895. The year 2015 was one of the wettest on record throughout the year and included severe flooding during the spring and fall.

Floods and droughts control the creation and maintenance of river and floodplain habitats and the sustainability of the high biodiversity observed along river systems. Therefore, understanding of flow characteristics is a fundamental step to assessing environmental flow requirements and other aspects of water resources management. By assessing environmental instream flow issues, this research is designed to support basic information regarding river system hydrology on selected major rivers of Texas.

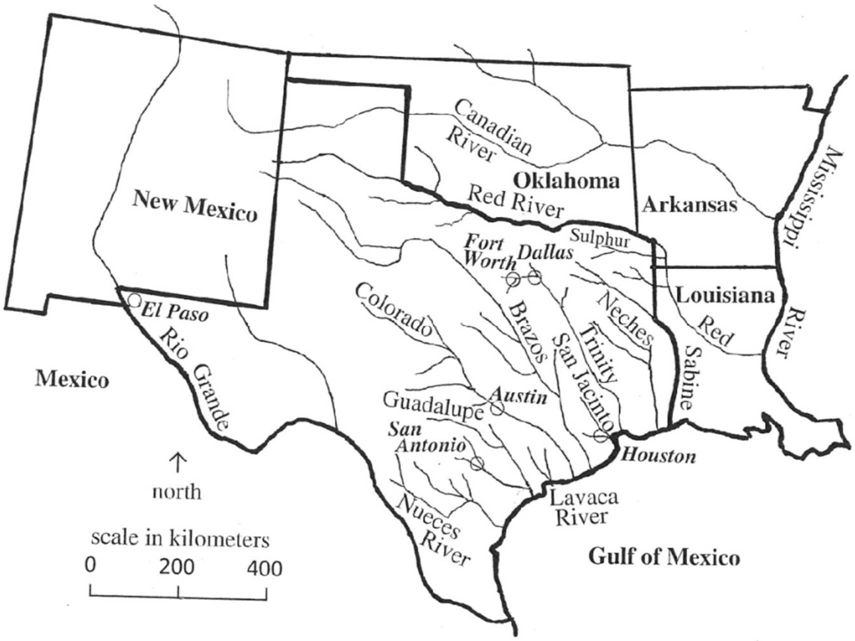


Figure 1.1 Major Rivers and Largest Cities in Texas

Figure 1.2 Texas River Basins as Delineated by the Texas Water Development Board

The Texas Commission on Environmental Quality (TCEQ) maintains a WAM System that consists of the generalized Water Rights Analysis Package (WRAP) developed at Texas A&M University (TAMU), as well as datasets for all river basins of Texas. The generalized WRAP modeling system, combined with an input dataset from the TCEQ WAM System for a particular river basin, is called a water availability model. The Texas Legislature enacted Senate Bill 3 (SB3) in 2007 to create a process for establishing environmental flow standards incorporated in the WAMs. Research and development at TAMU has been sponsored by TCEQ during the past several years to further expand the WRAP/WAM modeling system. The expansion has focused on integrating environmental flow needs in comprehensive water management, updating hydrology input datasets, and various other modeling issues. Expanded WRAP modeling capabilities and WAM datasets have been developed for the Sabine, Neches, Guadalupe-San Antonio (GSA), Trinity, Brazos, and Colorado River Basins. These are the case study WAMs adopted for this dissertation research. The TCEQ WAMs combine historical natural river basin hydrology with specified scenarios of water resource development, allocation, management, and usage. Hydrologic period-of-analysis sequences of naturalized, regulated, and unappropriated flows are generated. The naturalized stream flows represent natural conditions without anthropogenic resources development and use. The WAM naturalized monthly flows were computed by adjusting observed flows to remove the historical impacts of water development and use. Regulated and unappropriated flows were computed by simulation models for a specified water management scenario. Regulated flows are physical flows at a location reflecting the water management scenario incorporated in the simulation model. Unappropriated flows represent water still available after all required streamflow depletions are made. Unappropriated flows may be less than regulated flows as some water may be committed to in-stream flow requirements at that location or committed to other diversion, storage, and in-stream flow requirements at downstream locations.

In 2007, the 80th Texas Legislature passed Senate Bill 3 (SB3), which created a stakeholder-driven process designed to establish environmental flow recommendations and standards for all Texas river basins and estuaries for incorporation into the TCEQ WAM System (Wurbs and Hoffpauir, 2013a; Wurbs, 2017; Christancho, 2017). SB3 environmental flow standards have been established for several priority river systems including those discussed in this research. The SB3 environmental flow standards are incorporated into the WAMs, with priority dates corresponding to the dates that appointed science teams and stakeholder committees submitting their recommendations to the TCEQ. Thus, the environmental flow standards conceptually do not affect existing water right permit holders but do impact the amount of unappropriated flow available for future water right permit applicants.

1.3. Literature Review

A number of studies are reported in the literature related to flow characteristics based on statistical analyses that quantify impacts on the ecological environment, as changes in flow characteristics may occur over time in response to water resource development and use. Some investigations are limited to analyzing reservoir operations, while others consider environmental flow standards impacted by full hydrological regime alteration on river flows. Nearly all the investigations are based on either statistical trend analyses of gauged stream flow data or watershed precipitation-runoff computer simulated flow. Related references are cited in the following discussion.

1.3.1. Methods for Analyzing Stream Flow Changes

The impacts of various factors on stream flow are investigated and published in a myriad of papers and reports. These factors include urbanization, agricultural practices, other land use changes, reservoirs, water resources management, and climate change. Many methods and technologies have been used to deal with the impacts of global warming on hydrology and water resources. The USGS has applied regression and other trend analysis methods to observed flows to detect flow changes in many studies of specific river systems (e.g., Barbaro, 2007), as well as in nationwide studies (e.g., Lins and Slack, 1999; McCabe and Wolock, 2002). The effects of land and water management practices on 4,196 rivers located throughout the United States were investigated by the USGS. The results reflect that, based on statistical regression analyses of gauged daily flow sequences, road density and number and size of dams were dominant metrics in explaining the causes of long-term trends of both flow increases and decreases (Eng et al., 2013). In addition, agricultural development and wastewater discharges were also found to be closely associated with flow increases and decreases in some regions. Zhang and Schilling (2006) analyzed the trend of increasing base flow in the Mississippi River attributed to land-use changes. Changes in the flow regime of the Yangtze and Qingyi Rivers in China are attributable to constructing large dams (Huang et al. 2015 and Gao et al. 2012). Increases in evapotranspiration resulting from global warming over abandoned land were suggested as possible causes of the reduced stream flow. Wurbs and Zhang (2014e) explore river system hydrology in all the river basins of Texas, using observed streamflow data, WAM monthly naturalized and regulated flows, and the Texas Water Development Board (TWDB) precipitation and evaporation datasets. They concluded that hydrology is extremely variable both spatially across Texas and over time. They detected no long-term trends or changes in precipitation. Long-term changes in stream flow varied from negligible for some river reaches to dramatic for other locations. Changes in low flow regimes are very different than changes in flood flows. The WRAP modeling systems were widely applied in Texas and other places, providing a broad range of analysis capabilities representative of the perspective of water management dealing with complex river systems (Wurbs, 2012). Wurbs et al. (2005) combined climate model output with the SWAT and WRAP/WAM models to assess potential future impacts of global warming on water-supply capabilities in the Brazos River Basin of Texas. SWAT was applied to develop stream flows with and without the selected climate change scenario. This was used to adjust the stream flows and evaporation rates in the WRAP/WAM simulation, allowing assessments of changes in water supply reliabilities.

1.3.2. Methods for Analyzing Environmental Instream Flows

Hydrologic regimes play an important role in riverine ecosystem health, including the biotic composition structure and function of aquatic, wetland, and riparian ecosystems. The hydrologic cycle is complex, with human activities superimposed on natural hydrologic processes. However, with increase of population, water demand rises substantially. Flow regimes could shrink under many human activities, which leads to growing deterioration of riverine ecosystems. A variety of approaches have been used for quantifying the hydrologic regime. The commonly-used environmental flow assessment methods are classified by Tharme (2003) into four general categories: 1) Hydrological; 2) Hydraulic rating; 3) Habitat simulation; and 4) Heuristic methodologies based on different viewpoints of sustaining the biotic integrity of rivers. In the United States, there is no nationwide framework for establishing environmental flows, and different states describe limits to flow alteration independently. Traditionally, habitat simulation methods have been used extensively to determine suitable environmental flows, targeting some valued species (Tharme, 2003) and is still the preferred method in many states. However, an increasing number of states have adopted various ways to classify rivers based on their ecological or societal value and to establish environmental flow standards based on a combination of hydrological methods within the river classes or types. Several representative studies are briefly reviewed as follows.

Using characteristics of a riverine flow regime to quantify impacts on the ecosystem by water resource management is not a new concept. With the same fundamental goal of supporting better stewardship of an managed aquatic system, researchers have taken a variety of approaches to characterizing streamflow. Early studies focused on average flow conditions (Hawkes et al., 1986; Moss et al., 1987; Townsend et al., 1987), variation in mean daily flow (Horwitz, 1978), minimum flow (Jowett 1997), temporal predictability of flows (monthly data) (Colwell, 1974; e.g. Bunn et al., 1986; Resh et al., 1988; Gan et al., 1991), skewness in flow and peak discharges (Jowett and Duncan, 1990), short-term estimates of flood frequency (Cushing et al., 1983; Minckley and Meffe, 1987), slopes of flood-frequency curves (Farquharson et al., 1992), seasonal distributions of monthly flows (Haines et al., 1988), flow and flood frequency duration curves, and time series of annual discharge (McMahon et al., 1992). In 1995, Gippel and Stewardson (1995) evaluated the impact of minimum monthly environmental flow requirements on water supply availability by using the Melbourne Water Corporation water supply simulation model.

There is now widespread acceptance that hydrologic indicators should be used to summarize instream flow. The Indicators of Hydrologic Alteration (IHA), developed by the Nature Conservancy, is a suite of statistics tools consisting of 67 parameters, subdivided into two groups of 34 Environmental Flow Component (EFC) and 33 IHA parameters. These hydrologic parameters were developed by representing the flow characteristics for assessing the ecological implications of a particular water management scenario (Richter et al., 1996). The IHA software package has been applied in locations around the World. Kiesling (2003) described a collaborative investigation by USGS and TCEQ of the potential usefulness of IHA for studies in Texas, illustrating the application of streamflow data for five gaging stations ranging from 43 to 80 years in the Trinity River Basin and suggesting that IHA analysis can provide a first assessment of the ecological risks to aquatic ecosystems due to human altered flow regimes. The Hydroecological Integrity Assessment Process (HIP) and the associated Hydrologic Assessment Tool (HAT) by USGS form another software package for statistical template used with a stream classification system to customize statistics for instream flow management with the objective of addressing ecological integrity at the reach or watershed scale (Henriksen et al., 2006). Hersh and Maidment (2006) compared IHA and HAT for their potential application to instream flow studies in Texas, concluding that a Texas-customized version of HAT was suitable and preferable to IHA for the Texas instream flow program.

A Hydrology-based Environmental Flow Regime (HEFR) method was developed by the TCEQ in order to identify environmental flow standards statewide through coordinated efforts of scientific and stakeholder groups. An add-in for Microsoft Excel, available at the TCEQ environment flow resources website, HEFR computes seasonal, annual, and inter-annual flow components, coupled with biology, water quality, geomorphology overlays, and large-scale water supply projects to populate an initial estimate of environmental flow standards under current water-rights permit conditions. Whereas IHA and HAT focus more on evaluating over long time periods, HEFR emphasizes real-time operations under permit conditions for instream flow (Opdyke et al., 2014). The Hydrologic Engineering Center-Ecosystems Function Model (HEC-EFM) was designed by the U.S. Army Corps of Engineers (USACE) to help determine ecosystem responses to changes in the flow regimes of a river or connected wetland (Charley, 2009). The advantage of applying HEC-EFM analyses is obvious: It goes further than statistical analyses of relationships between hydrology and ecology, to hydraulic modeling and Geographic Information Systems (GIS). Mapping relevant habitat and display spatial data offers opportunities to engage study teams to visualize and define existing ecologic conditions, highlight promising restoration sites, and assess and rank alternatives according to predicted changes in different aspects of the ecosystem (Brunner, 1995). Hickey (2015) introduced HEC-EFM and described its use for statistical analyses and habitat mapping via two examples: the Sacramento split tail minnow spawning habitat in San Joaquin River, CA; and the cottonwood seedling establishment in Bill Williams River, AZ (Hickey et al., 2015).

1.4. Computer Modeling Systems and Datasets Employed in the Research

This research focuses primarily on statistical analyses of observed stream flows from the USGS National Water Information System (http://waterdata.usgs.gov/tx/nwis/nwis) and computed flows from the WAM simulation models. The monthly WRAP input datasets for all the river basins of the state, along with an array of information regarding water availability modeling, are available at the TCEQ WAM website:

http://www.tceq.state.tx.us/permitting/water_rights/wr_technical-resources/wam.html.

The latest publically released versions of the WRAP computer programs and documentation and the developmental daily WAM datasets for the Brazos, Colorado, Trinity, Neches, Sabine, and Guadalupe and San Antonio (GSA) River Basins are available at the TAMU WRAP website:

https://ceprofs.civil.tamu.edu/rwurbs/wrap.htm.

The August 2015 version of the WRAP software and manuals on the WRAP website have been replaced with significantly expanded October 2018 versions. Both daily and monthly modeling capabilities have been expanded. The six-case study daily WAM datasets found at the TAMU WRAP website are also presently being updated and expanded.

The TCEQ WAM System consists of the WRAP and datasets for all Texas river basins (Wurbs 2005, 2015a). The WRAP modeling system developed at TAMU is generalized for application to river systems in any other places around the World (Wurbs 2013, 2015b, 2015c). The WRAP/WAM modeling system is routinely applied by the Texas water management community to support regional and statewide planning and administration of the water-rights permit system and is based on a monthly computational time step.The WRAP/WAM-related research and development at TAMU during the past several years, motivated by environmental flow issues, has focused on development of a daily version of WRAP (Wurbs and Hoffpauir 2013, 2015) and developmental case study daily WAM datasets for the Sabine, Neches, Guadalupe-San Antonio (GSA), Trinity, Brazos, and Colorado River Basins (Wurbs and Hoffpauir, 2014a; Wurbs and Hoffpauir, 2014b; Wurbs and Hoffpauir, 2014c, Hoffpauir and Pauls, 2013).

Watershed drainage areas for the six case study river basins are tabulated at the top of Table 1.1 The river basins encompass 131,000 square miles in Texas and 5,100 square miles in New Mexico and Louisiana. The locations of the river basins are shown on the maps of Figures 1.1 and 1.2.

Table 1.1 Six Developmental Daily WAMs

WAM	Brazos	Trinity	Colorado	GSA	Neches	Sabine	Total
	Watershed Area (square miles)						
Watershed area in Texas	44,300	17,910	41,280	10,130	9,940	7,450	131,010
Watershed area outside Texas	2,710	0	200	0	0	2,190	5,100
	Number of Control Points						
Total number of sites	3,852	1,398	2,422	1,338	378	387	5,923
Primary control points	77	40	45	46	20	27	255
Number of reservoirs	678	697	518	238	180	212	2,523
Sites of SB3 Flow Standards	19	4	14	15	5	5	62

Locations of stream flow, dams, diversions, return flows, and other system components are defined in WAMs as control points. Counts of control points in the daily WAMs are provided in Table 1. The 255 primary control points in the six WAMs are gauge sites at which hydrologic period-of-analysis sequences of monthly naturalized stream flows are provided in the simulation input files. The naturalized flows are observed flows adjusted to remove the effects of water resources development and use. Naturalized flows are distributed to 5,668 other control points within the simulation, based on the flows at the primary control points and input watershed parameters. The six WAMs model a total of 2,523 reservoirs. SB3 environmental flow standards have been established and incorporated in the WAMs at 62 gauge sites.

The official monthly hydrology datasets for the Brazos, Trinity, Colorado, GSA, Neches, and Sabine WAMs on the TCEQ WAM website cover the hydrologic periods-of-analysis of 1940-1997, 1940-1996, 1940-1998, 1934-1989, 1940-1996, and 1940-1996, respectively. The hydrologic periods-of-analysis has been extended through 2015 for the six developmental daily WAMs at TAMU and are presently being extended through 2016.

WRAP consists of a set of computer programs that include monthly and daily time step models that simulate river system management and post-simulation software, which computes water supply reliability metrics and flow and storage frequency metrics from simulation results. HEC-DSS and HEC-DSSVue, developed by the HEC of USACE, are integrally connected with WRAP. The HEC Data Storage System (DSS) is applied with non-HEC, as well as HEC simulation modeling systems. The HEC-DSSVue software provides flexible capabilities for managing and plotting data in DSS files and performing various statistical analyses. WRAP programs and HEC-DSSVue also include flexible options for connecting with Microsoft Excel. WRAP and HEC-DSSVue and, to a lesser extent, Microsoft Excel are employed in this dissertation.

The IHA software package developed by the Nature Conservancy is designed for performing ecologically-meaningful statistical analyses of daily flows (Richter et al., 1998 Matthews and Richter, 2007 Nature Conservancy, 2009). The IHA has been employed in many countries over many years. A hydrograph of daily observed flows is parsed into individual flow regime components. The parsed flow sequences representing various low, normal, and high flow conditions are analyzed to develop a large number of different relevant statistical metrics. Selected sets of statistics can be computed for pre-development and post-development sequences of daily observed flows. The IHA software package also includes options for performing linear trend analysis.

Precipitation and evaporation rates are key climatic variables driving streamflow. The TWDB maintains datasets of monthly precipitation and reservoir surface evaporation from 1940 to the present for 92 one-degree quadrangles comprising a grid that encompasses the 682,000-km^2 state. However, reservoir evaporation rates prior to 1954 are not used, due to inconsistencies in data compilation methods before 1954. The databases were updated by the TWDB in May 2017 to extend through December 2016.

The impacts of climate change associated with global warming on hydrology and water resources management have been addressed extensively in the literature. The TWDB quadrangle precipitation and reservoir evaporation datasets are employed in this dissertation to investigate changes in climate change.

1.5. Research Organization, Objectives, and Scope

The overall objectives of the proposed dissertation research are as follows:

1. Develop a better understanding of flow characteristics and long-term changes in flow characteristics of the Sabine, Neches, Guadalupe-San Antonio (GSA), Trinity, Brazos, and Colorado Rivers and their major tributaries.
2. Assess capabilities of these river systems to meet recently established environmental flow standards and the impacts of the environmental flow standards on unappropriated flows available for future water right permit applicants.

The datasets and modeling analysis tools provided by IHA and WRAP/WAM modeling systems are applied to achieve these objectives. The exploration of techniques to incorporating environmental flow standards in water availability models is a key focus.

The Sabine, Neches, Guadalupe-San Antonio (GSA), Trinity, Brazos, and Colorado Rivers Basins serve as the case studies.

This dissertation is organized in eight chapters. The present Chapter I includes research objectives, background information, and literature review regarding models and methodologies used to analyze stream flow changes and the environmental flows rulemaking process in Texas. Chapter II describes the methodologies used to model daily time-step stream flows and environmental flows adopted for this research. Chapter III describes the basin information, WAM datasets, and Senate Bill 3 Environmental Flow Standards for the Sabine, Neches, Guadalupe-San Antonio (GSA), Trinity, Brazos, and Colorado rivers basins that serve as the case studies for this research. Chapter IV presents the statistical trend analyses conclusions of long-term flow characteristics of river flows based on datasets derived from NWIS and maintained by USGS. In this same chapter long-term alterations in streamflow characteristics have also be analyzed by IHA, by dividing a long historical record of observed daily stream flows into pre-impact and post-impact periods to assess the impacts of water resources development. Chapter V focuses on developing naturalized flows and regulated flow under present river basin conditions. The documents result from frequency analysis comparisons between observed gauged flows and WAM simulated flows. Chapter VI investigates and evaluates environmental flow standard influences on river flows through the simulation results of the daily WRAP model. Conclusions are presented in Chapter VII by synthesizing and analyzing the information regarding relative effects of flow frequency characteristics, water resources development, and other factors on ecological environment systems. Some future works are also outlined at the end of Chapter VII.

2. RESEARCH METHODOLOGY

2.1. Overview of WRAP and the Texas WAM System

The WAM/WRAP simulations were performed for present conditions of water resources development and management. WRAP consists mainly of the computer programs WinWRAP, SIM/SIMD, and TABLES. WinWRAP is a user interface which connects executable programs and data files. SIM is the basic monthly time step simulation model, and SIMD is an expanded version of SIM, with additional features for daily time steps. TABLES is a post-simulation program used to summarize or organize simulation results. (Wurbs, 2012). The model has typically been applied using a monthly time-step; however, recently improved SIMD and a new program, DAY (a pre-simulation program for daily hydrology data input), enable the use of a daily or other sub-monthly time interval, with additional features for flow forecasting and routing, environmental pulse flows, and flood control reservoir operations.

Daily naturalized stream flows are computed within the SIMD simulation, based on distributed monthly flows from primary to secondary control points and disaggregated monthly flow volumes to daily flow. Methods for disaggregating naturalized monthly flows to daily flows range in complexity from a linear interpolation routine requiring no additional input data to methodologies requiring sequences of daily flows or flow patterns provided as input data.

Daily regulated flows are the stream flows at a site after considering reservoir evaporation, storage, releases, water supply diversions, return flows, and other actions of all the water rights in the model. The basic daily WAM input files are found at the TAMU

WRAP website (Wurbs and Hoffpauir, 2015). The results of the WAM regulated flows reflect a specified condition of water resources development at the current scenario. WRAP is also employed to quantify the alterations of river flow regime under SB3 environmental flow standards by comparing naturalized, regulated, and unappropriated flows from the simulations.

Frequency analyses has been performed for the simulated flows to determine the flows that equaled or exceeded 0.5% to 99.5% of the hydrologic period-of-analysis. In other words, flow rates that equal or exceed the specified percentages of time are based on the following relative frequency formula:

$$\text{exceedance frequency} = \frac{\mathrm{m}}{\mathrm{N}}(100\%)$$

where m is rank, and N is sample size. Mean, minimum and maximum flows have also been determined. Flow-frequency relationships for naturalized and regulated flows have been compared in various formats.

2.2. Water Availability Modeling Improvements and Updates

The October 2018 version of WRAP is the latest developmental test version of the modeling system. The SIM/SIMD hydrologic input datasets of the Trinity, Brazos, Neches, Sabine, Guadalupe-San Antonio, and Colorado were updated and improved during 2016-2017.

One of the major improvements in the October 2018 WRAP is that the HEC-DSS and HEC-DSSVue components are fully integrated into the developmental version. The SIM and the other WRAP programs have been modified to fully incorporate DSS. The new features allow any or all time series input data to be read from a hydrology DSS input file and any or all simulation results to be recorded in a DSS output file. The Reference, Users, and Fundamentals Manuals have been updated to reflect the full integration of the new HEC-DSS and HEC-DSSVue options. Instead of separating FLO, EVA, FAD, RUF, HIS, TSF, DAT, and DCF text files, the new version's series can be input in a single hydrology DSS input file read by SIM and SIMD. Meanwhile, the multiple sequences of CRM simulation results and all other simulation results recorded to a DSS output file can be of any length. These new DSS-based capabilities described above are added as alternatives, while all the old existing input/output features of SIM, SIMD, and the other WRAP programs are preserved as well.

In addition to DSS' being fully integrated into SIM and SIMD, other modifications to SIM that will be addressed in the following have also been investigated and improved. For example, records of CO, RO, WO, GO, IF, FY, TO, JO, DI, SV/SA, PV/PE, and IS/IP, more options for distributing naturalized flows from primary to secondary control points, and refinements for SIM iterative algorithm for computing storage and evaporation-precipitation volumes have been expanded.

The TIN file input records activate the TABLES program to organize selected input data from the SIM/SIMD input DAT file or to create reliability tables and various other tables by reading the SIM monthly output OUT and SIMD daily output SUB files. The October 2018 version of TABLES has significantly improved, the analysis SIM input data by adding 1RCT and 1RES records and by expanding 1SRT, 1SUM, and 1CPT records. The new version has also significantly improved organizing simulation results by adding new parameters and options to 2REL and 2FRE records. All the new SIM and

TABLES simulation capabilities are documented in the October 2018 updates of the Reference and Users Manuals.

2.3. Analyses of Environmental Flow Standards

In 2007, the 80th Texas Legislature Enacted SB3, which established a new regulatory approach to environmental needs via the use of flow standards developed through a stakeholder process culminating in TCEQ rulemaking (Wurbs and Hoffpauir, 2013). In the Texas Water Code, Title 2, Section 11.002.16, an environmental flow is defined as an amount of water that should remain in a stream or river for the benefit of the environment of the river, bay or estuary, while simultaneously balancing human needs. The SB3 environmental flow standards include four components during different seasons: 1) subsistence flow which is the minimum streamflow needed during critical drought periods to maintain tolerable water quality conditions and to provide minimal aquatic habitat space for the survival of aquatic organisms; 2) base flow which is the "normal" flow conditions found in a river between storms, and it provides an adequate habitat for support of diverse, native aquatic communities and maintain ground water levels to support riparian vegetation; 3) high flow pluses consisting of within-bank high-flow pulses; 4) overbank high-flow pulses. The within-bank high flow pluses are short-duration, and high flows within the stream channel occur during or immediately following a storm event to maintain important physical habitat features and provide longitudinal connectivity along the channel; The overbank flows are infrequent high flow events that exceed the normal channel to maintain riparian areas and provide lateral connectivity between the river channel and active floodplain (TCEQ, TPWD, TWDB 2008). Figure 2.1

presents an example of daily streamflow components from the Guadalupe River at Victoria, Texas (USGS Gage No. 08176500) for the water year 2000. The details of flow recommendations and standards were established separately for each basin reflecting seasonality and hydrologic conditions.

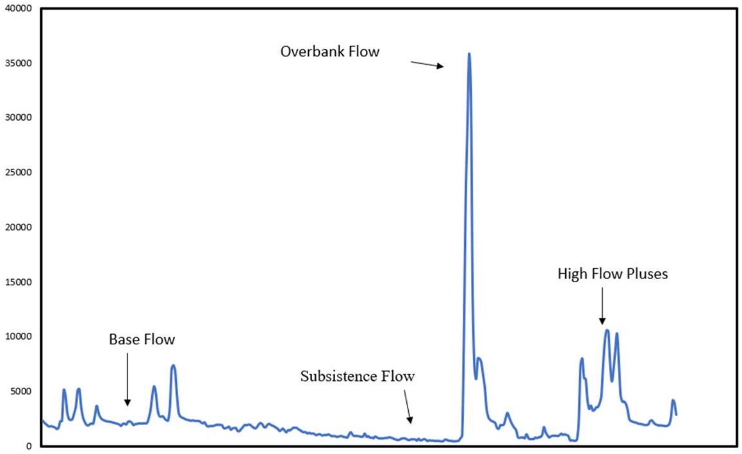


Figure 2.1 Example of daily streamflow hydrograph depicting flow components

The WRAP program simulates the priority-based allocation of water dictated by the water rights permitting system via the record of historical flows. The environmental flow standards were incorporated into the WRAP system at a priority date corresponding to the submission date for the TCEQ. Thus, the environmental flow standards are junior to most other water rights; hence, because of their lower priority, instead of affecting existing senior water rights, the standards reduce unappropriated flows available for future water right applicants.

The environmental flow standards for the basins performed through a modification of input options based on the daily WAM system. The different flow frequency metrics at each selected station are presented in a table to examine whether the SB3 environmental flow targets are met. Unappropriated flows are simulated to evaluate the impacts on future water rights by SB3 environmental flow standards or not. The environmental instream flows are specified using an instream flow (IF) record and complex instream flow requirements by water right (WR) records in a monthly time step simulation. However, the daily version of WRAP has greatly expanded capabilities for modeling and analysis of environmental instream flow requirements (Wurbs and Hoffpauir, 2013). Although the method for modeling environmental flow standards at each control point is different, a common modeling paradigm is as follows:

- An instream flow (IF) record with a target equal to the maximum target established by the target-setting water right records is used for setting the instream flow target.
- Subsistence and base flow standards are modeled for either a monthly SIM or daily SIMD using Environmental Flow Standards (ES) records in combination with Hydrologic condition record (HC), options Hydrologic index (HI) records.
- These new HC and ES records, in contrast to the previous approaches, combine target-setting water right (WR) with flow switch (FS), target options (TO), daily data (DW), and daily options (DO) records to model subsistence and base flow standards in the October 2018 version.
- Pulse flow standards are modeled only in daily SIMD simulation by applying pulse flow (PF) and pulse flow options (PO) records.
- All complex pulse flow targets, including criteria for pulse event initiation and termination, frequency, and tracking can be developed by PF and PO records without differentiation between “in-bank” versus “overbank”.

2.4. Indicators of Hydrologic Alteration (IHA) Methodology

The IHA software uses a sufficiently long hydrologic record (at least 20 years) of daily data for its calculations. If data are missing from the input files, IHA performs a linear interpolation across the missing data gap. IHA analyzes hydrologic data by calculating a total of 67 statistical parameters, including 33 IHA parameters and 34 EFC parameters (The Nature Conservancy 2009). Table 2.1 shows the 33 hydrologic attributes in five parameter groups used in the IHA program and the 34 IHA EFC parameters.

Table 2.1. Summary of hydrologic attributes utilized in the IHA

IHA Parameter Group	**Hydrologic Parameters**	**EFC Types**	**Hydrologic Parameters**
Magnitude of monthly water conditions	Mean or median value for each calendar month	Monthly low flows	Mean or median value for each calendar month
Magnitude and duration of annual extreme water conditions	Annual minima, 1-day mean Annual minima, 3-day means Annual minima, 7-day means Annual minima, 30-day means Annual minima, 90-day means Annual maxima, 1-day mean Annual maxima, 3-day means Annual maxima, 7-day means Annual maxima, 30-day means Annual maxima, 90-day means Number of zero-flow days Base flow index: 7-day minimum flow/mean flow for year	Extreme low flows	Frequency of extreme low flows during each water year or season Mean or median values of extreme low flow event Duration (days) Peak flow (minimum flow during event) Timing (Julian date of peak flow)
Timing of annual extreme water conditions	Julian date of each annual 1-day maximum Julian date of each annual 1-day minimum	High flow pulses	Frequency of high flow pulses during each water year or season Mean or median values of high flow pulse event Duration (days) Peak flow (maximum flow during event) Timing (Julian date of peak flow) Rise and fall rates
Frequency and duration of high and low pulses	Number of low pulses within each water year Mean or median duration of low pulses (days) Number of high pulses within each water year Mean or median duration of high pulses (days)	Small floods	Frequency of small floods during each water year or season Mean or median values of small floods event Duration (days) Peak flow (maximum flow during event) Timing (Julian date of peak flow) Rise and fall rates
Rate and frequency of water condition change	Rise rates: Mean or median of all positive differences between consecutive daily values Fall rates: Mean or median of all negative differences between consecutive daily values Number of hydrologic reversals	Large floods	Frequency of large floods during each water year or season Mean or median values of large floods event Duration (days) Peak flow (maximum flow during event) Flush organism materials (food)and woody Timing (Julian date of peak flow) Rise and fall rates

To study the accumulation of anthropogenic modification effect on flow regime, IHA computes the hydrologic parameters for two-time periods, before and after the impact. To evaluate the trend, IHA computes and graphs linear regressions. IHA parameters can be calculated using parametric (characterized by a normal distribution around the mean with a standard deviation) or nonparametric (no a priori frequency distribution, characterized by the median and percentiles) statistics. This dissertation has used non-parametric analysis to characterize the changes in flow regimes because many hydrologic datasets are non-normally distributed. To quantify the change between two times, the IHA enables users to implement the Range of Variability Approach (RVA). (Richter et al. 1996). In the RVA analysis, the full range of pre-impact data for each parameter is divided into three different categories. For example, we place the category boundaries at the 17th percentile from the median, then the three classes of equal size are in the following order: the lowest category containing all values less than or equal to the 33rd percentile; the middle category containing all values falling in the range of the 34th to 67th percentile; and the highest category containing all values greater than the 67th percentile. A Hydrologic Alteration factor is calculated for each of the three categories as:

IHA Factor = (observed frequency – expected frequency) / expected frequency

where expected frequency is equal to the number of values in the category during the pre-impact period, multiplied by the ratio of post-impact years to pre-impact years.

A positive Hydrologic Alteration value means that the frequency of values in the category has increased from the pre-impact to the post-impact period (with a maximum value of infinity), while a negative value means that the frequency of values has decreased (with a minimum value of -1). The IHA can compute Flow Duration Curves (FDCs) for all data, for each month. It can also compute FDCs for years and shortened water years.

There are five different types of Environment Flow Components (EFCs) (shown in table 2.2) in the IHA calculation parameters: low flows, extreme low flows, high flow pulses, small floods, and large floods. The default thresholds include: flow magnitude, recurrence intervals, and rate of change. For example, extreme low flows are the 10th percentile of all low flow in the period, and the default value for a small flood event is a high flow pulse with a recurrence time of at least 2 years. These default parameters for the delineation of the EFCs are based on the scientific judgment of the software developers but can also be modified by the user. The EFCs algorithm assigns the flow of each day to one of the 2-5 EFC types through three passes described as follows:

- First pass: separation of data into high flows and low flows.
- Second pass: all days that are initially assigned as high flows are re-assigned to three categories of high flow classes.
- Third pass: some of the initial low flow days are re-assigned to the extreme low flow class.

After adjusting the EFC parameters by displaying the graph of daily flow data coded by the EFC type, while using Analysis Properties, IHA automatically reruns the analysis, and the daily EFC results automatically displays. FDCs are computed in IHA based on the Weibull formula:

$$P = \frac{m}{(N+1)}(100\%),$$

where P is the probability that a given flow is equaled or exceeded (% of time). m is the ranked position on the listing (dimensionless), and N is the number of events for period-of-records (dimensionless).

Outputs from the IHA are available in two formats: as tabular output and graphical output. All the output tables generated by the IHA are available as text (.txt) files easily exported to Microsoft Excel. Various graph output presentations can be displayed individually on-screen, saved in various graphic file types, or exported to other image processing software packages.

3. CASE STUDY BASINS

3.1. Sabine River Basin

3.1.1. Description of the Basin

The Sabine River Basin is located in east Texas, with a length of approximately 300 miles and a maximum width of approximately 48 miles. The River Basin is crescent shaped, and the total drainage area of the watershed is about 9,760 square miles, with 7,400 square miles (76 percent) in Texas and 2,360 square miles (24 percent) in Louisiana. The Sabine River extends in a general southeasterly direction for a distance of 165 miles from its source in Hunt County, Texas, to the Texas-Louisiana border in the vicinity of Logansport, Louisiana, thence in a southerly direction to Sabine Lake and the Gulf of Mexico. The drainage area of the upper basin is 4,850 square miles where the river becomes the state boundary at the town of Logansport, Louisiana. The Sabine River, along with Toledo Bend Reservoir, serves as a 265-mile segment of the state border. Major tributaries include Cow Bayou, Bayou Anacoco, Bayou Toro, Tenaha Creek, Martin Creek, Murvaul Bayou, Big Sandy Creek, and Lake Fork Creek. The largest city in the river basin is Longview with a population of 80,500 and it is located in the upper basin. Mean annual rainfall ranges from 44 inches in the upper basin to 56 inches near the Gulf of Mexico (Wurbs et al., 2014a).

3.1.2. Sabine WAM

The original Sabine WAM dataset was developed by Brown & Root Services, under contract with the Texas Natural Resource Conservation Commission (TNRCC). Now the TCEQ periodically updates the Sabine WAM water rights data files, along with the WAMs for the other river basins of the state. Conversion of a WAM dataset from a monthly to daily time step was developed for modeling the SB3 environmental instream flow standards. The base WRAP dataset that was modified for daily time-step simulation was developed during the 2011-2014 period as documented by *Daily Water Availability Model for the Sabine River Basin*.

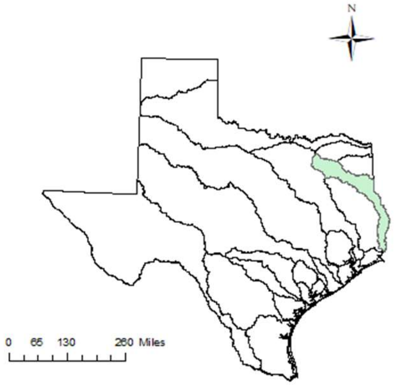


Figure 3.1 Sabine River Basin

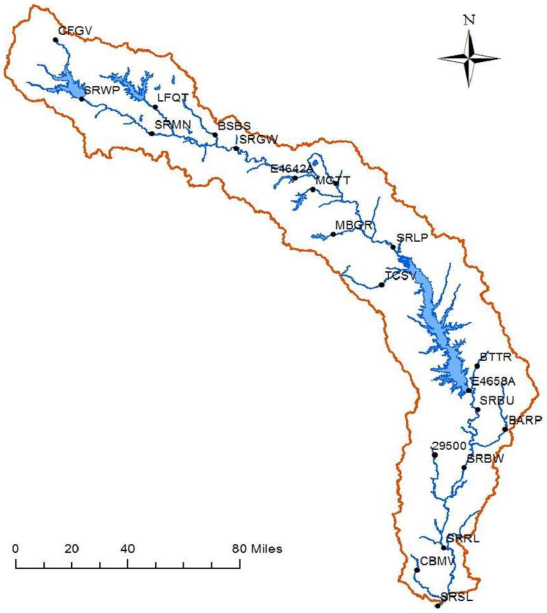


Figure 3.2 Map of Primary Control Points

The Sabine WAM has 27 primary control point locations at which naturalized flows are provided as input. 360 secondary control points are computed within the SIM simulation, based on the naturalized flows provided at the primary control points and watershed parameters (Wurbs et al., 2014a). Figure 3.2 is a map indicating the locations of the primary control points. Information for each of the primary control points is given in Table 3.1, the five control points at which environmental flows were modeled are indicated in black.

Table 3.1 Control Points in the Sabine WAM

Control Point	Location	Gage Number	Area (mile2)	Period of Record
17 Primary Control Points at USGS Stream Gages				
CFGV	Cowleech Fork Sabine at Greenville	8017200	77.7	03/59 to present
SRWP	Sabine River near Wills Point, TX	8017410	756	10/70 to present
SRMN	Sabine River near Mineola, TX	8018500	1,357	5/39–9/59, 10/67 to present
LFQT	Lake Fork Creek near Quitman, TX	8019000	585	7/24-4/26, 3/39 to present
BSBS	**Big Sandy Creek near Big Sandy, TX**	**8019500**	**231**	**02/39 to present**
SRGW	**Sabine River near Gladewater, TX**	**8020000**	**2,791**	**10/32 to present**
SRBE	**Sabine River near Beckville, TX**	**8022040**	**3,589**	**10/38 to present**
MCTT	Martin Creek near Tatum, TX	8022070	148	4/74 to 1996
MBGR	Murvaul Bayou near Gary, TX	8022300	134	58-83
SRLP	Sabine River at Logansport, LA	8022500	4,842	7/03-2/68 (Q), 3/68-pres (stage)
TCSV	Tenaha Creek near Shelbyville, TX	8023200	97.8	03/52-06/81
BTTR	Bayou Toro near Toro, LA	8025500	148	10/55-09/86, 10/88-present
SRBU	Sabine River near Burkeville, TX	8026000	7,482	9/55 to present
BARP	Bayou Anacoco near Rosepine, LA	8028000	365	10/51-10/99
SRBW	Sabine River near Bon Wier, TX	8028500	8,229	10/23 to present
SRRL	**Sabine River near Ruliff, TX**	**8030500**	**9,329**	**10/24 to present**
CBMV	Cow Bayou near Mauriceville, TX	8031000	83.3	04/52-09/86
SRSL	Sabine River at Sabine Lake		9,756	
Secondary Control Point with SB-3 Environmental Flow Standards				
29500	**Big Cow Creek near Newton, TX**	**8029500**	**128**	**5/52 to present**

The 13 major reservoirs in the Sabine River Basin with storage capacities of 5,000 acre-feet or greater are given in the map of Figure 3.3. The numbers next to each reservoir in Figure 3.3 correspond to the map identifiers in Table 3.2. The August 2007 authorized use scenario (run 3) DAT file contains 321 water right (WR) records and 22 instream flow (IF) records that model water allocated to Louisiana, as well as Texas WR records. The current use scenario (run 8) DAT file contains 328 WR records and 23 IF records (Wurbs et al., 2014a).

Table 3.2 major reservoirs in the Sabine River Basin

Drainage Reservoir (sq miles)	Initial Stream	Conservation Area	Impoundment	Reservoir Storage (acre-feet)	Control ID	Map Point	ID
Toledo Bend	Sabine River	7,178	Oct 1966	4,477,000	TOLEDO	E4658A	1
Lake Tawakoni	Sabine River	756	Oct 1960	927,440	TAWAKO	E4670A	2
Lake Fork	Lake Fork Creek	493	July 1979	675,819	FORK	E4669A	3
Martin Lake	Martin Creek	130	April 1974	77,619	MARTIN	E4649A	4
Lake Cherokee	Cherokee Bayou	158	Oct 1948	62,400	CHEROK	E4642A	5
Lake Murvaul	Murvaul Bayou	115	Dec 1957	44,650	MURVAU	E4654A	6
Brandy Branch	Brandy Branch	4	1982	29,513	BRANDY	E4647A	7
Hawkins	Little Sandy	30	Aug 1962	11,890	HAWKIN	E4736A	8
Winnsboro	Big Sandy	27	June 1962	8,100	WINNSB	E4749A	9
Holbrook	Keys Creek	15	Sept 1962	7,990	HOLBRK	E4690A	10
Quitman	Dry Creek	31	May 1962	7,440	QUITMA	E4708A	11
Lake Gladewater	Glade Creek	35	Sept 1952	6,950	GLADE	E4762A	13
Greenville City Lakes	Cowleech Fork of Sabine River	Minimal (off-channel)	1888-1957	6,969	R4665A	E4665A	12

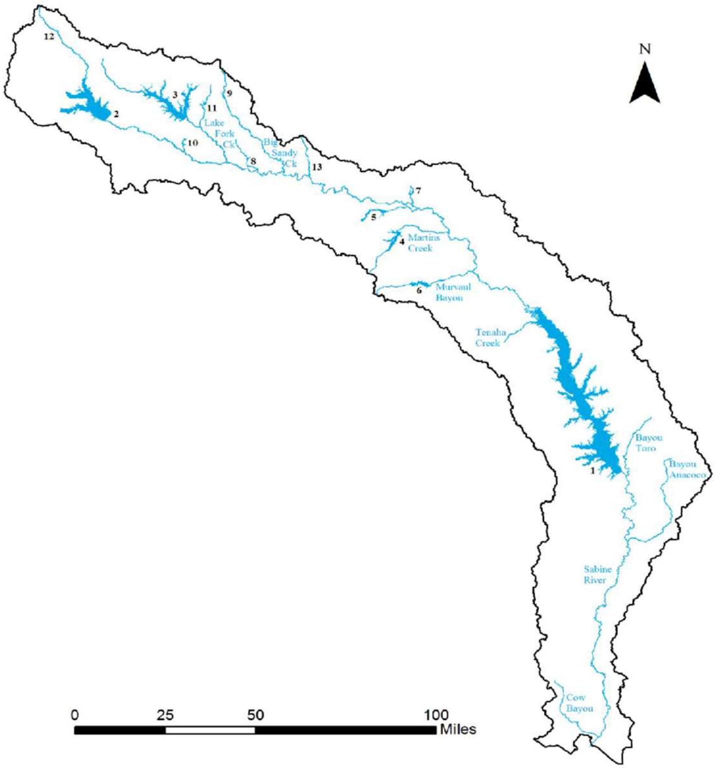


Figure 3.3 Major Reservoirs in Sabine WAM

3.1.3. Senate Bill 3 Environmental Flow Standards for Sabine River Basin

The environmental flow standards for surface water for the Sabine and Neches Rivers are documented in Texas Administrative Code Title 30, Part 1, Chapter 298, Subchapter C and were developed for ten USGS gaging stations, including five sites in the Sabine River Basin and five sites in the Neches River Basin. The identifiers for the new control points added to the daily WAM are the same as the identifiers of the control points, with a letter “E” replacing the sixth character, such as BSBSE, SRGWE, SRBEE, 29500E, and SRRLE. The environmental flow standards consist of recommendations for seasonal subsistence flows, base flows, and high flow pulse events according to hydrologic conditions. Four seasons are defined by the months, listed in Table 3.3.

Table 3.3 Seasons Defined by SB3 Environmental Flow Standards

Season	Months
Winter	January, February, March
Spring	April, May, June
Summer	July, August, September
Fall	October, November, December

The subsistence flow standard is applicable when flow at a control point is less than the base flow standard. If the flow at a control point is less than the applicable subsistence flow standard, then water right holders may not make diversions from the river (Wurbs et al., 2014a). If the flow is greater than the subsistence flow standard and less than the applicable base flow standard, water right holders may make diversions as long as the flow does not drop below the subsistence flow (Wurbs et al., 2014a). The subsistence flow standards and base flow standards for the control points in the Sabine River Basin are shown in Table 3.4. If the flow at a control point is greater than the applicable base flow standard and less than the applicable pulse flow trigger level, then water right holders may make diversions as long as the flow does not drop below the base flow standard (Wurbs et al., 2014a).

Table 3.4 Subsistence and Base Flow Standards (cfs) for the Sabine River Basin

WAM CP ID	Winter	Spring	Summer	Fall
Subsistence Flow Standards				
BSBS	20	9	8	8
SRGW	45	22	14	17
SRBE	66	28	22	22
29500	28	20	20	20
SRRL	949	436	396	396
Base Flow Standards				
BSBS	73	33	15	22
SRGW	305	131	37	54
SRBE	482	255	56	83
29500	62	42	31	40
SRRL	1672	1329	737	809

The high flow pulse standards shown in Table 3.5 are applied when flow at a control point goes beyond the applicable high flow pulse trigger level. If the high flow pulse trigger level has been met, junior water right holders may not divert water until either the specified volume or specified duration time has passed, except when diversions do not lead the flow to go below the high-flow pulse trigger level.

3.2. Neches River Basin

3.2.1. Description of the Basin

The Neches River Basin is located in the east of Texas, as shown in Figure 3.4, extending approximately 200 miles in length, with a drainage area of about 10,000 square miles. The headwaters of the river originate in Van Zandt County east of Rhine Lake, and the river discharges into Sabine Lake near Port Arthur. One-third of the drainage area is drained by the Angelina River and two-thirds by the Neches River, Pine Island Bayou, and Village Creek. The Neches River Basin is bounded on the south by Neches-Trinity Coastal Basin, on the east by the Sabine River Basin, and on the west by the Trinity River Basin. Tyler is the largest city in the basin; other cities include Beaumont, Lufkin, and Nacogdoches. The 2010 population of the Neches River Basin of about 802,000 is projected by the TWDB to increase by 34% by the year 2030. Average annual rainfall ranges from 41 inches at the headwaters of the basin to 57 inches at the outlet (Wurbs et al., 2014b). The mean annual precipitation is about 1,236 mm.

3.2.2 Neches WAM

The TCEQ updated the original Neches WAM, which was developed by Brown & Root Services under contract with the TNRCC, as documented by a 1999 report. Now, the TCEQ periodically updates the Neches WAM water rights data files, along with the WAMs for the other river basins of the state (Wurbs et al., 2014b). The latest TCEQ WAM dataset revisions, dated October 1, 2012, were used for developing the daily WAM, which includes SB3 environmental flow standards. The WAM files for the authorized use scenario (run 3) have filename roots neches3 and current use scenario (run 8) named neches8.

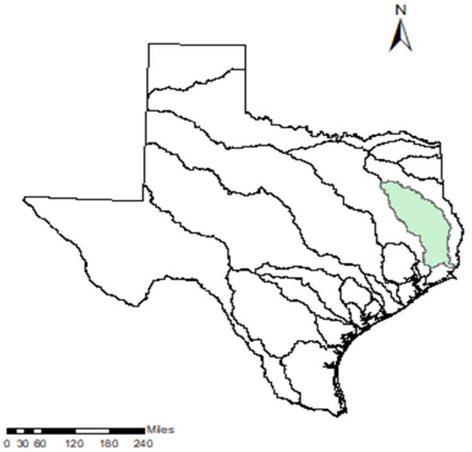


Figure 3.4. Location of Neches River Basin

The information for each of the 20 primary control points in the Neches WAM is listed in Table 3.6, and locations and connectivity are shown in Figures 3.4. Primary control points have monthly naturalized flow data as IN records in a FLO file in a SIM input dataset. The naturalized flows for secondary control points are calculated by SIM simulation, which is based on naturalized flows provided at the primary control points and watershed parameters. The five control points at which environmental flows were modeled are indicated in black.

Table 3.6 Primary Control Points in the Neches WAM

Control Point	Gage No.	Location	Drainage Area (sq. miles)
KIBR	08031200	Kickapoo Creek near Brownsboro	232
NEPA	–	Neches River at Lake Palestine	837
NENE	**08032000**	**Neches River near Neches**	**1,145**
NEAL	08032500	Neches River near Alto	1,943
NEDI	08033000	Neches River near Diboll	2,724
NERO	**08033500**	**Neches River near Rockland**	**3,631**
MUTY	–	Mud Creek at Lakes Tyler and Tyler East Dams	114
MUJA	08034500	Mud Creek near Jacksonville	376
EFACU	08033900	East Fork Angelina River near Cushing	157
ANAL	**08036500**	**Angelina River near Alto**	**1,273**
ANLU	08037000	Angelina River near Lufkin	1,601
ATCH	08038000	Attoyac Bayou near Chireno	504
AYSA	08039100	Ayish Bayou near San Augustine	89
ANSR	–	Angelina River at Sam Rayburn Reservoir	3,452
NETB	08040600	Neches River near Town Bluff	7,571
NEEV	**08041000**	**Neches River at Evadale**	**7,885**
VIKO	**08041500**	**Village Creek near Kountze**	**861**
PISL	08041700	Pine Island Bayou near Sour Lake	368
NEBA	08041780	Neches River Saltwater Barrier at Beaumont	9,826
NESL	–	Neches River at Sabine Lake	

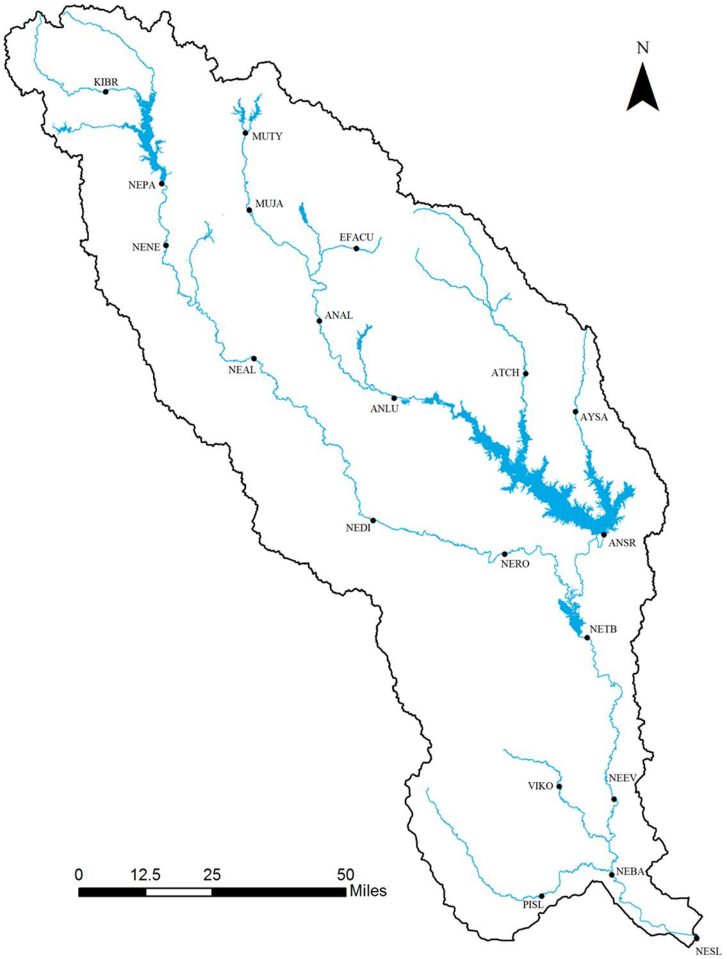


Figure 3.5 Map of Primary Control Points in the Neches WAM

The 11 existing major reservoirs and two permitted reservoirs (but not yet constructed), reservoirs in the Neches River Basin are listed in Table 3.7, and their locations are shown in the map of Figure 3.8. Sam Rayburn Reservoir, the biggest reservoir the Neches River Basin, contains 75.2 percent of the total conservation storage capacity of 3,852,160 acre-feet of the 180 reservoirs in the authorized use scenario.

Table 3.7 Major Reservoirs in the Neches River Basin

			Initial	Reservoir	Conservation Capacity	
Reservoir	Dam	Stream	Impound	Identifier	Authorized	Current
					(acre-feet)	(acre-feet)
Sam Rayburn	Sam Rayburn	Angelina River	1965	RAYBRN	2,898,200	2,887,736
Steinhagen	Town Bluff	Neches River	1951	STEINH	94,250	66,972
Palestine	Blackburn Crossing	Neches River	1962	PALEST	411,840	403,825
Tyler East	Mud Creek Dam	Mud Creek	1966	TYLERW	43,100	36,158
Tyler	Whitehouse Dam	Prairie Creek	1949	TYLERE	44,000	44,000
Athens	Athens	Flat Creek	1962	ATHENS	32,840	29,475
Jacksonville	Buckner	Gum Creek	1957	JACKSN	30,500	30,239
Striker Creek	Striker Creek	Striker Creek	1957	STRIKR	26,960	22,618
Kurth	Kurth (off-channel)	Angelina River	1961	KURTH	16,200	14,600
Pinkston	Pinkston	Sandy Creek	1978	PINKST	7,380	7,349
Nacogdoches	Nacogdoches	Bayo Loco Crk	1976	NACH	42,318	39,427
Proposed Projects Permitted but Not Yet Constructed						
Columbia	Columbia	Mud Creek	–	COLUM	195,500	–
Naconiche	Naconiche	Naconiche Crk	–	NACKNK	9,072	9,072

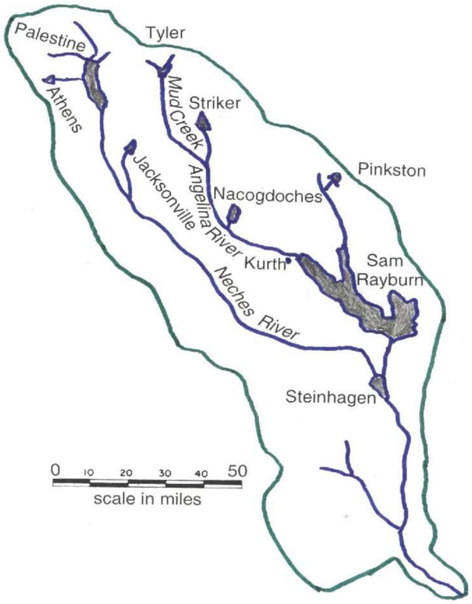


Figure 3.6 Major Reservoirs in the Neches River Basin

The October 2012 authorized use scenario Neches WAM contains 378 WR records and 75 IF records, accounting for yearly diversions totaling 1,730,431 acre-feet per year, with approximately 30.2% used for municipal purposes, 25.7% used for irrigation, 43.4% used for industrial purposes, 0.07 % used for mining, and 0.59% used for other purposes (Wurbs et al., 2014b).

3.2.3. Senate Bill 3 Environmental Flow Standards for Neches River Basin

The environmental flow standards for surface water for the Sabine and Neches Rivers are documented in Texas Administrative Code Title 30, Part 1, Chapter 298, Subchapter C. Instreamflow standards at the five Neches River Basin locations are incorporated into the daily Neches WAM (Wurbs et al., 2014b). The techniques are described in the report, which is titled Daily Water Availability Model for the Neches River Basin. The Neches WAM primary control points corresponding to the five USGS gage sites in black are listed with descriptive information in Table 3.7. Four seasons are defined according to the months listed in Table 3.8.

Table 3.8 Months Included in Each Season

Season	Months
Winter	December, January, February
Spring	March, April, May
Summer	June, July, August
Fall	September, October, November

The subsistence flow standards for the four control points in the Neches River Basin are shown in Table 3.9.

Table 3.9 Subsistence Flow Standards (cfs)

WAM CP ID	Winter	Spring	Summer	Fall
NENE	51	21	12	13
NERO	67	29	21	21
ANAL	55	18	11	16
NEEV	228	266	228	228
VIKO	83	49	41	41

Base flow standards are shown in Table 3.10, and Table 3.11 specifies high flow pulse standards depending on four seasons for the Neches River Basins.

Table 3.10 Base Flow Standards (cfs)

WAM CP ID	Winter	Spring	Summer	Fall
NENE	196	96	46	80
NERO	603	420	67	90
ANAL	277	90	40	52
NEEV	1,925	1,804	580	512
VIKO	264	117	77	98

Table 3.11 High Flow Pulse Standards for the Neches River Basin

WAM CP	Criteria	Winter	Spring	Summer	Fall
NENE	Trigger (cfs)	833	820	113	345
	Volume (ac-ft)	19,104	20,405	1,339	5,391
	Duration (days)	10	12	4	8
NERO	Trigger (cfs)	3,080	1,720	195	515
	Volume (ac-ft)	82,195	39,935	1,548	8,172
	Duration (days)	14	12	5	8
ANAL	Trigger (cfs):	1,620	1,100	146	588
	Volume (ac-ft)	37,114	24,117	2,632	12,038
	Duration (days)	13	14	8	12
NEEV	Trigger (cfs)	2,020	3,830	1,540	1,570
	Volume (ac-ft)	20,920	68,784	21,605	17,815
	Duration (days)	6	12	9	7
VIKO	Trigger (cfs)	2,010	1,380	341	712
	Volume (ac-ft)	36,927	23,093	6,159	11,426
	Duration (days)	13	13	8	9

3.3. Guadalupe and San Antonio River Basin

3.3.1. Description of the Basin

The GSA Basin is located in the southern part of Texas, which combines the Guadalupe and San Antonio River Basins. Figure 3.7 shows the geographical location of the GSA Basins. The total combined watershed area is 10,100 square miles, in which Guadalupe River basin covers 5,900 square miles and San Antonio River basin covers 4,200 square miles. The Guadalupe and San Antonio Rivers are about 230 miles long and

240 miles long, respectively. Principal tributaries to the Guadalupe River are the San Marcos River, Peach Creek, Sandies Creek, and Coleto Creek. The Blanco River and Plum Creek flow into the San Marcos River which flows into the Guadalupe River. The major tributaries of the San Antonio River are the Medina River, Leon Creek, Salado Creek, and Cibolo Creek. Average annual rainfall in the basins varies spatially, ranging from about 28 inches in the upper basins to 40 inches near the coast (Wurbs et al., 2014c).

Figure 3.7. Location of Guadalupe and San Antonio River Basin

3.3.2. GSA WAM

HDR, Inc., working for TCEQ, developed the original GSA WAM, as documented by a 1999 report, Water Availability in the GSA River Basin. Two scenarios are developed for the GSA WAM files. One is the Authorized Use Scenario (filename roots gsa_run3), and the other is the Current Use Scenario (filename roots gsa_run8). The GSA WAM has 46 primary control points, the naturalized flows of which are provided in a WRAP-SIM input dataset. More information is shown in Table 3.12 and Figure 3.8. Twenty-two of the primary control points are in the Guadalupe River Basin, including CP38 at the San Antonio River Confluence and CPEST at the outlet at the estuary. The remaining twenty-four primary control points are in the San Antonio River Basin (Wurbs et al., 2014c).

Table 3.12 Primary Control Points in the GSA WAM

Control Point	USGS Gage No.	Location	Drainage Area (sq. miles)
		Guadalupe River Basin	
CP01	**08167000**	**Guadalupe River at Comfort**	**838**
CP02	**08167500**	**Guadalupe River near Spring Branch**	**1,315**
CP03	08167800	Guadalupe River at Canyon Lake	1,432
CP04	08168500	Guadalupe River above Comal River at New Braunfels	1,519
CP05	08169000	Comal River at New Braunfels	130
CP06	–	Guadalupe River at Lake Wood	2,103
CP08	**08171000**	**Blanco River at Wimberley**	**355**
CP09	08171300	Blanco River near Kyle	412
CP10	**08172000**	**San Marcos River at Luling**	**839**
CP11	**08173000**	**Plum Creek near Luling**	**311**
CP12	08174600	Peach Creek below Dilworth	460
CP13	**08175000**	**Sandies Creek near Westhoff**	**549**
CP14	**08175800**	**Guadalupe River at Cuero**	**4,935**
CP15	**08176500**	**Guadalupe River at Victoria**	**5,196**
CP16	08177400	Coleto Creek Reservoir near Victoria	493
CP38	08188800	Guadalupe River near Tivoli	10,122
CP71	–	Sink Creek	43
CP72	–	Purgatory Creek	34
CP73	–	York Creek	12
CP74	–	Alligator Creek	4
CP75	–	San Marcos Springs	0.1
CPEST	–	Guadalupe Estuary	10,122

Table 3.12 Continued

		San Antonio River Basin	
CP17	–	Olmos Creek at Edwards	8
CP18	08178000	San Antonio River at San Antonio	44
CP19	08178700	Salado Creek at San Antonio Upper Station	136
CP20	08178800	Salado Creek at San Antonio Lower Station	187
CP21	08179500	Medina Lake	634
CP22	–	Tributaries to Diversion Lake	16
CP23	08180500	Medina River near Rio Medina	649
CP241	–	West Tributaries downstream of Diversion Lake	4
CP242	–	East Tributaries downstream of Diversion Lake	7
CP25	–	San Geronimo Creek at Edwards	58
CP261	–	Leon Creek at Edwards	60
CP262	–	Helotes Creek at Edwards	28
CP263	–	Government Creek at Edwards	12
CP27	08180800	Medina River near Somerset	962
CP28	**08181500**	**Medina River at San Antonio**	**1,310**
CP29	**08181800**	**San Antonio River near Elmendorf**	**1,737**
CP30	–	Braunig Lake	9
CP31	08182500	Calaveras Lake	65
CP32	**08183500**	**San Antonio River near Falls City**	**2,108**
CP33	08183900	Cibolo Creek near Boerne	68
CP34	08185000	Cibolo Creek at Selma	274
CP35	**08186000**	**Cibolo Creek near Falls City**	**825**
CP36	08186500	Ecleto Creek near Runge	239
CP37	**08188500**	**San Antonio River at Goliad**	**3,906**

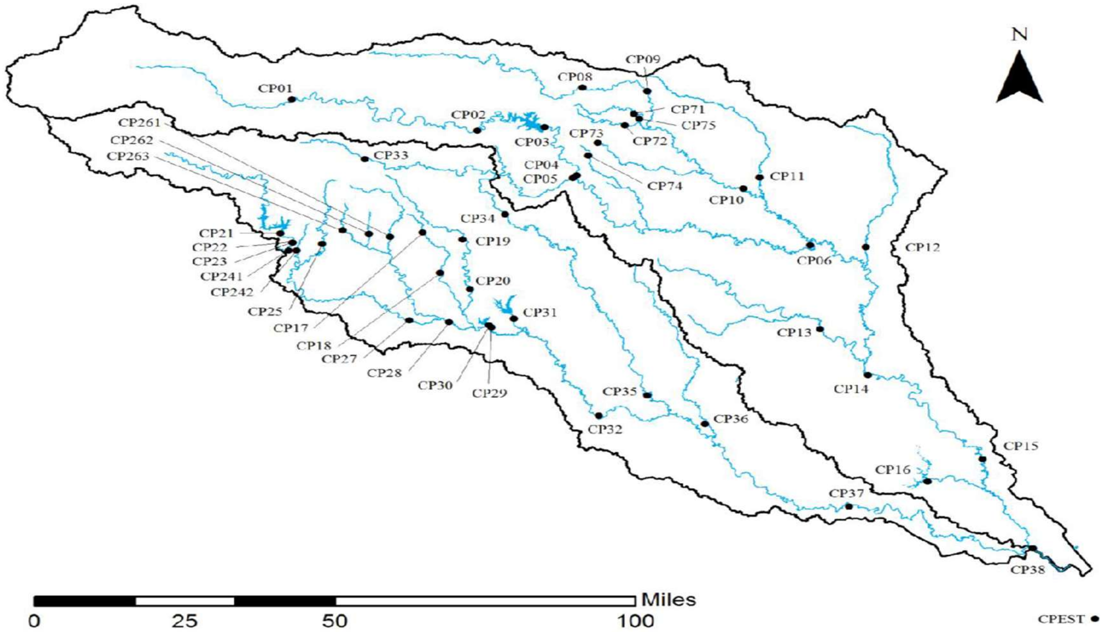


Figure 3.8 Map of Primary Control Points in the GSA WAM

In the October 2008 authorized use scenario GSA WAM, all nine major reservoirs, which have storage capacities over 1,400 acre-feet, are listed in Table 3.13. The locations of the nine major reservoirs (238 total) are shown in Figure 2.4. The numbers in the map refer to the first column of Table 3.13. The 9 major reservoirs with total permitted conservation storage capacity of 775,868 acre-feet account for 96.1 percent of the total storage capacity of 806,875 acre-feet in the 238 reservoirs. Canyon Lake, owned and operated by the Fort Worth District of the U.S. Army Corps of Engineers, contains 47.9 percent of the total permitted conservation storage capacity of the 238 reservoirs in the authorized use scenario GSA WAM. But, the 394,900 acre-feet flood control pool in Canyon Lake is not included in the WAM (Wurbs et al., 2014c)

Table 3.13 Major Reservoirs in the GSA WAM

Map ID	Reservoir	Stream	Identifier	Control Point	Authorized Capacity (acre-feet)
1	Canyon Lake	Guadalupe River	CANYON	207401	386,200
2	Medina Lake	Medina River	MEDINA	CP21	237,875
3	Calaveras Lake	Calaveras Creek	CALVER	216231	63,200
4	Coleto Creek Reservoir	Coleto Creek	COLETO	548631	35,084
5	Victor Braunig Lake	Arroyo Seco	BRAUNG	216131	26,500
6	Olmos Reservoir	Olmos Creek	R3898	P38981	14,240
7	Cooling Reservoir		R5178	517801	4,770
8	Boerne Lake	Cibolo Creek	BOERNE	114302	4,046
9	Diversion Lake	Medina River	DIVERS	CP23	3,953

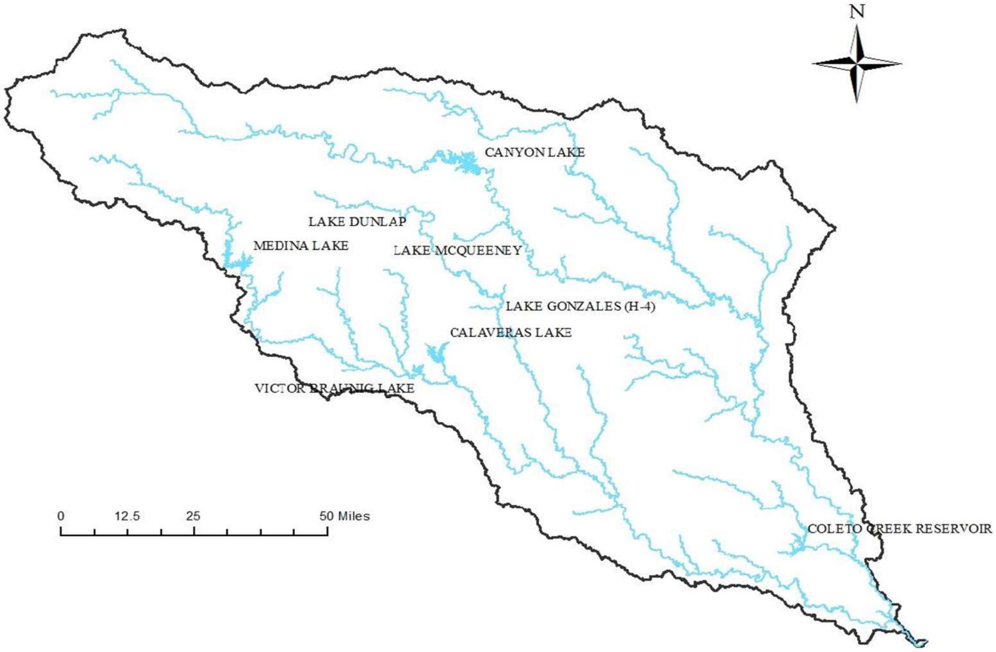


Figure 3.9 Major Reservoirs in the GSA River Basins

3.3.3. Senate Bill 3 Environmental Flow Standards for GSA River Basin

The Bay and Basin Expert Science Team (BBEST) submitted its Recommendation Report for the Guadalupe, San Antonio, Mission, and Aransas rivers and Mission, Copano, Aransas, and San Antonio bays to the Bay and Basin Area Stakeholder Committee (BBASC) and TCEQ in March 2011. The BBASC also submitted a Recommendation Report in September 2011, and a Work Plan in May 2012. Environmental flow standards for the Guadalupe, San Antonio, Mission, and Aransas rivers and Mission, Copano, Aransas, and San Antonio bays were adopted by the TCEQ effective August 30, 2012 (Wurbs et al., 2014c).

The environmental flow standards for surface water for the Guadalupe, San Antonio, Mission, and Aransas rivers and Mission, Copano, Aransas, and San Antonio bays are documented in the Texas Administrative Code Title 30, Part 1, Chapter 298, Subchapter E. Flow standards have been established for 16 control point locations, including 9 sites in the Guadalupe River Basin, 6 sites in the San Antonio River Basin, and 1 site in the Mission River Basin. SB3 environmental flow standards have been established at 15 USGS stream-gaging stations, including 13 of the primary control points listed in Table 3.11. and two additional secondary control points, C38461 and P38241, at USGS gaging stations 08173900 and 08178880 (Wurbs et al., 2014c).

The environmental flow standards vary seasonally; the recommendations for subsistence flows, base flows, and high flow pulses keep changing. The four seasons are listed in Table 3.14, and each season includes three months, with the winter season beginning in January.

Table 3.14 Months Included in Each Season for the GSA River Basins

Season	Months
Winter	January, February, March
Spring	April, May, June
Summer	July, August, September
Fall	October, November, December

In the San Antonio River Basin, environmental flow standards are classified according to three hydrologic conditions (dry, average, and wet), defined based on 12-month cumulative streamflows. Table 3.15 lists the cumulative streamflow limits for each hydrologic condition, determined by assessing the exceedance frequency curves for 12-month cumulative monthly naturalized flows from the GSA WAM, such that dry conditions and wet conditions each occurred 25% of the time, and average conditions occurred 50% of the time (Wurbs et al., 2014c).

Table 3.15 12-Month Cumulative Naturalized Streamflow Limits for Evaluating Hydrologic Conditions at Control Points in the San Antonio River Basin

	Hydrologic Condition		
Control Point	Dry	Average	Wet
	Original 1934-1989 Dataset		
P382411	26,591	26,591 - 103,345	103,345
CP28	71,879	71,879 - 245,191	245,191
CP29	111,543	111,543 - 379,920	379,920
CP32	136,710	136,710 - 436,835	436,835
CP35	30,622	30,622 - 119,904	119,904
CP37	220,177	220,177 - 713,915	713,915
	Original 1934-1989 and WRAP-HYD Extended 1990-2012 Dataset		
P382411	29,845	29,845 – 108,419	108,419
CP28	74,460	74,460 – 250,583	250,583
CP29	121,364	121,364 – 402,324	402,324
CP32	149,603	149,603 – 457,485	457,485
CP35	35,672	35,672 – 132,946	132,946
CP37	231,340	231,340 – 765,797	765,797

As seen in Table 3.16, the subsistence flow levels vary by season and location. For control points located in the Guadalupe River Basin, the subsistence flow standard is normally applied when measured stream flow falls below the subsistence flow standard. However, the subsistence flow standard is applicable during dry hydrologic conditions for control points located in the San Antonio River Basin, (Wurbs et al., 2014c). The base flow standard is applicable when measured streamflow is greater than the applicable base flow level and less than any applicable high flow pulse trigger magnitudes in the Guadalupe River Basin, as listed in Table 3.17. For the control points in the San Antonio River Basin, the standards are according to hydrologic conditions, as listed in Table 3.18.

Table 3.16 Subsistence Flow Standards (cfs) in the GSA River Basins

WAM CP ID	Winter	Spring	Summer	Fall
CP01E	31	18	2	25
CP02E	18	18	18	18
CP08E	10	13	8	10
CP10E	89	89	73	81
CP11E	3	2	1	1
C3846E	210	210	210	180
CP13E	4	1	1	2
CP14E	130	120	130	86
CP15E	160	130	150	110
P3824E	6	7	1	2
CP28E	14	12	8	13
CP29E	60	60	60	60
CP32E	60	60	60	60
CP35E	8	8	8	8
CP37E	60	60	60	60

Table 3.17 Base Flow Standards (cfs) in the Guadalupe River Basin

WAM CP ID	Winter	Spring	Summer	Fall
CP01E	110	100	75	110
CP02E	160	160	110	150
CP08E	52	64	56	64
CP10E	210	220	220	200
CP11E	12	10	5	8
C3846E	796	791	727	746
CP13E	12	9	4	9
CP14E	980	940	800	870
CP15E	975	945	795	865

Table 3.18 Base Flow Standards (cfs) in the San Antonio River Basin

WAM	Winter			Spring			Summer			Fall		
CP ID	Dry	Avg	Wet	Dry	Avg	Wet	Dry	Avg	Wet	Dry	Avg	Wet
P3824E	17	32	54	10	22	48	6	16	41	16	33	49
CP28E	20	53	71	37	62	77	33	57	72	27	60	74
CP29E	115	262	328	106	237	364	87	178	341	92	223	367
CP32E	152	292	424	137	264	467	113	199	430	117	246	479
CP35E	20	28	39	16	28	44	11	20	37	13	24	40
CP37E	200	329	469	174	313	502	139	237	481	167	280	584

The high flow pulse event standards are described in terms of trigger, duration, volume, and frequency criteria. For control points located in the GSA River Basins, criteria were specified for one or two "small" and two or three "large" pulses per season, except for control points P38241E and CP28E, which have two "small" and one "large" high flow pulse events per season (Wurbs et al., 2014c). If the high flow pulse trigger level has been met, junior water right holders may not divert water until either the specified volume or specified duration time has passed. Although the diversion rate for the water right is less than 20% of the trigger magnitude for the high flow pulse event, water right permits issued after the effective date of the environmental flow standards are not required to protect a high flow pulse.

3.4. Trinity River Basin

3.4.1 Description of the Basin

The Trinity River extends approximately 400 miles in length with a drainage area of 18,000 square miles, as seen in Figure 3.10. The origin of the river is north of the Dallas-Fort Worth Metropolitan area near the Texas-Oklahoma border, and the river terminates to Galveston Bay east of Houston. Average annual precipitation gradually decreases from 53 inches near Galveston Bay at the southeast to 29 inches at the northwest of the basin. West Fork Trinity River, Elm Fork Trinity River, East Fork Trinity River, Cedar Creek, Chambers Creek, and Richland Creek are major tributaries (Wurbs et al., 2014d). According to the 2012 State Water Plan, the population of Region C, which includes the Dallas Fort-Worth area, was approximately 6.7 million, which represented about one-fourth of the population of Texas.

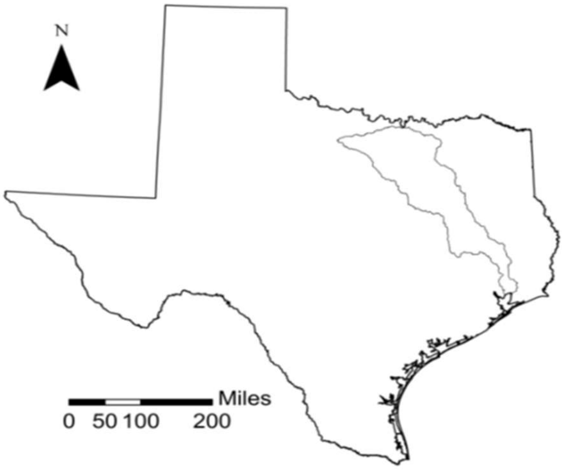


Figure 3.10 Trinity River Basin

3.4.2. Trinity WAM

The original Trinity WAM dataset was completed in 2002 by Espey Consultants, as documented in the report entitled *Trinity River and Trinity-San Jacinto and Neches-Trinity Coastal Basins Water Availability Study*, for modeling the SB3 environmental instream flow requirements (Espey Consultants, 2002). The original Trinity WAM modeled 552 water right permits, representing a total diversion of 5,322,610 acre-feet/year, with about 58% municipal, 35% industrial, and 7% agricultural irrigation use. The October 2012 Trinity WAM contains 1,061 water right records and 71 instream flow records, while the Oct 2014 Trinity WAM contains 1,057 water right records and 71 instream flow records (Wurbs et al., 2014d). In 2012, Wurbs et al. (2012) converted the Trinity WAM from a monthly to a daily time-step simulation and described the records used to model SB3 instream flow standards and reservoir flood control operations documented in the report entitled *Application of Expanded WRAP Modeling Capabilities to the Trinity WAM.* The

Trinity WAM has 40 primary control points, which are described in Table 3.19, with locations and connectivity information shown in Figure 3.11.

Table 3.19 Primary Control Points in the Trinity WAM

WAM CP	USGS Gage	Location	Basin Area (mile^2)	Period-of Record
8WTJA	08042800	West Fork Trinity River near Jacksboro	683	Mar 1956-present
8BSBR	08044000	Big Sandy Creek near Bridgeport	333	Oct 1936-present
8WTBO	08044500	West Fork Trinity River near Boyd	1,725	Jan 1947-present
8CTAL	08046000	Clear Fork Trinity River near Aledo	251	Aug 1947-Oct 1975
8CTBE	08047000	Clear Fork Trinity River near Benbrook	431	Jul 1947-present
8CTFW	08047500	Clear Fork Trinity River at Fort Worth	518	Mar 1924-present
8WTFW	08048000	West Fork Trinity River at Fort Worth	2,615	Oct 1920-present
8WTGP	08049500	West Fork Trinity River at Grand Prairie	3,065	Mar 1925-present
8MCGP	08050100	Mountain Creek at Grand Prairie	298	Oct 1960-present
8ELSA	08050500	Elm Fork Trinity River near Sanger	381	May 1949-Dec 1984
8IDPP	08051000	Isle Du Bois Creek near Pilot Point	266	May 1949-Dec 1984
8CLSA	08051500	Clear Creek near Sanger	295	Mar 1949-present
8ELLE	08053000	Elm Fork Trinity River near Lewisville	1,673	Mar 1949-present
8DNJU	08053500	Denton Creek near Justin	400	Oct 1949-present
8DNGR	08055000	Denton Creek near Grapevine	705	Oct 1947-present
8TRDA	08057000	Trinity River at Dallas	6,106	Oct 1903-present
8WRDA	08057200	White Rock Creek at Greenville Ave	66	Aug 1961-present
8ETMK	08059000	East Fork Trinity River near McKinney	190	Sep 1949-present
8SGPR	08059500	Sister Grove Creek near Princeton	113	Sep 1949-Jan 1975
8ETLA	08061000	East Fork Trinity River near Lavon	773	Oct 1953-Sep 1989
8ETFO	08061750	East Fork Trinity River near Forney	1,118	Jan 1973-present
8ETCR	08062000	East Fork Trinity River near Crandall	1,256	Jul 1949-present
8TRRS	08062500	Trinity River near Rosser	8,146	Aug 1924-present
8TRTR	08062700	Trinity River at Trinidad	8,538	Oct 1964-present
8CEKE	08062800	Cedar Creek near Kemp	189	Jan 1963-present
8KGKA	08062900	Kings Creek near Kaufman	233	Jan 1963-Sep 1987
8CEMA	08063000	Cedar Creek near Mabank	733	Oct 1938-Feb 1966
8RIDA	08063100	Richland Creek near Dawson	333	Oct 1960-present
8RIRI	08063500	Richland Creek near Richland	734	Apr 1939-Jun 1989
8WABA	08063800	Waxahachie Creek near Bardwell	178	Oct 1963-present
8CHCO	08064500	Chambers Creek near Corsicana	963	Apr 1939-Sep 1984
8RIFA	08064600	Richland Creek near Fairfield	1,957	Gage is missing
8TEST	08064700	Tehuacana Creek near Streetman	142	Apr 1968-present
8TROA	08065000	Trinity River near Oakwood	12,833	Oct 1923-present
8TRCR	08065350	Trinity River near Crockett	13,911	Jan 1964-present
8TRMI	08065500	Trinity River near Midway	14,450	Apr 1939-Nov 1970
8BEMA	08065800	Bedias Creek near Madisonville	321	Oct 1967-present
8TRRI	08066000	Trinity River at Riverside	15,589	Oct 1923-Sep 1968
8TRRO	08066500	Trinity River at Romayor	17,186	May 1924-present
8TRGB	no gage	Trinity River at Galveston Bay	17,949	no gage

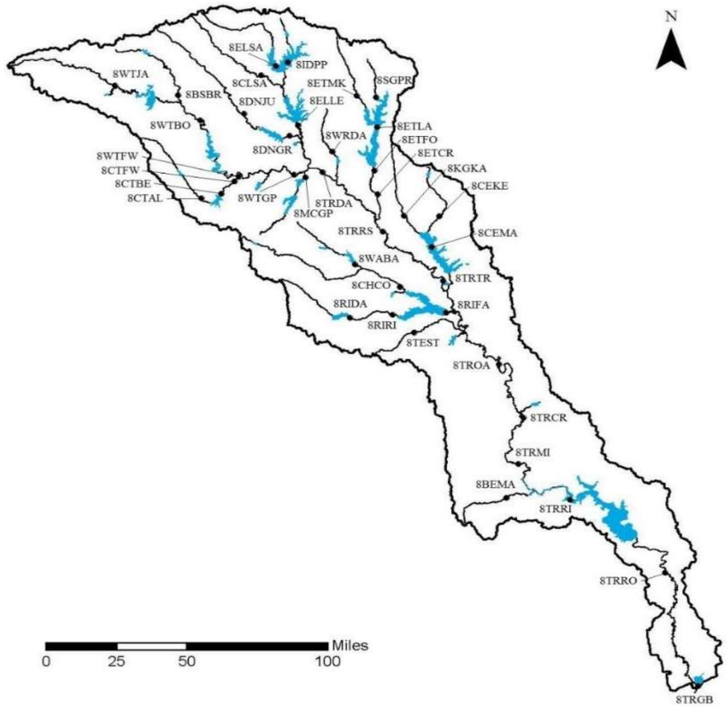


Figure 3.11 Map of Primary Control Points in the Trinity WAM

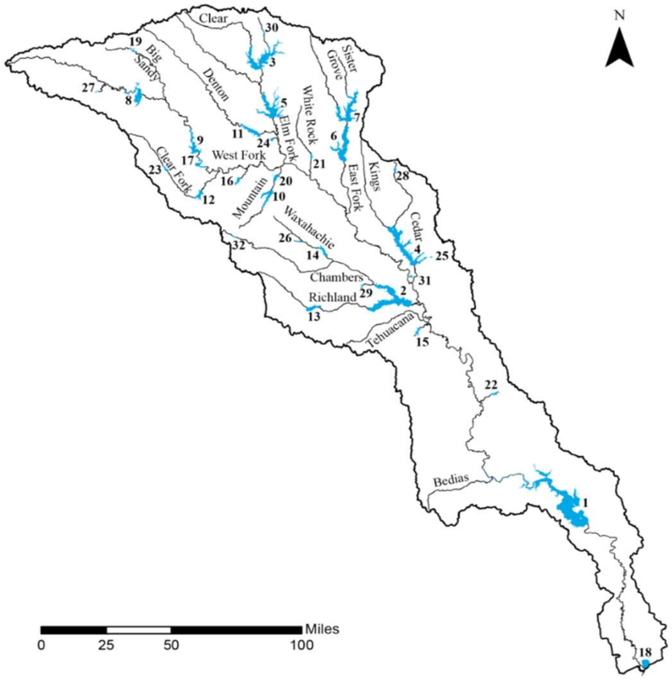


Figure 3.12 Major Tributaries and Largest Reservoirs

Figure 3.12 is a map showing the 32 major reservoirs in the Trinity basin with storage capacities exceeding 5,000 acre-feet. The numbers in the first column of Table 3.20 refer to the reservoir labels on the map of Figure 3.12. Lake Livingston, located on the lower Trinity River, is the largest reservoir in the basin. The Trinity River Authority (TRA) owns and operates Lake Livingston under contract with the City of Houston.

Table 3.20 Major Reservoirs in the Trinity River Basin

Map ID	Reservoir	WAM Identifier	WAM CP ID	Initial Impoundment	Authorized Storage
					(acre-feet)
1	Lake Livingston	LIVSTN	B4248B	1969	1,750,000
2	Richland-Chambers Reservoir	RICHCH	B5035A	1987	1,135,000
3	Ray Roberts Lake	ROBDEN	B2335A	1987	799,600
4	Cedar Creek Reservoir	CEDAR	B4976A	1965	678,900
5	Lewisville Lake	LEWDE1	B2456A	1954	618,400
6	Lake Ray Hubbard	HUBBRD	B2462A	1968	490,000
7	Lavon Lake	LAVON0	B2410A	1953	456,500
8	Lake Bridgeport	BRIDGE	B3808A	1932	387,000
9	Eagle Mountain Lake	EGLMTN	B3809A	1934	210,000
10	Joe Pool Lake	JOPOOL	B3404A	1986	176,900
11	Grapevine Lake	GPVGP1	B2362A	1952	162,500
12	Benbrook Lake	BENBRK	B5157P	1952	88,250
13	Navarro Mills Lake	NAVARO	B4992A	1963	63,300
14	Bardwell Lake	BARDWL	B5021A	1965	54,900
15	Fairfield Lake	FAIRFD	B5040A	1969	50,600
16	Lake Arlington	ARLING	B3391A	1957	45,710
17	Lake Worth	WORTH	B3340A	1914	38,124
18	Lake Anahuac	ANAHUA	B4279C	1914	35,300
19	Lake Amon G. Carter	CARTER	B3320B	1956	28,589
20	Mountain Creek Lake	MTNCRK	B3408A	1937	22,840
21	White Rock Lake	WHITER	B2461A	1911	21,345
22	Houston County Lake	HOUCTY	B5097A	1966	19,500
23	Lake Weatherford	WTHRFD	B3356A	1957	19,470
24	North Lake	NORTH	B2365A	1957	17,100
25	Forest Grove Reservoir	FOREST	B4983A	1976	16,348
26	Lake Waxahachie	WAXAHC	B5018A	1956	13,500
27	Lost Creek Reservoir	LOSTCK	B3313B	1990	11,961
28	New Terrell City Lake	TERREL	B4972A	1955	8,712
29	Lake Halbert	HALBRT	B5030A	1921	7,357
30	Lake Kiowa	KIOWA	B2334A	1970	7,000
31	Trinidad Lake	TRINDD	B4970A	1925	6,200
32	Alvarado Park Lake	B5001	B5001A	1966	4,781

3.4.3. Senate Bill 3 Environmental Flow Standards for Trinity River Basin

The environmental flow standards for surface water for the Trinity, San Jacinto River and Galveston Bay are documented in Texas Administrative Code Title 30, Part 1, Chapter 298, Subchapter B. In May 2011, environmental flow standards from Senate Bill 3 (SB3) were effectively adopted by the TCEQ. The identifiers of the new control points (control point 8WTGPE, 8TRDAE, 8TROAE, and 8TRROE) are the same as the identifiers of the primary control points, with a letter "E" replacing the sixth character (Wurbs et al., 2014d). The SB3 standards in the Trinity River Basin were created using four seasons listed in Table 3.21.

Table 3.21 Seasons Defined by SB3 Environmental Flow Standards

Season	Months
Winter	December, January, February
Spring	March, April, May
Summer	June, July, August
Fall	September, October, November

The instream flow standards consist of seasonal subsistence flows, base flows, and high flow pulses, shown in Table 3.22, 3.23, and 3.24, respectively.

Table 3.22 Subsistence Flow Standards (cfs)

WAM CP ID	Winter	Spring	Summer	Fall
8WTGPE	19	25	23	21
8TRDAE	26	37	22	15
8TROAE	120	160	75	100
8TRROE	495	700	200	230

If the flow at a control point is greater than the applicable base flow standard and less than the applicable pulse flow trigger level, then water right holders may make diversions as long as the flow does not drop below the base flow standards shown in Table 3.23.

Table 3.23 Base Flow Standards (cfs)

WAM CP ID	Winter	Spring	Summer	Fall
8WTGPE	45	45	35	35
8TRDAE	50	70	40	50
8TROAE	340	450	250	260
8TRROE	875	1,150	575	625

The summer and fall seasons are combined as a single six-month season for the purposes of tracking high flow pulse events, according to Table 3.24.

Table 3.24 High Flow Pulse Standards

WAM CP ID	Criteria	Winter	Spring	Summer/Fall
8WTGPE	Trigger (cfs):	300	1,200	300
	Volume (af):	3,500	8,000	1,800
	Duration (days):	4	8	3
8TRDAE	Trigger (cfs):	700	4,000	1,000
	Volume (af):	3,500	40,000	8,500
	Duration (days):	3	9	5
8TROAE	Trigger (cfs):	3,000	7,000	2,500
	Volume (af):	18,000	130,000	23,000
	Duration (days):	5	11	5
8TRROE	Trigger (cfs):	8,000	10,000	4,000
	Volume (af):	80,000	150,000	60,000
	Duration (days):	7	9	5

3.5. Brazos River Basin

3.5.1. Description of the Basin

The Brazos Basin is the second largest river basin by area within Texas, which has a total area of 45,870 square miles, with about 43,160 square miles in Texas and the remainder in New Mexico. The climate, hydrology, and geography of the basin vary widely across Texas, from the upper basin in New Mexico to the discharge area in the Gulf of Mexico. Mean annual precipitation varies from 19 inches in the upper basin near the High Plains to 45 inches in the lower basin in the Gulf Coast region. The Brazos River has the largest average annual flow volume in the state, with a meandering path about 920 miles from the confluence of the Salt Fork and Double Mountain Fork to the city of Freeport at the Gulf of Mexico. The major metropolitan cities of Dallas-Fort Worth, Austin and Houston are just outside the watershed boundaries. In 2010, the population of the Brazos River Basin was about 2,440,000 people (Wurbs and Zhang 2014). The geographical location of the Brazos River Basin in Texas is delineated in Figure 3.13.

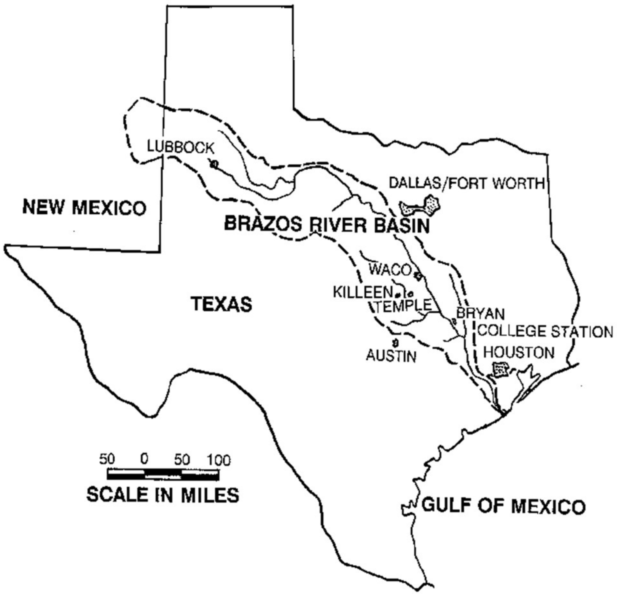


Figure 3.13 Brazos River Basin and San Jacinto-Brazos Coastal Basin

3.5.2. Brazos WAM

The original Brazos WAM completed in 2001 contained 1,216 water rights, combining the Brazos River Basin and adjoining San Jacinto-Brazos Coastal Basin. The total water rights included 1,160 rights in the Brazos River Basin and 56 rights in the San

Jacinto-Brazos Coastal Basin (HDR 2001). Excluding hydropower and the portion of thermal electric cooling water returned to streams, the diversion rights are divided as follows: approximately 47.6% for municipal purposes, 30.1% for industrial, 18.0% for agricultural irrigation purposes, and 4.3% for other purposes. The total authorized consumptive water use in the Brazos River Basin and adjoining coastal basin are 95.2% and 4.8%, respectively. The September 2008 versions of the Brazos WAM contains 3,852 control points, including 77 primary control points with IN records and the 67 control points with EV records (Wurbs and Hoffpauir, 2013).

The authorized use scenario Brazos WAM contains 678 reservoirs cited in water right permits, including 43 reservoirs with conservation storage capacities of 5,000 acre-feet or greater. Table 3.25 tabulates the 16 largest reservoirs that have a combined conservation and flood control storage capacity of greater than 75,000 acre-feet.

Table 3.25. Largest Reservoirs in the Brazos River Basin

Reservoir	Reservoir Identifier	Control Point	initial impoundment	Storage (acre-feet) Bwam3	Diversion (ac-ft/year) Bwam3
			Brazos River Authority System		
Possum Kingdom	POSDOM	515531	1941	724,739	230,750
Granbury	GRNBRY	515631	1969	155,000	64,712
Whitney	WHITNY	515731	1951	387,024	0
	BRA	515731		50,000	18,336
	CORWHT	515731		199,076	0
Aquilla	AQUILA	515831	1983	52,400	13,896
Waco	LKWACO	509431	1965	39,100	39,100
	WACO2	509431		65,000	20,000
	WACO4	509431		88,062	20,777
	WACO5	509431		14,400	0
Proctor	PRCTOR	515931	1963	59,400	19,658
Belton	BELTON	516031	1954	457,600	112,257
Stillhouse Hollow	STLHSE	516131	1968	235,700	67,768
Georgetown	GRGTWN	516231	1980	37,100	13,610
Granger	GRNGER	516331	1980	65,500	19,840
Limestone	LMSTNE	516531	1978	225,400	65,074
Somerville	SMRVLE	516431	1967	160,110	48,000
Allens Creek	ALLENS	292531	proposed	145,533	99,650
			City of Lubbock		
Alan Henry	ALANHN	4146P1	1993	115,937	35,000
			West Central Texas Municipal Water District		

Hubbard Creek	HUBBRD	421331	1962	317,750	56,000
		Texas Utilities Services			
Squaw Creek	SQWCRK	409702	1977	151,500	23,180

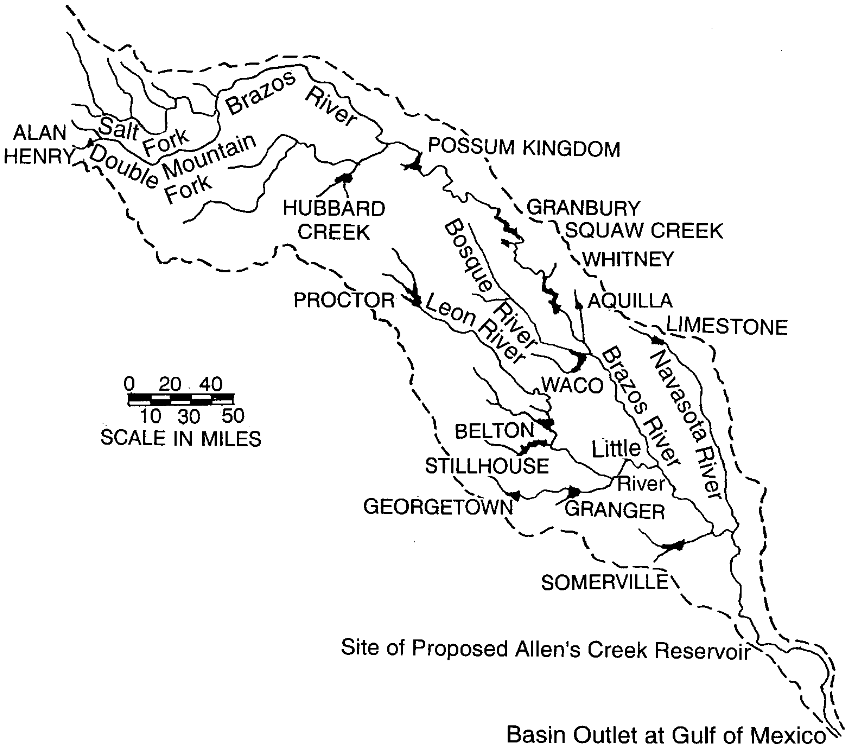


Figure 3.14 Major Tributaries and Largest Reservoirs

Possum Kingdom Lake has a conservation storage capacity of 724,739 ac-ft., the largest storage capacity in the Brazos River Basin. Lake Whitney is the largest reservoir in the Brazos River Basin when considering the total of both flood control and conservation capacity (Wurbs and Hoffpauir, 2013).

3.5.3. Senate Bill 3 Environmental Flow Standards for Brazos River Basin

Environmental flow standards that have been adopted for the river systems of the state are published in Chapter 298 in Title 30 of the Texas Administrative Code. Environmental flow standards for the Brazos River and its associated bay and estuary system are in Subchapter G (Wurbs and Hoffpauir, 2013). Seasons are defined by the SB3 environmental flow standards as shown in Table 3.27. Base flow and high flow pulse components are shown in Table 3.28.

Table 3.26. Seasons Defined by SB3 Environmental Flow Standards

Season	Brazos River Basin
Winter	November, December, January, February
Spring	March, April, May, June
Summer	July, August, September, October
Fall	−

Table 3.27 Subsistence Flow Standards (cfs)

WAM CP ID	Subsist Flow	WAM CP ID	Subsist Flow
SFAS06	1	LEGT47	1
DMAS09	1	LAKE50	10
BRSE11	1	LRLR53	55
CFNU16	1	LRCA58	32
CON026	1	BRBR59	300
BRSB23	1	NAEA66	1
BRPP27	17	BRHE68	510
BRGR30	16	BRRI70	550
NBCL36	1	BRRO72	430
BRWA41	56		

Table 3.28 Base Flow and High Flow Pulse Components of the Environmental Flow Standards

	Winter					Spring					Summer				
	BF (cfs)	Qp (cfs)	F	Vol (ac-ft)	Dur (days)	BF (cfs)	Qp (cfs)	F	Vol (ac-ft)	Dur (days)	BF (cfs)	Qp (cfs)	F	Vol (ac-ft)	Dur (days)
		SFAS06 Salt Fork Brazos at Aspermont													
dry	1	–	–	–	–	1	160	1	720	10	1	140	1	560	8
avg	4	–	–	–	–	2	160	2	720	10	1	140	2	560	8
wet	9	–	–	–	–	5	300	1	1,350	11	3	260	1	1,090	10
		DMAS09 Double Mountain at Aspermont													
dry	1	–	–	–	–	1	280	1	1,270	10	1	230	1	990	9
avg	4	–	–	–	–	3	280	2	1,270	10	2	230	2	990	9
wet	15	–	–	–	–	8	570	1	2,600	12	7	480	1	2,160	12
		BRSE11 Brazos River at Seymour													
dry	10	–	–	–	–	7	560	1	2,960	10	4	370	1	1,870	8
avg	25	–	–	–	–	19	560	2	2,960	10	13	370	2	1,870	8
wet	46	–	–	–	–	35	1,040	1	5,870	12	32	800	1	4,290	11
		CFNU16 Clear Fork Brazos at Nugent													
dry	5	–	–	–	–	3	180	1	860	9	1	100	1	460	8
avg	8	–	–	–	–	6	180	2	860	9	4	100	2	460	8
wet	13	26	1	160	9	12	590	1	2,800	12	9	390	1	1,890	12
		CON026 Clear Fork Brazos at Lueders													
dry	7	–	–	–	–	4	18	1	74	2	1	18	1	74	2
avg	10	–	–	–	–	7	37	2	148	2	5	37	2	148	2
wet	16	26	1	158	9	15	355	1	2,054	9	11	170	1	779	5
		BRSB23 Brazos River at South Bend													
dry	36	–	–	–	–	29	1,260	1	7,280	10	16	580	1	3,140	8
avg	73	–	–	–	–	60	1,260	2	7,280	10	46	580	2	3,140	8
wet	120	–	–	–	–	100	2,480	1	15,700	13	95	1,180	1	7,050	11
		BRPP27 Brazos River at Palo Pinto													
dry	40	850	2	3,690	5	39	1,400	2	6,600	6	40	1,230	2	5,920	6
avg	61	850	4	3,690	5	75	1,400	4	6,600	6	72	1,230	4	5,920	6
avg		1,390	2	7,180	7		3,370	2	20,200	10		2,260	2	13,000	9
wet	100	850	4	3,690	5	120	1,400	4	6,600	6	120	1,230	4	5,920	6
wet		1,390	3	7,180	7		3,370	3	20,200	10		2,260	3	13,000	9
		BRGR30 Brazos River at Glen Rose													
dry	42	930	2	5,400	8	47	2,350	2	14,300	10	37	1,320	2	7,830	8
avg	77	930	4	5,400	8	92	2,350	4	14,300	10	70	1,320	4	5,920	6
avg		1,700	2	10,800	10		6,480	2	46,700	14		3,090	2	21,200	12
wet	160	930	4	5,400	8	170	2,350	4	14,300	10	160	1,230	4	7,830	6
wet		1,700	3	10,800	10		6,480	3	46,700	14		3,090	2	21,200	12
		NBCL36 North Bosque River at Clifton													
dry	5	–	–	–	–	7	710	1	3,490	12	3	–	–	–	–
avg	12	–	–	–	–	16	710	3	3,490	12	8	–	–	–	–
wet	25	120	2	750	10	33	710	3	3,490	12	17	130	2	500	6
		BRWA41 Brazos River at Waco													
dry	120	2,320	1	12,400	7	150	5,330	1	32,700	10	140	1,980	1	10,500	7
avg	210	2,320	3	12,400	7	270	5,330	3	32,700	10	250	1,980	3	10,500	7
wet	480	4,180	2	25,700	9	690	13,600	2	102,000	14	590	4,160	2	26,400	10

Table 3.28 continued

	Winter					Spring					Summer				
	BF (cfs)	Qp (cfs)	F	Vol (ac-ft)	Dur (days)	BF (cfs)	Qp (cfs)	F	Vol (ac-ft)	Dur (days)	BF (cfs)	Qp (cfs)	F	Vol (ac-ft)	Dur (days)
	LEGT47 Leon River at Gatesville														
dry	9	–	–	–	–	10	340	1	1,910	10	4	58	1	220	4
avg	20	–	–	–	–	24	340	3	1,910	10	12	58	3	220	4
wet	52	100	2	540	6	54	630	2	4,050	13	27	140	2	600	6
	LAKE50 Lampasas River at Kempner														
dry	18	78	1	430	8	21	780	1	4,020	13	16	77	1	270	4
avg	27	78	3	430	8	29	780	3	4,020	13	23	77	3	270	4
wet	39	190	2	1,150	11	43	1,310	2	6,860	16	32	190	2	680	6
	LRLR53 Little River at Little River														
dry	82	520	1	2,350	5	95	1,420	1	9,760	10	84	430	1	1,560	4
avg	110	520	3	2,350	5	150	1,420	3	9,760	10	129	430	3	1,560	4
wet	190	1,600	2	11,800	11	340	3,290	2	32,200	17	200	1,060	2	5,890	8
	LRCA58 Little River at Cameron														
dry	110	1,080	1	6,680	8	140	3,200	1	23,900	12	97	560	1	2,860	6
avg	190	1,080	3	6,680	8	310	3,200	3	23,900	12	160	560	3	2,860	6
wet	460	2,140	2	14,900	10	760	4,790	2	38,400	14	330	990	2	5,550	8
	BRBR59 Brazos River at Bryan														
dry	540	3,230	1	21,100	7	710	6,050	1	49,000	11	630	2,060	1	12,700	7
avg	860	3,230	3	21,100	7	1260	6,050	3	49,000	11	920	2,060	3	12,700	7
wet	1760	5,570	2	41,900	10	2460	10,400	2	97,000	14	1470	2,990	2	20,100	8
	NAEA66 Navasota River at Easterly														
dry	9	260	1	1,610	9	10	720	1	4,590	11	3	–	–	–	–
avg	14	260	3	1,610	9	19	720	3	4,590	11	8	–	–	–	–
wet	23	800	2	5,440	12	29	1,340	2	8,990	13	16	49	2	220	5
	BRHE66 Brazos River at Hempstead														
dry	920	5,720	1	49,800	10	1130	8,530	1	85,000	13	950	2,620	1	17,000	7
avg	1440	5,720	3	49,800	10	1900	8,530	3	85,000	13	1330	2,620	3	17,000	7
wet	2890	11,200	2	125,000	15	3440	16,800	2	219,000	19	2050	5,090	2	40,900	9
	BRRI70 Brazos River at Richmond														
dry	990	6,410	1	60,600	11	1190	8,930	1	94,000	13	930	2,460	1	16,400	6
avg	1650	6,410	3	60,600	11	2140	8,930	3	94,000	13	1330	2,460	3	16,400	6
wet	3310	12,400	2	150,000	16	3980	16,300	2	215,000	19	2190	5,430	2	46,300	10
	BRRO72 Brazos River at Rosharon														
dry	1140	9,090	1	94,700	12	1250	6,580	1	58,500	10	930	2,490	1	14,900	6
avg	2090	9,090	3	94,700	12	2570	6,580	3	58,500	10	1420	2,490	3	14,900	6
wet	4700	13,600	2	168,000	16	4740	14,200	2	184,000	18	2630	4,980	2	39,100	9

3.6. Colorado River Basin

3.6.1. Description of the Basin

The Colorado River Basin extends from southeast New Mexico and discharges into Matagorda Bay and the Gulf of Mexico, with a drainage area of 42,460 square miles, and is about 600 miles in length. The locations of the Colorado River Basin and the Brazos-Colorado Coastal Basin are shown in the map of Figure 3.15. Its average annual precipitation varies from 12 inches in the arid northwest to 44 inches in the humid southeast. The major tributaries of the Colorado River are Beals Creek, Pecan Bayou, Concho River, San Saba River, Llano River, and Pedernales River. Austin, with a population of about 843,000, in 2012 is the largest city located near the Colorado River (Hoffpauir et al., 2013).

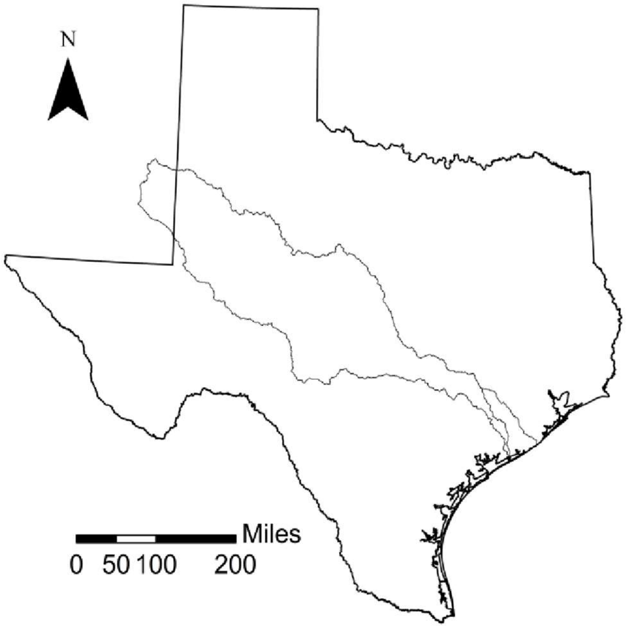


Figure 3.15 Colorado River Basin and Brazos-Colorado Coastal Basin

3.6.2. Colorado WAM

The Colorado WAM, incorporated by TCEQ, includes the WRAP input data files for the Colorado River Basin and adjoining Brazos-Colorado Coastal Basin. The TCEQ incorporated a daily time-step revision in March 22, 2010, since the daily version of the authorized version was developed for modeling the SB3 environmental instream flow standards. The Colorado WAM has 45 primary control points, at which naturalized flows are provided in the FLO file as input. The locations and other information for each of the primary control points are given in Figure 3.16 and Table 3.29. The water rights include authorized diversions totaling 3.3 million acre-feet per year, allocated between types of use as follows: municipal (66%), industrial (8%), irrigation (25%), and mining, recreation, and other purposes (1%) (Hoffpauir et al., 2013). The 14 control points at which environmental flows were built are indicated in black.

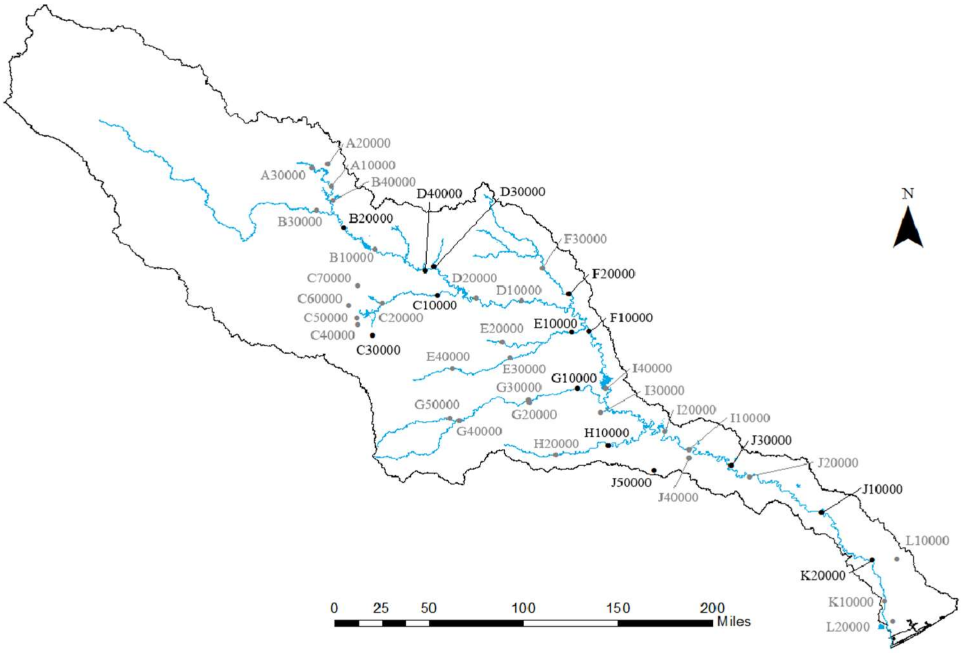


Figure 3.16 Map of Primary Control Points in the Colorado WAM

Table 3.29 Primary Control Points in the Colorado WAM

WAM CP ID	USGS Gage No.	Location	Watershed Area (sq miles)	USGS Gage Period-of-Record
A30000	08119500	Colorado River near Ira	1,074	1947-1989
A20000	08120500	Deep Creek near Dunn	193	1953-present
A10000	08121000	Colorado River at Colorado City	1,575	1923-present
B40000	08123600	Champion Creek Reservoir	176	reservoir releases
B30000	08123800	Beals Creek near Westbrook	1,974	1958-present
B20000	**08123850**	**Colorado River above Silver**	**4,560**	**1967-present**
B10000	08124000	Colorado River at Robert Lee	5,046	1923-present
C70000	08134000	North Concho R near Carlsbad	1,202	1924-present
C60000	08128400	Middle Concho R nr Tankersley	1,613	1961-present
C50000	08129300	Spring Creek above Tankersley	340	1960-1995
C40000	08130500	Dove Creek at Knickerbocker	164	1960-2009
C30000	**08128000**	**South Concho R at Christoval**	**258**	**1930-present**
C20000	08136000	Concho River at San Angelo	4,139	1915-present
C10000	**08136500**	**Concho River at Paint Rock**	**5,185**	**1915-present**
D40000	**08126380**	**Colorado River near Ballinger**	**6,090**	**1907-present**
D30000	**08127000**	**Elm Creek at Ballinger**	**464**	**1932-present**
D20000	08136700	Colorado River near Stacy	12,548	1968-present
D10000	08138000	Colorado River at Winchell	13,788	1923-2011
E40000	08144500	San Saba River at Menard	1,137	1915-present
E30000	08144600	San Saba River nr Brady	1,636	1979-present
E20000	08145000	Brady Creek at Brady	589	1939-present
E10000	**08146000**	**San Saba River at San Saba**	**3,048**	**1915-present**
F30000	08143500	Pecan Bayou at Brownwood	1,654	1923-1983
F20000	**08143600**	**Pecan Bayou near Mullin**	**2,074**	**1967-present**
F10000	**08147000**	**Colorado River near San Saba**	**19,830**	**1915-present**
G50000	08148500	North Llano River near Junction	897	1915-present
G40000	08150000	Llano River near Junction	1,859	1915-present
G30000	08150700	Llano River near Mason	3,251	1968-present
G20000	08150800	Beaver Creek near Mason	215	1963-present
G10000	**08151500**	**Llano River at Llano**	**4,201**	**1939-present**
H20000	08152900	Pedernales R nr Fredericksburg	370	1979-present
H10000	**08153500**	**Pedernales R near Johnson City**	**901**	**1939-present**
I40000	08148000	Lake Buchanan nr Burnet	20,521	reservoir releases
I30000	08152000	Sandy Creek near Kingsland	346	1966-present
I20000	08154500	Lake Travis near Austin	27,357	reservoir releases
I10000	**08158000**	**Colorado River at Austin**	**27,611**	**1898-present**
J50000	**08158700**	**Onion Creek near Driftwood**	**124**	**1979-present**
J40000	08159000	Onion Creek at U.S. Hwy 183	324	1924-present
J30000	**08159200**	**Colorado River at Bastrop**	**28,580**	**1960-present**
J20000	08159500	Colorado River at Smithville	29,062	1930-present
J10000	08161000	Colorado River at Columbus	30,244	1916-present
K20000	**08162000**	**Colorado River at Wharton**	**30,601**	**1938-present**
K10000	08162500	Colorado River near Bay City	30,862	1948-present
L20000	08117900	Big Boggy Creek nr Wadsworth	14	1970-1977
L10000	08117500	San Bernard River near Boling	725	1954-present

There are 488 reservoirs included in the March 2010 updated authorized scenario. The 31 major reservoirs with permitted storage capacities exceeding 5,000 acre-feet in Colorado WAM are listed in Table 3.30. The numbers in the Map ID column of Table

3.29 are the identifiers labeling the reservoirs in the map of Figure 3.17. The Upper and Lower Colorado River is divided by Lake Buchanan. Most of the reservoir storage capacity in the lower basin is controlled by the Lower Colorado River Authority (LCRA), and the Colorado River Municipal Water District (CRMWD) controls the majority of the reservoir storage capacity in the upper basin (Hoffpauir et al., 2013).

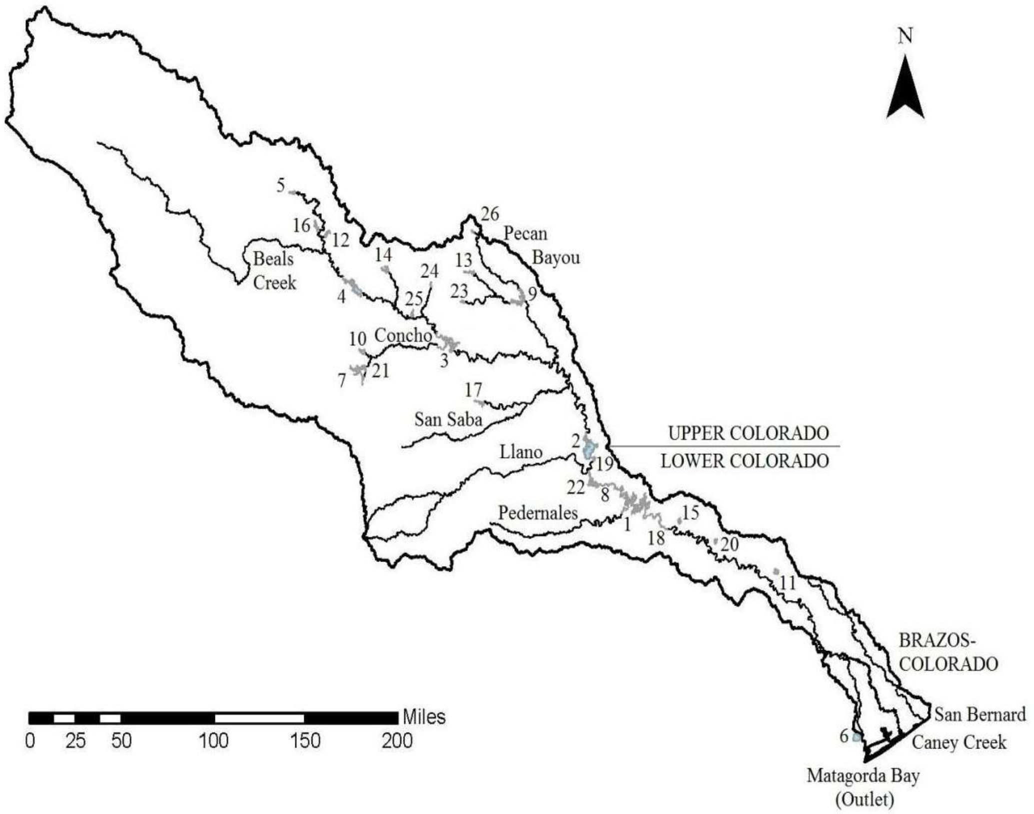


Figure 3.17 Major Reservoirs in the Colorado River Basin

Table 3.30 Major Reservoirs in the Colorado River Basin

Map ID	Reservoir	WAM Identifier	Initial Impoundment	Permitted Capacity
				(acre-feet)
1	Lake Travis	TRAVIS	1940	1,170,752
2	Lake Buchanan	BUCHAN	1937	992,475
3	O.H. Ivie Reservoir	OHIVIE	1990	554,340
4	E.V. Spence Reservoir	SPENCE	1968	488,760
5	Lake J.B. Thomas	THOMAS	1952	204,000
6	STP Main Cooling Pond	STHTEX	1979	202,988
7	Twin Buttes Reservoir	TWINBU	1962	186,200
8	Lake LBJ	LAKLBJ	1951	138,500
9	Lake Brownwood	BROWNW	1933	135,963
10	O.C. Fisher Lake	OCFISH	1952	119,200
11	Fayette County (Cedar Cr)	CEDARC	1977	71,400
12	Champion Creek Reservoir	CHAMPI	1959	42,500
13	Lake Coleman	COLEMA	1966	40,000
14	Oak Creek Reservoir	OAKCRK	1953	39,360
15	Walter E. Long Lake	DECKER	1967	33,940
16	Lake Colorado City	COLOCI	1949	29,934
17	Brady Creek Reservoir	BRADYC	1963	30,000
18	Lake Austin	LKAUST	1939	21,000
19	Inks Lake	ROYINK	1938	17,545
20	Lake Bastrop	BASTRO	1964	16,590
21	Lake Nasworthy	NASWOR	1930	12,500
22	Lake Marble Falls	MARBLE	1957	8,760
23	Hords Creek Lake	HORDSC	1948	7,959
24	Lake Winters	ELMCRK	1983	8,374
25	Ballinger Municipal Lake	BALLIN	1978	6,050
26	Clyde Lake	LCLYDE	1970	5,748

3.6.3. Senate Bill 3 Environmental Flow Standards for Colorado River Basin

The environmental flow standards for surface water for the Colorado and Lavaca Rivers and Matagorda and Lavaca Bays are documented in Texas Administrative Code Chapter 298, Subchapter D. Flow standards have been established for 21 control point locations, including 14 sites in the Colorado River Basin, 5 sites in the Lavaca River Basin, and 2 sites in the Colorado-Lavaca and Lavaca-Guadalupe Coastal Basins (Hoffpauir et al., 2013). The seasons and hydrologic conditions have different definitions by different control point locations. The month of November is included in the Winter season for control points located on the Colorado River and its tributaries above Lake Travis. The month of November is included in the Fall season for control points located on the Colorado River below Lake Travis. Hydrologic conditions are also determined using cumulative streamflow for the previous 12 months for control points located on the Colorado River above Lake Travis. For control points located on the Colorado River below Lake Travis, hydrologic conditions are determined using the combined reservoir storage in Lakes Travis and Buchanan. The parameters used to calculate hydrologic conditions are documented in Table 3.31.

Table 3.31 Parameters Used for Calculating Hydrologic Conditions

WAM	Hydrologic Condition			
CP ID	Severe	Dry	Average	Wet
Cumulative Streamflow (acre-feet)				
B20000	< 4,090	4,090 - 16,600	16,600 - 57,490	> 57,490
C30000	< 5,270	5,270 - 7,380	7,380 - 21,660	> 21,660
C10000	< 7,110	7,110 - 17,000	17,000 - 49,900	> 49,900
D40000	< 3,120	3,120 - 11,150	11,150 - 67,700	> 67,700
D30000	< 820	820 - 4,990	4,990 - 46,560	> 46,560
E10000	< 40,550	40,550 - 61,100	61,100 - 149,890	> 149,890
F20000	< 11,860	11,860 - 26,700	26,700 - 187,740	> 187,740
F10000	< 80,510	80,510 - 205,110	205,110 - 568,970	> 568,970
G10000	< 90,810	90,810 - 145,660	145,660 - 364,540	> 364,540
H10000	< 27,710	27,710 - 70,210	70,210 - 222,700	> 222,700
J50000	< 810	810 - 10,460	10,460 - 59,610	> 59,610
Combined Reservoir Storage in Lakes Travis and Buchanan (acre-feet)				
J30000	< 1,103,700	1,103,700 - 1,737,460	> 1,737,460	
J10000	< 1,103,700	1,103,700 - 1,737,460	> 1,737,460	
K20000	< 1,103,700	1,103,700 - 1,737,460	> 1,737,460	

The base flow, subsistence flow, and high flow pulse standards vary by control point location in Colorado River Basin. For control points located on the upper Colorado River, the subsistence flow standard varies seasonally, and high flow pulse criteria are specified for a two-per-season pulse, a one-per-season pulse, and an annual pulse; for control points located on the lower Colorado River, the subsistence flow standard varies monthly, and high flow pulse criteria are specified as atwo-per-season pulse, a one per 18-

month pulse, and a one per 2-year pulse (Hoffpauir et al., 2013). The subsistence flow standards are included in Tables 3.32 and 3.33.

Table 3.32 Subsistence Flow Standards (cfs) for upper Colorado River

WAM	**Winter**	**Spring**	**Summer**	**Fall**
CP ID	Severe	Severe	Severe	Severe
B20000	1	1	1	1
C30000	2	3	2	2
C10000	1	1	1	1
D40000	1	1	1	1
D30000	1	1	1	1
E10000	29	22	3	13
F20000	1	1	1	1
F10000	50	50	30	30
G10000	44	35	3	20
H10000	7	4	1	1
J50000	1	1	1	1

Table 3.33 Subsistence Flow Standards (cfs) for lower Colorado River

Season	Month	Hydrologic Condition	J30000	J10000	K20000
Winter	December	Severe	186	301	202
	January	Severe	208	340	315
	February	Severe	274	375	303
Spring	March	Severe	274	375	204
	April	Severe	184	299	270
	May	Severe	275	425	304
	June	Severe	202	534	371
Summer	July	Severe	137	342	212
	August	Severe	123	190	107
Fall	September	Severe	123	279	188
	October	Severe	127	190	147
	November	Severe	180	202	173

Tables 3.34 and 3.35 contain the base flow standards, which, for all control points, vary seasonally, according to hydrologic conditions. However, four hydrologic conditions—severe, dry, average, and wet—are applied for control points located on the Colorado River above Lake Travis while three hydrologic conditions-severe, dry, and average-are considered for control points located on the Colorado River below Lake Travis (Hoffpauir et al., 2013).

Table 3.34 Base Flow Standards (cfs) Colorado River above Lake Travis

WAM	Winter				Spring				Summer				Fall			
CP ID	Sev	Dry	Avg	Wet	Sev	Dry	Avg	Wet	Sev	Dry	Avg	Wet	Sev	Dry	Avg	Wet
B20000	2	2	4	7	2	2	5	12	1	1	3	8	1	1	4	10
C30000	9	9	15	22	9	9	15	22	7	7	12	22	7	7	12	22
C10000	8	8	20	36	4	4	14	27	1	1	4	12	5	5	16	29
D40000	4	4	9	14	3	3	9	19	2	2	6	14	4	4	9	17
D30000	1	1	1	4	1	1	1	5	1	1	1	1	1	1	1	1
E10000	56	56	81	110	56	56	81	110	32	32	46	62	40	40	64	87
F20000	3	3	7	12	3	3	9	19	2	2	4	8	3	3	7	12
F10000	95	95	150	210	120	120	190	360	72	72	120	210	95	95	150	210
G10000	100	100	150	190	100	100	150	190	67	67	92	130	87	87	120	190
H10000	23	23	45	80	29	29	60	110	16	16	29	49	16	16	29	49
J50000	2	2	6	26	4	4	12	34	1	1	3	7	1	1	3	7

Table 3.35 Base Flow Standards (cfs) Colorado River below Lake Travis

Season	Month	Hydrologic Condition	J30000	J10000	K20000
Winter	December	Severe	311	464	470
		Dry	311	464	470
		Average	450	737	746
	January	Severe	313	487	492
		Dry	313	487	492
		Average	433	828	838
	February	Severe	317	590	597
		Dry	317	590	597
		Average	497	895	906
Spring	March	Severe	274	525	531
		Dry	274	525	531
		Average	497	1,020	1,036
	April	Severe	287	554	561
		Dry	287	554	561
		Average	635	977	1,011
	May	Severe	579	966	985
		Dry	579	966	985
		Average	824	1,316	1,397
	June	Severe	418	967	984
		Dry	418	967	984
		Average	733	1,440	1,512
Summer	July	Severe	347	570	577
		Dry	347	570	577
		Average	610	895	906
	August	Severe	194	310	314
		Dry	194	310	314
		Average	381	516	522
Fall	September	Severe	236	405	410
		Dry	236	405	410
		Average	423	610	617
	October	Severe	245	356	360
		Dry	245	356	360
		Average	433	741	749
	November	Severe	283	480	486
		Dry	283	480	486
		Average	424	755	764

4. IHA ANALYSES OF OBSERVED DAILY FLOWS

4.1. Linear Trend Analyses of Observed Flows Before and After Human Influences

Graphs and statistical analyses of observed flows at selected U.S. Geological Survey (USGS) gauging stations are investigated in Chapter 4. Hydrology is extremely variable in Texas, subject to major flood events and multiple-year droughts along with seasonal and continuous fluctuations. The 1950-1957 drought, which ended dramatically with a major flood in April-May 1957, is evident from the record of daily mean flows. On the other hand, the year 2015 had extremely high flows, ending the 2010-2014 drought (Wurbs,R.A. 2017). However, the variability of daily low flow and high flow fluctuations conceptually may be hidden in monthly mean flow rates. Significant changes in flow characteristics are evident in some of the results. The National Water Information System (NWIS) maintained by the USGS includes daily flow data for 11,247 named streams in Texas. Whereas the period-of-record is relatively short for most of the gauges, the selected gauges in this research have either long record years or existing environmental flow standards. These sites were selected as being representative of flows on the major rivers of the state. The initial impoundment of the major reservoirs in Texas began in the 1960s. There was a rapid population growth beginning in the 1970s. Consequently, in this thesis, periods-of-record are divided into three time segments. The first is the pre-impact period, which represents the stream flow conditions during the years prior to 1940. The second is the beginning impact period, which shows the flow situations from 1940 to 1970. The third is the impact period, which describes the impact of population change on flow from the year 1970 to present USGS gauge station records.

4.1.1. Sabine River Basin

The five selected gauging stations in Sabine River Basin are listed in Table 4.1 with locations and descriptive information. The selected gauges include all sites in the Sabine River Basin for which SB3 environmental flow standards have been established.

Table 4.1 Selected USGS Streamflow Gauging Stations in the Sabine River Basin

ID	WAM CP ID	USGS Gauge ID	Location by River and Nearest City	Watershed (mile^2)	USGS Period of Record	SB3 IFS
S1	BSBS	8019500	Big Sandy Creek near Big Sandy	231	02/39 to present	SB3 IFS
S2	SRGW	8020000	Sabine River near Gladewater	2,791	10/32 to present	SB3 IFS
S3	SRBE	8022040	Sabine River near Beckville	3,589	10/38 to present	SB3 IFS
S4	SRRL	8030500	Sabine River near Ruliff	9,329	10/24 to present	SB3 IFS
S5	29500	8029500	Big Cow Creek near Newton	128	5/52 to present	SB3 IFS

Table 4.2 demonstrates the output of basic statistical and linear regression analysis. The gauge sites are referenced by the identifiers in Table 4.1. This dataset consists of the mean flow in each day of the period-of-record through June 2017. The data was downloaded from the USGS NWIS website and calculated and organized using Microsoft Excel worksheets. All statistical metrics provided in Table 4.2 are measured in units of cubic feet per second (cfs). Standard last-squares linear regression was applied to determine the slope. The slope of river flow is expressed as mean river flows and is computed by dividing the slope of flow of the river by the mean flow and multiplying by 100 percent. This regression slope as percentage of mean was used to reflect the changes in observed flow. Three of the gauges have no record before 1940 which is represented in spaces. The slope of river flows, expressed as mean river flow equivalents in the last column of each period in Table 4.2, illustrates the dramatic differences between the characteristics of the different periods.

Table 4.2 Linear Regression Analysis of Four Periods Sabine Monthly Flows

Before 1940					1940-1970				1971-Present			
ID	Mean	Med	SD	Slope% Mean	Mean	Med	SD	Slope% Mean	Mean	Med	SD	Slope% Mean
S1					181	96	216	-0.0061	185	101	216	-0.0009
S2	1,411	398	2,298	-0.0063	2,008	755	3,110	-0.0061	1,760	750	2,422	-0.0014
S3					2,527	1,086	3,667	-0.0058	2,588	1,221	3,220	-0.0007
S4	7,585	3,927	8,416	-0.0006	8,488	4,868	9,487	-0.0085	8,163	5,493	7,455	-0.0012
S5					95	64	100	-0.0068	143	95	135	-0.0012

As shown in Table 4.2, in the Sabine River Basin, although the long-term trend for each period is different, there is no wide fluctuation trend from before 1940 to the present. According to Table 4.2, all three periods have negative percentage when dividing slope by the mean factor, which represents a decrease in flow rate. The percentages from the third period slightly increased from the previous period.

4.1.2. Neches River Basin

The seven USGS gauging stations on the Neches River Basin adopted for this investigation are listed in Table 4.3, including the periods-of-record and identification of the sites at which environmental flow standards have been established pursuant to the 2007 Senate Bill 3 (SB3).

Table 4.3 Selected USGS Streamflow Gauging Stations in the Neches River Basin

ID	WAM CP ID	USGS Gauge ID	Location by River and Nearest City	Drainage (sq miles)	USGS Period of Record	SB3 IFS
N1	NENE	8032000	Neches River near Neches	1,145	1939-02-09-present	SB IFS
N2	NEDI	8033000	Neches River near Diboll	2,724	1923-10-01-present	
N3	NERO	8033500	Neches River near Rockland	3,631	1903-07-01 -present	SB IFS
N4	MUJA	8034500	Mud Creek near Jacksonville	376	1939-05-06 -present	
N5	ANAL	8036500	Angelina River near Alto	1,273	1940-10-01 -present	SB IFS
N6	NEEV	8041000	Neches River at Evadale	7,885	1904-08-01 -present	SB IFS
N7	VIKO	8041500	Village Creek near Kountze	861	1924-06-01 -present	SB IFS

The mean, median, standard deviation, and slope% mean for the flows at each of the seven gauges on the Neches River Basin are tabulated in Table 4.4. Comparing table 4.3 and 4.4, we found that the statistical parameters such as mean and standard deviation of observed flow dataset are highly related to basin area because of its homogeneity or statistic stationarity. Compared with smaller watersheds, larger watershed areas are usually represented by higher flow rates and are more varied.

Table 4.4 Linear Regression Analysis of Four Periods Neches Monthly Flows

	Before 1940				1940-1970				1971-Present			
ID	Mean	Med	SD	Slope% Mean	Mean	Med	SD	Slope% Mean	Mean	Med	SD	Slope% Mean
N1					747	365	987	-0.0042	654	271	863	0.0001
N2	1,084	279	1,689	-0.0183	1,670	875	2,204	-0.0071	1,678	961	1,931	0.0054
N3	2,204	909	2,927	0.0000	2,333	1,142	3,180	-0.0078	2,541	1,270	3,014	0.0005
N4					261	101	364	-0.0071	232	102	321	-0.0007
N5					677	330	949	0.0058	876	434	1,040	-0.0006
N6	6,270	2,786	7,840	-0.0021	5,839	2,957	7,252	-0.0090	5,942	3,796	5,205	-0.0004
N7	711	249	902	-0.0170	756	389	1,018	-0.0096	977	583	1,081	-0.0022

4.1.3. GSA River Basin

The 17 sites at the Guadalupe and San Antonio River Basins are listed in Table 4.5, incorporating Senate Bill 3 (SB3) environmental flow standards. There are nine control points from the Guadalupe River Basin and eight control points from the San Antonio River Basin.

Table 4.5 Selected USGS Streamflow Gauging Stations in the Guadalupe and San Antonio River Basins

ID	WAM CP ID	USGS Gauge ID	Location by River and Nearest City	Drainage Area	USGS Period of Record	SB3 IFS
Guadalupe River Basin						
G1	CP01	8167000	Guadalupe River at Comfort	838	1939-present	SB3 IFS
G2	CP02	8167500	Guadalupe River near Spring Branch	1,315	1922-present	SB3 IFS
G3	CP05	8169000	Comal River at New Braunfels	130	1927-present	
G4	CP08	8171000	Blanco River at Wimberley	355	1924-present	SB3 IFS
G5	CP10	8172000	San Marcos River at Luling	839	1939-present	SB3 IFS
G6	CP11	8173000	Plum Creek near Luling	311	1930-present	SB3 IFS
G7	CP13	8175000	Sandies Creek near Westhoff	549	1930-present	SB3 IFS
G8	CP14	8175800	Guadalupe River at Cuero	4,935	1964-present	SB3 IFS
G9	CP15	8176500	Guadalupe River at Victoria	5,196	1934-present	SB3 IFS
San Antonio River Basin						
A1	CP18	8178000	San Antonio River at San Antonio	44	1915-present	
A2	CP23	8180500	Medina River near Rio Medina	649	1923-present	
A3	CP28	8181500	Medina River at San Antonio	1,310	1939-present	SB3 IFS
A4	CP29	8181800	San Antonio River near Elmendorf	1,737	1962-present	SB3 IFS
A5	CP32	8183500	San Antonio River near Falls City	2,108	1925-present	SB3 IFS
A6	CP34	8185000	Cibolo Creek at Selma	274	1946-present	
A7	CP35	8186000	Cibolo Creek near Falls City	825	1930-present	SB3 IFS
A8	CP37	8188500	San Antonio River at Goliad	3,906	1924-present	SB3 IFS

Table 4.6 summarizes the statistical results for the GSA River Basins. The variances of mean and slope are slightly bigger at all control points in the Guadalupe River Basin than those in the Sabine and Neches River Basin. This means that the flow variability in the Guadalupe River Basin is higher in different periods. The observed streamflow at the San Antonio River illustrates increases in recent decades that may presumably be due to return flows from municipal groundwater use and increased runoff from urbanization.

Table 4.6 Linear Regression Analysis of Four Periods GSA Monthly Flows

	Before 1940				1940-1970				1971-Present			
ID	Mean	Med	SD	Slope% mean	Mean	Med	SD	Slope% Mean	Mean	Med	SD	Slope% Mean
G1					143	85	168	-0.0012	274	150	462	-0.0029
G2	263	102	5,745	0.0118	260	138	331	-0.0010	473	226	821	-0.0024
G3	320	316	35	0.0045	271	289	96	-0.0025	314	316	126	-0.0007
G4	99	33	174	0.0006	120	55	177	0.0016	171	75	305	0.0002
G5					341	213	335	0.0004	468	261	615	0.0004
G6	87	17	214	0.0000	97	19	174	0.0006	139	19	303	0.0005
G7	49	8	83	0.0781	132	17	406	0.0095	134	17	339	-0.0024
G8					1,605	1,105	1,490	0.0167	2,072	1,207	2,707	-0.0015
G9	1,989	1,101	2,720	-0.0734	1,575	934	1,689	-0.0008	2,191	1,263	2,831	-0.0014
A1	75	60	59	-0.0159	40	26	36	-0.0096	59	33	62	-0.0054
A2	10	0	14	0.0767	34	21	73	-0.0005	162	68	313	-0.0052
A3					106	76	131	-0.0004	325	146	644	-0.0015
A4					294	228	267	0.0139	637	403	866	-0.0008
A5	282	167	399	0.0179	326	229	353	-0.0005	676	424	923	-0.0016
A6					11	0	51	0.0067	34	0	180	0.0017
A7	101	27	218	0.0128	113	34	224	-0.0038	167	49	368	0.0006
A8	269	191	293	-0.0102	590	321	935	-0.0013	965	530	1,389	-0.0008

4.1.4. Trinity River Basin

A variety of the Trinity River Basin information for seven selected gauging stations, including period of analysis, USGS gauge identifiers, location by river and nearest city, WAM CP identifiers, and watershed area are described in Table 4.7. All these control points have daily recorded flows for relatively long-term periods.

Table 4.7 Selected USGS Streamflow Gauging Stations in the Trinity River Basin

ID	USGS Gauge ID	WAM CP ID	Location by River and Nearest City	Drainage (sq miles)	SB3 IFS	USGS Period of Record
T1	08044000	8BSBR	Big Sandy Creek near Bridgeport	333		Oct 1936-present
T2	08047500	8CTFW	Clear Fork Trinity River at Fort Worth	518		Mar 1924-present
T3	08049500	8WTGP	West Fork Trinity River at Grand Prairie	3,065	SB IFS	Mar 1925-present
T4	08057000	8TRDA	Trinity River at Dallas	6,106	SB IFS	Oct 1903-present
T5	08062500	8TRRS	Trinity River near Rosser	8,146		Aug 1924-present
T6	08065000	8TROA	Trinity River near Oakwood	12,833	SB3 IFS	Oct 1923-present
T7	08066500	8TRRO	Trinity River at Romayor	17,186	SB3 IFS	May 1924-present

Table 4.8 presents the results of the analysis. However, long-term changes in observed daily flows of the Trinity River are relatively minimal at each period. Monthly average, median, and standard deviation for each control point increase from the first period to the third period. Houston is supplied primarily by local groundwater, and surface water is transported from the Trinity and San Jacinto River Basins. Return flows are discharged into the Buffalo Bayou. Increased rainfall runoff due to urbanization in these watersheds can also be expected to contribute to increased streamflow (Wurbs and Zhang 2016).

Table 4.8 Linear Regression Analysis of Four Periods Trinity Monthly Flows

	Before 1940				1940-1970				1971-Present			
ID	Mean	Med	SD	Slope% mean	Mean	Med	SD	Slope% Mean	Mean	Med	SD	Slope% Mean
T1	31.8	13.8	56.8	-0.1773	81.4	12.6	199.3	-0.0130	79.6	10.5	227.0	0.0024
T2	75.9	15.3	152.5	0.0046	115.5	24.2	264.6	-0.0070	155.6	43.1	311.6	0.0007
T3	428.5	166.8	597.9	-0.0053	594.7	214.2	1,066	-0.0082	863.0	396.2	1,400	0.0028
T4	1,318	421.4	2,343	0.0003	1,611	517.7	2,782	-0.0065	2,244	925.4	3,052	0.0027
T5	495.8	125.7	994.6	0.0058	2,683	1,016	4,227	-0.0050	3,773	1,824	4,643	0.0025
T6	4,320	1,995	6,171	-0.0023	4,977	2,112	7,410	-0.0054	5,725	2,546	7,524	0.0019
T7	6,578	4,324	8,203	-0.0013	7,507	3,775	9,917	-0.0060	8,788	4,401	10,191	0.0011

4.1.5. Brazos River Basin

Table 4.9 tabulates the basic geographical information of 18 selected control points in the Brazos River Basin. The table contains the WAM ID, the USGS gauge ID, the locations by rivers and the nearest cities, the drainage areas, periods-of-analysis, and the SB3 application. All selected control points in the Brazos River Basin have environmental flow standards, as indicated by SB3 IFS. The oldest gauge is B10 on the Brazos River at Waco with a record period from 1898 to present.

Table 4.9 Selected Stream Flow Gauging Stations in the Brazos River Basin

ID	USGS Gauge ID	WAM CP ID	Location by River and Nearest City	Drainage Area (sq mile)	USGS Period of Record	SB3 IFS
B1	08080500	DMAS09	Double Mountain Fork near Aspermont	1,891	1924–present	SB3 IFS
B2	08082000	SFAS06	Salt Fork Brazos River near Aspermont	2,504	1924–present	SB3 IFS
B3	08082500	BRSE11	Brazos River near Seymour	5,996	1923–present	SB3 IFS
B4	08084000	CFNU16	Clear Fork Brazos near Nugent	2,236	1924–present	SB3 IFS
B5	08085500	CFFG18	Clear Fork Brazos near Fort Griffin	4,031	1924–present	SB3 IFS
B6	08088000	BRSB23	Brazos River near South Bend	13,171	1938–present	SB3 IFS
B7	08089000	BRPP27	Brazos River near Palo Pinto	14,309	1924–present	SB3 IFS
B8	08091000	BRGR30	Brazos River near Glen Rose	16,320	1923–present	SB3 IFS
B9	08095000	NBCL36	North Bosque River near Clifton	977	1923–present	SB3 IFS
B10	08096500	BRWA41	Brazos River at Waco	20,065	1898–present	SB3 IFS
B11	08100500	LEGT47	Leon River near Gatesville	2,379	1950–present	SB3 IFS
B12	08103800	LAKE50	Lampasas River near Kempner	817	1962–present	SB3 IFS
B13	08104500	LRLR53	Little River near Little River	5,266	1923–present	SB3 IFS
B14	08106500	LRCA58	Little River near Cameron	7,100	1916–present	SB3 IFS
B15	08110500	NAEA66	Navasota River at Easterly	936	1924–present	SB3 IFS
B16	08111500	BRHE68	Brazos River near Hempstead	34,374	1938–present	SB3 IFS
B17	08114000	BRRI70	Brazos River near Richmond	35,541	1903–present	SB3 IFS
B18	08116650	BRRO72	Brazos River near Rosharon	35,773	1967–present	SB3 IFS

Compared to those in the Trinity River Basin, the changes in the Brazos River and its tributaries are relatively more complex. Changes differ greatly between the different sites. As shown in table 4.10, mean flow rate has decreased at sites B1 to B8 and increased at sites B9-B18. Gauge B10 below Lakes Whitney, Waco, and Aquilla is located a short distance below USACE reservoirs, thus presenting the possible long-term changes in flow characteristic effects of three multiple-purpose reservoirs (Wurbs and Zhang 2016).

Table 4.10. Linear Regression Analysis of Four Periods Brazos Monthly Flows

	Before 1940				1940-1970				1971-Present			
ID	Mean	Med	SD	Slope% mean	Mean	Med	SD	Slope% Mean	Mean	Med	SD	Slope% Mean
B1	164	29	341	-0.009	169	21	386	-0.0021	102	26	221	-0.0050
B2	113	20	212	-0.006	128	14	314	-0.0101	58	15	127	-0.0046
B3	456	91	870	-0.006	371	67	818	-0.0053	250	80	469	-0.0042
B4	175	33	407	0.004	85	18	287	-0.0041	60	18	149	-0.0052
B5	288	59	592	0.004	195	26	577	-0.0057	183	48	459	-0.0041
B6	546	32	1081	0.108	905	213	2123	-0.0058	586	169	1157	-0.0028
B7	1218	331	2008	-0.003	1025	431	2288	-0.0042	724	243	1440	-0.0017
B8	1573	595	2287	-0.005	1436	689	3077	-0.0043	1054	293	2196	-0.0012
B9	179	56	289	0.018	217	46	427	-0.0038	242	42	582	0.0046
B10	2563	1110	3766	0.000	2404	1057	4018	-0.0035	2186	861	3724	0.0012
B11					297	72	630	0.0117	336	72	692	0.0057
B12					175	52	356	0.0262	162	45	369	0.0034
B13	658	280	841	-0.027	1018	429	1339	0.0125	1081	332	1690	0.0033
B14	1751	663	2716	-0.001	1782	657	2538	-0.0029	1781	640	2484	0.0029
B15	422	102	815	-0.004	403	64	760	-0.0008	451	54	800	0.0002
B16	2333	972	2895	-0.028	6920	3583	8987	-0.0036	6825	2985	8543	0.0020
B17	7274	4098	8582	-0.001	7371	3881	9674	-0.0035	7821	3575	9662	0.0013
B18					8188	3646	8908	-0.0167	8206	4012	10303	0.0011

4.1.6. Colorado River Basin

Information for each of the 24 selected control points in the Colorado River Basin is given in Table 4.11. Fourteen of the 24 control points at which environmental flows were modeled are indicated in SB3 IFS. A large portion of the basin is located within relatively arid regions of Texas, which results in important and complex environmental flow standards for the Colorado River Basins.

Table 4.11 Selected USGS Streamflow Gauging Stations in the Colorado River Basin

ID	WAM CP ID	USGS Gauge ID	Location by River and Nearest City	Watershed (mile2)	USGS Period of Record	SB3 IFS
C1	A10000	8121000	Colorado River at Colorado City	1,575	1923-present	
C2	B20000	8123850	Colorado River above Silver	4,560	1967-present	SB3 IFS
C3	B10000	8124000	Colorado River at Robert Lee	5,046	1923-present	
C4	C70000	8134000	North Concho R near Carlsbad	1,202	1924-present	
C5	C30000	8128000	South Concho R at Christoval	258	1930-present	SB3 IFS
C6	C20000	8136000	Concho River at San Angelo	4,139	1915-present	
C7	C10000	8136500	Concho River at Paint Rock	5,185	1915-present	SB3 IFS
C8	D40000	8126380	Colorado River near Ballinger	6,090	1907-present	SB3 IFS
C9	D30000	8127000	Elm Creek at Ballinger	464	1932-present	SB3 IFS
C10	E40000	8144500	San Saba River at Menard	1,137	1915-present	
C11	E20000	8145000	Brady Creek at Brady	589	1939-present	
C12	E10000	8146000	San Saba River at San Saba	3,048	1915-present	SB3 IFS
C13	F20000	8143600	Pecan Bayou near Mullin	2,074	1967-present	SB3 IFS
C14	F10000	8147000	Colorado River near San Saba	19,830	1915-present	SB3 IFS
C15	G50000	8148500	North Llano River near Junction	897	1915-present	
C16	G40000	8150000	Llano River near Junction	1,859	1915-present	

C17	G10000	8151500	Llano River at Llano	4,201	1939-present	SB3 IFS
C18	H10000	8153500	Pedernales R near Johnson City	901	1939-present	SB3 IFS
C19	I10000	8158000	Colorado River at Austin	27,611	1898-present	
C20	J50000	8158700	Onion Creek near Driftwood	124	1979-present	SB3 IFS
C21	J40000	8159000	Onion Creek at U.S. Hwy 183	324	1924-present	
C22	J30000	8159200	Colorado River at Bastrop	28,580	1960-present	SB3 IFS
C23	J10000	8161000	Colorado River at Columbus	30,244	1916-present	SB3 IFS
C24	K20000	8162000	Colorado River at Wharton	30,601	1938-present	SB3 IFS

Table 4.12 provides information for all sites with environmental flow standards and sites with long-record years in the Colorado River Basin. Means are tabulated in Table 4.12 to illustrate the average flow quantities. These are relatively low for the Colorado River Basin. As indicated by Table 4.12, there is a decreasing trend on mean monthly observed flow, which could be due to both relatively dry climate and human impacts, such as agricultural activities and the construction of dams and reservoirs.

Table 4.12 Linear Regression Analysis of Four Periods Colorado Monthly Flows

	Before 1940				1940-1970				1971-Present			
ID	Mean	Med	SD	Slope% Mean	Mean	Med	SD	Slope% Mean	Mean	Med	SD	Slope% Mean
C1					50	4	151	-0.0182	25	2	75	-0.0080
C2					42	13	91	0.0707	64	13	166	-0.0074
C3	296	103	493	0.0098	157	14	377	-0.0154	15	2	62	-0.0047
C4	64	7	320	0.0062	27	2	117	-0.0092	10	1	46	-0.0069
C5	65	19	261	0.0204	21	11	68	-0.0024	25	17	31	-0.0066
C6	192	49	840	0.0123	90	11	322	-0.0139	21	11	43	-0.0070
C7	264	59	1,110	0.0132	121	25	386	-0.0111	59	31	115	-0.0063
C8	431	79	811	0.0014	213	41	513	-0.0115	53	13	123	-0.0067
C9	81	4	200	-0.0334	42	4	109	-0.0006	37	7	105	-0.0052
C10	86	31	357	0.0177	45	17	135	-0.0063	50	27	121	-0.0057
C11					19	0	92	-0.0065	7	0	34	-0.0165
C12	296	124	848	0.0111	188	89	315	-0.0016	163	97	256	-0.0052
C13					261	35	438	-0.1225	164	18	499	0.0036
C14	1,683	595	3,544	0.0076	1,018	378	1,947	-0.0048	612	217	1,148	-0.0034
C15	5,146	23	322	0.0003	41	20	95	0.0041	61	24	142	-0.0095
C16	240	96	603	0.0080	139	83	250	0.0033	198	123	307	-0.0038
C17					327	156	537	0.0035	385	197	638	-0.0036
C18					158	55	395	-0.0014	216	82	418	-0.0026
C19	2,720	1,187	4,490	0.0024	1,970	1,617	2,306	-0.0018	1,627	1,134	2,400	-0.0033
C20									53	11	98	0.0009
C21	74	7	238	0.0396					87	13	223	0.0009
C22					2,125	1,704	1,830	0.0056	2,084	1,508	2,848	-0.0022
C23	1,191	628	2,111	-0.4554					2,391	1,568	3,112	-0.0061
C24					2,754	1,682	3,222	-0.0028	2,616	1,340	3,737	-0.0011

4.2. Indicators of Hydrologic Alteration Analyses for Observed Flows

Flow rates at all of the sites exhibit tremendous variability, with floods, droughts, and continual daily, seasonal, and year-to-year fluctuations (Wurbs and Zhang 2015). Long-term trends or permanent changes resulting from human activities are not clearly evident at some sites because they are largely hidden by the tremendous natural variability of river flows. However, long-term changes in flow characteristics are significant at many of the sites but vary greatly between sites (Wurbs and Zhang 2014). These long-term flow changes in different time periods resulted from reservoir storage, water supply diversions and return flows, land use changes, and other factors. The results of 7-day maximum and minimum observed flow rates, which were performed with the Indicators of Hydrologic Alteration (IAH), are presented in Appendices A and B, respectively. Appendix C consists of flow duration curves of observed flow rates for selected gauging stations. Appendix D contains the results for changes on hydrologic alteration factors of observed flow rates for the same gauging stations.

As an example of interpreting the IAH results, the USGS gauging station (08147000, F10000) located on the upper Colorado River near San Saba (5.2 mi downstream from San Saba River, 9.2 mi east of San Saba) has daily recorded flow data for the period 1915 to present. The three water suppliers in the upper Colorado River basin are J.B. Thomas, E.V. Spence, and O.H. Ivie Reservoir, operated by Colorado River Municipal Water District (CRMWD), withinitially impounded in 1952, 1969 and 1990, respectively (Pauls, M. A 2014). The period-of-record is divided into two segments: the un-impacted period 1915 to 1969, and the impacted period 1969 to 2017. Figures 4.1-4.4

present the results of the analysis, with 75th percentile flow line, median flow line, and 25th percentile flow line shown as guidelines. According to Figures 4.1 and 4.2, flow timings of both 7-day minimum and maximum flows are almost identical, but the magnitude of flow rates decreased during the impacted period.

Figure 4.1 7-day Minimum Flows for USGS Gauging Station 08147000

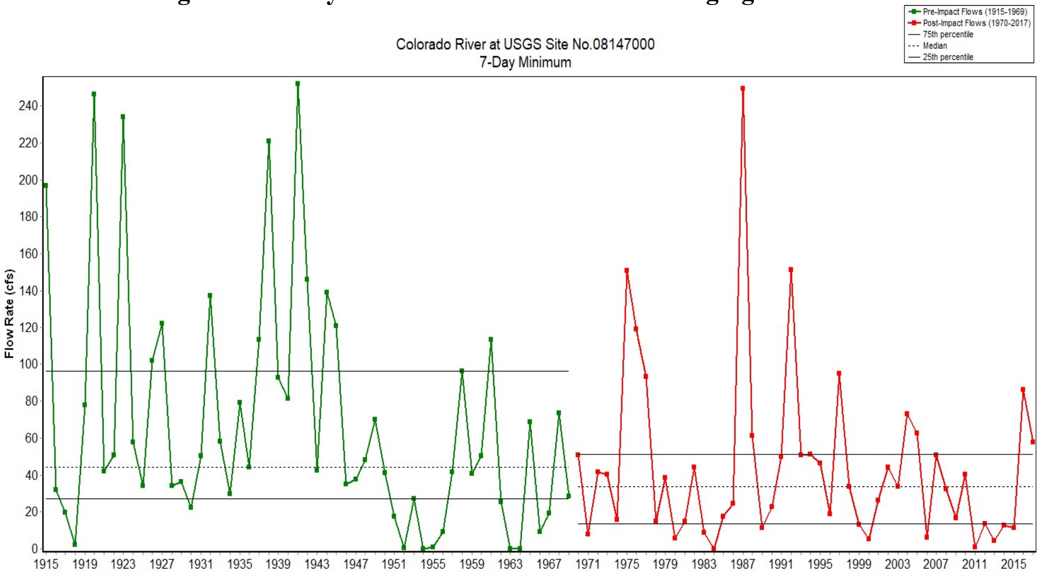


Figure 4.2 7-Day Maximum Flows for USGS Gauging Station 08147000

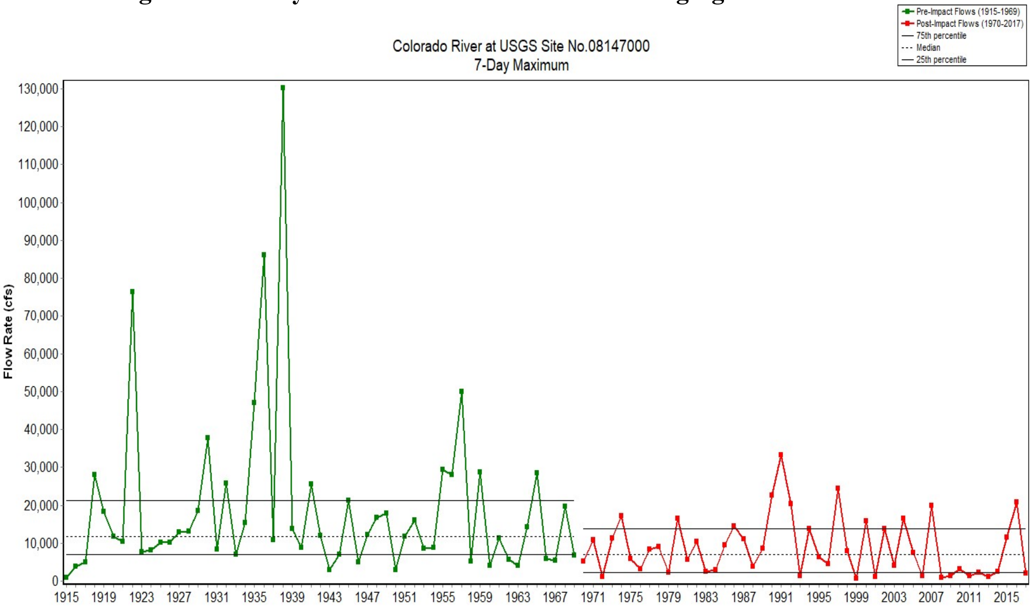


Figure 4.3 shows the Hydrologic Alteration (HA) factors using the RVA analyses in the IHA program. If the HA factor is positive, the frequency of values in each category (lowest third, middle third, highest third) increased in the post-impact period; in contrast, if the HA factor is negative, the frequency of values in the category has decreased in the post-impact period (Conservancy, N. 2009).

Figure 4.3 Hydrologic Alteration Factors for the Colorado River Near San Saba

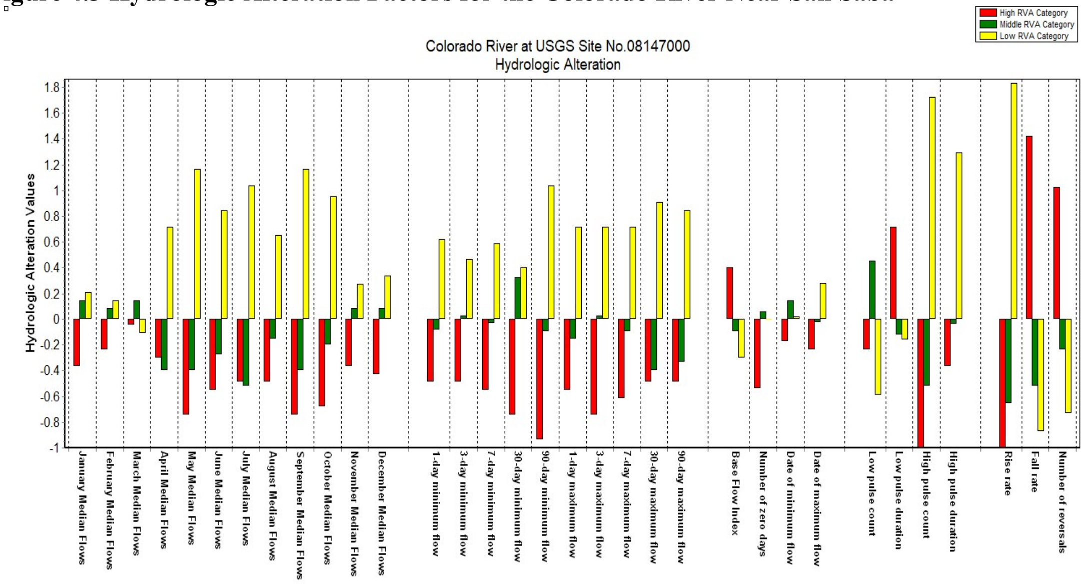
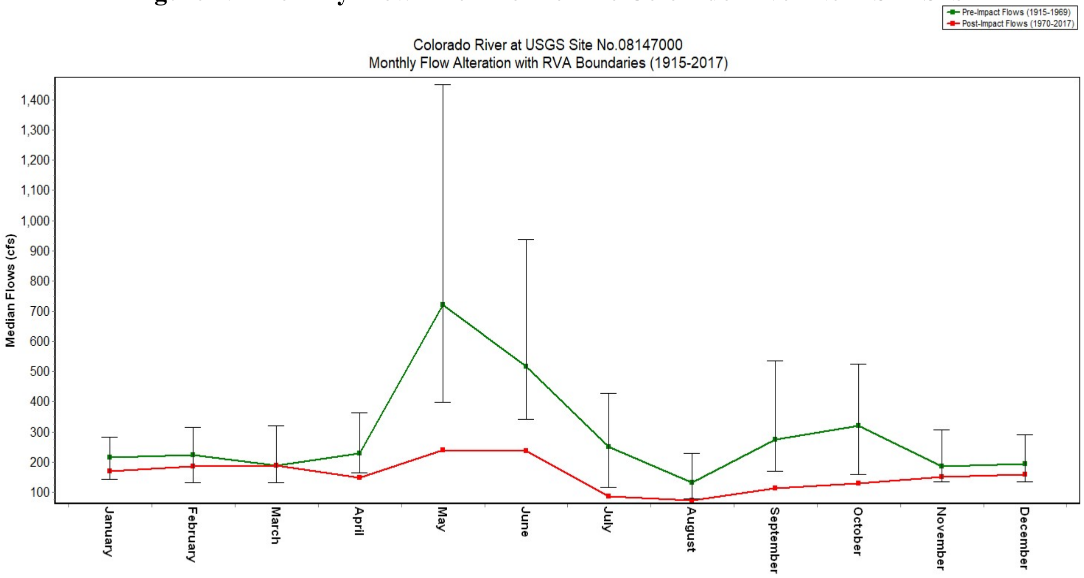
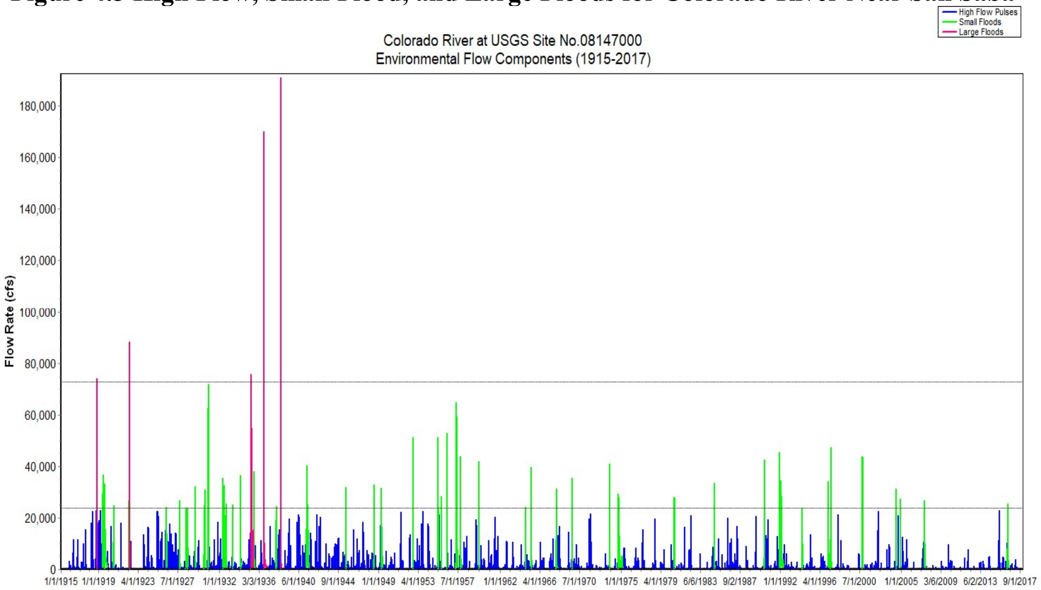


Figure 4.4 Monthly Flow Alteration for the Colorado River Near San Saba



Figures 4.3 and 4.4 show that the runoff of the Colorado River near San Saba generally peaks in spring (usually May), the flow varying widely month-to-month. The greatest Hydrologic Alteration (HA) factors were the increase in magnitude of base flows, low-flow events and monthly flows from April to October. Monthly flows from January to March are essentially unchanged for the impacted period. Although the magnitude and duration are similar, extreme low-flow events tend to show a gradual decline in the post-impact period.

Figure 4.5 High Flow, Small Flood, and Large Floods for Colorado River Near San Saba



The flows plotted in Figure 4.5 illustrate the high flow characteristics of the Colorado River near San Saba. In January, June, July 1938, and June 1939, parts of Texas experienced floods that exceeded previously recorded stages at many places. The floods were caused by heavy rain storms occurring in northeast Texas, and in the Upper Colorado River Basin. The resulting flood in the Colorado River was the greatest on record and the peak discharge at Colorado River near San Saba was about 224,000 cfs (Breeding and

Dalrymple 1944). High flows and floods after 1940s tend to be not as high as high flows before the 1940s.

The driest record in 1950-1957 and the least dry 2010-2013 droughts are seen in the flows of Figures 4.6 and 4.7 at the Colorado River gauge near San Saba. A major water source for the Colorado River is precipitation. Thus, the decade of drought is reflected in the precipitation received in the Upper Colorado River Basin. For example, the rainfall in years 1947-1956 was generally less than in the preceding drought of the 1930s (Thomas, H. E. 1963). The early 2000s were very dry, with the Upper Colorado's Palmer Hydrological Drought Index (PHDI) reaching record low levels during the summer of 2002. The Upper Colorado River Basin supplies approximately 90 percent of the water for the entire basin. Thus, drought conditions in the Upper Basin impact water supply and resources in both the upper and lower basins of the Colorado River.

Figure 4.6 Extreme Low Flow for the Colorado River Near San Saba.

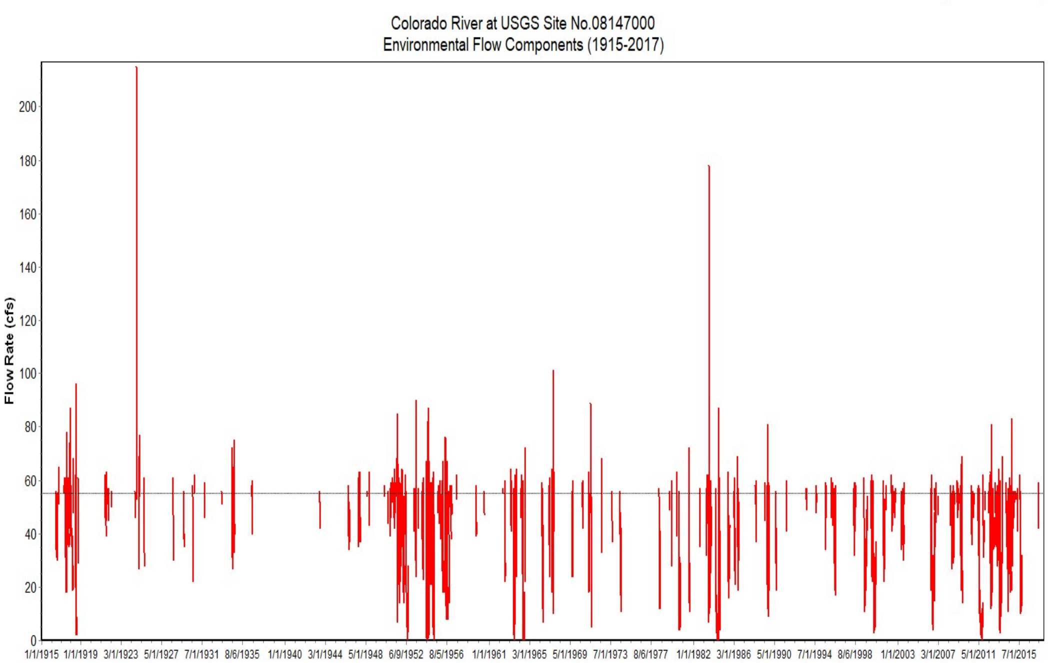
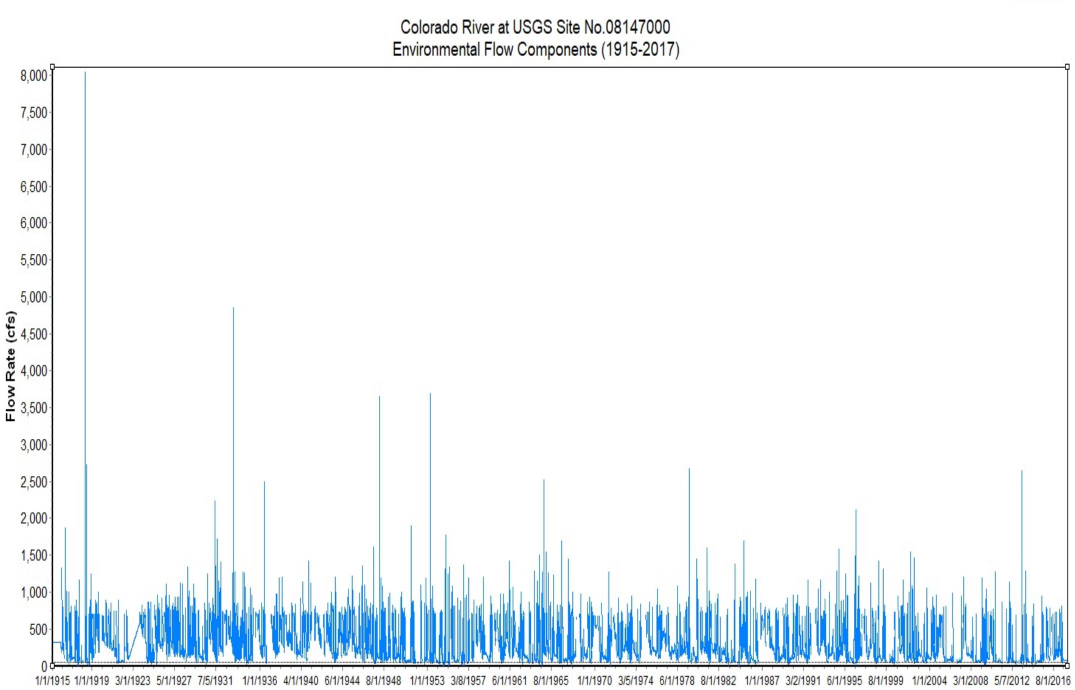


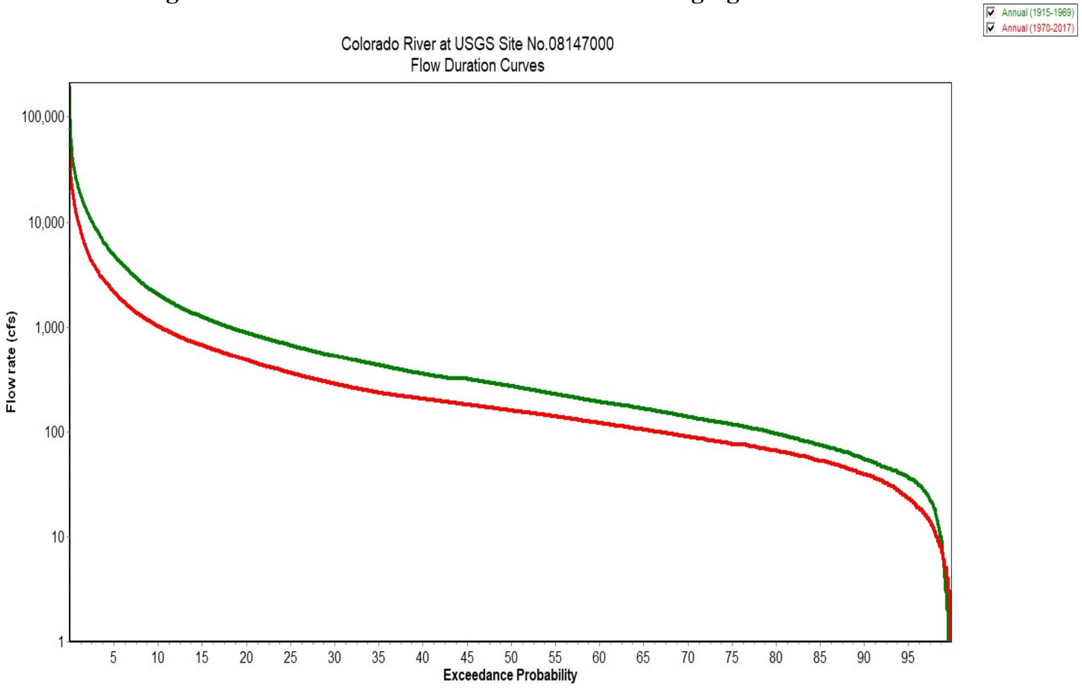
Figure 4.7 Low Flow for the Colorado River Near San Saba



4.3 Frequency Metrics for Selected Observed Flows

Flow frequency curves for all 77 selected gauging stations are plotted in Appendix C to illustrate flow characteristics of a stream throughout the range of discharge in Pre-Impact and Post-Impact periods. The exceedance frequency represents the likelihood or probability of a certain amount of water that can be expected to occur. Flow duration curves commonly provide a graphical illustration of the overall hydrologic state of flow sequences (Vogel et al, 2007). The metrics are generated using the duration analysis tool in the IHA software. In Figure 4.8, frequency duration curves for gauging station 08147000 are provided as an example of interpretation.

Figure 4.8 Flow Duration Curves for USGS Gauging Station 08147000



In Figure 4.8, the green line represents the flows of the Pre-Impact pe,riod while the red line represents flows during the Post-Impact period. The magnitude and duration are similar, while Figure 4.8 shows that the flows of the Pre-Impact period are higher than the flows of the Post-Impact period for most exceedance values. The annual median flow for USGS gauging station 08147000 is 270 cfs in the Pre-Impact period and 159 cfs in the Post-Impact period.

The frequency statistics in Table 4.13 were computed using the basic statistics and duration analysis features of IAH for six selected river basins. Frequency tables show what percentages of the observed daily flow equal or exceed 99%, 98%, 95%, 90%, 85%, 80%, 75%, 70%, 60%, 50%, 40%, 30%, 20%, 15%, 10%, 5%, 2%, and 1% of the simulation sequence time. The exceedance frequencies are listed in the first column. Eq. (*P*= 100×

$[M/ (n + 1)]$]) expresses the relative frequency equation. The frequency statistics of Pre-Impact and Post-Impact periods-of-record are listed individually. The table contains exceedance probabilities and their correlated observed daily mean flow rates in cubic feet per second.

Table 4.13 Frequency Metrics for Observed Daily Flow in the Sabine WAM (Unit: cfs)

WAM ID	BSBS		SRGW		SRBE		SRRL		29500	
	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact
1%	1,640	1,550	19,100	14,300	20,900	17,000	47,500	39,500	865	1,320
2%	1,138	1,150	13,100	10,400	14,400	13,300	39,600	32,400	625	941
5%	698	706	7,510	6,930	9,280	10,700	29,500	23,000	285	467
10%	425	413	5,060	4,950	6,420	7,640	21,700	18,100	153	244
15%	301	287	3,540	3,660	4,900	5,840	17,200	16,000	114	174
20%	237	223	2,510	2,650	3,740	4,450	13,800	14,200	94	146
30%	163	150	1,320	1,310	2,130	2,490	9,170	9,290	72	109
40%	113	110	692	743	1,200	1,420	5,520	6,550	60	86
50%	75	77	412	460	700	853	3,520	4,850	50	69
60%	53	56	256	299	440	507	2,420	3,490	42	56
70%	38	37	150	173	262	310	1,640	2,280	35	47
75%	32	31	113	141	197	234	1,360	1,850	32	43
80%	27	25	81	118	146	174	1,180	1,600	29	38
85%	22	20	54	96	96	135	950	1,370	27	33
90%	18	15	38	72	57	100	730	1,180	24	28
95%	14	9	23	47	23	59	498	949	21	21
98%	10	5	14	32	19	36	379	813	17	15
99%	8	4	11	27	13	24	332	717	15	10

Winnsboro Lake is located upstream of control point BSBS, but the daily flow frequencies of this control point have remained essentially the same. At control points SRGWE, SRBE, and SRRL, high-flows are projected to be lower and low-flows are expected to increase due to water uses and flow controls by two large dams. The exceedance frequency in two periods of control point 29500 have almost identical flow frequency metrics at low-flow (60% and up). But the observed daily flow for 1%, 2%, 5%, and 10 % of the period-of-analysis are considerably higher at the Post-Impact period. Flow frequency metrics for observed daily flow in the Neches River Basin at the seven control points are listed in Table 4.14.

Table 4.14 Table Frequency Metrics for Observed Daily Flow in the Neches WAM (Unit: cfs)

ID	NENE		NEDI		NERO		MUJA		ANAL		NEEV		VIKO	
	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact
1%	6,400	5,000	11,800	10,900	15,900	18,100	3,000	2,300	5,450	6,970	40,600	23,900	6,850	11,600
2%	4,470	3,790	9,070	8,230	12,800	14,600	1,940	1,520	3,930	5,170	31,000	21,300	4,580	7,890
5%	2,700	2,440	6,260	5,620	9,420	9,670	960	775	2,100	3,140	22,200	18,700	3,390	4,330
10%	1,710	1,600	4,300	3,860	6,510	6,420	618	538	1,350	2,120	16,300	15,200	1,960	2,600
15%	1,250	1,210	3,210	3,030	4,790	4,770	438	393	1,130	1,630	12,400	11,300	1,350	1,860
20%	1,020	964	2,500	2,600	3,720	3,740	313	287	1,080	1,280	9,740	8,870	998	1,370
30%	694	587	1,600	1,940	2,310	2,440	183	161	803	789	6,500	6,050	598	830
40%	441	373	944	1,170	1,350	1,490	112	107	573	501	3,910	4,170	376	563
50%	280	210	553	699	785	882	68	72	355	335	2,420	3,230	264	392
60%	183	146	351	460	495	537	43	48	208	218	1,610	2,710	193	283
70%	108	108	237	242	299	338	27	33	128	130	1,080	2,240	147	194
75%	80	94	182	179	226	266	19	26	100	98	855	1,950	124	163
80%	55	83	131	131	160	208	12	22	89	76	692	1,730	104	137
85%	39	75	88	96	118	159	7	16	70	61	524	1,420	86	113
90%	24	65	49	69	73	116	3	11	49	47	414	1,050	68	91
95%	12	52	22	66	40	80	0	7	26	26	282	786	50	67
98%	5	30	8	46	18	56	0	4	16	12	198	453	38	45
99%	3	25	3	35	9	44	0	2	11	7	66	365	32	27

According to Table 4.14, daily flows have slightly different flow frequency metrics from two periods at most control points in the Neches River Basin. However, at control point NEEV, there are comparatively different flow frequencies between Pre-Impact and

Post-Impact periods. This control point is located on the Neches River at Evadale, and downstream of Town Bluff Dam and Sam Rayburn, which was initially impounded in 1965. Low daily flows for the impacted period are significantly larger than the un-impacted period, while high flows for certain periods are smaller than those in the un-impacted period. The median (50%) of daily flow for the impacted period is 3,230 cfs and for the un-impacted period is 2,420 cfs. Control point NENE, located downstream of Palestine Lake, presents similar results, with minimum and maximum daily flows slightly increasing and decreasing, respectively. The USGS gauging station VIKO, located on Village creek near Kountze, has a long period of daily recorded flow data, with no critical water development above this control point. The median daily flows value slightly increase, which may be attributed to the cumulative effect of human activities.

Table 4.15 presents the flow frequency metrics at seven control points in the Trinity River Basin. Control points 8TROA and 8BSBR illustrate increases in low flows combined with decreases in high flows. As an example of interpreting Table 4.16, control point 8TRRO is on the Trinity River at Romayor, 20 miles below Lake Livingston, the largest reservoir in the basin. The gauge is about fifty miles above the Trinity River outlet at Galveston Bay. Low flows in this gauge since about the 1970s tend to be not as low as low flows before the 1970s. The metrics in Table 4.15 show that the observed flow rates in the Pre-Impact period are significantly smaller than those in the Post-Impact period in control points 8CTFW, 8WTGP, 8TRDA, 8TRRS and 8TRRO.

Table 4.15 Frequency Metrics for Observed Daily Flow in the Trinity WAM (Unit: cfs)

ID	8BSBR		8CTFW		8WTGP		8TRDA		8TRRS	
	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact
1%	1,700	1,460	1,890	2,340	6,430	10,100	18,000	18,500	27,400	27,600
2%	820	780	969	1,540	4,570	6,215	12,000	13,300	17,600	20,700
5%	211	276	352	828	2,360	3,605	6,840	9,315	10,600	14,700
10%	100	105	166	366	1,340	2,250	3,700	6,460	6,630	10,400
15%	49	51	103	215	864	1,320	2,110	4,880	4,190	7,810
20%	30	32	70	123	570	883	1,320	3,760	2,760	6,110
30%	16	16	33	53	270	491	682	1,560	1,440	3,230
40%	9	11	17	34	164	346	385	848	822	1,800
50%	5	6	9	24	122	265	263	602	522	1,210
60%	1	2	5	17	97	218	184	489	399	969
70%	0	0	2	13	75	188	119	428	289	834
75%	0	0	1	11	64	175	92	401	248	782
80%	0	0	0	9	54	163	69	368	202	726
85%	0	0	0	7	43	152	50	334	162	660
90%	0	0	0	4	30	138	28	282	133	589
95%	0	0	0	2	21	118	13	226	69	499
98%	0	0	0	0	15	102	0	189	39	410
99%	0	0	0	0	13	90	0	175	39	382

ID	8TROA		8TRRO	
	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact
1%	47,700	42,000	53,000	58,300
2%	33,800	33,800	44,600	48,800
5%	19,400	2,100	31,200	34,500
10%	13,500	15,500	21,000	24,700
15%	9,830	11,400	15,400	19,000
20%	6,650	8,050	11,800	14,400
30%	3,220	4,700	6,620	8,080
40%	1,860	2,590	3,910	4,890
50%	1,110	1,610	2,460	2,880
60%	708	1,230	1,610	2,080
70%	525	980	1,090	1,570
75%	437	891	905	1,360
80%	347	819	730	1,200
85%	279	746	580	1,080
90%	196	669	440	969
95%	128	580	316	777
98%	86	483	230	525
99%	66	418	186	382

Table 4.16 Frequency Metrics for Observed Daily Flow in the Brazos WAM (Unit: cfs)

ID	DMAS09		SFAS06		BRSE11		CFNU16		CFFG18	
	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact
1%	3,425	1,500	2,760	860	7,190	3,510	2,290	879	4,910	3,040
2%	1,980	876	1,370	489	3,970	1,970	1,260	483	2,740	1,610
5%	615	340	500	206	1,530	905	435	211	923	622
10%	214	155	160	93	670	440	124	88	296	260
15%	112	95	86	58	340	276	59	51	140	152
20%	56	67	45	38	198	201	37	35	84	115
30%	22	37	18	19	106	115	20	23	38	66
40%	8	23	9	11	54	75	13	16	21	46
50%	3	15	4	7	30	52	9	12	13	33
60%	1	8	2	4	17	37	6	8	8	23
70%	0	3	1	2	7	23	4	5	3	15
75%	0	2	0	1	4	17	3	3	1	11
80%	0	1	0	0	2	11	2	2	0	8
85%	0	0	0	0	0	6	1	1	0	4
90%	0	0	0	0	0	2	0	0	0	1
95%	0	0	0	0	0	0	0	0	0	0
98%	0	0	0	0	0	0	0	0	0	0
99%	0	0	0	0	0	0	0	0	0	0
ID	**BRPP27**		**BRGR30**		**NBCL36**		**LEGT47**		**LAKE50**	
	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact
1%	18,100	12,700	21,800	18,000	3,570	3,980	3,690	5,530	1,520	2,750
2%	11,400	6,720	13,300	9,820	1,660	1,840	2,040	3,570	870	1,570
5%	3,590	2,270	5,660	3,680	652	775	949	1,790	430	708
10%	2,000	1,290	2,950	2,040	315	366	498	1,120	224	345
15%	1,370	889	1,820	1,330	196	229	340	644	144	198
20%	1,070	651	1,340	1,330	130	154	213	438	99	140
30%	626	353	844	518	68	82	92	198	55	86
40%	359	201	553	289	34	44	42	102	38	54
50%	212	122	379	120	20	27	22	63	29	36
60%	121	89	265	66	11	19	13	35	23	27
70%	70	65	180	43	7	11	8	19	18	21
75%	51	56	151	36	4	8	6	14	16	19
80%	38	47	112	30	3	5	4	9	14	17
85%	30	38	81	25	2	4	2	4	13	15
90%	20	31	52	20	1	2	1	3	11	12
95%	8	24	23	15	0	1	0	1	8	10
98%	0	18	7	10	0	0	0	0	6	8
99%	0	15	1	8	0	0	0	0	4	8

Table 4.16 Continued

ID	LRCA58		NAEA66		BRHE68		BRRI70		BRRO72	
	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact
1%	17,200	13,100	7,440	8,180	61,900	51,100	66,200	59,000	60,600	62,150
2%	12,000	10,800	4,290	5,050	48,100	42,000	51,500	47,550	49,400	49,900
5%	7,230	8,420	1,860	2,270	27,450	28,700	29,700	32,500	34,000	35,200
10%	4,430	5,420	784	854	17,000	17,600	17,900	20,300	21,400	21,500
15%	3,060	3,600	340	330	11,900	12,400	12,900	14,800	15,950	15,400
20%	2,140	2,620	188	145	8,800	9,290	9,690	11,400	12,400	11,800
30%	1,120	1,370	87	64	5,170	5,730	5,940	7,090	7,770	7,370
40%	680	790	44	43	3,320	3,820	3,960	4,770	4,000	4,960
50%	411	488	24	29	2,220	2,450	2,750	3,045	2,700	3,180
60%	248	301	12	20	1,610	1,690	1,900	2,030	1,930	2,050
70%	158	200	6	15	1,190	1,240	1,360	1,470	1,390	1,390
75%	125	163	4	13	1,020	1,080	1,140	1,250	1,170	1,165
80%	102	135	3	11	850	981	962	1,070	945	954
85%	68	111	2	9	669	831	802	889	675	738
90%	39	90	1	7	588	687	685	719	370	517
95%	21	69	0	3	435	517	525	530	50	357
98%	9	49	0	1	332	420	383	400	50	238
99%	2	37	0	1	276	338	282	333	50	172

ID	BRSB23		LRLR53		BRWA41	
	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact
1%	15,700	9,790	6,800	9,070	29,300	27,200
2%	9,320	5,440	4,320	7,480	19,800	22,400
5%	3,590	1,970	3,480	5,570	10,100	10,200
10%	1,480	962	2,410	3,350	5,240	4,850
15%	800	621	1,380	2,350	3,490	3,260
20%	526	430	1,320	1,490	2,540	2,430
30%	264	256	650	741	1,520	1,530
40%	149	157	366	436	1,060	1,070
50%	89	112	182	242	715	785
60%	55	80	146	145	440	556
70%	34	52	96	107	261	362
75%	23	44	79	95	199	278
80%	14	29	66	85	143	210
85%	7	16	56	74	102	158
90%	2	7	50	64	73	108
95%	1	1	35	55	40	53
98%	0	0	18	46	16	29
99%	0	0	14	39	10	19

In Table 4.16, frequency metrics for daily flow in the Brazos River Basin at each selected control point are listed individually. Comparing the analysis results between two periods, both high flows and low flows evidence a slightly increasing tendency at many of the gauge stations in the middle and lower Brazos Basin. At other sites, high flows have decreased, and low flows have increased at several sites due to construction and operation of reservoir projects. For instance, the Brazos River at the USGS gauge near Waco (BRWA41 in Table 4.16), located \downstream of three multiple-purpose reservoirs (Lakes Whitney, Waco, and Aquilla) has a 1% exceedance frequency daily flow of 29,300 cfs before impact and 27,200 cfs after impact, while 90% exceedance frequency daily flow 108 cfs before impact and 73 cfs after impact

Table 4.17 Frequency Metrics for Observed Daily Flow in the GSA WAM (Unit: cfs)

ID	CP01		CP02		CP05		CP08		CP10		CP11	
	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact
1%	1,190	2,040	2,300	4,330	466	609	1,000	1,440	2,850	3,780	2,050	2,640
2%	698	1,190	1,400	2,510	412	491	612	927	1,470	2,380	1,010	1,290
5%	408	649	755	1,340	382	446	350	500	823	1,230	285	512
10%	270	433	501	842	361	418	226	323	582	816	77	178
15%	198	338	366	638	347	400	160	240	464	647	41	94
20%	158	272	287	506	338	380	119	187	372	536	29	59
30%	114	208	197	356	326	356	75	122	272	392	18	29
40%	87	165	140	259	312	334	52	89	210	296	11	17
50%	71	133	102	200	302	309	39	69	176	242	8	13
60%	55	110	80	155	286	288	27	54	147	200	6	10
70%	41	85	61	116	262	255	20	41	118	168	4	7
75%	35	74	52	98	246	240	17	35	108	151	3	6
80%	29	65	45	83	220	222	14	29	99	133	3	5
85%	22	53	34	64	196	204	12	22	91	118	2	4
90%	14	41	23	44	162	177	10	18	84	107	1	3
95%	0	29	10	25	93	144	8	13	76	93	0	2
98%	0	15	0	7	51	92	6	10	65	80	0	1
99%	0	10	0	0	17	75	5	8	58	69	0	1

Table 4.17 Continued

ID	CP13		CP14		CP15		CP18		CP23		CP28	
	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact
1%	2,420	2,670	13,400	17,000	15,600	17,200	243	491	410	947	986	3,340
2%	1,050	1,380	10,500	11,800	10,400	12,000	209	286	242	827	583	1,870
5%	270	469	5,000	7,020	5,050	7,510	152	187	55	587	278	956
10%	73	135	2,660	4,150	2,800	4,650	120	138	31	434	150	956
15%	34	55	1,825	2,750	2,120	3,050	100	98	29	268	112	384
20%	23	32	1,700	2,200	1,700	2,350	84	79	27	215	97	286
30%	12	17	1,300	1,660	1,300	1,760	58	46	25	109	82	196
40%	8	12	1,070	1,300	1,040	1,380	38	32	22	74	71	153
50%	5	9	877	1,030	844	1,090	27	25	19	48	59	132
60%	4	7	747	841	691	885	22	21	15	35	47	116
70%	2	5	624	702	579	740	17	16	0	31	34	102
75%	2	4	573	634	542	655	16	15	0	29	27	96
80%	1	3	520	560	455	573	14	13	0	27	19	89
85%	0	2	460	483	375	490	12	12	0	25	14	81
90%	0	2	388	416	276	403	11	10	0	25	11	68
95%	0	1	225	288	165	290	9	7	0	22	8	58
98%	0	0	152	174	97	162	7	5	0	20	6	49
99%	0	0	138	132	54	136	6	4	0	19	5	45

ID	CP29		CP32		CP34		CP35		CP37	
	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact
1%	2,070	5,700	2,740	5,450	140	505	2,270	2,820	6,990	10,200
2%	1,130	3,460	1,710	3,550	27	182	907	1,350	3,800	6,610
5%	633	1,770	816	1,920	0	4	243	432	1,460	3,070
10%	402	1,100	497	1,200	0	0	90	181	782	1,670
15%	321	814	380	904	0	0	55	115	594	1,210
20%	278	655	316	733	0	0	42	90	521	956
30%	232	480	250	528	0	0	31	61	368	694
40%	197	390	208	426	0	0	25	47	296	548
50%	174	334	191	360	0	0	20	38	243	453
60%	154	287	146	308	0	0	17	31	202	380
70%	152	241	122	262	0	0	14	27	163	316
75%	144	218	112	237	0	0	13	25	146	286
80%	133	195	102	210	0	0	11	22	131	256
85%	117	169	90	182	0	0	10	19	113	227
90%	99	148	78	157	0	0	8	16	96	202
95%	79	115	64	120	0	0	7	11	76	153
98%	61	92	50	89	0	0	4	7	54	115
99%	49	81	43	74	0	0	3	4	45	98

Flow frequency metrics for observed daily flow in the GSA River Basin are developed as presented in Table 4.17. The daily flows have nearly similar frequency metrics at many control points but slightly different flow frequency metrics at the 9 control points, CP01, CP02, CP08, CP10, CP11, CP14, and CP15 in the Guadalupe River Basin.

Four control points located on the San Antonio River reveal considerably different flow frequency metrics, possibly due to water usage and flow at by Medina Lake. The analysis results provided in Table 4.17 show that both minimum and maximum flows increase more in the impacted period than the un-impacted period for most control points. Control points CP01, CP02, CP08, CP10, and CP35 have similar analysis results, with no obvious human influences on these gauges. Although for CP15 located on downstream from Canyon Lake results are also almost the same as the above control points.

Table 4.18 Frequency Metrics for Observed Daily Flow in the Colorado WAM (Unit: cfs)

ID	**A10000**		**B20000**		**B10000**		**C70000**		**C30000**		**C20000**	
	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact
1%	1,260	489	528	1,180	3,170	650	448	70	29	106	15,700	9,790
2%	512	219	335	631	1,970	203	151	24	54	85	9,320	5,440
5%	109	55	140	199	618	17	29	12	40	57	3,590	1,970
10%	35	19	37	71	204	13	13	7	31	42	1,480	962
15%	24	11	23	39	128	11	9	5	25	36	800	621
20%	10	6	16	26	74	9	7	4	21	31	526	430
30%	4	1	10	15	27	4	5	3	17	24	264	256
40%	2	0	6	9	12	2	3	1	13	19	149	157
50%	2	0	5	6	5	1	2	0	11	15	89	112
60%	1	0	5	4	2	0	0	0	8	12	55	80
70%	0	0	4	2	0	0	0	0	6	9	34	52
75%	0	0	3	1	0	0	0	0	5	8	23	44
80%	0	0	2	1	0	0	0	0	4	7	14	29
85%	0	0	0	0	0	0	0	0	4	6	7	16
90%	0	0	0	0	0	0	0	0	3	5	2	7
95%	0	0	0	0	0	0	0	0	1	4	1	1
98%	0	0	0	0	0	0	0	0	1	3	0	0
99%	0	0	0	0	0	0	0	0	1	2	0	0

Table 4.18 Continued

ID	C10000		D40000		D30000		E40000		E20000		E10000	
	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact
1%	3,390	619	7,730	726	1,000	511	468	171	468	99	2,760	1,350
2%	1,260	330	3,690	553	405	273	152	108	101	47	1,240	766
5%	328	144	1,140	210	103	93	78	75	18	17	517	399
10%	153	92	410	78	28	50	59	56	7	4	292	244
15%	108	68	194	43	15	29	47	48	4	2	220	188
20%	79	55	107	31	7	18	42	41	2	1	188	156
30%	48	41	60	19	3	10	35	34	0	0	133	121
40%	33	28	33	13	1	6	26	29	0	0	104	100
50%	21	24	20	9	0	3	20	24	0	0	85	85
60%	11	17	12	6	0	1	14	20	0	0	68	71
70%	5	10	7	3	0	0	9	16	0	0	53	55
75%	2	7	4	2	0	0	7	14	0	0	46	49
80%	1	4	3	1	0	0	5	13	0	0	39	42
85%	0	1	1	1	0	0	3	10	0	0	33	35
90%	0	0	0	0	0	0	1	7	0	0	25	27
95%	0	0	0	0	0	0	0	3	0	0	16	18
98%	0	0	0	0	0	0	0	1	0	0	7	11
99%	0	0	0	0	0	0	0	0	0	0	2	7

ID	F20000		F10000		G50000		G40000		G10000		H10000	
	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact
1%	3,780	3,130	20,600	9,650	470	464	1,280	1,010	3,730	3,710	1,820	2,590
2%	2,230	1,680	12,200	5,160	208	254	540	538	1,900	1,990	932	1,350
5%	800	570	4,820	2,160	117	131	306	320	788	880	384	588
10%	397	217	2,040	1,020	64	86	207	229	459	539	220	324
15%	229	101	1,250	671	47	64	164	196	330	402	156	224
20%	173	52	880	485	38	53	142	175	263	327	120	174
30%	55	26	527	285	29	36	112	149	184	247	71	120
40%	23	16	356	205	23	28	94	135	140	201	45	88
50%	18	12	270	159	18	22	82	120	112	168	31	63
60%	16	9	192	121	13	17	71	106	89	141	20	45
70%	16	6	138	90	9	12	60	94	73	113	12	31
75%	16	5	117	76	7	10	56	87	62	101	10	26
80%	16	4	96	66	4	8	49	80	50	89	8	21
85%	15	3	74	53	2	5	43	73	38	74	5	16
90%	13	1	55	39	1	3	35	62	27	61	3	7
95%	8	0	36	23	0	0	26	52	12	42	0	1
98%	6	0	18	11	0	0	18	44	1	20	0	0
99%	4	0	6	6	0	0	14	41	0	9	0	0

Table 4.18 Continued

ID	I10000		J30000		K20000	
	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact	Pre-Impact	Post-Impact
1%	27,800	18,000	10,000	23,900	27100	29700
2%	16,400	7,550	7,400	12,000	15600	19500
5%	6,990	5,030	6,495	6,180	7445	9160
10%	4,300	3,110	4,240	3,840	5170	5370
15%	3,200	2,380	3,500	2,780	3940	3780
20%	2,570	2,090	3,020	2,370	3280	2810
30%	1,920	1,710	2,230	1,950	2360	1850
40%	1,470	1,350	1,885	1,640	1740	1400
50%	1,060	1,020	1,540	1,280	1350	1130
60%	734	589	1,160	969	1140	911
70%	490	313	724	625	892	711
75%	404	253	545	507	808	619
80%	328	202	375	430	700	544
85%	260	158	246	368	585	493
90%	206	122	172	290	444	412
95%	148	87	122	224	326	305
98%	66	55	101	191	258	212
99%	43	36	90	175	228	128

Attainment metrics for all 20 control points in the Colorado River Basin are tabulated in Table 4.18. Flow frequency metrics in this river basin vary, depending on whether the control point is located on the Lower Colorado River below Lake Travis or on the Upper Colorado River above Lake Travis. For control points J3000 and K2000 on the lower Colorado River, as expected, high stream flows were observed to be larger at the Post-Impact period and super low stream flows were observed a much smaller percentage of time at this location.

5. ANALYSES OF DAILY WATER AVAILABILITY MODEL SIMULATION

5.1. Daily Modeling System

The daily version of the WRAP modeling system can be used to model all aspects of water management and is especially relevant for simulating flood control operations and environmental instream flow requirements. In August 2012, developmental versions of SIMD and DAY were added to WRAP. The latest publicly released versions of SIMD were developed May 2018. The major new features listed below result in this expanded version of the daily modeling system.

- The 1940-1997 IN and EV records have been updated up to 2017 and stored in the hydrology input DSS file. The daily flow (DF) records are updated up to 2017 to subdivide monthly flow volumes into daily quantities.
- The routing (RT) records have been added in a new DIF file and applied to calibrate lag and attenuation parameters. The new FR, FF, FV, and FQ records have been added to the DAT file in order to model the flood control operation of reservoirs.
- The IF, ES, HC, and PF records in the DAT file are applicable to describe the SB3 environmental flow standards by a new method. Details are explained in Chapter 6.

There are two main features incorporated in SIMD: (1) monthly to daily disaggregation (including disaggregated monthly naturalized streamflows and development of daily diversion and targets); and (2) flow routing and forecasting.

Alternative options have been designed for subdividing monthly naturalized flows into daily flows. In this research, monthly naturalized streamflows are disaggregated to daily using the flow pattern option as defined by a sequence of daily flow volumes (DF records) stored in the DSS input file. This option is the default recommended standard method, based on daily volumes proportioned to monthly volumes in the same ratio as the daily pattern flows divided by monthly total, computed via the equation below.

$$Q_d = \frac{P_d}{P_m} Q_m \qquad (5.1)$$

where Q_m is monthly naturalized flow volume, Q_d is daily flow volume, P_d is a sequence of daily pattern flows, and P_m is monthly total volume.

Although SIMD provides non-uniform distribution options, monthly water supply diversion targets and monthly reservoir net evaporation-precipitation depths are uniformly disaggregated to daily in this research. The propagation of changes in streamflows downstream result from an upstream change to streamflow, such as upstream diversions, return flows, reservoir releases, and streamflow depletions for refilling reservoir storage. Flow routing and forecasting are the other main features added to SIMD (not included in SIM). Routing in SIMD simulates by the lag and attenuation method, which simulates the travel time and storage effects of a stream reach on flow changes for upstream. Forecasting in SIMD considers the effects of routing flow changes in future time periods. Thus, it can be activated only when routing is employed. The purpose of forecasting is to determine the volume of streamflow available for downstream water supply, water rights, and preventing releases, which contribute to flooding by facilitating flood control operations. The lag parameters and attenuation parameters are calibrated based on statistical analyses of upstream and downstream changes via program daily flows (DAY) and daily hydrographs (DAYH). However, the routing and forecasting options would likely add to the complexity of the model and greatly increase computer execution time. Thus, these functions are not employed in this research.

Compared with the monthly Brazos WAM, a daily time step significantly increases the accuracy for modeling reservoir flood control operations, because, during flood events, flow rates change dramatically over short time spans. Flood control reservoir operations in SIMD are simulated via the flood control reservoir FR record, flood flow FF record, and volume and outflow FV/FQ record. The regular operating rules are: so long as the water storage is not exceeded flood control pool storage capacities, releases are made to empty the flood control pools as expeditiously as possible without contributing to river flows exceeding the allowable flow limits at the downstream sites. Emergency operating plans are activated whenever the water surface level is above the top of the flood control pool elevation. In this case, the excess flows pass through the reservoir without any storage attenuation, even if the down streamflow limits are exceeded.

5.2. Daily SIMD Simulation Dataset

All the SIM monthly simulation features and input files are also included in the daily dataset to be read by SIMD. With the exception of those input records, which serve both monthly and daily simulation, some additional records are added in SIMD to provide input for daily time step features. The JT record is one of the daily-only records, which is also the only required record to activate daily features. The other optional records are listed in Table 5.1. The HEC-DSSVue was used to create the DSS files to combine and evaluate datasets. The file with filename ending “HYD.DSS” contains sets of net evaporation-precipitation depths, monthly naturalized flows, daily flows, and index HI records, and serves as the SIMD hydrology input file. The DSS file option is much more convenient for storing and editing a large dataset. Therefore, this option is considered as the standard method for storing daily flows input to be read by daily SIMD simulations in the future.

Table 5.1. Records for Daily Simulations

DAT File Input	JT, JU W2, C2, C3, G2, R2 DW, DO, PF, PO FR, FF, FV, FQ	Control time step, output, and forecasting options Control output of selection daily simulation results Specify water right targets and options. Flood control simulation operations.
DIF File Input	RT, DC	Provide routing and disaggregation parameters.
DSS File Input	DF	Daily flows or daily flow patterns stored in the DSS File

5.2.1 Daily SIMD Simulation Dataset for the Brazos River Basin

The input records in the DAT file used for conversion of monthly Brazos WAM to daily Brazos WAM are shown in Table 5.2, with the new added records and modified fields. The part of SB3 environmental flow standards added in the DAT file is discussed in the next chapter.

Table 5.2 Beginning Part of SIMD Input DAT File for the Brazos River Basin

```
**  October2018RW Begin
JD    76    1940       1       1       0               7              -1       13
JO     6                   1                           1                       3
JT     0   0   0   0   0   0   0   0   0   0   0   0
JU     1   1   0   0   0   0   0   0   0     0.0     0.0
OF     1   0   2                                              Brazos
**OF    15  16  27  28
HI         LOWER  MIDDLE   UPPER
DF        227901  509431  515531  515631  515731  515831  515931  516031  516131
516231  516331  516431  516531  AQAQ34  BGNE71
DF        BRAQ33  BRBR59  BRDE29  BRGR30  BRHB42  BRHE68  BRPP27  BRRI70  BRRO72
BRSB23  BRSE11  BRWA41  CBALC2  CFFG18  CFNU16
DF        CLPEC1  CON070  CON095  CON102  CON129  CON137  CON145  CON147  CON231
DMAS09  DMJU08  EYDB61  GAGE56  GALA57  LAKE50
DF        LEBE49  LEGT47  LRCA58  LRLR53  NABR67  NAEA66  NBCL36  NBVM37  PAGR31
RWPL01  SFAS06  SGGE55  YCSO62
CO        SFAS06  DMAS09  BRSE11  CFNU16  CFFG18  BRSB23  BRPP27  BRGR30  NBCL36
BRWA41
CO        BRHB42  LEHM46  LEGT47  LEBE49  LAKE50  LRLR53  LRCA58  BRBR59  YCSO62
DCLY63
CO        NAEA66  NABR67  BRHE68  BRRI70  BRRO72
C2        SFAS06  DMAS09  BRSE11  CFNU16  CFFG18  BRSB23  BRPP27  BRGR30  NBCL36
BRWA41
C2        BRHB42  LEHM46  LEGT47  LEBE49  LAKE50  LRLR53  LRCA58  BRBR59  YCSO62
DCLY63
C2        NAEA66  NABR67  BRHE68  BRRI70  BRRO72
**
```

The main options activated on the five records are the:

- JD record—Negative incremental flow ADJINC options 7 selected in JD record field 8 is recommended for SIMD simulation. This option limits the downstream control points considered in determining flow availability for a right to those control points at which senior water rights are relevant. The dimension limit TL in JD record field 11 can be increased above the default of 12 to raise the maximum limit on the number of entries on IS, IP, SV, SA, PV, PE, TQ, and TE records.
- JO record—the INEV option in JO is used to organize IN and EV records. With 6 in field 2, the IN and EV records are read as input from a DSS file. Option 1 selected in the JO record field 6 instructs SIMD to read the Hydrologic index (HI records) also from the DSS file.
- JT record—fields 2 and 3 in JT combine with C2 and W2 to select control points and water rights output in the SUB file. The JT record is required for SIMD simulation, while the JU record is activated for certain daily options.
- JU record—Flow disaggregation and forecasting options are controlled by the JU record, without which SIMD automatically sets with default values. The default for flow disaggregation is the daily flow pattern hydrographs method. The default option 1 in the JU record field 3 is to read the daily flow pattern hydrographs from the hydrology DSS file. The integer 2 entries in both the JU record field 4 and 6, mean that streamflow forecasting is activated, and forecast flow changes are placed in priority sequence. If fields 7 and 8 are blank, forecasting parameters will set automatically.
- OF record—Options for the DSS and SOU files are activated by OF record. Option 3 selected in the OF record field 4 means that the DSS output file contains SIMD daily results only. With option 4 selected in OF record column 20, the 4 variables are included in the simulation results. Instream flow target (IFT) and Instream flow shortage (IFS) for both control points and water rights are the four simulation variables in this research.

Flood control operations modeled in SIMD activated by flood flow (FF), flood reservoir (FR) records, and required the tables of volume-area (SV/SA records) and volume-outflow (FV/FQ records) include the flood control pools of the reservoirs. The FR and FF records are used to model operation of the flood control pools of the reservoirs based on considering flows at downstream gaging station. The WS records are added along with FR records to provide pool storage capacities. Storage index DI records and accompanying index storage IS and index percentages IP are added to the FF records to model the variation of flood flow limits with reservoir storage capacity. The storage volumes (FV record in acre-feet) and outlet capacity flow rates (FQ records in cfs) are applied for the reservoirs in which outlet capacities are relevant. The Brazos River Basin is illustrated in this chapter to show the method that SIMD input records use to describe flood control operations based on flood control operating rules and outlet capacity data. The nine largest reservoirs in the Brazos River Basin are listed in Table 5.3 and 5.4 with their Reservoir ID, flood control storage capacities, and flood flow limits by dam or control point. The information entered on FR records and WS records is summarized in Table 5.3. The total storage volumes at the top of flood control pools are placed in the FR record fields 8, while the volumes at the bottom of the flood control pools are entered in the FR record fields 9. The maximum allowable flood flow limits at downstream control points are tabulated in Table 5.4. These limits are entered in cubic feet per second in the FF records field 3 in Table 5.5.

Table 5.3 Flood Control Reservoir Information in the Brazos WAM

Reservoir	Reservoir ID	Control point identifiers	Top of the flood control pool (acre-feet)	Bottom of the flood control pool (acre-feet)	Outflow Limit at Dam (cfs)
Whitney	WTNYFC	515731	1,227,060	0	25,000
Belton	BELTON	516031	1,097,600	457,600	2,134 to 2,721
Waco	WACOFC	509431	519,838	0	–
Somerville	SMRVLE	516431	507,400	160,100	–
Stillhouse	STLHSE	516131	630,400	235,700	24,100 to 28,490
Proctor	PRCTOR	515931	374,200	90,880	6,200 to 7,400
Granger	GRNGER	516331	244,000	65,500	1,500 and 3,000
Georgetown	GRGTWN	516231	130,800	37,100	650/3,000/6,000
Aquilla	AQUILA	515831	146,000	52,400	–

Table 5.4 Maximum Allowable Flood Flow Limits at Control Points

Control Point	Location	Flood Flow Limit (cfs)	% of flood control
CON070	Brazos/Aquilla Creek Confluence	25,000	
BRWA41	Brazos River at Waco	60,000	
BRBR59	Brazos River at Bryan	60,000	
BRHE68	Brazos River at Hempstead	60,000	
BRRI70	Brazos River at Richmond	60,000	
BOWA40	Bosque River at Waco	3,000	3
		5,000	7
		10,000	14
		20,000	23
		30,000	100
LEHS45	Leon River at Hasse	2,000	
LEGT47	Leon River at Gatesville	5,000	
LRLR53	Little River at Belton	3,000	5
	Little River at Stillhouse	6,000	35&34
		10,000	100
LRCA58	Little River at Cameron	10,000	
NGGE54	San Gabriel River at Laneport	6,000	
SGGE55	North Fork San Gabriel River	6,000	
YCSO62	Yequa Creek	1,000	18
		2,500	100
516231	Georgetown Dam	1,500	10
		3,000	100
516331	Granger Dam	650	5.1
		3,000	47
		6,000	100

Table 5.5 FR, WS and FF Records in the DAT File

```
**  October2018RW Begin Flood Control
**  Flood Control Reservoirs
**
FR5157319100000094000000   0   0   49587 1227060               0
WTNYFC-FRSTOR   WTNYFC-FRREL
WSWTNYFC                                                       1      -1
FR5160319100000094000000   0   0         1097600          457600
BELTON-FRSTOR   BELTON-FRREL
WSBELTON
FR5094319100000094000000   0   0          519838               0
WACOFC-FRSTOR   WACOFC-FRREL
WSWACOFC                                                       2      -1
FR5164319100000094000000   0   0          507400          160110
SMRVLE-FRSTOR   SMRVLE-FRREL
WSSMRVLE
FR5161319200000093000000   0   0          630400          235700
STLHSE-FRSTOR   STLHSE-FRREL
WSSTLHSE
FR5159319200000093000000   0   0          374200           90880
PRCTOR-FRSTOR   PRCTOR-FRREL
WSPRCTOR
FR5163319200000093000000   0   0          244000           65500
GRNGER-FRSTOR   GRNGER-FRREL
WSGRNGER
FR5162319200000093000000   0   0          130800           37100
GRGTWN-FRSTOR   GRGTWN-FRREL
WSGRGTWN
FR5158319200000093000000   0   0          146000           52400
AQUILA-FRSTOR   AQUILA-FRREL
WSAQUILA
**
FFCON070  25000.
FFBRWA41  60000.
FFBOWA40  30000.               2
FFLEHS45   2000.
FFLEGT47   5000.
FFLRLR53  10000.               3
FF516231   3000.               4
FF516331   6000.               5
FFSGGE55   6000.
FFNGGE54   6000.
FFLRCA58  10000.
FFYCSO62   2500.               6
FFBRBR59  60000.
FFBRHE68  60000.
FFBRRI70  60000.
**
**
FVAQUILA      0.  52400. 146000.
FQ            0.   2134.   2721.
FVBELTON      0. 457600.1097600.
FQ            0.  24100.  28490.
FVSTLHSE      0. 235700. 630400.
FQ            0.   6200.   7400.
```

Table 5.5 Continued

```
**
DI     2       5  LKWACO   WACO2   WACO4   WACO5  WACOFC
IS    11      0. 222156. 222157. 242950. 242951. 279338. 279339. 326124.
326125. 726399. 726400.
IP            0.      0.     10.     10.  16.667  16.667  33.333  33.333
66.667  66.667   100.0
DI     3       2  BELTON  STLHSE
IS     7      0. 745034. 745035. 1051497 1051498 1727900 1728000
IP            0.      0.     30.     30.     60.     60.    100.
DI     4       1  GRGTWN
IS     5      0.  46469.  46470. 130799. 130800.
IP            0.      0.     50.     50.    100.
DI     5       1  GRNGER
IS     7      0.  74604.  74605. 149394. 149395. 243999. 244000.
IP            0.      0.   10.83   10.83     50.     50.    100.
DI     6       1  SMRVLE
IS     4      0. 222621. 222622. 507399. 507400.
IP            0.      0.     40.     40.    100.
**
**  October2018RW End   |-------|-------|-------|-------|-------|-------|------
-|-------|-------|-------|
**
```

5.2.2. Daily SIMD Simulation Dataset for the Trinity River Basin

This section of the report documents the datasets employed to model the daily time-step Trinity WAM. The input records used to disaggregate the monthly Trinity WAM to daily are included in this section for demonstration purposes. Essentially, the modeling methodology used for the Trinity WAM is similar to the methodology described for the Brazos WAM. The Trinity WAM currently uses the hydrology DSS as an input with IN, EV, and DF records and filename "TrinityHYD.DSS." The Trinity WAM utilizes a default dual simulation option 333 on the JO record field 12 parameter DUALD for all water rights. The dual option of 333 is offered as a convention; when reservoir storage is completely refilled at first simulation, then the cumulative total is reset to zero in the second simulation. Option 333 also allows excess water from the prior month to be added to the current month.

Table 5.6 Beginning Part of SIMD Input DAT File for the Trinity River Basin

```
** daily WAM are marked withcomment lines that begin with #SIMD.
**
**       1         2         3         4         5         6         7
8
**345678901234567890123456789012345678901234567890123456789012345678901234567890123456789
012345678
**
** #SIMD: Change negative incremental option from 5 to 7 and TL is changed to
13.
**     |       |       |       |       |       |       |       |       |
|       |
JD    76    1940       0       1       0       0       7       0       0
13       0
JO     6
333
** #SIMD: Add SIMD records to initiate a daily time step simulation
**
JT     0   0   0   0   0   0   0   0   0       0   0   0
JU     1   1   0   0   0   0   0   0   0     0.0     0.0
OF     1   0   2   4   0   0
OF    15  16  27  28
DF          8WTJA   8BSBR   8WTBO   8CTAL   8CTFW   8WTFW   8WTGP   8MCGP
8ELSA   8IDPP   8CLSA   8DNJU   8TRDA   8WRDA   8ETMK
DF          8SGPR   8ETCR   8TRRS   8TRTR   8CEKE   8KGKA   8CEMA   8RIRI
8CHCO   8TEST   8TROA   8TRMI   8BEMA   8TRRI   8TRRO
DF        B3808A  B3809A  B3349A  B5157P  B3404A  B5136A  B2335A  B2456A
B304  B2362A  B2457C  B2462A  B2410A  B4976A  B4992A
DF        B5021A  B5035A  B4248A  B4248B
CO        8WTGP   8TRDA   8TROA   8TRRO
WO            EFS-8WTGP       EFS-8TRDA       EFS-8TROA       EFS-8TRRO
C2        8WTGP   8TRDA   8TROA   8TRRO
W2            EFS-8WTGP       EFS-8TRDA       EFS-8TROA       EFS-8TRRO
**
```

The conservation and flood control pool storage capacities for eight multiple-purpose reservoirs in the Trinity River Basin are listed in Table 5.7. Flood flow limits, shown in Table 5.8, are set as FF records and added immediately after the last WR record in the DAT file. Drought index records are used to alter the daily targets of the FF records by holding in the upstream flood control reservoirs storage. Seven of the 14 FF records in the Trinity WAM are connected to drought index DI/IS/IP records. Input Trinity reservoir records associated with flood control operations are a set of modifications to the Trinity DAT file shown in Table 5.9.

Table 5.7 Flood Control Reservoir information in the Trinity River Basin

Reservoir	Reservoir ID	Control point identifiers	Top of the flood control pool (acre-feet)	Bottom of the flood control pool (acre-feet)
Benbrook	BENBRK	B5157P	410000	88250
Joe Pool	JOPOOL	B3404A	642400	176900
Ray Roberts	ROBDEN	B2335A	1931900	799600
Lewisville	LEWDE1	B2456A	2060214	618400
Grapevine	GPVGP1	B2362A	769400	162500
Lavon	LAVON0	B2410A	921200	456500
Navarro Mills	NAVARO	B4992A	335800	63300
Bardwell	BARDWL	B5021A	268400	54900

Table 5.8 Maximum Allowable Flood Flow Limits at Control Points in Trinity

Control Point	Location	Flood Flow Limit (cfs)
8WTFW	W Fk Trinity Rv at Ft Worth	600
8WTGP	W Fk Trinity Rv at Grand Prairie	3000
8MCGP	Mountain Ck at Grand Prairie	6000
8DNGR	Denton Ck nr Grapevine	1000 to 4000
839	Elm Fk Trinity Rv abv Lewisville Lake	2000
B2457C	Elm Fk Trinity Rv nr Carrollton	2000 to 6000
8TRDA	Trinity Rv at Dallas	4000 to 7000
8ETCR	E Fk Trinity Rv nr Crandall	13000
8TRRS	Trinity Rv nr Rosser	8000
8RIDA	Richland Ck nr Dawson	15000
8WABA	Waxahachie Ck nr Bardwell	1200 to 2000
B5023A	Chambers Ck nr Rice	600 to 2000
8TROA	Trinity Rv nr Long Lake	4000

Table 5.9 FR, WS and FF Records in the Trinity DAT File

```
**
FF 8CTFW    600.
FF 8WTFW   3000.
FF 8WTGP   6000.
FF 8MCGP   4000.              6
FF 8DNGR   2000.
FF   839   6000.              7
FFB2457C   7000.
FF 8TRDA  13000.
FF 8ETCR   8000.
FF 8TRRS  15000.
FF 8RIDA   2000.             11
FF 8WABA   2000.             12
FFB5023A   4000.
FF 8TROA  24000.
```

Table 5.9 Continued

```
**  Flood Control Reservoirs
**  CPID STORAGE RELEASE FFNUM     FCMAX   FCTOP  FCGATE FCBOTOM   FCMUL
FCADD    STORAGE WRID    RELEASE WRID
**     |       |       |     FCDEP     |       |       |       |       |
FRB5157P9100000092000000       2          410000  164800   88250
BENBRK-FRSTOR   BENBRK-FRREL
WSBENBRK                                                       4
FRB3404A9100000092000000       2          642400  304000  176900
JOPOOL-FRSTOR   JOPOOL-FRREL
WSJOPOOL
FRB2335A9100000092000000       2         1931900 1064600  799600
ROBDEN-FRSTOR   ROBDEN-FRREL
WSROBDEN                                                       1
FRB2456A9100000092000000       2         2060214  959177  618400
LEWDE1-FRSTOR   LEWDE1-FRREL
WSLEWDE1                                                       2
FRB2362A9100000092000000       2          769400  406900  162500
GPVGP1-FRSTOR   GPVGP1-FRREL
WSGPVGP1                                                       3
FRB2410A9100000092000000       2          921200  748200  456500
LAVON0-FRSTOR   LAVON0-FRREL
WSLAVON0                                                       5
FRB4992A9100000092000000       2          335800  212200   63300
NAVARO-FRSTOR   NAVARO-FRREL
WSNAVARO
FRB5021A9100000092000000       2          268400  140000   54900
BARDWL-FRSTOR   BARDWL-FRREL
WSBARDWL
**  Storage vs Discharge Relationships
**  FV/FQ receords given for reservoirs with outlet structre capacities that
**  are less than the downstream channel capacities defined by FF records.
**                     |               |               |               |
|
FVBENBRK      0.  88250. 164800. 258600. 410000.
FQ            0.  11640.  13080.  30700. 161192.
FVJOPOOL      0. 176900. 304000. 362700. 642400.
FQ            0.   3460.   3880.   3880.  16363.
FVROBDEN      0. 799600.1064600.1261500.1931900.
FQ            0.  13090.  13686.  14083.  43834.
FVLEWDE1      0. 618400. 959177.2060214.
FQ            0.  10200.  11000. 229101.
FVGPVGP1      0. 162500. 406900. 769400.
FQ            0.   5890.   7240. 191311.
FVLAVON0      0. 456500. 748200. 921200.
FQ            0.   1000.   1300. 359002.
FVNAVARO      0.  63300. 212200. 335800.
FQ            0. 224001. 224001. 224001.
FVBARDWL      0.  54900. 140000. 268400.
FQ            0.   2360.   3120.  78001.
```

Table 5.9 Continued

```
** #SIMD: Adjusted peak storage to reflect addition of flood control storage
** Drought index for Lake Lavon. No diversion if total storage is less than
12,700
DI     5       1  LAVON0
IS     4       0   12700   12701  921200
IP             0       0     100     100
DI     6       1  JOPOOL
IS     5       0  176900  189610  189611  642400
IP          25.0    25.0    25.0   100.0   100.0
**
** #SIMD: Drought Index for the flood flow gauges: Elm Fk Trinity Rv abv
Lewisville Lake, 839
DI     7       1  ROBDEN
IS     7       0  799600  828750  828751  908250  908251 1931900
IP          33.3    33.3    33.3    66.7    66.7   100.0   100.0
**
** #SIMD: Drought Index for the flood flow gauges: Elm Fk Trinity Rv nr
Carrollton, B2457C
DI     8       1  ROBDEN
IS     7       0  799600  828750  828751  908250  908251 1931900
IP          57.1    57.1    57.1    78.6    78.6   100.0   100.0
**
** #SIMD: Drought Index for the flood flow gauges: Elm Fk Trinity Rv nr
Carrollton, B2457C
DI     9       1  LEWDE1
IS     7       0  618400  654736  654737  745577  745578 2060214
IP          57.1    57.1    57.1    78.6    78.6   100.0   100.0
**
** #SIMD: Drought Index for the flood flow gauges: Elm Fk Trinity Rv nr
Carrollton, B2457C
DI    10       1  GPVGP1
IS     7       0  162500  188800  188801  222990  222991  769400
IP          57.1    57.1    57.1    78.6    78.6   100.0   100.0
**
** #SIMD: Drought Index for the flood flow gauges: Richland Ck nr Dawson, 8RIDA
DI    11       1  NAVARO
IS     5       0   63300   78190   78191  335800
IP          60.0    60.0    60.0   100.0   100.0
**
** #SIMD: Drought Index for the flood flow gauges: Waxahachie Ck nr Bardwell,
8WABA
DI    12       1  BARDWL
IS     7       0   54900   63410   63411   80430   80431  268400
IP          30.0    30.0    30.0    60.0    60.0   100.0   100.0
**
ED
```

5.3. Assessment of Naturalized versus Simulated Regulated Flows

In WAM, naturalized flows at primary control points were developed by adjusting actual observed flows recorded to delete the effects of human activities according to the equation:

Naturalized Flow = Historical Gaged Flow + Upstream Diversions – Upstream Return Flows + Changes in Upstream Reservoir Storage + Upstream Reservoir Evaporation

Where *Historical Gaged Flow* and *Historical changes in reservoir storage* were determined using USGS data. *Upstream diversions* were estimated by the use of municipal, industrial and agricultural water rights records. *Historical return flows* for municipal and industrial users were estimated based on information from Texas Natural Resource Conservation Commission (TNRCC). Return flow data for agricultural users are neglected. Values of *Upstream Reservoir Evaporation* were computed by multiplying the net evaporation rate by the average reservoir surface area.

The original 1940-1997 monthly naturalized flows for primary control points were developed by the equation above and continue to be adopted without change. Program HYD was employed to extend the naturalized flows for the period from January 1998 through December 2015. The input DCF file, which included unregulated flows from the U.S. Army Corps of Engineers (USACE) system and observed flows from USGS gauges, are used by SIMD to disaggregate monthly naturalized flows to daily flows.

5.3.1. Daily Simulation Results for the Brazos River Basin

The daily WAM performs the SIMD simulation computations in a daily time step, employing both input and output DSS files. The hydrology input DSS files for the Brazos River Basin contains monthly naturalized flows in acre-feet (IN records), monthly net evaporation-precipitation depths in feet (EV records), daily flow volumes in cubic feet per second (DF records), and monthly hydrologic index (HI records). The DF records at 58 control points are used to disaggregate monthly naturalized streamflows at more than 3,000 Brazos WAM control points to daily. the JU record DFMETH option 1 activates the uniform distribution at the sites in the coastal basin and certain other control points not connected to the Brazos River and its tributaries. The DC record (`DCBRGM73     2     4`) in the DIF file applies record with REPEAT and DFMETHOD options 2 and 4 at all control points on the Brazos River and its tributaries located upstream of the Brazos outlet at control point BRGM73. This option 4 method is based on daily flow pattern hydrographs input on DF records and distributes monthly volumes to daily volumes in proportion to daily flows while maintaining monthly volumes.

Daily naturalized, regulated, and unappropriated flows at control points LRCA58 on the Little River and BRSE11, BRWA41, and BRRI70 on the Brazos River are plotted by HEC-DSSVue and presented as Figures 5.1, 5.2, 5.3, and 5.4. Information regarding these four gauges sites is found in Chapter 3. The blue solid lines represent daily naturalized flows, the red dashed lines represent daily regulated flows, and the black dotted lines represent daily unappropriated flows. The unit of flow rates is acre feet per day. All the naturalized, regulated, and unappropriated flows show great variability from zero flow to extreme high flows. Figures 5.1-5.4 show that the year 2011 was extremely dry throughout the Brazos River Basin, with several very wet years from 1998-2012. Long-term changes or trends could be hidden in the tremendous continuous variability. Thus, there is nothing very clearly evident in the plots. However, flows appear to have slightly reduced at Control Point BRSE11 Brazos River near Seymour, but slightly increased at Control Point LRCA58 on the Little River. In general, regulated flows were influenced by reservoir operations. For example, higher reservoir storages can result in greater consumption by evaporation, which leads to slightly lower mean regulated flows in the daily simulation. The unappropriated flows in the Brazos River Basin are greatly affected by instream flow requirements exclusively within high flow pulse requirements. Moreover, the lower mean naturalized flow also contributes to a lower mean unappropriated flow. Simulation results for 19 selected control points in the Brazos River Basin are summarized and compared in Table 5.6. Daily flow frequency metrics for naturalized and regulated flows are presented in Table 5.6 in cubic feet per second.

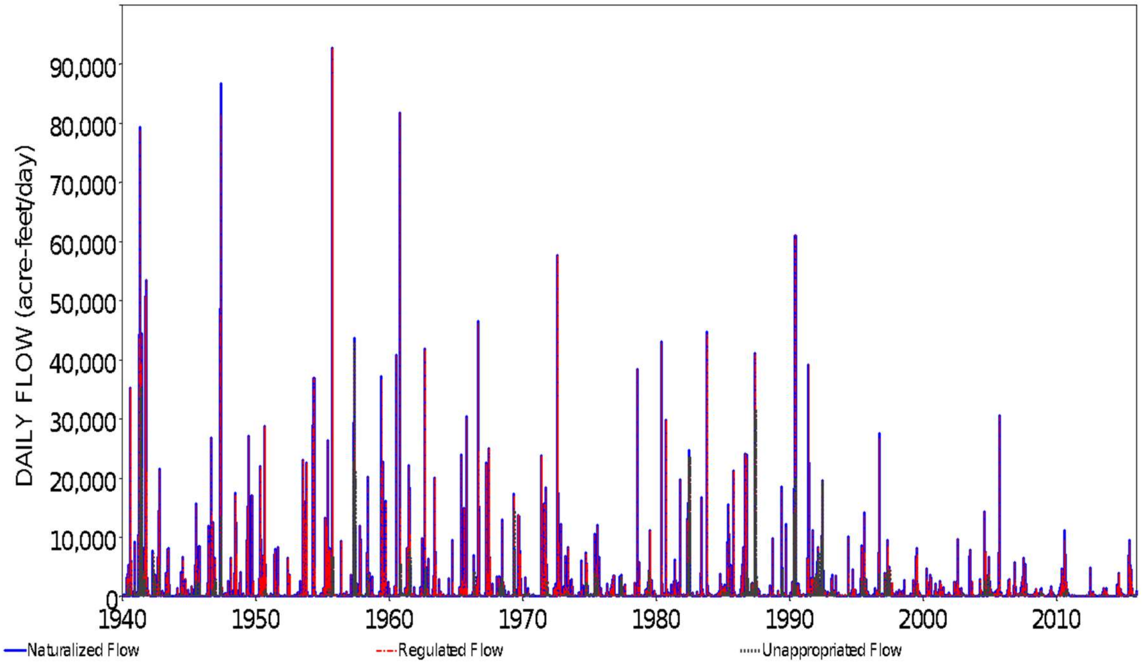


Figure 5.1 Daily Naturalized, Regulated and Unappropriated Flow at Control Point BRSE11

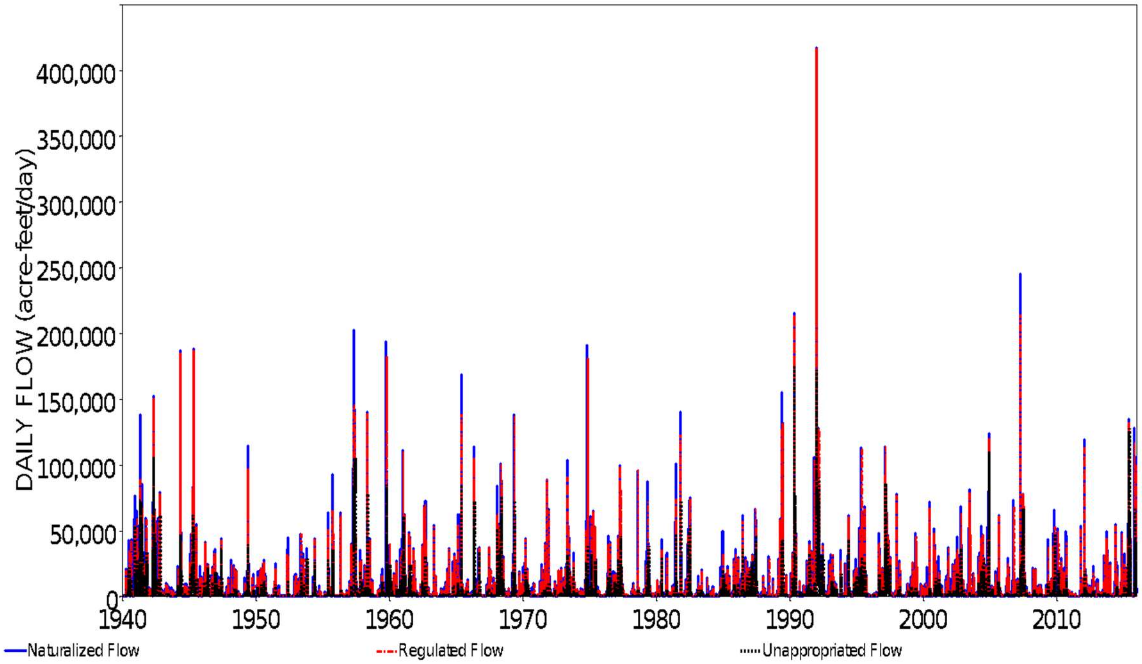


Figure 5.2 Daily Naturalized, Regulated and Unappropriated Flow at Control Point BRWA41

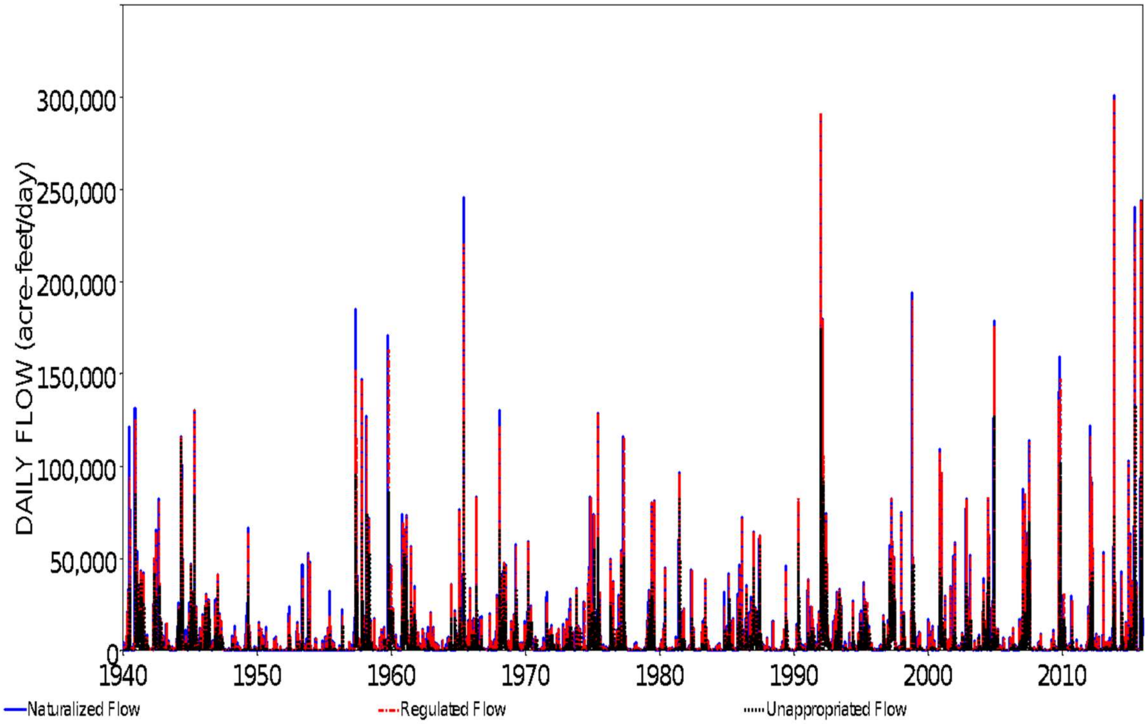


Figure 5.3 Daily Naturalized, Regulated and Unappropriated Flow at Control Point LRCA58

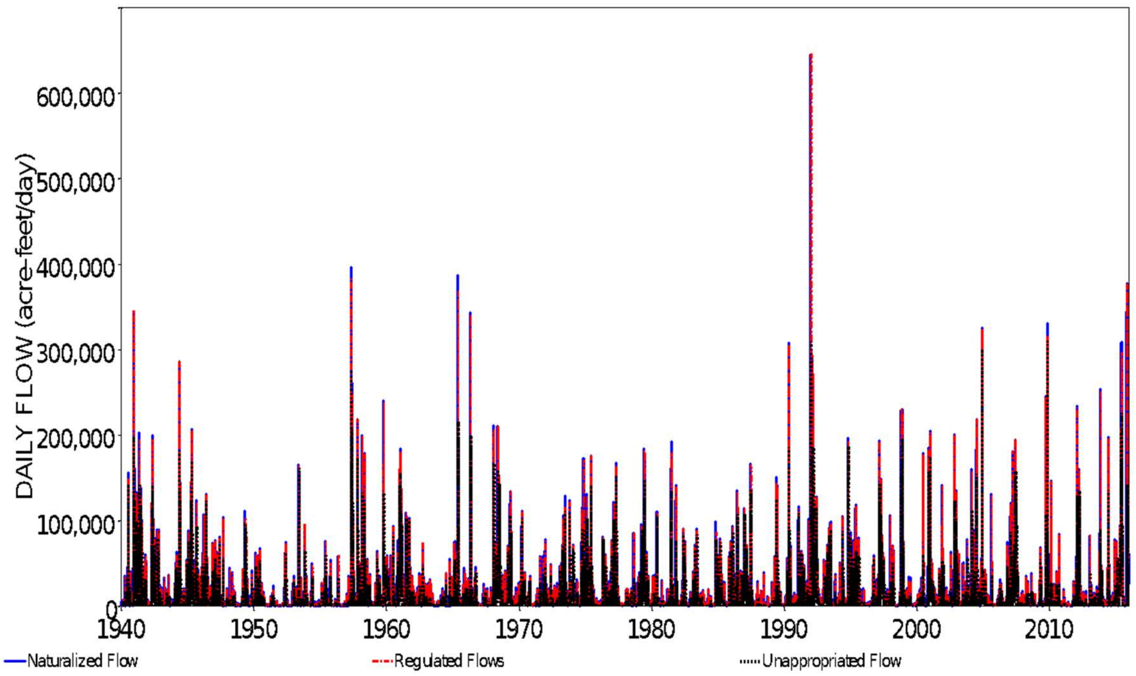


Figure 5.4 Daily Naturalized, Regulated and Unappropriated Flow at Control Point BRRI70

Table 5.6 Frequency of Naturalized and Regulated Flows in the Brazos WAM (Unit: cfs)

ID	DMAS09		SFAS06		BRSE11		CFNU16		CFFG18	
	NAT	REG	NAT	REG	NAT	REG	NAT	REG	NAT	REG
MEAN	133	123	91	86	307	298	125	98	208	178
SD	847	815	560	556	1,367	1,353	542	477	1,166	1,117
MIN	0	0	0	0	0	0	0	0	0	0
99.5%	0	0	0	0	0	0	0	0	0	0
99%	0	0	0	0	0	0	0	0	0	0
98%	0	0	0	0	0	0	0	0	0	0
95%	0	0	0	0	0	0	0	0	0	0
90%	0	0	0	0	1	1	0	0	0	0
85%	0	0	0	0	4	3	0	0	0	0
80%	0	0	0	0	8	7	3	1	0	0
75%	1	1	1	0	12	11	5	3	2	0
70%	2	1	1	1	17	16	8	4	5	0
60%	5	4	3	2	29	27	13	8	11	4
50%	10	10	6	5	45	43	21	13	20	12
40%	20	18	11	9	70	67	31	20	34	22
30%	34	31	19	16	116	110	46	31	59	40
25%	46	43	28	23	152	144	57	40	80	54
20%	68	62	42	35	214	201	75	54	113	79
15%	107	96	68	58	321	300	110	80	165	124
10%	194	173	124	109	558	522	192	146	285	222
5%	489	448	311	284	1,202	1,152	462	358	744	609
2%	1,196	1,099	785	763	2,720	2,673	1,204	927	2,081	1,783
1%	2,230	2,024	1,588	1,570	4,694	4,575	2,237	1,788	3,882	3,508
0.5%	3,915	3,571	3,036	2,926	7,855	7,695	3,606	3,051	6,584	6,019
MAX	55,594	55,594	23,299	23,295	46,799	46,750	19,355	19,287	81,030	81,018

Table 5.6 Continued

ID	BRSB23		BRPP27		BRGR30		NBCL36		LEGT47	
	NAT	REG	NAT	REG	NAT	REG	NAT	REG	NAT	REG
MEAN	789	715	1,083	917	1,515	1,312	237	232	366	347
SD	2,969	2,831	3,862	3,739	4,800	4,693	1,297	1,294	1,390	1,368
MIN	0	0	0	0	0	0	0	0	0	0
99.5%	0	0	0	0	0	0	0	0	0	0
99%	0	0	0	0	0	0	0	0	0	0
98%	0	0	0	0	0	0	0	0	0	0
95%	1	0	0	0	15	0	0	0	0	0
90%	6	0	10	0	40	0	0	0	0	0
85%	15	5	24	0	65	0	2	1	1	0
80%	26	13	37	0	93	0	4	2	4	2
75%	37	26	51	0	119	6	7	5	8	5
70%	49	37	71	0	149	22	9	7	14	10
60%	78	63	118	2	221	75	16	13	30	22
50%	117	98	188	56	321	152	25	21	56	45
40%	181	150	307	146	475	277	43	37	96	79
30%	305	254	534	335	730	501	79	71	168	147
25%	406	339	706	487	949	680	112	104	222	198
20%	565	473	951	701	1,298	991	158	151	307	279
15%	843	724	1,385	1,069	1,930	1,550	240	231	463	427
10%	1,441	1,226	2,138	1,759	3,031	2,660	384	376	740	696
5%	3,021	2,753	3,798	3,420	6,303	5,736	814	794	1,472	1,411
2%	8,048	7,512	10,585	9,844	14,025	13,397	1,974	1,962	3,479	3,376
1%	13,879	13,084	18,380	17,627	22,724	21,980	4,134	4,102	5,577	5,410
0.5%	20,840	19,881	26,620	25,995	33,208	32,604	6,928	6,928	8,111	7,926
MAX	93,060	93,058	133,271	131,984	140,192	138,305	92,318	92,315	47,666	47,665

ID	LAKE50		LRLR53		LRCA58		NAEA66		BRHE68	
	NAT	REG	NAT	REG	NAT	REG	NAT	REG	NAT	REG
MEAN	164	164	1,177	1,099	1,920	1,797	440	399	7,436	6,713
SD	716	715	3,312	3,229	5,280	5,103	1,642	1,615	14,626	13,817
MIN	0	0	0	0	0	0	0	0	2	0
99.5%	0	0	0	0	0	0	0	0	113	0
99%	1	1	2	0	2	0	0	0	150	0
98%	2	2	5	0	6	0	0	0	205	0
95%	4	4	11	1	20	5	0	0	319	144
90%	8	7	28	9	45	23	2	0	482	287
85%	10	10	44	21	78	47	3	0	655	434
80%	12	12	62	35	117	76	5	0	830	575
75%	15	14	88	50	162	107	8	0	1,032	747
70%	17	17	114	68	205	143	11	1	1,247	922
60%	23	23	182	118	314	234	20	4	1,752	1,355
50%	31	31	285	203	485	377	33	9	2,543	2,016
40%	44	43	465	369	748	619	60	26	3,829	3,154
30%	71	70	750	642	1,210	1,074	118	73	5,912	5,088
25%	99	99	971	860	1,569	1,414	174	120	7,469	6,626
20%	141	141	1,276	1,168	2,103	1,941	274	200	9,620	8,758
15%	210	209	1,779	1,676	2,890	2,728	474	374	13,003	11,919
10%	341	340	2,651	2,532	4,414	4,219	926	789	18,711	17,323
5%	657	656	4,905	4,783	8,022	7,733	2,153	1,998	30,569	28,700
2%	1,264	1,262	9,771	9,649	15,486	14,919	4,634	4,485	51,229	48,180
1%	2,110	2,108	14,475	14,202	23,354	22,607	7,497	7,413	69,297	64,686
0.5%	3,391	3,388	19,508	19,451	32,749	32,361	10,511	10,414	87,846	83,560
MAX	42,495	42,447	107,250	102,553	151,782	150,801	68,657	68,440	383,117	382,958

Table 5.6 Continued

ID	BRRI70		BRRO72		BRWA41		LEHM46		LEBE49	
	NAT	REG	NAT	REG	NAT	REG	NAT	REG	NAT	REG
MEAN	8,199	7,479	8,557	7,838	2,630	2,126	230	210	722	665
SD	14,937	14,417	14,514	14,030	6,615	5,971	932	893	2,157	2,117
MIN	0	0	0	0	0	0	0	0	0	0
99.5%	0	0	135	0	0	0	0	0	0	0
99%	149	0	228	0	9	0	0	0	0	0
98%	244	0	313	0	23	0	0	0	0	0
95%	397	23	477	178	58	0	0	0	0	0
90%	588	289	712	416	104	2	0	0	0	0
85%	797	469	926	629	150	34	2	1	4	0
80%	995	656	1,166	822	199	69	4	3	11	0
75%	1,213	841	1,423	1,043	254	107	6	5	23	0
70%	1,461	1,062	1,695	1,298	318	150	9	7	37	4
60%	2,102	1,613	2,348	1,861	478	258	18	13	71	27
50%	3,037	2,445	3,292	2,693	712	421	32	24	125	72
40%	4,511	3,790	4,828	4,127	1,057	680	53	41	238	164
30%	6,834	6,022	7,283	6,417	1,648	1,134	93	76	426	347
25%	8,558	7,682	9,038	8,145	2,110	1,510	126	107	586	498
20%	10,808	9,895	11,540	10,571	2,769	2,091	177	152	784	699
15%	14,458	13,449	15,185	14,169	3,892	3,018	269	236	1,176	1,086
10%	20,625	19,351	21,138	19,909	6,046	4,955	452	408	1,832	1,719
5%	32,937	31,447	34,839	33,320	11,250	9,583	882	812	3,363	3,221
2%	55,428	53,388	57,906	56,521	22,142	19,621	2,146	2,010	5,687	5,564
1%	73,622	70,835	73,865	71,312	32,189	29,604	3,684	3,462	8,595	8,390
0.5%	93,007	89,516	90,029	87,306	43,993	39,483	5,719	5,452	12,199	11,820
MAX	325,188	325,384	194,122	193,994	210,539	210,210	31,375	31,150	100,188	96,924

ID	BRHB42		BRBR59		YCSO62		DCLY63		NABR67	
	NAT	REG	NAT	REG	NAT	REG	NAT	REG	NAT	REG
MEAN	3,145	2,633	5,569	4,941	324	270	66	66	611	562
SD	7,403	6,767	12,540	11,829	1,226	1,100	249	249	1,944	1,907
MIN	0	0	0	0	0	0	0	0	0	0
99.5%	26	0	48	0	0	0	0	0	0	0
99%	38	0	87	0	0	0	0	0	0	0
98%	58	0	119	0	0	0	0	0	0	0
95%	102	0	200	68	0	0	0	0	0	0
90%	158	47	313	165	0	0	0	0	3	0
85%	216	91	425	255	0	0	0	0	6	0
80%	280	137	539	350	0	0	0	0	10	0
75%	352	190	667	452	2	0	0	0	15	2
70%	428	249	815	565	4	0	1	1	23	5
60%	617	393	1,179	862	13	0	2	2	41	17
50%	892	604	1,716	1,284	28	0	4	4	71	37
40%	1,328	925	2,525	1,966	51	9	9	8	123	80
30%	2,062	1,543	3,867	3,156	102	49	19	18	225	172
25%	2,644	2,044	4,886	4,146	149	89	28	28	326	258
20%	3,468	2,742	6,383	5,527	229	161	45	45	517	427
15%	4,813	3,977	8,765	7,752	402	297	75	74	852	743
10%	7,408	6,238	13,258	11,967	714	601	137	136	1,504	1,361
5%	13,252	11,902	23,764	22,142	1,551	1,393	323	323	2,996	2,872
2%	26,253	23,454	44,074	41,202	3,256	2,836	696	695	5,882	5,702
1%	37,608	34,884	59,484	56,240	5,041	4,687	1,106	1,102	8,703	8,581
0.5%	48,910	45,074	79,789	75,707	7,556	6,748	1,555	1,555	12,180	11,967
MAX	214,417	214,120	362,504	360,793	50,829	50,811	8,098	8,097	60,646	60,604

5.3.2. Daily Simulation Results for the Trinity River Basin

The daily time step Trinity WAM simulation results examine several aspects of the daily simulation model and provide a comparison with simulation storages and flow frequencies. Figures 5.5-5.8 display the daily naturalized flows (blue solid lines), regulated flows (red dashed lines), and unappropriated flows (black dotted lines) at each control point to which SB3 has been applied in the Trinity WAM. Daily simulated flows are plotted to illustrate the differences between actual physical streamflow at a control point location before and after accounting for all water rights. Frequency metrics for the daily naturalized and regulated flows in Trinity River at the four control points where the SB3 has been applied are listed in Table 5.7.

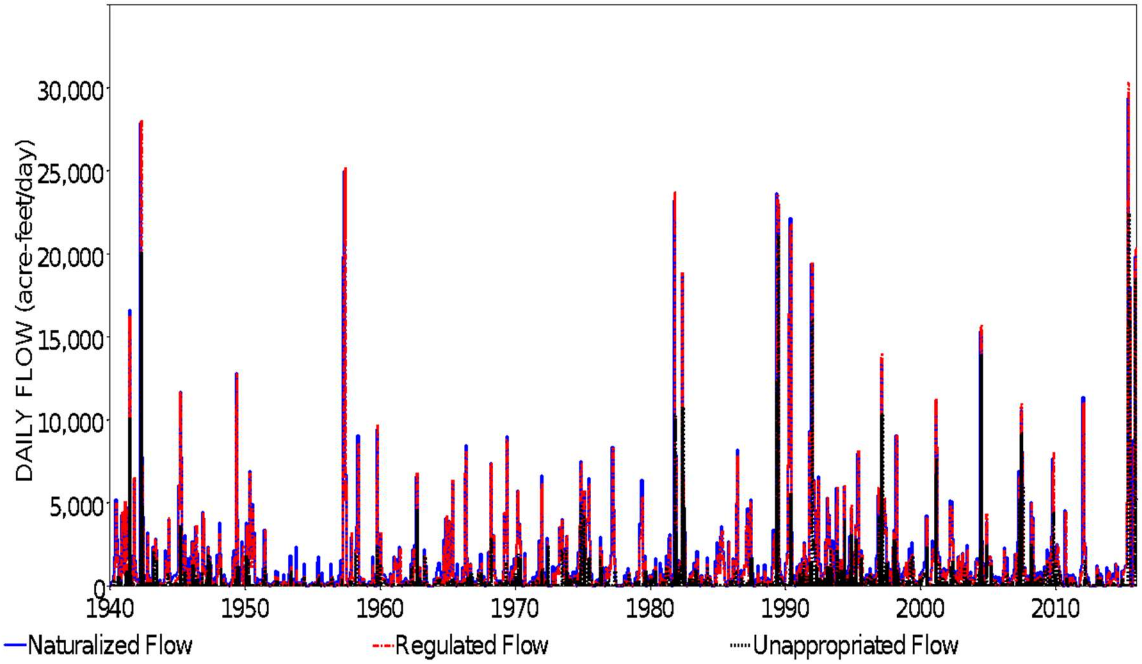


Figure 5.5 Daily Naturalized, Regulated and Unappropriated Flow at Control Point 8WTGP

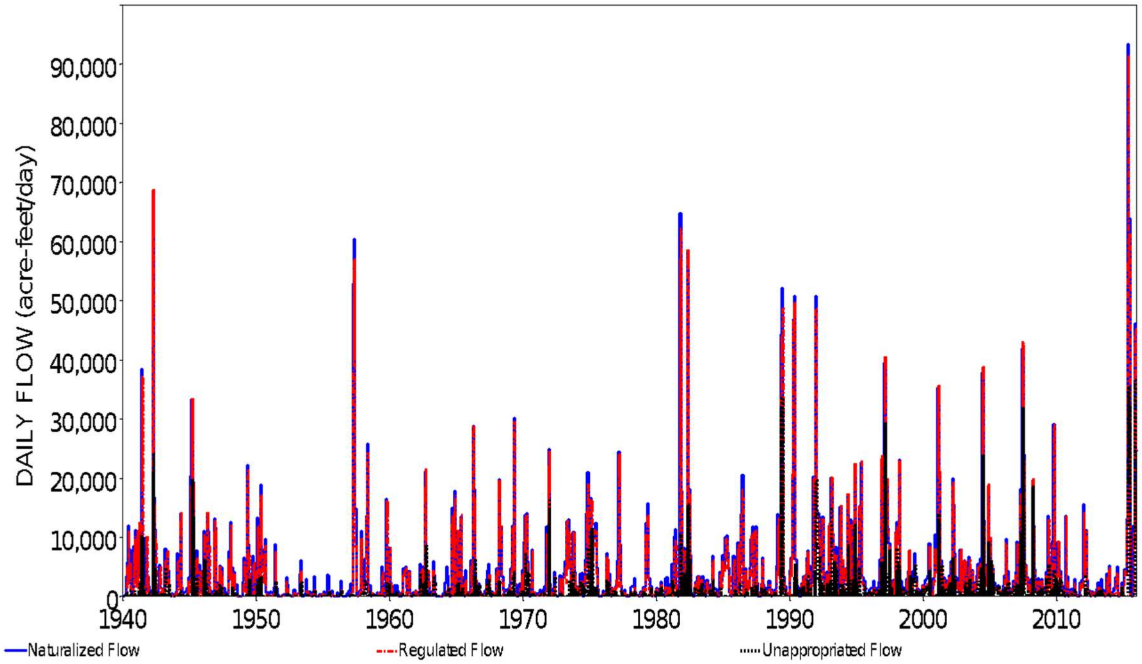


Figure 5.6 Daily Naturalized, Regulated and Unappropriated Flow at Control Point 8TRDA

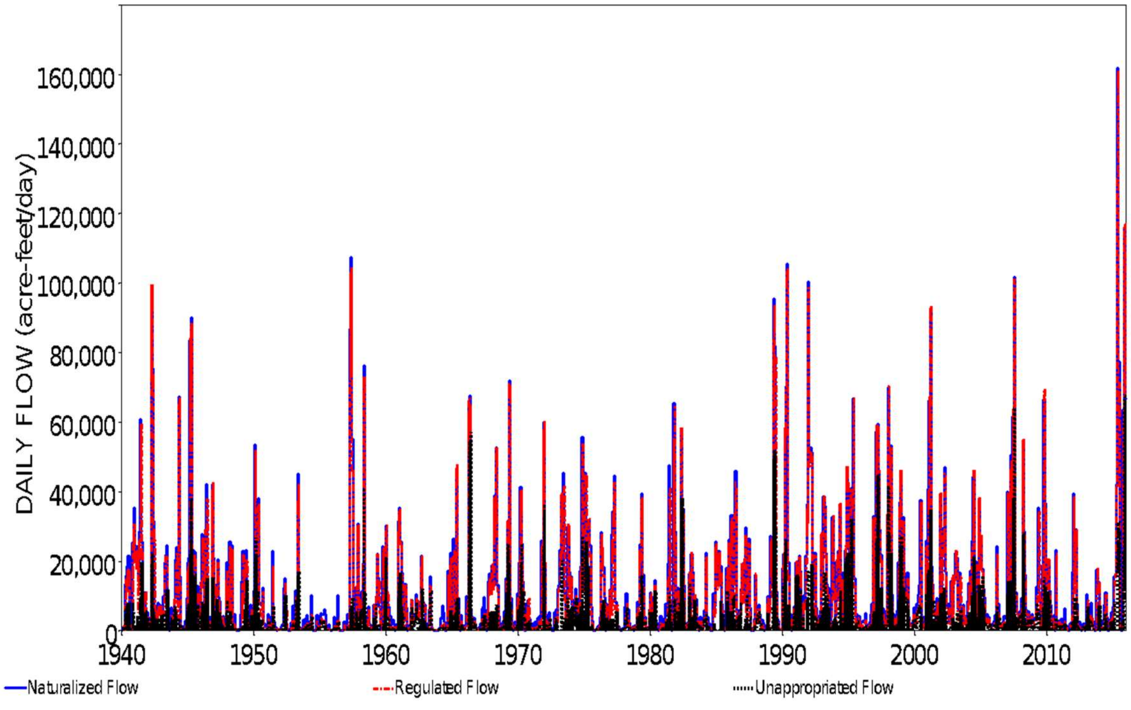


Figure 5.7 Daily Naturalized, Regulated and Unappropriated Flow at Control Point 8TROA

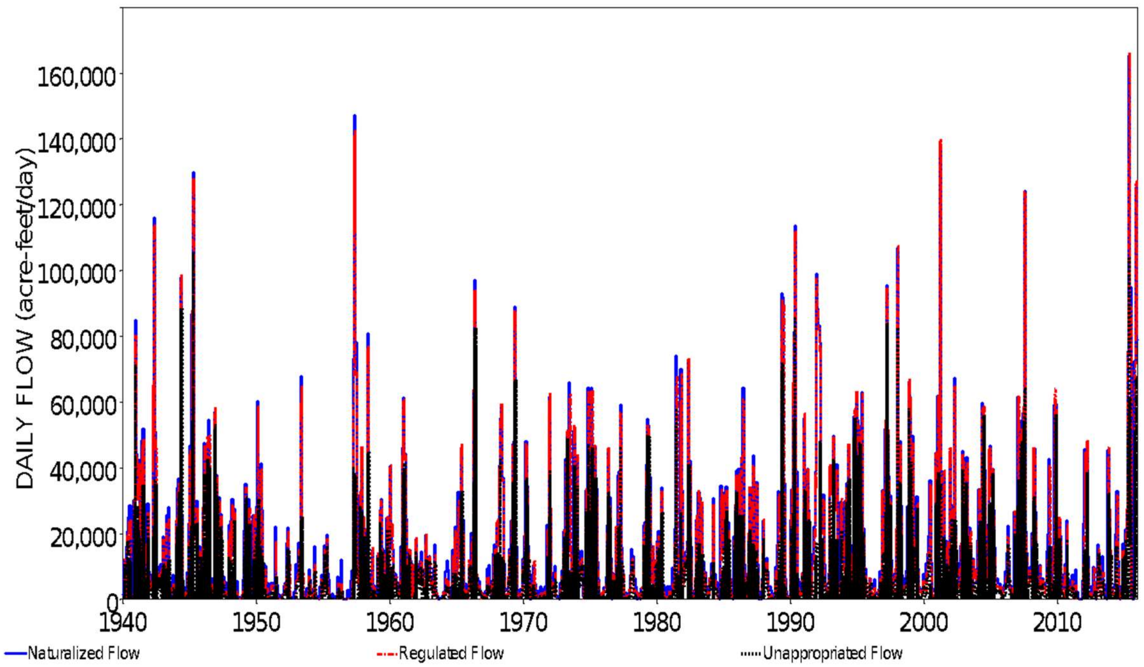


Figure 5.8 Daily Naturalized, Regulated and Unappropriated Flow at Control Point 8TRRO

Table 5.7 Frequency of Naturalized and Regulated Flows in the Trinity WAM (Unit: cfs)

ID	8WTGP		8TRDA		8TROA		8TRRO	
	NAT	REG	NAT	REG	NAT	REG	NAT	REG
MEAN	849.16	715.6	2,411.70	1,981.13	6,277.98	5,452.54	9,109.07	8,178.62
SD	161,4.7	155,6.44	4,390.61	4,046.83	9,035.99	8,690.19	11,132.84	10,905.42
MIN	0	0	0	0	0	0	0	0
99.5%	0	0	0	0	0	0	0	0
99%	0	0	0	0	0	0	0	0
98%	0	0	0	0	0	0	84.38	0
95%	0	0	0	0	43.20	0	270.93	0
90%	18.45	0	59.67	0	288.03	104.69	586.46	58.28
85%	57.15	9.76	135.76	22.33	468.36	200.63	916.46	285.26
80%	91.91	21.06	219.23	53.93	727.32	313.49	1,401.06	671.28
75%	122.75	35.86	305.49	85.65	953.54	454.98	1,805.70	1,024.22
70%	150.44	49.11	393.05	140.87	1,259.41	643.24	2,275.99	1,410.19
60%	238.61	106.58	607.26	296.84	1,929.66	1,075.90	3,324.12	2,305.61
50%	340.96	192.06	903.53	489.88	2,897.09	1,784.61	4,755.43	3,744.89
40%	473.5	314.41	1,412.35	880.67	4,083.31	2,991.23	7,162.16	5,890.76
30%	685.88	497.62	2,074.48	1,516.49	6,394.85	5,363.28	10,548.31	9,269.97
25%	849.52	630.9	2,497.54	1,925.07	8,058.81	6,993.24	12,264.04	11,620.37
20%	105,9.74	851.61	3,209.90	2,566.90	9,931.15	9,015.22	15,230.98	14,134.81
15%	145,8.7	125,0.35	4,498.17	3,819.62	12,049.64	10,961.73	19,017.87	17,649.89
10%	202,3.59	184,9.43	6,012.64	5,551.32	16,472.28	15,337.01	23,234.18	22,457.12
5%	334,1.19	322,0.32	9,484.68	8,647.97	23,994.11	23,103.04	31,117.05	30,250.00
2%	571,6.72	552,1.25	16,812.93	14,844.12	35,228.50	34,348.84	43,768.23	41,714.89
1%	976,6.77	948,4.62	25,588.55	23,398.10	45,842.29	43,440.47	51,530.46	49,792.77
0.5%	117,08.39	115,37.47	30,480.24	27570.95	51,244.57	50299.35	63,143.95	62504.96
MAX	148,06.32	152,77.22	47,074.20	46051.32	81,553.65	81356.9	83,300.30	83588.48

According to Figures 5.5-5.8, flows are extremely variable, including extremely high flows in 1957 and 2015, and low flows in 1950-1957 and 2010-2014. It is expected that, during the 1950’s-1980’s, high flows in the Trinity River Basin decreased, whereas, low flows increased since the 1970’s due to construction of eight major USACE flood-control reservoirs. Figures 5.5-5.8 show that the regulated flow rates at four control points in the Trinity WAM are significantly smaller than the naturalized flows. Meanwhile, the Romayor gauge reports the highest average unappropriated flow in the daily simulation versus the other three gauges.

Table 5.7 provides concise statistical comparisons of regulated flows for the WAM current use scenario with naturalized flows. For the Trinity River at Romayor (8TRRO), the means of the WAM naturalized flows and regulated flows are 9,109.07cfs and 8,178.62 cfs, respectively. This mean regulated flow is 89.8 percent of the mean naturalized flow. Thus, water rights modeled by SIMD results in reductions in river flows.

6. MODELING SB3 ENVIRONMENTAL FLOW STANDARDS

6.1. Setting Environmental Instream Flow Standards

Both SIM and SIMD can be employed to set instream flow (IF) targets at a control point location as a target minimum regulated flow rate for a particular month of a SIM monthly simulation or day of a SIMD daily simulation. At each water right, water allocation routines are simulated based on user-assigned priority sequence. By establishing an instream flow target, upstream junior WR record water rights are curtailed as necessary to maintain downstream regulated flows equal to or greater than senior instream flow targets. The original approach for setting instream flow rights is to allocate annual targets for the 12 months of the year in proportion to the number of days in each month based on the NDAYS option specified in the IF record field 4. Likewise, monthly targets are uniformly distributed to become daily targets. Alternatively, these instream flow targets could also be modeled with ES records using −9 in IF record field 3, which activates the hydrologic condition (HC), environmental standard (ES), pulse flow (PF), and pulse flow options (PO) records. When employed, the targets have the same results, regardless of the alternative strategies used to determine results in the same manner. Otherwise, SIM and SIMD also have capabilities for computing IF and WR records and adjusting them with optional features such as UC, TO, SO, TS, WS, BU, PX, DI, IP, IS, IM, CV, and TS records.

6.2. SB3 Environmental Flow Standards

Details of Senate Bill 3 (SB3) environmental flow standards (EFS) for each river basin have been discussed in Chapter 3. Summary information regarding these EFS are in

Table 6.1. Seasons and priority dates are listed respectively in columns 2 and 3 of Table 6.1. The number of stations with flow standards and hydrologic conditions are tabulated in columns 4 and 5. Information regarding SB3 EFS for seven groups of river systems can be found at the following TCEQ website:

https://www.tceq.texas.gov/permitting/water_rights/wr_technical-resources/eflows

Table 6.1. Contact Information for SB3 Environmental Flow Standards

River System	Seasons				Priority Date	Number Gauges	Hydrologic Conditions (Number)
	Winter	Spring	Summer	Fall			
Sabine & Neches	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Apr 2011	10	none
Trinity & San Jacinto	Dec-Feb	Mar-May	Jun-Aug	Sep-Nov	Apr 2011	6	none
Brazos	Nov-Feb	Mar-Jun	Jul-Oct	none	Mar 2012	19	Palmer HDI (3)
Colorado & Lavaca	Nov-Feb Dec-Feb	Mar-Jun Mar-Jun	Jul-Aug Jul-Aug	Sep-Nov Sep-Nov	Aug 2012	22	12-Month flow (4) Reservoir storage (3)
GSA	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Aug 2012	17	12-month flow (3)
Nueces	Dec-Mar	Apr-Jun	Jul-Aug	Sep-Oct	Feb 2014	19	none

In general, components can vary between river systems and between sites in the same system. The priority dates presented in Table 6.1 are based on the date that the appointed expert science and stakeholder committees submitted recommendations to the TCEQ. Standards for the Brazos River system have three seasons, while the other five river systems have four seasons per year. The SB3 environmental flow standards for the Brazos, Colorado, and GSA river systems are applied by three hydrologic conditions (dry, average, wet), while the other three river systems do not consider hydrologic conditions. Dry, average, and wet hydrologic conditions for the GSA and part of the Colorado River Basin are defined based on the cumulative river flow over the 12 months preceding the beginning of the current season. The combined storage content of specified major reservoirs is used to define hydrologic conditions for the other regions of the Colorado

River Basin SB3 environmental flow standards. The standards for the Brazos River Basin have been determined by regional values of the Palmer hydrological drought index (PHDI). The PHDI for each of the 10 climatic zones in Texas for the period of record from 1895 through 2017 were downloaded from the National Weather Service ftp site. The weighted average PHDI time series at the 19 Brazos WAM gauges were computed via the factors recommended in the Brazos BBEST report. The 25th and 75th percentiles of the PHDI time series at the 19 gauges were represented by the BBEST definition of hydrologic conditions, as shown in Table 6.2. For example, when the data is less than or equal to the 25th percentile then it represents the DRY hydrologic condition. Data greater than or equal to the 75th percentile indicates the WET hydrologic condition, while the data between the 25th and 75th percentile indicates the AVERAGE hydrologic condition. The hydrologic index HI records for the 19 gauges are stored in the input DSS HIS file for the Brazos WAM. The remainder of this chapter describes the incorporation of SB3 instream flow standards at control points via SIM and SIMD simulation. The updated Trinity WAM and Brazos WAM represent the inaugural use of the new environmental flow standards option for setting and modeling environmental instream flow standards.

Table 6.2. Hydrologic Conditions Defined by PHDI Ranges

WAM ID	Stream Gauge Name	USGS gauge no	25% tile	75%tile
DMAS09	Double Mountain Fork Aspermont	8080500	-1.917	2.211
SFAS06	Salt Fork Brazos River Aspermon	8082000	-1.88	2.19
BRSE11	Brazos River Seymour	8082500	-1.903	2.205
CFNU16	Clear Fork Brazos Nugent	8084000	-1.929	2.252
CFFG18	Clear Fork Brazos Fort Griffin	8085500	-1.835	2.214
BRSB23	Brazos River South Bend	8088000	-1.786	2.186
BRPP27	Brazos River Palo Pinto	8089000	-1.776	2.187
BRGR30	Brazos River Glen Rose	8091000	-1.791	2.204
NBCL36	North Bosque River Clifton	8095000	-1.953	2.39
BRWA41	Brazos River Waco	8096500	-1.83	2.222
LEGT47	Leon River Gatesville	8100500	-1.953	2.39
LAKE50	Lampasas River Kempner	8103800	-1.777	2.23
LRLR53	Little River Little River	8104500	-1.839	2.3
LRCA58	Little River Cameron	8106500	-1.847	2.313
BRBR59	Brazos River Bryan	8109000	-1.826	2.242
NAEA66	Navasota River Easterly	8110500	-1.837	2.197
BRHE68	Brazos River Hempstead	8111500	-1.751	2.16
BRRI70	Brazos River Richmond	8114000	-1.743	2.138
BRRO72	Brazos River Rosharon	8116650	-1.734	2.128

6.3. Modeling SB3 Environmental Flow Standards

In an earlier study, Wurbs and Hoffpauir preliminarily applied PF and PO records to describe the subsistence and base flow components by combinations of multiple water right (WR), target options (TO), flow switch (FS), daily water rights (DW), daily options (DO) records. As previously noted, environmental flow standards can be modeled via IF, HC, HI, ES, and PF (only for a daily SIMD simulation) records in the 2018 version of SIM/SIMD. The HC and ES records and associated computational routines were added to SIM and SIMD during 2018. This new method adopted for all EFS control points can be further refined beyond the previous method. Although alternate modeling methodologies were used based on control point location in this research, basic modeling consists of:

- Development of input data for modeling the environmental flow standards.
  - ➢ Instream Flow (IF) record water rights are set to the SIM/SIMD Input DAT File.
  - ➢ The HC and HI Records are used to develop seasonal hydrologic conditions.

  - Daily subsistence and base flow targets are set by ES records.
  - Daily High Pulse Flow requirements are defined by PF/PO records.
- Modeling the EFS in either a SIM monthly simulation or SIMD daily simulation.
  - The final target and shortages at a control point are determined based on the flow regime classification determination, and hydrologic conditions are computed for each month of a monthly SIM simulation or each day of a daily SIMD simulation.
- Post-Simulation analyses of simulation results
  - Program TABLES, with sets of TIN input file, reads the SIM or SIMD, or .OUT or .SUB files to perform an assortment of statistical frequency and reliability frequency metrics for monthly or daily environmental flow targets and shortages.
  - HEC-DSSVue could also be used to create a variety of tables to summarize and prepare plots for displaying environmental flow simulation results.

The input records used for modeling the environmental flow standards for control point BRHE68 (in the Brazos River Basin) and 8TRRO (in the Trinity River Basin) are described to illustrate WRAP modeling capabilities using realistic datasets. The DAT file input records developed for the EFS flow requirement are provided in Table 6.3.

Table 6.3 Input DAT File Records Used to Model Environmental Flow Standards

```
**** Set Environmental Flow Requirements
**     !       !       !       !       !       !       !       !       !
IFBRHE68   -9.            201203
**
HC         1  HI   0  M   J   N      0.0     1.5     2.5     -9.
**
ES SF501    510.    510.    510.    510.    510.    510.    510.    510.
510.    510.    510.    510.
ES BASE1    920.    920.   1130.   1130.   1130.   1130.    950.    950.
950.    950.    920.    920.
ES BASE2   1440.   1440.   1900.   1900.   1900.   1900.   1330.   1330.
1330.   1330.   1440.   1440.
ES BASE3   2890.   2890.   3440.   3440.   3440.   3440.   2050.   2050.
2050.   2050.   2890.   2890.
**
PF   1 1    5720.  49800.  10   1   0  11   2   0   0   2   0   3
PF   1 2    5720.  49800.  10   3   0  11   2   0   0   2   0   3
PF   1 3  11200. 125000.  15   2   0  11   2   0   0   2   0   3
PF   1 1    8530.  85000.  13   1   0   3   6   0   0   2   0   3
PF   1 2    8530.  85000.  13   3   0   3   6   0   0   2   0   3
PF   1 3  16800. 219000.  19   2   0   3   6   0   0   2   0   3
PF   1 1    2620.  17000.   7   1   0   7  10   0   0   2   0   3
PF   1 2    2620.  17000.   7   3   0   7  10   0   0   2   0   3
PF   1 3    5090.  40900.   9   2   0   7  10   0   0   2   0   3
**
****  Set Environmental Flow Requirements
**
**       1         2         3         4         5         6         7
8       9         10
**3456789012345678901234567890123456789012345678901234567890123456789012345678 9
0123456789012345678901234
**     !       !       !       !       !       !       !       !       !
IF 8TRRO     -99          200912
**
ES SUBS     495.    495.    700.    700.    700.    200.    200.    200.
230.    230.    230.    495.
ES BASE     875.    875.   1150.   1150.   1150.    575.    575.    575.
625.    625.    625.    875.
**
PF 0   0    8000.  80000.   7   0   0  12   2   0   0   2   0   3
PF 0   0  10000. 105000.   9   0   0   3   5   0   0   2   0   3
PF 0   0    4000.  60000.   5   0   0   6   8   0   0   2   0   3
PF 0   0    4000.  60000.   5   0   0   9  11   0   0   2   0   3
**
```

An alternative approach using HC, ES, and PF records to set monthly or daily targets can be activated by the IF records if −99 or −9 is entered in the annual amount target (AMT) in IF record field 3. In Table 6.3, a −99.0 in IF record in field 3 generates a table of ES record target results in the message MSS file. The beginning of the MSS file table for control point 8TRRO is shown in Tables 6.4 and 6.5 for monthly SIM and daily

SIMD simulations. The IF record for control points BRHE68 and 8TRRO in Table 8.4 has priorities of 201203 and 200912 consistent with the actual SB3 environmental flow standards. The HC records for hydrologic condition reference hydrologic index HI records in Table 6.3. The HC records are also applied for pulse flow PF records, containing values of either 1.0, 2.0, or 3.0, representing dry, average, and wet conditions. There are no definitions of hydrologic conditions for the the Trinity River Basin. Thus, no HC/HI records are shown for control point 8TRRO in Table 6.3. The purpose for the ES record here is to set the subsistence and base flow targets. The parameter ESF entered in the Environmental Standard (ES) record in Field 2 describes the different options of instream flow standards. The SF50 record in field 2, is applied for subsistence flow, employing the 50% rule, defined as if the regulated flow exceeds the subsistence flow limit but as if less than the base flow limit. The instream flow target is set equal to the subsistence flow limit plus 50 percent of the difference between the actual flow and subsistence flow limits (Wurbs, 2018). The subsistence flow target limits in cfs for each of the 12 months of the year are entered in fields 4 through 15. A separate base flow BASE record provides for base flow instream flow target limits. The basic high pulse flow target limits are described by PF records. The values entered in fields 4, 5, 6, and 7 for trigger, volume, duration, and frequency define the pulse event initiation and termination criteria.

Table 6.4 Beginning of ES Record Target Results Table from MSS File for Monthly SIM

```
Environmental  Flow  Standard  Targets  in  cfs  and  acre-feet  (af)  for  Selected  Hydrologic
Condition  (HC)  Subsistence Flow  (SF),  Base Flow  (BF),  and High Flow  (HF)  ESQ Limits  from
ES Records
WRID               Year  M      XRF(af)        HCV  HC    SF(cfs)  BF(cfs)  HF(cfs)    SF(af)
BF(af)    HF(af)   AMT(af)
8TRRO              1940  1      46303.8        0.0  0     495.0    875.0     -9.0   30436.4
53801.7       0.0   30436.4
8TRRO              1940  2     340287.8        0.0  0     495.0    875.1     -9.0   28472.7
50336.3       0.0   50336.3
8TRRO              1940  3      47016.8        0.0  0     700.0    150.1     -9.0   43041.3
9229.3       0.0   43041.3
8TRRO              1940  4     479715.8        0.0  0     700.0    150.1     -9.0   41652.9
8931.6       0.0   41652.9
8TRRO              1940  5     641129.8        0.0  0     700.0    150.0     -9.0   43041.3
9223.1       0.0   43041.3
8TRRO              1940  6     750025.8        0.0  0     200.0    575.0     -9.0   11900.8
34214.9       0.0   34214.9
8TRRO              1940  7     885959.8        0.0  0     200.0    575.0     -9.0   12297.5
35355.4       0.0   35355.4
8TRRO              1940  8     104411.8        0.0  0     200.0    575.0     -9.0   12297.5
35355.4       0.0   35355.4
8TRRO              1940  9      38697.8        0.0  0     230.0    625.0     -9.0   13686.0
37190.1       0.0   37190.1
8TRRO              1940 10      22190.8        0.0  0     230.0    625.0     -9.0   14142.1
38429.8       0.0   14142.1
8TRRO              1940 11     906306.8        0.0  0     230.0    625.0     -9.0   13686.0
37190.1       0.0   37190.1
8TRRO              1940 12    2631241.8        0.0  0     495.0    875.0     -9.0   30436.4
53801.7       0.0   53801.7
```

Table 6.5 Beginning of ES Record Target Results Table from MSS File for SIMD Simulation

```
Environmental  Flow  Standard  Targets  in  cfs  and  acre-feet  (af)  for  Selected  Hydrologic
Condition (HC)
Subsistence Flow (SF), Base Flow (BF), and High Flow (HF) ESQ Limits from ES Records
WRID              Year  M  D      XRF(af)        HCV HC    SF(cfs) BF(cfs) HF(cfs)    SF(af)
BF(af)    HF(af) Target(af)
8TRRO             1940  1  1      1517.7        0.0  0     495.0   875.0    -9.0      981.8
1735.5       0.0     758.9
8TRRO             1940  1  2      1565.9        0.0  0     495.0   875.0    -9.0      981.8
1735.5       0.0     783.0
8TRRO             1940  1  3      1614.1        0.0  0     495.0   875.0    -9.0      981.8
1735.5       0.0     807.1
8TRRO             1940  1  4      1662.3        0.0  0     495.0   875.0    -9.0      981.8
1735.5       0.0     831.1
8TRRO             1940  1  5      1710.5        0.0  0     495.0   875.0    -9.0      981.8
1735.5       0.0     855.2
8TRRO             1940  1  6      1758.6        0.0  0     495.0   875.0    -9.0      981.8
1735.5       0.0    1735.5
8TRRO             1940  1  7      1806.8        0.0  0     495.0   875.0    -9.0      981.8
1735.5       0.0    1735.5
8TRRO             1940  1  8      1855.0        0.0  0     495.0   875.0    -9.0      981.8
1735.5       0.0    1735.5
8TRRO             1940  1  9      1903.2        0.0  0     495.0   875.0    -9.0      981.8
1735.5       0.0    1735.5
8TRRO             1940  1 10      1951.4        0.0  0     495.0   875.0    -9.0      981.8
1735.5       0.0    1735.5
8TRRO             1940  1 11      1999.6        0.0  0     495.0   875.0    -9.0      981.8
1735.5       0.0    1735.5
8TRRO             1940  1 12      2047.7        0.0  0     495.0   875.0    -9.0      981.8
1735.5       0.0    1735.5
8TRRO             1940  1 13      2095.9        0.0  0     495.0   875.0    -9.0      981.8
1735.5       0.0    1735.5
8TRRO             1940  1 14      2144.1        0.0  0     495.0   875.0    -9.0      981.8
1735.5       0.0    1735.5
```

Table 6.5 Continued

```
8TRRO            1940  1 15      2192.3       0.0  0    495.0   875.0    -9.0     981.8
1735.5       0.0    1735.5
8TRRO            1940  1 16      2216.4       0.0  0    495.0   875.0    -9.0     981.8
1735.5       0.0    1735.5
8TRRO            1940  1 17      2095.9       0.0  0    495.0   875.0    -9.0     981.8
1735.5       0.0    1735.5
8TRRO            1940  1 18      1951.4       0.0  0    495.0   875.0    -9.0     981.8
1735.5       0.0    1735.5
8TRRO            1940  1 19      1806.8       0.0  0    495.0   875.0    -9.0     981.8
1735.5       0.0    1735.5
8TRRO            1940  1 20      1662.3       0.0  0    495.0   875.0    -9.0     981.8
1735.5       0.0     831.1
8TRRO            1940  1 21      1517.7       0.0  0    495.0   875.0    -9.0     981.8
1735.5       0.0     758.9
8TRRO            1940  1 22      1373.2       0.0  0    495.0   875.0    -9.0     981.8
1735.5       0.0     686.6
8TRRO            1940  1 23      1228.6       0.0  0    495.0   875.0    -9.0     981.8
1735.5       0.0     614.3
8TRRO            1940  1 24      1084.1       0.0  0    495.0   875.0    -9.0     981.8
1735.5       0.0     542.0
8TRRO            1940  1 25       939.6       0.0  0    495.0   875.0    -9.0     981.8
1735.5       0.0     469.8
8TRRO            1940  1 26       795.0       0.0  0    495.0   875.0    -9.0     981.8
1735.5       0.0     397.5
8TRRO            1940  1 27       650.5       0.0  0    495.0   875.0    -9.0     981.8
1735.5       0.0     325.2
8TRRO            1940  1 28       505.9       0.0  0    495.0   875.0    -9.0     981.8
1735.5       0.0     253.0
8TRRO            1940  1 29       361.4       0.0  0    495.0   875.0    -9.0     981.8
1735.5       0.0     180.7
8TRRO            1940  1 30       216.8       0.0  0    495.0   875.0    -9.0     981.8
1735.5       0.0     108.4
8TRRO            1940  1 31        72.3       0.0  0    495.0   875.0    -9.0     981.8
1735.5       0.0      36.1
```

As seen in Tables 6.4 and 6.5, regulated flow (XRF) in acre-feet with control point identifier 8TRRO, comes from priority-sequence simulation computations. Hydrologic condition variable (HCV), hydrologic condition (HC), subsistence (SF), and base (BF) flows are also presented in Tables 6.4 and 6.5. High Flow (HF) pulse targets are determined only by a daily SIMD simulation. The final selected instream flow target for the month or day are created in the last column of SMM file in acre-feet.

Determination of the final daily instream flow target for monthly SIM and pulse flow target for daily SIMD simulations are outlined as follows:

1. If the simulated regulated flow at the control point is less than or equal to the subsistence flow limit, the minimum flow limit target is set equal to the

subsistence flow limit. Ones greater than subsistence flow but less than the base flow limit are also set equal to the subsistence flow, unless SF50 is entered.

2. If the regulated flow exceeds the base flow limit but is less than the high pulse flow limit, the minimum instream flow limit is set equal to the base flow limit.
3. If the regulated flow is equal to or exceeds the high pulse flow limit, the final instream flow target for SIMD simulation is set at the maximum target of the high flow (ES record) or pulse flow (PF record) limit.

The shortages demonstrate that, during those simulated periods, regulated flows fail to reach goals. Values of shortages are computed as the difference between the targeted minimum flow limits and regulated streamflow. If the current-day regulated flow is less than instream flow targets, the shortages will equal instream flow targets, minus the regulated streamflow. Otherwise the shortages are 0.0.

A monthly SIM simulation was performed with the set of IF, HC, ES, and TS records incorporated in the DAT file to control computation for the environmental standard at the 19 WAM control points. The TS records in the monthly SIM DAT file are shown in Table 6.6. These records were aggregated to monthly quantities in acre-feet/month from daily simulation by reference to the DSS output file.

Table 6.6 Instream Flow Rights that Model the EFS in the Monthly Brazos WAM DAT File

```
IFSFAS06                20120301                EFS-SFAS06
TS      DSS
IFDMAS09                20120301                EFS-DMAS09
TS      DSS
IFBRSE11                20120301                EFS-BRSE11
TS      DSS
IFCFNU16                20120301                EFS-CFNU16
TS      DSS
IFCFFG18                20120301                EFS-CFFG18
TS      DSS
```

Environmental instream flow simulation results are organized in various formats via HEC-DSSVue and WRAP program TABLES. The TABLES time series 2FRE and

6FRE are set in the TIN file to deal with the monthly simulation results record and develop the probability statistics of daily versions. The DSS output file created by SIMD or SIM contains total simulation results that can be quickly selected and plotted or tabulated in numerous time series in HEC-DSSVue. HEC-DSSVue also provides flexible options for analyses, such as mathematical operations, statistical analyses, and unit conversions. The TABLES input TIN file records used to develop the statistical frequency are shown in Table 6.7.

Table 6.7 TABLES Input TIN File

```
****  Frequency tables for naturalized flows.

IDEN   SFAS06    DMAS09      BRSE11    CFNU16    CFFG18    BRSB23
BRPP27  BRGR30
6FRE   1   0  -2   2   0   1
****  Frequency tables for regulated flows.
IDEN   SFAS06    DMAS09      BRSE11    CFNU16    CFFG18    BRSB23
BRPP27  BRGR30
6FRE   2   0  -2   2   0   1
****  Frequency tables for unappropriated flows.
IDEN   SFAS06    DMAS09      BRSE11    CFNU16    CFFG18    BRSB23
BRPP27  BRGR30
6FRE   3   0  -2   2   0   1
****  Frequency tables for Instream flow target for IF record rights.
6FRE  11   0   2   2   0   1
IDEN   EFS-SFAS06    EFS-DMAS09     EFS-BRSE11      EFS-CFNU16
EFS-CFFG18
IDEN   EFS-BRRO72
****  Frequency tables for Instream flow shortage for IF record rights.
6FRE  12   0  -2   2   0   1
****  Frequency tables for IF shortage as % of target for IF record
rights.
6FRE  13   0  -1   2   0
ENDF
```

6.4. Simulation Results Analyses of the Brazos River Basin

The daily time step for Brazos WAM simulation examines several aspects of the daily simulation model and provides a comparison with the monthly simulation results. All the relevant simulation results variables recorded in the OUT, SUB, and DSS files consist of 912 months from 1940 to 2015. The discussion of the simulation results is focused on a comparison of Senate Bill 3 environmental instream flow targets, simulation storages, and flow frequencies.

6.4.1. Simulation Results Analyses between control points of the Brazos River Basin

The SB3 instream flow shortage as a percentage of the instream flow target developed by daily simulation is presented in Figure 6.1. This exceedance frequency plot is useful for making comparisons and investigating complex characteristics of the environmental flow regime. Tables 6.8 contains instream flow target and instream flow shortage frequencies at the 19 instream flow control points. However, the target and instream flow shortages in the tables are independent. For instance, values for 50% exceedance represent the flow target and do not occur on the same day as flow shortages. Frequencies are plotted in Figure 6.1 for 19 individual environmental flow regimes, based on results of the WRAP/WAM simulation, with the SB3 standards being priorities of 20120301. Instream flow shortages expressed as percentage of monthly target volume range from zero to 100%. The frequency metrics of Figure 6.1 are presented in Table 6.8. The first two statistics in Table 6.8 are the mean and standard (SD). The exceedance frequency is computed by program TABLES, based on the relative frequency formula:

[P = (m/N)100%].

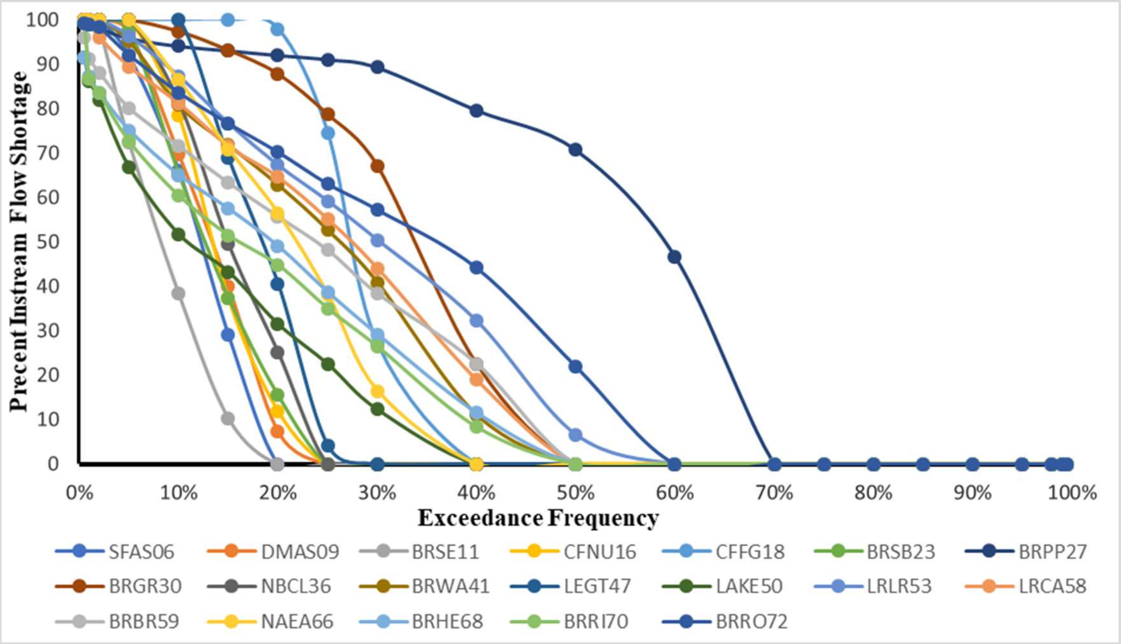


Figure 6.1 Exceedance Frequency Plot of Instream Flow Shortage as A Percentage of the Instream Flow Target for All Selected Control Points

As seen in Figure 6.1 and Table 6.8, instream flow shortages equivalent to 0 percent of the instream flow target were observed approximately 20 percent of the time at control point BRSE11, located on the Brazos River near Seymour. Control point BRSE11 represents a range of flow regimes from the upper portion of the basin. Control point BRRI70 at the Brazos River near Richmond is immediately downstream of a major reservoir. The average values of the shortage as a percentage of the instream flow target at BRRI70 is 18.1, and the instream flow target is satisfied or exceeded on 50 percent of the days in the 76 years. At least 30% of the daily instream flow targets are met without shortage at all control points. The shortages are resulted by base flow and subsistence flow requirements, except when pulse flow shortage is affected by flood control operations. The mean, standard deviation, and frequency quantities tabulated in Table 6.9 are computed for 27,760 daily volumes in the 1940-2015 period-of-analysis from Daily SIMD Simulation. Statistical frequency metrics for the 19 selected control points in cfs are presented in Table 6.9. The TABLES converts daily volumes in acre-feet to cfs and are activated by parameter CFS, which simply applyies the multiplier factor 0.50416667.

Table 6.8 Frequency Metrics for Shortage as A Percentage of the Target for Selected Control Points

	SFAS	DMAS	BRSE	CFNU	CFFG	BRSB	BRPP	BRGR	NBCL	BRWA
CP	06	09	11	16	18	23	27	30	36	41
Mean	11.8	13.3	8.7	13.9	27.5	13.1	51.9	32.4	15.5	24.8
SD	28.2	29.6	23.3	31.0	42.3	28.7	40.6	41.0	31.7	33.9
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
99.5 %	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
99%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
98%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
95%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
85%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60%	0.0	0.0	0.0	0.0	0.0	0.0	46.6	0.0	0.0	0.0
50%	0.0	0.0	0.0	0.0	0.0	0.0	70.7	0.0	0.0	0.0
40%	0.0	0.0	0.0	0.0	0.0	0.0	79.7	22.4	0.0	11.1
30%	0.0	0.0	0.0	0.0	27.1	0.0	89.3	67.1	0.0	40.9
25%	0.0	0.0	0.0	0.0	74.5	0.0	91.1	78.7	0.0	52.7
20%	0.0	7.3	0.0	12.0	97.9	15.5	92.1	87.8	25.1	62.9
15%	29.1	40.0	10.3	37.3	100.0	37.4	93.1	93.2	49.5	71.8
10%	66.1	69.7	38.3	78.5	100.0	65.3	94.1	97.4	81.5	80.8
5%	91.9	97.3	72.4	100.0	100.0	97.8	95.9	100.0	100.0	95.1
2%	100.0	100.0	98.2	100.0	100.0	100.0	98.1	100.0	100.0	99.9
1%	100.0	100.0	100.0	100.0	100.0	100.0	99.0	100.0	100.0	100.0
0.5%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Max	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 6.8 Continued

CP	LEGT47	LAKE50	LRLR53	LRCA58	BRBR59	NAEA66	BRHE68	BRRI70	BRRO72
Mean	18.0	13.7	29.4	25.4	23.1	21.0	19.8	18.1	32.0
SD	34.8	23.2	34.9	33.3	29.6	34.5	27.1	26.0	34.5
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
99.5%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
99%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
98%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
95%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
85%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50%	0.0	0.0	6.6	0.0	0.0	0.0	0.0	0.0	21.9
40%	0.0	0.0	32.2	19.0	22.6	0.0	11.5	8.3	44.1
30%	0.0	12.3	50.4	44.1	38.3	16.5	29.2	26.4	57.2
25%	4.1	22.6	59.2	55.1	48.1	38.2	38.7	35.0	63.1
20%	40.5	31.5	67.2	64.6	55.7	56.5	49.1	44.8	70.2
15%	68.8	43.3	76.7	71.5	63.3	70.9	57.5	51.5	76.7
10%	100.0	51.7	87.3	81.2	71.6	86.4	65.1	60.4	83.7
5%	100.0	66.8	96.3	89.5	80.1	100.0	75.2	72.6	92.1
2%	100.0	81.9	100.0	96.1	88.1	100.0	83.6	83.4	98.4
1%	100.0	86.2	100.0	100.0	91.3	100.0	87.3	86.9	98.9
0.50%	100.0	91.6	100.0	100.0	96.2	100.0	91.6	99.1	99.1
Max	100.0	97.6	100.0	100.0	100.0	100.0	96.0	99.9	99.7

Figures 6.2 through 6.19, plotted by the HEC-DSSVue, present annual instream flow targets in addition to instream shortages in acre-feet/year. The annual volumes of the instream flow targets and shortages are summed by daily volumes for 19 control points. Environmental flow targets are shown as thick solid red lines, and the corresponding shortages are plotted as thick dashed blue lines. These plots illustrate the variability characteristics of instream flow targets in the Brazos Basin, the values of the monthly targets given in Appendix E. As expected, the environmental flow shortages are smaller than the environmental flow targets. Targets compared here are total targets, including subsistence, base, and pulse flows. Pulse flow requirement shortages are influenced by upstream flood control storage operations and reflected by maximum values of shortage.

For example, increased reservoir releases could benefit increase regulated flow and meet downstream system requirements.

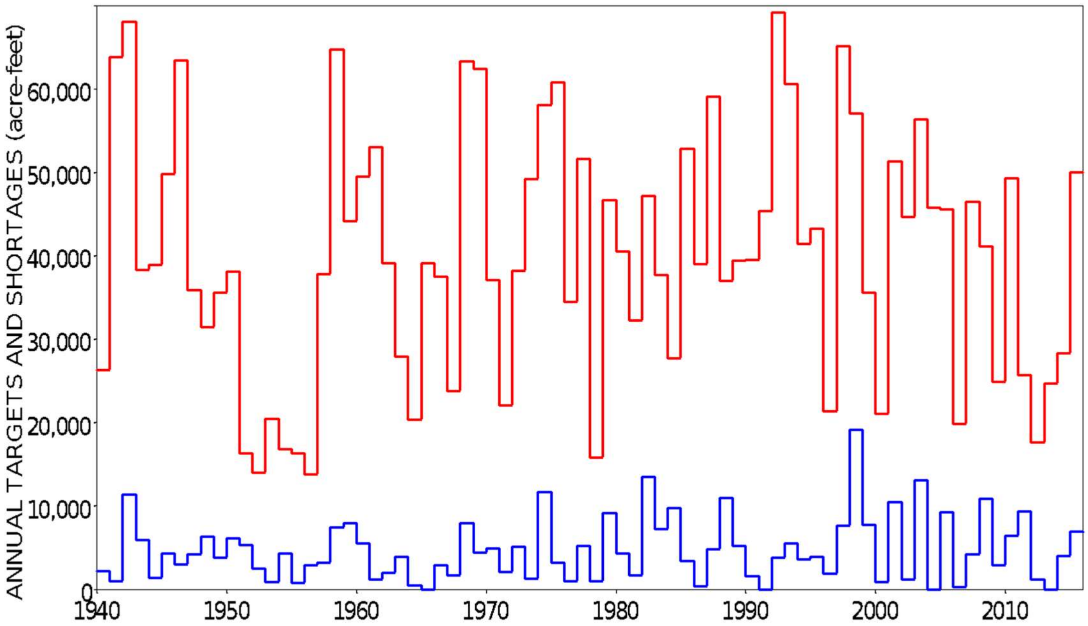


Figure 6.2 Annual Target and Shortage Volume in Acre-Feet/Year for Control Point BRBR59

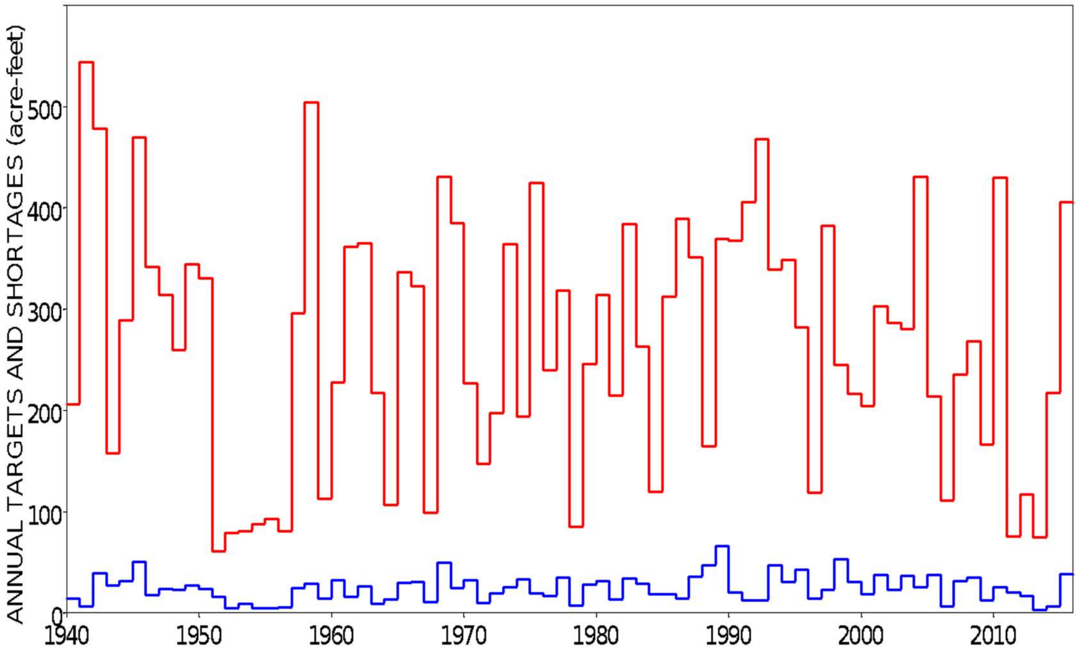


Figure 6.3. Annual Target and Shortage Volume in Acre-Feet/Year for Water Right BRGR30

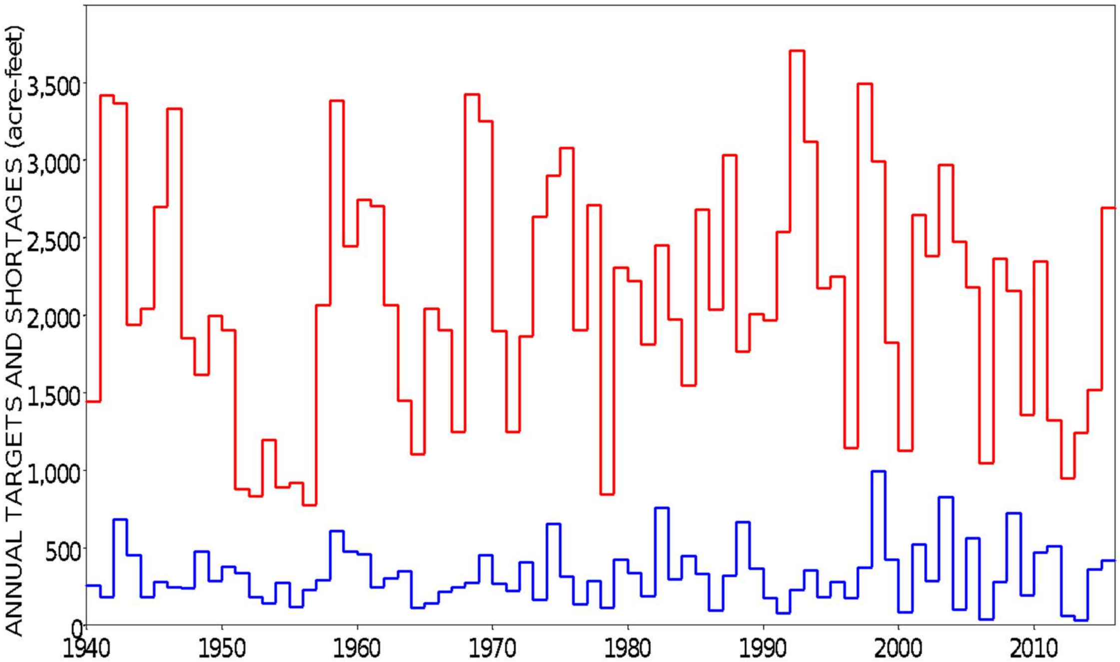


Figure 6.4 Annual Target and Shortage Volume in Acre-Feet/Year for Water Right BRHE68

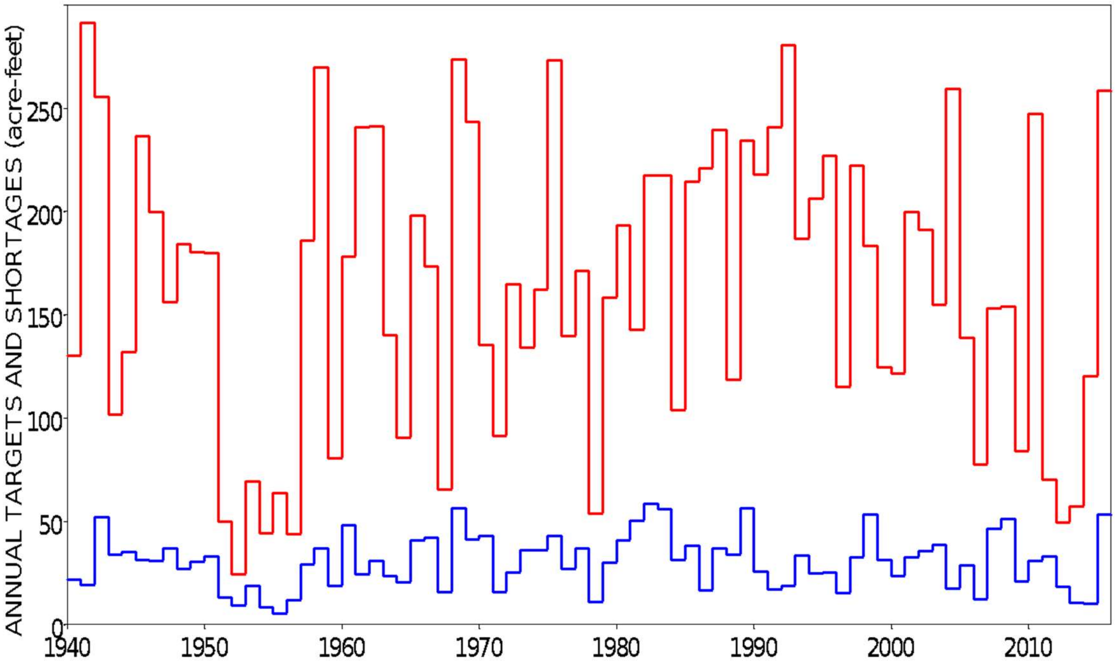


Figure 6.5 Annual Target and Shortage Volume in Acre-Feet/Year for Water Right BRPP27

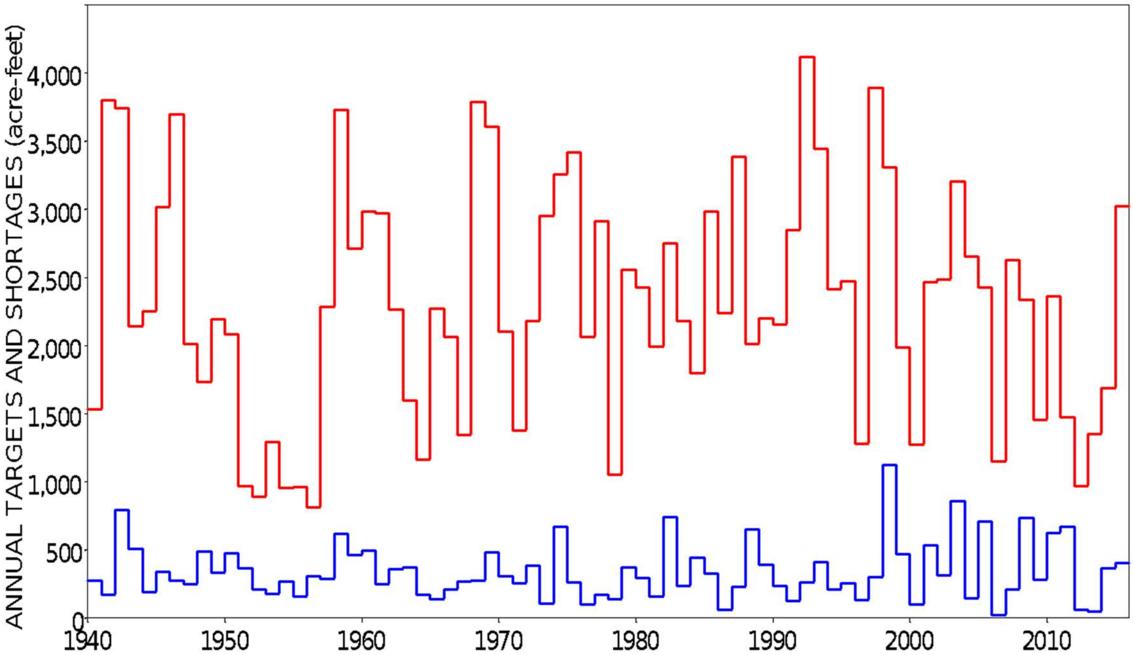


Figure 6.6 Annual Target and Shortage Volume in Acre-Feet/Year for Water Right BRRI70

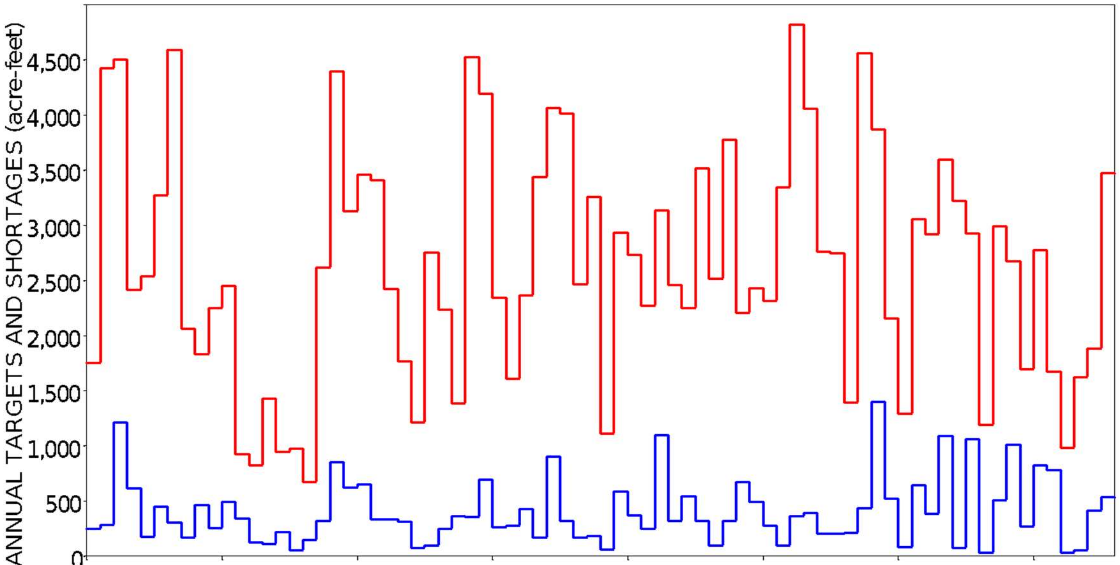


Figure 6.7 Annual Target and Shortage Volume in Acre-Feet/Year for Water Right BRRO72

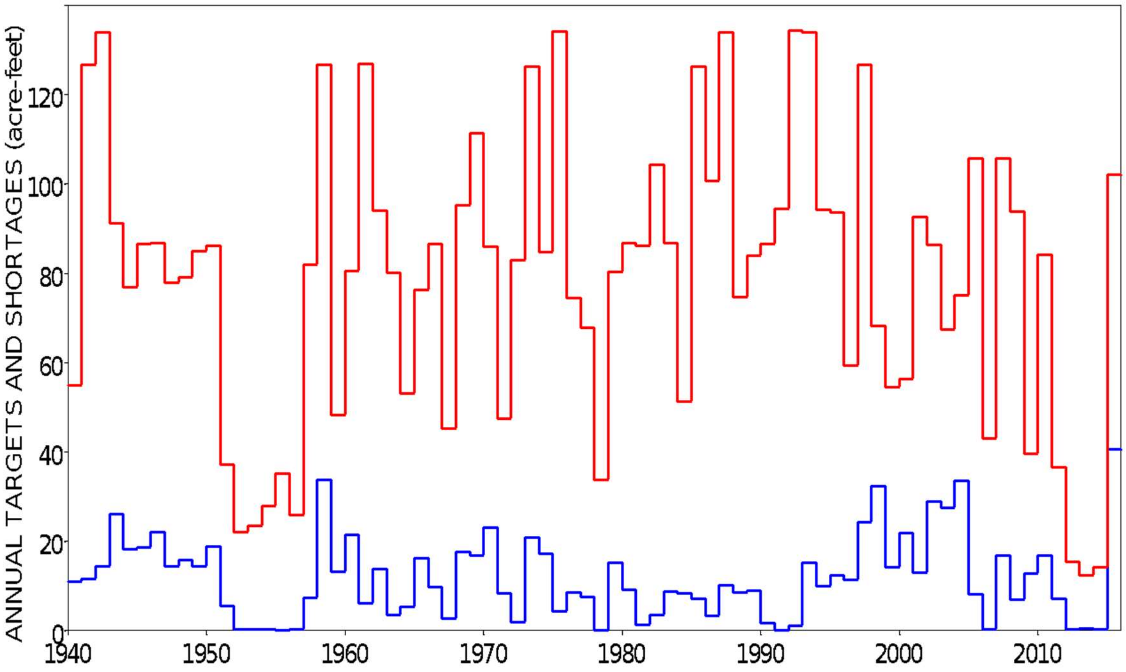


Figure 6.8 Annual Target and Shortage Volume in Acre-Feet/Year for Water Right BRSB23

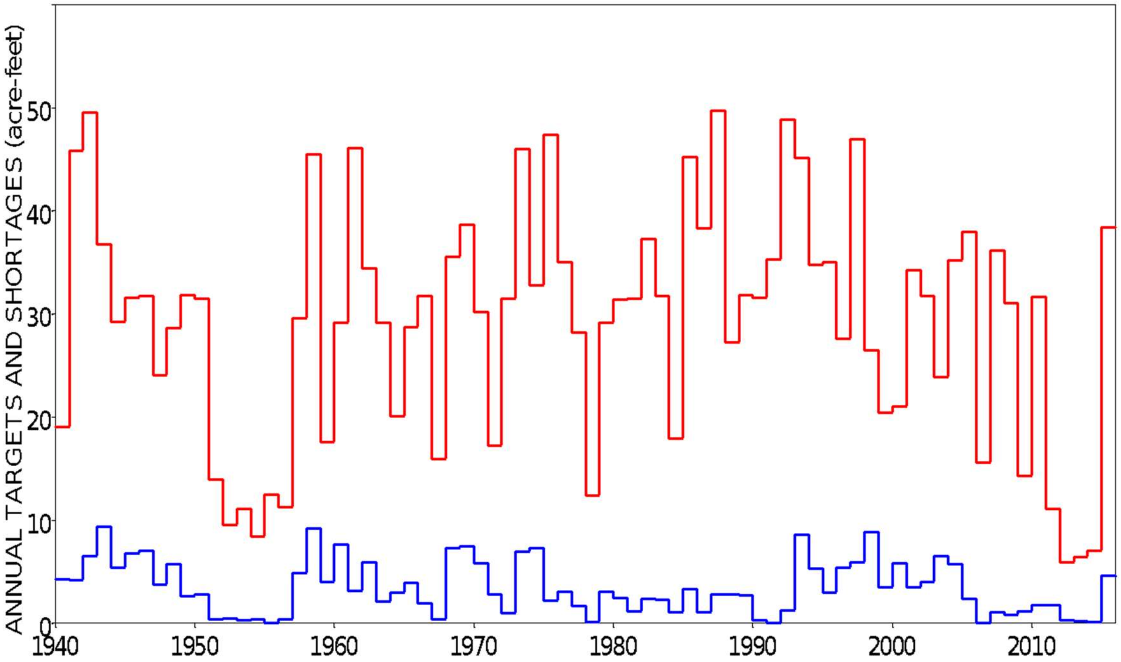


Figure 6.9 Annual Target and Shortage Volume in Acre-Feet/Year for Water Right BRSE11

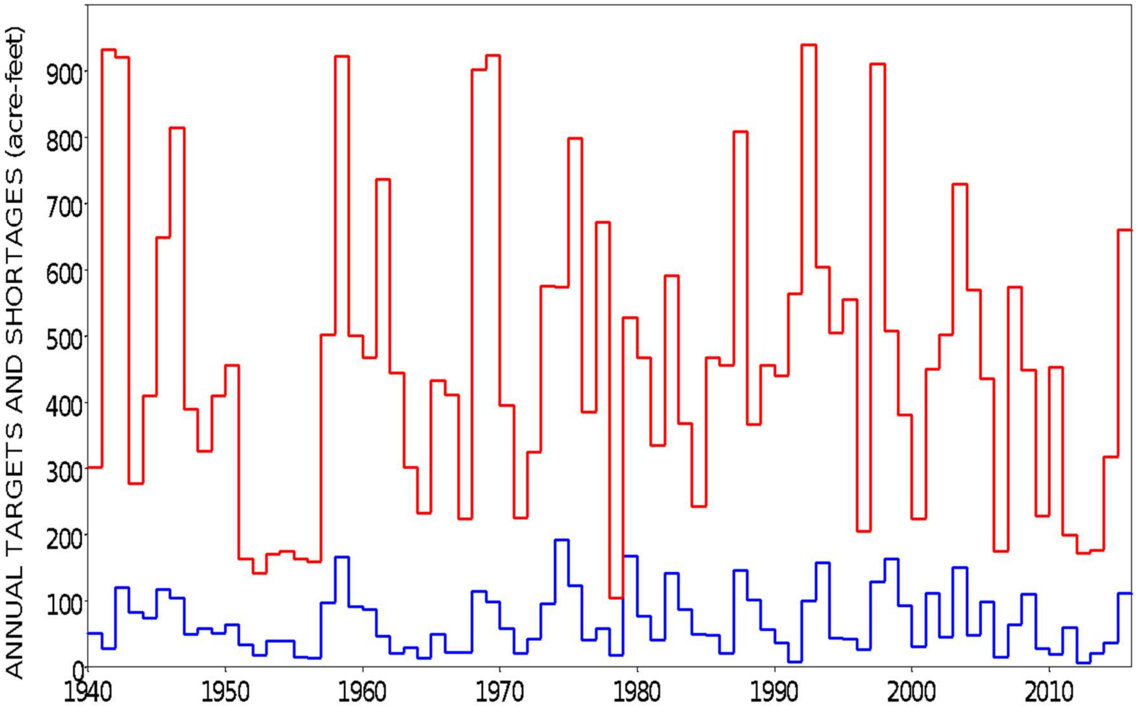


Figure 6.10 Annual Target and Shortage Volume in Acre-Feet/Year for Water Right BRWA41

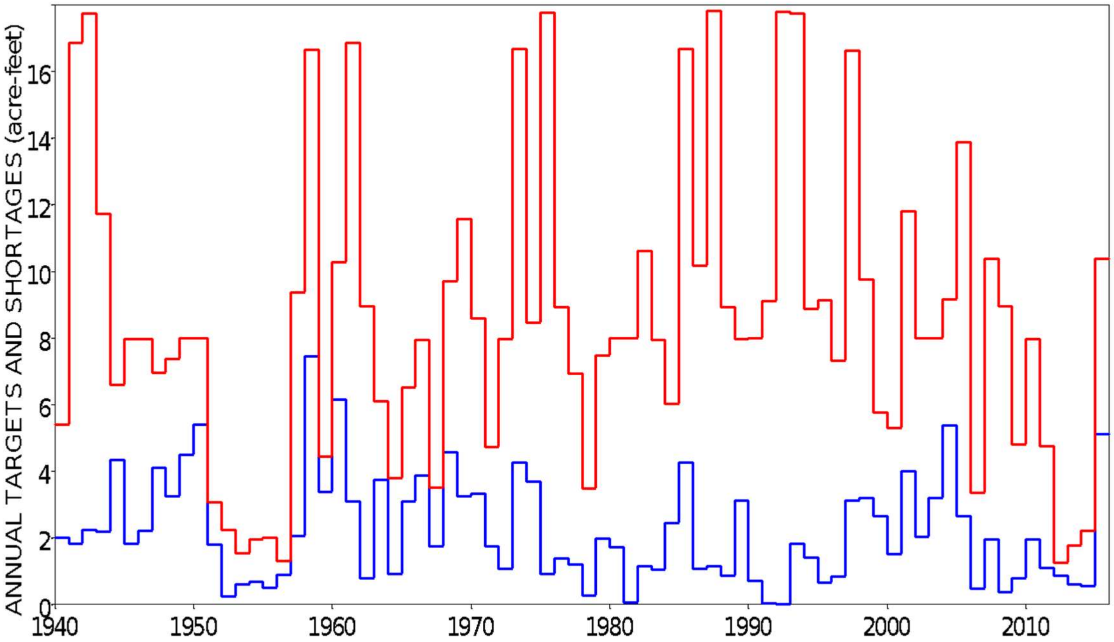


Figure 6.11 Annual Target and Shortage Volume in Acre-Feet/Year for Water Right CFFG18

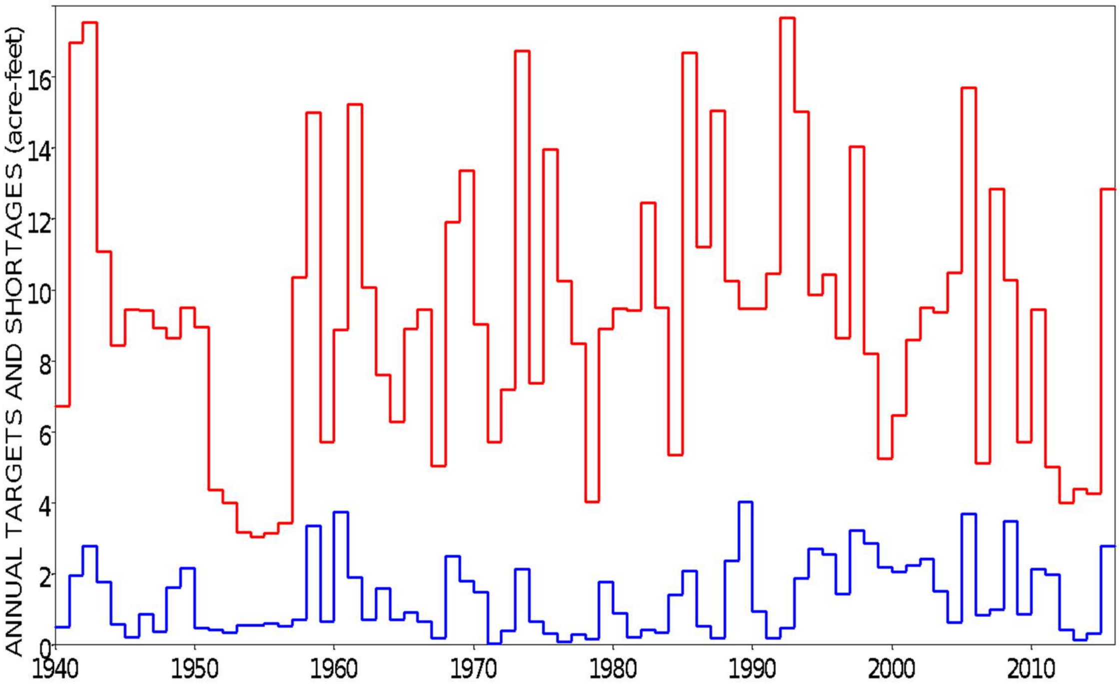


Figure 6.12 Annual Target and Shortage Volume in Acre-Feet/Year for Water Right CFNU16

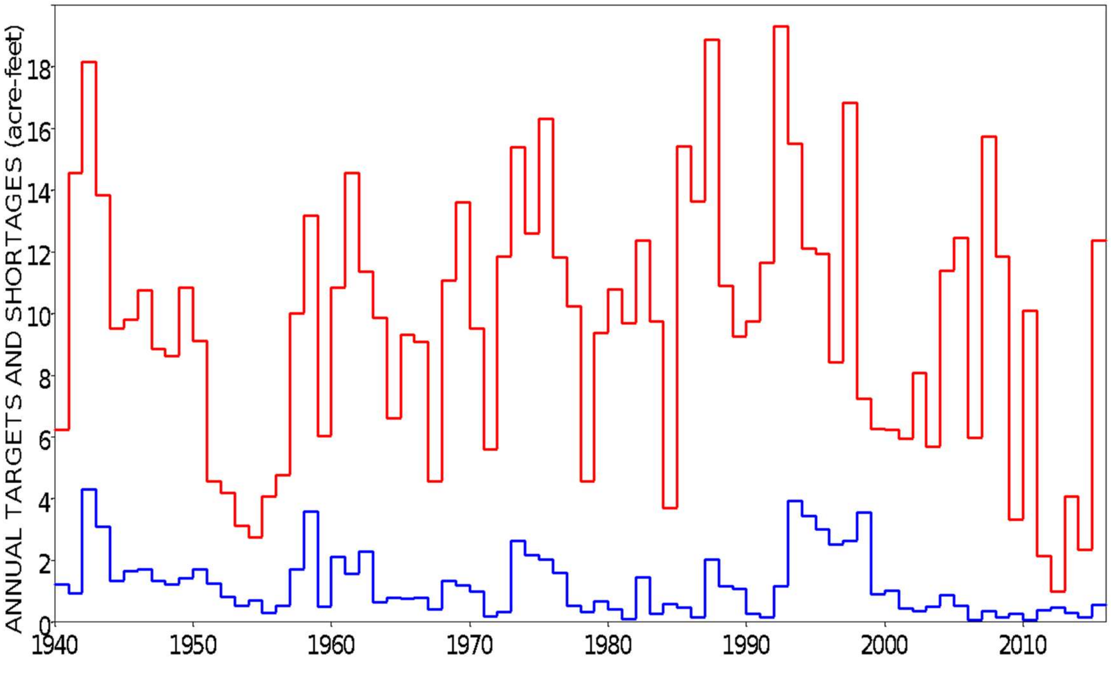


Figure 6.13 Annual Target and Shortage Volume in Acre-Feet/Year for Water Right DMAS09

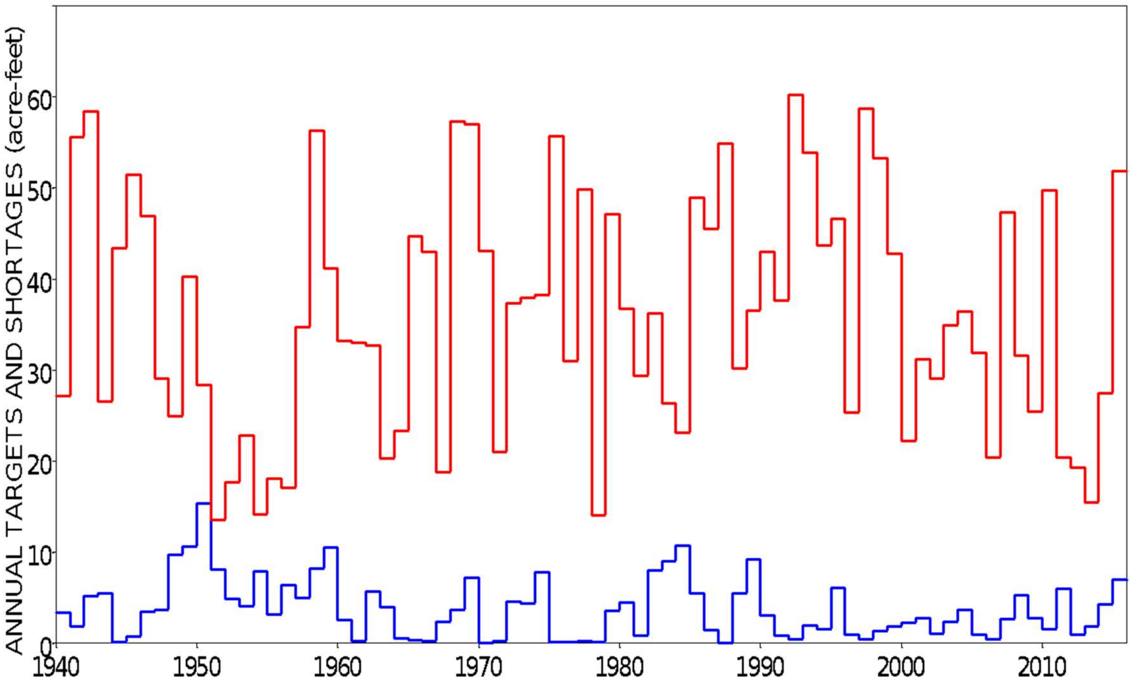


Figure 6.14 Annual Target and Shortage Volume in Acre-Feet/Year for Water Right LAKE50

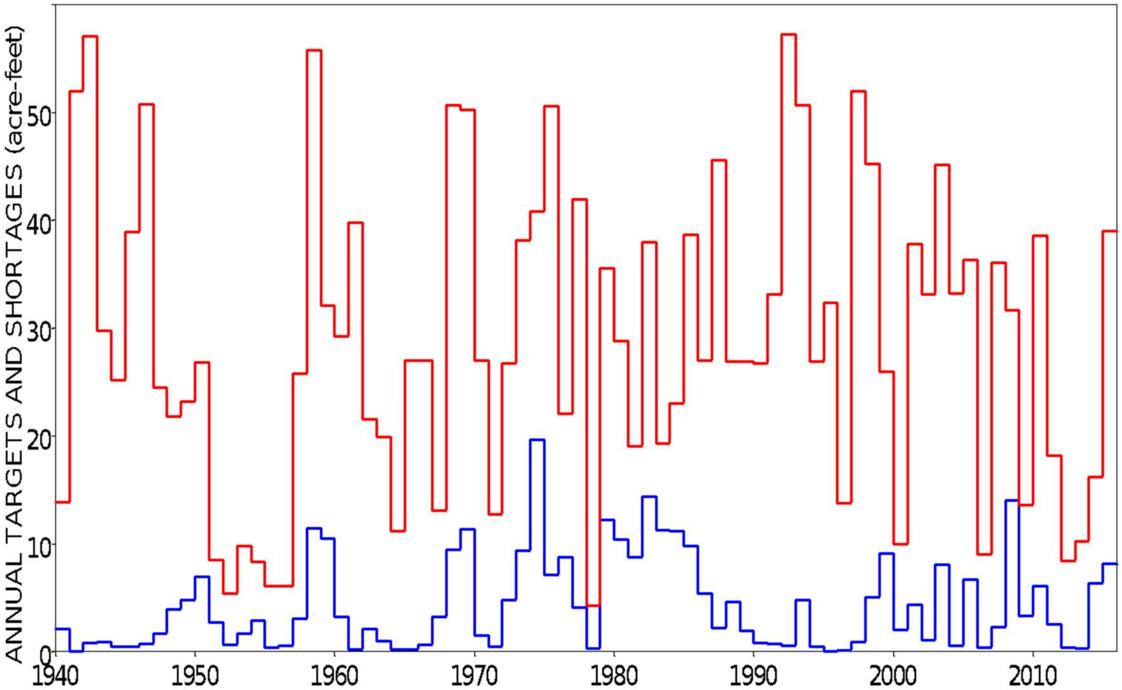


Figure 6.15 Annual Target and Shortage Volume in Acre-Feet/Year for Water Right LEGT47

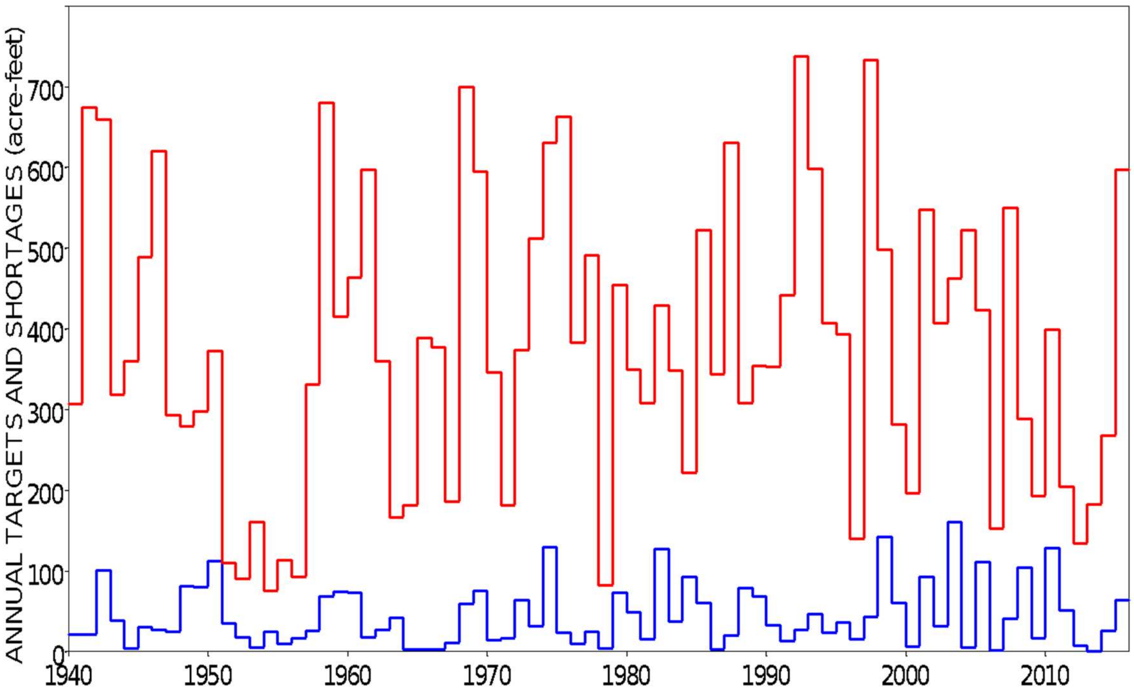


Figure 6.16 Annual Target and Shortage Volume in Acre-Feet/Year for Water Right LRCA58

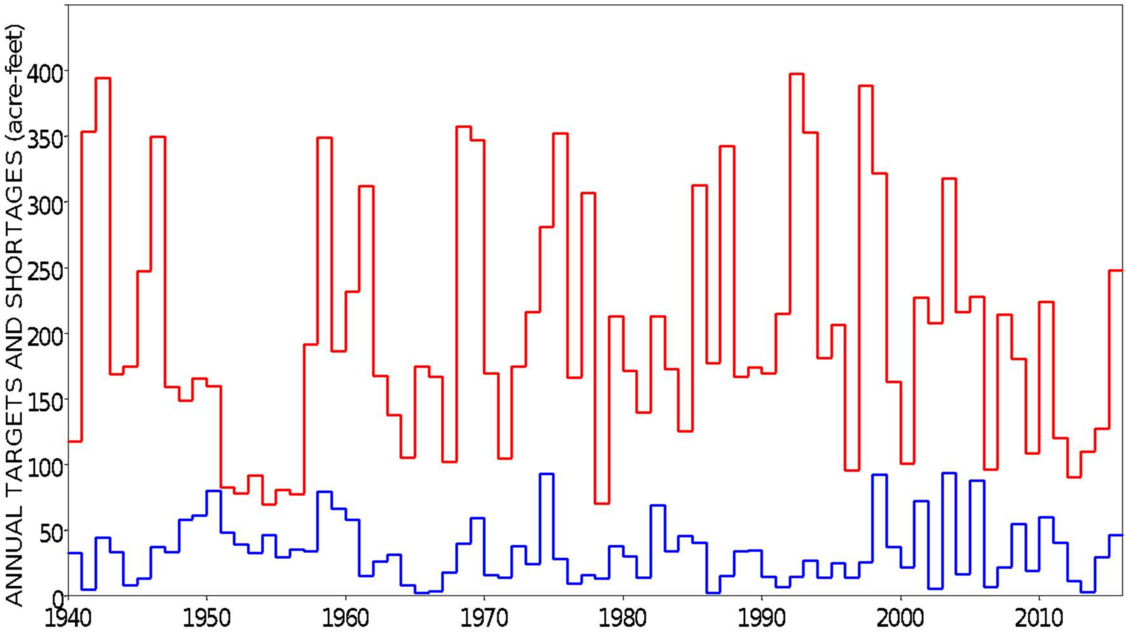


Figure 6.17 Annual Target and Shortage Volume in Acre-Feet/Year for Water Right LRLR53

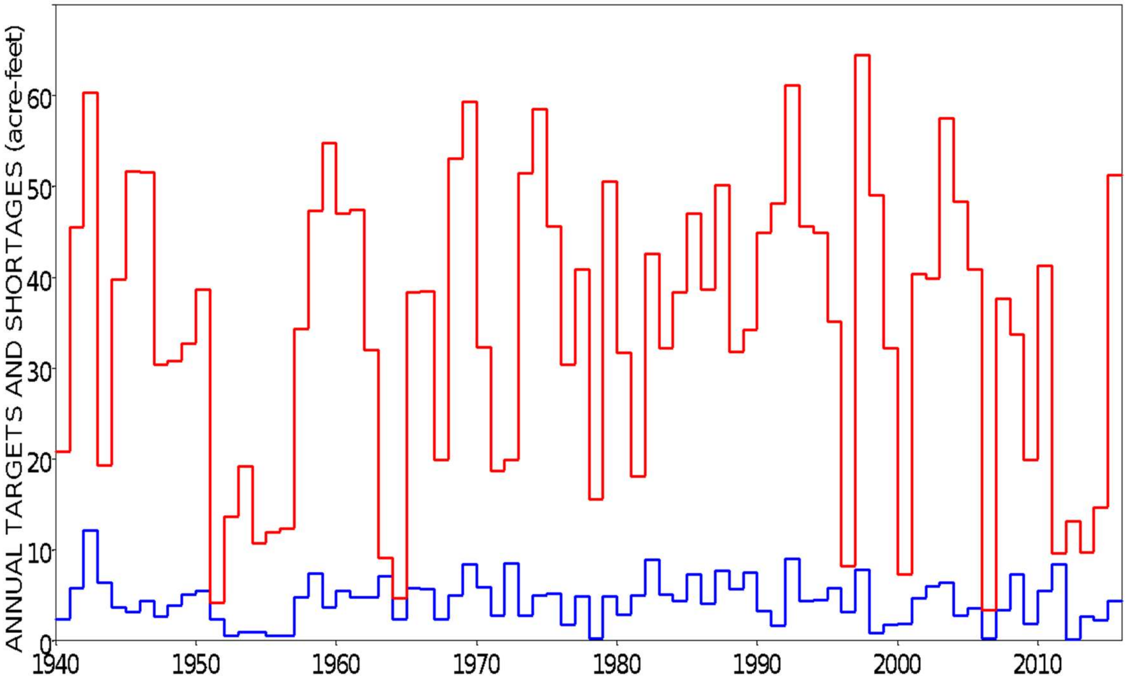


Figure 6.18 Annual Target and Shortage Volume in Acre-Feet/Year for Water Right NAEA66

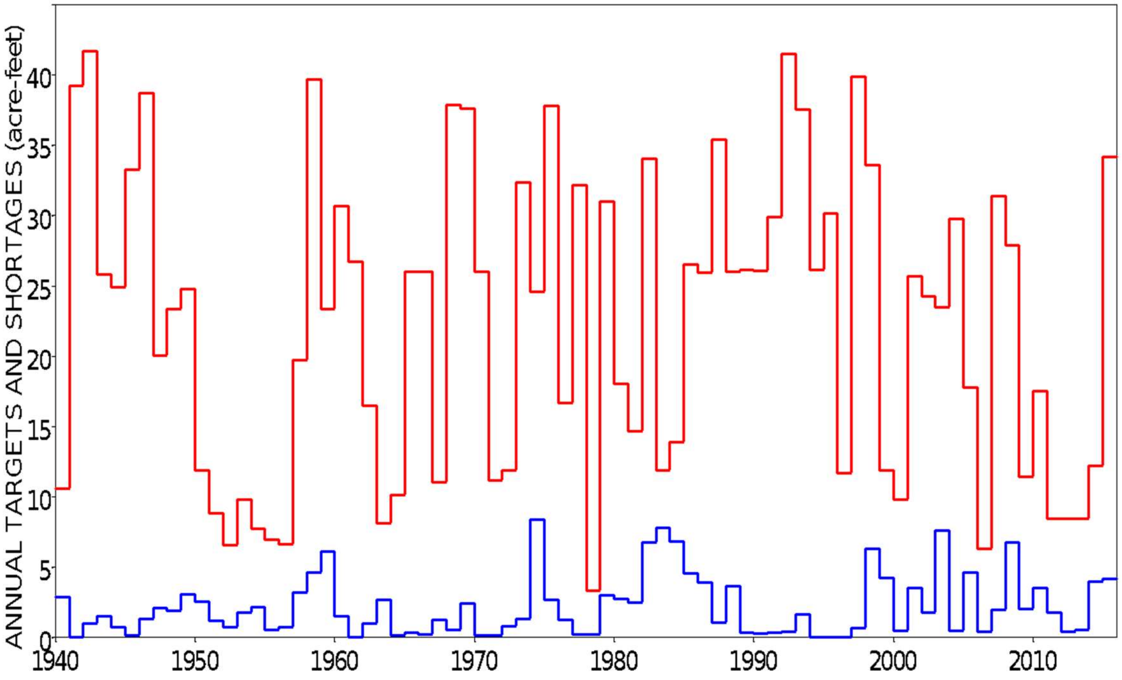


Figure 6.19 Annual Target and Shortage Volume in Acre-Feet/Year for Water Right SFAS06

Table 6.9 Frequency Statistics monthly Targets and Shortages for Selected Control Points from Daily SIMD Simulation

ID	SFAS06		DMAS09		BRSE11		CFNU16		CFFG18	
	IFT	IFS	IFT	IFS	IFT	IFS	IFT	IFS	IFT	IFS
Mean	2.7	0.8	9.7	1.2	29.4	3.4	9.4	1.3	8.8	1.7
Sd	2.3	1.4	53.0	2.4	98.3	7.3	35.4	2.7	20.8	3.3
Min	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0
99.5%	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0
99%	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0
98%	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0
95%	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0
90%	1.0	0.0	1.0	0.0	4.0	0.0	1.0	0.0	1.0	0.0
85%	1.0	0.0	1.0	0.0	5.1	0.0	3.0	0.0	2.2	0.0
80%	1.0	0.0	1.0	0.0	7.0	0.0	3.0	0.0	4.0	0.0
75%	1.0	0.0	1.0	0.0	10.0	0.0	4.0	0.0	5.0	0.0
70%	1.0	0.0	2.0	0.0	13.0	0.0	4.0	0.0	5.0	0.0
60%	1.0	0.0	2.0	0.0	13.0	0.0	5.0	0.0	7.0	0.0
50%	2.0	0.0	3.0	0.0	19.0	0.0	6.0	0.0	7.0	0.0
40%	2.0	0.1	4.0	0.0	25.0	0.0	8.0	0.0	7.0	0.0
30%	4.0	0.8	4.0	1.0	25.0	0.0	8.0	0.7	10.0	1.0
25%	4.0	1.0	4.0	1.1	25.0	1.0	8.0	1.0	10.0	1.0
20%	4.0	1.0	7.0	2.0	32.0	5.5	9.0	2.2	11.0	3.8
15%	5.0	1.8	8.0	2.8	35.0	11.2	12.0	4.0	15.0	5.0
10%	5.0	2.7	8.8	3.8	35.0	13.4	12.0	5.5	15.0	7.0
5%	9.0	4.0	15.0	6.5	46.0	20.1	13.0	8.0	16.0	10.0
2%	9.0	5.0	15.0	10.2	46.0	27.5	13.0	10.1	16.0	11.0
1%	9.0	6.3	210.1	13.4	395.0	32.0	89.3	11.7	32.3	13.9
0.5%	9.0	8.2	499.1	14.5	815.5	33.1	231.9	12.4	74.6	15.0
Max	9.0	9.0	1,310.8	15.0	2,959.5	46.0	1,411.7	13.0	1,035.6	16.0
ID	**BRPP27**		**BRGR30**		**NBCL36**		**LEGT47**		**LAKE50**	
	IFT	**IFS**	**IFT**	**IFS**	**IFT**	**IFS**	**IFT**	**IFS**	**IFT**	**IFS**
Mean	165.1	30.6	269.1	24.2	22.5	2.2	29.0	4.3	36.3	3.8
Sd	610.1	56.7	1,158.2	41.7	105.2	4.7	84.1	9.4	124.7	6.4
Min	17.0	0.0	16.0	0.0	1.0	0.0	1.0	0.0	10.0	0.0
99.5%	17.0	0.0	16.0	0.0	1.0	0.0	1.0	0.0	10.0	0.0
99%	17.0	0.0	16.0	0.0	1.0	0.0	1.0	0.0	10.0	0.0
98%	17.0	0.0	16.0	0.0	1.0	0.0	1.0	0.0	10.0	0.0
95%	17.0	0.0	16.0	0.0	1.0	0.0	1.0	0.0	10.0	0.0
90%	17.0	0.0	16.0	0.0	1.3	0.0	1.7	0.0	10.3	0.0
85%	39.0	0.0	37.0	0.0	3.2	0.0	4.0	0.0	13.4	0.0
80%	40.0	0.0	42.0	0.0	7.0	0.0	10.0	0.0	18.0	0.0
75%	40.0	0.0	47.0	0.0	8.0	0.0	12.0	0.0	23.0	0.0
70%	61.0	0.0	70.0	0.0	8.0	0.0	12.0	0.0	23.0	0.0
60%	61.0	0.0	70.0	0.0	8.0	0.0	12.0	0.0	23.0	0.0
50%	72.0	2.1	77.0	0.0	12.0	0.0	20.0	0.0	27.0	0.0
40%	75.0	17.0	92.0	0.0	16.0	0.0	24.0	0.0	29.0	0.0
30%	75.0	61.0	92.0	16.0	16.0	1.0	24.0	1.0	29.0	3.7
25%	100.0	61.0	160.0	33.1	17.0	1.0	27.0	1.0	32.0	6.0
20%	100.0	72.0	160.0	68.4	17.0	3.4	27.0	8.4	32.0	8.3
15%	120.0	75.0	160.0	70.0	25.0	6.4	52.0	12.0	39.0	10.6
10%	120.0	75.0	170.0	78.2	33.0	8.0	54.0	17.3	43.0	14.2
5%	172.0	106.4	519.4	117.9	33.0	12.0	54.0	24.0	43.0	18.6
2%	1,822.6	120.0	3,136.4	160.0	33.0	16.9	54.0	37.5	57.5	22.1
1%	2,990.9	120.0	5,445.0	160.0	226.9	22.5	184.3	47.4	188.9	25.2
0.5%	4,131.0	120.0	7,801.8	170.0	800.2	25.1	548.2	52.0	637.8	27.7
Max	10,184.2	1,860.4	23,544.6	170.0	1,759.5	33.0	2,041.9	54.0	3,458.6	39.4

Table 6.9 Continued

ID	LRCA58		NAEA66		BRHE68		BRRI70		BRRO72	
	IFT	IFS	IFT	IFS	IFT	IFS	IFT	IFS	IFT	IFS
Mean	381.9	44.5	34.6	4.4	2,119.2	325.3	2,328.6	342.4	2,655.5	405.9
Sd	854.4	96.7	194.1	6.7	2,990.3	557.7	3,184.1	620.0	3,188.2	804.9
Min	32.0	0.0	1.0	0.0	510.0	0.0	550.0	0.0	430.0	0.0
99.5%	32.0	0.0	1.0	0.0	510.0	0.0	550.0	0.0	430.0	0.0
99%	32.0	0.0	1.0	0.0	510.0	0.0	550.0	0.0	430.0	0.0
98%	32.0	0.0	1.0	0.0	510.0	0.0	550.0	0.0	430.0	0.0
95%	32.0	0.0	1.0	0.0	510.0	0.0	550.0	0.0	430.0	0.0
90%	49.6	0.0	1.0	0.0	534.1	0.0	586.0	0.0	582.1	0.0
85%	97.0	0.0	3.0	0.0	920.0	0.0	930.0	0.0	930.0	0.0
80%	140.0	0.0	8.0	0.0	1,130.0	0.0	1,190.0	0.0	1,250.0	0.0
75%	160.0	0.0	8.0	0.0	1,330.0	0.0	1,330.0	0.0	1,420.0	0.0
70%	160.0	0.0	8.0	0.0	1,330.0	0.0	1,330.0	0.0	1,420.0	0.0
60%	190.0	0.0	10.0	0.0	1,330.0	0.0	1,330.0	0.0	1,420.0	0.0
50%	190.0	0.0	14.0	0.0	1,440.0	0.0	1,650.0	0.0	2,090.0	0.0
40%	310.0	0.0	16.0	1.0	1,900.0	16.8	2,140.0	0.0	2,570.0	0.0
30%	310.0	20.7	19.0	6.5	1,900.0	337.4	2,140.0	327.8	2,570.0	234.5
25%	330.0	32.0	19.0	8.0	2,050.0	509.4	2,190.0	534.7	2,630.0	430.0
20%	460.0	76.5	19.0	9.9	2,890.0	687.8	3,310.0	652.0	3,600.0	749.7
15%	460.0	119.7	23.0	14.0	2,890.0	910.4	3,310.0	927.2	4,700.0	1,110.1
10%	760.0	159.1	29.0	16.0	3,440.0	1,143.4	3,980.0	1,260.6	4,740.0	1,420.0
5%	760.0	235.9	29.0	19.0	3,440.0	1,463.4	3,980.0	1,648.2	4,740.0	2,167.9
2%	2,165.4	330.0	110.9	23.0	10,206.7	2,027.1	10,700.5	2,209.8	10,697.8	3,217.8
1%	3,891.8	519.9	811.7	25.5	16,478.6	2,450.5	17,110.8	2,831.4	15,870.2	3,810.0
0.5%	6,181.4	605.4	1,432.3	29.0	21,566.0	2,838.9	23,342.9	3,252.7	21,913.3	4,086.5
Max	27,981.3	747.2	4,532.5	29.0	84,091.8	3,440.0	94,461.4	3,980.0	76,240.5	4,740.0
ID	**BRSB23**		**BRWA41**		**LRLR53**		**BRBR59**			
	IFT	**IFS**	**IFT**	**IFS**	**IFT**	**IFS**	**IFT**	**IFS**		
Mean	79.5	11.8	463.1	68.3	200.2	33.7	1,326.3	226.3		
Sd	230.0	23.0	1,422.9	133.3	444.2	61.5	1,785.7	384.2		
Min	1.0	0.0	56.0	0.0	55.0	0.0	300.0	0.0		
99.5%	1.0	0.0	56.0	0.0	55.0	0.0	300.0	0.0		
99%	1.0	0.0	56.0	0.0	55.0	0.0	300.0	0.0		
98%	1.0	0.0	56.0	0.0	55.0	0.0	300.0	0.0		
95%	1.0	0.0	56.0	0.0	55.0	0.0	300.0	0.0		
90%	7.9	0.0	75.1	0.0	55.0	0.0	316.2	0.0		
85%	16.0	0.0	120.0	0.0	82.0	0.0	540.0	0.0		
80%	29.0	0.0	150.0	0.0	95.0	0.0	710.0	0.0		
75%	36.0	0.0	210.0	0.0	110.0	0.0	860.0	0.0		
70%	46.0	0.0	210.0	0.0	110.0	0.0	860.0	0.0		
60%	46.0	0.0	210.0	0.0	110.0	0.0	860.0	0.0		
50%	60.0	0.0	250.0	0.0	120.0	0.0	920.0	0.0		
40%	73.0	0.0	270.0	0.0	150.0	2.6	1,260.0	27.1		
30%	73.0	1.0	270.0	47.4	150.0	41.5	1,260.0	236.7		
25%	73.0	9.3	480.0	56.0	190.0	51.8	1,470.0	317.2		
20%	95.0	26.5	590.0	130.1	200.0	60.8	1,470.0	486.3		
15%	100.0	39.5	590.0	195.7	200.0	86.1	1,760.0	637.7		
10%	100.0	47.8	690.0	250.0	430.0	110.0	2,460.0	786.4		
5%	120.0	64.3	690.0	383.8	430.0	142.8	2,460.0	1,030.3		
2%	120.0	75.2	2,681.8	549.4	786.5	200.0	5,067.2	1,355.8		
1%	671.6	95.0	5,902.6	590.0	1,641.9	340.6	9,498.4	1,637.9		
0.5%	1,583.1	100.0	8,933.5	595.6	3,036.9	382.0	13,250.3	1,979.9		
Max	7,915.4	120.0	51,425.0	690.0	14,006.0	430.0	48,904.2	2,460.0		

6.4.2. Simulation Results Analyses Between Alternative Scenarios in the Brazos River Basin

Results of two Brazos WAM simulations were compared at selected control points to characterize the effects of alternative water right priorities. In the first scenario, the priority number was modeled as 20110301, in conformity to the Texas Administrative Code. During the second scenario of the Brazos WAM, the priority number was changed to 18000301 to adjust SB3 EFSs to senior priority over all other water rights in the basin. The frequency metrics for daily instream flow shortage as a percentage of the instream flow target are presented in Table 6.10 for the selected control points, with comparisons made between different priority-order simulations of water allocation. There are two columns for each control point, with the environmental flow standard junior (less prioritized) versus senior (more prioritized) to all other water rights. As seen in Table 6.10, the shortage as a percentage of the target improved slightly at all of the exceedance frequency values as evidenced by greater values of mean value.

Table 6.10 Frequency Statistics Shortage as A Percentage of the Target for Selected Control Points

ID	**SFAS06**		**DMAS09**		**BRSE11**		**CFNU16**		**CFFG18**	
	Junior	Senior	Junior	Senior	Junior	Senior	Junior	Senior	Junior	Senior
Mean	30.4	27.2	30.9	30.1	19.7	19.0	24.1	18.6	38.4	28.3
Sd	40.8	38.8	42.5	42.2	34.9	34.3	39.3	36.5	47.0	42.6
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
99.5%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
99%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
98%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
95%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
85%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40%	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.4	0.0
30%	60.1	47.1	61.1	56.8	0.1	0.0	14.3	0.0	100.0	39.3
25%	75.3	65.3	80.8	78.8	26.0	23.0	46.5	0.0	100.0	76.9
20%	85.8	79.9	94.7	93.2	50.2	47.0	75.8	36.5	100.0	100.0
15%	93.3	88.2	100.0	100.0	72.2	69.4	96.4	85.9	100.0	100.0
10%	100.0	95.0	100.0	100.0	93.1	90.5	100.0	100.0	100.0	100.0
5%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
0.5%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Max	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
ID	**BRPP27**		**BRGR30**		**NBCL36**		**LEGT47**		**LAKE50**	
	Junior	Senior	Junior	Senior	Junior	Senior	Junior	Senior	Junior	Senior
Mean	45.0	26.8	31.6	15.9	23.4	19.9	26.0	24.2	16.4	16.1
Sd	47.9	40.4	43.6	33.2	37.9	35.4	40.5	39.5	26.3	25.9
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
99.5%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
99%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
98%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
95%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
85%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50%	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40%	94.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30%	100.0	34.9	64.6	0.0	19.0	2.0	26.4	13.1	18.6	17.8
25%	100.0	61.2	89.3	0.0	43.3	26.3	62.1	50.0	30.4	29.7
20%	100.0	83.5	100.0	21.1	64.7	47.9	82.9	74.5	40.7	39.5
15%	100.0	100.0	100.0	54.7	89.2	71.6	100.0	100.0	49.7	48.8
10%	100.0	100.0	100.0	94.8	100.0	100.0	100.0	100.0	60.5	59.4
5%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	74.5	73.3
2%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	88.3	87.6
1%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	95.4	94.1
0.5%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Max	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 6.10 Continued

ID	LRCA58		NAEA66		BRHE68		BRRI70		BRRO72	
	Junior	Senior	Junior	Senior	Junior	Senior	Junior	Senior	Junior	Senior
Mean	19.8	18.8	39.1	20.9	21.2	20.7	20.8	20.7	18.4	18.2
Sd	32.4	30.8	45.1	36.6	30.9	30.0	32.2	31.7	30.1	29.8
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
99.5%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
99%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
98%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
95%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
85%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
75%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
60%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40%	0.0	0.0	55.2	0.0	1.6	2.7	0.0	0.3	0.0	0.0
30%	18.6	17.0	87.2	0.0	31.8	32.1	27.0	27.8	17.9	18.2
25%	36.3	34.5	100.0	29.8	43.9	42.9	39.8	39.9	32.9	33.1
20%	51.6	48.3	100.0	57.5	53.8	52.4	51.5	51.2	46.7	46.7
15%	65.9	61.7	100.0	79.3	63.0	61.2	63.1	62.3	58.7	58.0
10%	79.1	74.2	100.0	100.0	72.9	70.1	77.5	75.6	70.3	69.0
5%	93.6	88.7	100.0	100.0	85.7	82.0	98.0	95.8	86.9	85.5
2%	100.0	99.8	100.0	100.0	100.0	99.5	100.0	100.0	100.0	100.0
1%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
0.5%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Max	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
ID	**BRSB23**		**BRWA41**		**LRLR53**		**BRBR59**			
	Junior	Senior	Junior	Senior	Junior	Senior	Junior	Senior		
Mean	21.9	17.1	23.8	24.3	25.7	23.4	22.3	21.8		
Sd	36.3	31.8	37.0	36.0	36.3	34.3	32.1	31.1		
Min	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
99.5%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
99%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
98%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
95%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
90%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
85%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
80%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
75%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
70%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
60%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
50%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
40%	0.0	0.0	0.0	0.9	2.3	0.0	3.6	4.5		
30%	15.6	0.0	27.2	32.2	42.0	34.3	34.8	34.8		
25%	37.8	19.0	47.6	49.4	57.2	50.3	46.9	45.9		
20%	55.7	38.7	65.3	64.3	69.6	63.5	56.8	55.4		
15%	79.8	56.4	82.5	78.8	80.2	74.8	66.4	64.4		
10%	99.8	79.6	98.7	92.7	90.0	85.1	76.4	73.2		
5%	100.0	98.5	100.0	100.0	98.1	93.3	89.4	85.3		
2%	100.0	100.0	100.0	100.0	100.0	99.8	100.0	100.0		
1%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
0.5%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
Max	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		

The exceedance frequency plots of instream flow shortage as a percentage of all instream flow targets for the Seymour, Cameron, Waco, and Richmond locations are presented in Figures 6.20 through 6.23. The four duration curves are plotted to compare the environmental flow shortage with the EFS under junior and senior priority to all other water rights. The flow duration curves of both priorities are nearly similar. There was a slight improvement to satisfy the environmental flow standards targets for the senior priority (red line) relative to the junior (blue line) simulation.

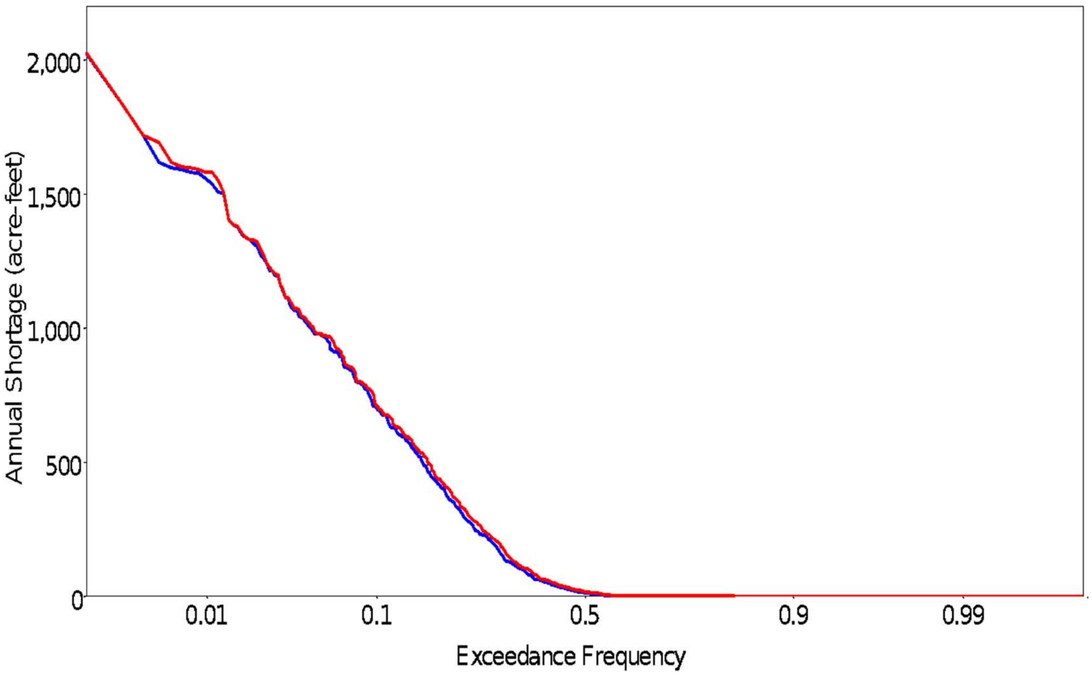


Figure 6.20 Annual Shortage Volume in Acre-Feet/Year for Control Point EFS-BRSE11

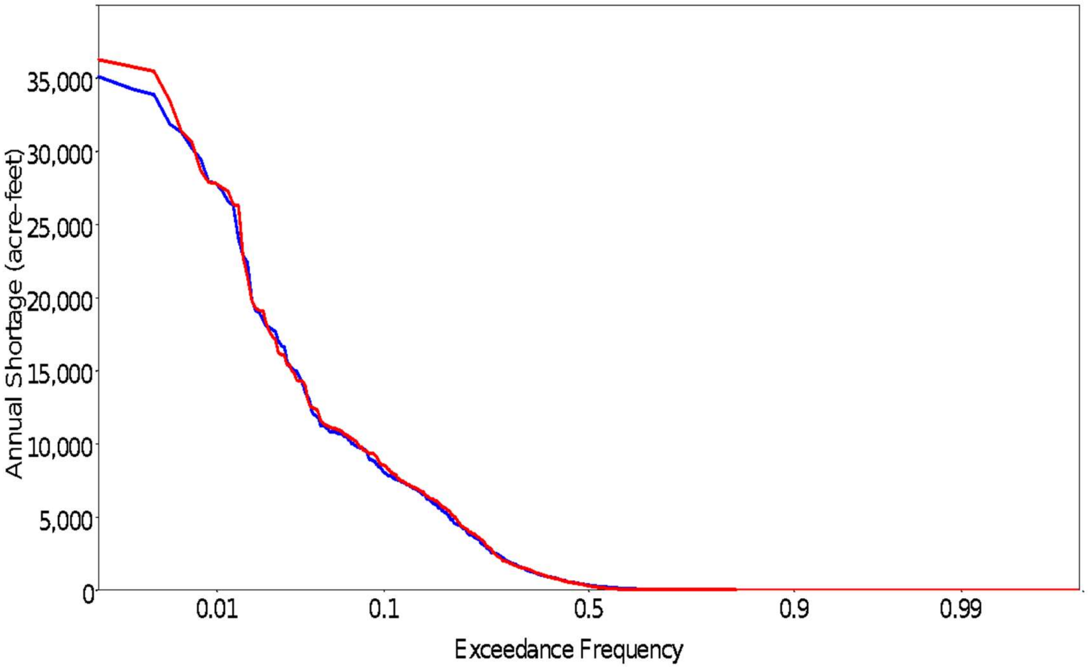


Figure 6.21 Annual Shortage Volume in Acre-Feet/Year for Control Point EFS- LRCA58

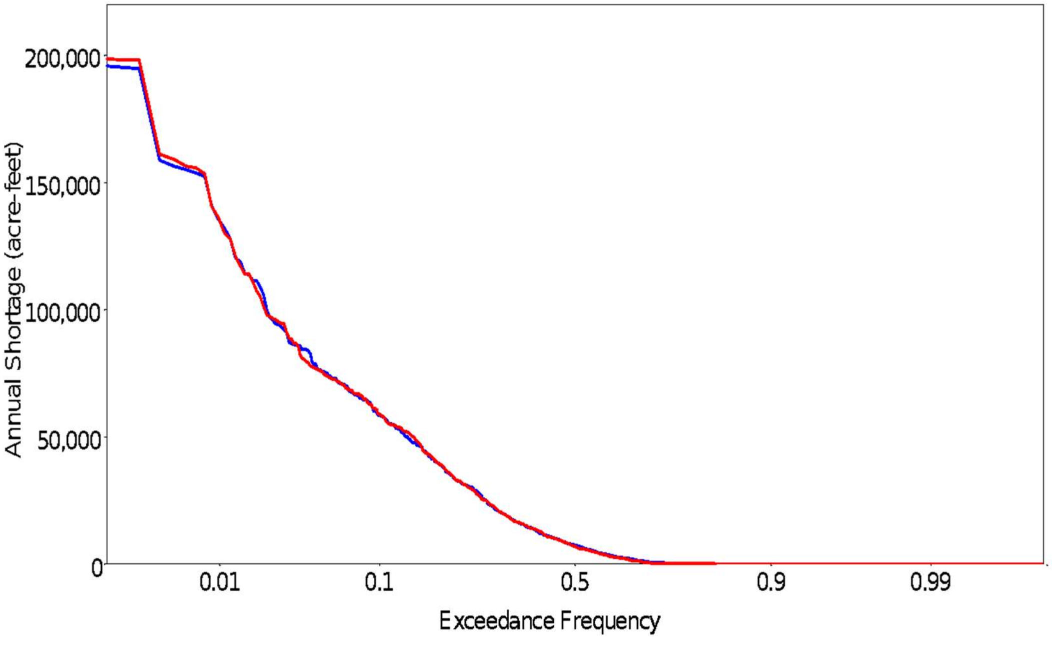


Figure 6.22 Annual Shortage Volume in Acre-Feet/Year for Control Point EFS- BRHE68

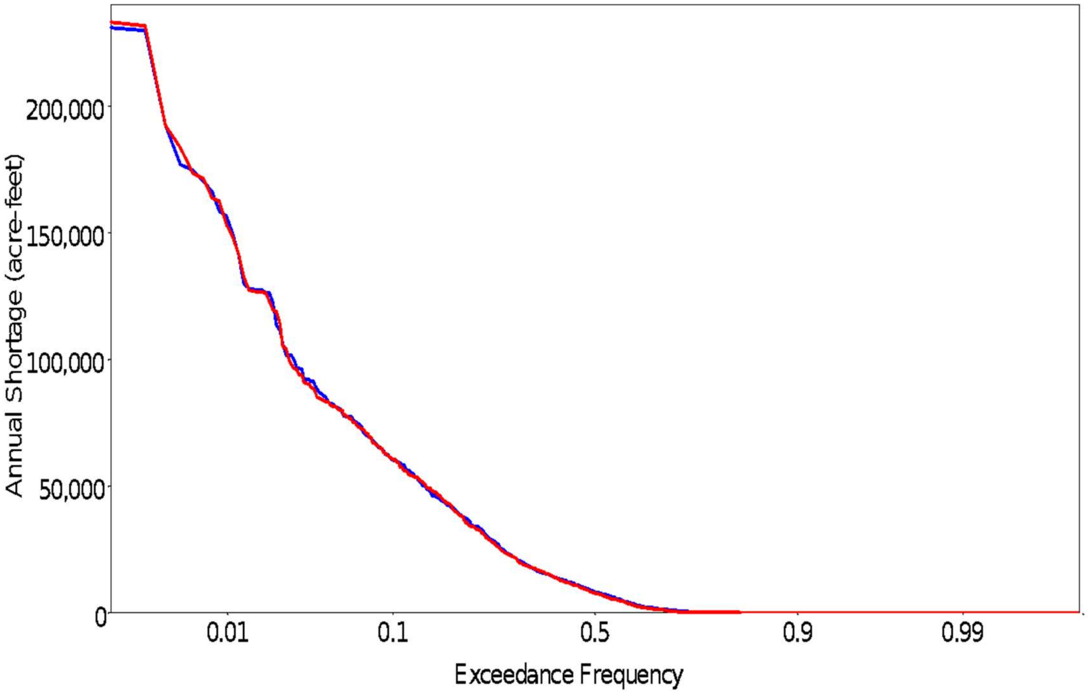


Figure 6.23 Annual Shortage Volume in Acre-Feet/Year for Control Point EFS- BRRI70

6.5. Simulation Results Analyses of the Trinity River Basin

In the daily Trinity WAM dataset, the environmental flow SB-3 standards were modeled at 4 control points with priority number 20091201 for a 76-year period-of-analysis. The plots in Figure 6.24 and the metrics documented in Table 6.10 were developed based on WRAP simulation. Figure 6.24 is a frequency plot of shortage as a percentage of the instream flow target versus allowable deficit as a percentage of the instream flow target for all instream flow targets at the four control points. The exceedance frequency curves for all four control points were relatively similar to one another, with the mean value of instream flow shortage as a percentage of the instream flow target at a minimum of 16.8% at control point 8TRROE and maximum of 26.0% at control point

8TRDAE. At control points 8WTGP and 8TRDA, the shortage is 100% of the target up to 20% of simulation period, after which significant decrease in the rest of the period-of-analysis was observed. For control points 8TROA and 8TRRO, the curves were relatively flat, with the instream flow target 100% satisfied during 40% of the 912 months. Meanwhile, the period reliability was relatively large at control points 8TROA and 8TRRO, both on the Trinity River and some distance downstream of most cities and major reservoirs. Control point 8TROA is about 40 miles below Richland Chambers Reservoir, while control point 8TRRO is 20 miles below Lake Livingston Reservoir and about 50 miles above the Trinity River outlet at Galveston Bay. Therefore, one assumption could be that water conservancies are helping decrease the proportion of low flow events. Another hypothesis involves groundwater releases and treated water discharge.

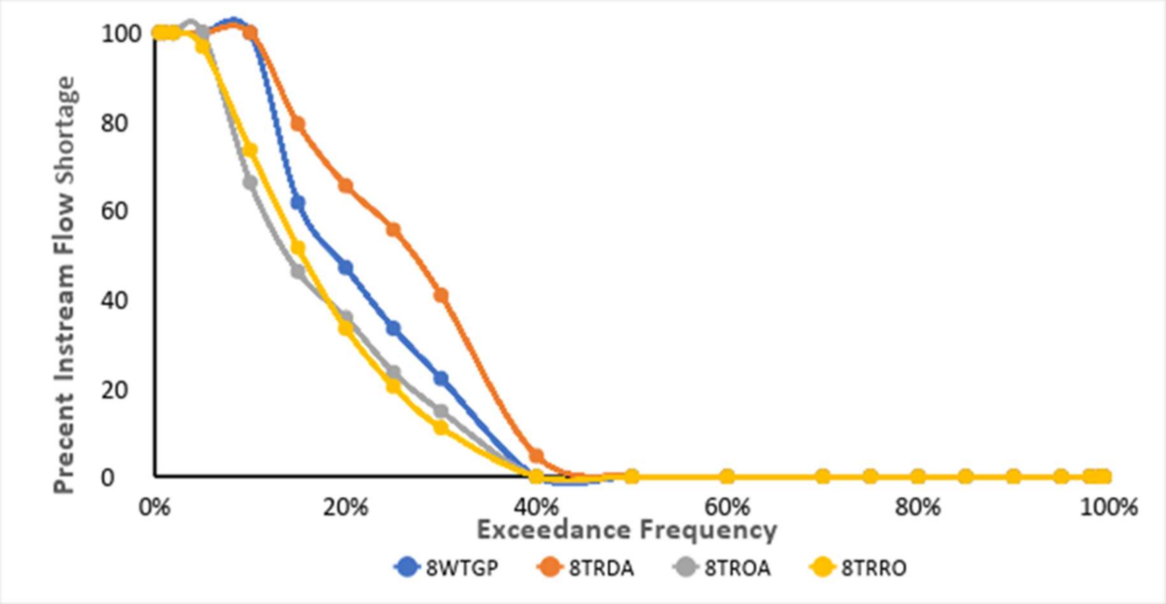


Figure 6.24 Exceedance Frequency Plot of Instream Flow Shortage as A Percentage of the Instream Flow Target for All Selected Control Points

Table 6.11 Flow Frequency Metrics for Shortage as A Percentage of the Instream Flow Target for All Selected Control Points

CP	8WTGP	8TRDA	8TROA	8TRRO
Mean	20.7	26.0	17.1	16.8
Std Dev	33.9	37.1	29.7	30.0
Minimum	0.0	0.0	0.0	0.0
99.50%	0.0	0.0	0.0	0.0
99%	0.0	0.0	0.0	0.0
98%	0.0	0.0	0.0	0.0
95%	0.0	0.0	0.0	0.0
90%	0.0	0.0	0.0	0.0
85%	0.0	0.0	0.0	0.0
80%	0.0	0.0	0.0	0.0
75%	0.0	0.0	0.0	0.0
70%	0.0	0.0	0.0	0.0
60%	0.0	0.0	0.0	0.0
50%	0.0	0.0	0.0	0.0
40%	0.0	4.7	0.0	0.0
30%	22.1	40.9	14.7	11.0
25%	33.4	55.6	23.5	20.4
20%	47.1	65.6	35.8	33.4
15%	61.8	79.5	46.2	51.6
10%	100.0	100.0	66.3	73.6
5%	100.0	100.0	100.0	96.9
2%	100.0	100.0	100.0	100.0
1%	100.0	100.0	100.0	100.0
0.50%	100.0	100.0	100.0	100.0
Maximum	100.0	100.0	100.0	100.0

Table 6.12 presents the flow frequency metrics corresponding to regulated flow, instream target, instream flow shortage, unappropriated flow, and shortage as percentage of target. Each table contains four columns to give flow frequencies at each of the four instream flow control points. Control point 8WTGP had the smallest watershed area of the four control points, and, as expected, the regulated flow, instream flow targets, and shortage are relatively small compared to other control points, suggesting that environmental flow requirements are in direct proportion to drainage area in the Trinity River. For example, the average values of instream target are 363.96 cfs at control point 8WTGP and 5967.70cfs at control point 8TRRO.

Table 6.12 Flow Frequency for Selected Control Points on the Trinity River

	Regulated Flow		**Instream Target**		**Instream Shortage**		**Unappropriated Flow**	
	8WTGP	8TRDA	8WTGP	8TRDA	8WTGP	8TRDA	8WTGP	8TRDA
Mean	715.6	1981.13	363.96	1097.95	83.39	433.21	132.09	295.49
Std Dev	1556.44	4046.83	699.28	2465.64	212.60	1074.17	756.03	1344.03
Min	0	0	0	0	0	0	0	0
99.50%	0	0	0	0	0	0	0	0
99%	0	0	0	0	0	0	0	0
98%	0	0	0	0	0	0	0	0
95%	0	0	0	0	0	0	0	0
90%	0	0	0	0	0	0	0	0
85%	9.76	22.33	5.68	13.52	0	0	0	0
80%	21.06	53.93	11.47	35.9	0	0	0	0
75%	35.86	85.65	20.37	40	0	0	0	0
70%	49.11	140.87	35	48.09	0	0	0	0
60%	106.58	296.84	35	50	0	0	0	0
50%	192.06	489.88	45	70	0	0	0	8.38
40%	314.41	880.67	45	70	0	0	6.82	28.14
30%	497.62	1516.49	344.82	890.79	0	3.35	19.85	78.84
25%	630.9	1925.07	447.93	1294.02	43.59	273.79	38.28	130.07
20%	851.61	2566.9	591.86	1764.58	122.16	587.99	67.54	226.06
15%	1250.35	3819.62	907.5	1764.58	207.13	948.57	107.11	320.44
10%	1849.43	5551.32	913.69	4170.15	288.22	1505.32	180.03	490.81
5%	3220.32	8647.97	1787.35	5065.5	459.64	2594.65	389.68	1078.26
2%	5521.25	14844.12	2070.55	7570.38	793.25	3973.73	1057.45	2542.29
1%	9484.62	23398.1	4033.33	10282.25	1068.80	4924.67	2805.85	6077.11
0.50%	11537.47	27570.95	4033.33	20166.67	1349.57	7065.08	7952.94	11650.27
Max	15277.22	46051.32	4033.33	20166.67	2320.70	10048.37	11243.88	18476.17
	8TROA	8TRRO	8TROA	8TRRO	8TROA	8TRRO	8TROA	8TRRO
Mean	5452.54	8178.62	3644.59	5967.70	801.89	1242.64	804.22	2223.02
Std Dev	8690.19	10905.42	6245.51	8733.64	2046.2	3110.02	2457.01	4668.89
Min	0.00	0	0	0.00	0	0	0	0
99.5%	0.00	0	0	0.00	0	0	0	0
99%	0.00	0	0	0.00	0	0	0	0
98%	0.00	0	0	0.00	0	0	0	0
95%	0.00	0	0	1.75	0	0	0	0
90%	104.69	58.28	56.03	40.69	0	0	0	0
85%	200.63	285.26	104.74	173.89	0	0	0	0
80%	313.49	671.28	250	465.70	0	0	0	0
75%	454.98	1024.22	250	575.00	0	0	0	7.12
70%	643.24	1410.19	260	625.00	0	0	0	22.86
60%	1075.90	2305.61	332.71	875.00	0	0	11.29	91.19
50%	1784.61	3744.89	450	1150.00	0	0	54.3	319.26
40%	2991.23	5890.76	1108.35	1736.18	0	0	138.28	856.83
30%	5363.28	9269.97	4194.08	8045.34	51.89	207.19	374.74	1716.53
25%	6993.24	11620.37	5222.86	10135.83	567.96	712.24	615.73	2364.46
20%	9015.22	14134.81	7333.23	13213.38	1282.75	1781.45	889.51	3103.81
15%	10961.73	17649.89	9075.00	14990.53	1971.81	2858.53	1301.85	4493.28
10%	15337.01	22457.12	10933.57	17750.05	2814.31	4287.28	1985.34	6072.40
5%	23103.04	30250.00	14392.66	25783.66	4465.75	6907.96	3806.37	10151.55
2%	34348.84	41714.89	22060.99	30250.00	6548.1	11450.36	7308.99	18429.53
1%	43440.47	49792.77	32715.28	40333.33	8419.31	14971.63	11624.56	24107.52
0.50%	50299.35	62504.96	33111.96	51673.97	10933.57	21269.59	15110.61	30671.96
Max	81356.90	83588.48	65541.66	52937.50	29783.67	34033.78	33951.36	53250.71

Annual total instream flow targets and annual total instream flow shortages are shown at the four SB-3 control points in Figures 6.25 through 6.28. In general, the average instream flow shortages (blue lines) are relatively small compared to the average instream flow targets (red lines) at all four control points.

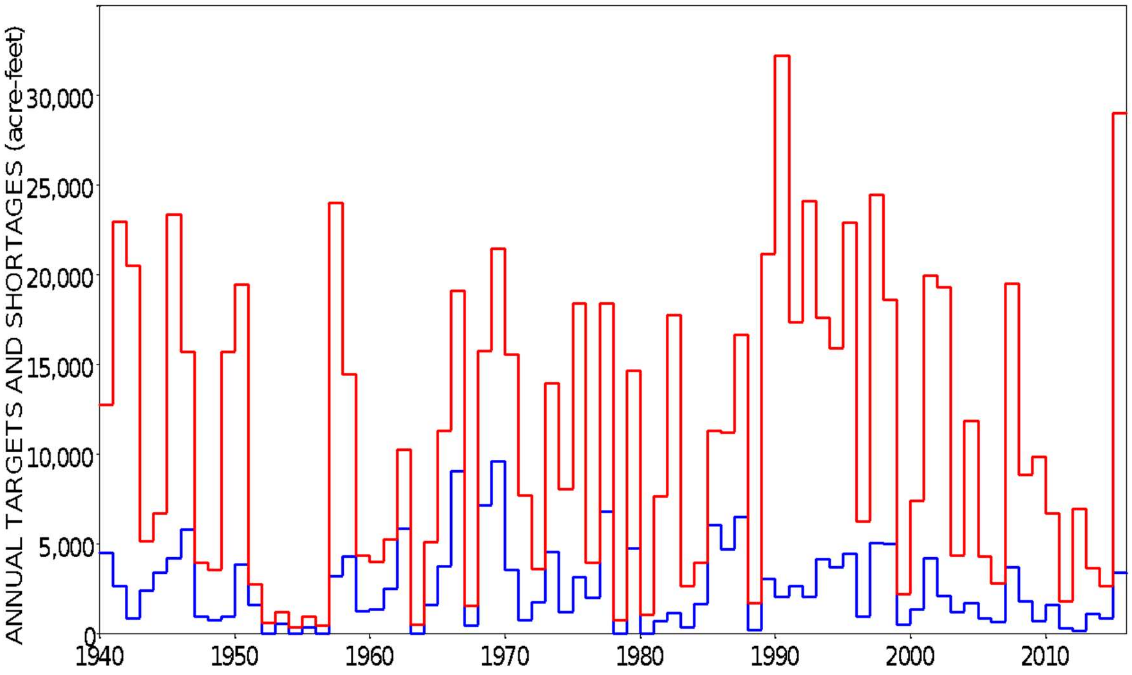


Figure 6.25 Annual Target and Shortage Volume in Acre-Feet/Year for 8WTGP

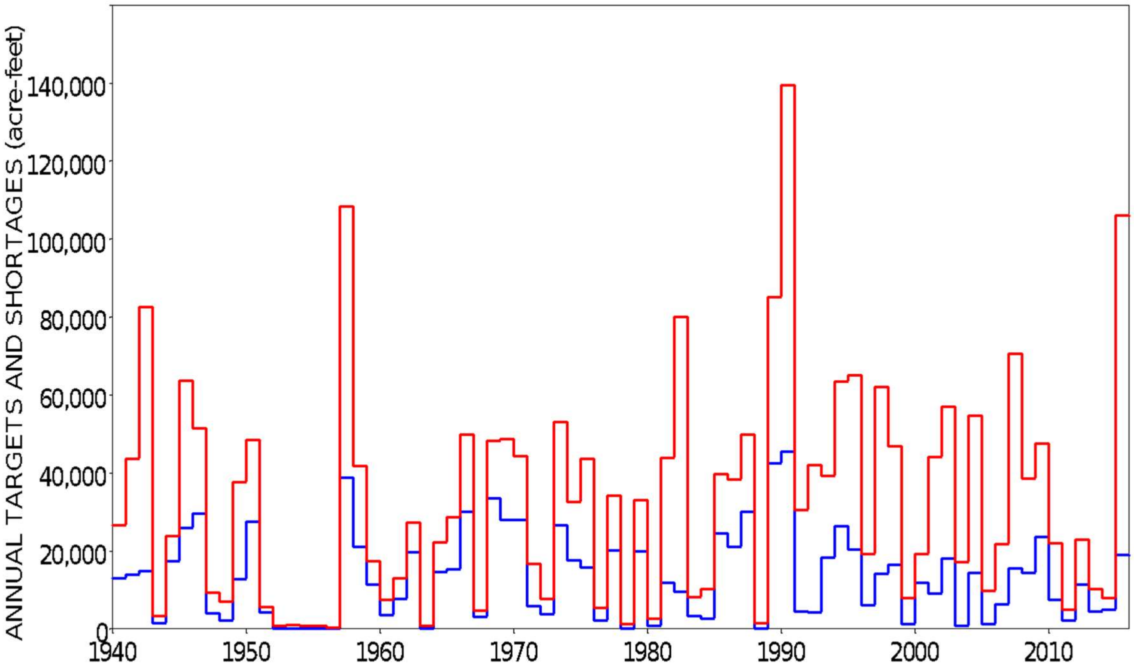


Figure 6.26 Annual Target and Shortage Volume in Acre-Feet/Year for 8TRDA

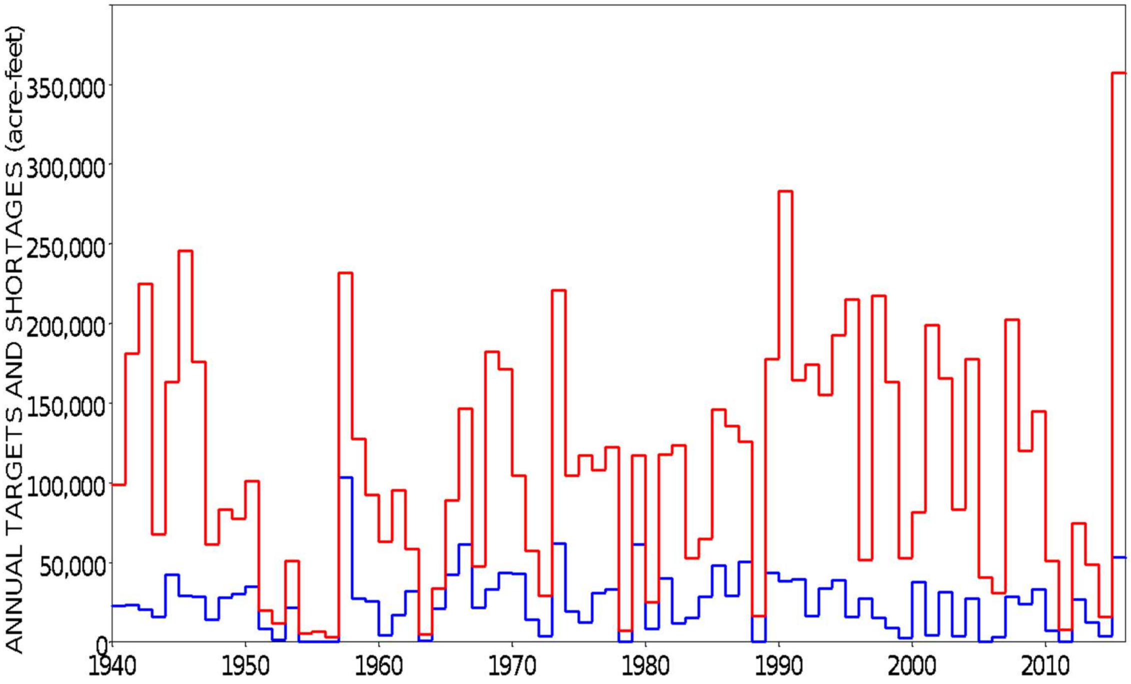


Figure 6.27 Annual Target and Shortage Volume in Acre-Feet/Year for 8TROA

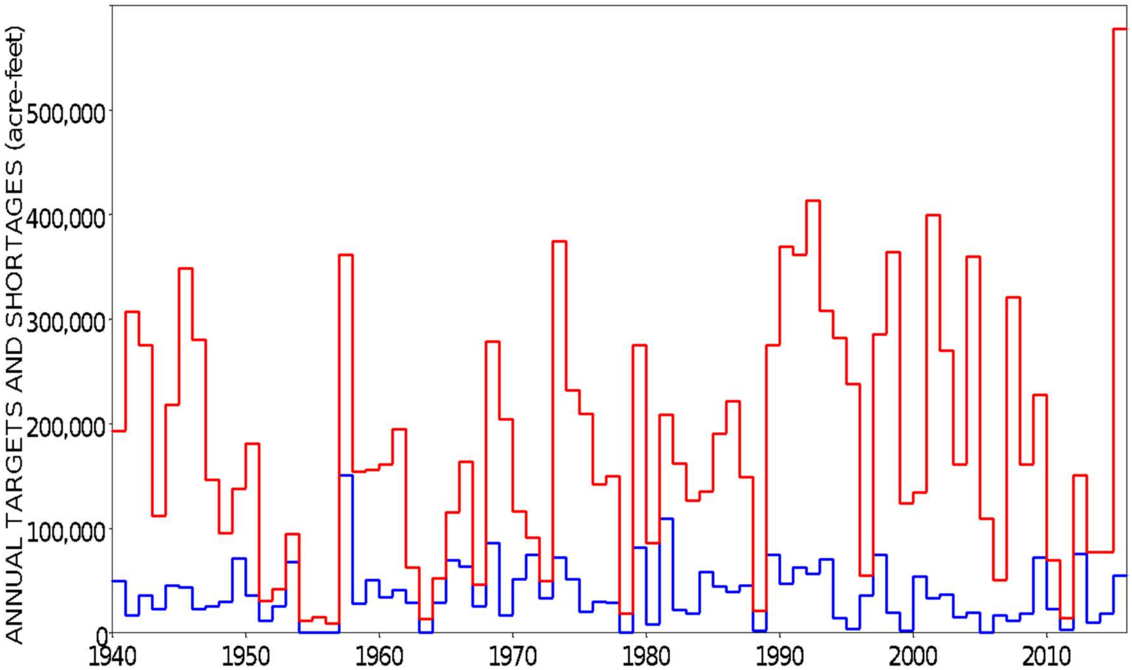


Figure 6.28 Annual Target and Shortage Volume in Acre-Feet/Year for 8TRRO

6.6. Simulation Results Analyses of Neches River Basin

The Daily SIMD of the WRAP modeling system are applied for the authorized use scenario Neches WAM to present comparative analyses of different daily flow sequences and frequency metrics. The frequency metrics result of for control point NENE, NERO, ANAL, NEEV are provided in Table 6.13.

Table 6.13 Flow Frequency for Selected Control Points at the Neches River

	Regulated Flow		**Instream Target**		**Instream Shortage**		**Unappropriated Flow**	
	NENE	NERO	NENE	NERO	NENE	NERO	NENE	NERO
Mean	679.06	2352.7	140.25	424.38	10.38	6.4	498.03	1881.32
SD	969.74	3079.81	184.4	515.12	38.65	58.43	900.39	2970.28
Min	0	0	0	0	0	0	0	0
99.5%	0	0	0	0.01	0	0	0	0
99%	0	0.03	0	1.65	0	0	0	0
98%	0	8.09	0	5.66	0	0	0	0
95%	0.15	34.83	0.13	17.95	0	0	0	0
90%	8.94	68.61	4.93	38.59	0	0	0	0
85%	18.09	117.5	9.36	67	0	0	0	0
80%	25.33	163.69	13.03	67	0	0	0	0
75%	34.42	242.49	17.96	74.33	0	0	0	0
70%	43.55	326.98	22.32	90	0	0	0	0
60%	85.01	623.18	46	90	0	0	8.83	163
50%	246.55	1067.11	80	233.45	0	0	25.87	445.89
40%	458.07	1704.33	96	420	0	0	147.31	978.03
30%	798.95	2707.03	196	420	0	0	414.6	1909.76
25%	1014.09	3366.67	196	603	0	0	616.76	2571.32
20%	1281.43	4264.46	196	603	0	0	913.63	3449.69
15%	1536.89	5258.69	229.27	603	0	0	1262.57	4668.8
10%	1917.31	6413.31	462.06	1546.09	28.85	0	1639.69	5714.62
5%	2583.04	8580.11	705.04	1725.8	75.22	5.87	2353.34	7977.11
2%	3605.99	11765.5	739.31	1858.95	130.24	82.18	3445.62	11163.39
1%	4501.91	13680.54	749.84	1865.62	207.21	166.99	4100.13	13077.53
0.50%	5268.62	15874.66	759.05	1912.67	302	375.54	5165.1	15269.7
Max	6976.54	23933.17	769.04	1975.32	390.78	1439.52	6880.53	23513.17
	ANAL	**NEEV**	**ANAL**	**NEEV**	**ANAL**	**NEEV**	**ANAL**	**NEEV**
Mean	880.02	6364.27	187.43	1215.96	3.51	178.17	668.25	5143.33
Std Dev	1136.05	7608.18	247.04	961.24	28.39	397.74	1072.84	7236.83
Min	0	0	0	0	0	0	0	0
99.50%	0	0	0	0	0	0	0	0
99%	0	0	0	0	0	0	0	0
98%	0	6.67	0	12.4	0	0	0	0
95%	7.87	59.56	4.24	63.27	0	0	0	0
90%	18.17	148.74	9.57	150.69	0	0	0	0
85%	34.17	260.44	18.34	250.34	0	0	0	0
80%	53.94	512	40	512	0	0	0	0
75%	86.69	580	40	512	0	0	0	0
70%	119.6	1070.37	43.56	512	0	0	0	152.44
60%	230.88	2027.15	52	580	0	0	29.3	743.7
50%	371.21	3285.2	90	873.23	0	0	152.69	1761.68
40%	640.55	5130.14	90	1804	0	0	314.33	3453.64
30%	1049.1	7959.77	277	1804	0	34.25	672.66	6211.02
25%	1292.57	9601.77	277	1925	0	134.95	919.69	7716.39
20%	1621.44	11746.75	277	1925	0	304.63	1193.33	10065
15%	1953.16	14312.71	287.14	1943.2	0	428.18	1673.72	12487.16
10%	2481.15	17269.03	782.31	2203.13	0	598.47	2161.4	15465.04
5%	3317.47	21828.86	1787.35	3394.31	459.64	2594.65	2992.43	20338.77
2%	4260.35	27783.37	2070.55	3755.11	793.25	3973.73	4074.28	25858.3
1%	4768.48	31429.82	4033.33	3856.83	1068.80	4924.67	4543.47	29504.82
0.50%	5176.96	27570.95	4033.33	3875.38	1349.57	7065.08	4899.96	32225.86
Max	7874.5	46051.32	4033.33	3934.81	2320.70	10048.37	7784.5	50905.55

As shown in Table 6.12 the mean shortage of environmental flow targets is from minimum 3.15 to maximum 185.17cfs. For control points ANAL and NERO, the regulated flow meets the environmental flow target engaged by the WRAP model for 95% of the period-of-analysis; while control points NENE and NEEV are 90% and 70%, respectively. Figures 6.25 through 6.28 present annual total SB3 environmental flow targets and shortages. The annual shortages (blue lines) developed in monthly simulations are significantly lower than the annual targets (red lines).

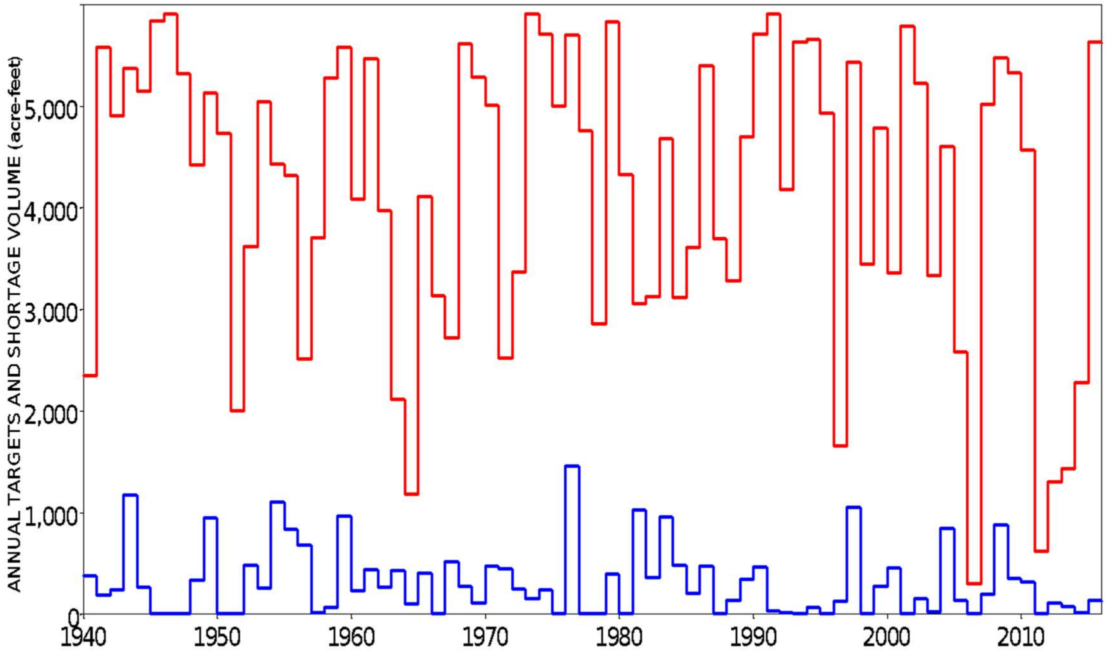


Figure 6.29 Annual Target and Shortage Volume in Acre-Feet/Year for NENE

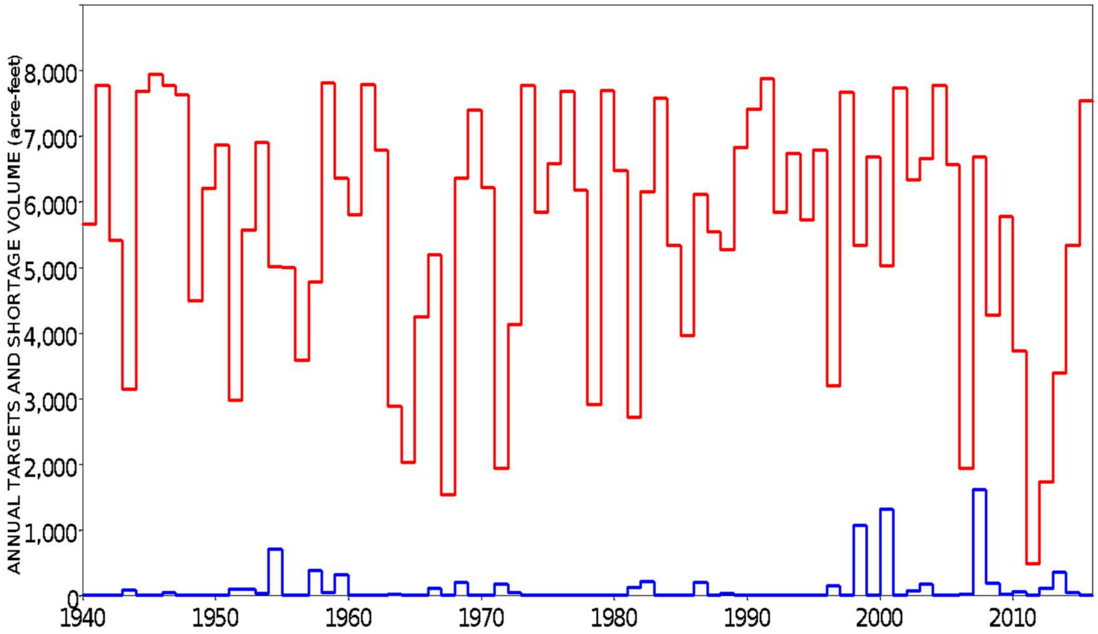


Figure 6.30 Annual Target and Shortage Volume in Acre-Feet/Year for ANAL

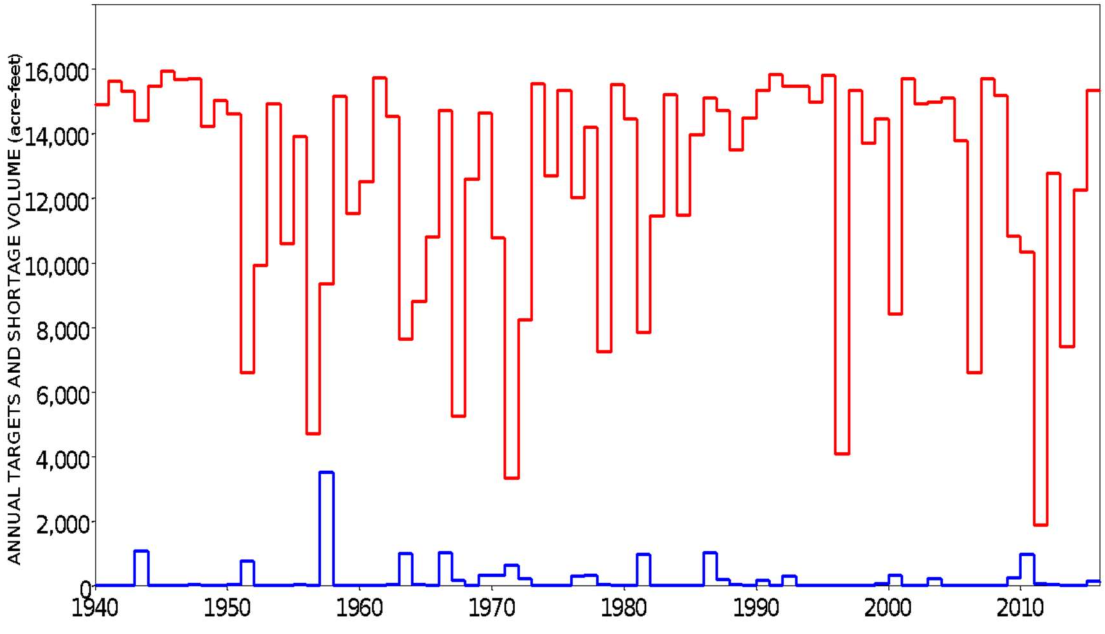


Figure 6.31 Annual Target and Shortage Volume in Acre-Feet/Year for NERO

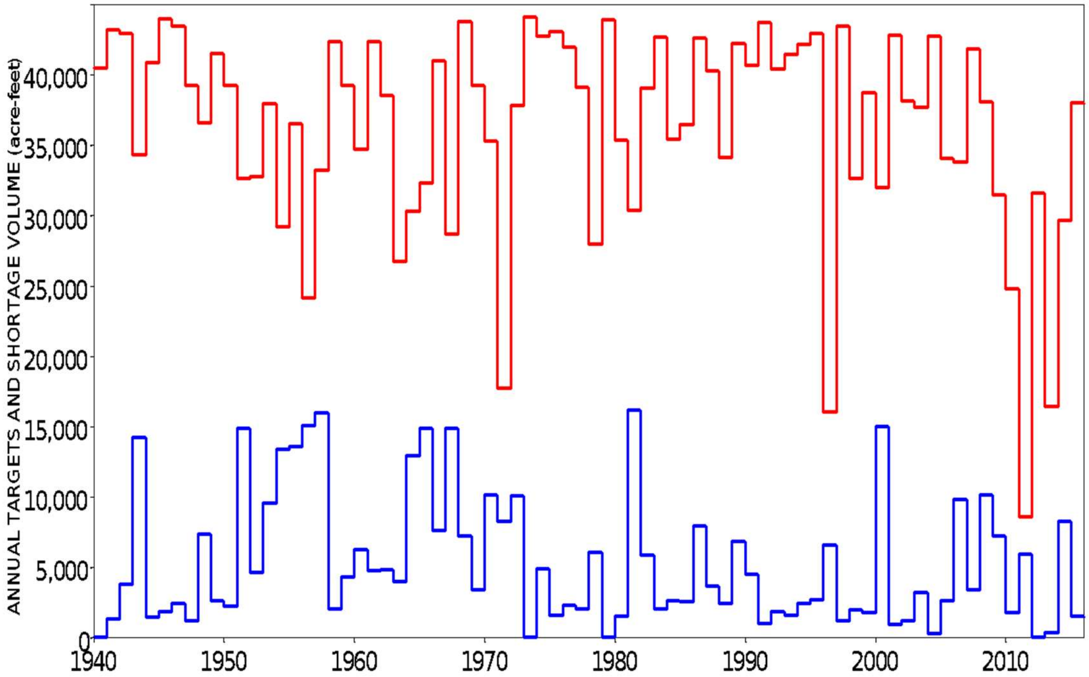


Figure 6.32 Annual Target and Shortage Volume in Acre-Feet/Year for NEEV

7. SUMMARY AND CONCLUSIONS

River basin hydrology in Texas is characterized by extreme variability and flow fluctuations, including severe multiple-year droughts and major floods. The worst droughts in the history of the Brazos, Trinity, Colorado, Guadalupe and San Antonio (GSA), river basins occurred during in 1950-1957. But for both the Neches and Sabine River basins located in East Texas, there is no severe drought period. These highly variable stream flows are not only distributed among numerous and diverse water users but also an important component of ecosystem health. Conversely, the cumulative effects of water use and water resource development have also been critical to alteration of streamflow characteristics, which can affect aquatic ecosystem structure and function. In order to maintain an ecological environment and reduce contention of future permit applications, the environmental flow standards for major Texas rivers and bays were established by Senate Bill 3. Water rights in Texas are managed by Water Availability Modeling (WAM), according to the doctrine of prior appropriation ("first in time, first in right"; Caroom and Maxwell 2009). The new daily version of the WAM modeling system was improved by hydrology updates and expanded capabilities for incorporating environmental instream flow standards. The simulation results by application to SB3 environmental flow standards at selected control points in the three River Basins are illustrated in this research.

The primary purpose of this dissertation is to develop a better understanding of flow characteristics and long-term changes in flow regime by applying of the IHA software for the Sabine, Neches, Guadalupe-San Antonio, Trinity, Brazos, Colorado Rivers and their major tributaries. The research also includes Brazos and Trinity case study assessments of capabilities of river systems to meet environmental flow standards and evaluations of the impacts of the environmental flow standards on river systems using the new daily version of the WRAP modeling system. Information developed and conclusions reached in this research are discussed in this final chapter.

7.1. Analyses of Flow Characteristics

River flow characteristics were displayed using time series plots, frequency or duration plots, and an array of different types of computed statistical frequency metrics. Changes in different flow types exhibit dramatic fluctuations at all sites. Long-term trends of decreases in flows are evident at some gauges; increases are evident at others. Some exhibit both increases and decreases, and some sites exhibit no evident long-term changes. The IHA program was applied to six selected river basins to assess the degree of hydrologic alteration attributed to human influence on an ecosystem. Analyzing flows by IHA in Chapter 4 presents examples assessment of the biologically relevant hydrologic alteration via streamflow data. The plots of 7-day maximum observed flow rates are in Appendix A, and 7-day minimums are in Appendix B.

The changes are very different between river basins and different sites. For example, the 7-day minimum flows for most stations on the Trinity River show an upward trend over the periods of record. Simultaneously, both 7-day minimum and maximum flows have increased over the past-periods at gage sites on the San Antonio River. Water supply entirely from groundwater, wastewater treatment and increased rainfall runoff due to urbanization can be expected to contribute to increased stream flow. Conversely, in the Colorado River basin, the post-impoundment 7-day maximum for most stations is significantly decreased from pre-impoundment; the changes in the 7-day minimum are relatively small. Dams, irrigation and lower precipitation accompanying with high evaporation in this watershed can explain reduced stream flow.

The observed daily flow duration curves are plotted in Appendix C for selected gaging stations with two time periods. The hydrologic alteration factors of Appendix D calculated with the IHA software can be quite useful when evaluating changes in hydrologic parameter values over time. The seasonal and statistical results generated via the IHA process are informative. These analyses supply a first approximation of the altered stream flow regimes and have proven the IHA is useful for characterizing unimpacted flow regimes and anthropogenic impacted river flows in six selected river basins. They can also be used to summarize long periods of daily data into a much more manageable series of ecological hydrologic parameters. Meanwhile, a feasible approach for calculating the characteristics of natural and altered hydrologic regimes is shown by application of the IHA software.

Current use scenario WAM simulations are presented in Chapter 5. Frequency metrics for naturalized and regulated flows at Brazos and Trinity River basins are also provided in Chapter 5. Although the characteristics of observed flows in Texas vary significantly due to development of water resources management, the WAM system naturalized and regulated flows should be conceptually homogeneous without a long-term trend. The simulated unappropriated flows equal the summation naturalized flows remaining after the streamflow depletions, and return flows from all water rights, represent that the flows can be appropriate for the future water rights.

Notwithstanding, there are differences in the methods of the IHA-analyzed un-impacted and impacted periods and WAM-defined naturalized and regulated flows. Consequently, the results based on these simulations both show that long-term changes in observed daily and monthly flows in the majority of gage sites are non-significant, but changes appear to be relatively more evident downstream of major dams and diminish with distance. For example, both high-flow and low-flow pulses show a significant upward trend in West Fork Trinity River at Grand Prairie during the period of record. This station is strongly influenced by human activities, including upstream reservoirs and urban development. Reservoirs commonly reduce the largest stream flows while increase low flow, which potential reductions in environmental flow shortage. Studies also indicate that flow variability and long-term changes vary depending on time intervals, and reduce with the larger average time interval.

7.2. Environmental Flow Modeling Capabilities of the WRAP/WAM System

The Water Right Analysis Package (WRAP) incorporated in the TCEQ WAM System is a priority-based surface water allocation model. The latest version (July 2018) of the WRAP includes all the capabilities of previous versions, plus fully integrated and incorporated DSS; a new approach for modeling SB3 environmental flow standards; the addition of more SIM/SIMD simulation options; a new daily flows (DAY) program; and TABLES improvements.

Assessments of hydrology, environmental flow needs, and institutional water availability are essential for effective water management. One motivation for development of the daily WRAP-SIMD simulation model is providing opportunities for simulation of environmental flow standards. Establishment and integration of environmental flow standards pursuant to 2007 Senate Bill 3 inevitably add complexities to modeling comprehensive water management and allocation. Environmental management is concerned with minimizing the negative effects of human activities to protection and enhance the meet of ecological system. The Texas WAM system has been continually expanded and improved during the last several years, which is essential for effective water resources planning and administration of the water rights permit system in Texas. Recently, environmental flow standards have been incorporated within the daily WRAP system to model environmental requirements and their impacts on other water rights.

Modifications to expand the use of DSS files and HEC-DSSVue are meant to support both input and output data so that they are managed and analyzed much more efficiently. The establishment and modeling of instream flow standards have been included in in the original TCEQ WAM System datasets and incorporated in the WRAP simulation model for many years. However, compared to the previous version, the recently added features of the WRAP modeling system, especially for the specific records for modeling high-flow pulse events, provides more accurate determination of environmental flow targets and corresponding shortages in meeting these targets. The WAM simulation results as to reliability, frequency, and duration metrics in the preceding chapters are examined to evaluate the impacts of environmental flow standards on current water availability.

The environmental flow standards at 19 control point locations in the Brazos River basin, 4 control point locations in the Trinity River basin, and 5 control point locations in the Neches River basin were modeled using recently updated daily time-step versions of

WAMs. As the descriptions in Chapter 3 and 6 show, the environmental flow standards for each of the Brazos, Trinity and Neches River basins are significantly different in their level of complexity, computation of priority sequence, definition of hydrologic conditions, and number of high flow pulse events. The new version of the modeling system effectively incorporates the environmental flow standards to current water right permit priority sequence. Compared to that of the Trinity and Neches River basins, the EFS in the Brazos River basin is more complex, including a greater number of control points, hydrologic conditions and high-flow pulse.

This study demonstrates new capabilities provided by the recently expanded version the WRAP programs. The four SB3 EFS components are applied within the WRAP/WAM system, which model offers many useful and more flexible functions for sets of simulation to model environmental instream flows. The methodology developed in Chapter 6 to model environmental instream flows at selected control points in the Brazos, Trinity and Neches River basins is illustrated in this research, which not only facilitated testing these new modeling capabilities but also contributes to the system of knowledge available for modeling standards in other basins. These results have been evaluated and summarized to assist future scientists and decision-makers to develop water management strategies for avoiding or mitigating impacts on natural environmental resources.

7.3. Evaluation of Environmental Flow Standards

The evaluation for the Brazos, Trinity and Neches River basins was performed using the results from WRAP-SIMD output files. The analyses were based on the results of two Brazos WAM simulations: one Trinity WAM and one Neches WAM simulation.

All simulation was completed for a 76-year period. For the first three simulations, in which the environmental flow standards were modeled at the priority dates specified by the Texas Administrative Code, these standards do not impact existing water rights because new environmental flow requirements are assigned as junior priority to all existing water rights. However, WAM also offered flexibility to set environmental flow requirements as the most senior priority in order to explore the impacts on current existing water rights. For the second Brazos WAM simulation, the environmental flow standards were set as the most senior priority date in the basin to compare the flow alterations. Sequenced results of statistics' likelihood, such as quantities, mean, standard deviation, and exceedance frequency are presented as plots and tables in Chapters 5 and 6. These metrics compare naturalized, regulated flows, instream flow targets and shortages at selected control points for alternative (daily and monthly) simulations. As expected and as the exceedance frequency plots have shown, the number of engaged days in which regulated flow was greater than or equal to the instream target, appearing to increase gradually upstream to downstream. Frequency analysis of unappropriated flows resulting from SIMD simulation were performed to evaluate the impacts of environmental flow standards on future water availability.

This research explored tools and ideas that have potential to improve the management of water resources from an ecological perspective. As the results in this dissertation show, water deficit went from being negligible at some sites to very large at other sites. The priority number influence the achievement of environmental flow standards. The amount of SB3 environmental flow standards shortage decreased when the instream flow standards were incorporated as the most senior priorities versus all other control points in the Brazos WAMs. Water management, like water marketing or transferring should be considered as an opportunity to improve the satisfaction of environmental flow requirements. Such transfers can move fresh water from other senior water right holder to environmental flows, which can be simulated and manage in the WAM system.

The validity of applying WAMs to model the impacts of environmental flow standards has been evidenced. The WRAP software significantly contributed to the effective provision of feedback regarding the existing SB3 flow standards and other water allocation planning. The output offered flexibility options to both evaluating the environmental flow standards individually and making comparisons with other simulated flow regimes. However, the results still have some inaccuracies in evaluating computed shortages. Further research may need more detailed investigations to enhance environmental flows by using multiple-purpose reservoir system operations while minimizing impacts on other water management purposes. Another important future research may need to be conducted to assess actual real-time capabilities for satisfying the instream flow targets under the effects of municipal, industrial, agricultural, and/or other water use, particularly during drought conditions. More research is needed to expand, evaluate and refine future water management strategies to avoid or mitigate anthropogenic effects on natural environmental resources, as appropriate.

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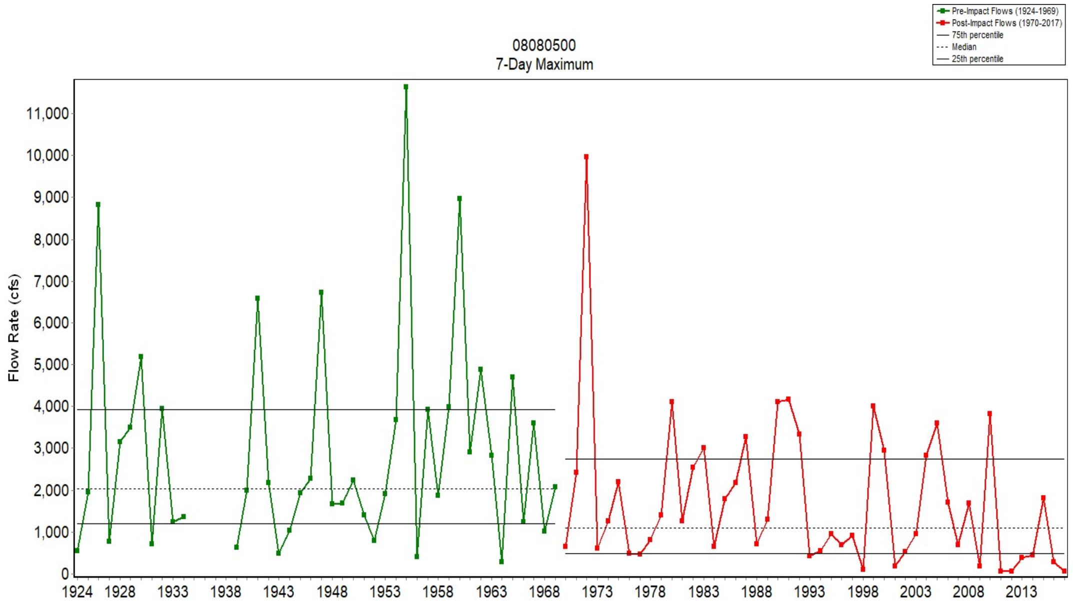
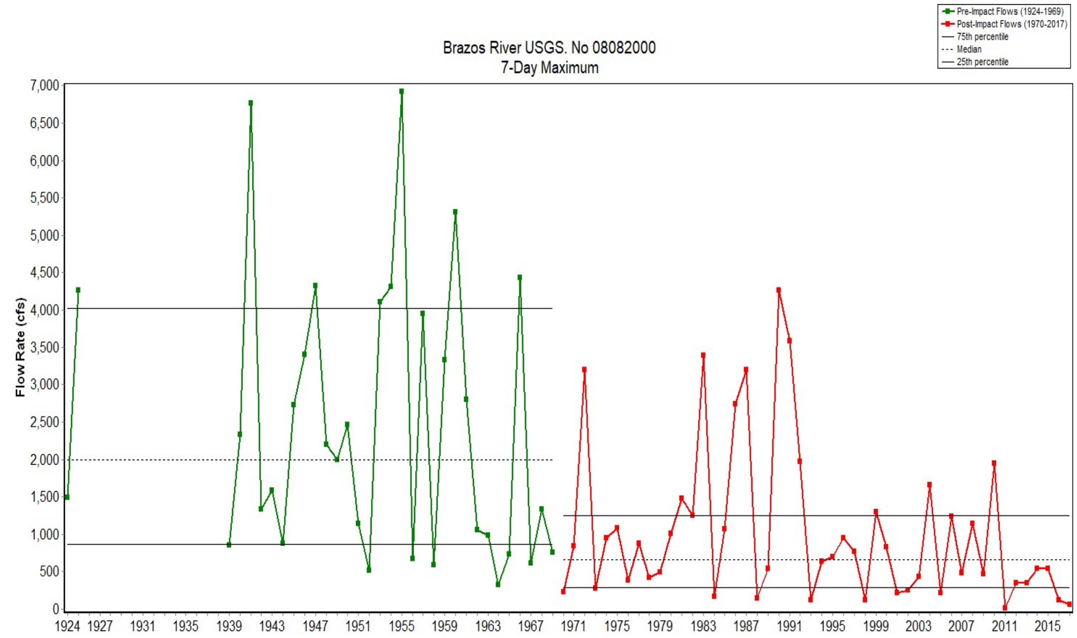
APPENDIX A



7-day Maximum Flow Rates of Double Mountain Fork near Aspermont



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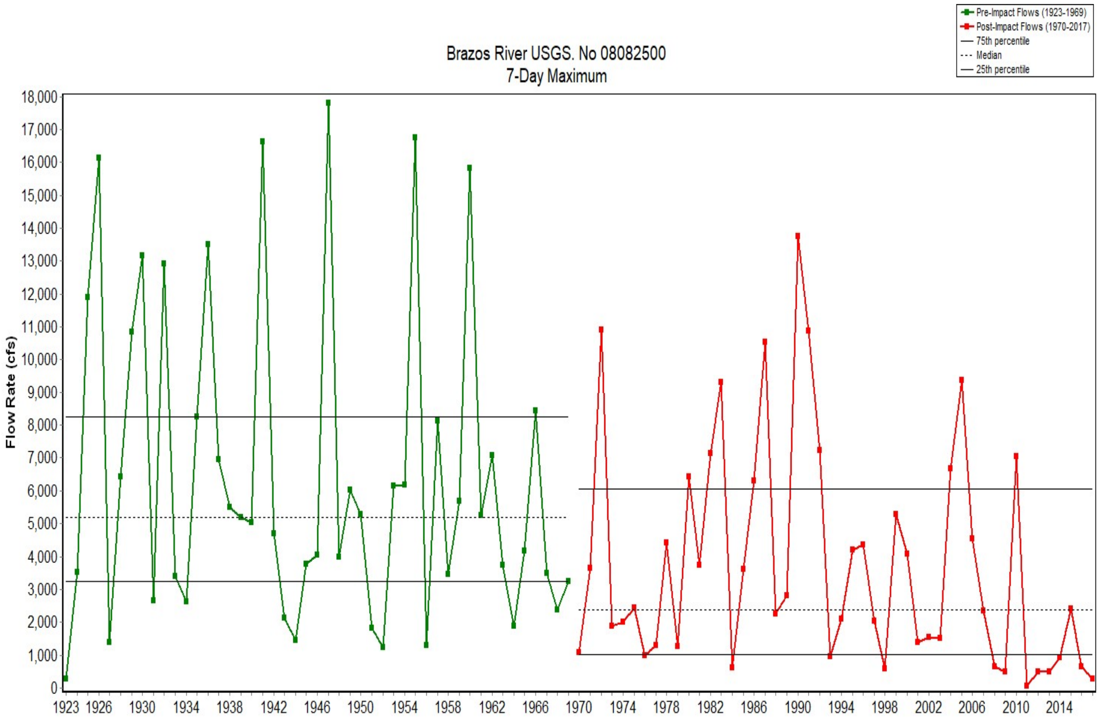

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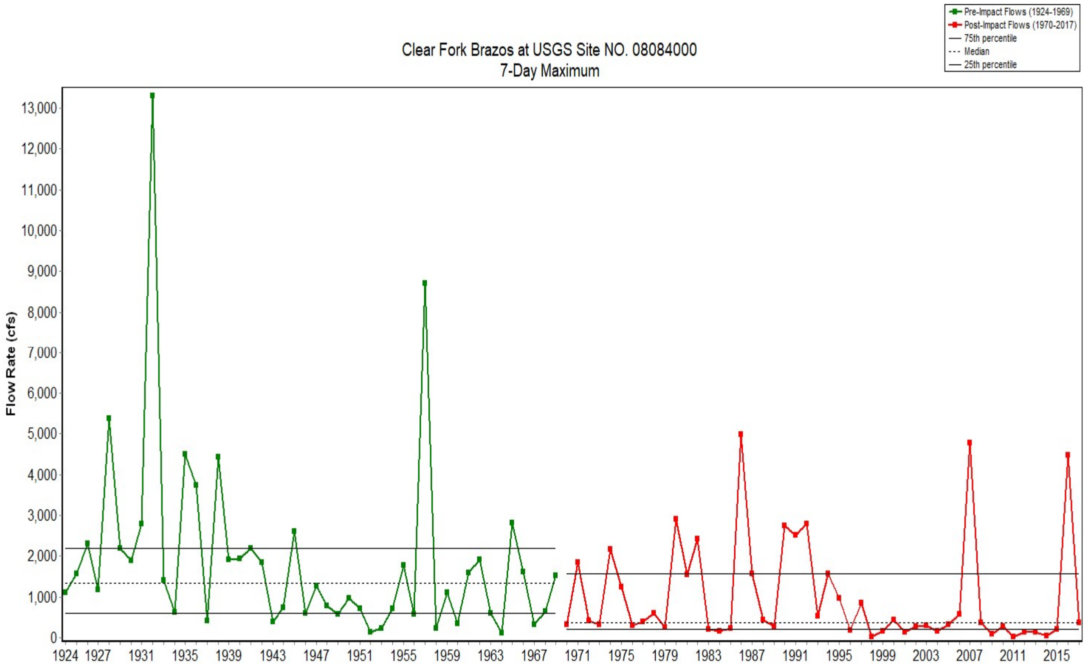

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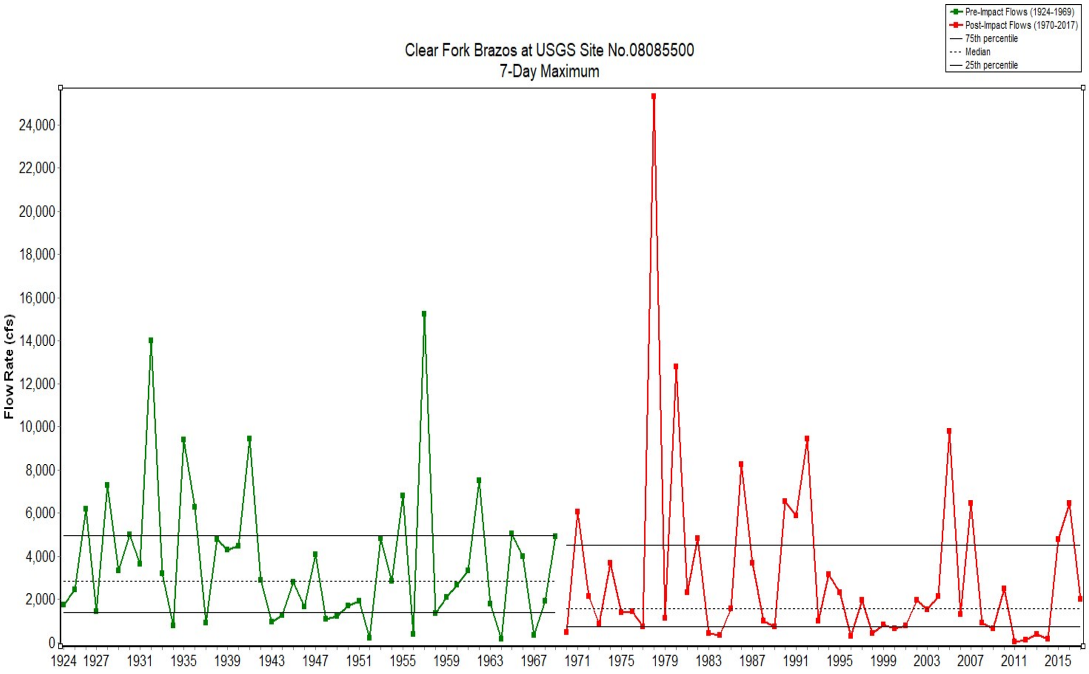

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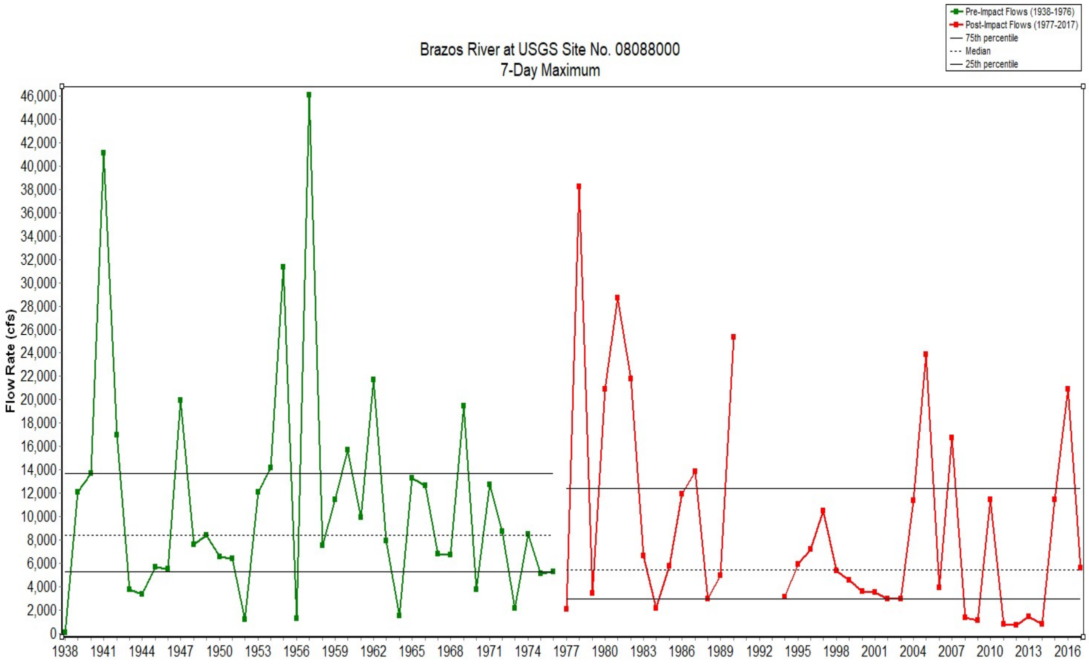

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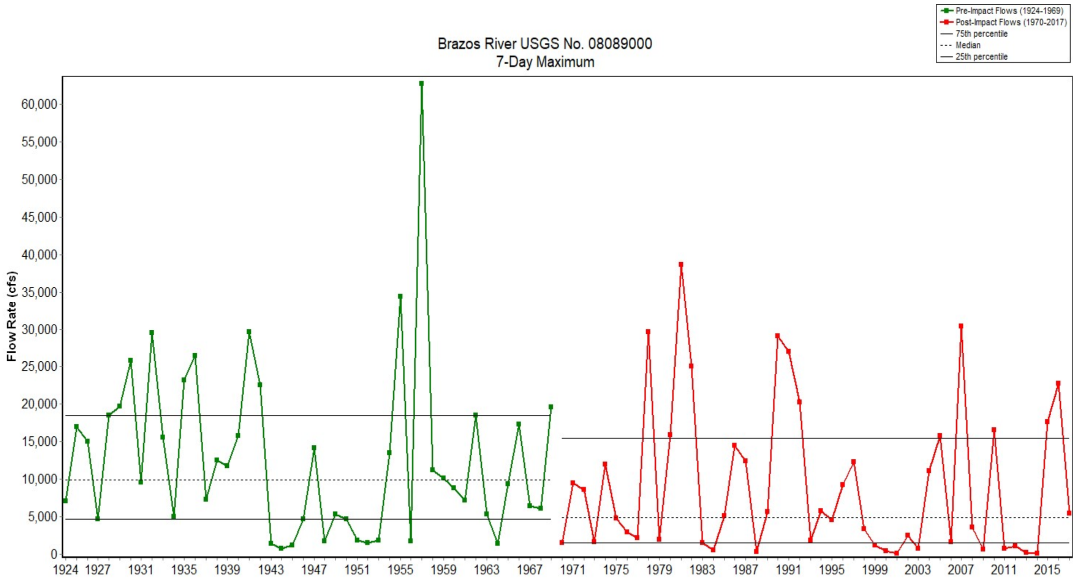

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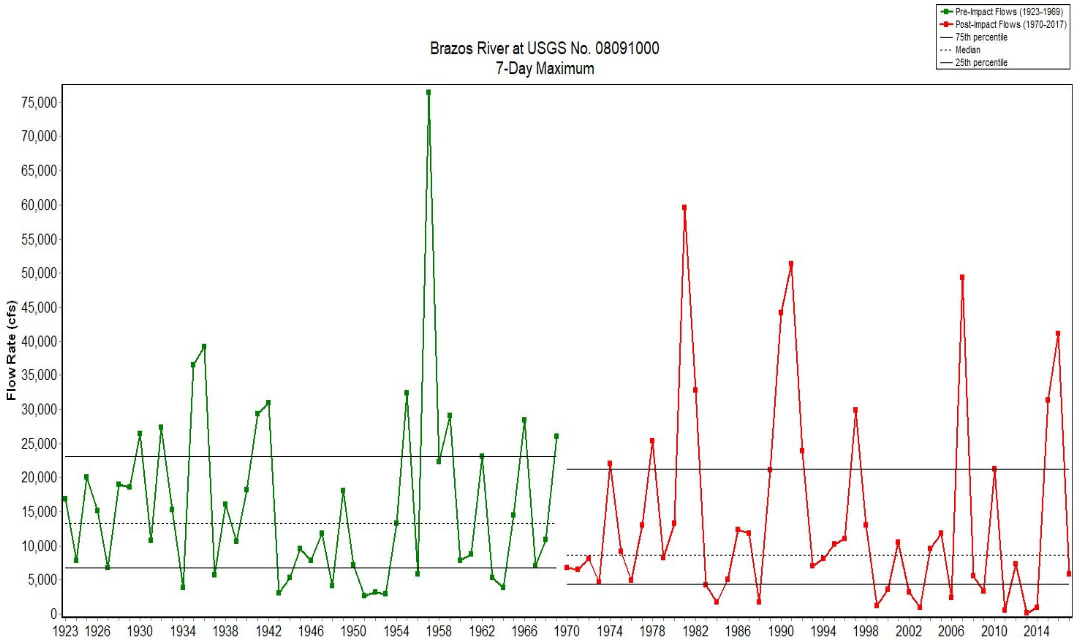

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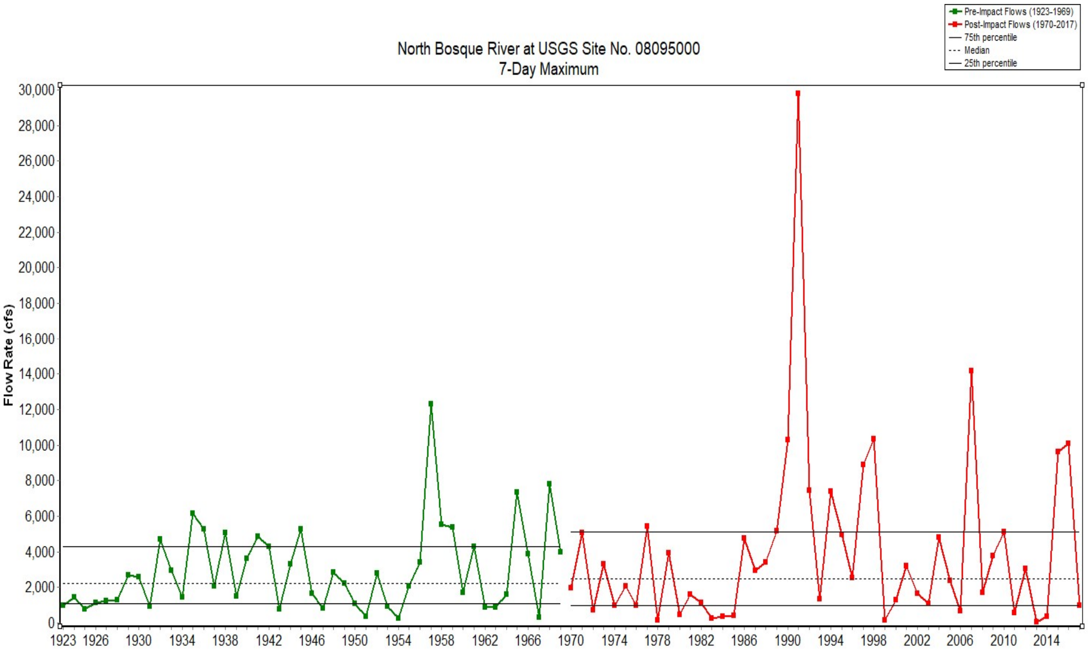

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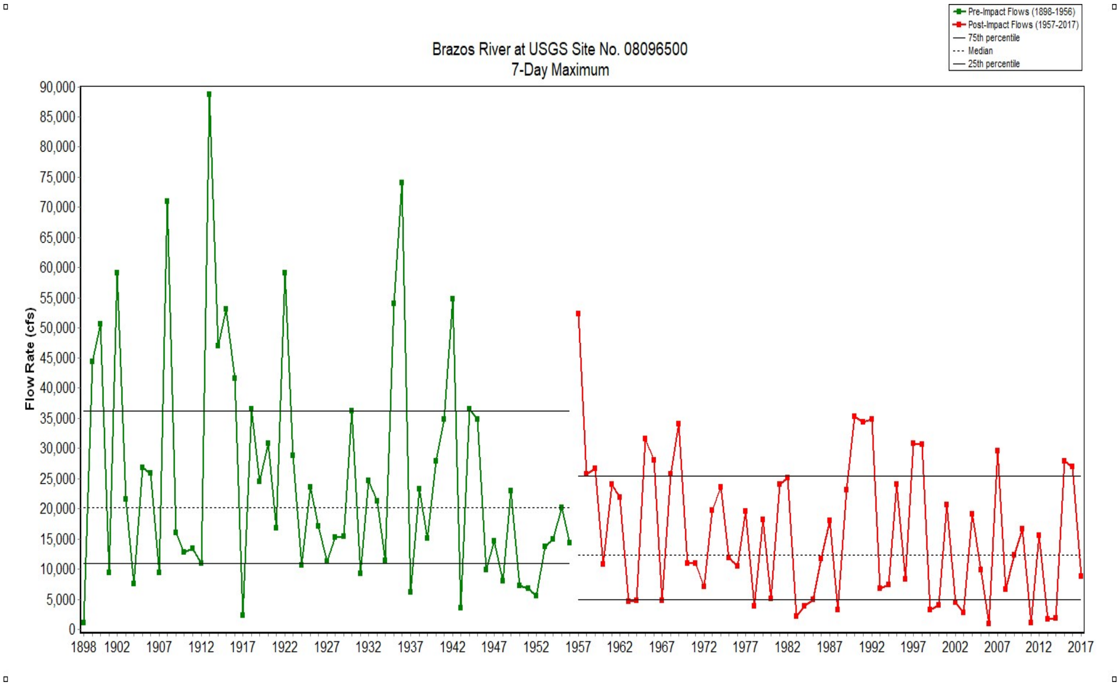

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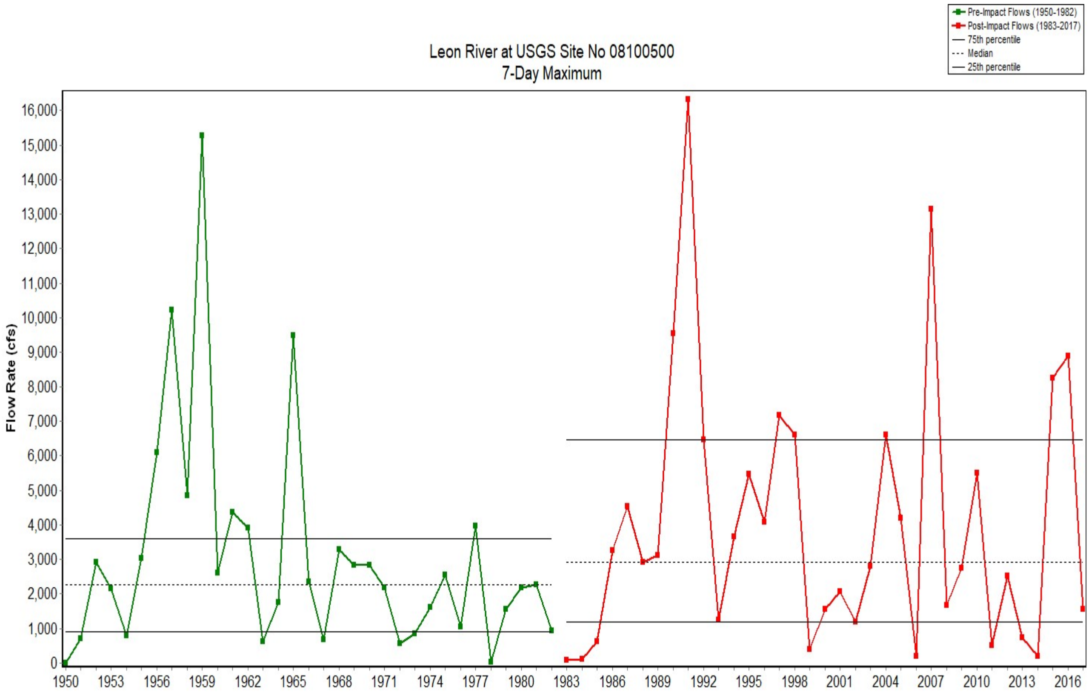

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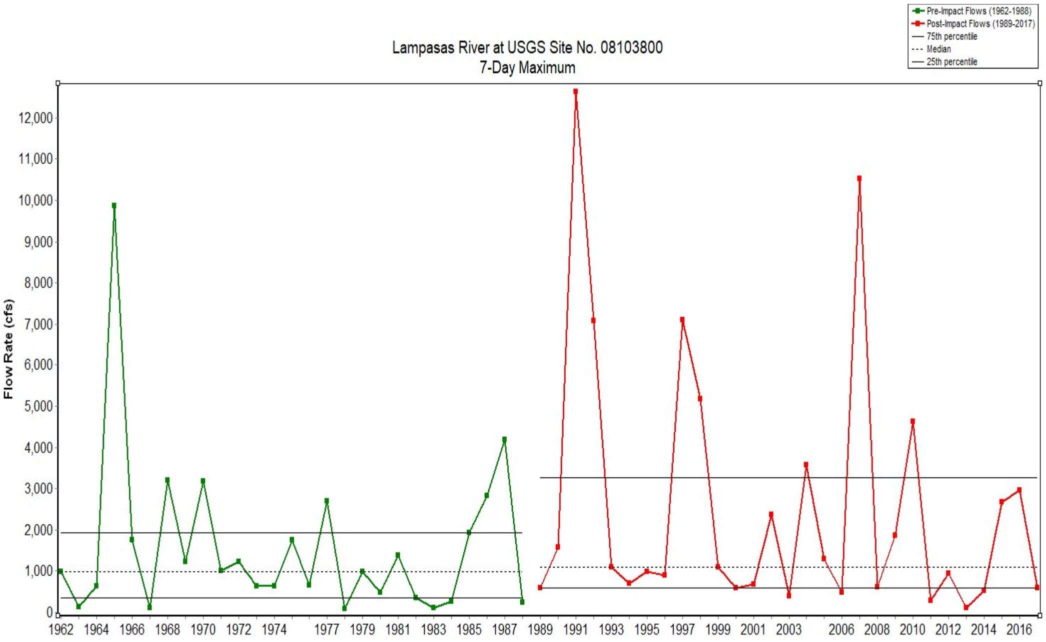

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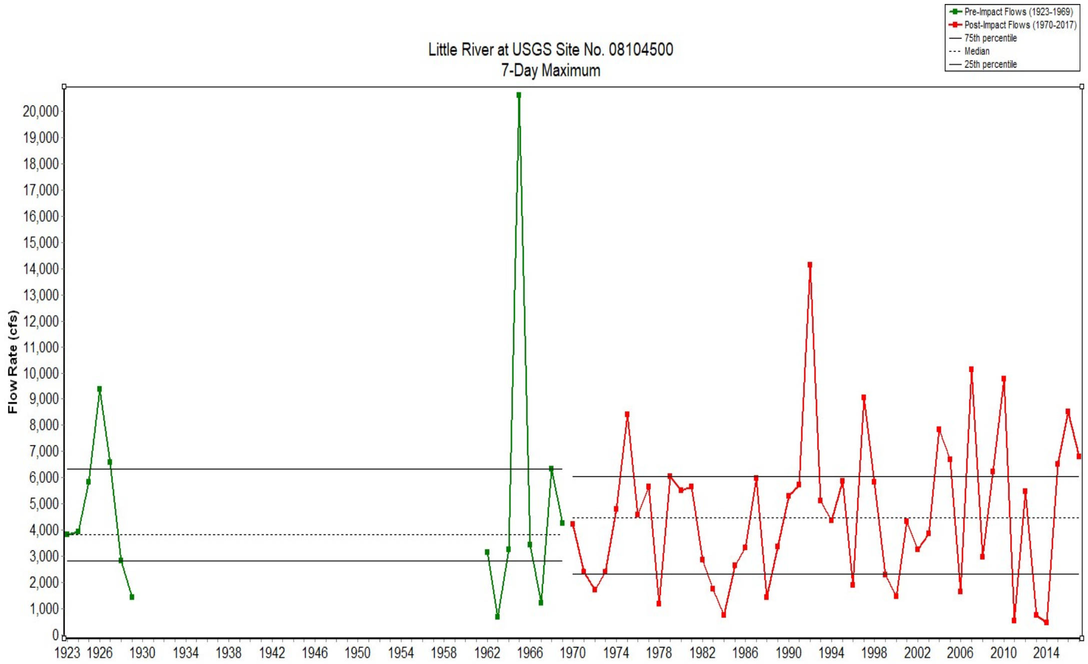

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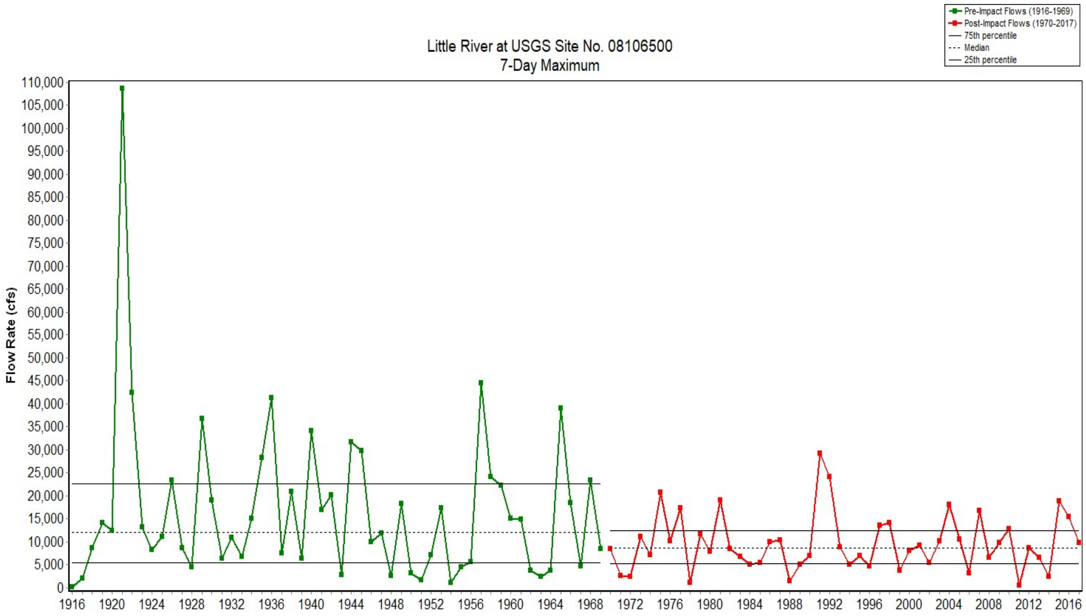

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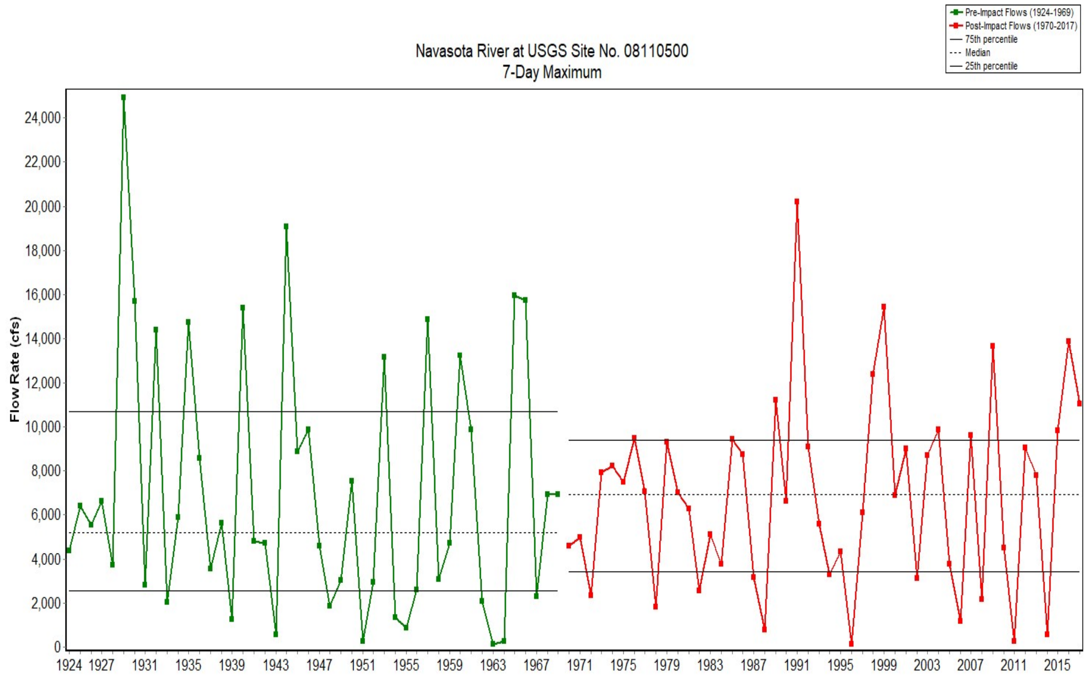

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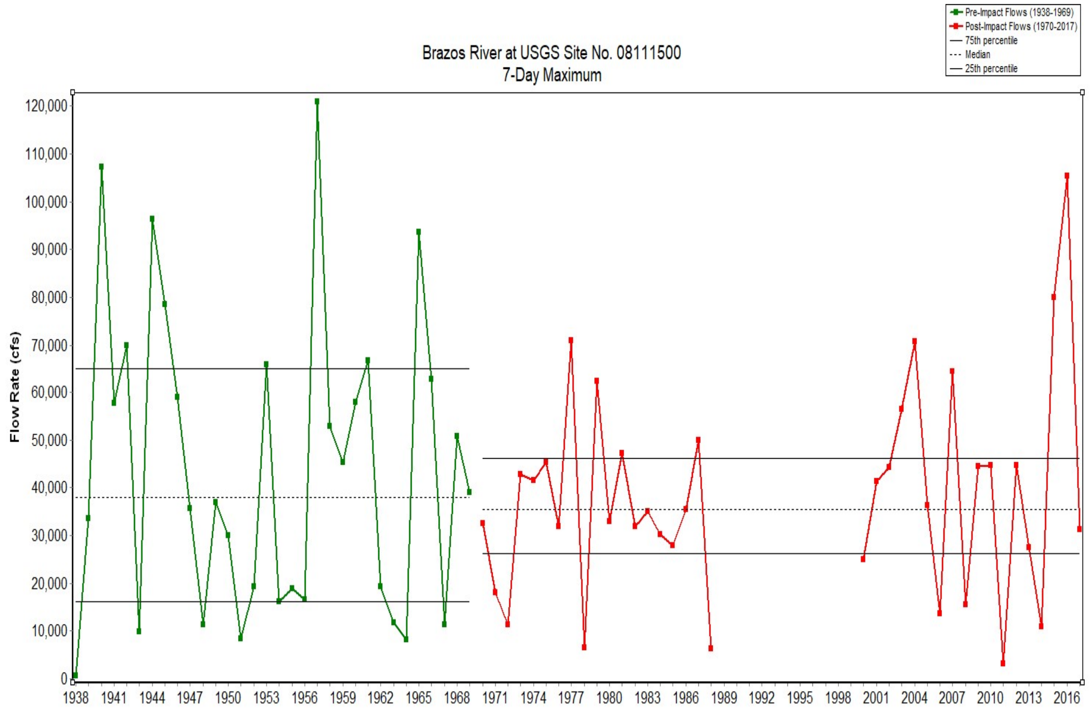

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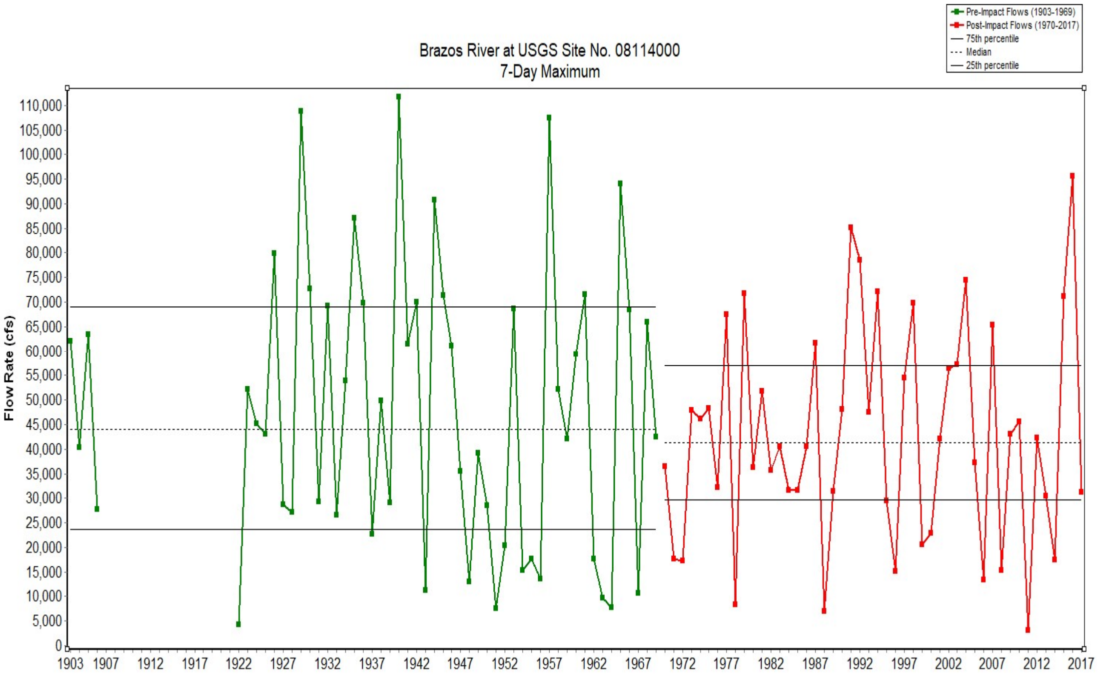

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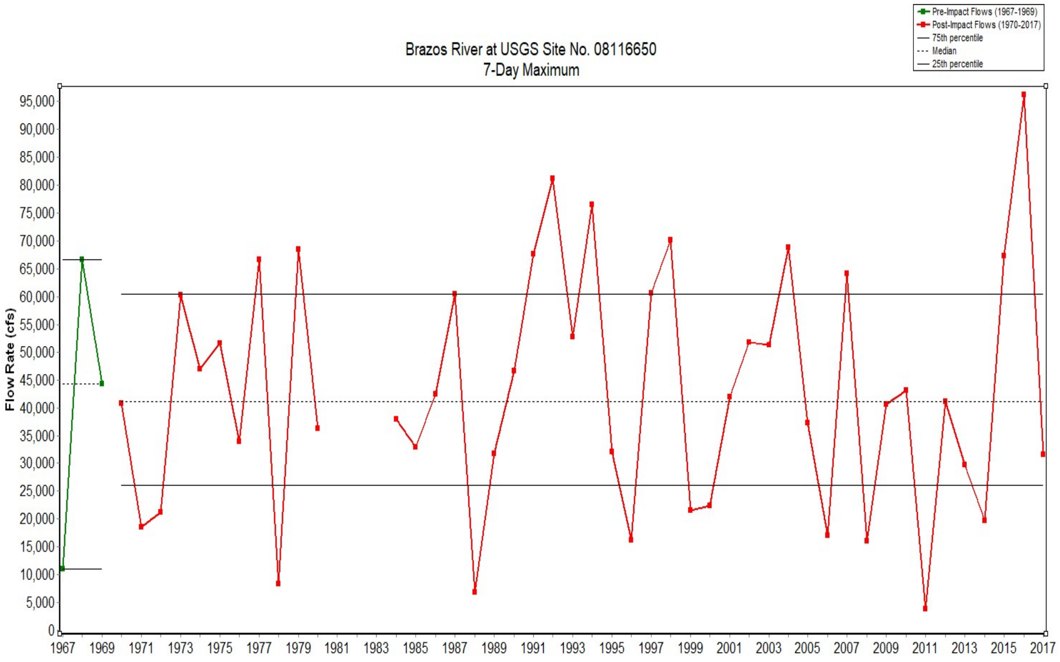

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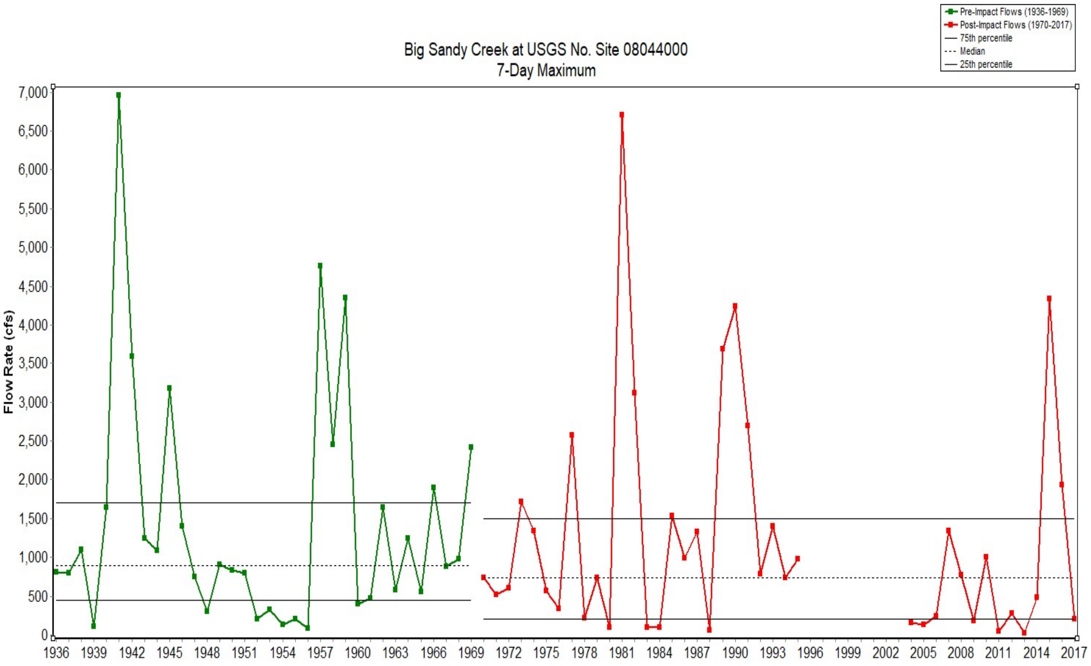

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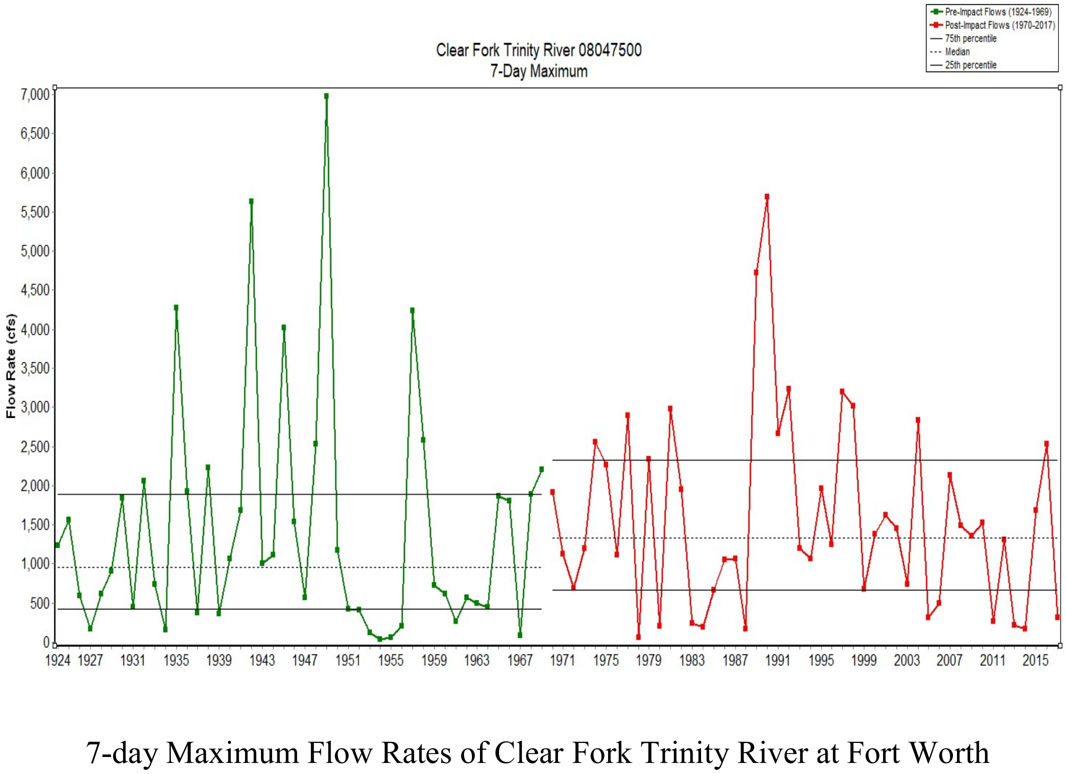
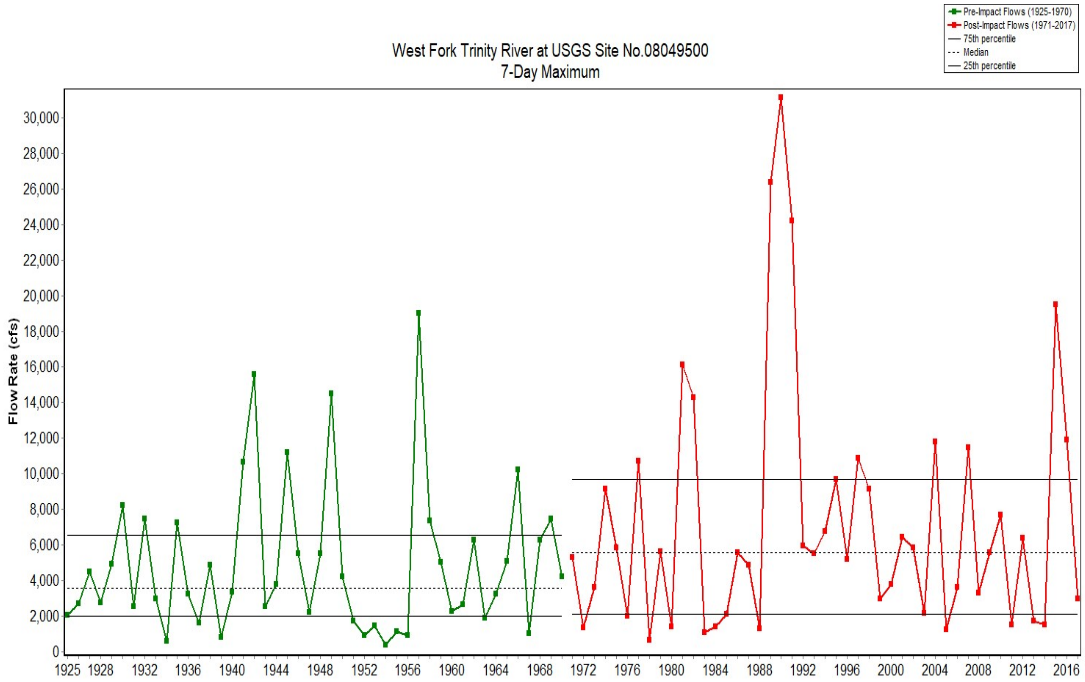


7-day Maximum Flow Rates of Clear Fork Trinity River at Fort Worth



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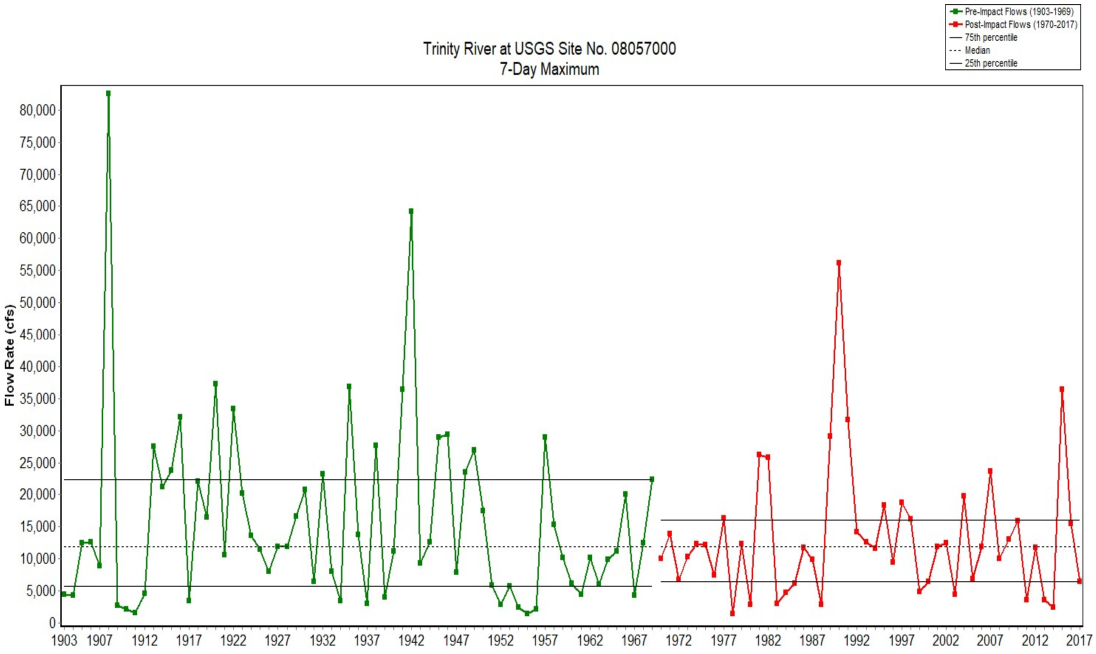

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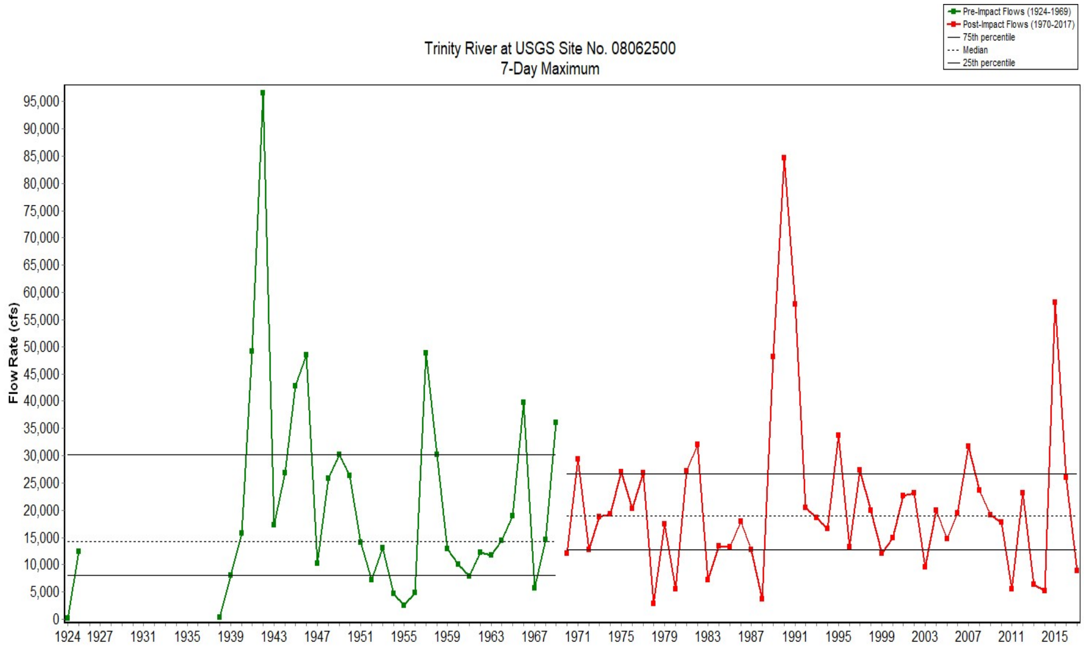

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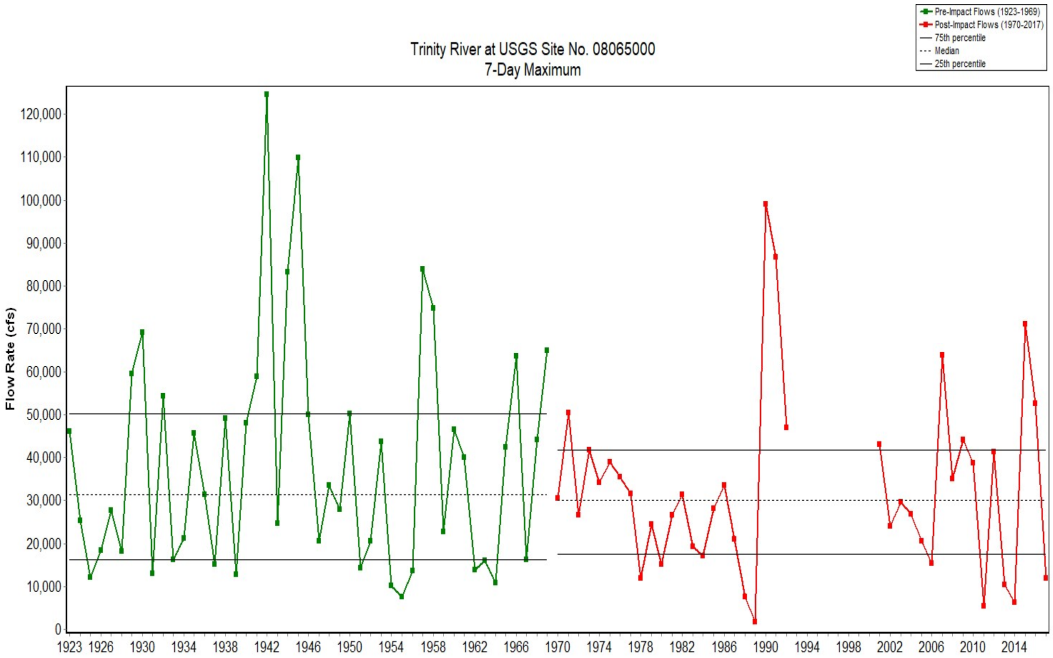

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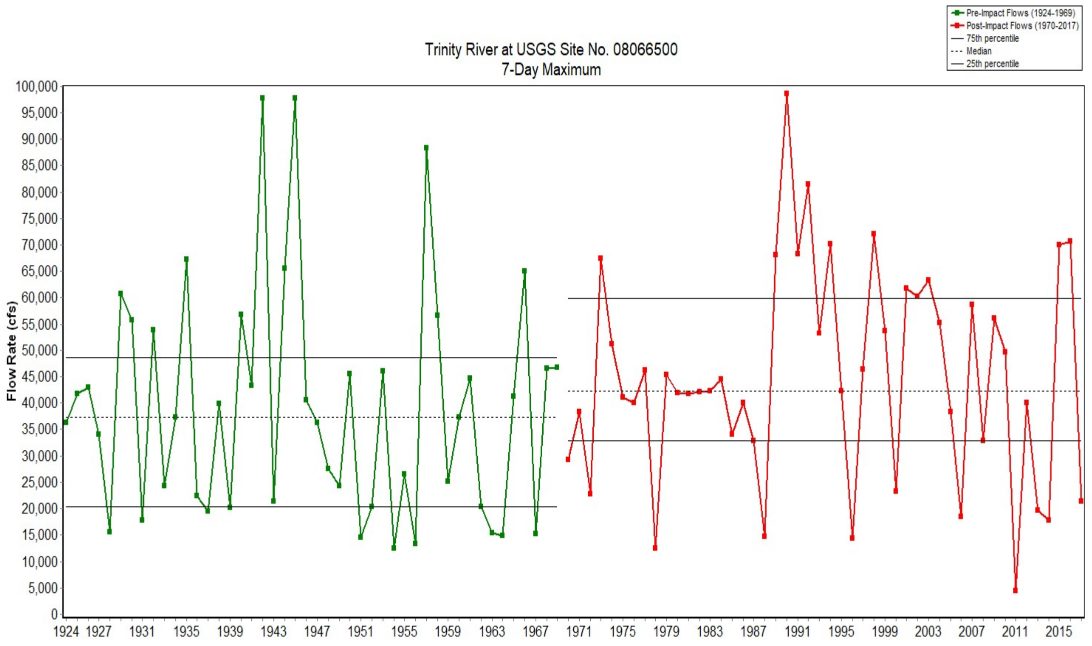

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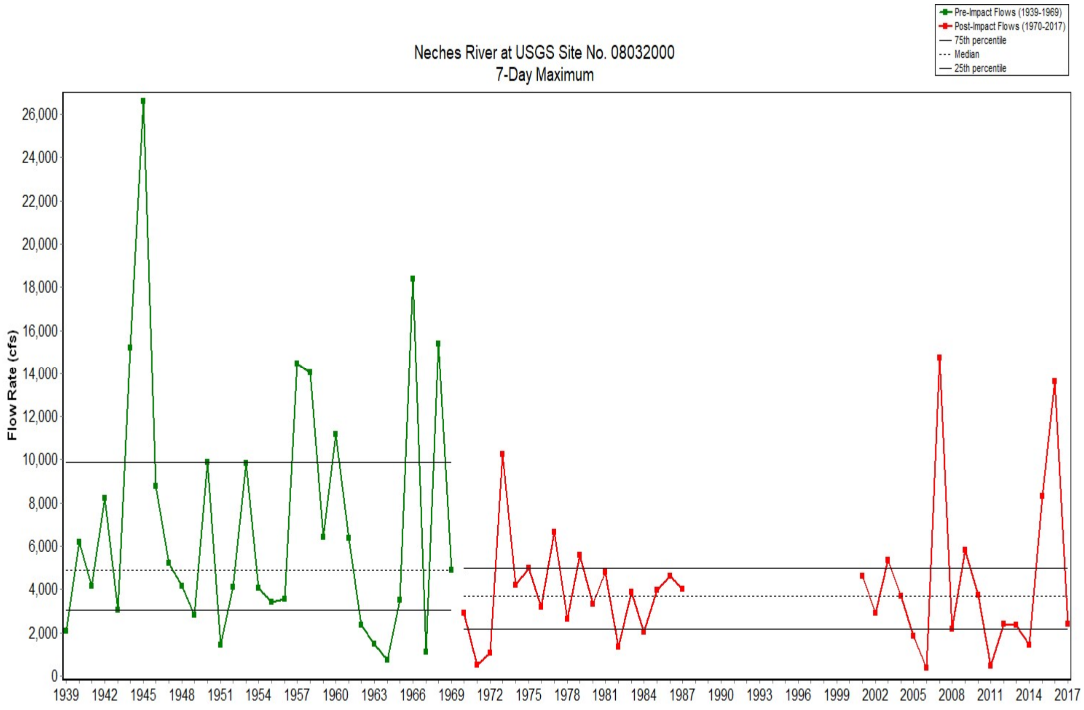

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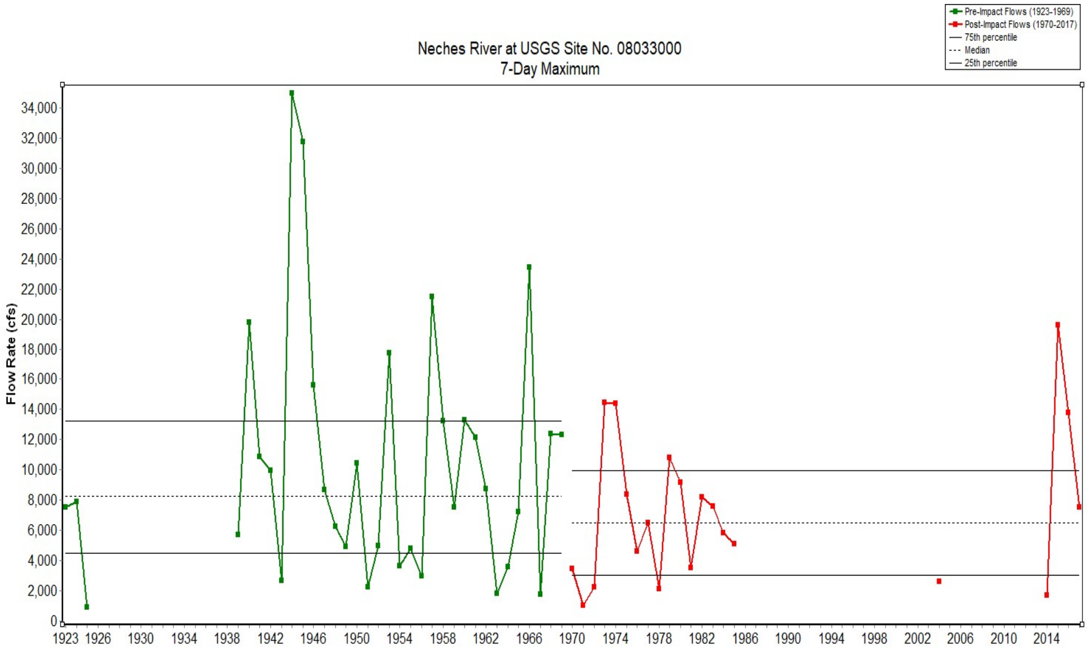

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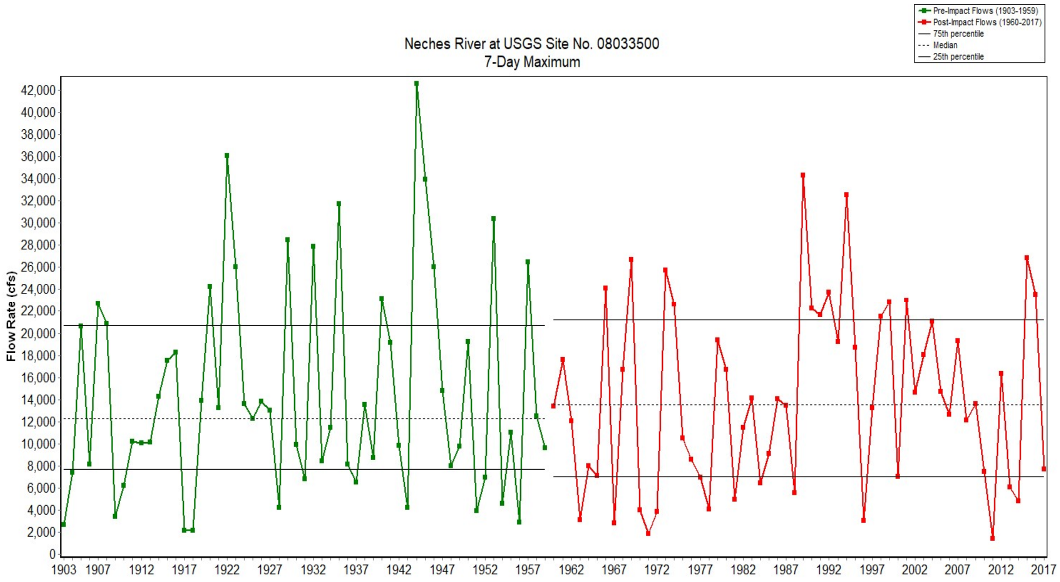

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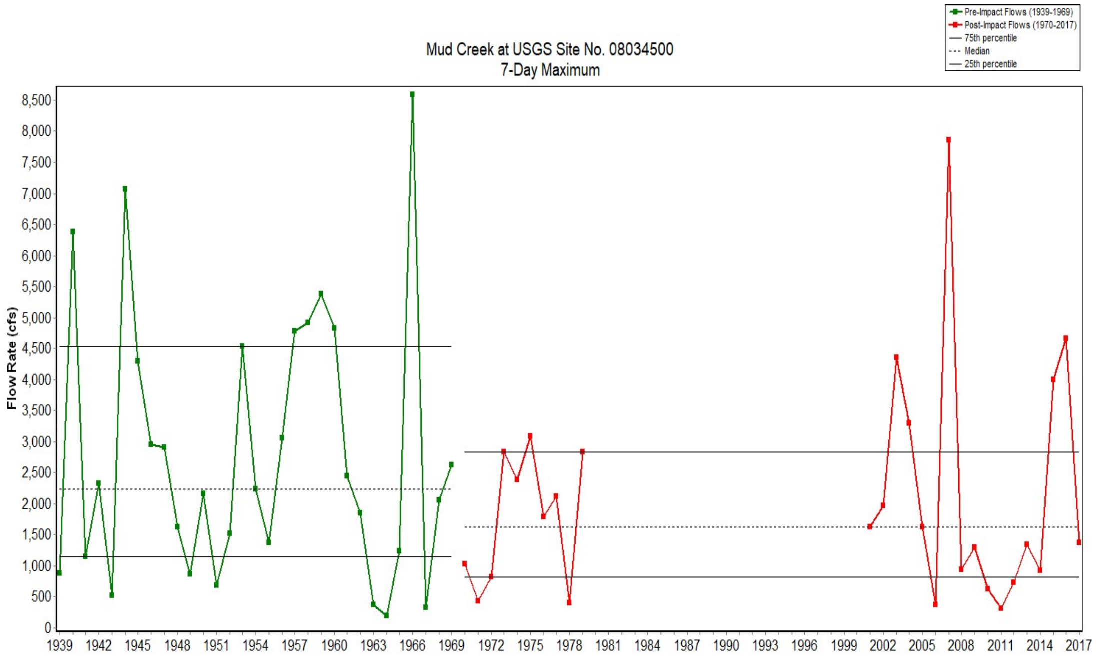

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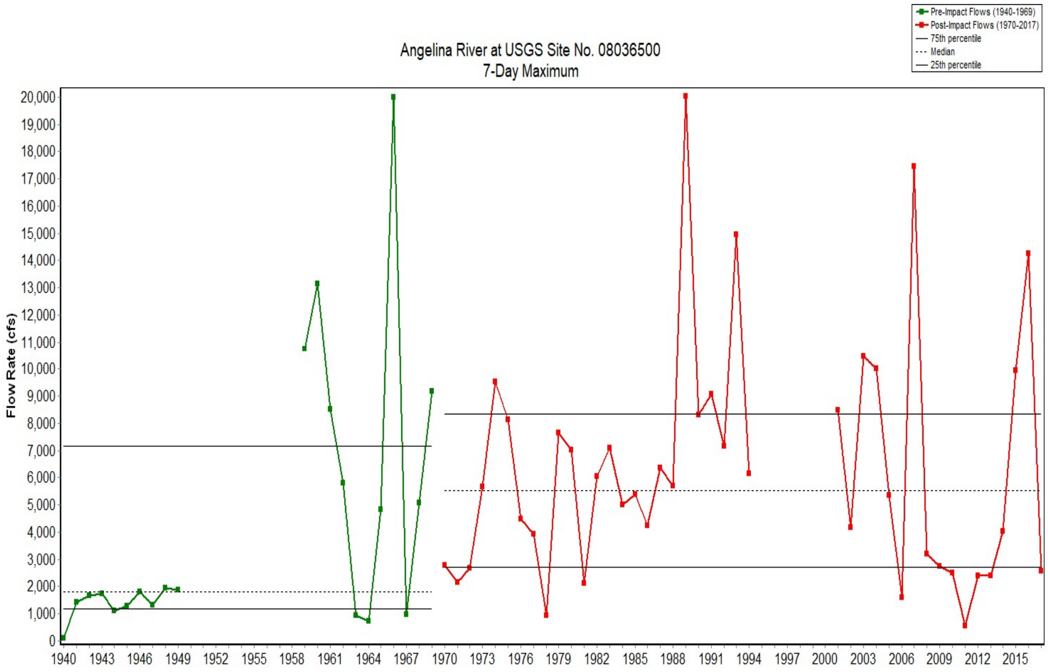

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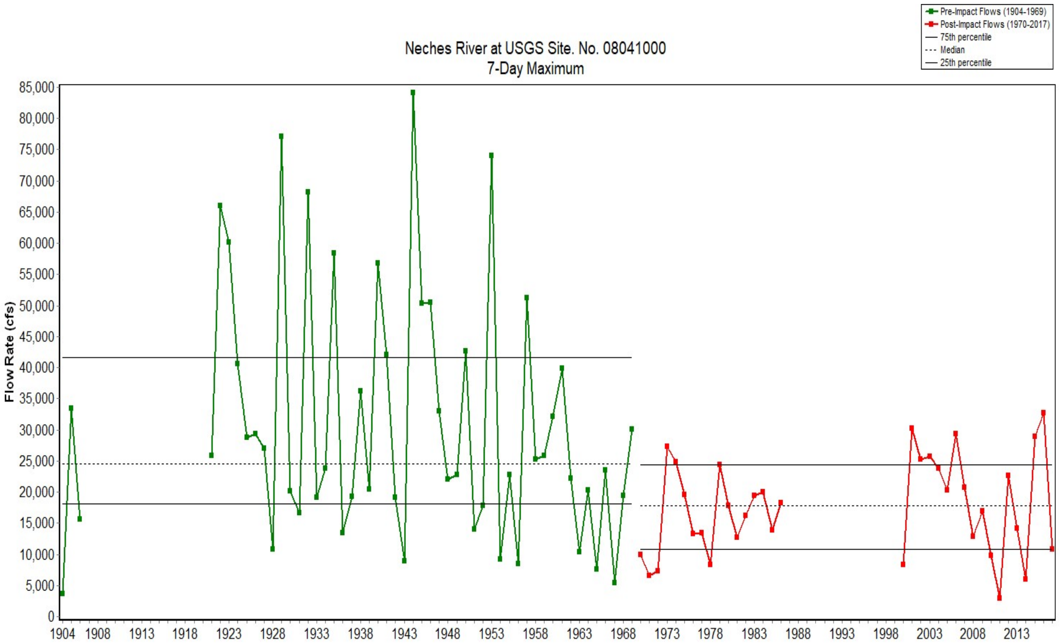

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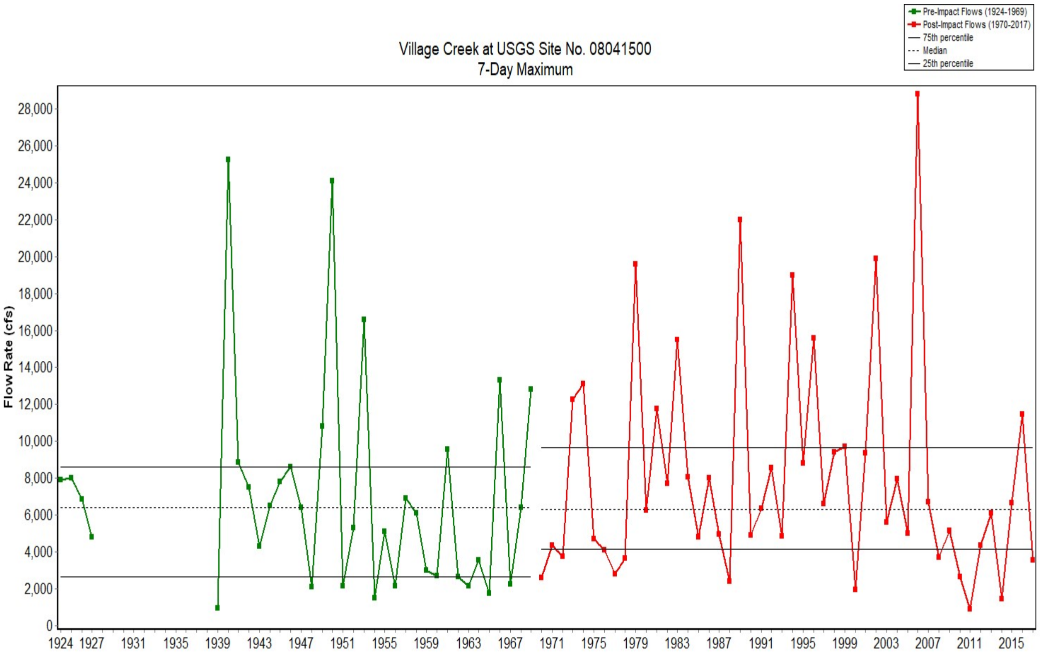

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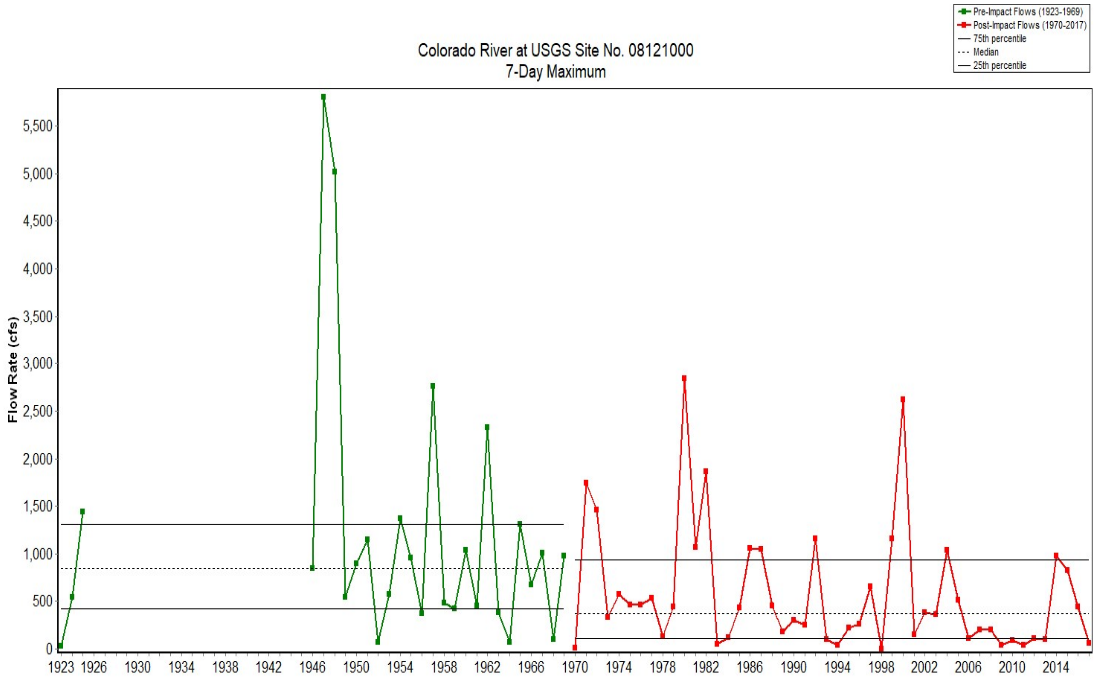

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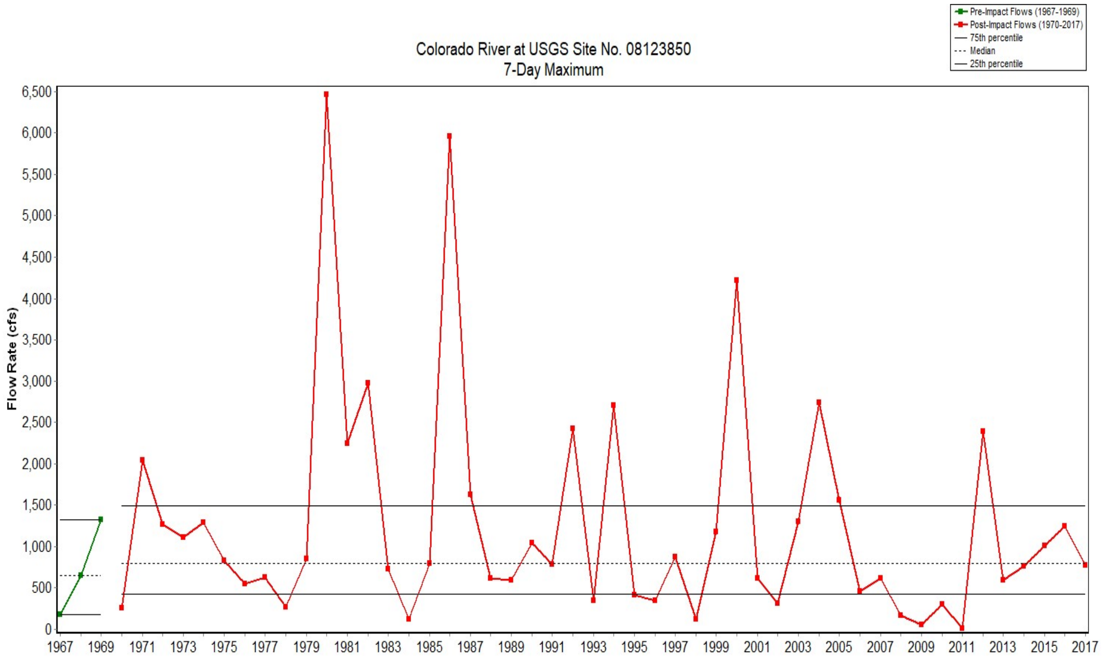

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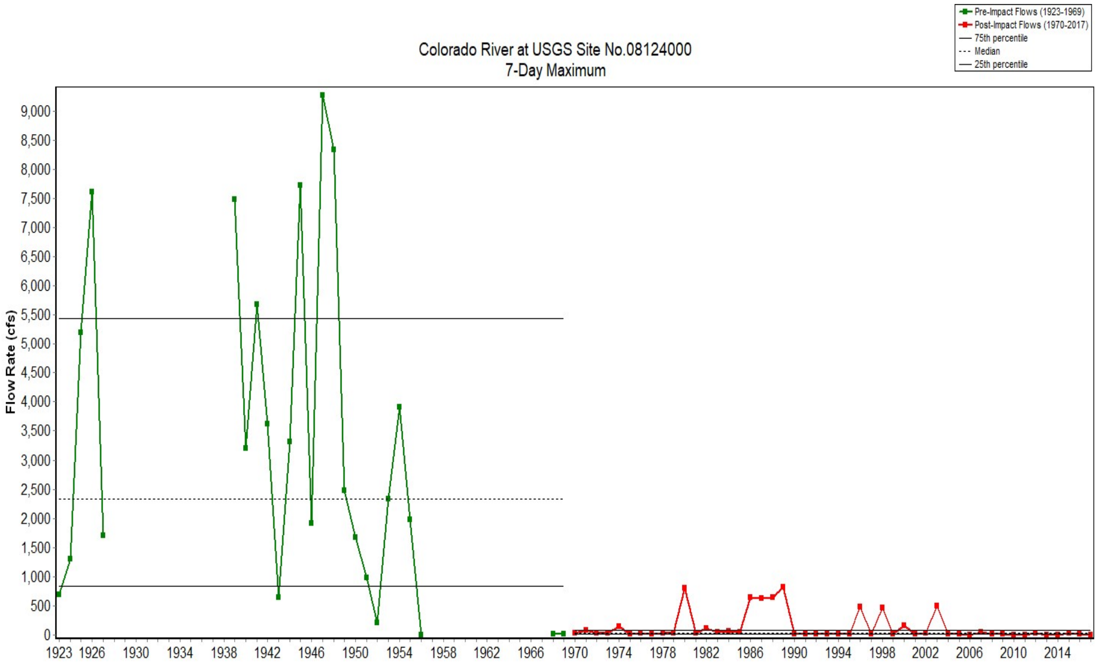
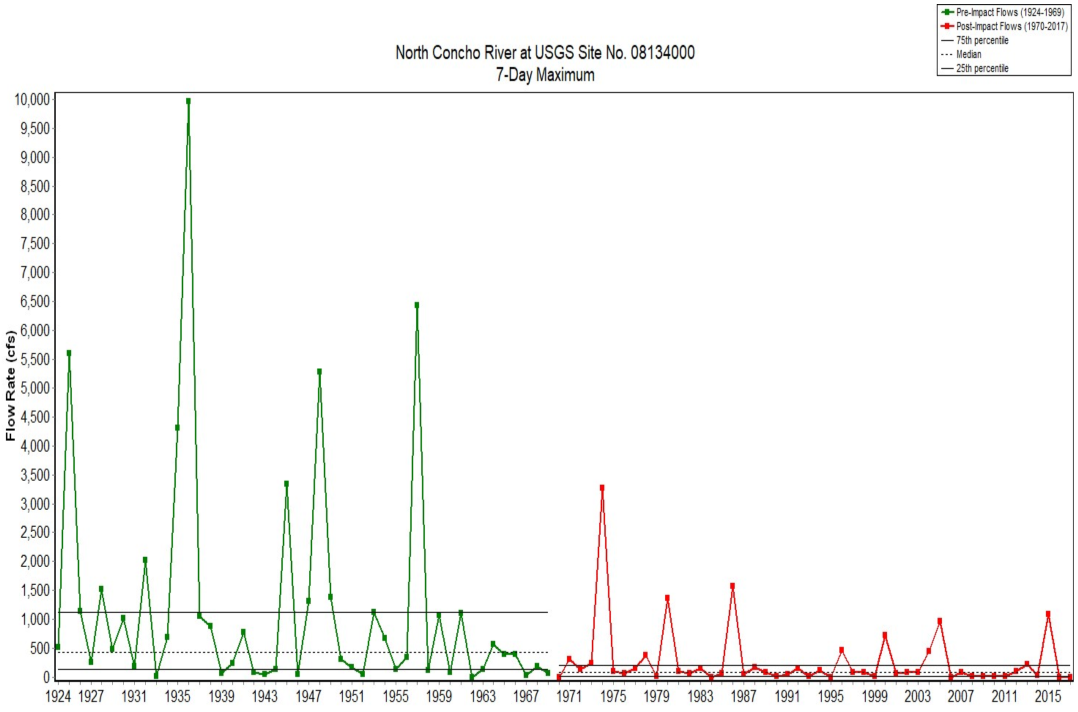
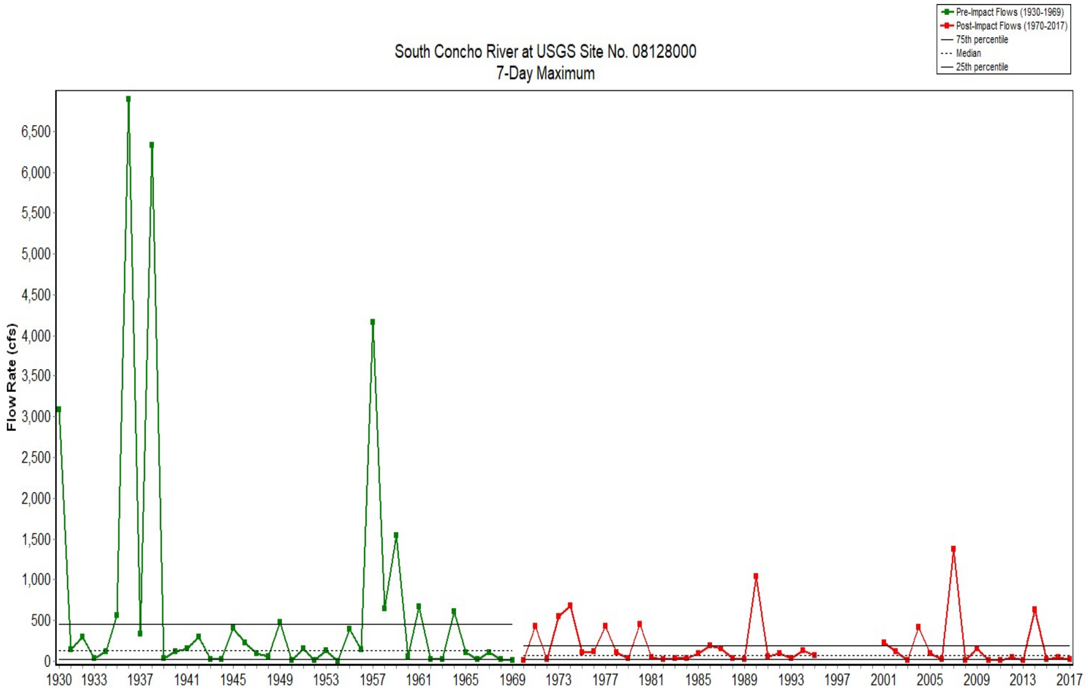


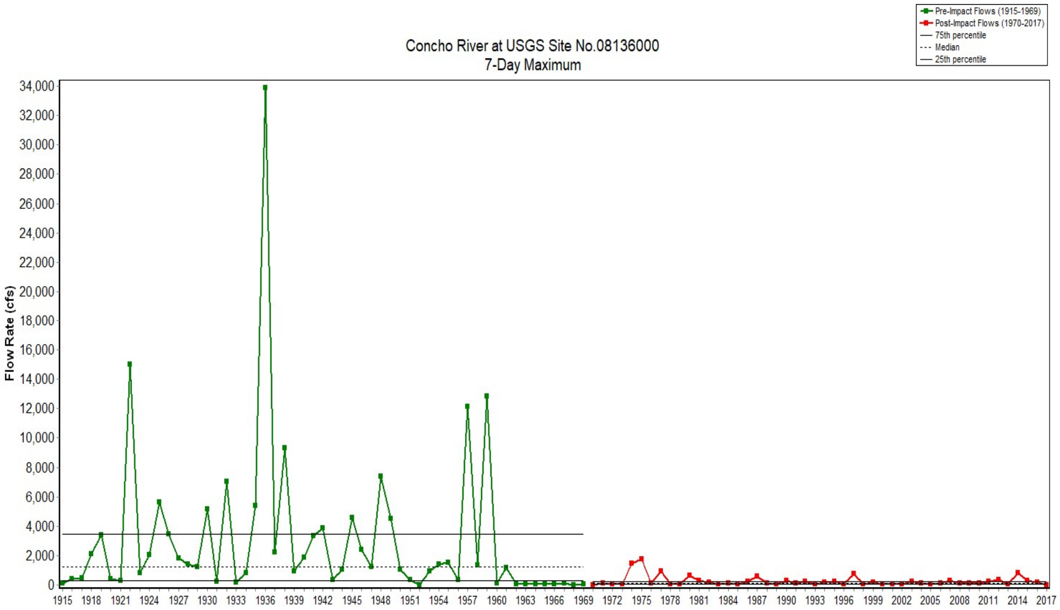
7-day Maximum Flow Rates of Colorado River at Robert Lee



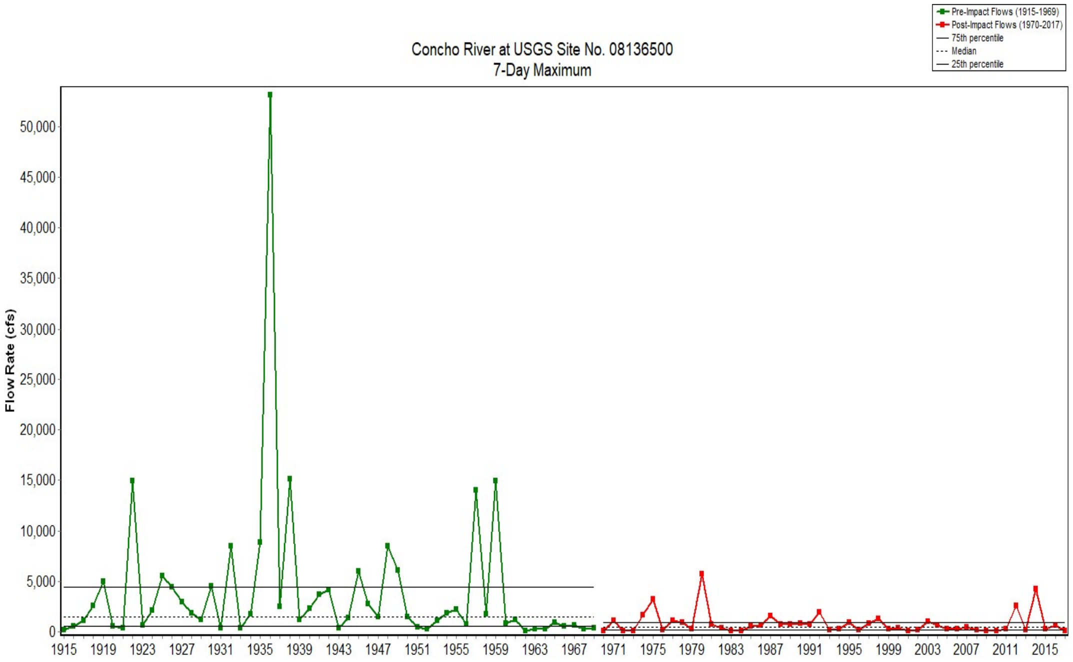
7-day Maximum Flow Rates ofNorth Concho River near Carlsbad



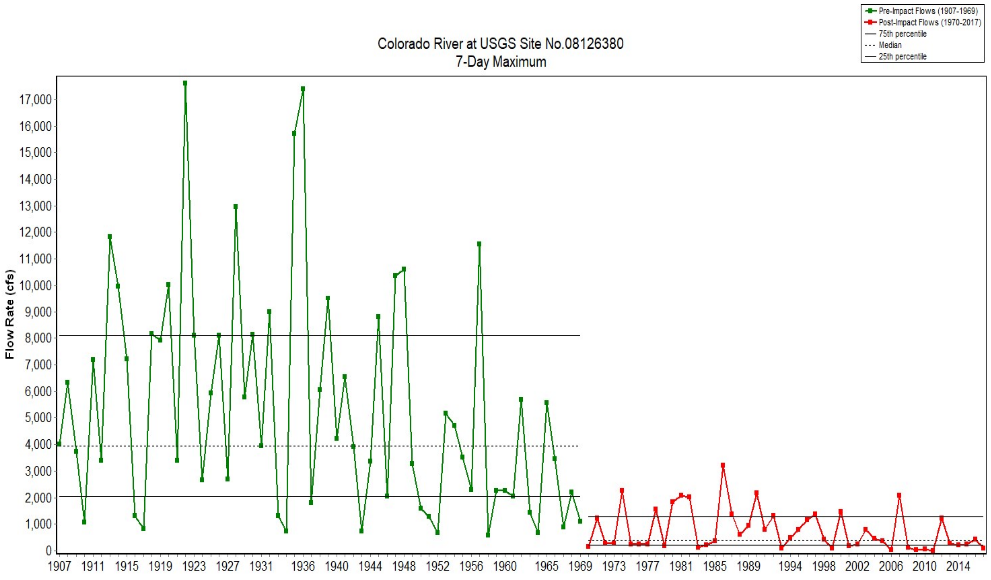
7-day Maximum Flow Rates of South Concho River at Christoval



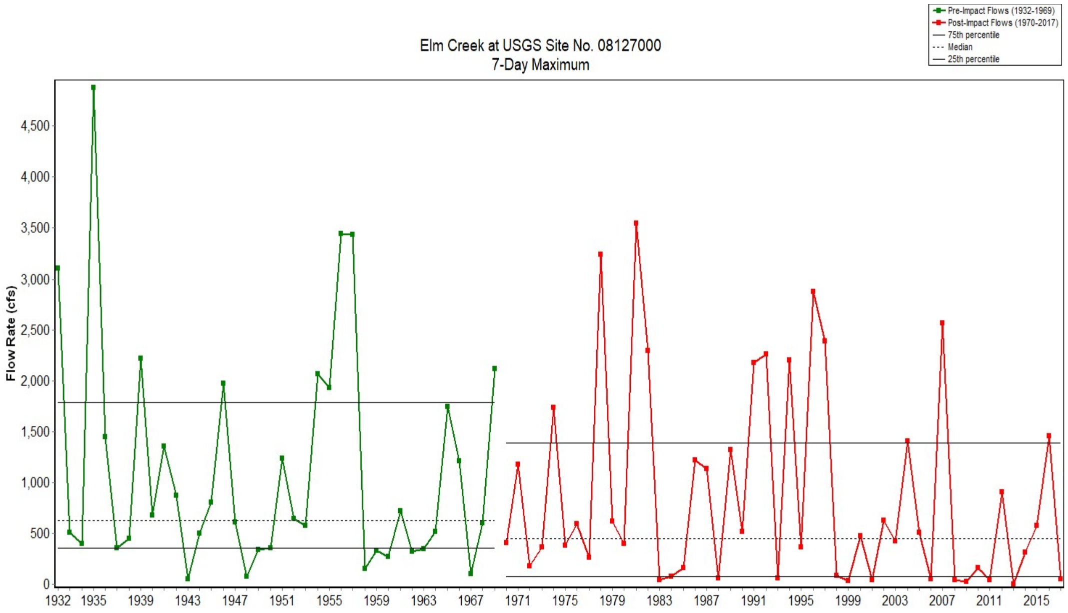
7-day Maximum Flow Rates of Concho River at San Angelo



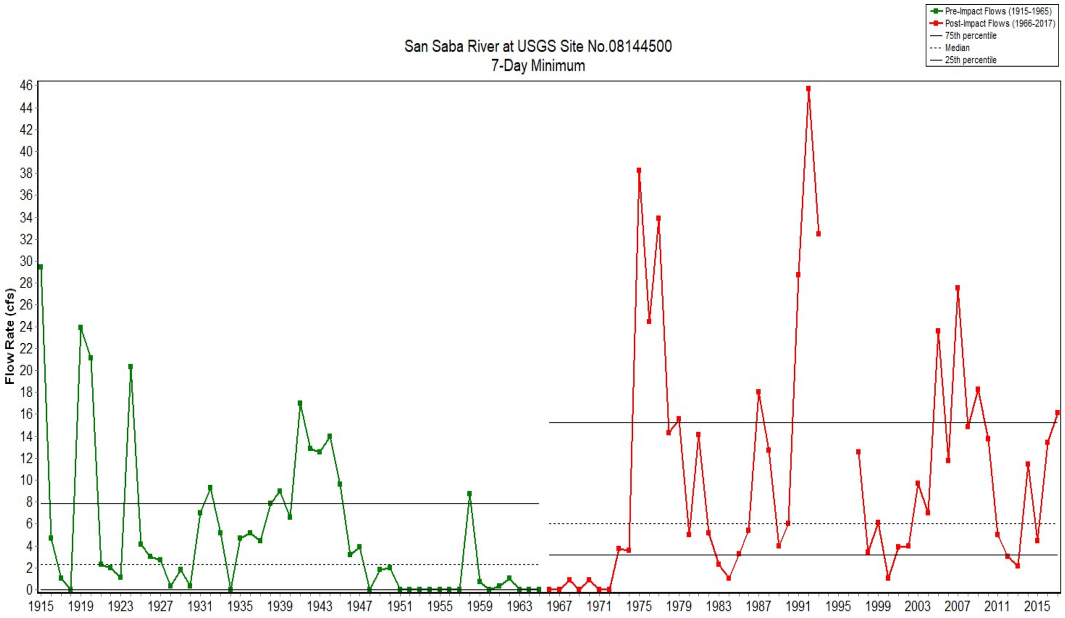
7-day Maximum Flow Rates of Concho River at Paint Rock



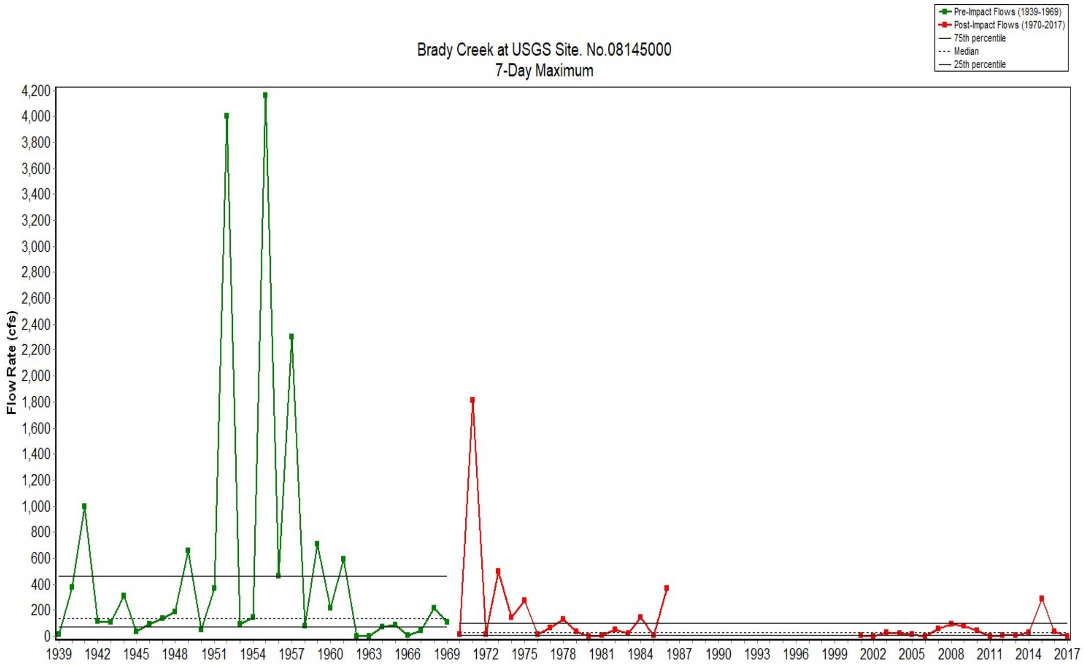
7-day Maximum Flow Rates of Colorado River near Ballinger



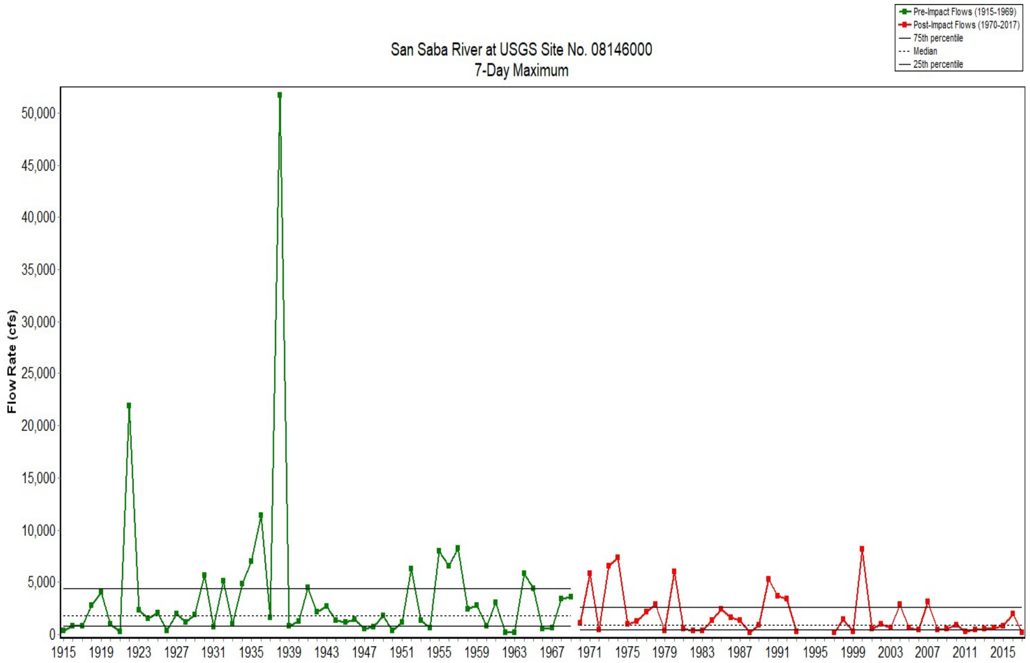
7-day Maximum Flow Rates of Elm Creek at Ballinger



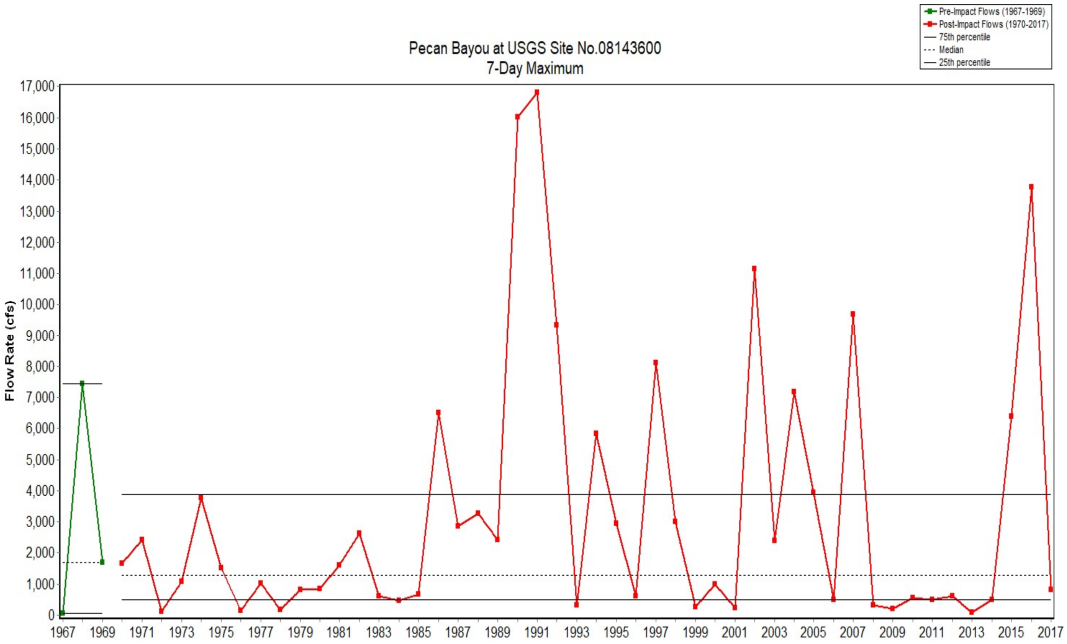
7-day Maximum Flow Rates of San Saba River at Menard



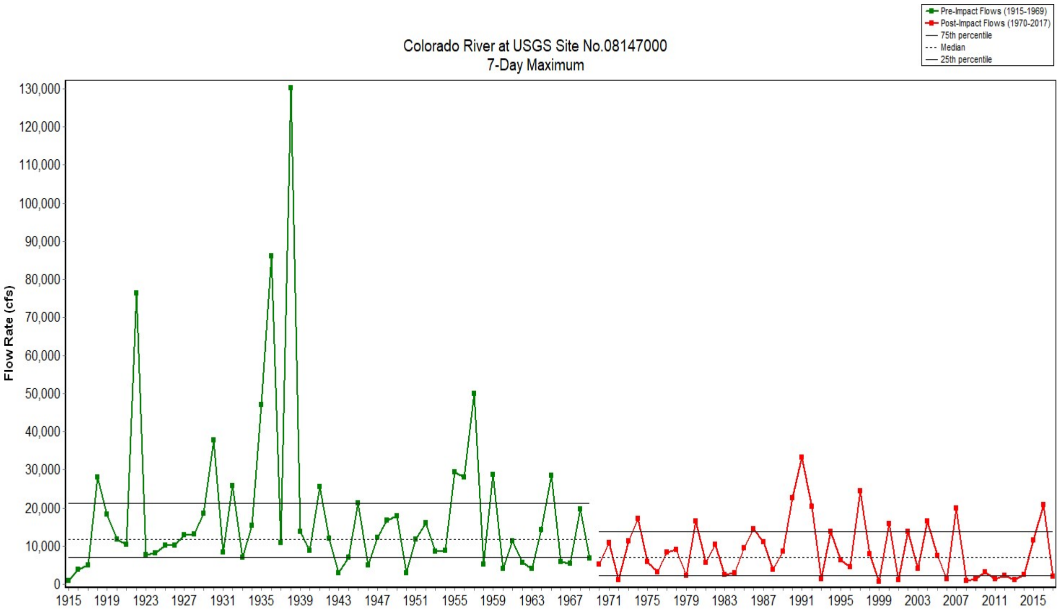
7-day Maximum Flow Rates of Brady Creek at Brady



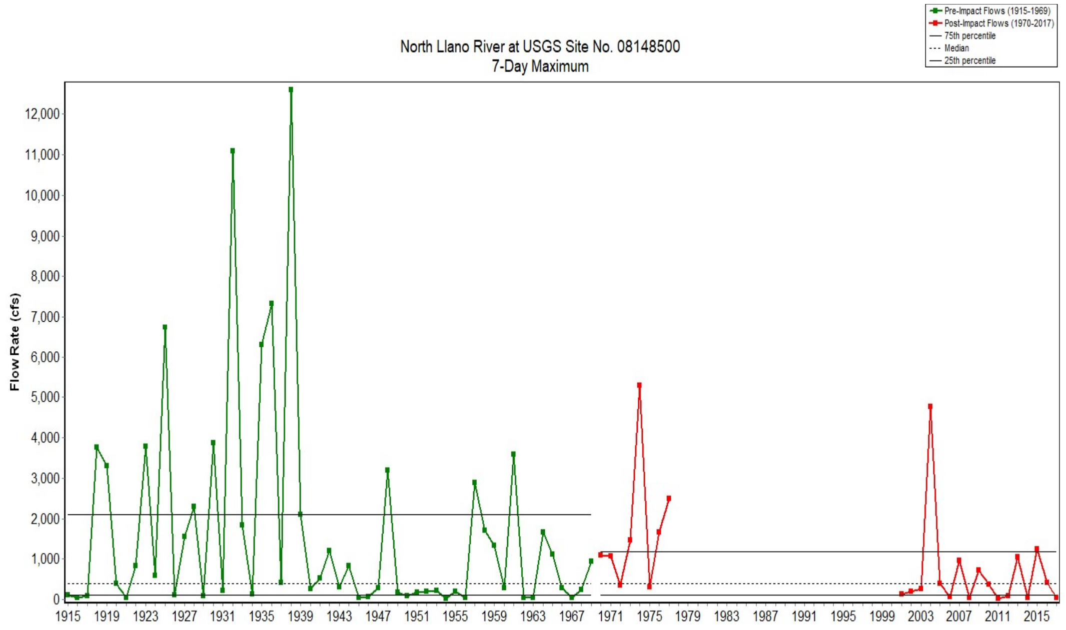
7-day Maximum Flow Rates of San Saba River at San Saba



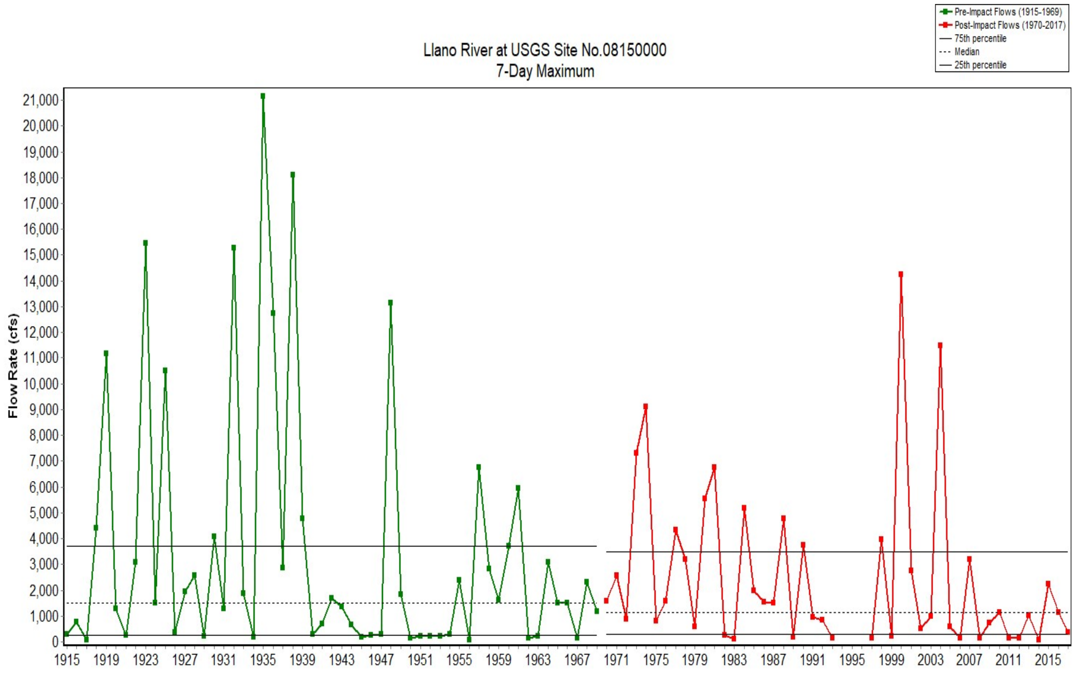
7-day Maximum Flow Rates of Pecan Bayou near Mullin



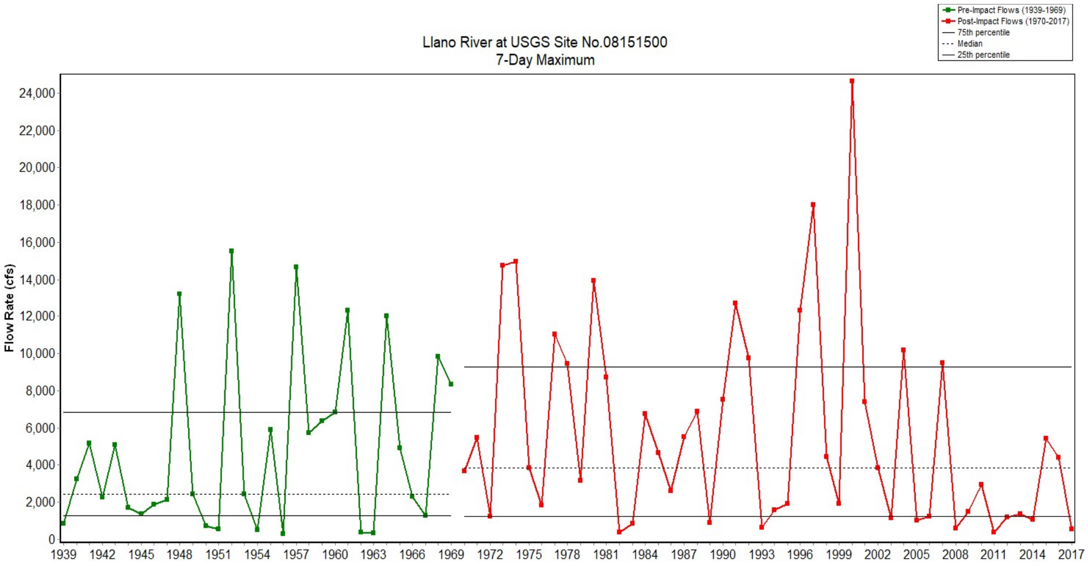
7-day Maximum Flow Rates of Colorado River near San Saba



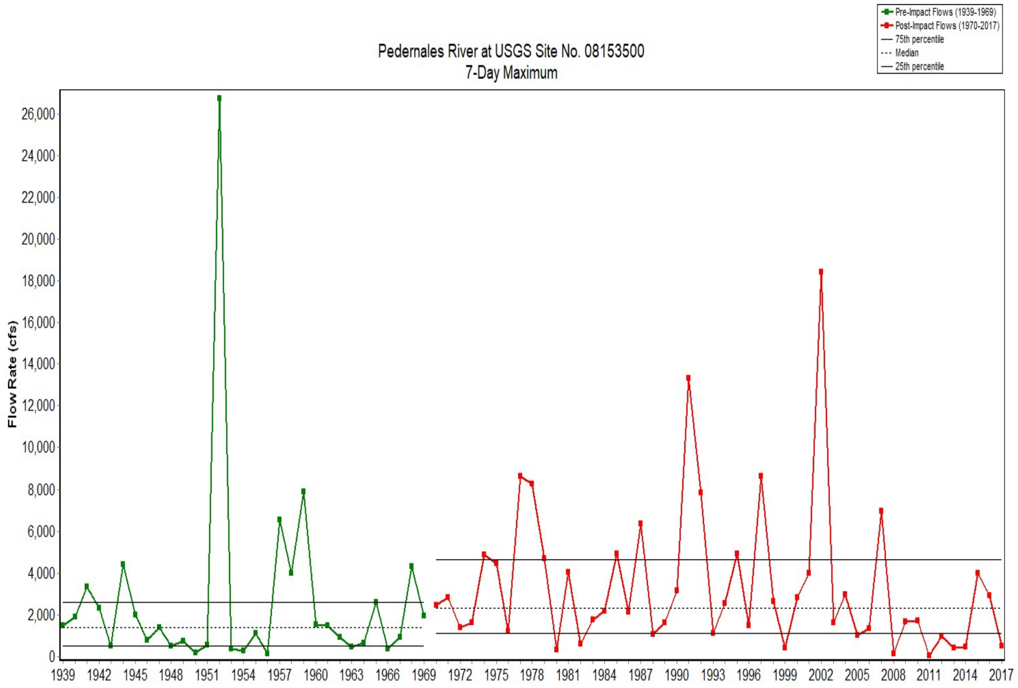
7-day Maximum Flow Rates of North Llano River near Junction



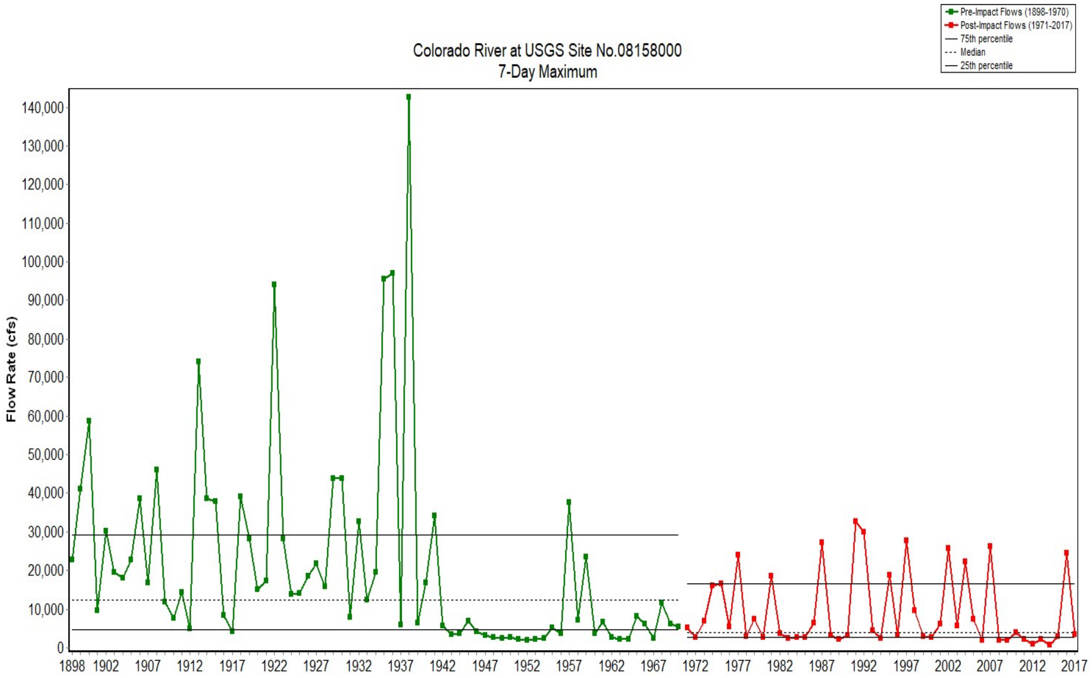
7-day Maximum Flow Rates of Llano River near Junction



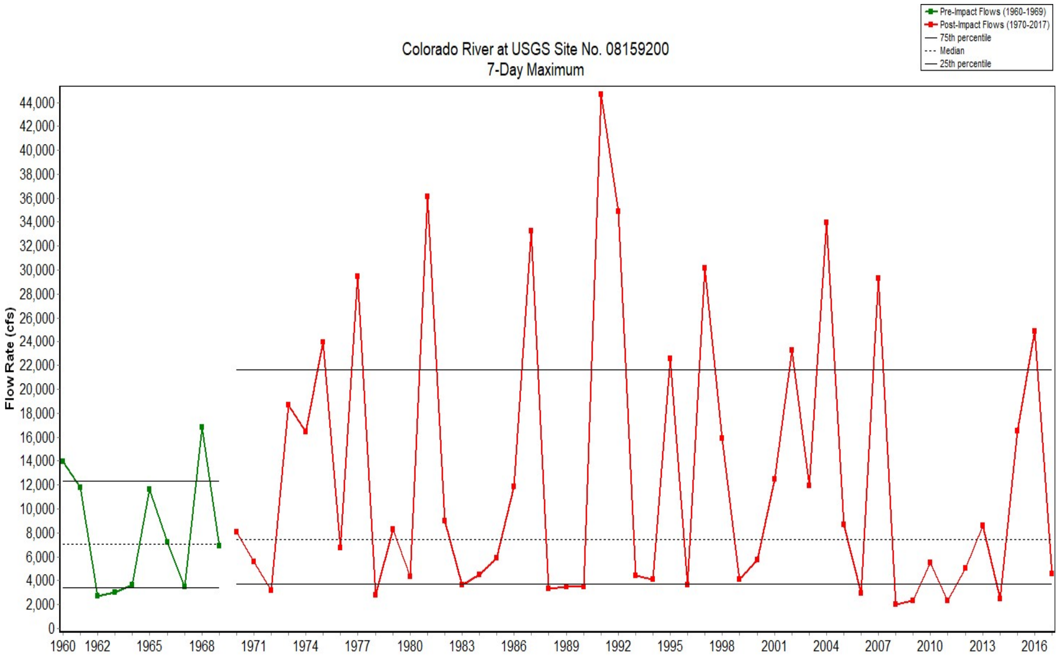
7-day Maximum Flow Rates of Llano River at Llano



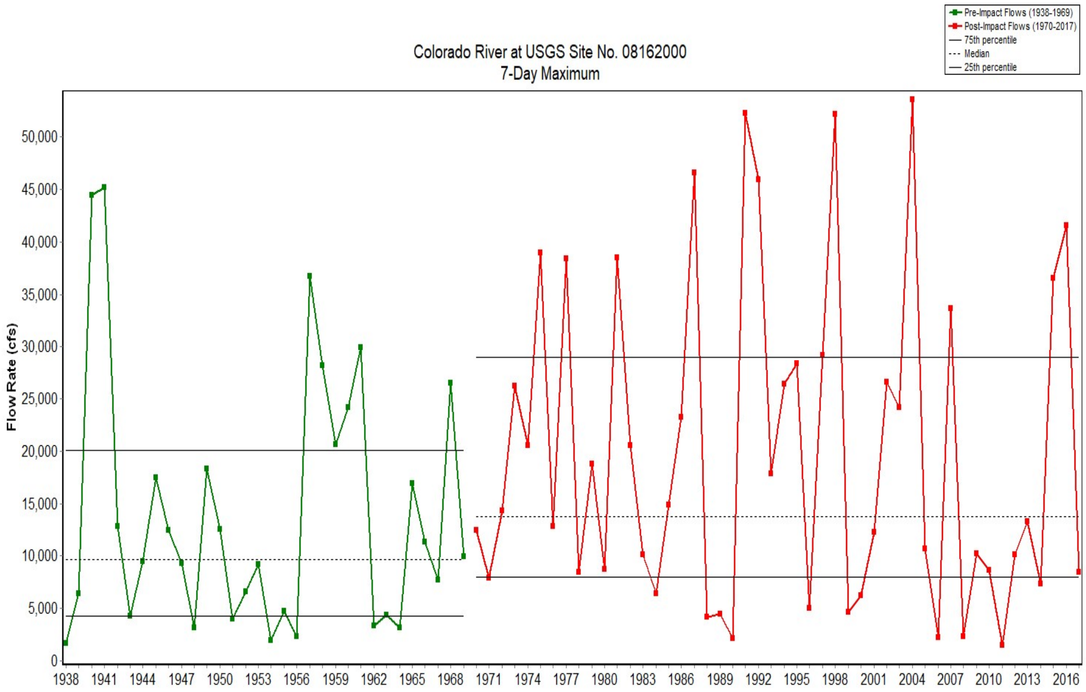
7-day Maximum Flow Rates of Pedernales River near Johnson City



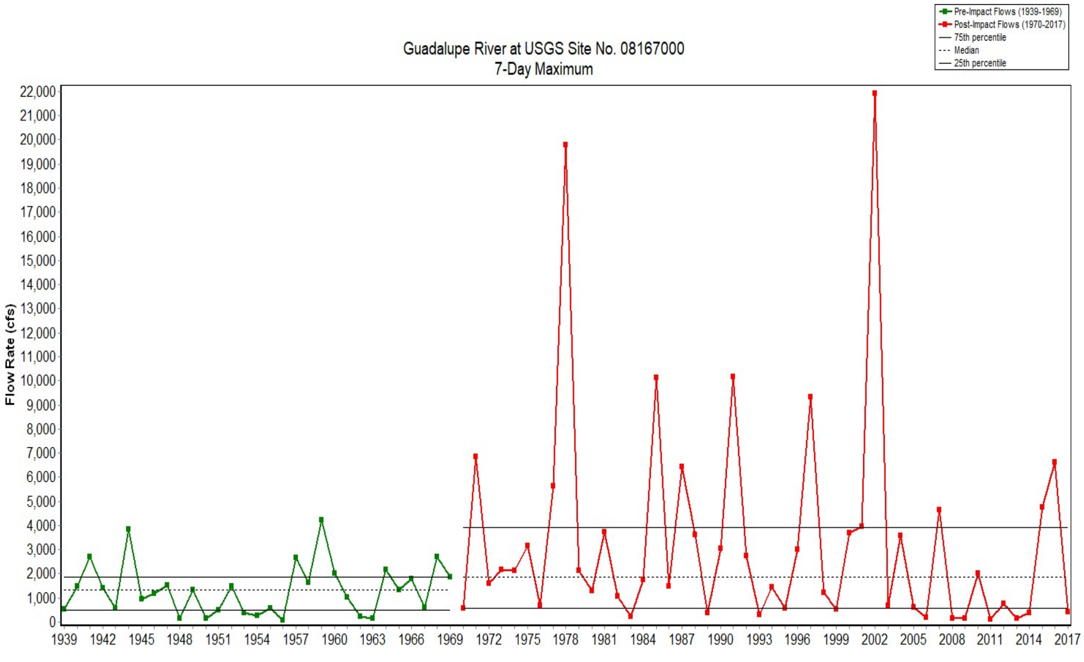
7-day Maximum Flow Rates of Colorado River at Austin



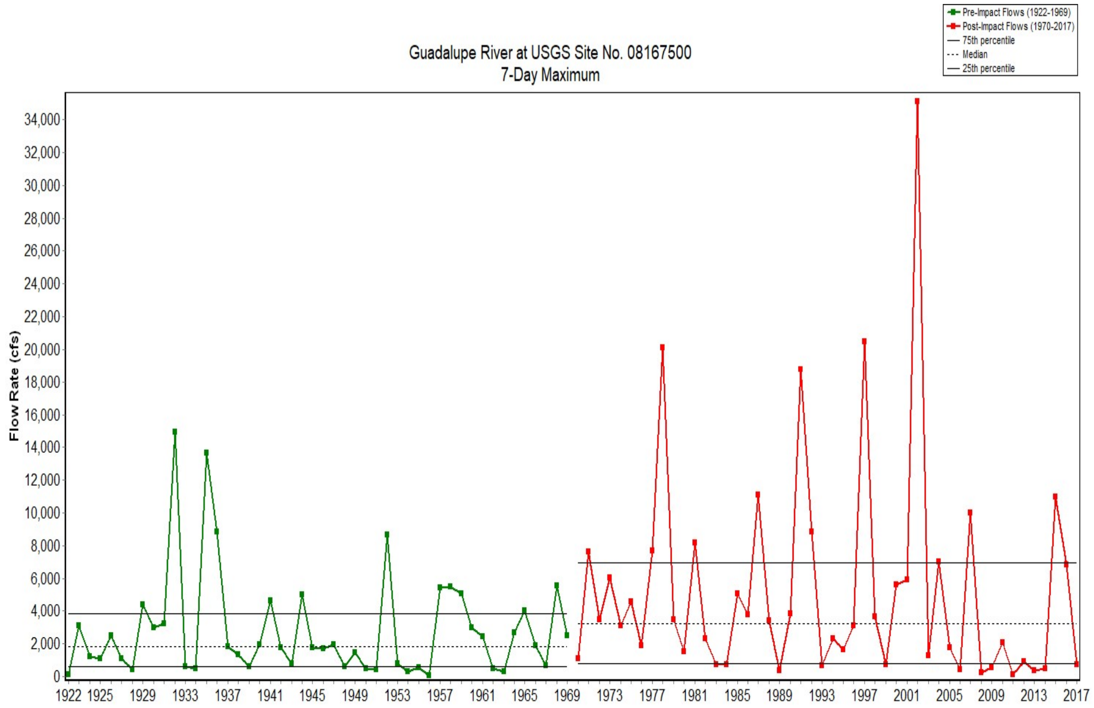
7-day Maximum Flow Rates of Colorado River at Bastrop



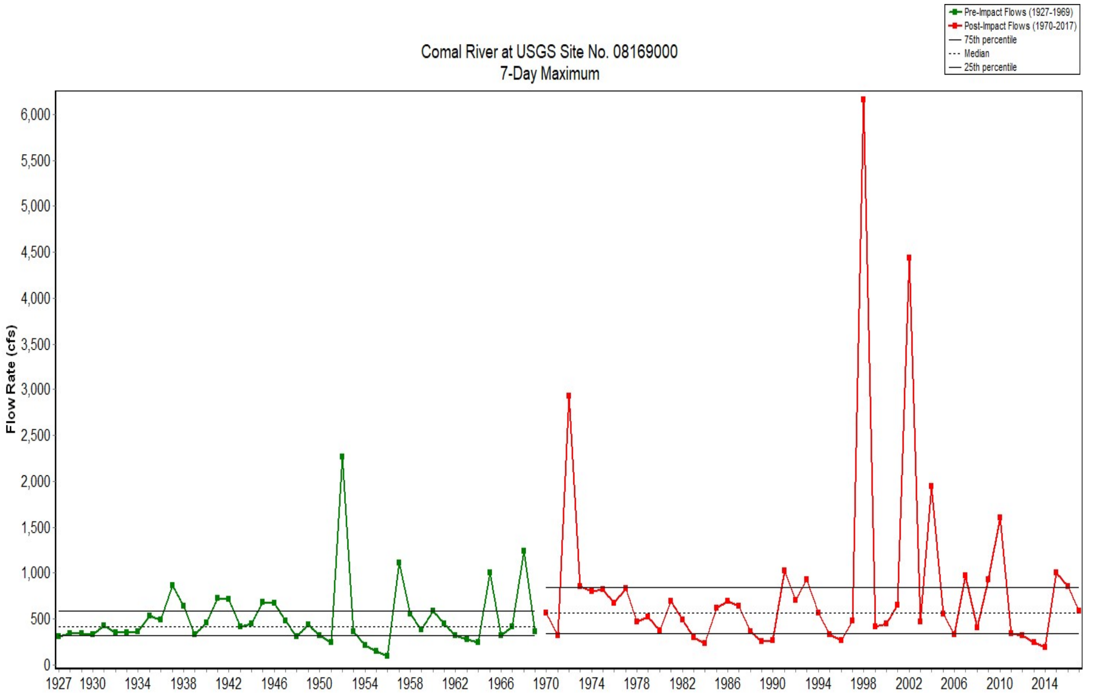
7-day Maximum Flow Rates of Colorado River at Wharton



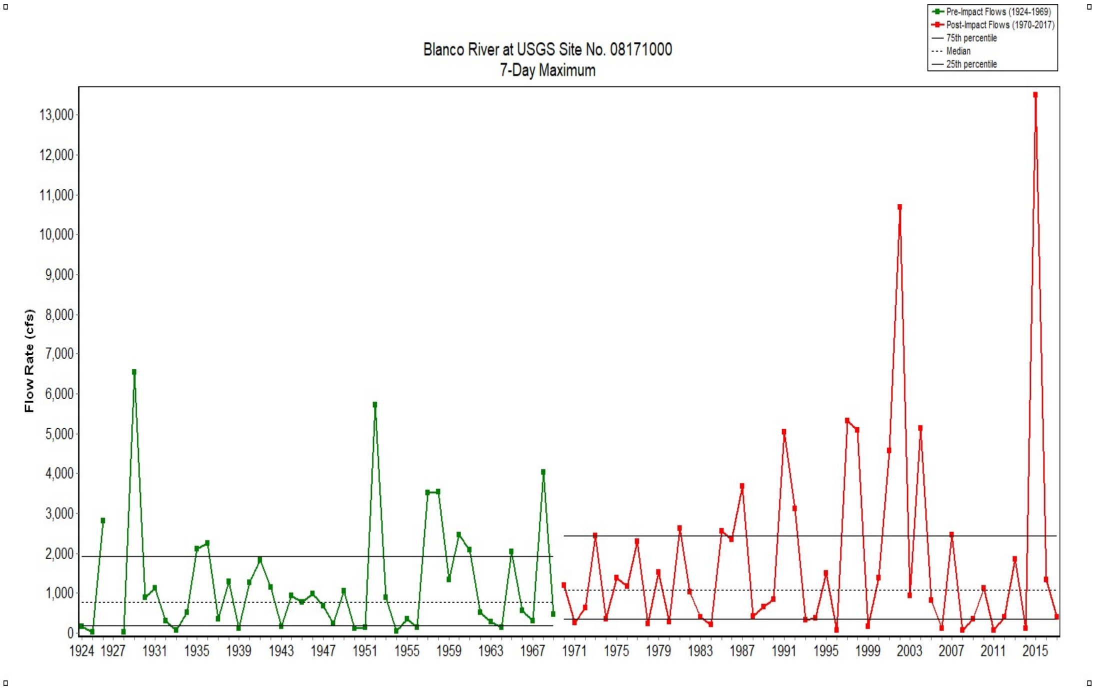
7-day Maximum Flow Rates of Guadalupe River at Comfort



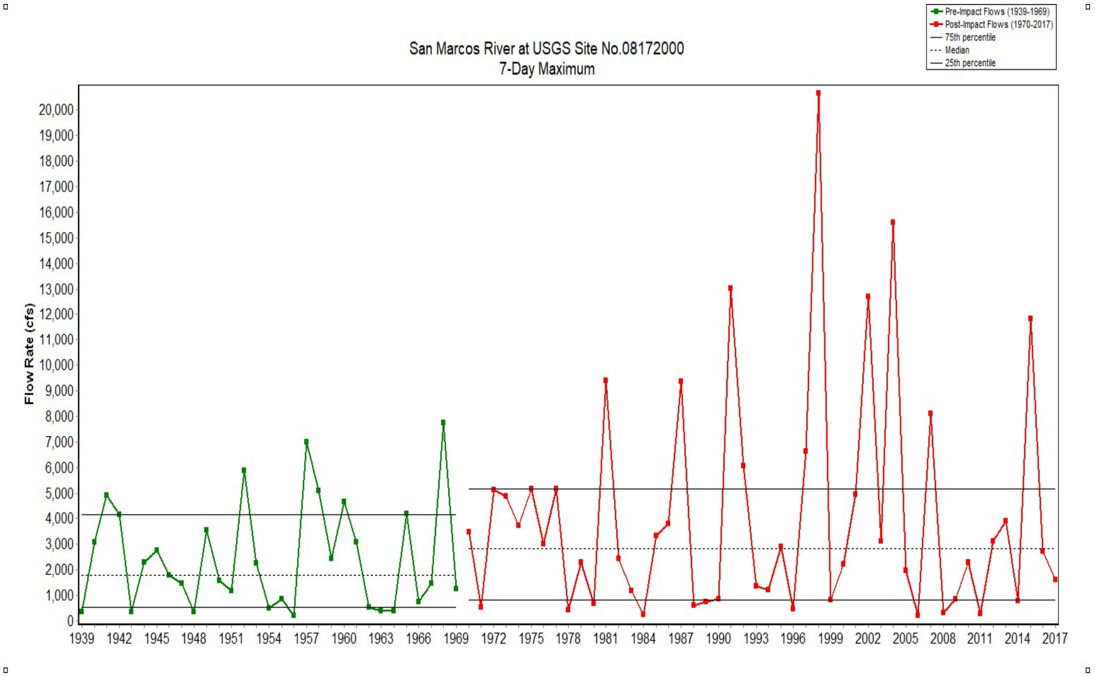
7-day Maximum Flow Rates of Guadalupe River near Spring Branch



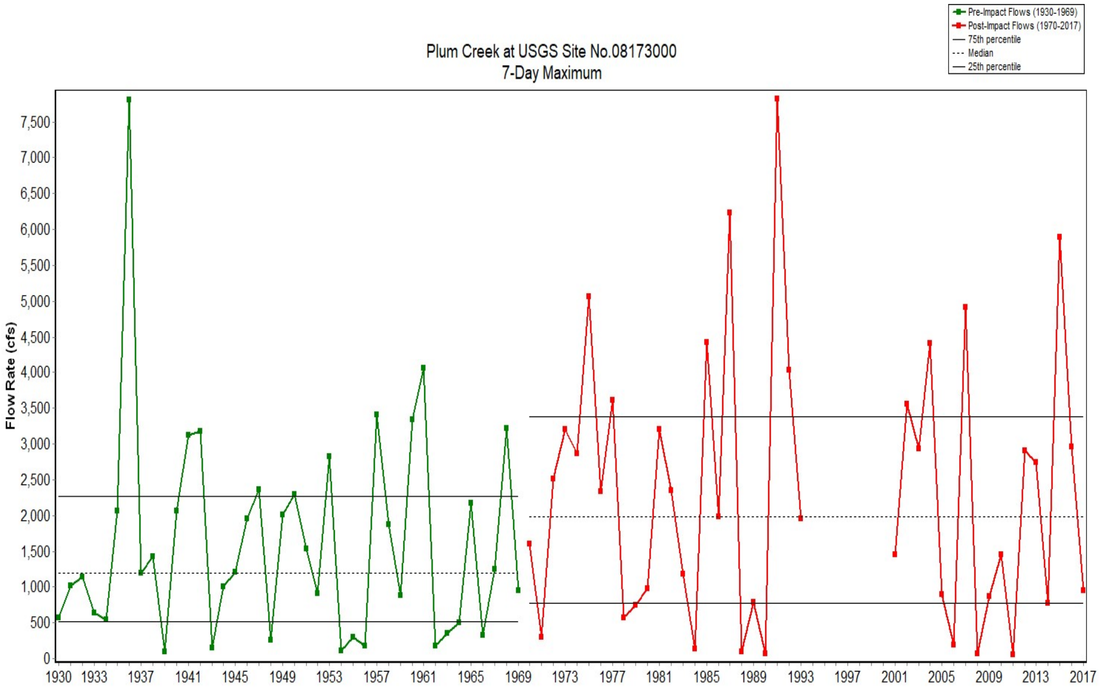
7-day Maximum Flow Rates of Comal River at New Braunfels



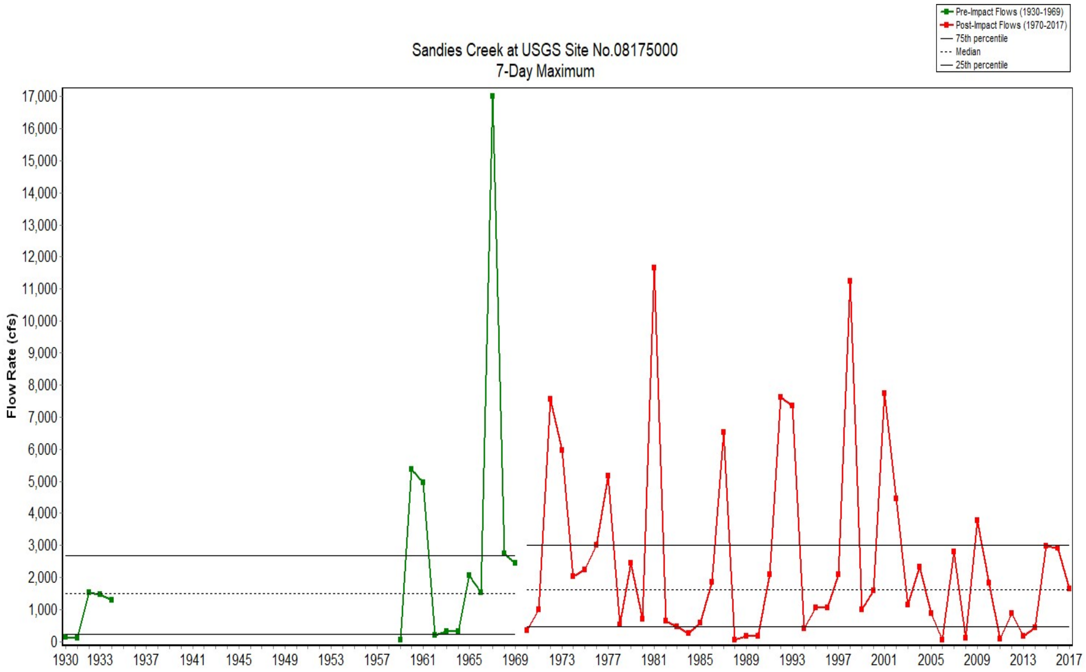
7-day Maximum Flow Rates of Blanco River at Wimberley



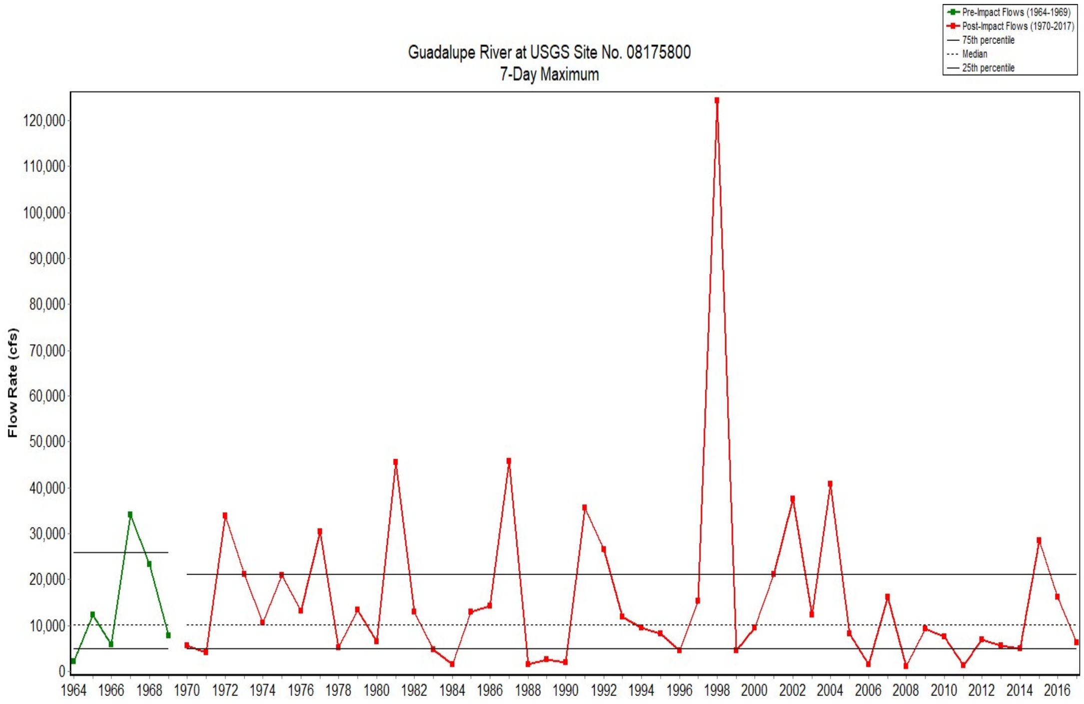
7-day Maximum Flow Rates of San Marcos River at Luling



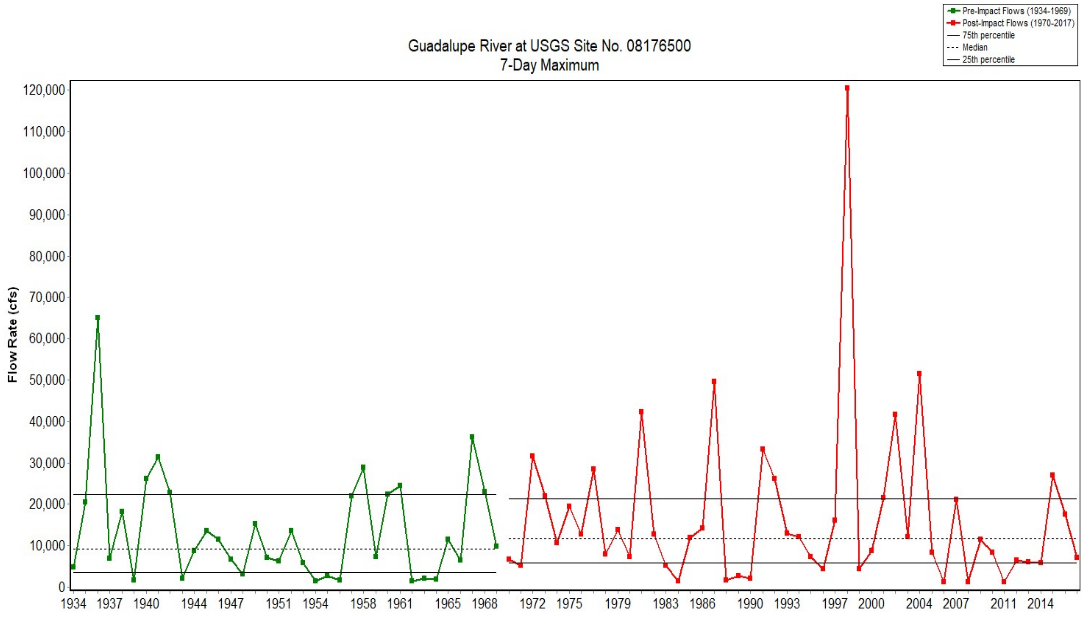
7-day Maximum Flow Rates of Plum Creek near Luling



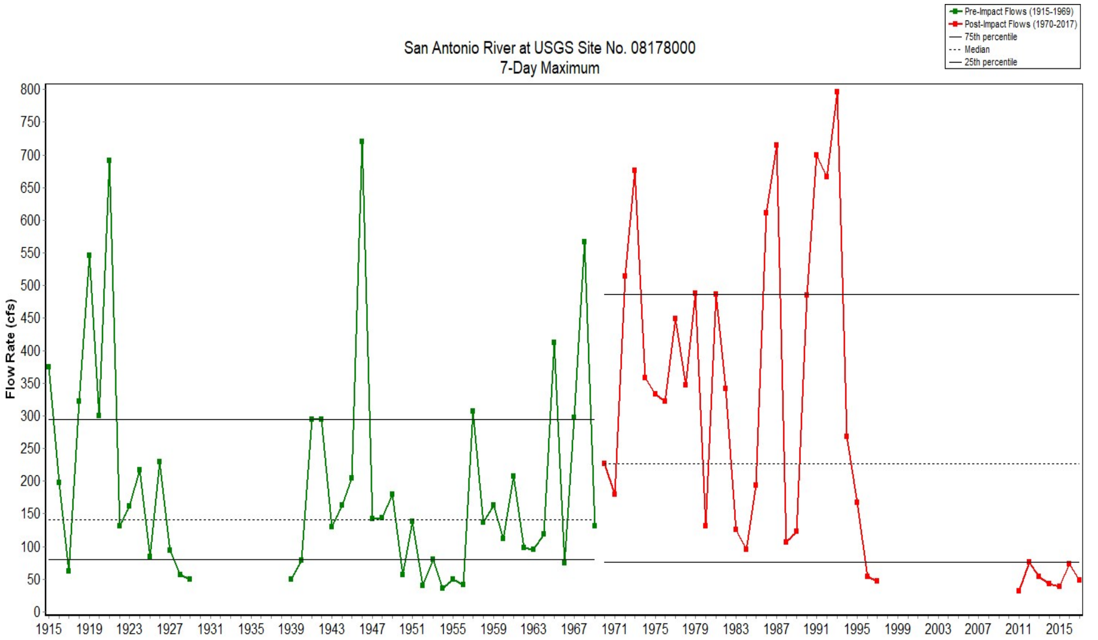
7-day Maximum Flow Rates of Sandies Creek near Westhoff



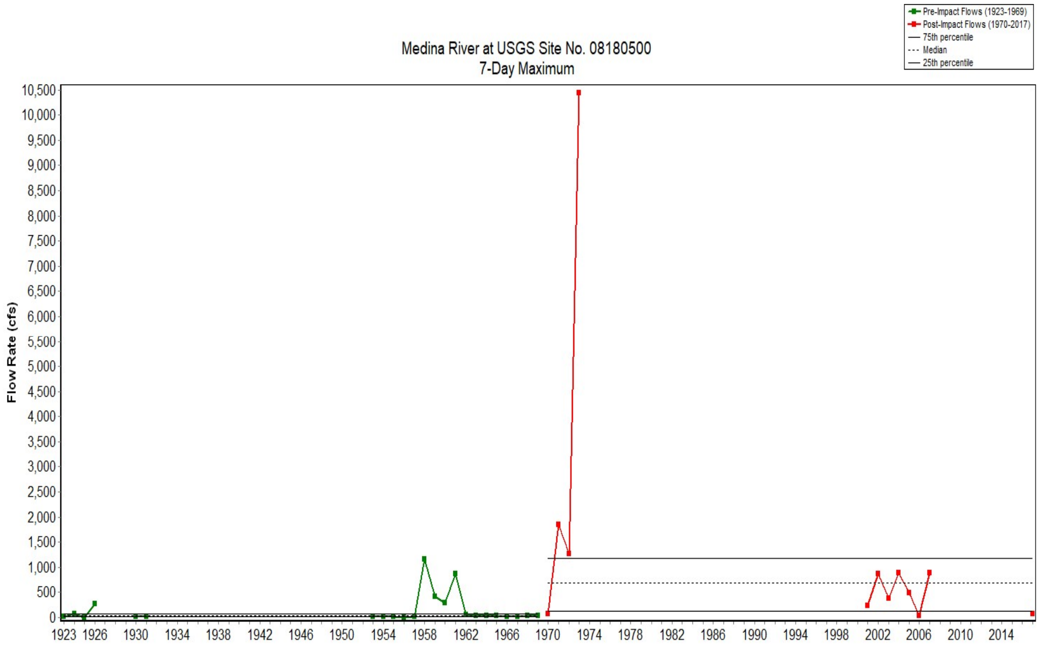
7-day Maximum Flow Rates of Guadalupe River at Cuero



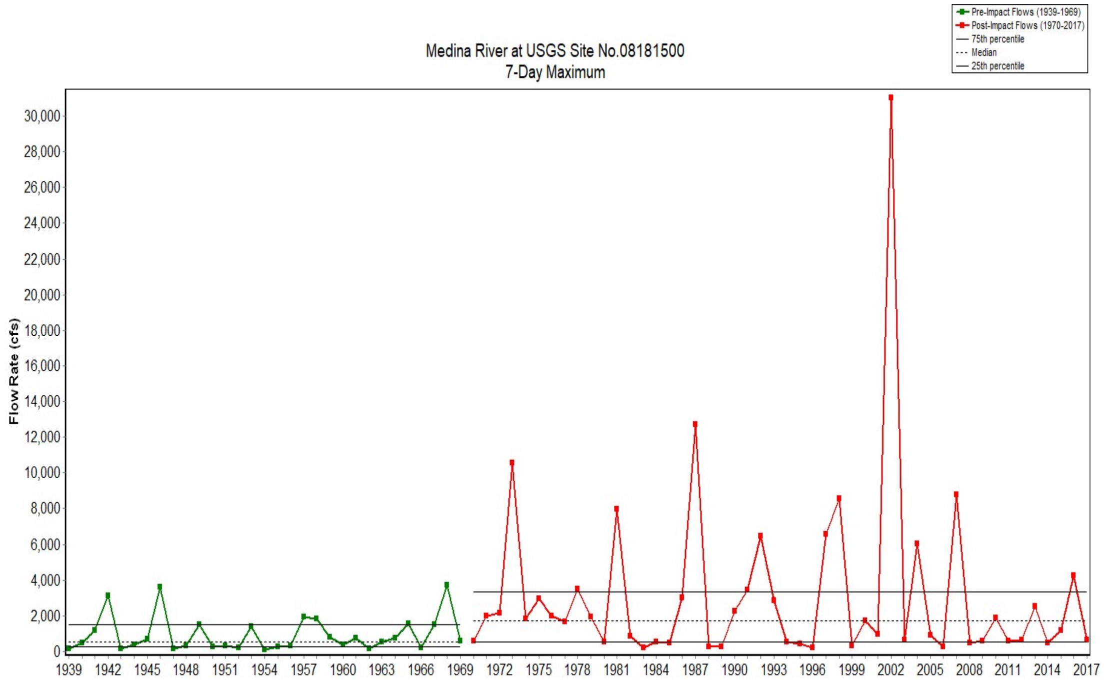
7-day Maximum Flow Rates of Guadalupe River at Victoria



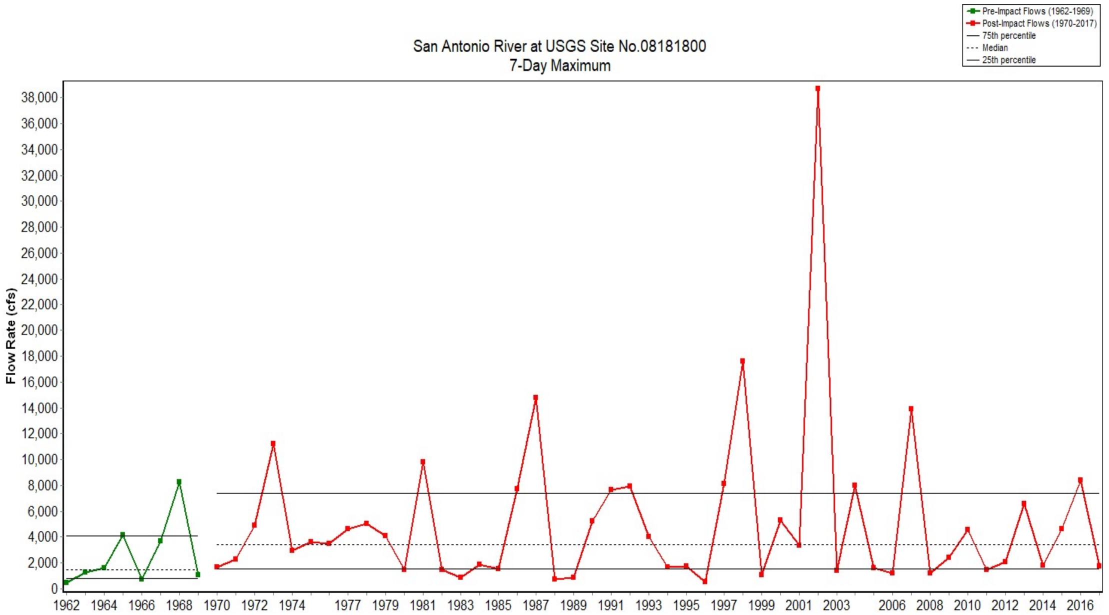
7-day Maximum Flow Rates of San Antonio River at San Antonio



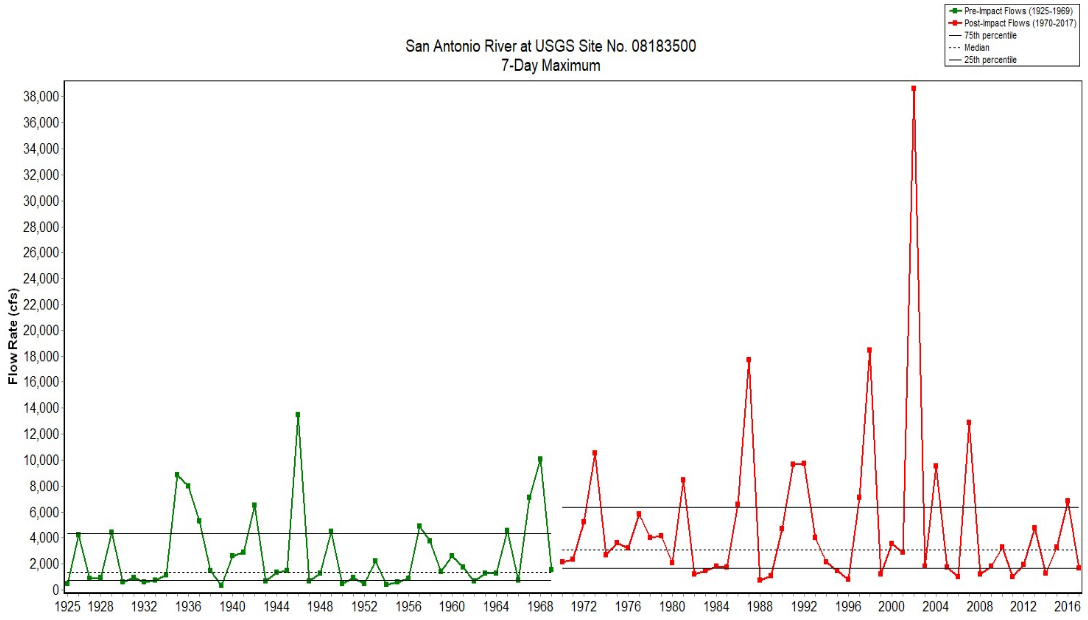
7-day Maximum Flow Rates of Medina River near Rio Medina



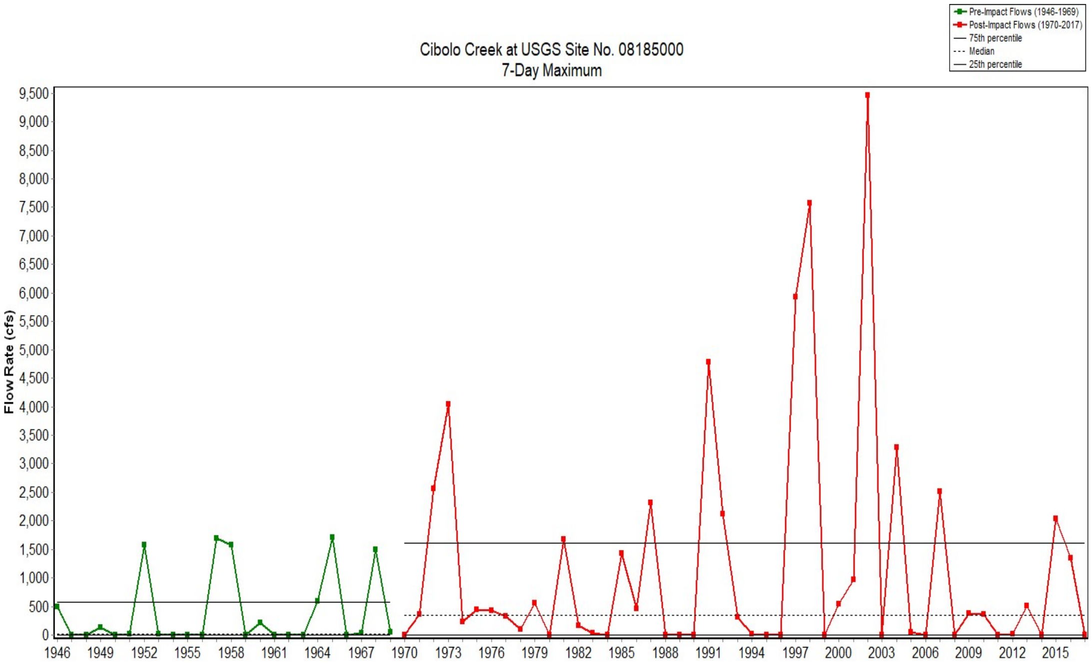
7-day Maximum Flow Rates of Leon River near Gatesville



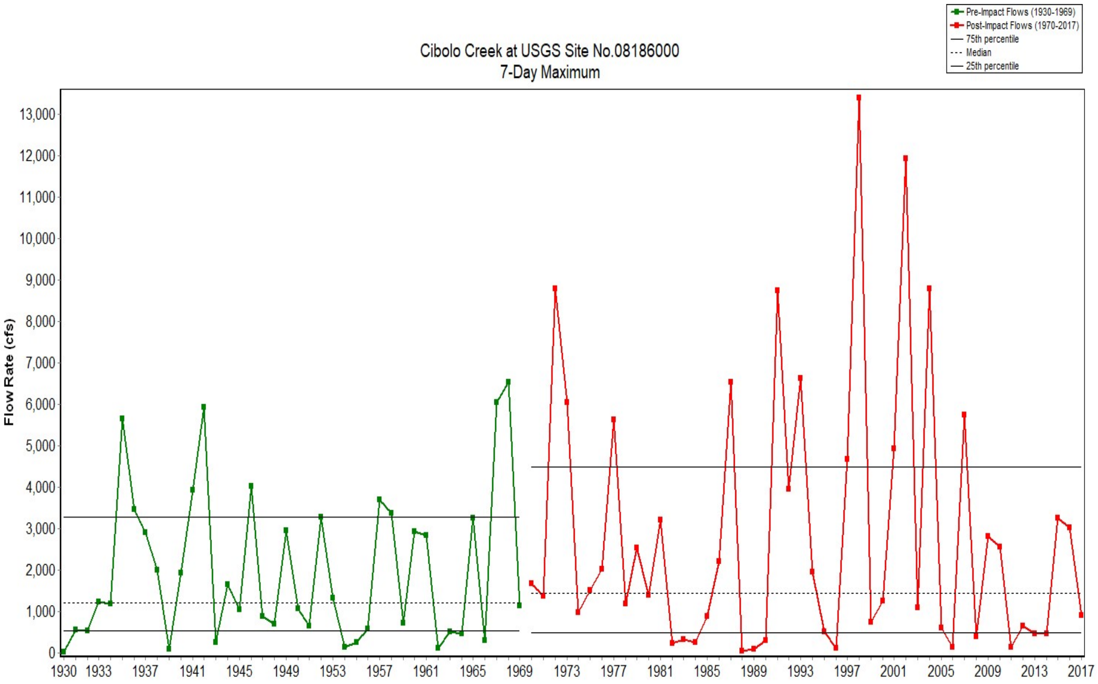
7-day Maximum Flow Rates of San Antonio River near Elmendorf



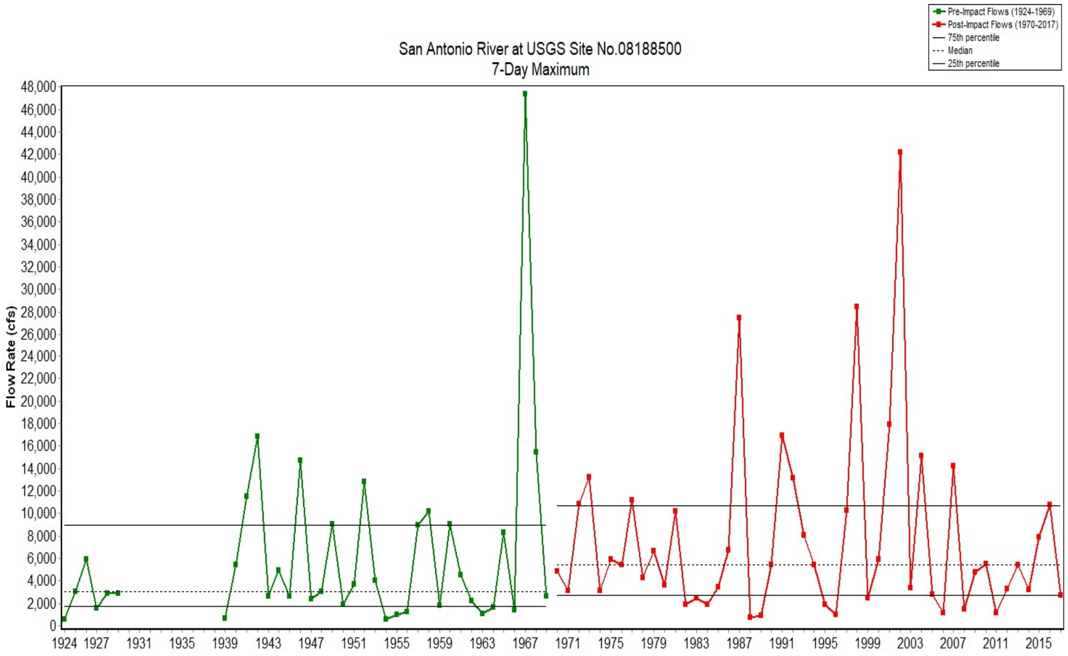
7-day Maximum Flow Rates of San Antonio River near Falls City



7-day Maximum Flow Rates of Cibolo Creek at Selma

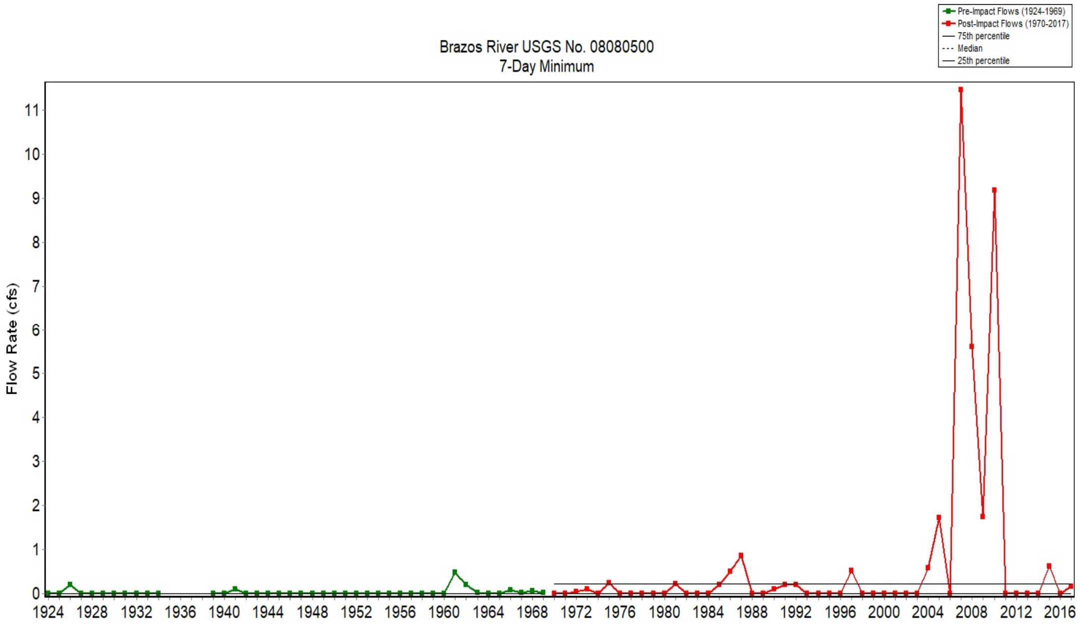


7-day Maximum Flow Rates of Navasota River at Easterly

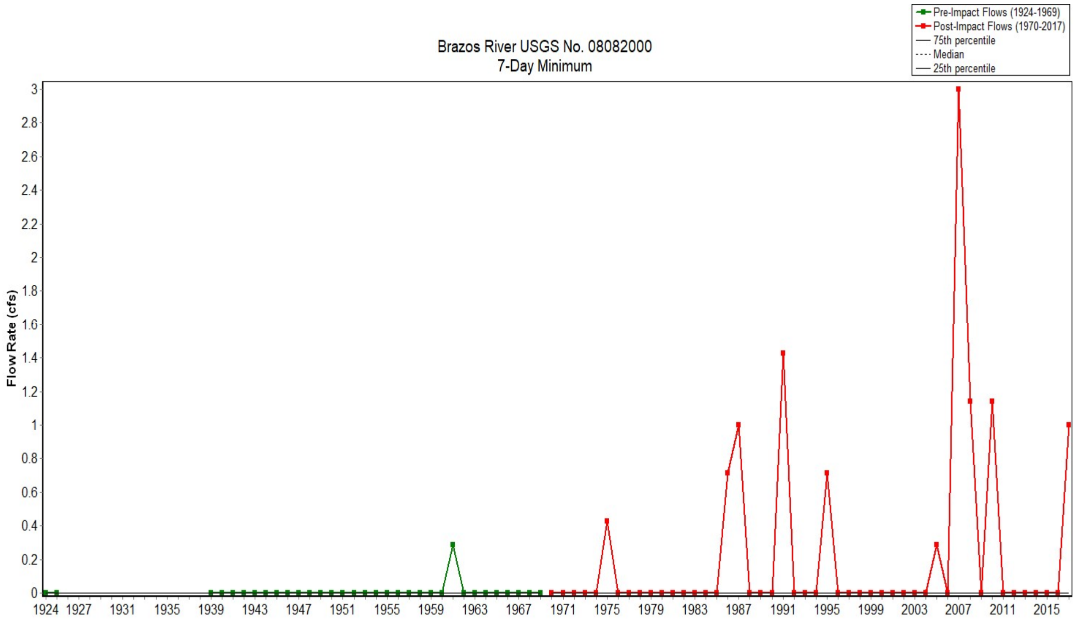


7-day Maximum Flow Rates of San Antonio River at Goliad

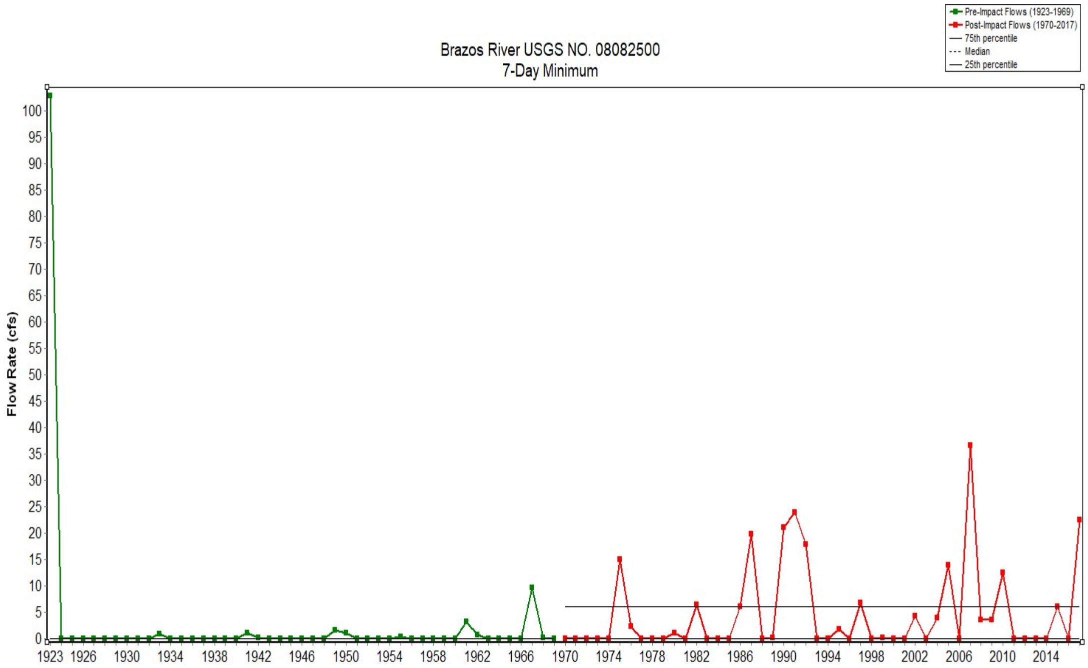
APPENDIX B



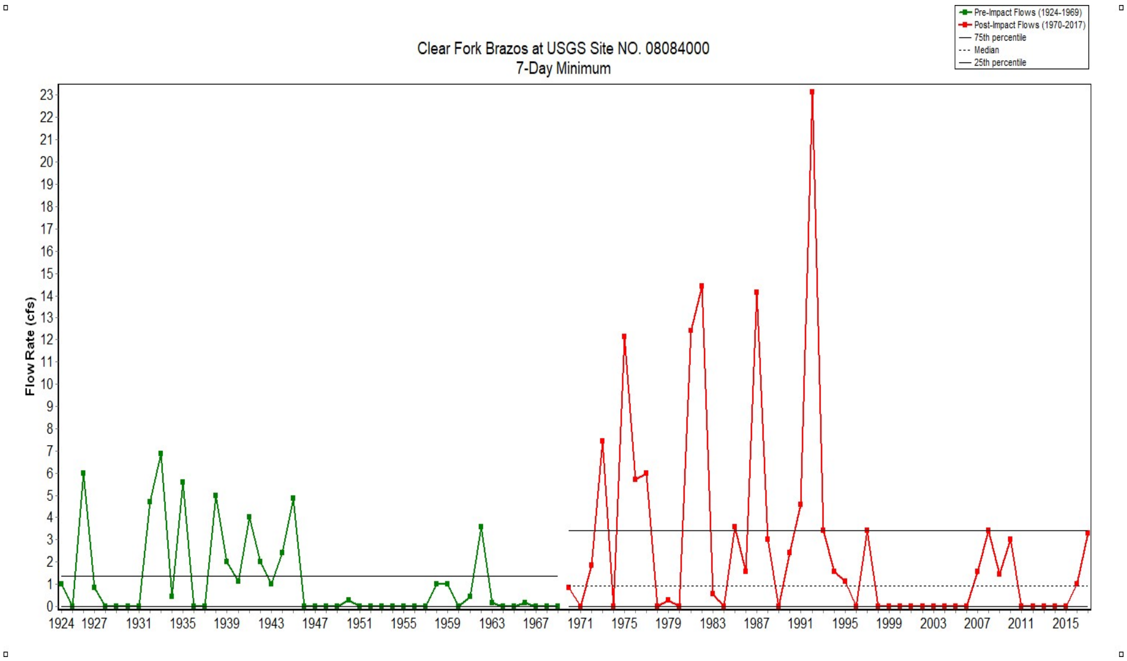
7-day Minimum Flow Rates of Double Mountain Fork near Aspermont



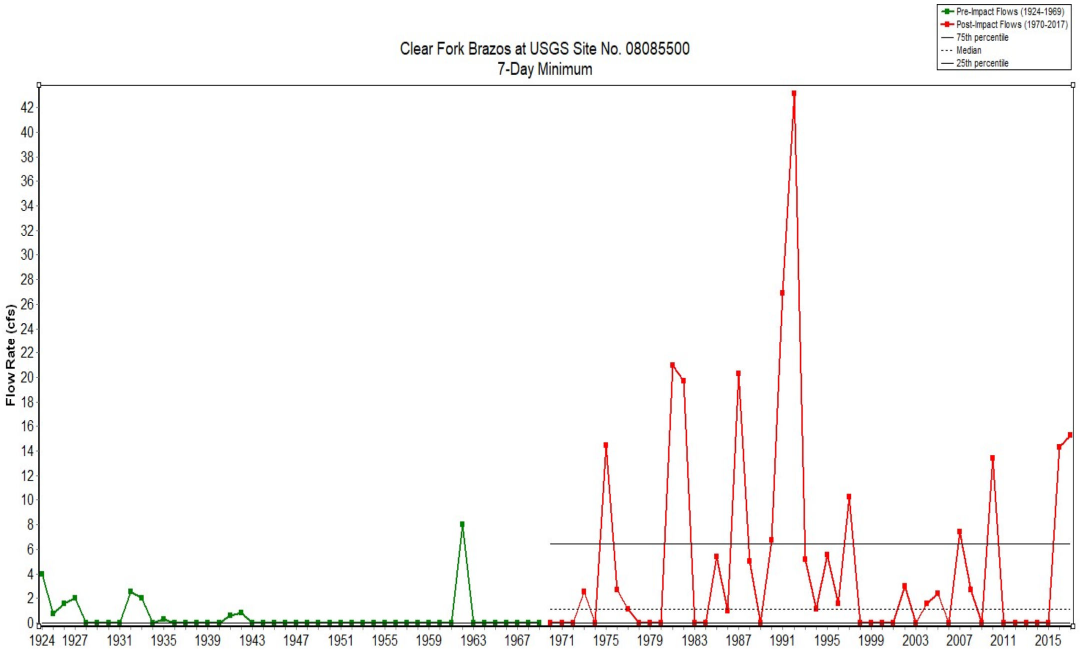
7-day Minimum Flow Rates of Salt Fork Brazos River near Aspermont



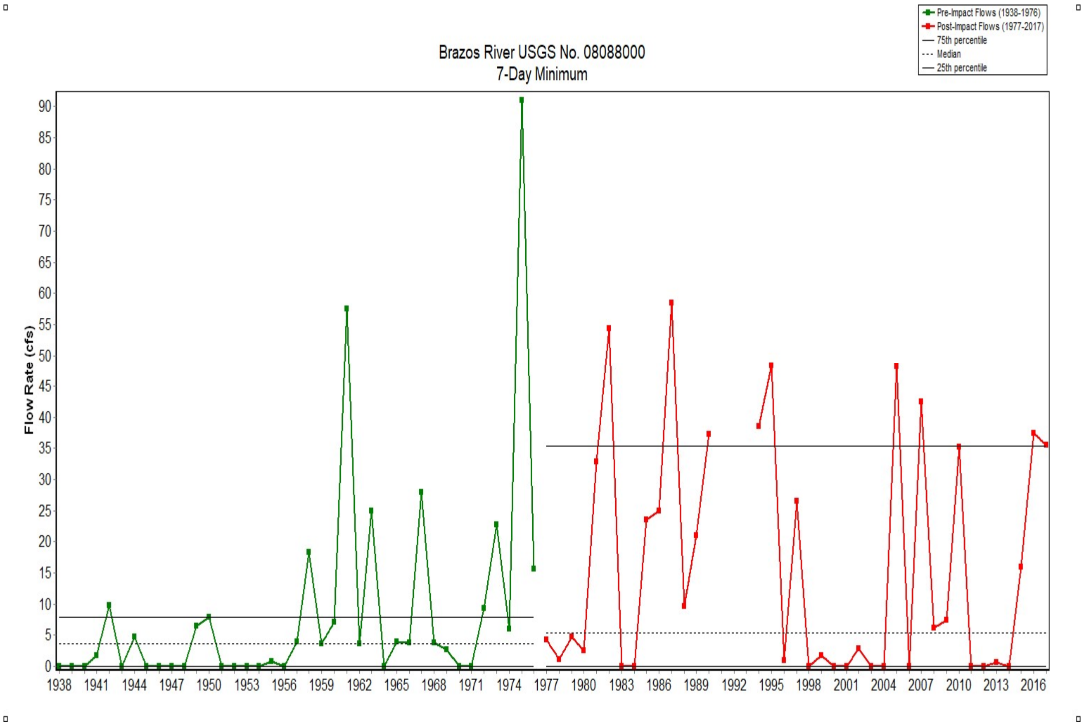
7-day Minimum Flow Rates of Brazos River near Seymour



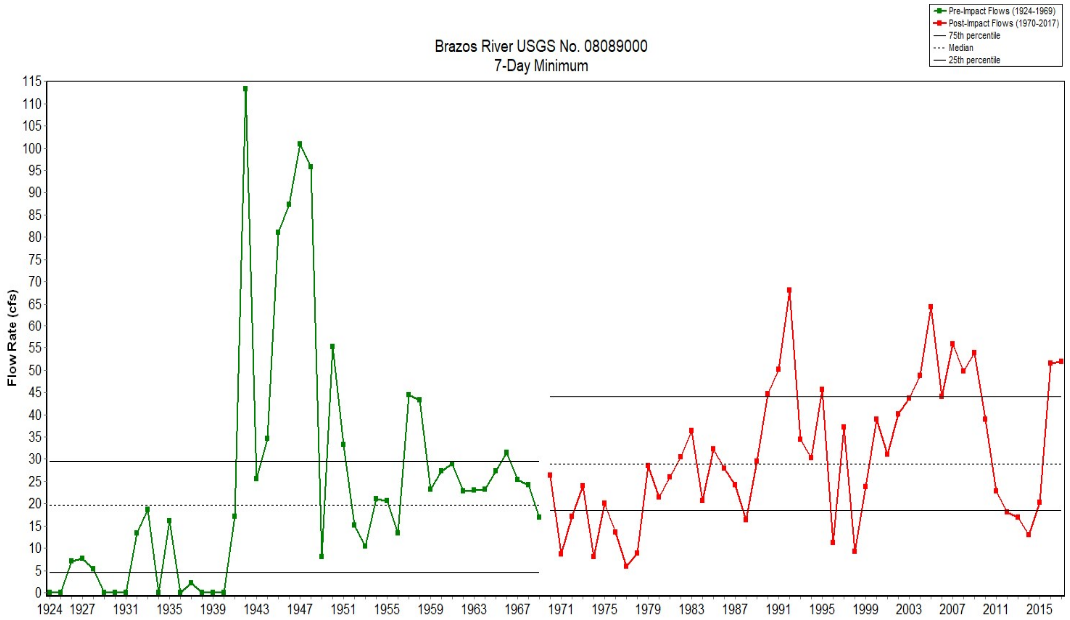
7-day Minimum Flow Rates of Clear Fork Brazos near Nugent



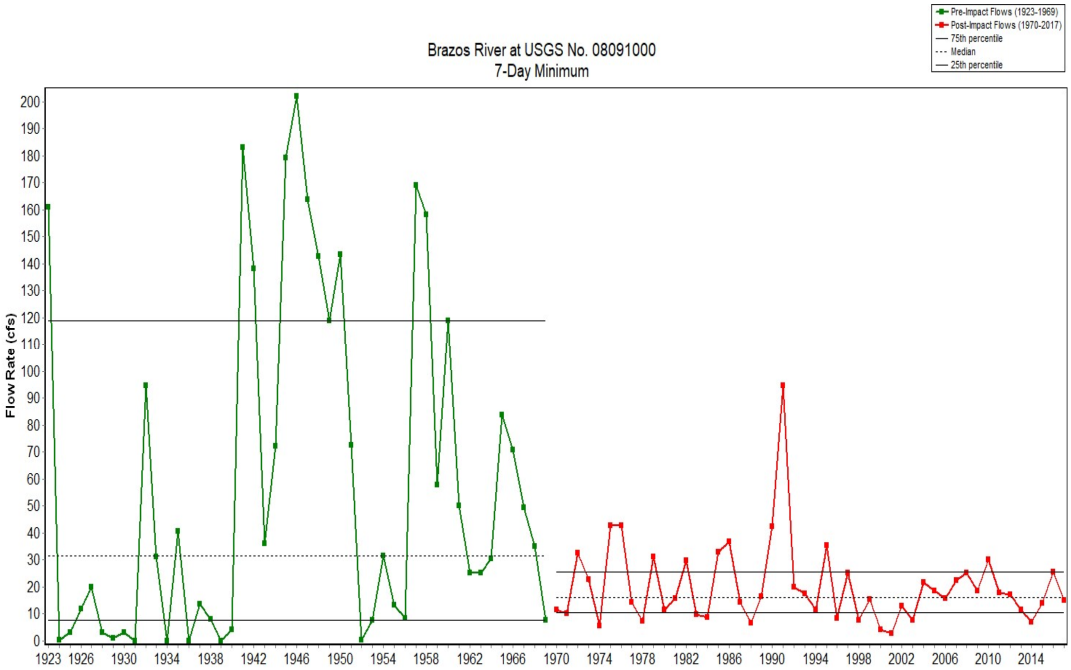
7-day Minimum Flow Rates of Clear Fork Brazos near Fort Griffin



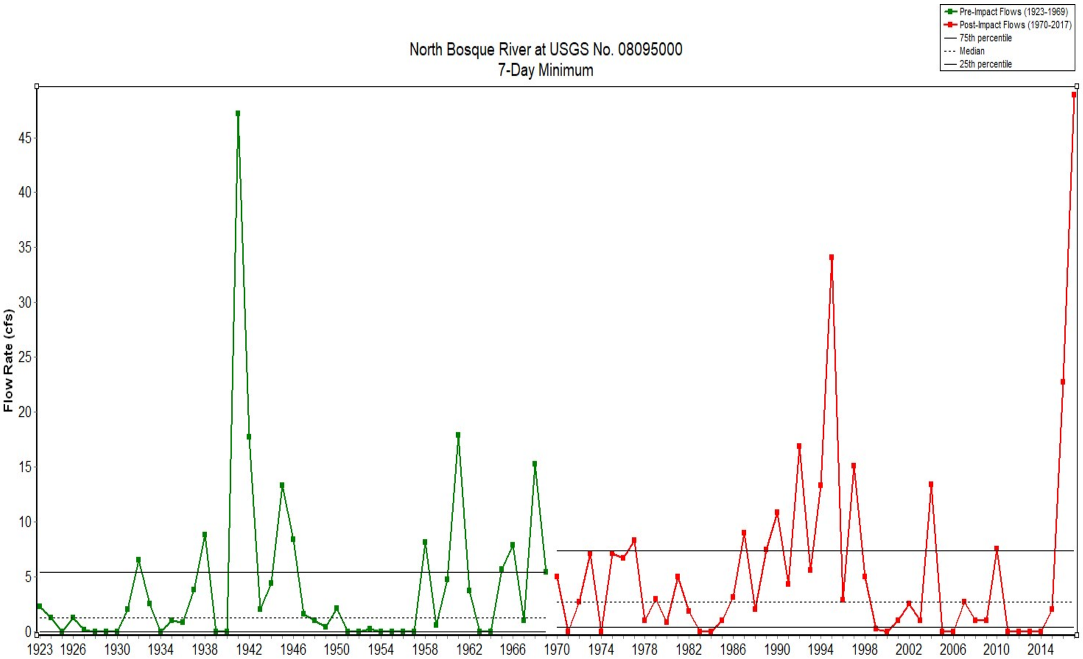
7-day Minimum Flow Rates of Brazos River near South Bend



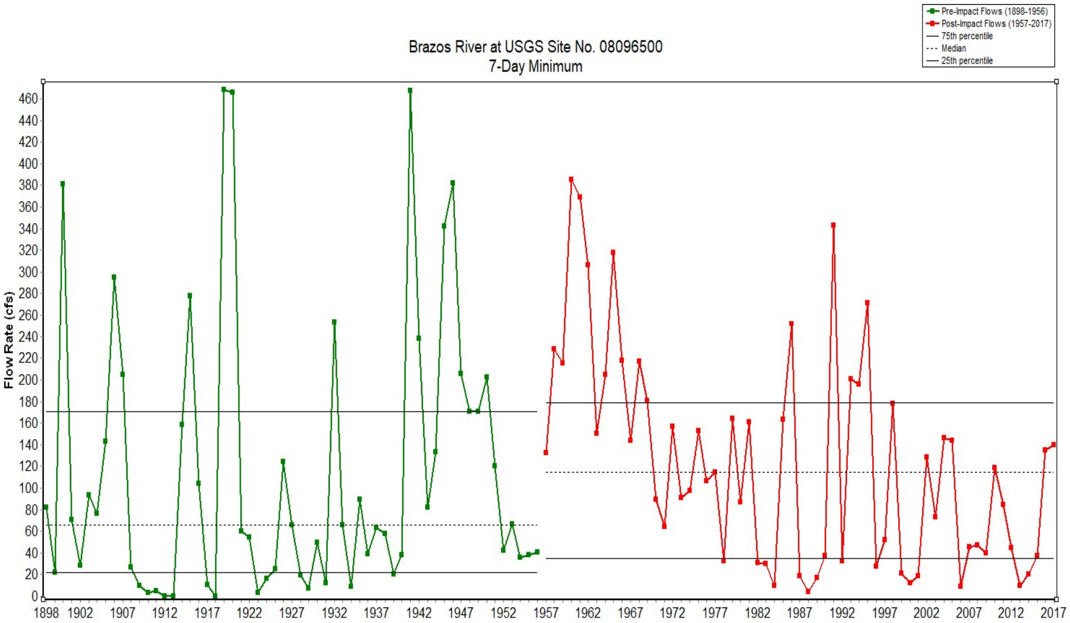
7-day Minimum Flow Rates of Brazos River near Palo Pinto



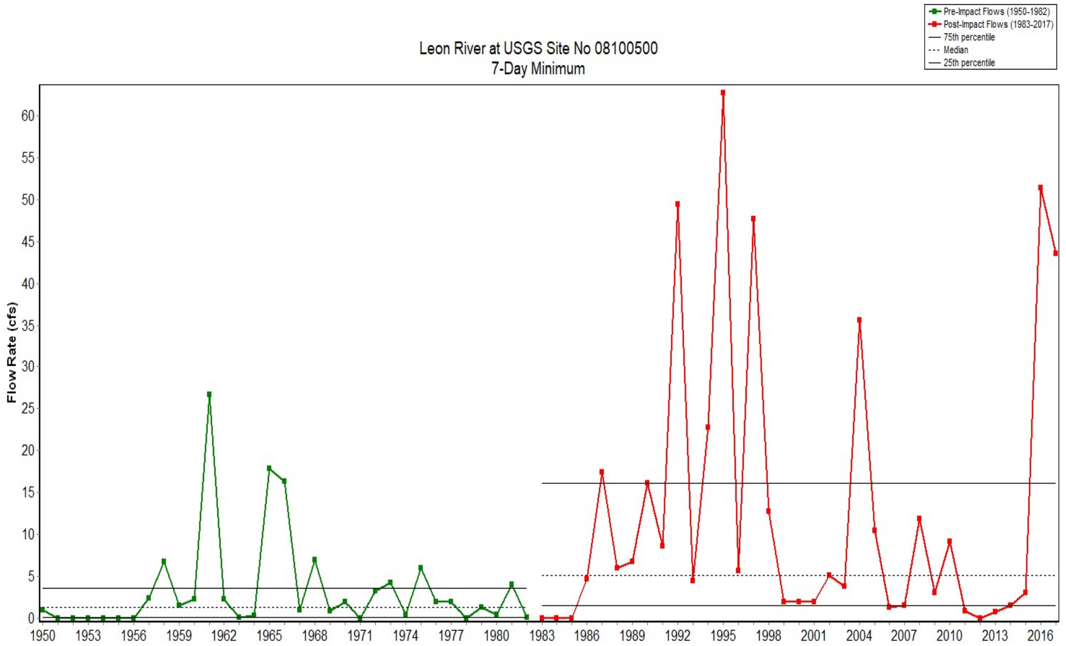
7-day Minimum Flow Rates of Brazos River near Glen Rose



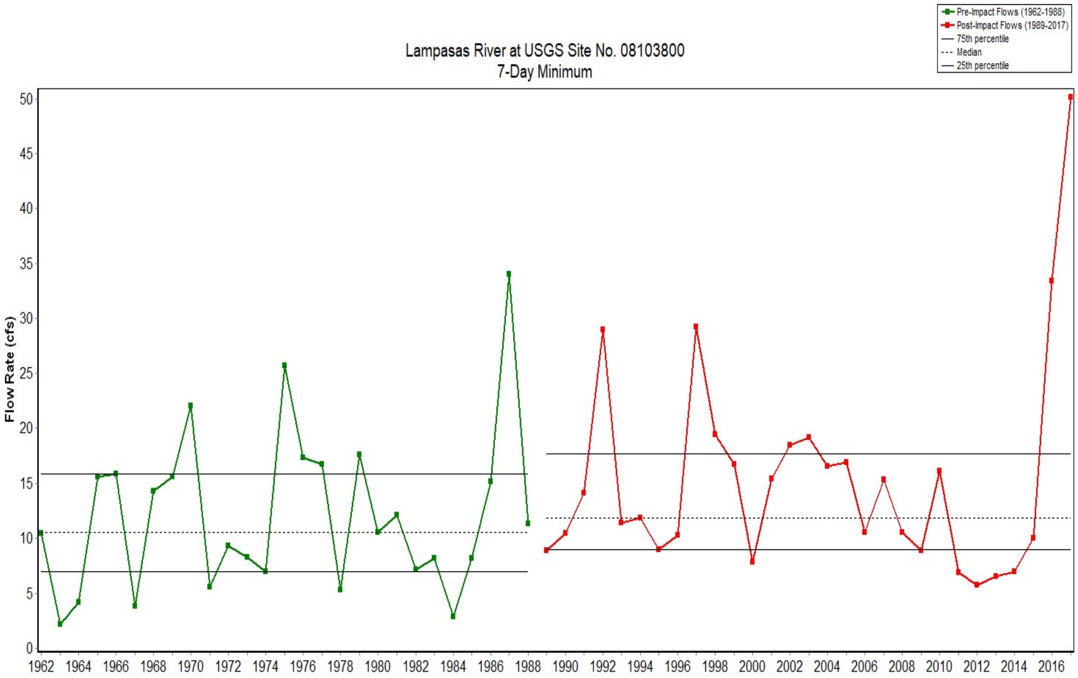
7-day Minimum Flow Rates of North Bosque River near Clifton



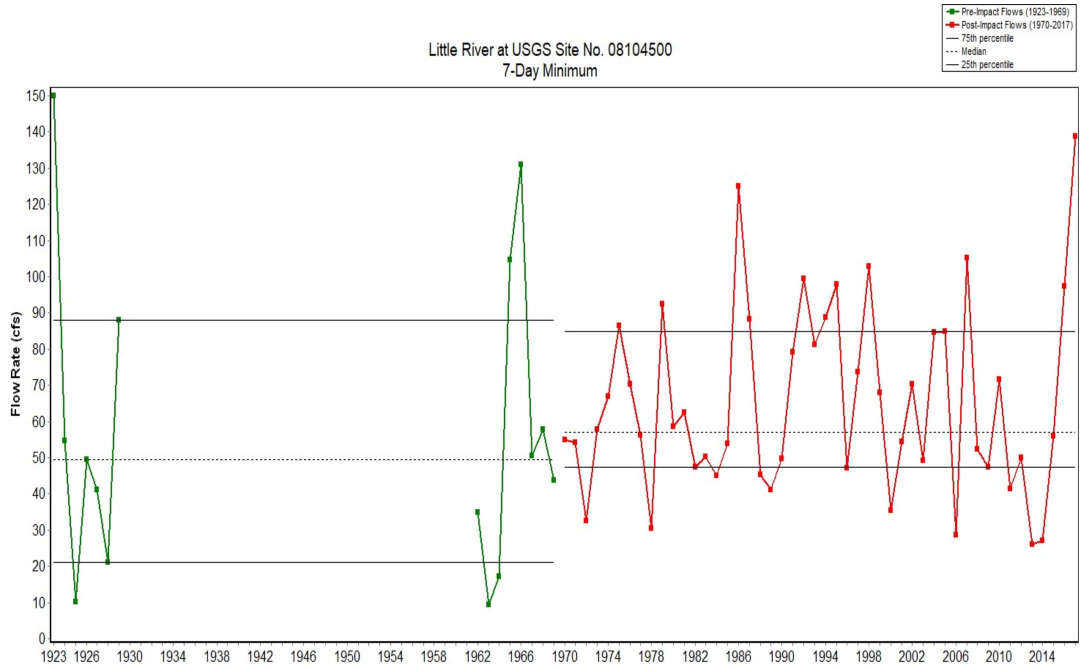
7-day Minimum Flow Rates of Brazos River at Waco



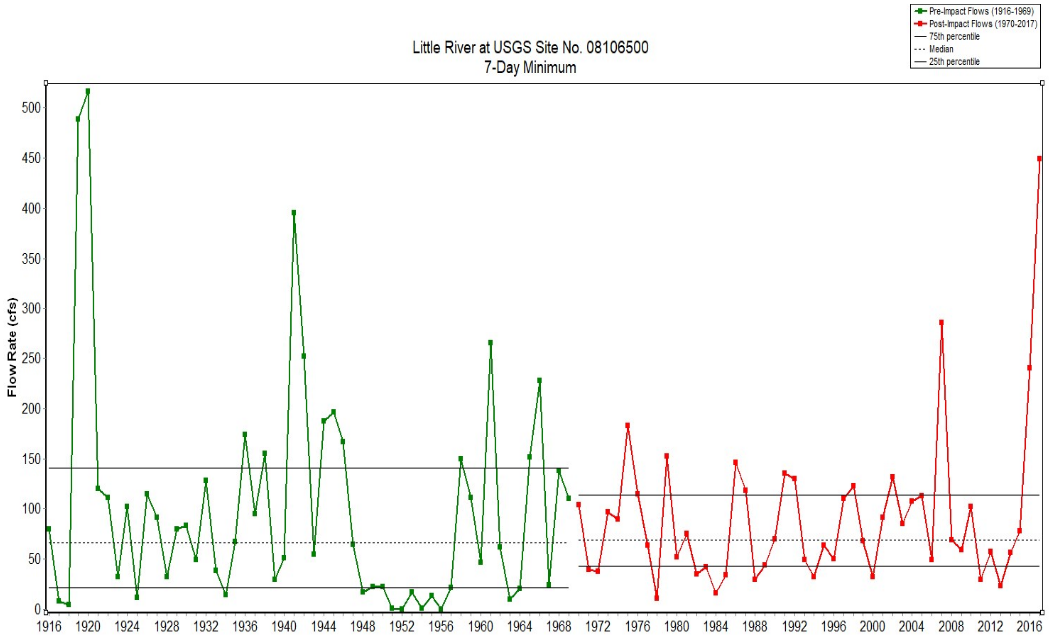
7-day Minimum Flow Rates of Leon River near Gatesville



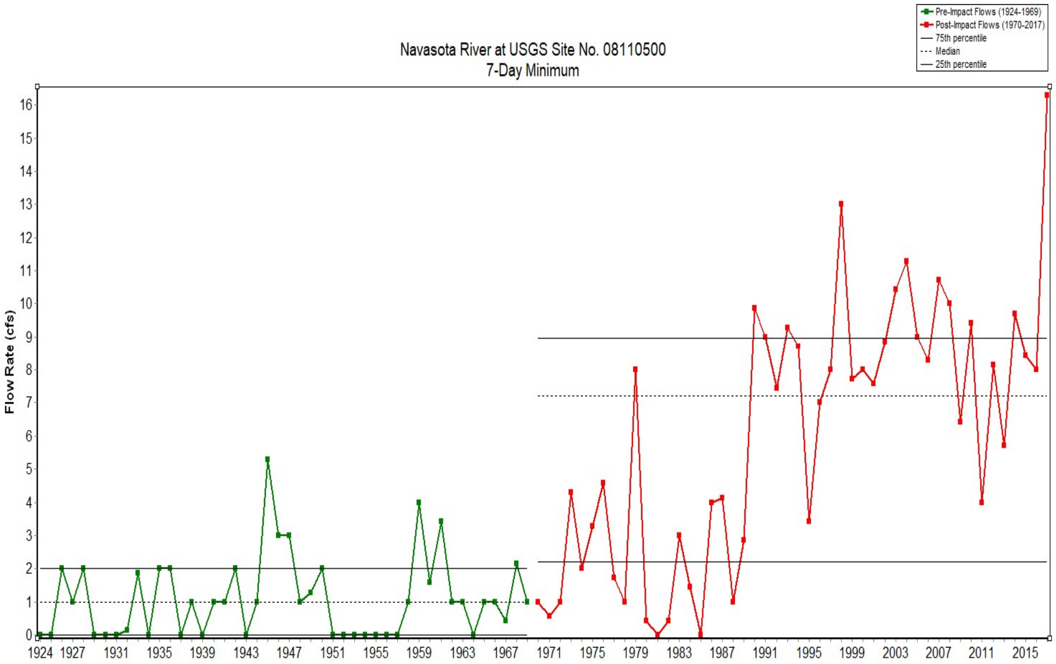
7-day Minimum Flow Rates of Lampasas River near Kempner



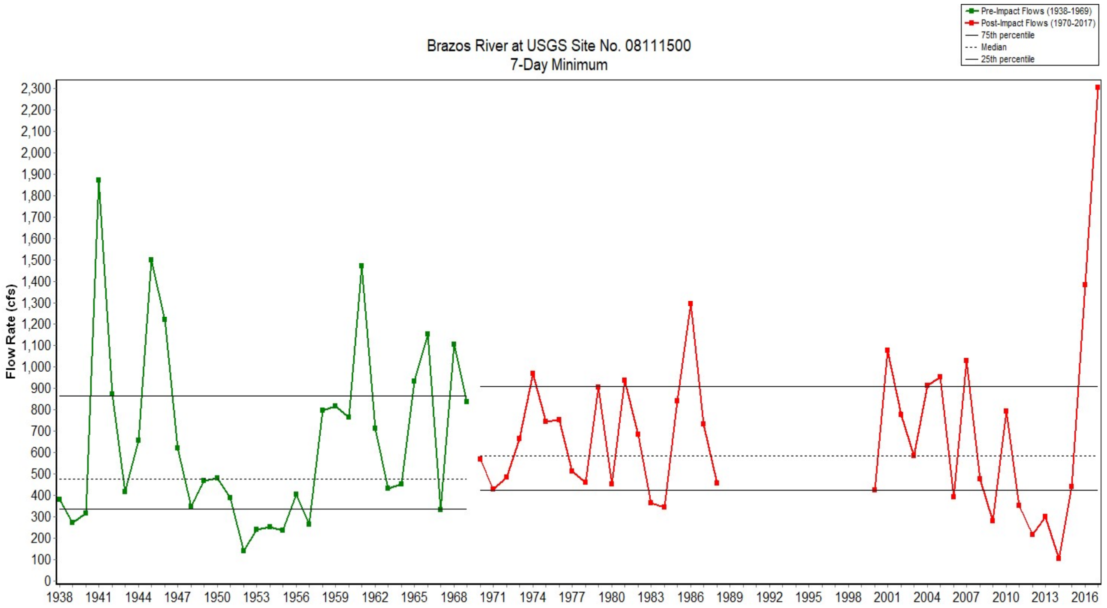
7-day Minimum Flow Rates of Little River near Little River



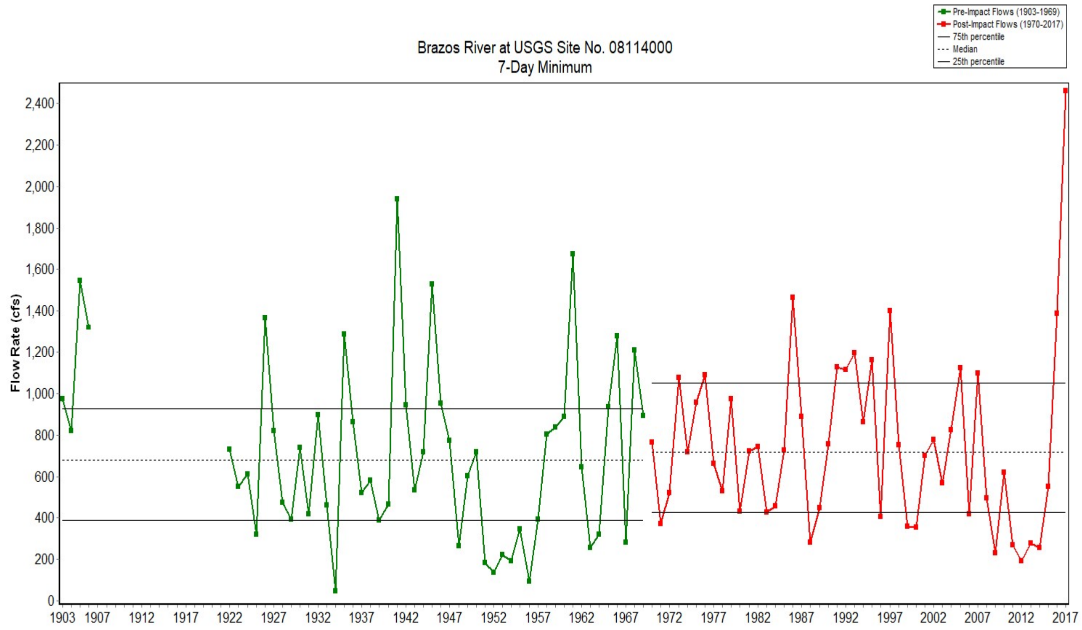
7-day Minimum Flow Rates of Little River near Cameron



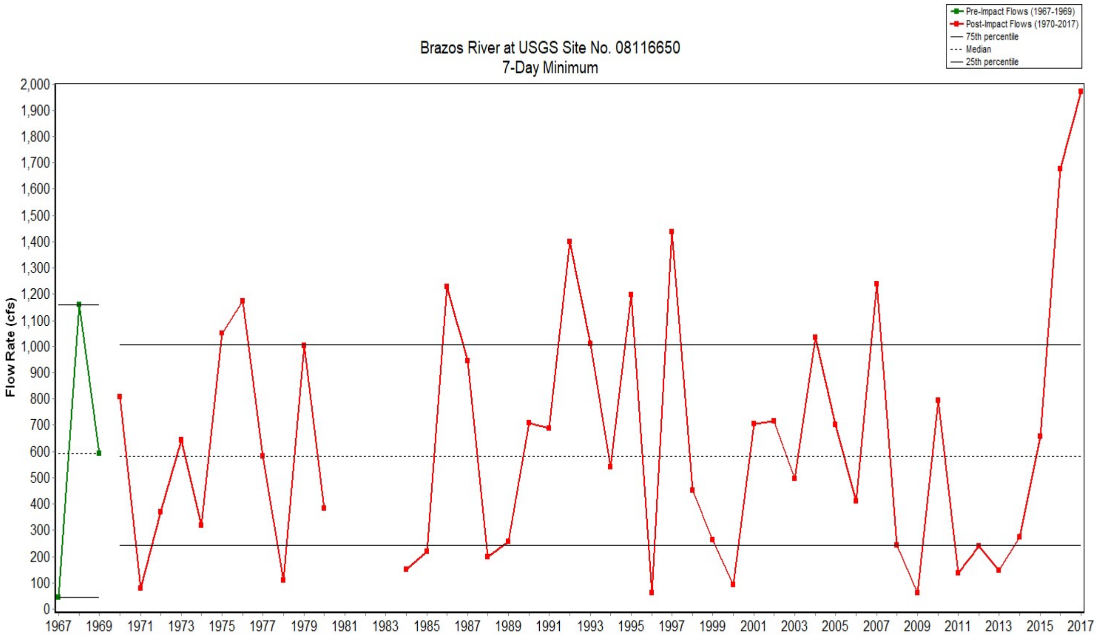
7-day Minimum Flow Rates of Navasota River at Easterly



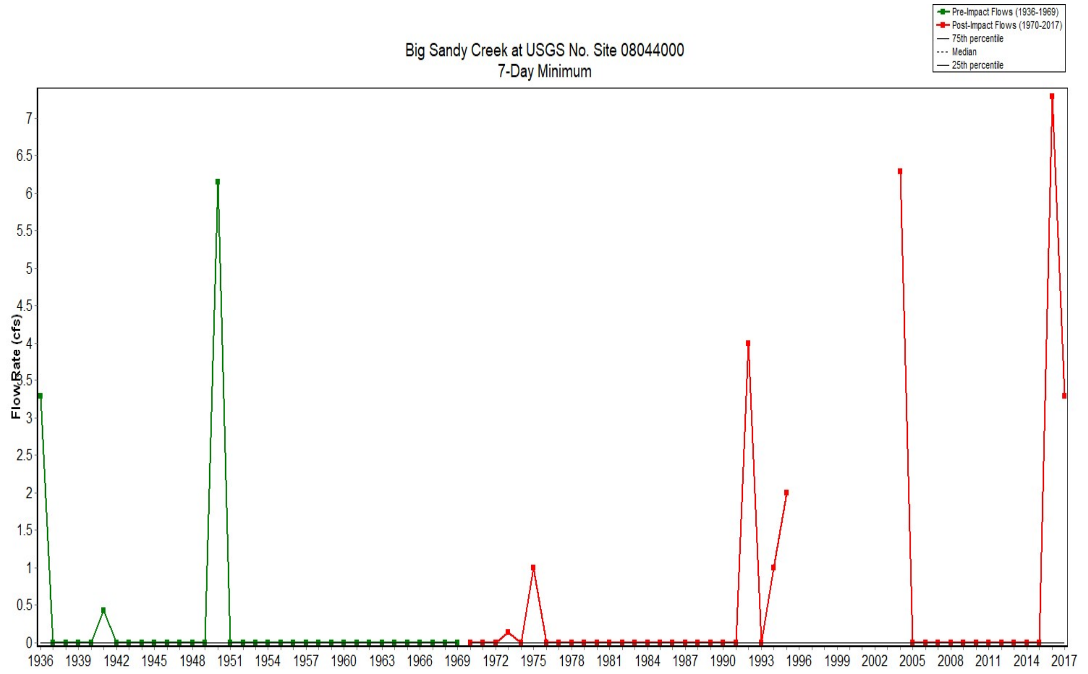
7-day Minimum Flow Rates of Brazos River near Hempstead



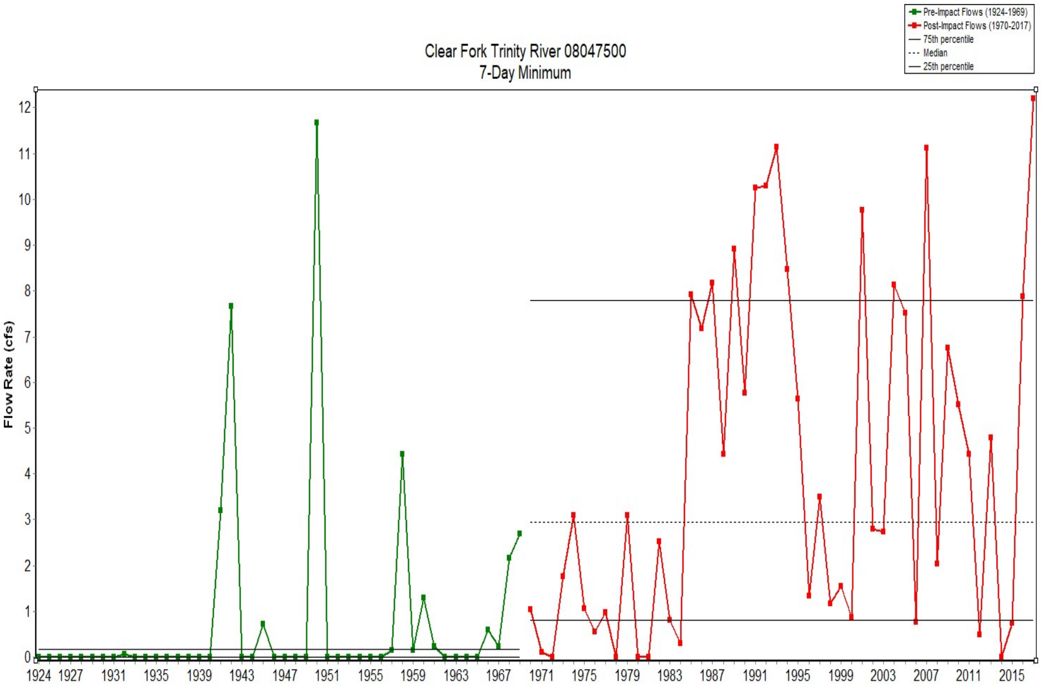
7-day Minimum Flow Rates of Brazos River near Richmond



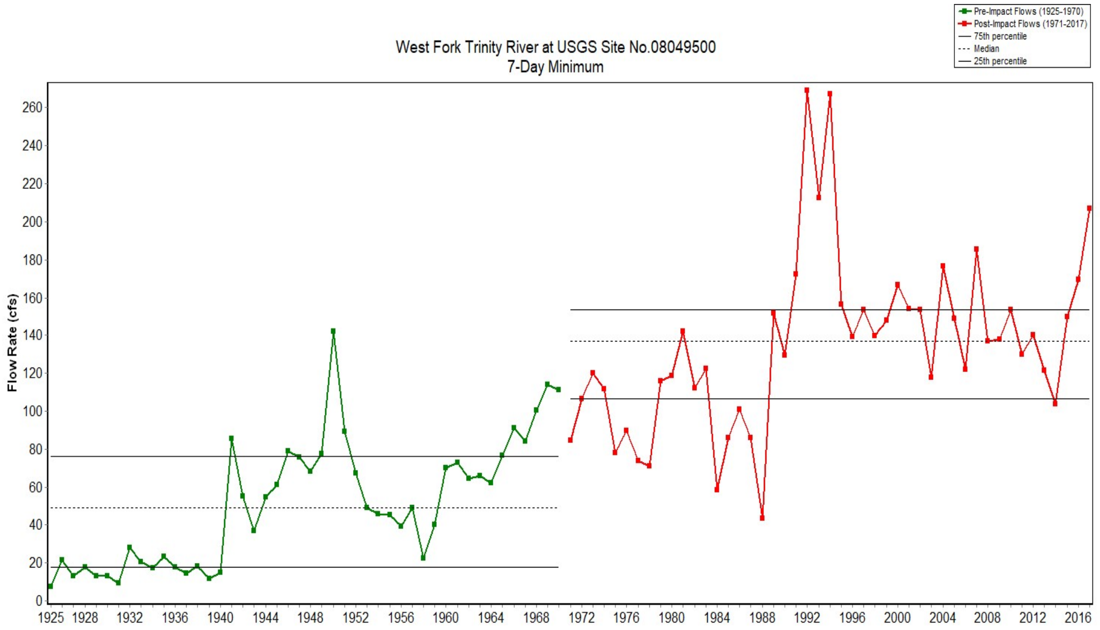
7-day Minimum Flow Rates of Brazos River near Rosharon



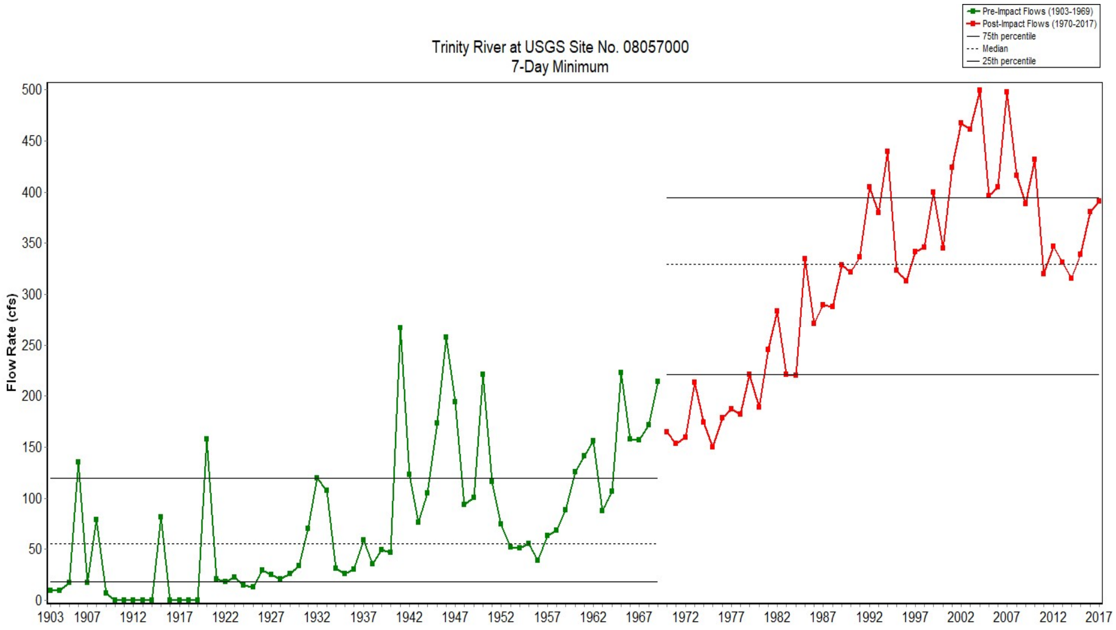
7-day Minimum Flow Rates of Big Sandy Creek near Bridgeport



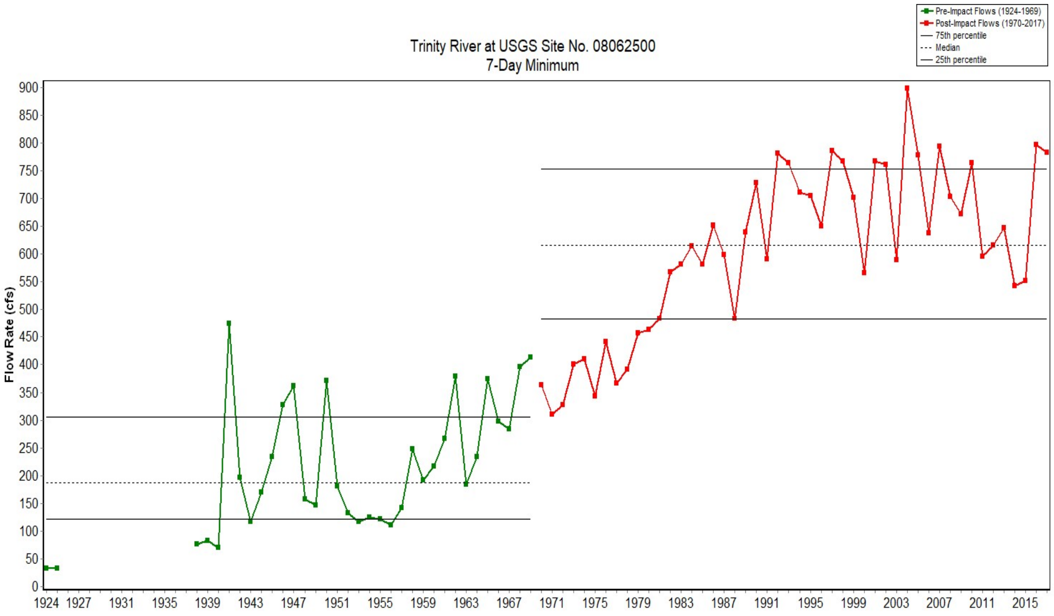
7-day Minimum Flow Rates of Clear Fork Trinity River at Fort Worth



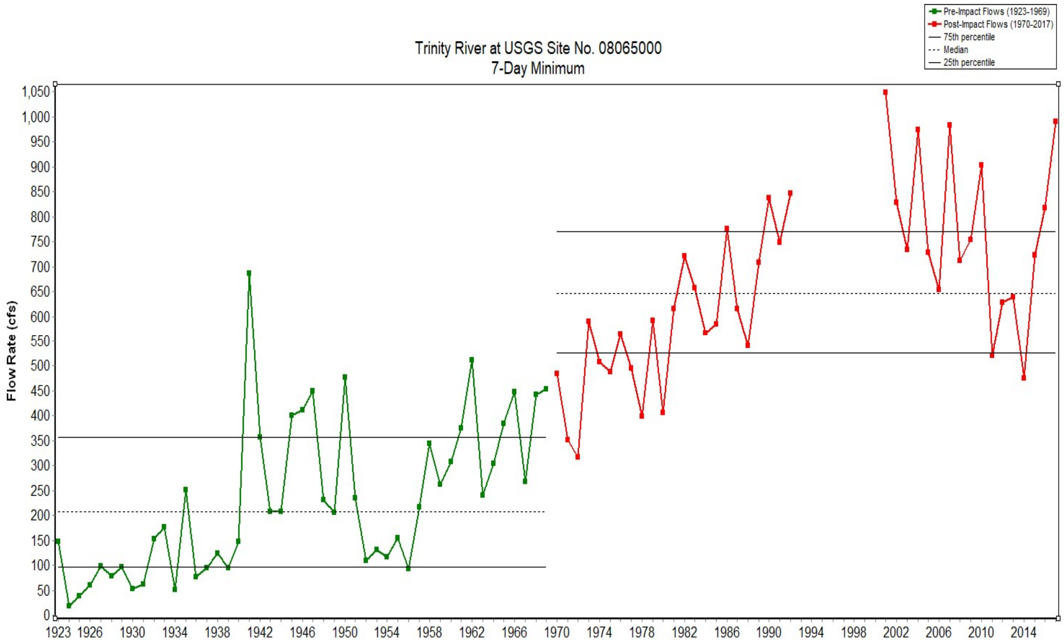
7-day Minimum Flow Rates of West Fork Trinity River at Grand Prairie



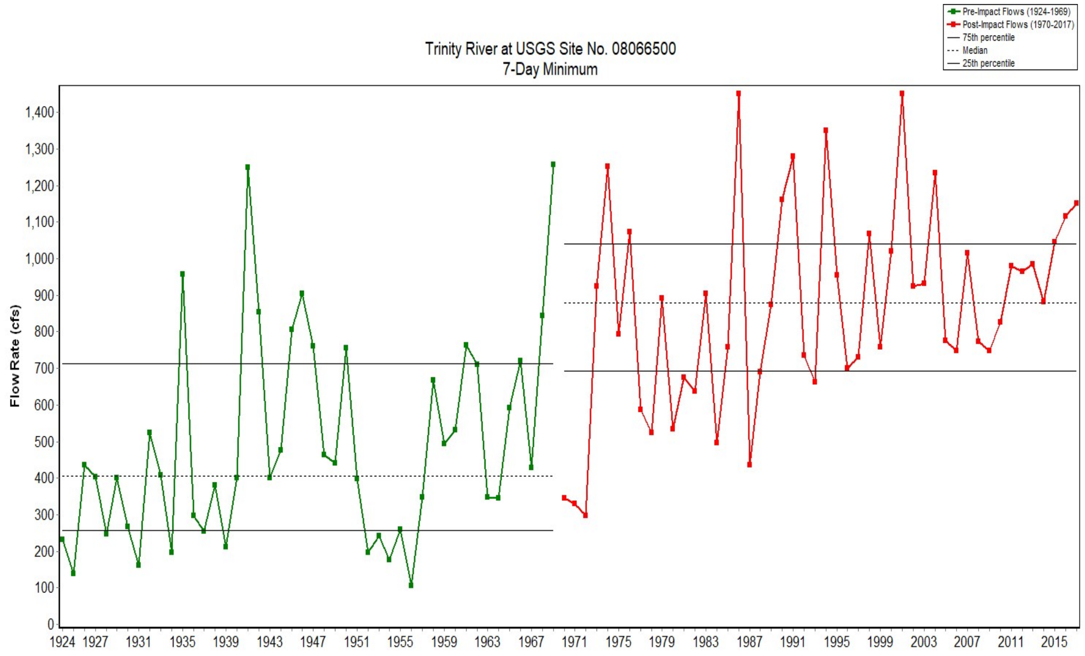
7-day Minimum Flow Rates of Trinity River at Dallas



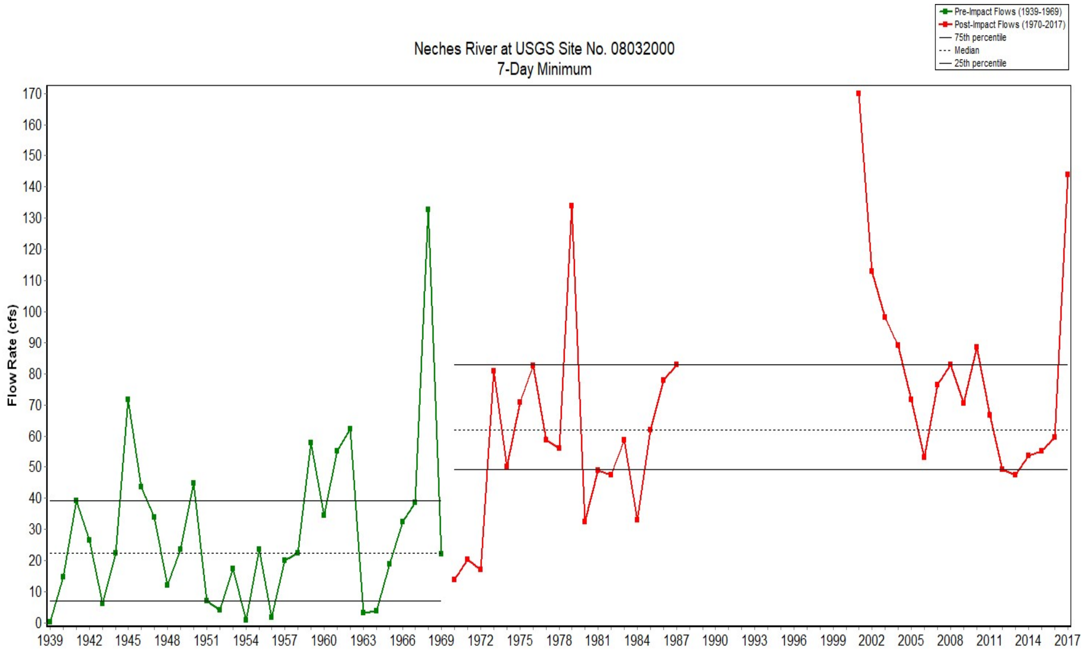
7-day Minimum Flow Rates of Trinity River near Rosser



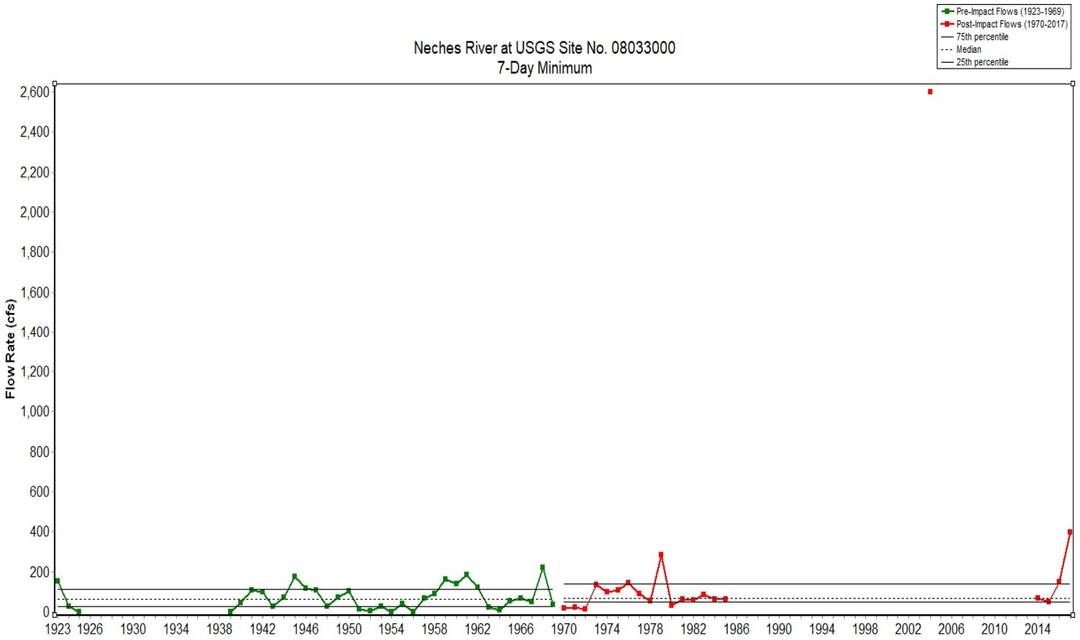
7-day Minimum Flow Rates of Trinity River near Oakwood



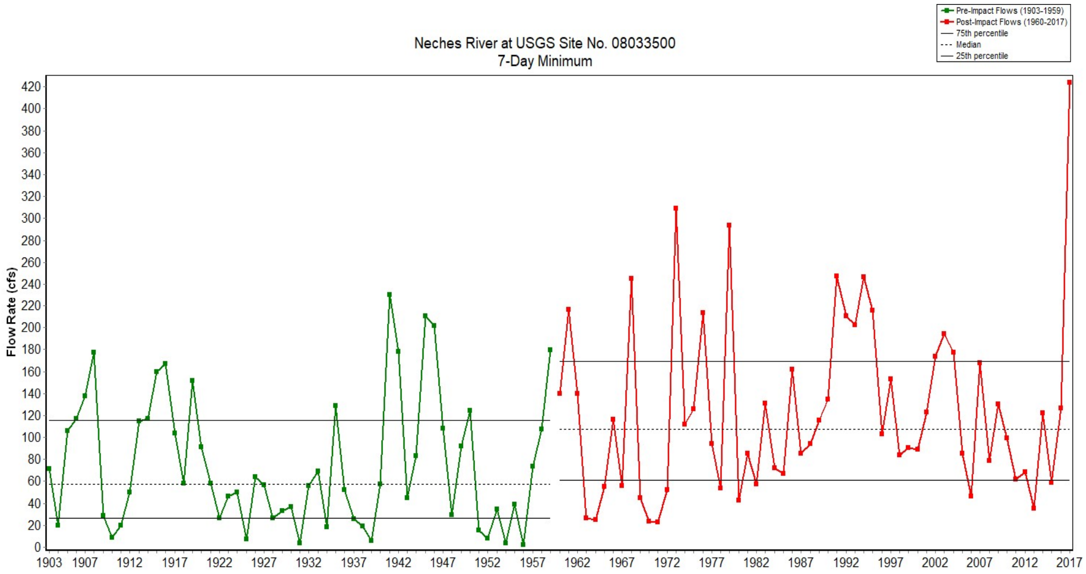
7-day Minimum Flow Rates of Trinity River at Romayor



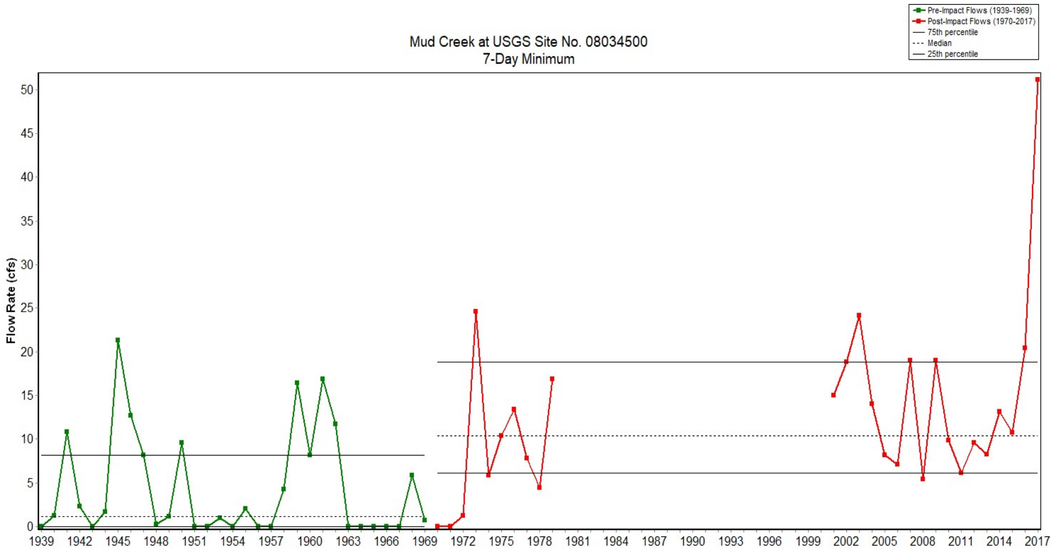
7-day Minimum Flow Rates of Neches River near Neches



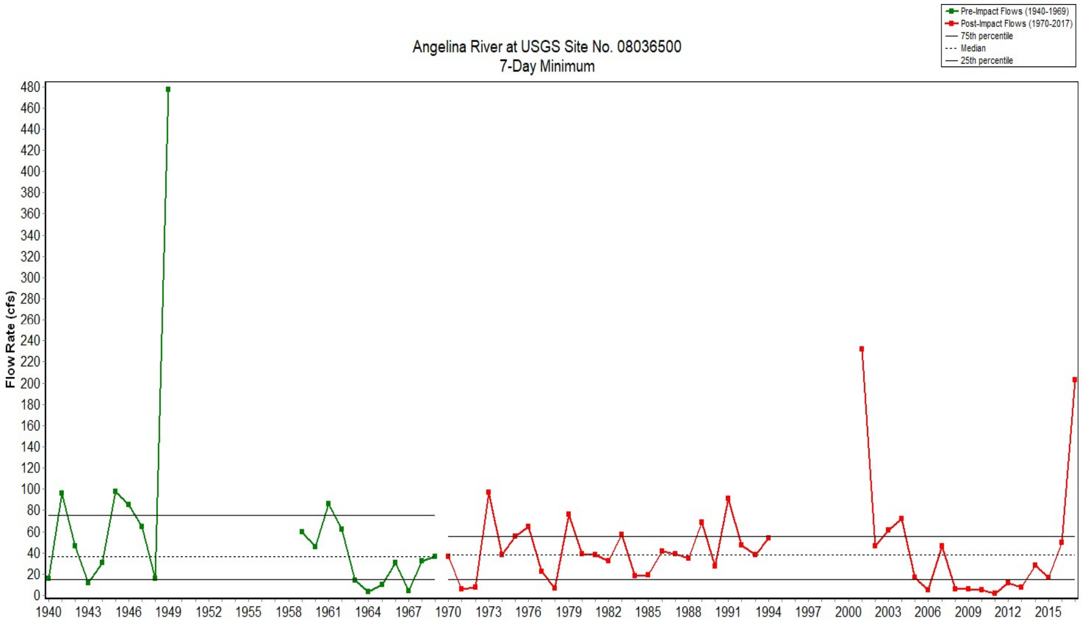
7-day Minimum Flow Rates of Neches River near Diboll



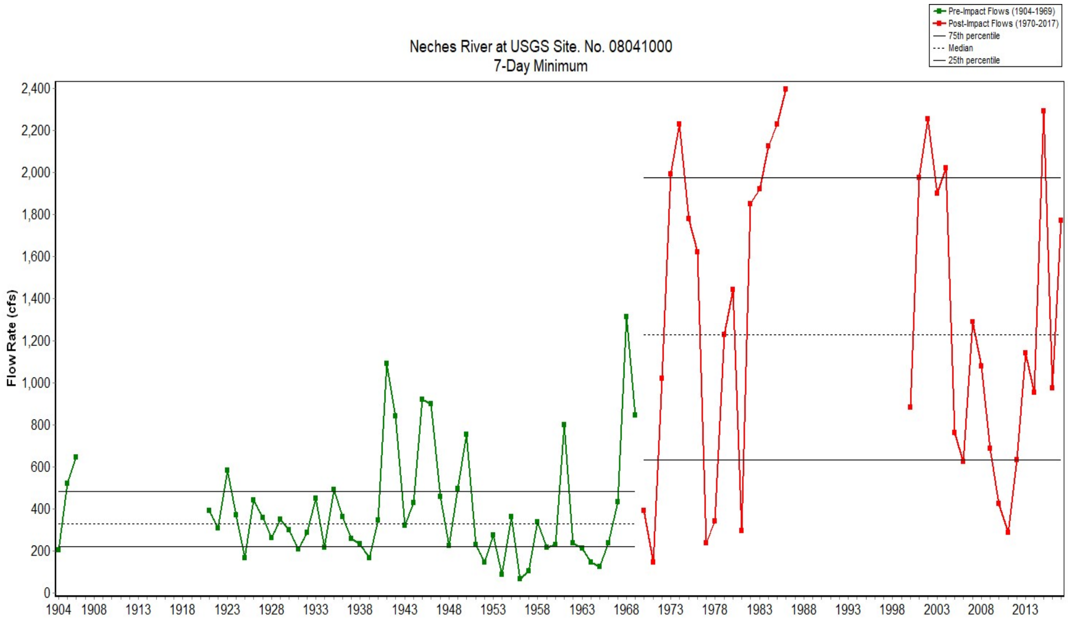
7-day Minimum Flow Rates of Neches River near Rockland



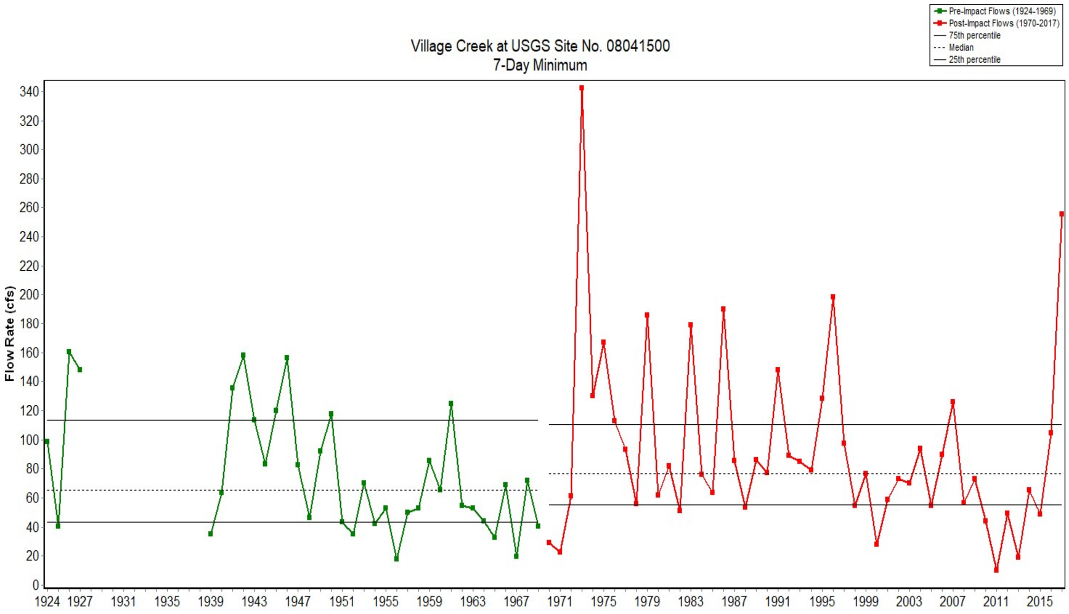
7-day Minimum Flow Rates of Mud Creek near Jacksonville



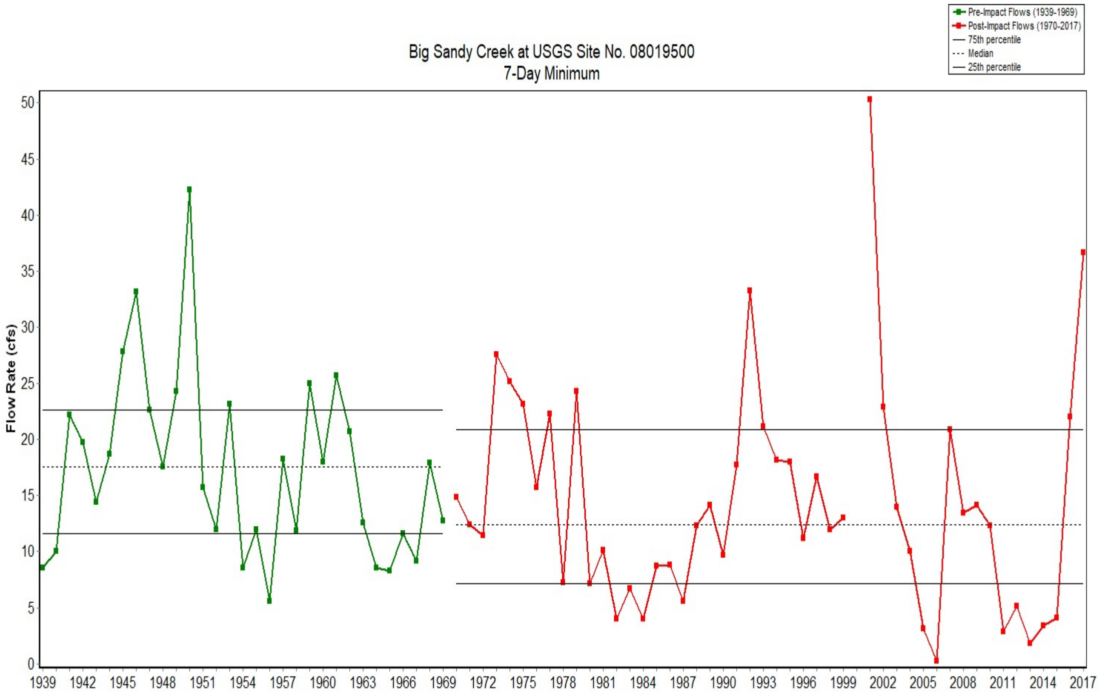
7-day Minimum Flow Rates of Angelina River near Alto



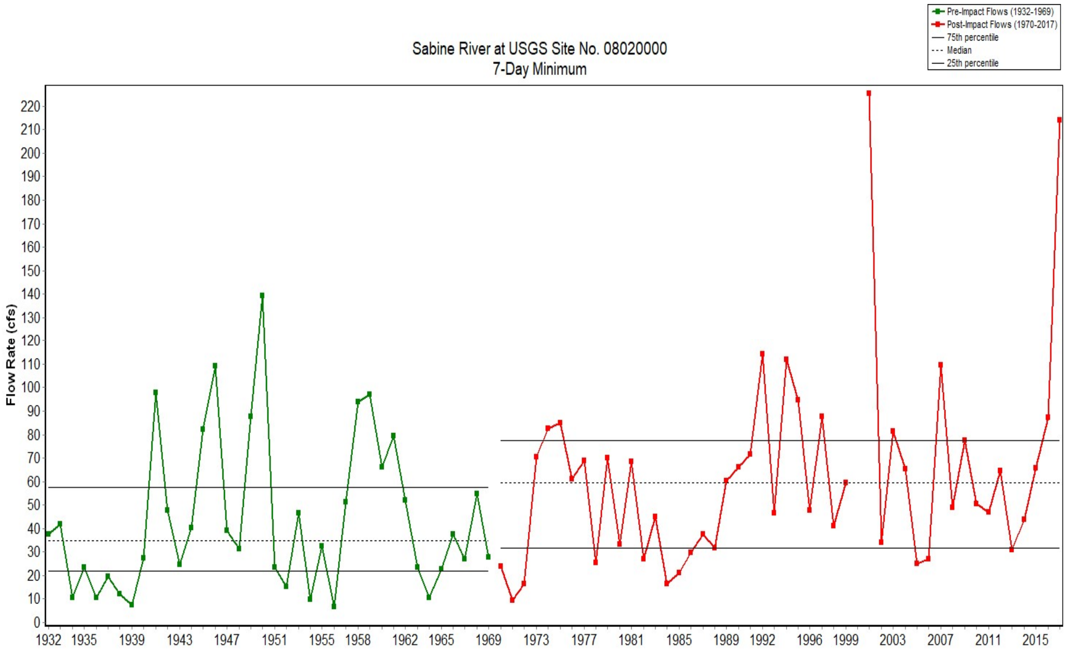
7-day Minimum Flow Rates of Neches River at Evadale



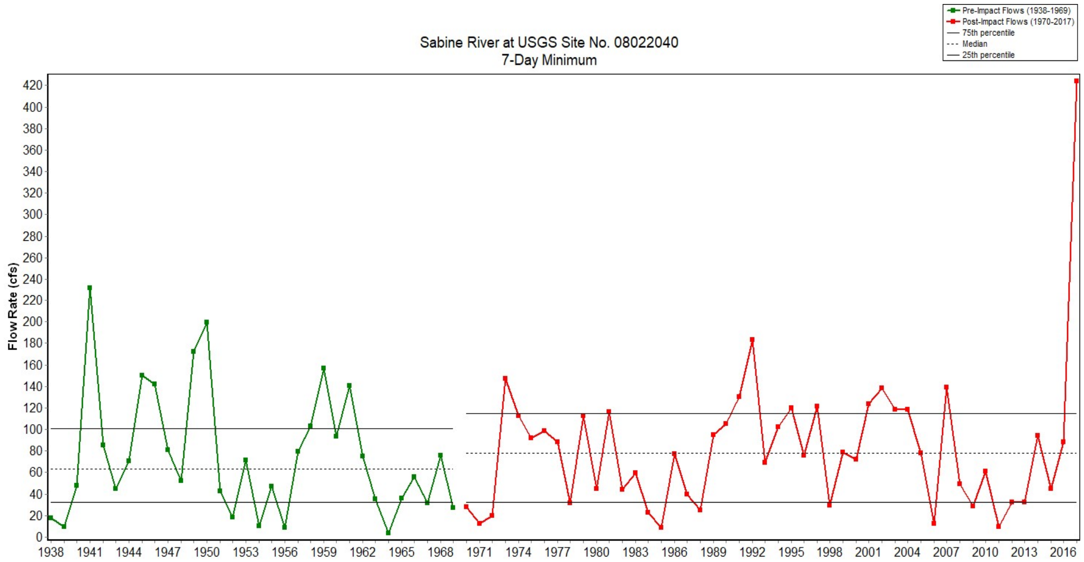
7-day Minimum Flow Rates of Village Creek near Kountze



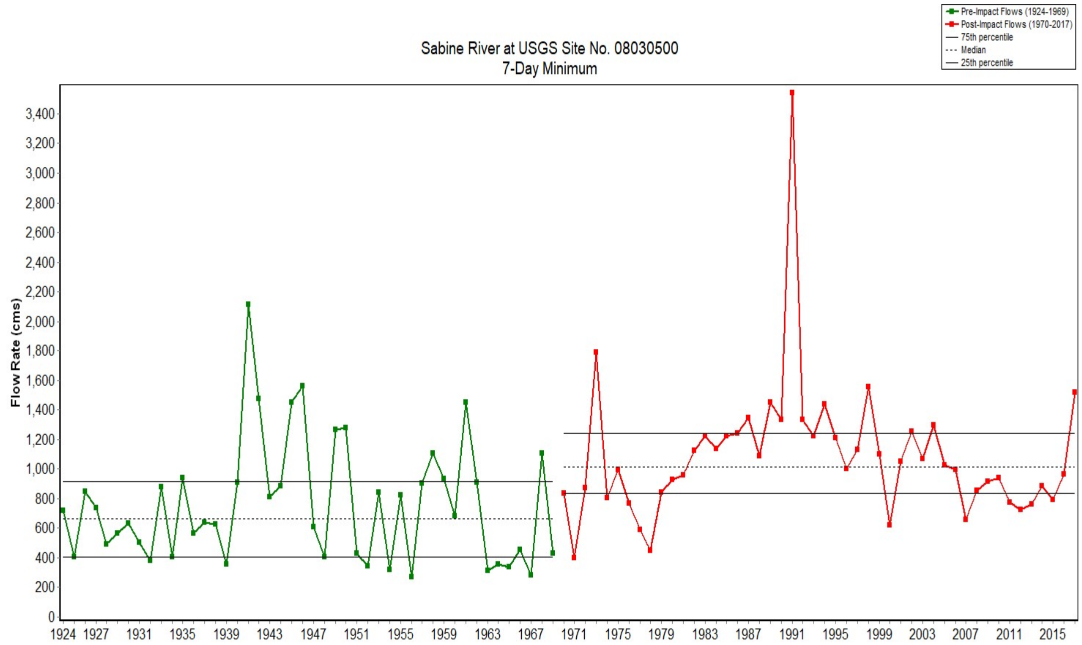
7-day Minimum Flow Rates of Big Sandy Creek near Big Sandy



7-day Minimum Flow Rates of Sabine River near Gladewater



7-day Minimum Flow Rates of Sabine River near Beckville



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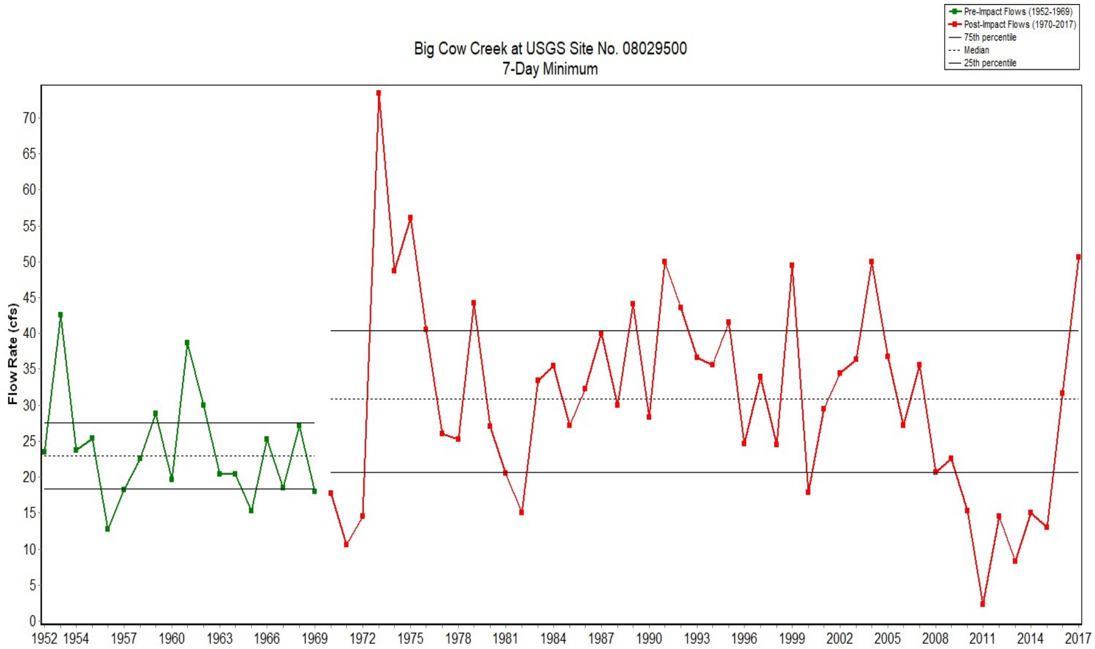
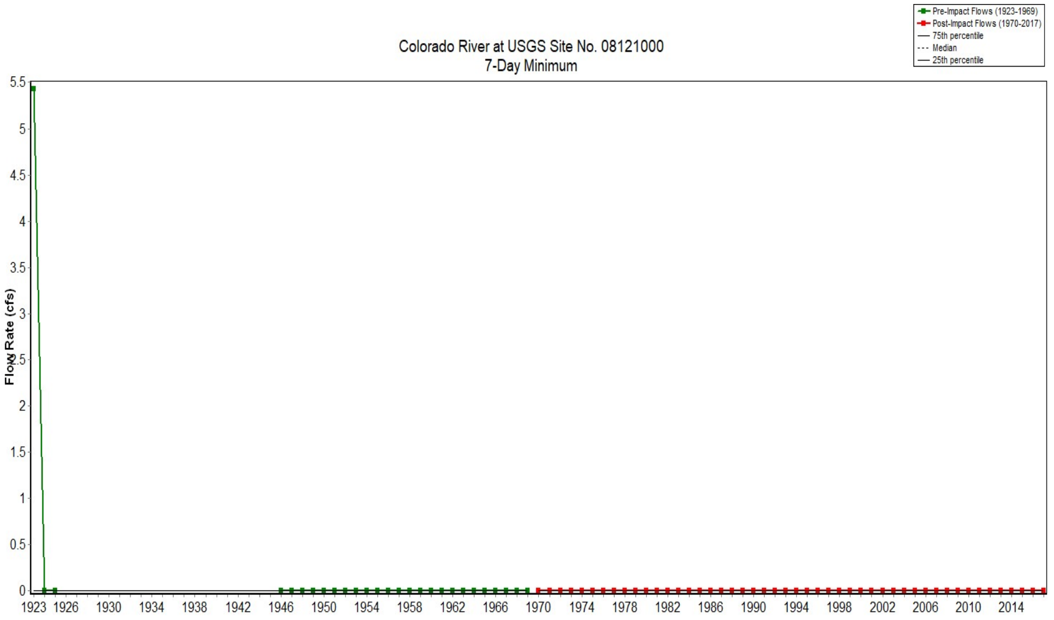
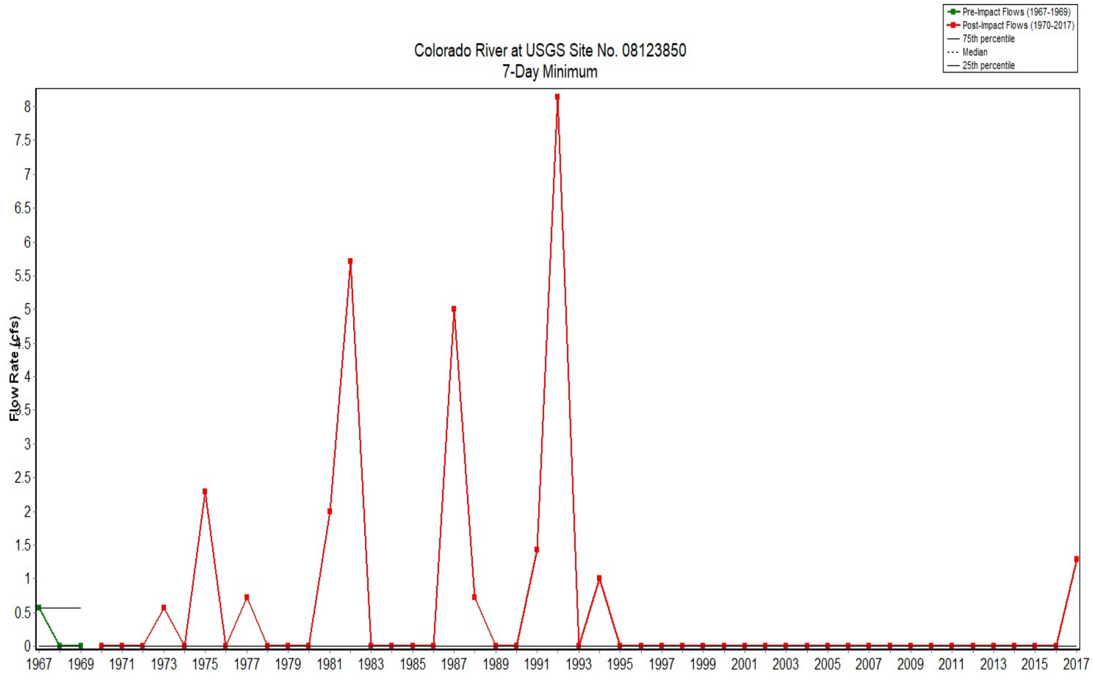


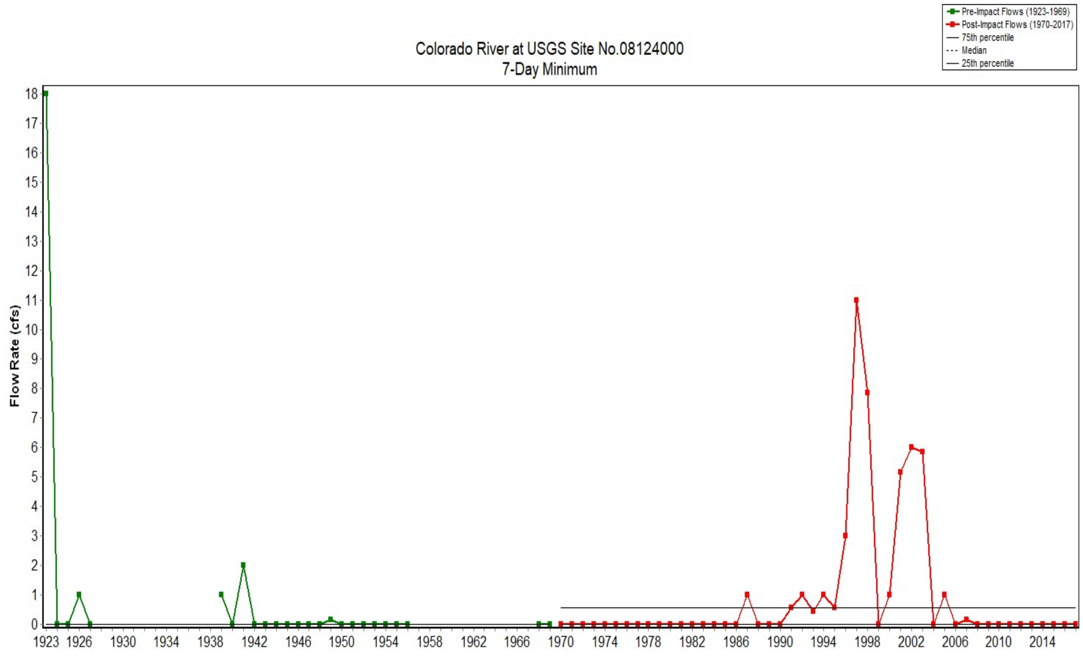
7-day Minimum Flow Rates of Big Cow Creek near Newton



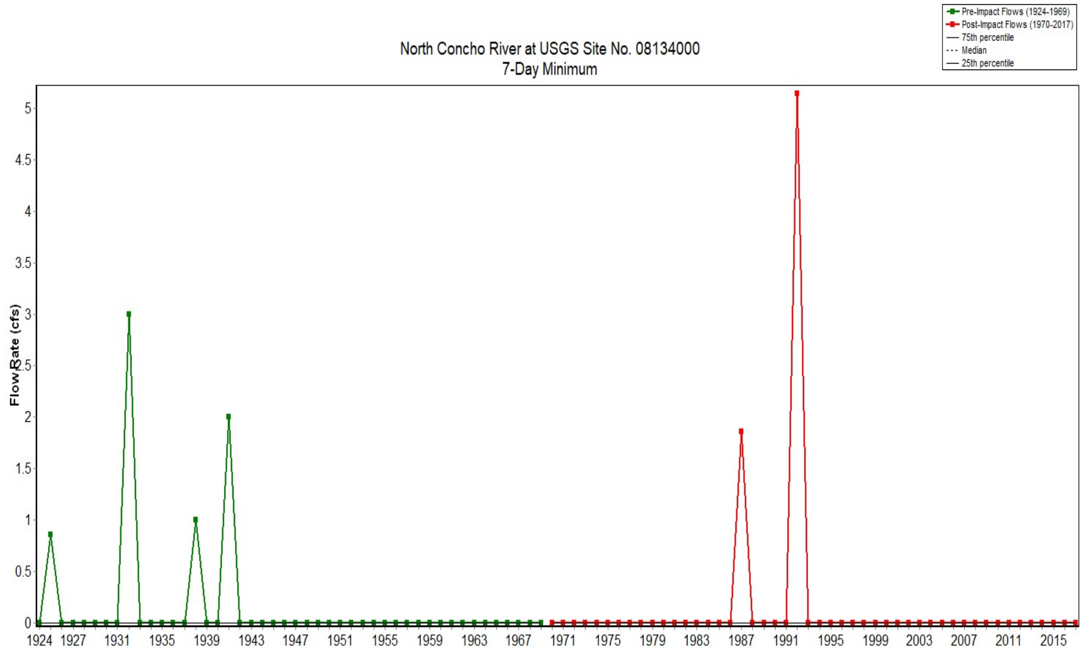
7-day Minimum Flow Rates of Colorado River at Colorado City



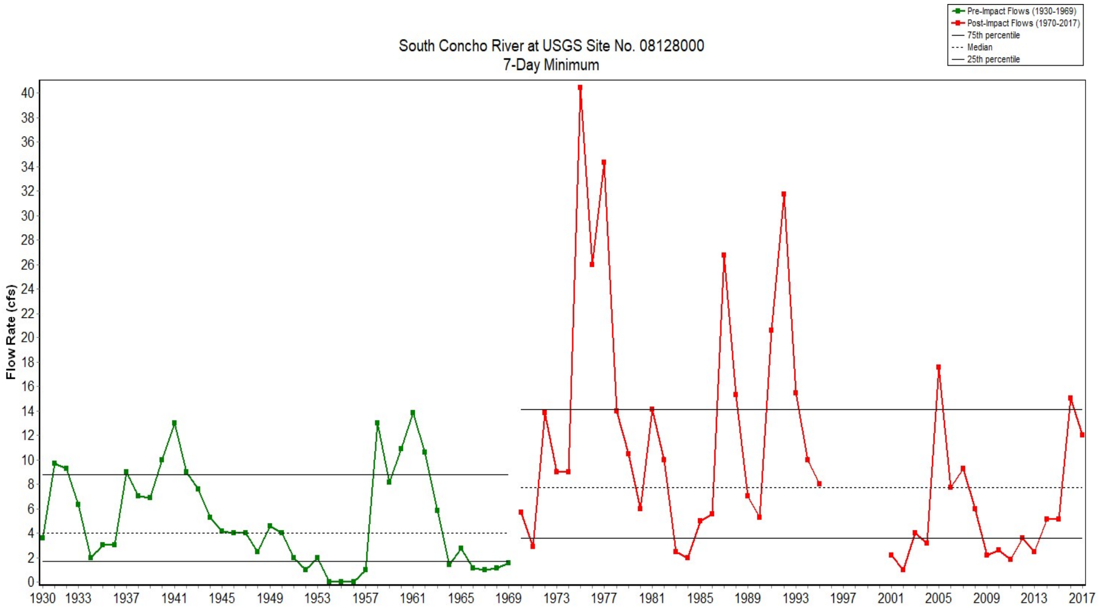
7-day Minimum Flow Rates of Colorado River above Silver



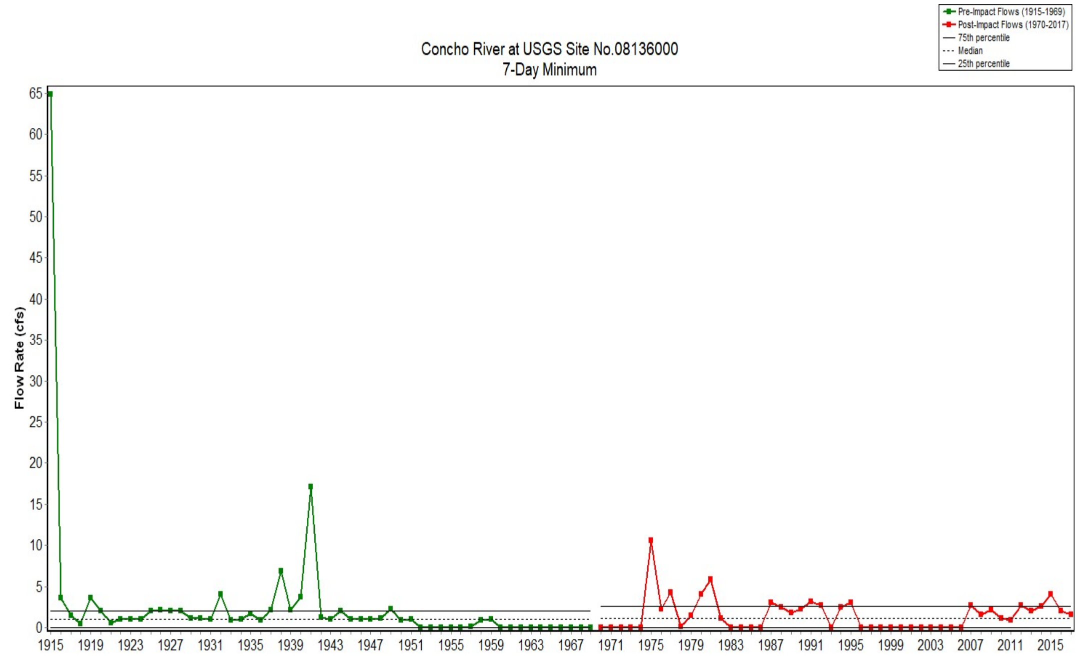
7-day Minimum Flow Rates of Colorado River at Robert Lee



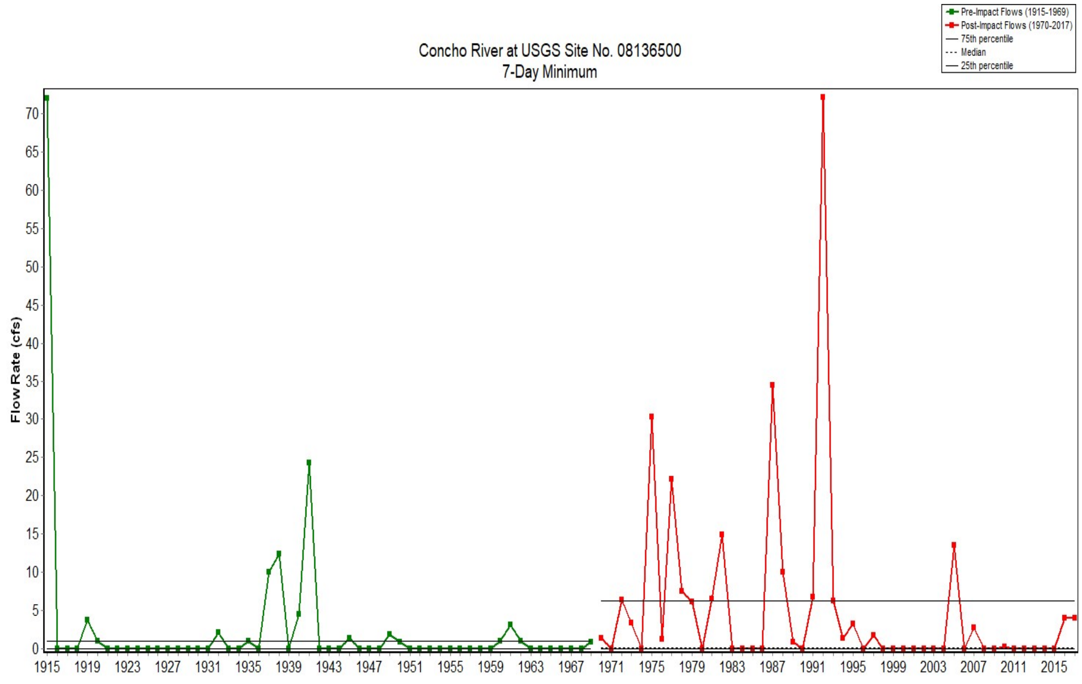
7-day Minimum Flow Rates of North Concho River near Carlsbad



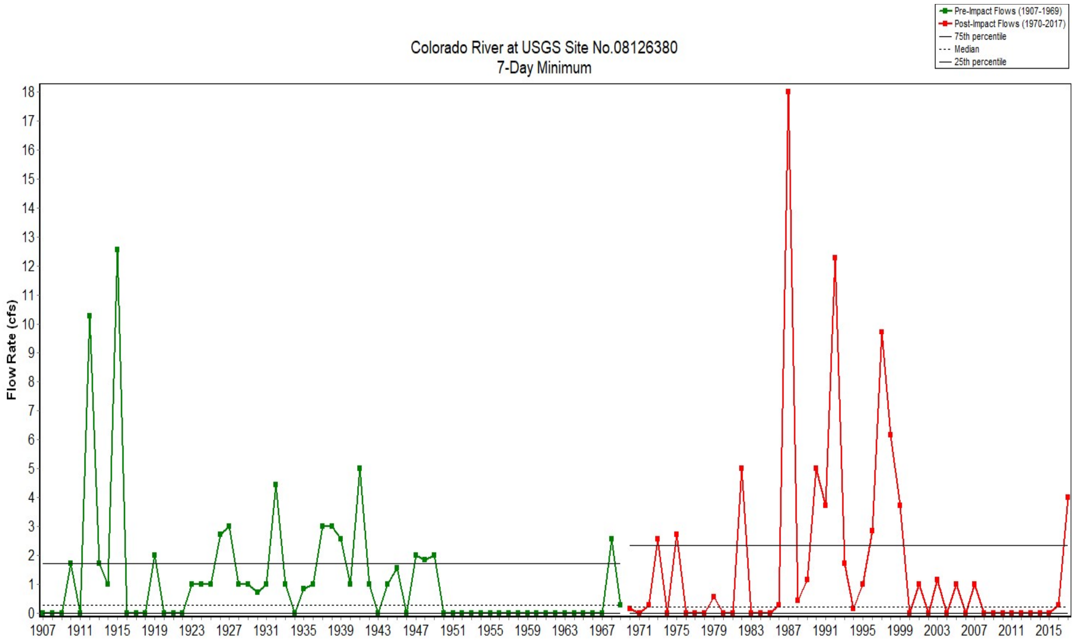
7-day Minimum Flow Rates of South Concho River at Christoval



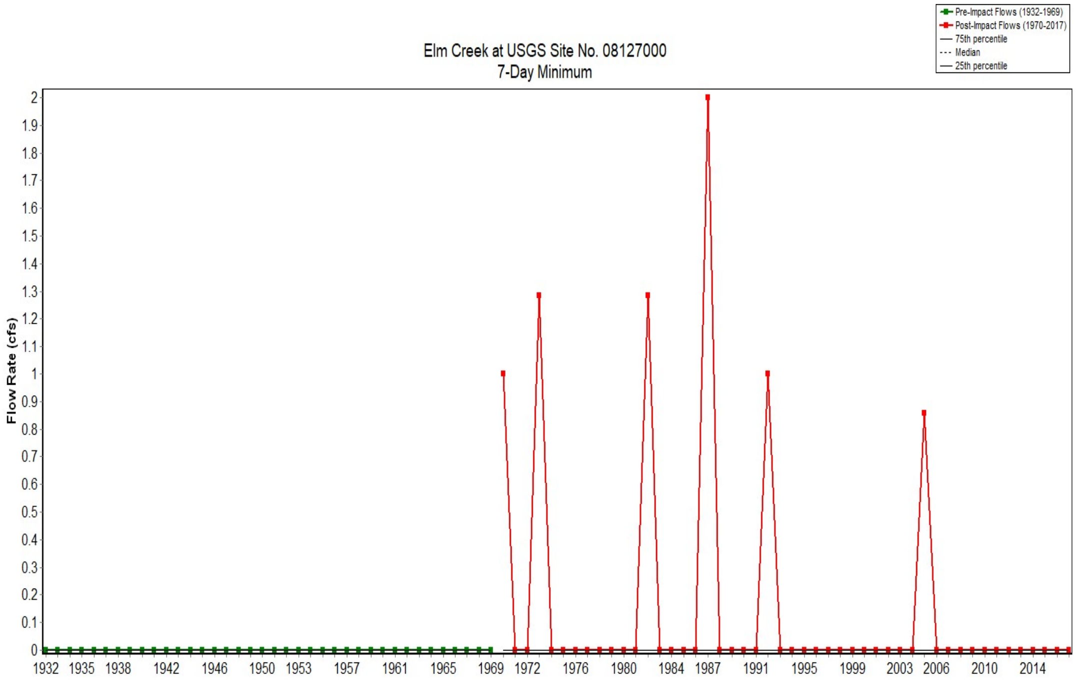
7-day Minimum Flow Rates of Concho River at San Angelo



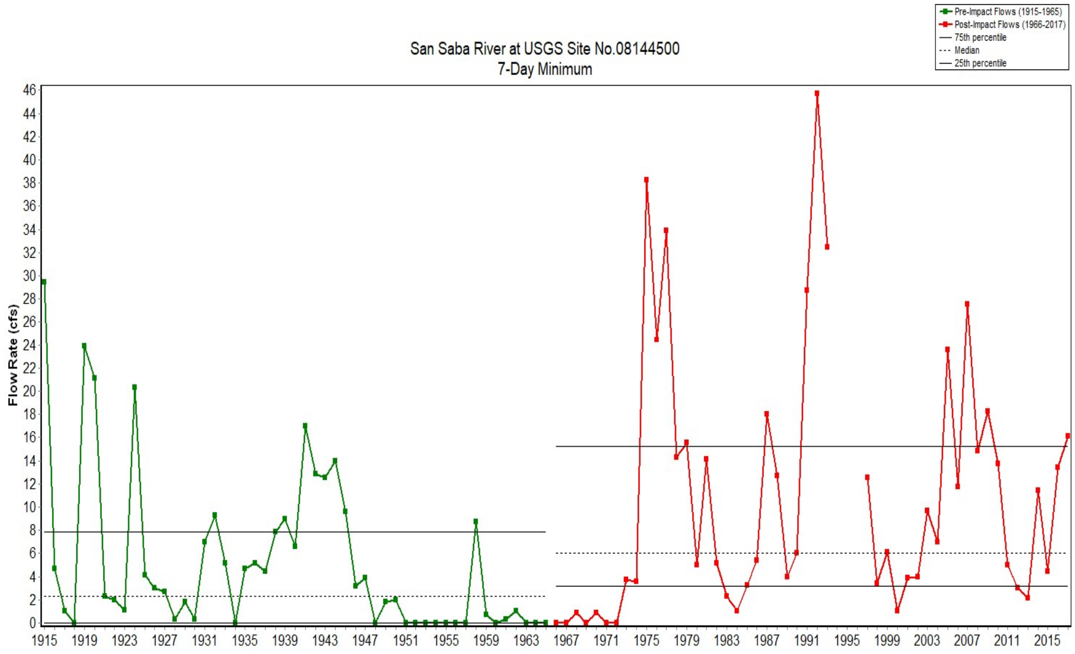
7-day Minimum Flow Rates of Concho River at Paint Rock



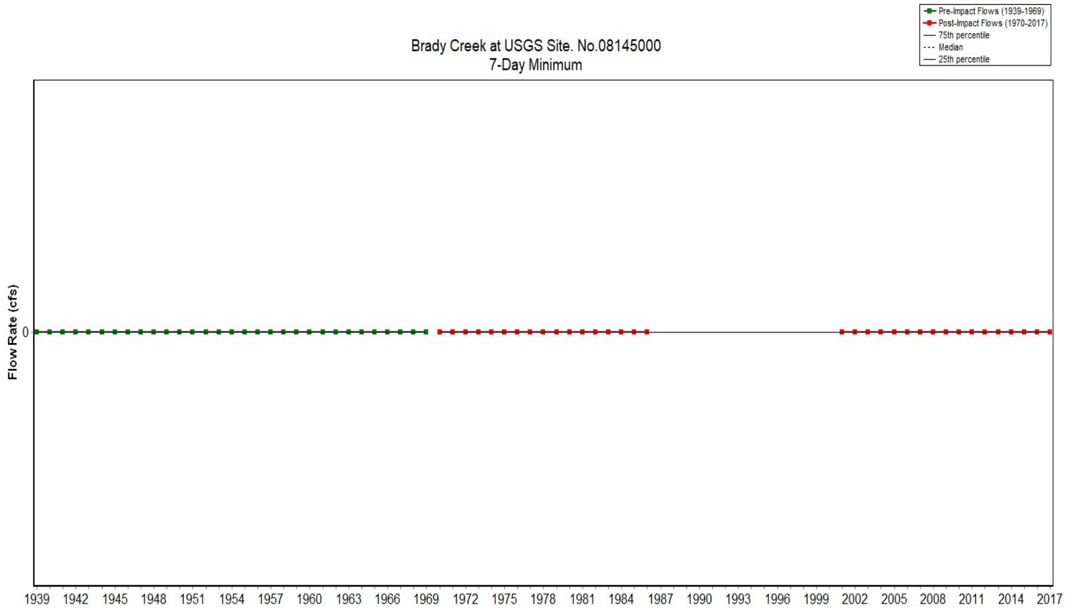
7-day Minimum Flow Rates of Colorado River near Ballinger



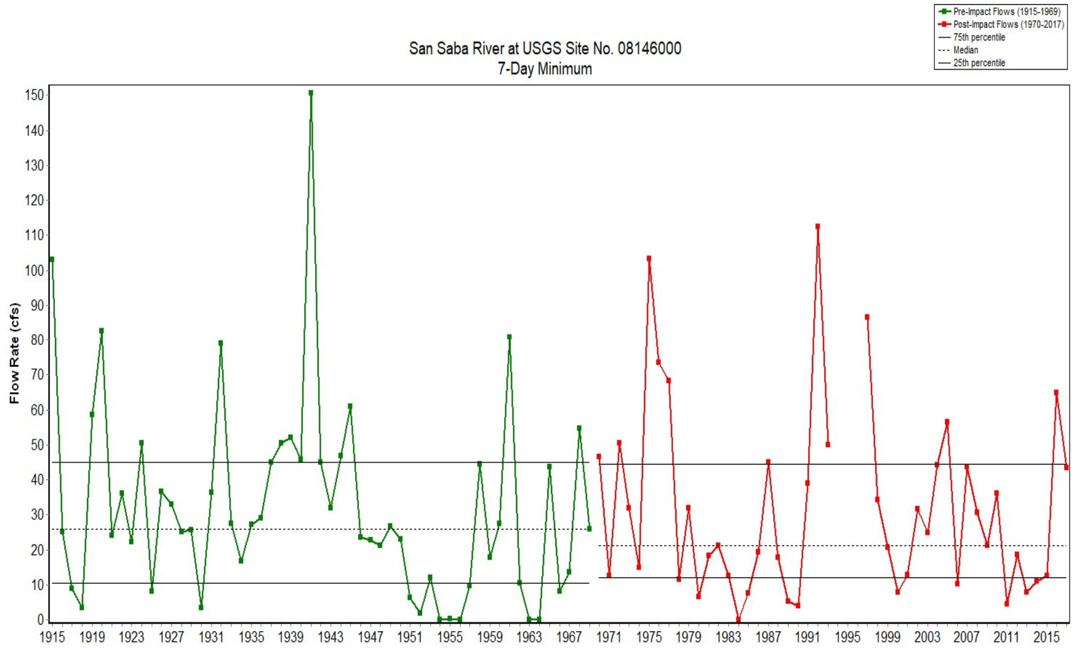
7-day Minimum Flow Rates of Elm Creek at Ballinger



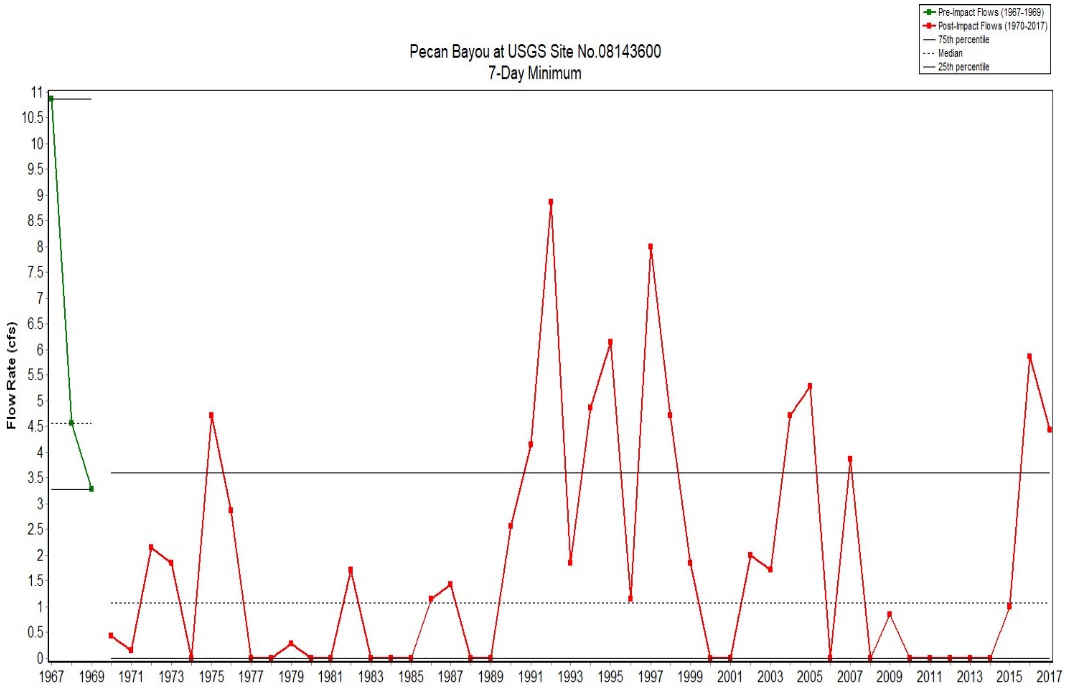
7-day Minimum Flow Rates of San Saba River at Menard



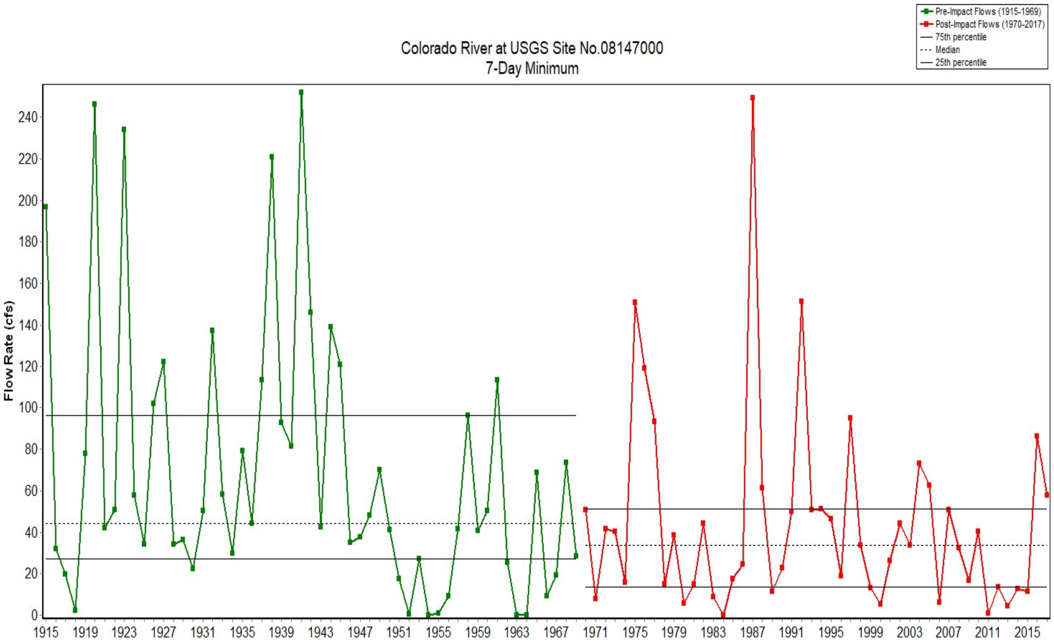
7-day Minimum Flow Rates of Brady Creek at Brady



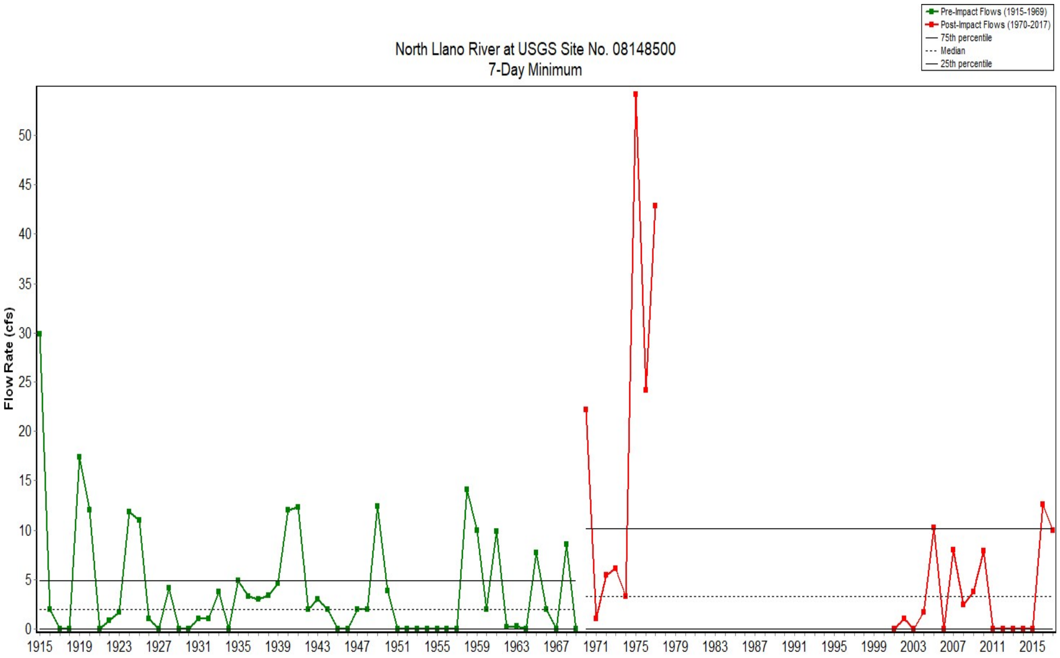
7-day Minimum Flow Rates of San Saba River at San Saba



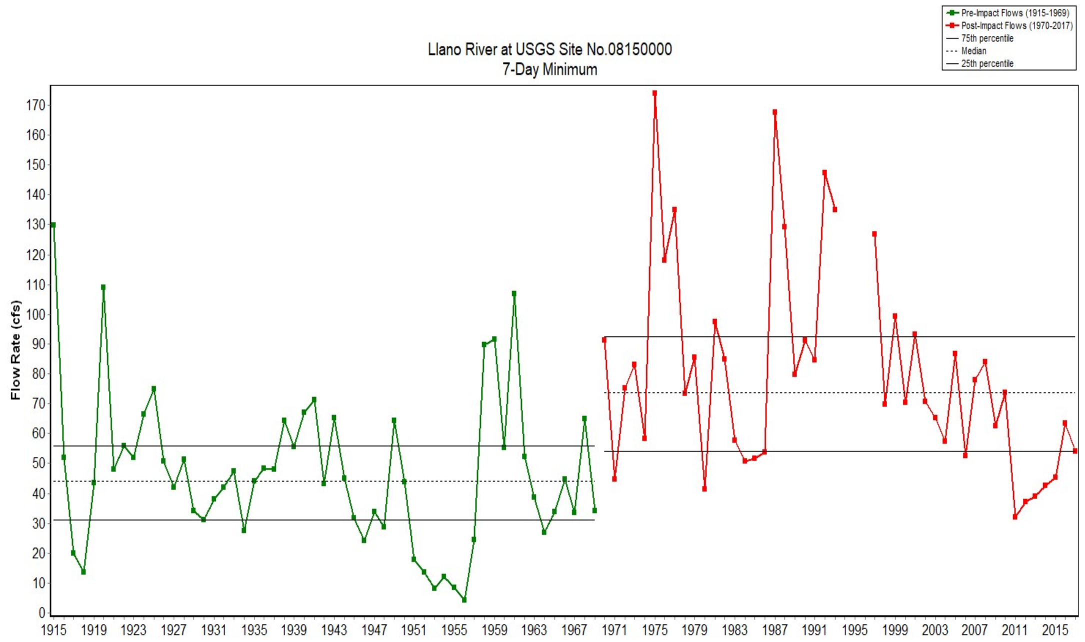
7-day Minimum Flow Rates of Pecan Bayou near Mullin



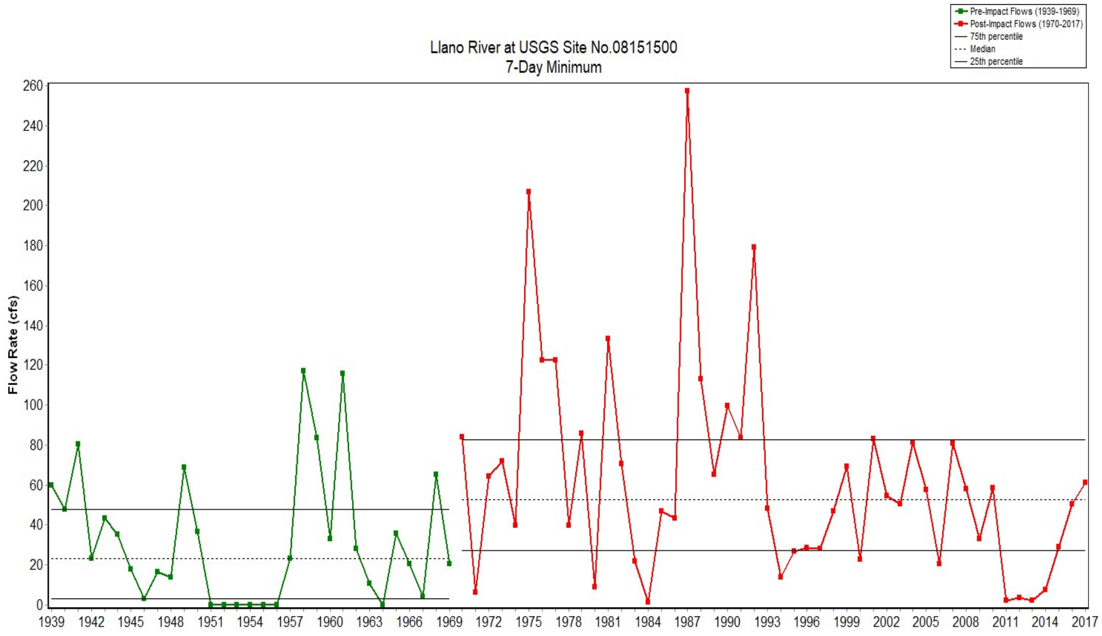
7-day Minimum Flow Rates of Colorado River near San Saba



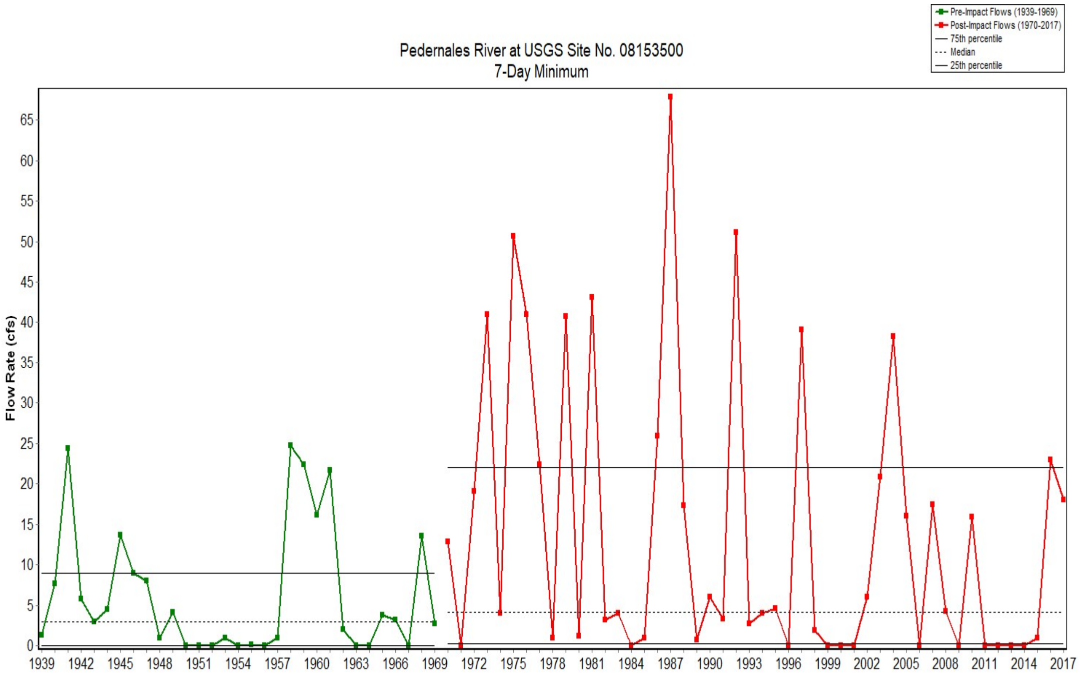
7-day Minimum Flow Rates of North Llano River near Junction



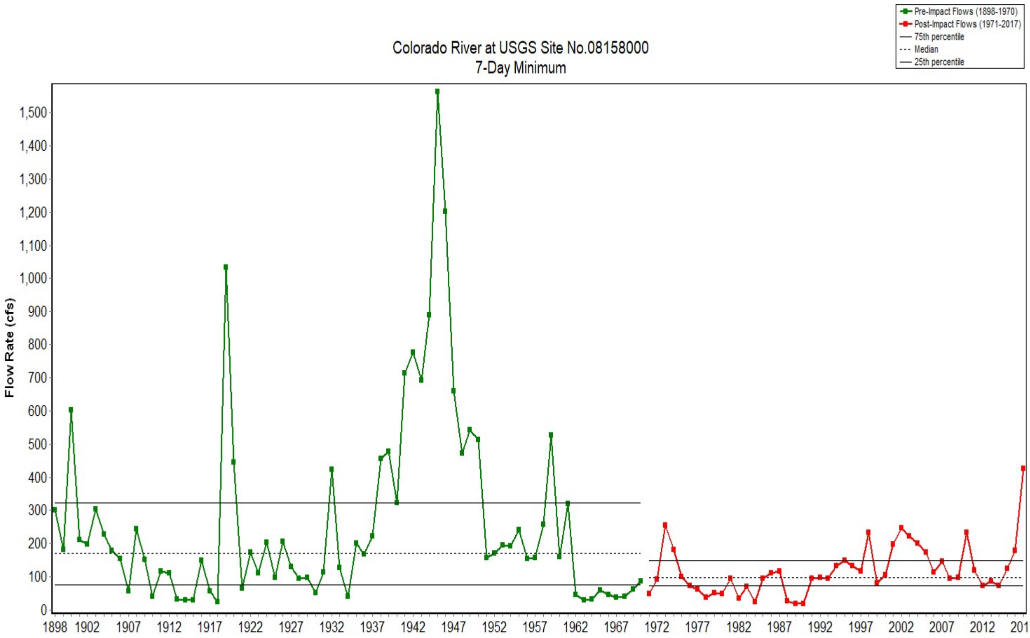
7-day Minimum Flow Rates of Llano River near Junction



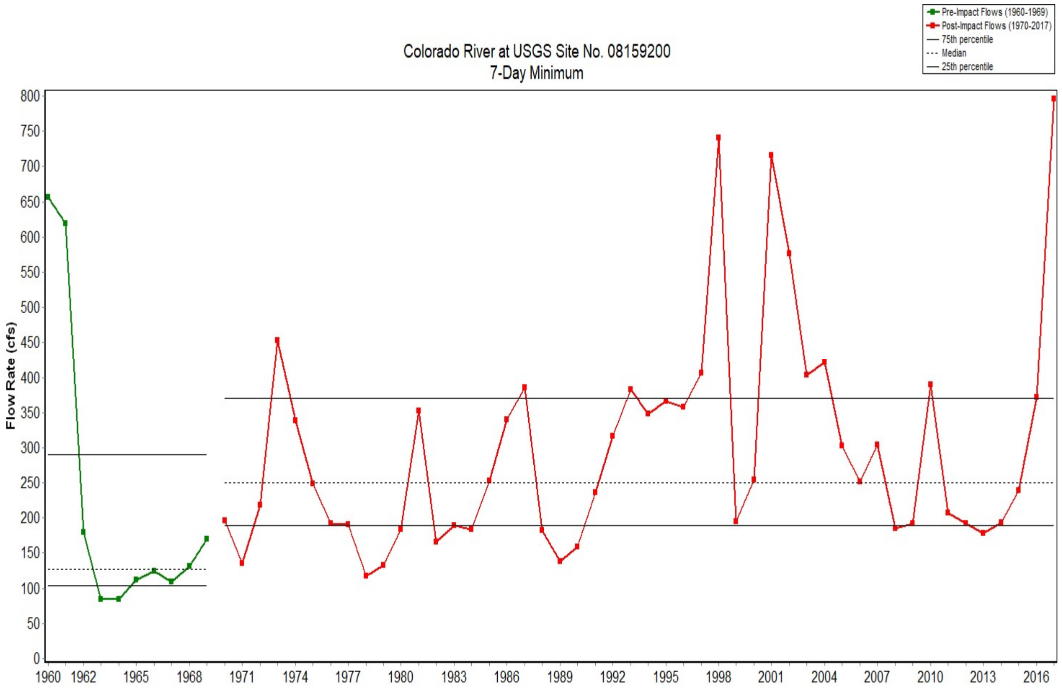
7-day Minimum Flow Rates of Llano River at Llano



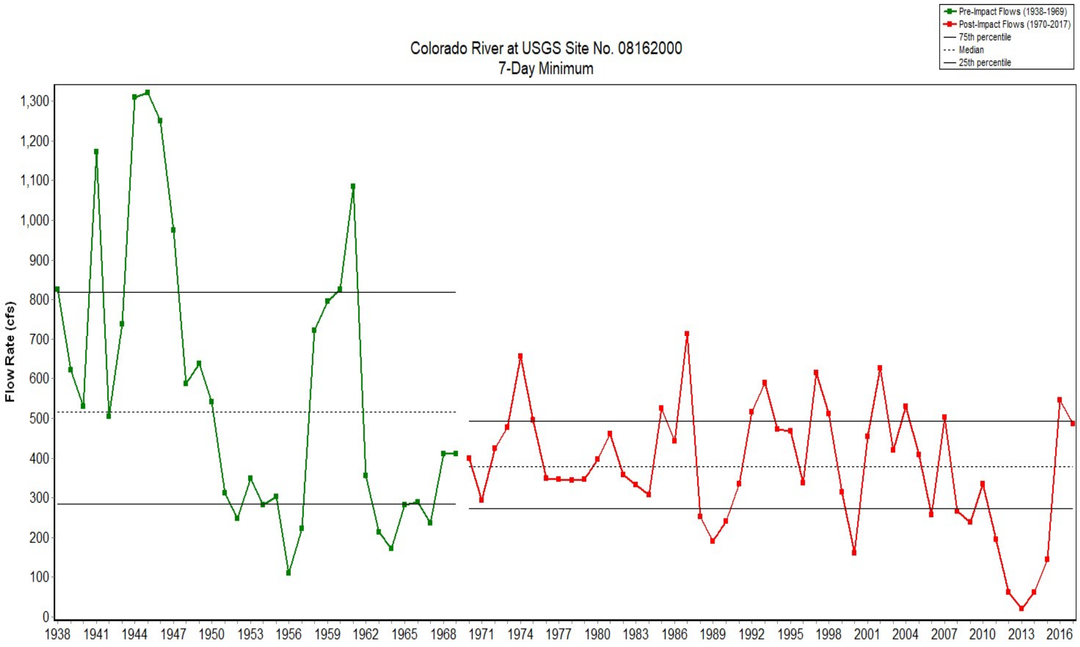
7-day Minimum Flow Rates of Pedernales River near Johnson City



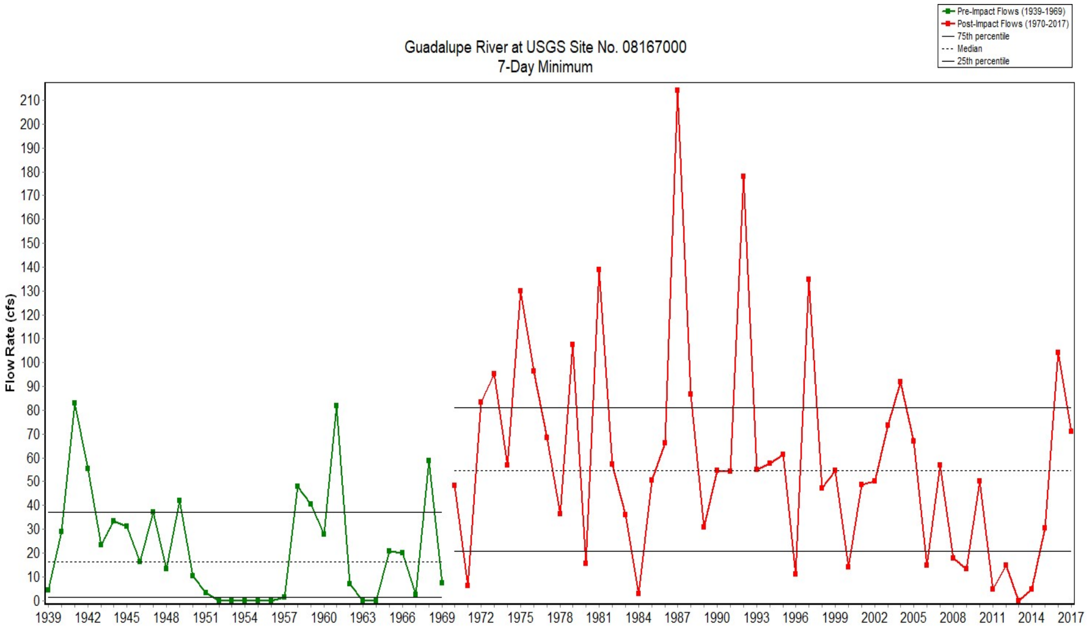
7-day Minimum Flow Rates of Colorado River at Austin



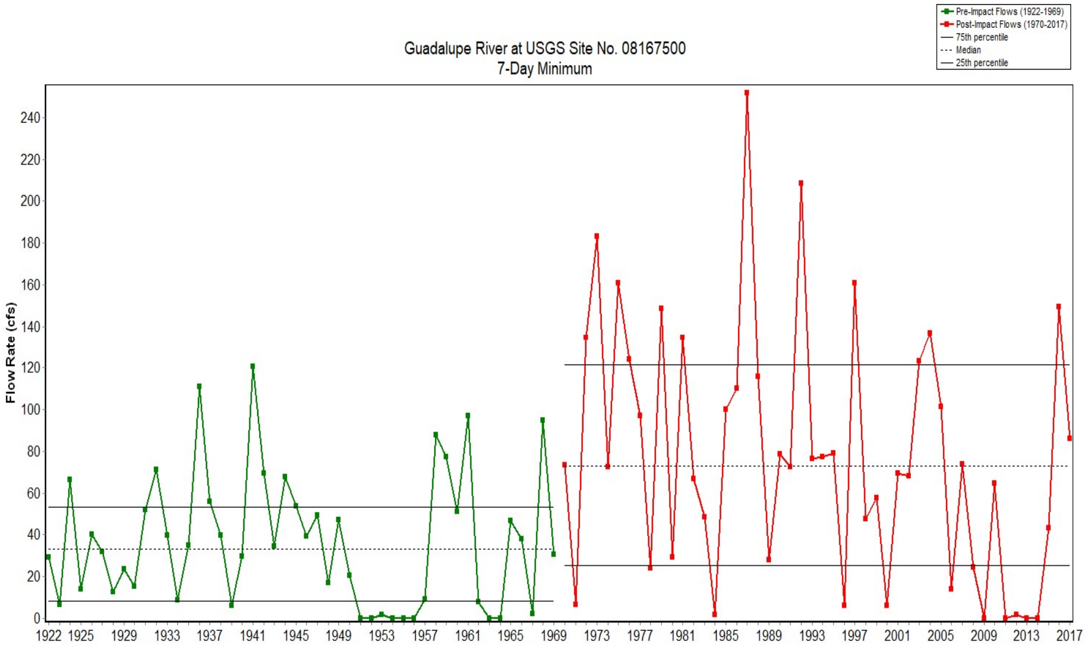
7-day Minimum Flow Rates of Colorado River at Bastrop



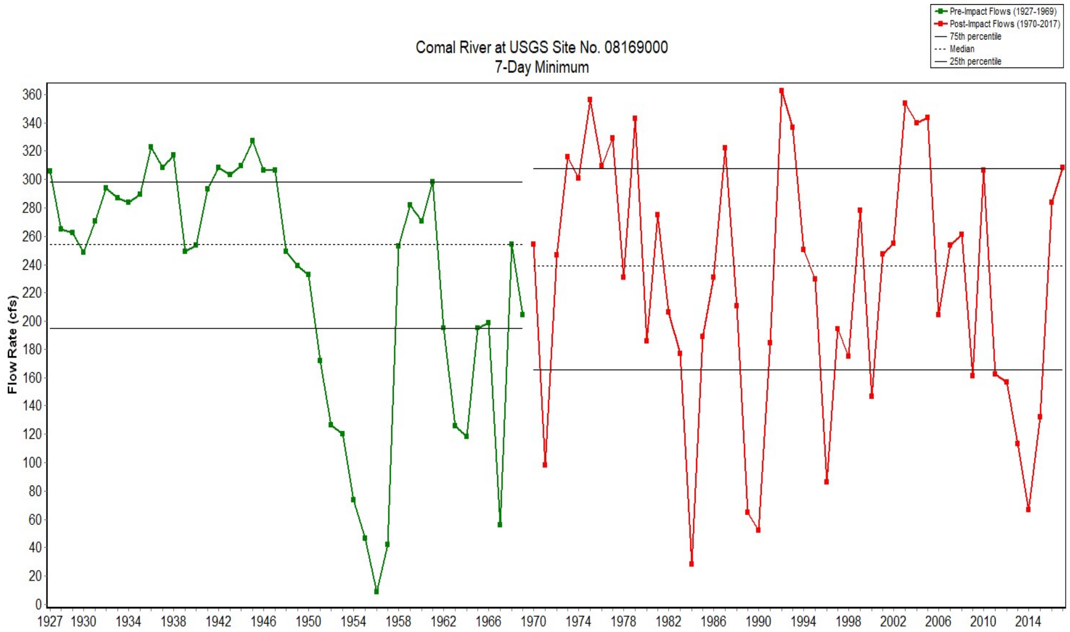
7-day Minimum Flow Rates of Colorado River at Wharton



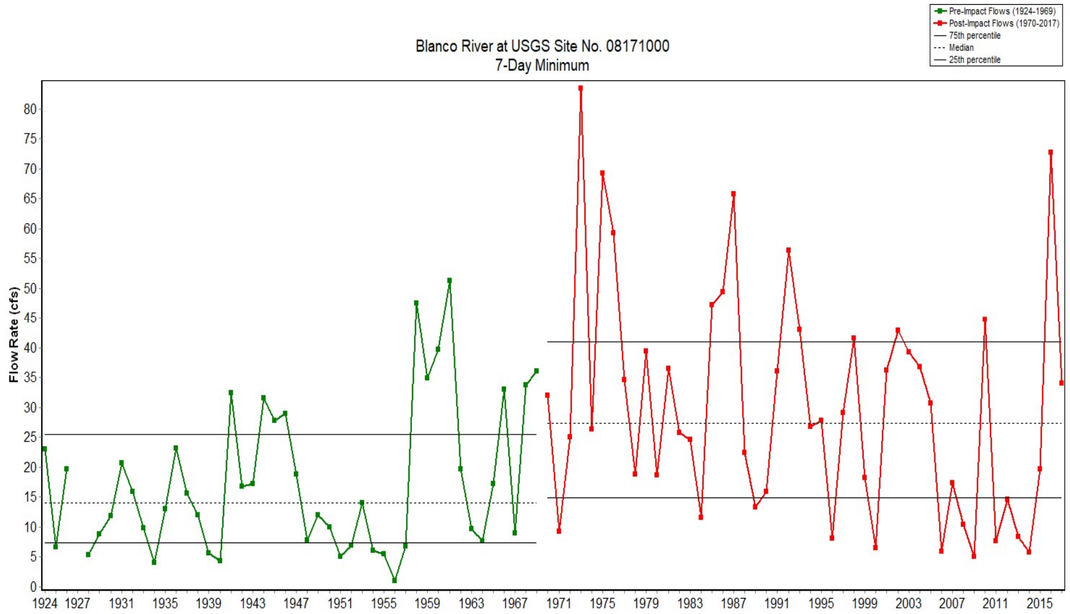
7-day Minimum Flow Rates of Guadalupe River at Comfort



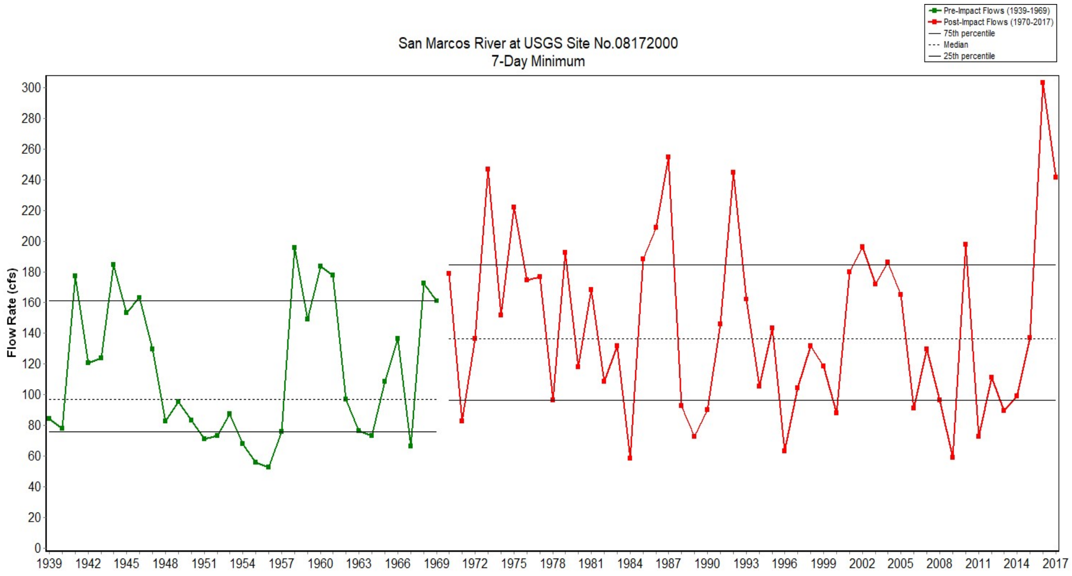
7-day Minimum Flow Rates of Guadalupe River near Spring Branch



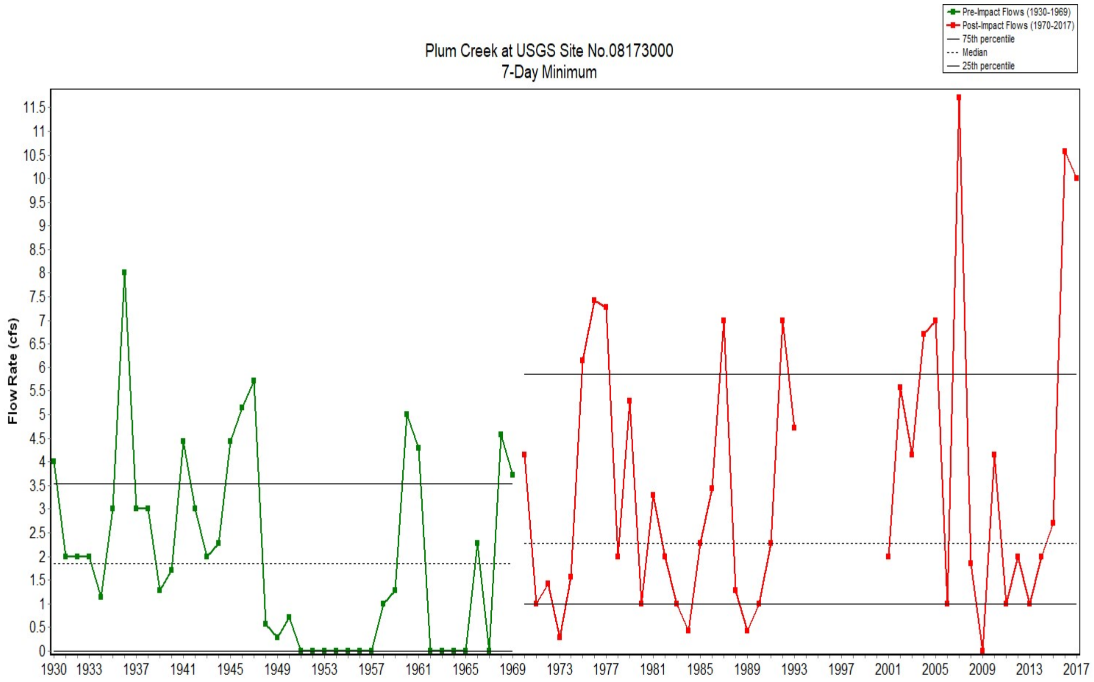
7-day Minimum Flow Rates of Comal River at New Braunfels



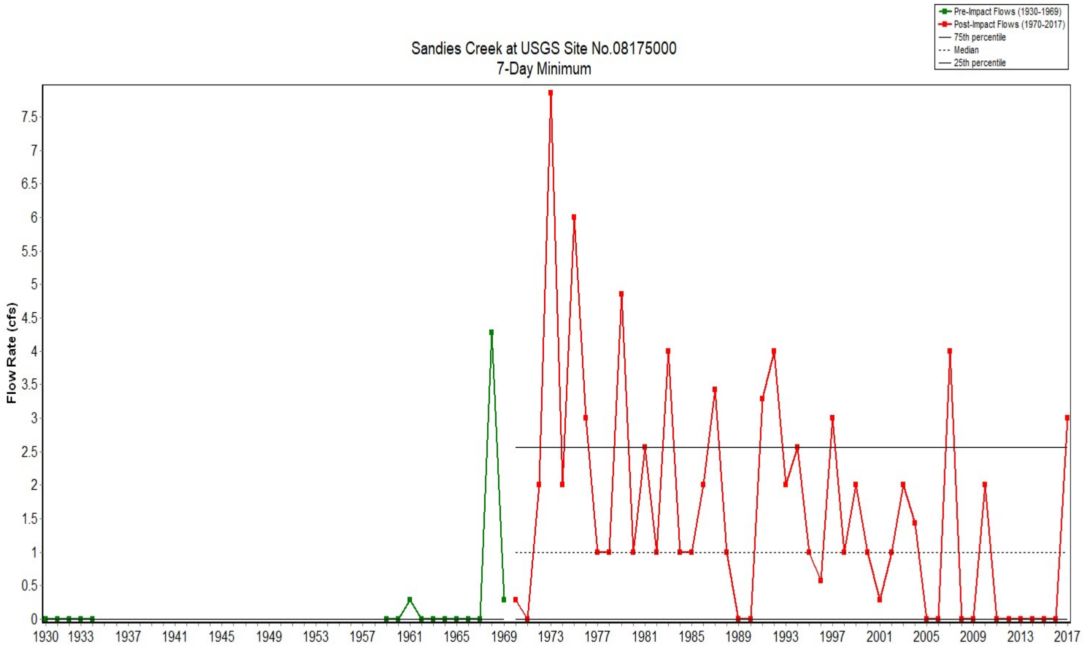
7-day Minimum Flow Rates of Blanco River at Wimberley



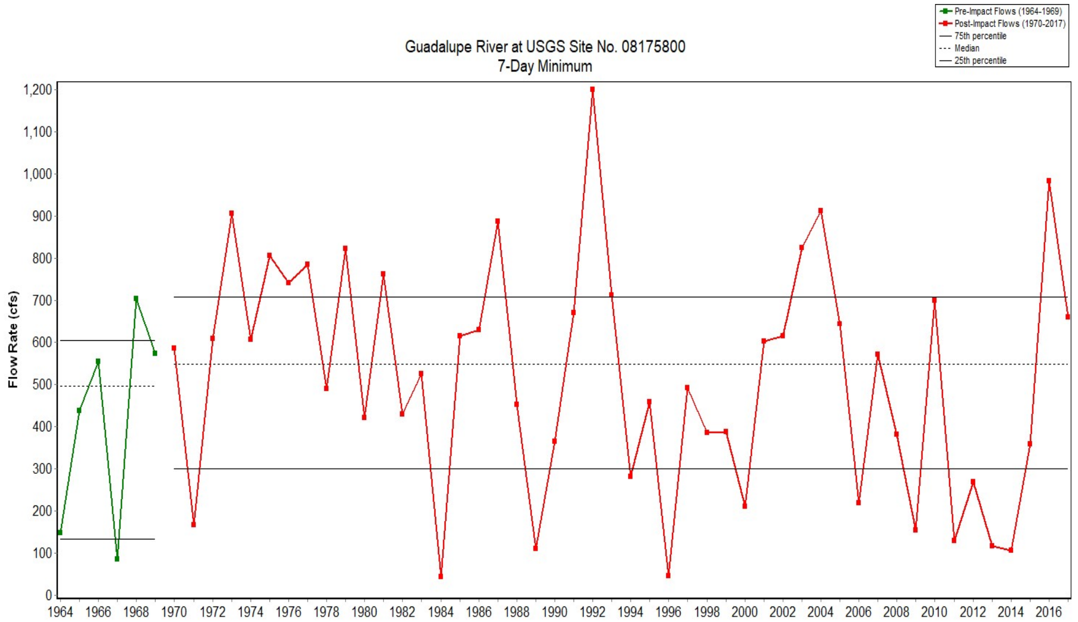
7-day Minimum Flow Rates of San Marcos River at Luling



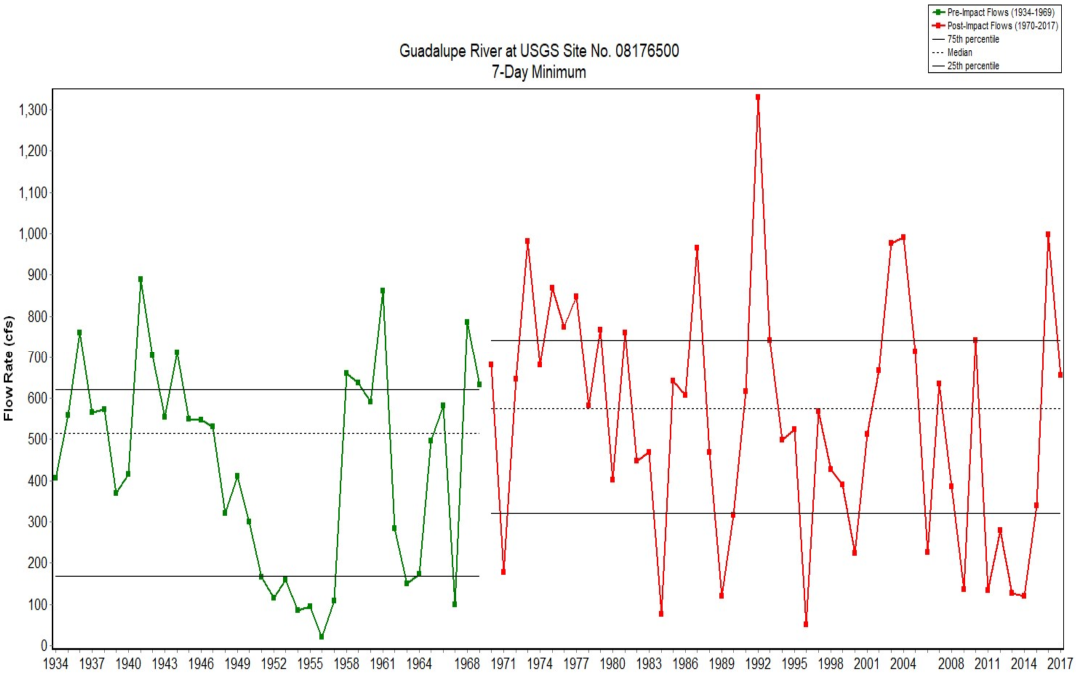
7-day Minimum Flow Rates of Plum Creek near Luling



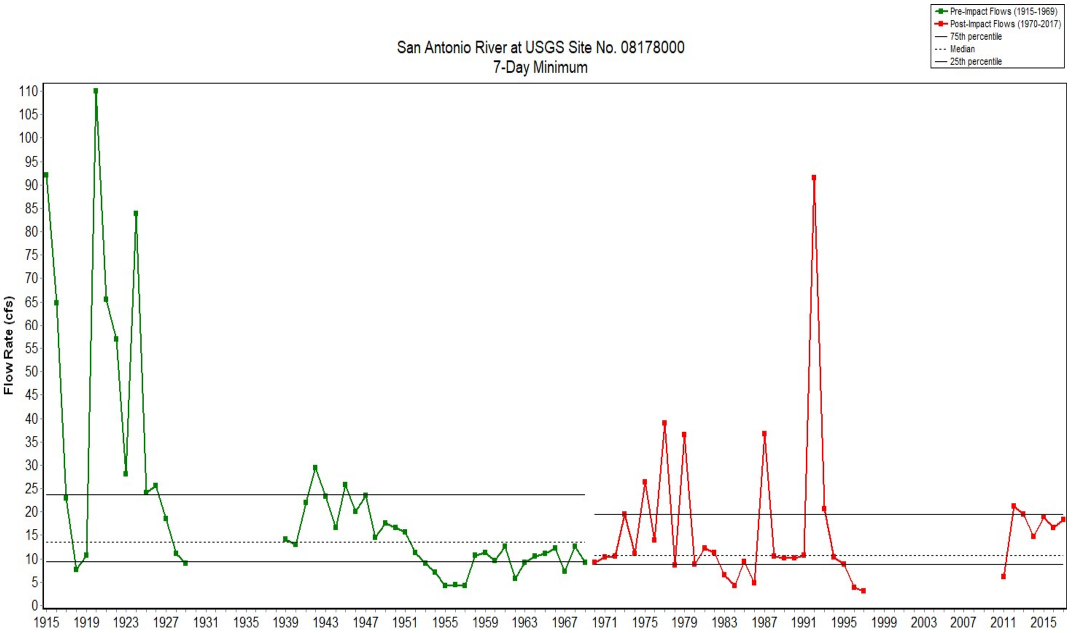
7-day Minimum Flow Rates of Sandies Creek near Westhoff



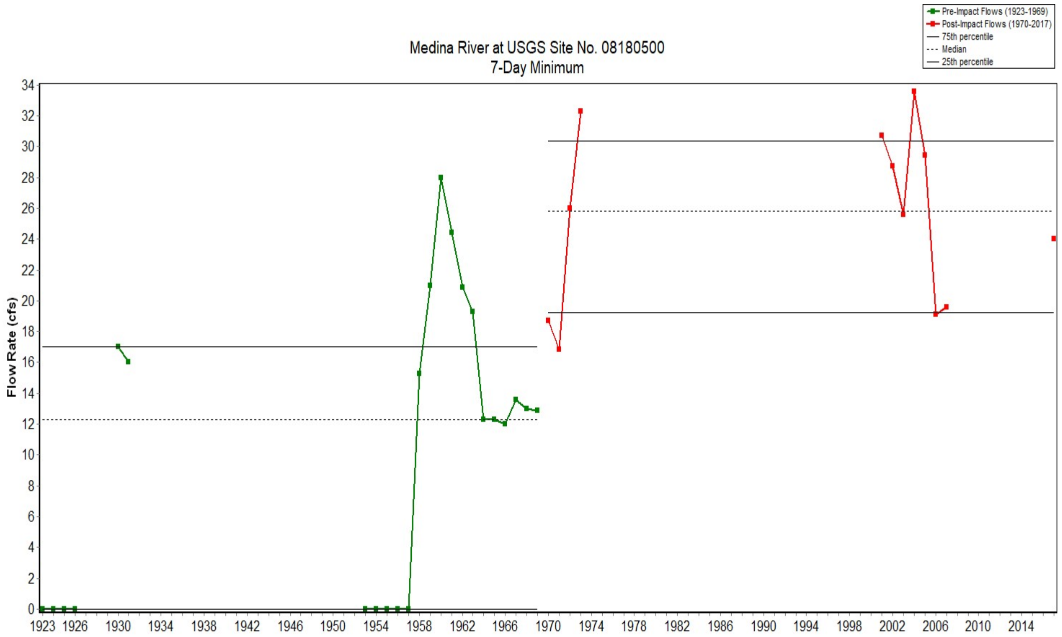
7-day Minimum Flow Rates of Brazos River near Glen Rose



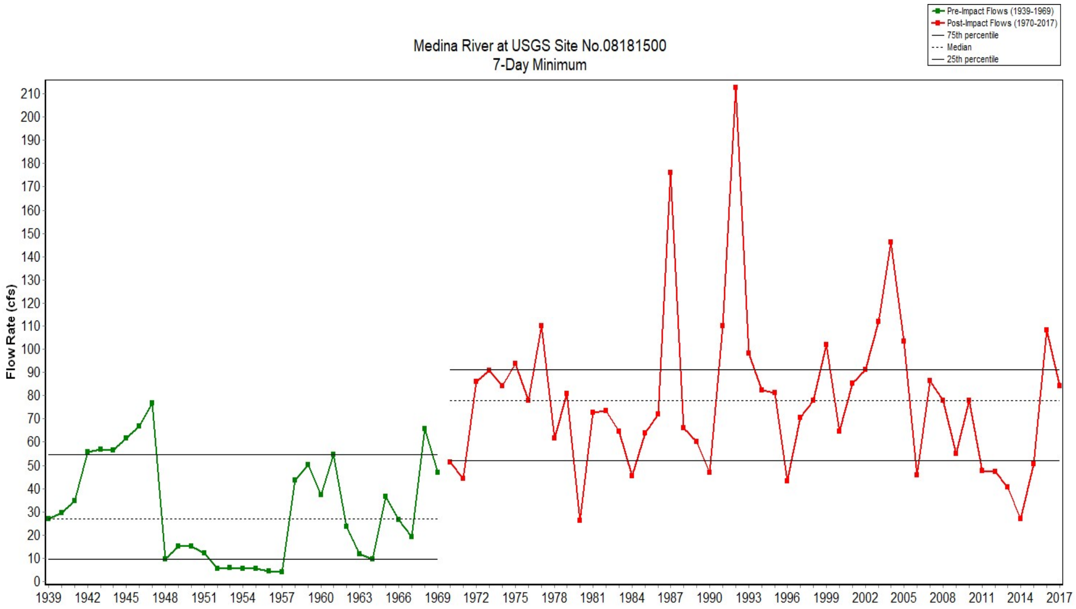
7-day Minimum Flow Rates of Guadalupe River at Victoria



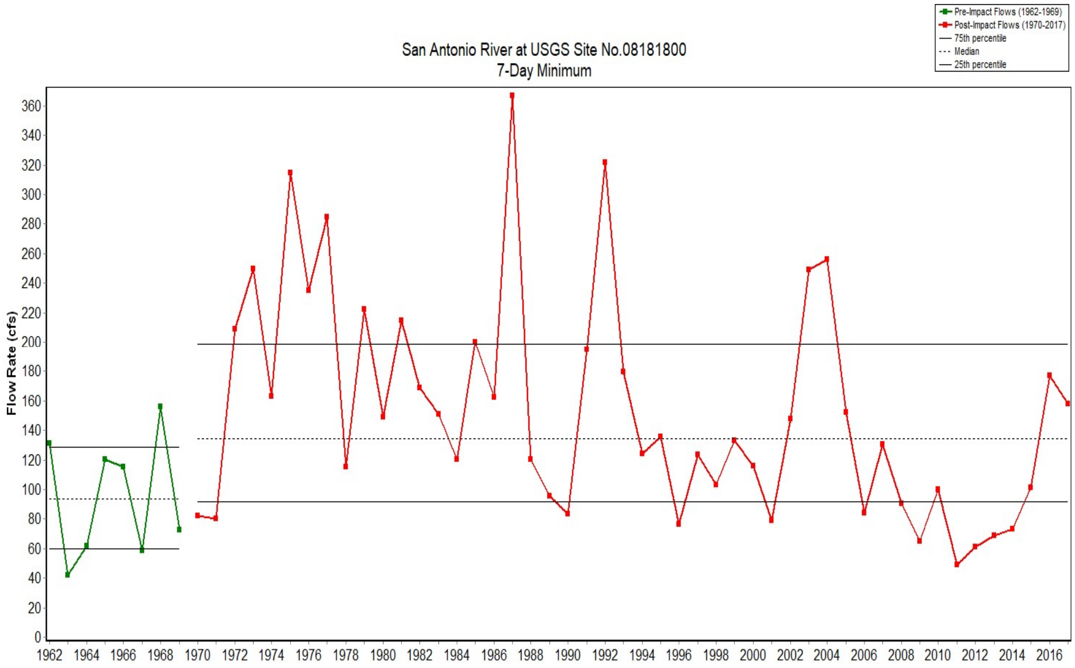
7-day Minimum Flow Rates of San Antonio River at San Antonio



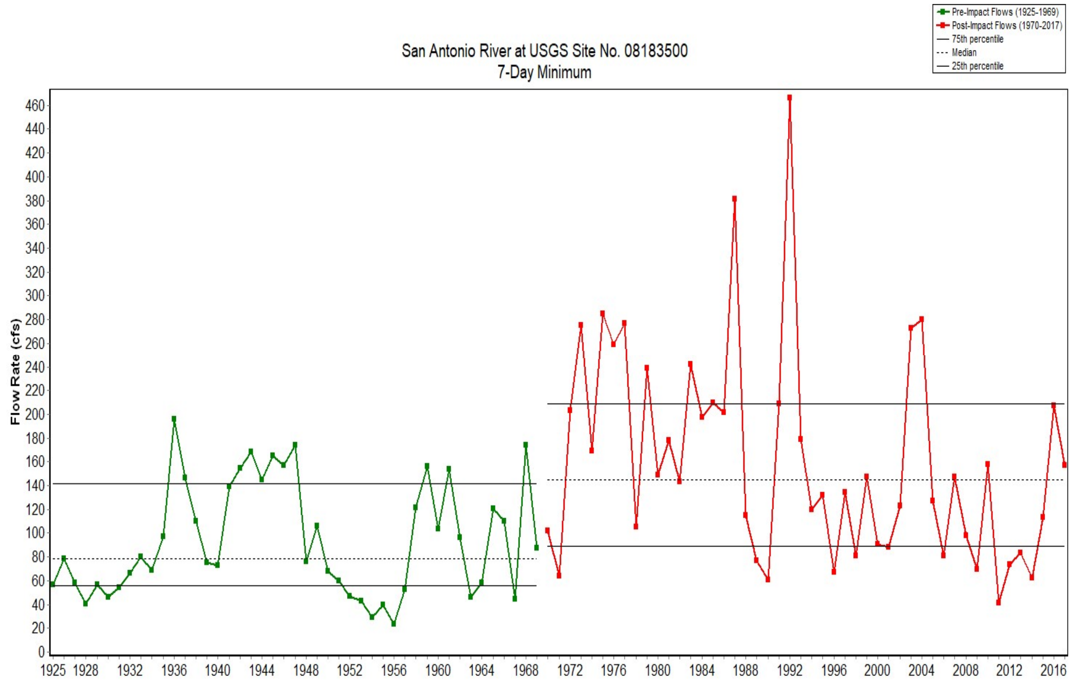
7-day Minimum Flow Rates of Medina River near Rio Medina



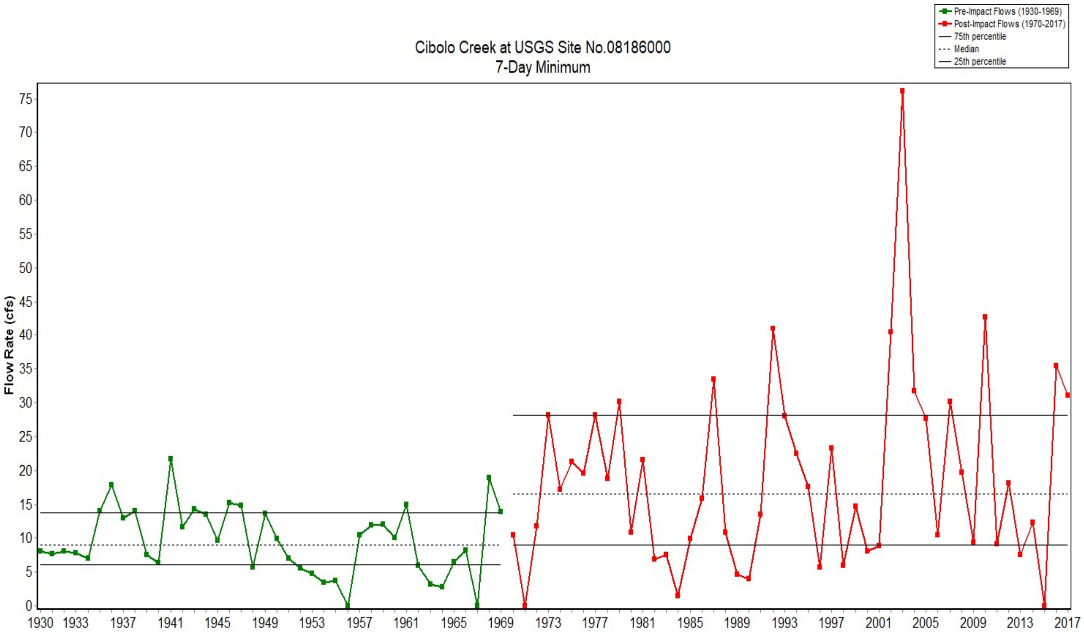
7-day Minimum Flow Rates of Medina River at San Antonio



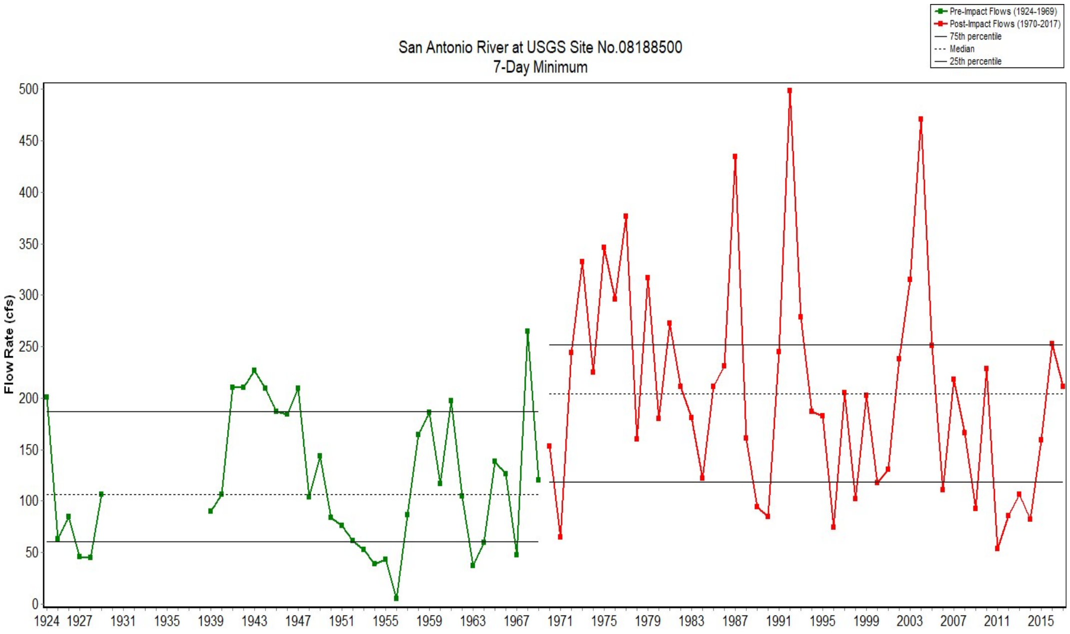
7-day Minimum Flow Rates of San Antonio River near Elmendorf



7-day Minimum Flow Rates of San Antonio River near Falls City

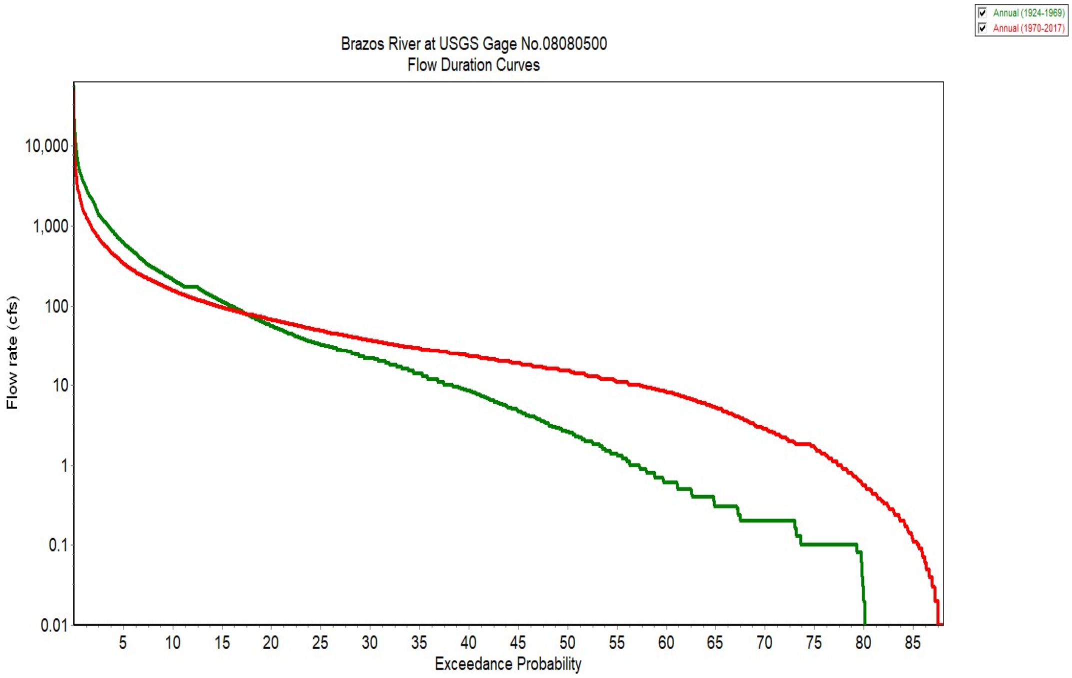


7-day Minimum Flow Rates of Cibolo Creek near Falls City

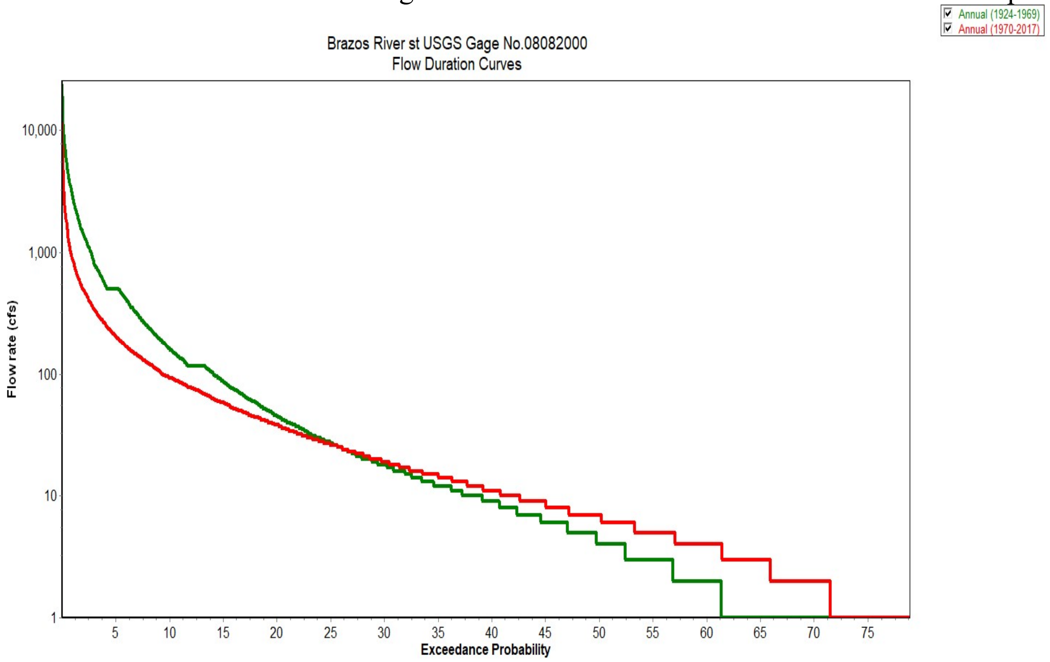


7-day Minimum Flow Rates of San Antonio River at Goliad

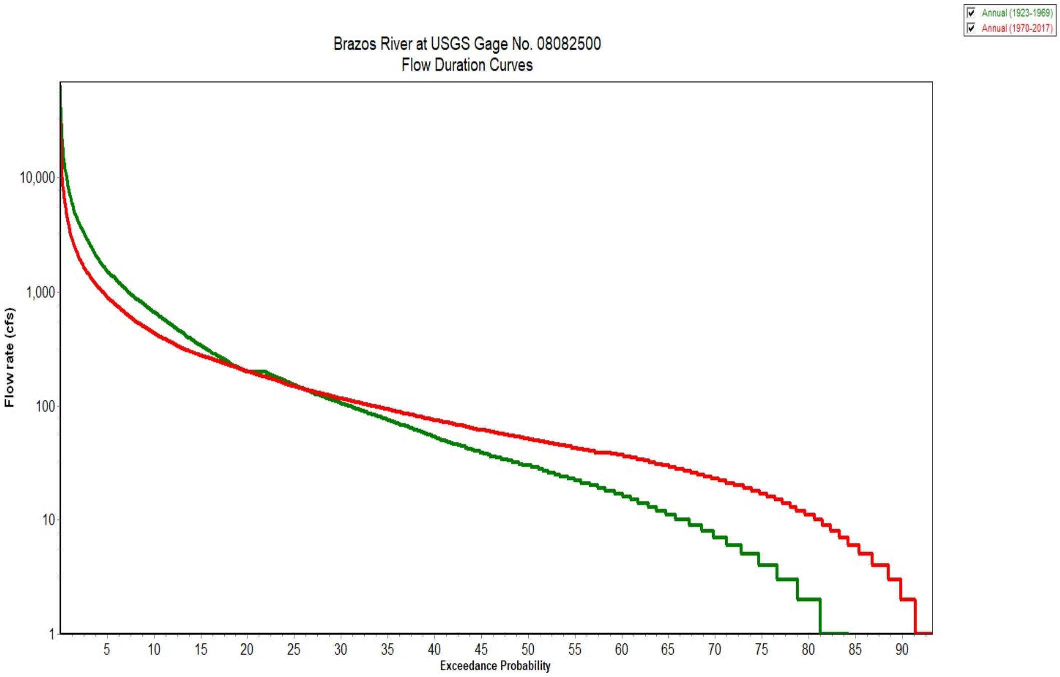
APPENDIX C



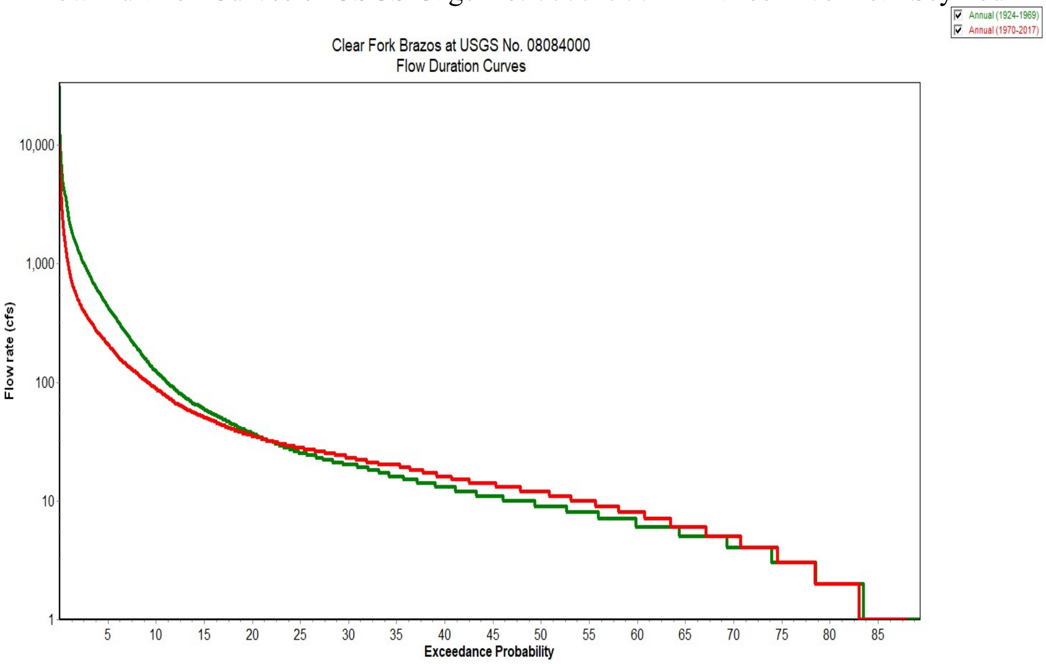
Flow Duration Curves of USGS Gage No. 08080500 in Double Mountain Fork near Aspermont



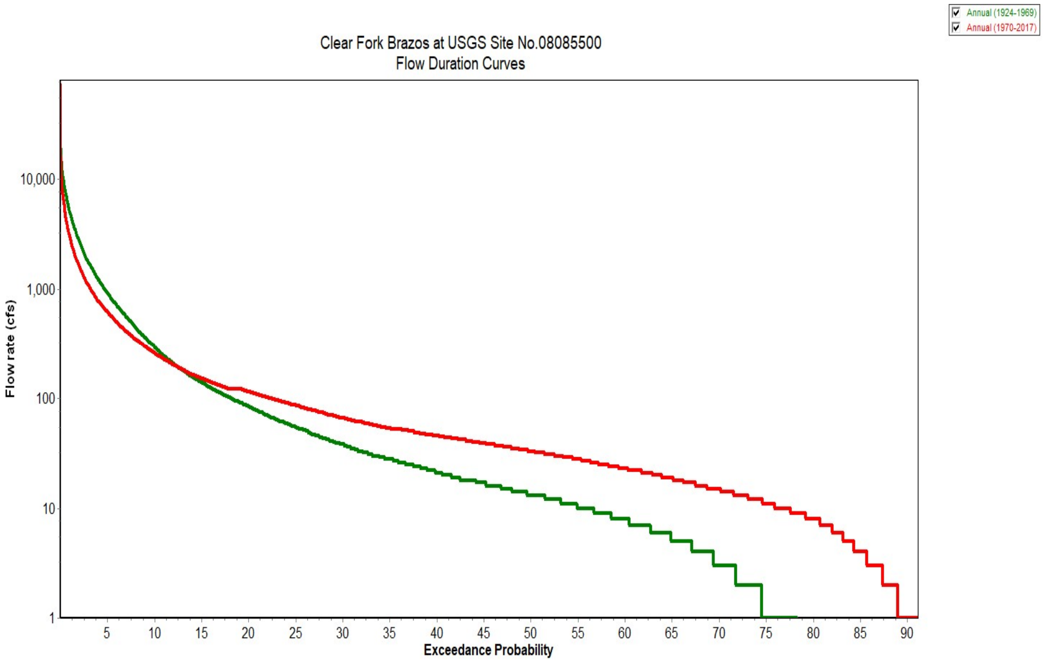
Flow Duration Curves of USGS Gage No. 08082000 in Salt Fork Brazos River near Aspermont



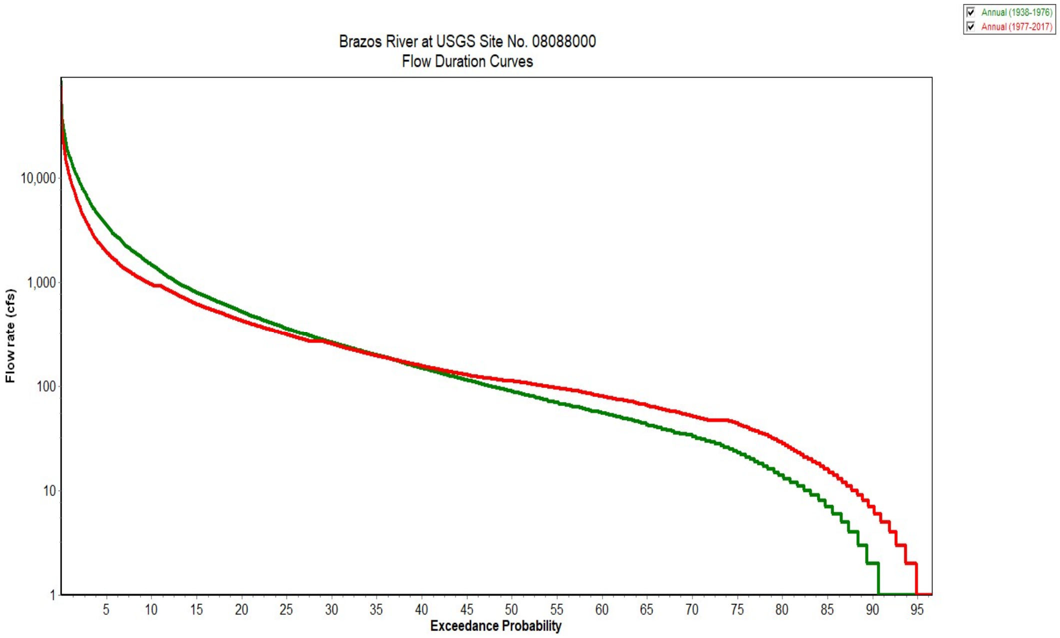
Flow Duration Curves of USGS Gage No. 08082500 in Brazos River near Seymour



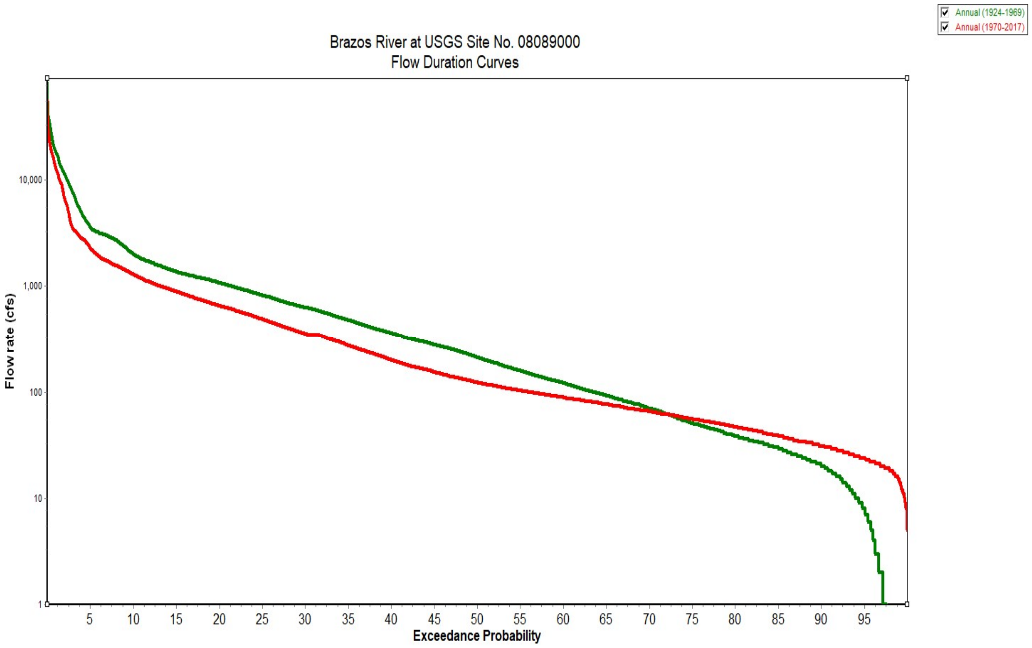
Flow Duration Curves of USGS Gage No. 08084000 in Clear Fork Brazos near Nugent



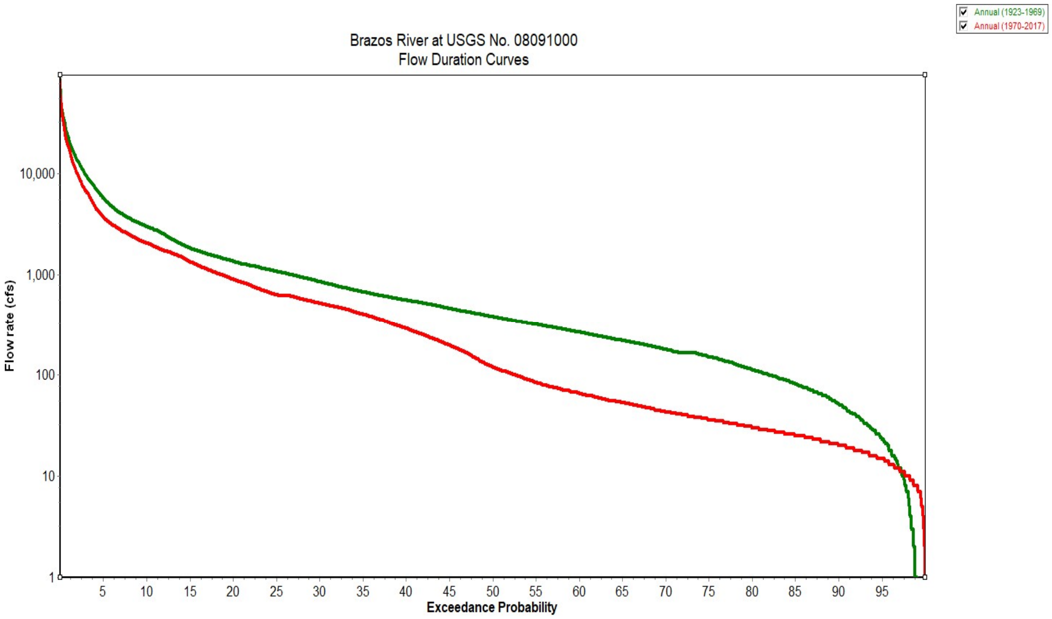
Flow Duration Curves of USGS Gage No. 08084000 in Clear Fork Brazos near Fort Griffin



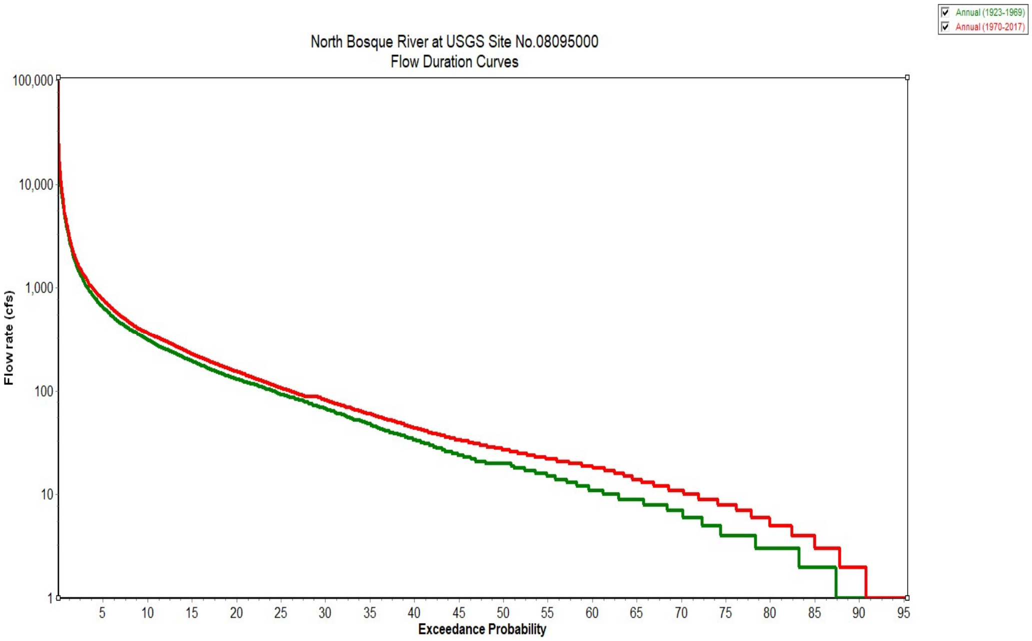
Flow Duration Curves of USGS Gage No. 08088000 in Brazos River near South Bend



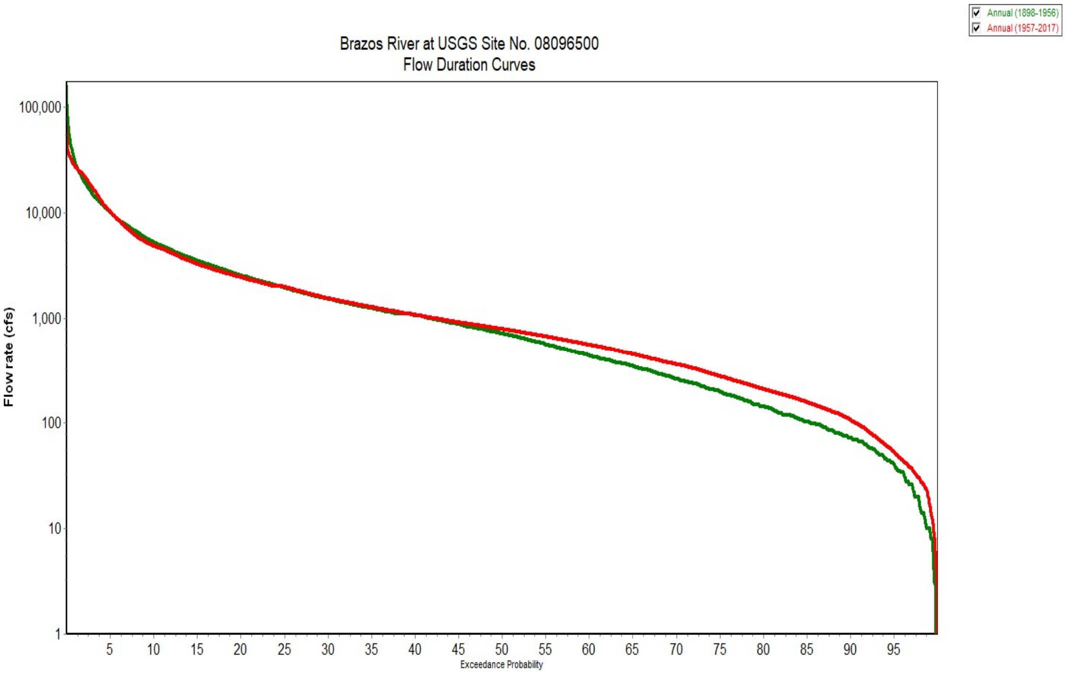
Flow Duration Curves of USGS Gage No. 08089000 in Brazos River near Palo Pinto



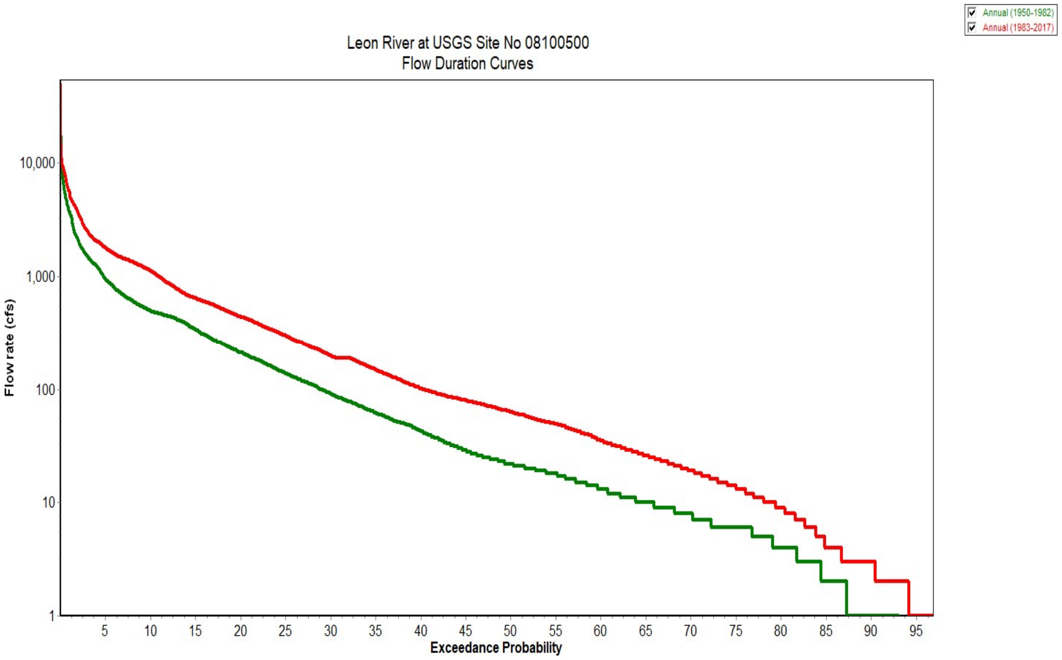
Flow Duration Curves of USGS Gage No. 08091000 in Brazos River near Glen Rose



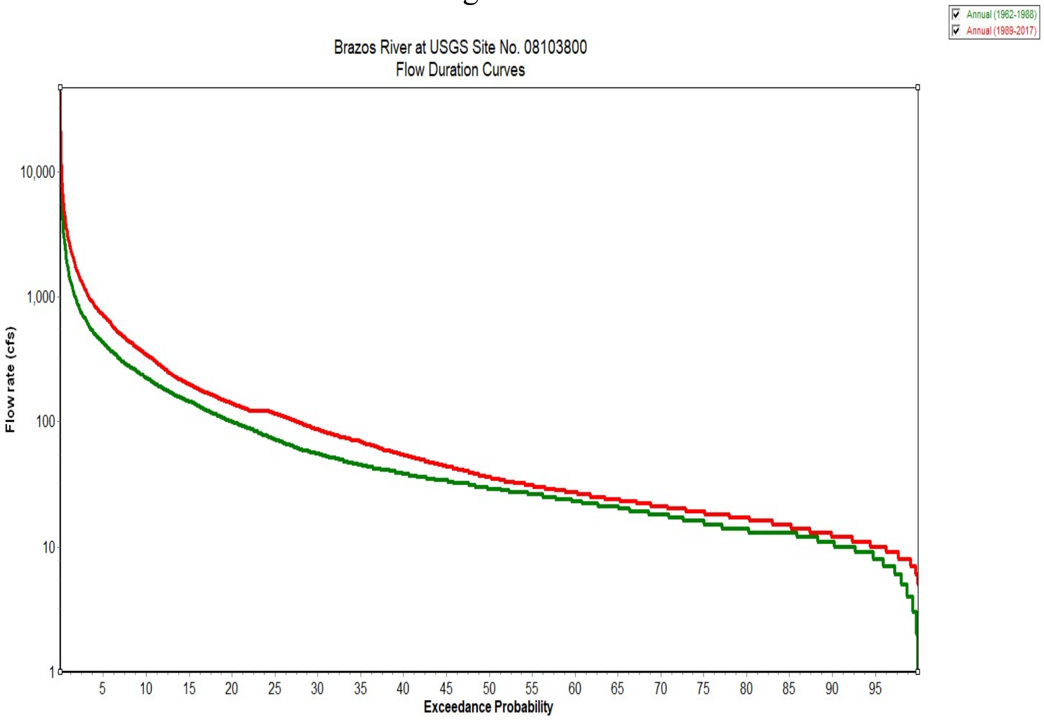
Flow Duration Curves of USGS Gage No. 08095000 in North Bosque River near Clifton



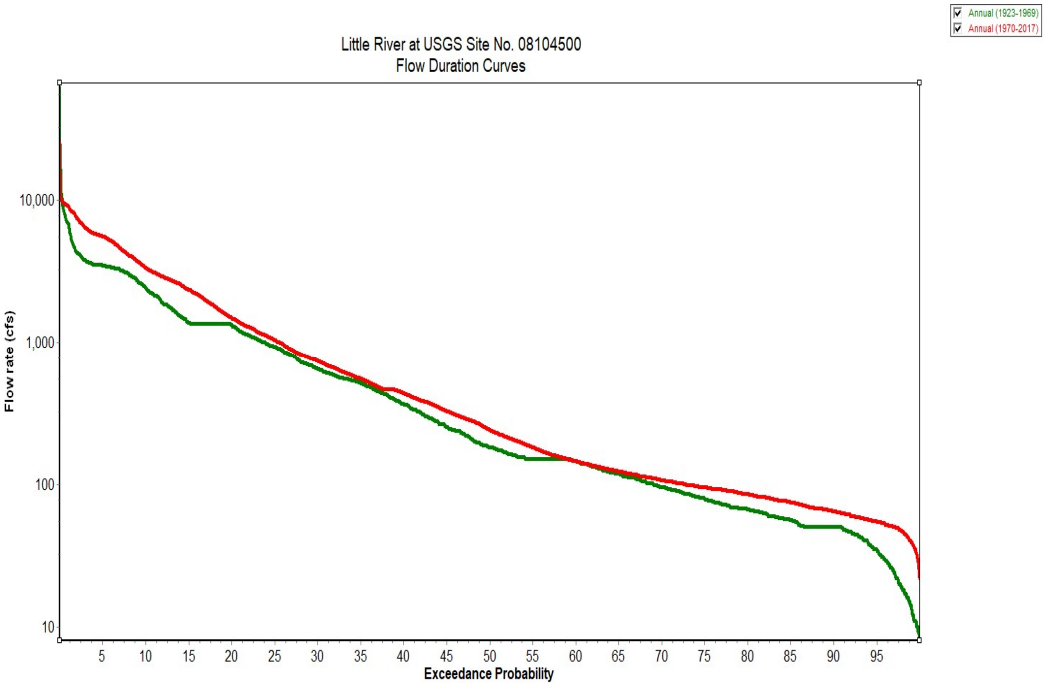
Flow Duration Curves of USGS Gage No. 08096500 Brazos River at Waco



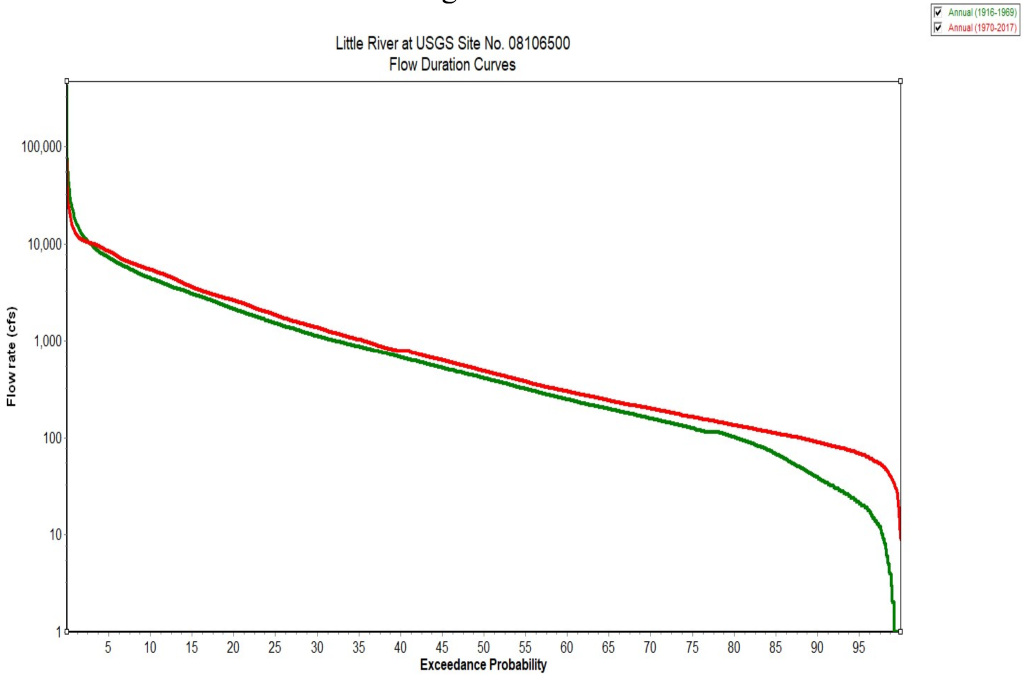
Flow Duration Curves of USGS Gage No. 08100500 Leon River near Gatesville



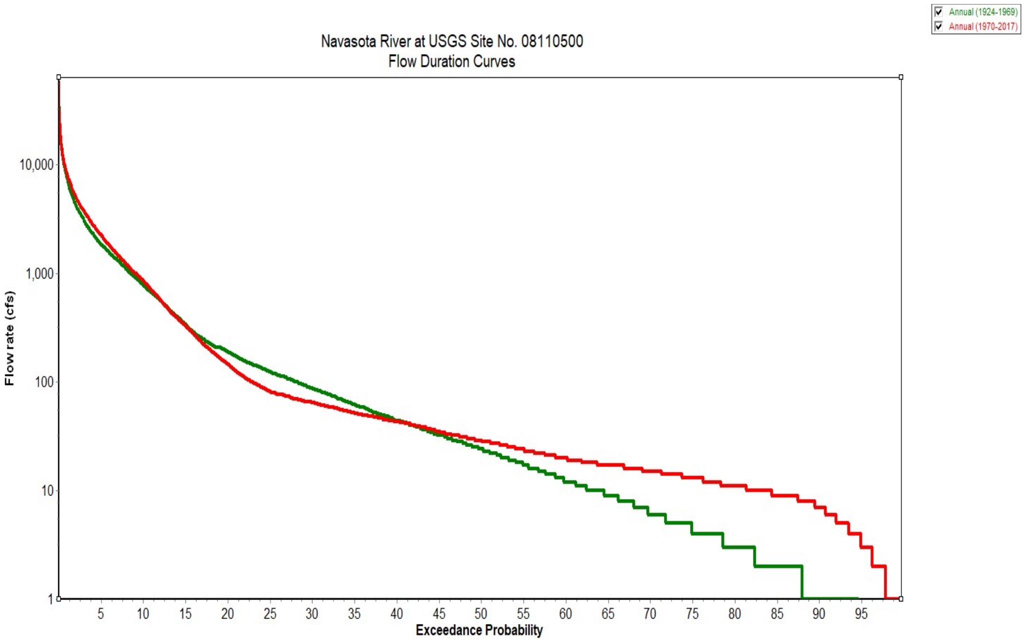
Flow Duration Curves of USGS Gage No. 08103800 Lampasas River near Kempner



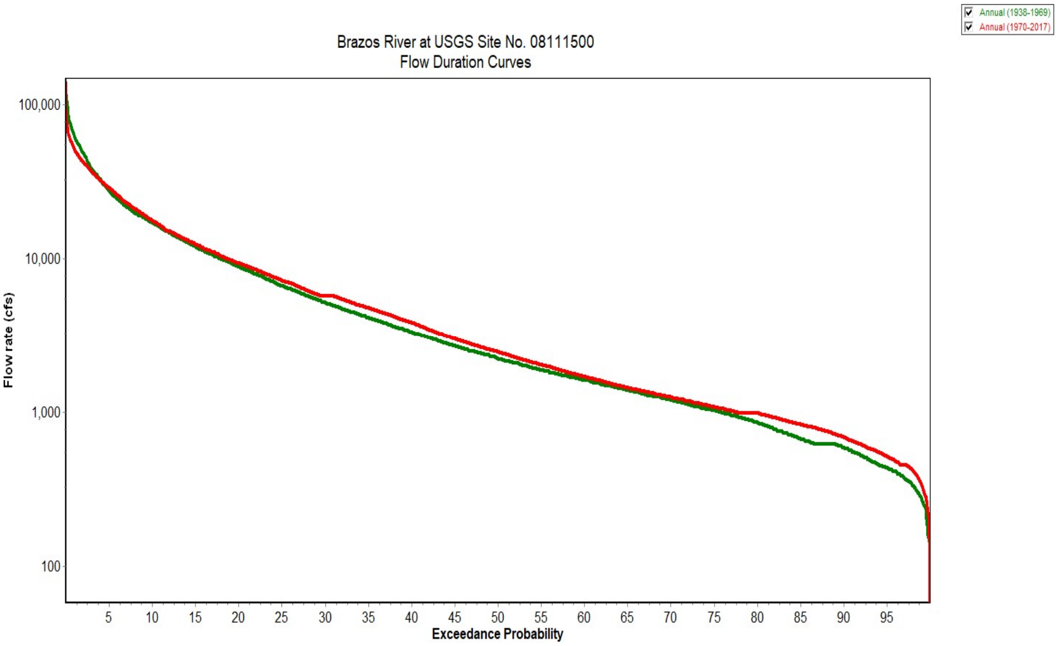
Flow Duration Curves of USGS Gage No. 08104500 Little River near Little River



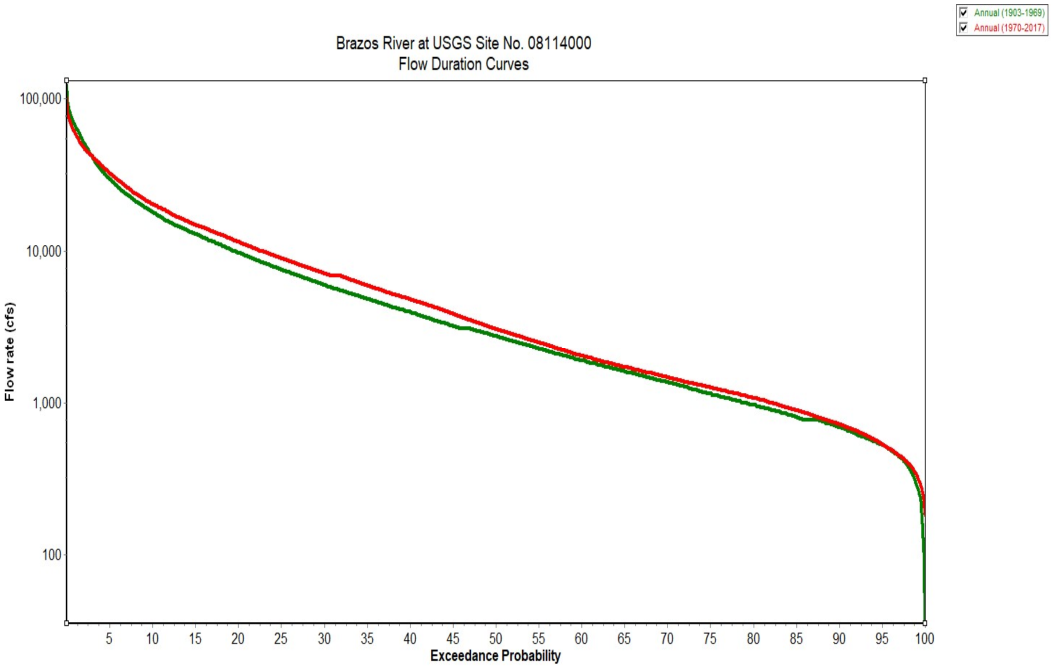
Flow Duration Curves of USGS Gage No. 08106500 Little River near Cameron



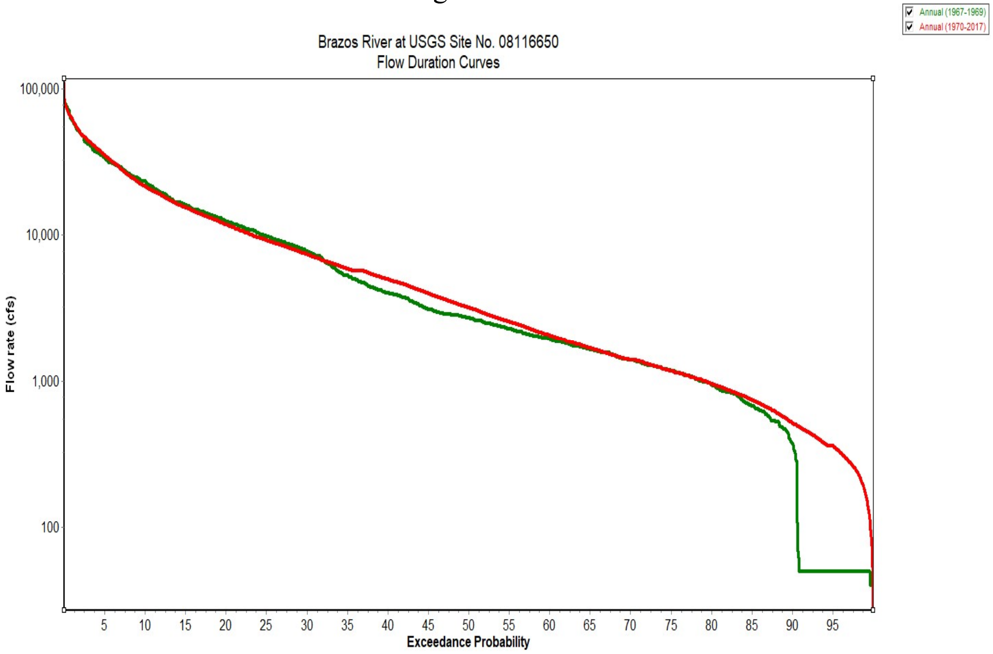
Flow Duration Curves of USGS Gage No. 08110500 Navasota River at Easterly



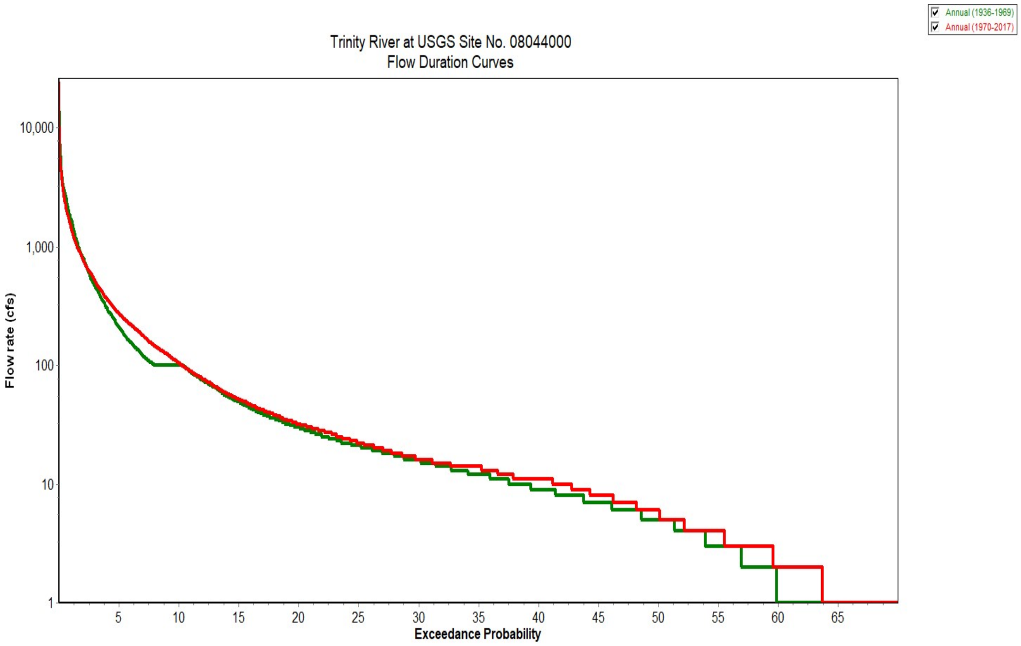
Flow Duration Curves of USGS Gage No. 08111500 Brazos River near Hempstead



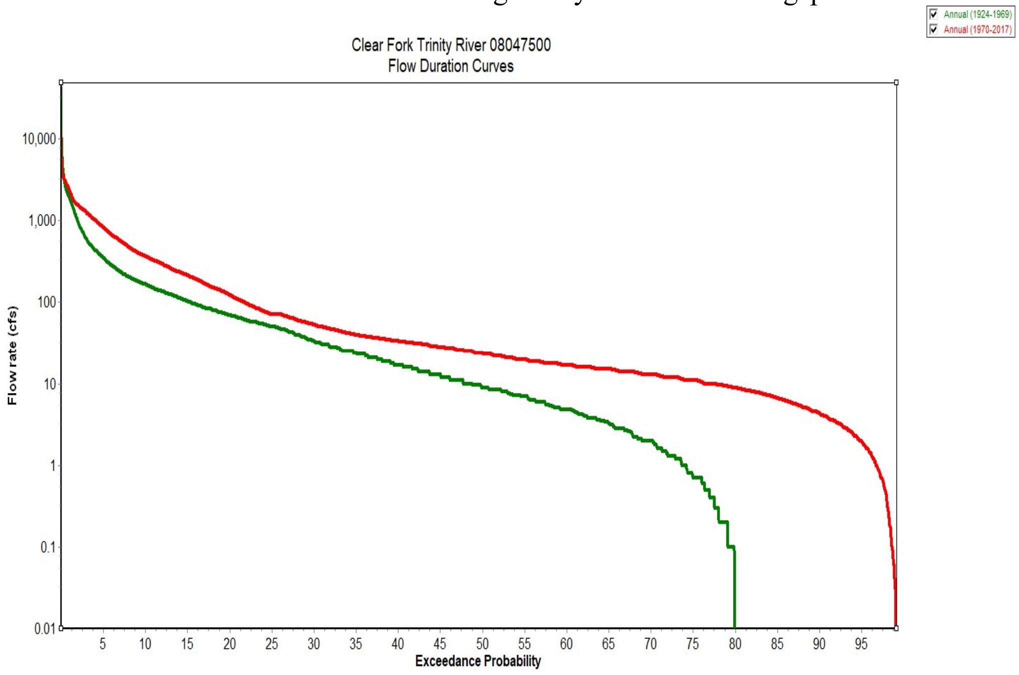
Flow Duration Curves of USGS Gage No.08114000 Brazos River near Richmond



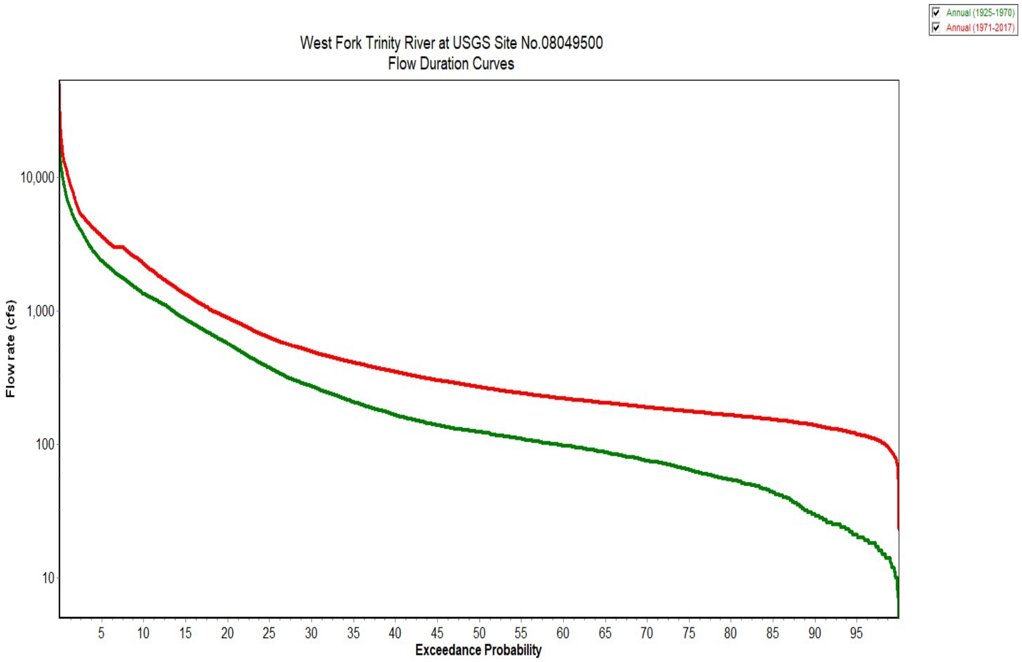
Flow Duration Curves of USGS Gage No. 08116650 Brazos River near Rosharon



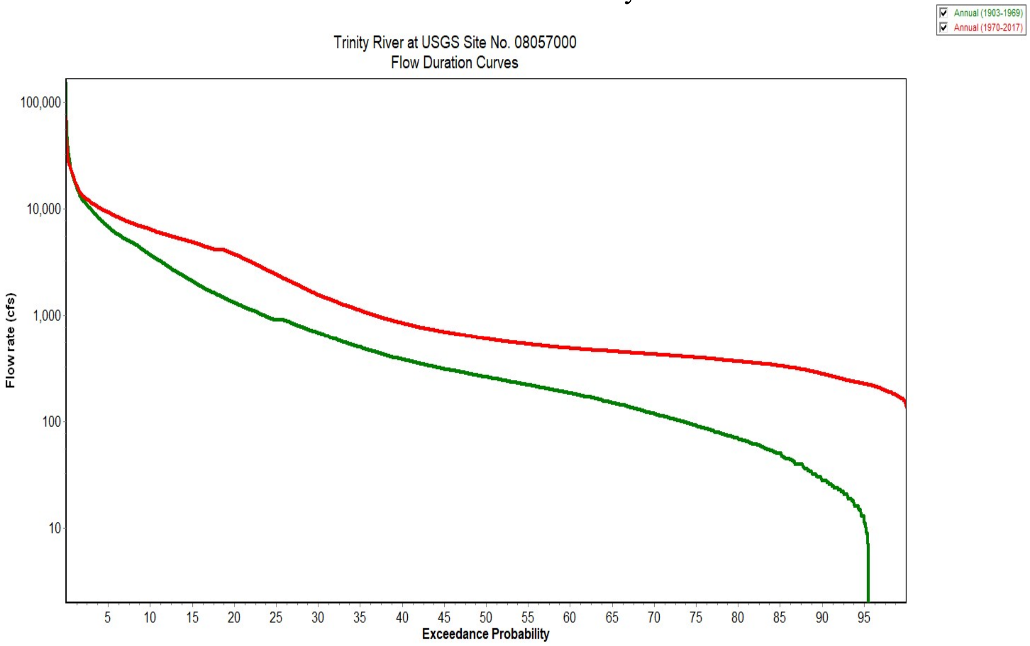
Flow Duration Curves of Big Sandy Creek near Bridgeport



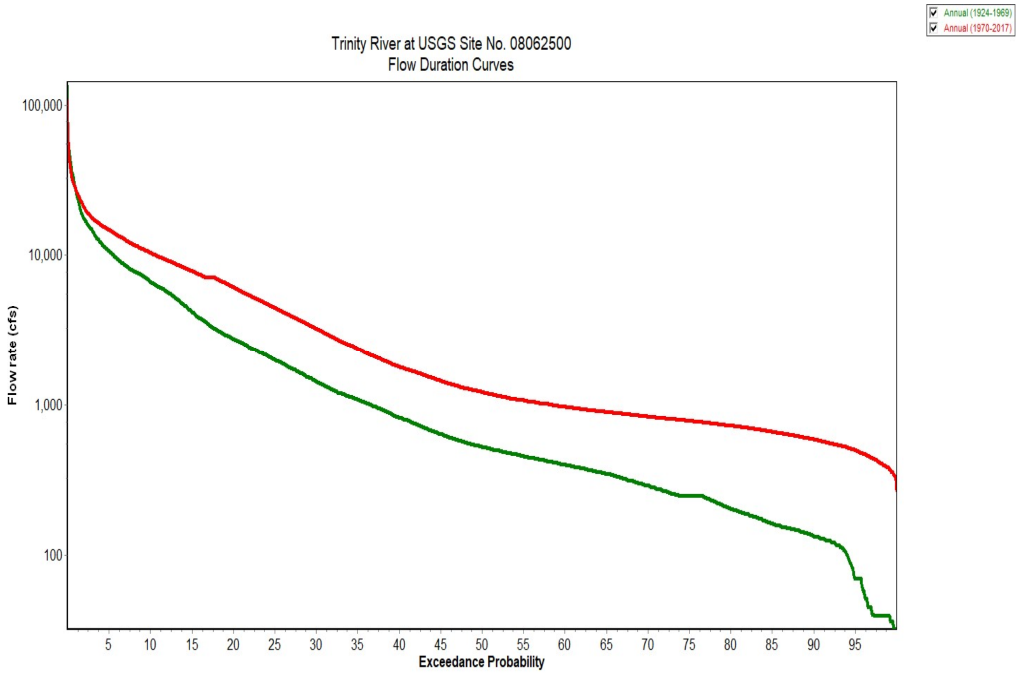
Flow Duration Curves of Clear Fork Trinity River at Fort Worth



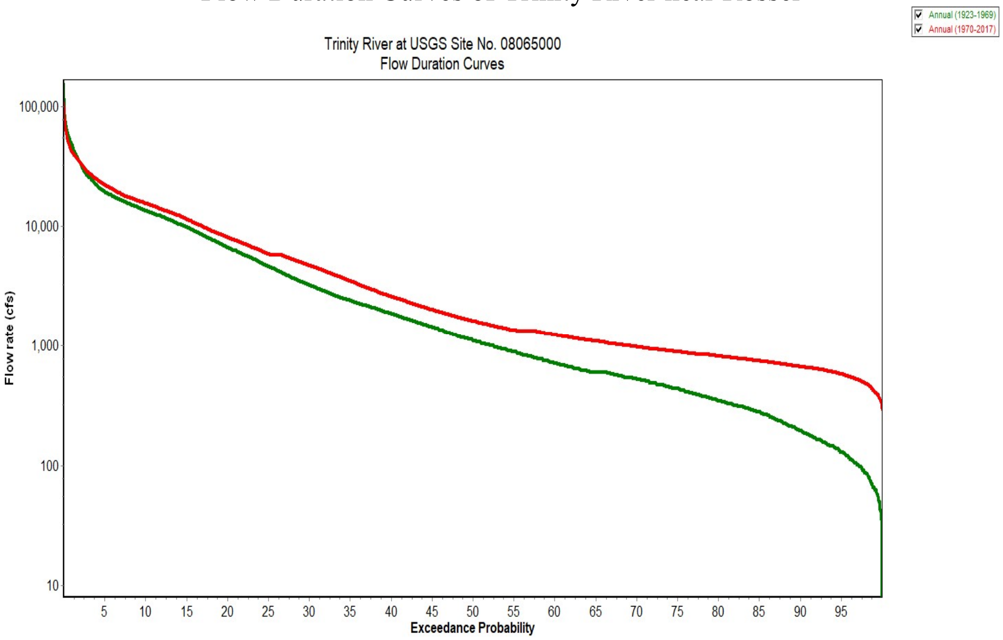
Flow Duration Curves of West Fork Trinity River at Grand Prairie



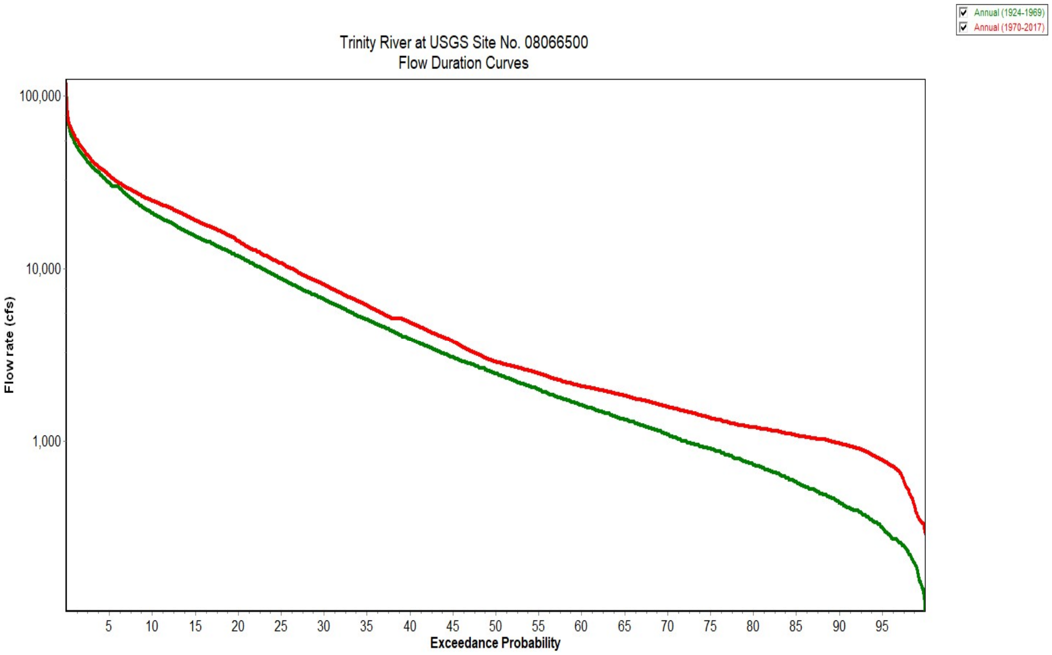
Flow Duration Curves of Trinity River at Dallas



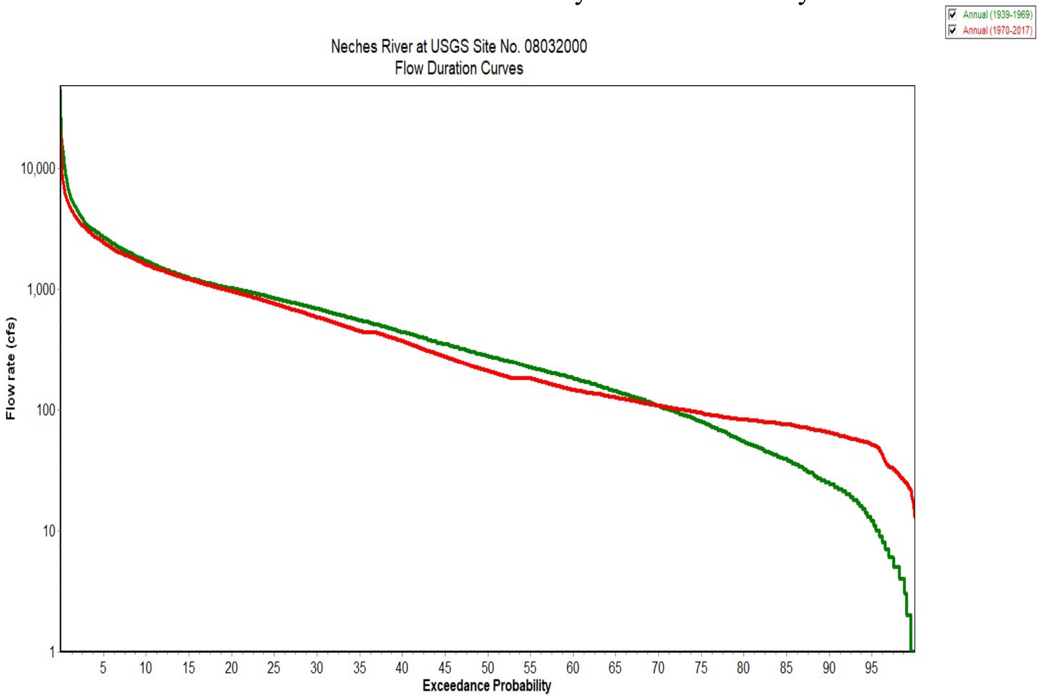
Flow Duration Curves of Trinity River near Rosser



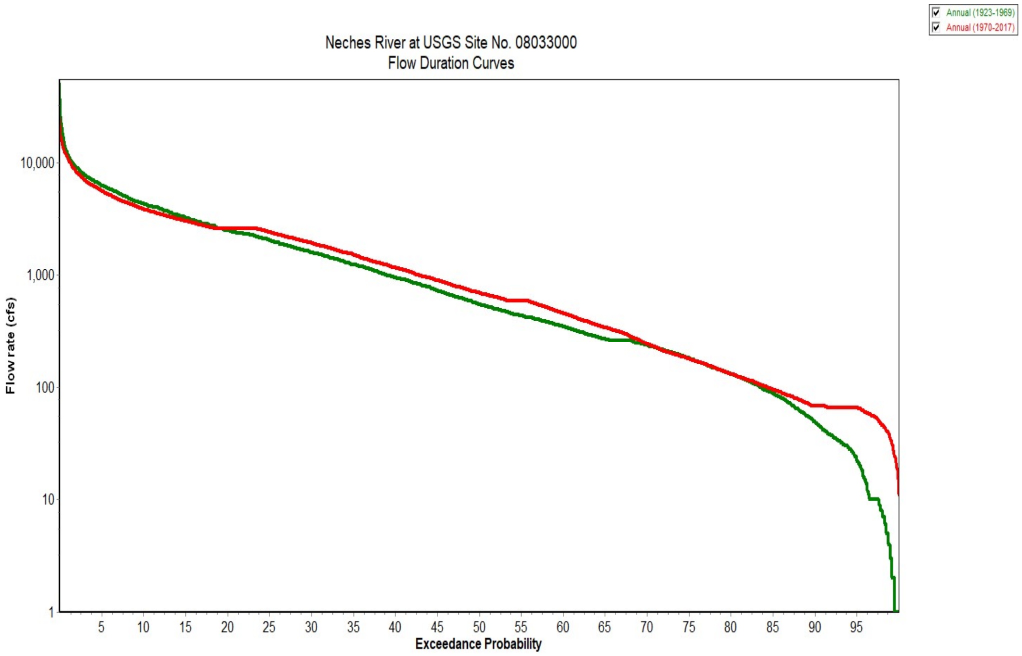
Flow Duration Curves of Trinity River near Oakwood



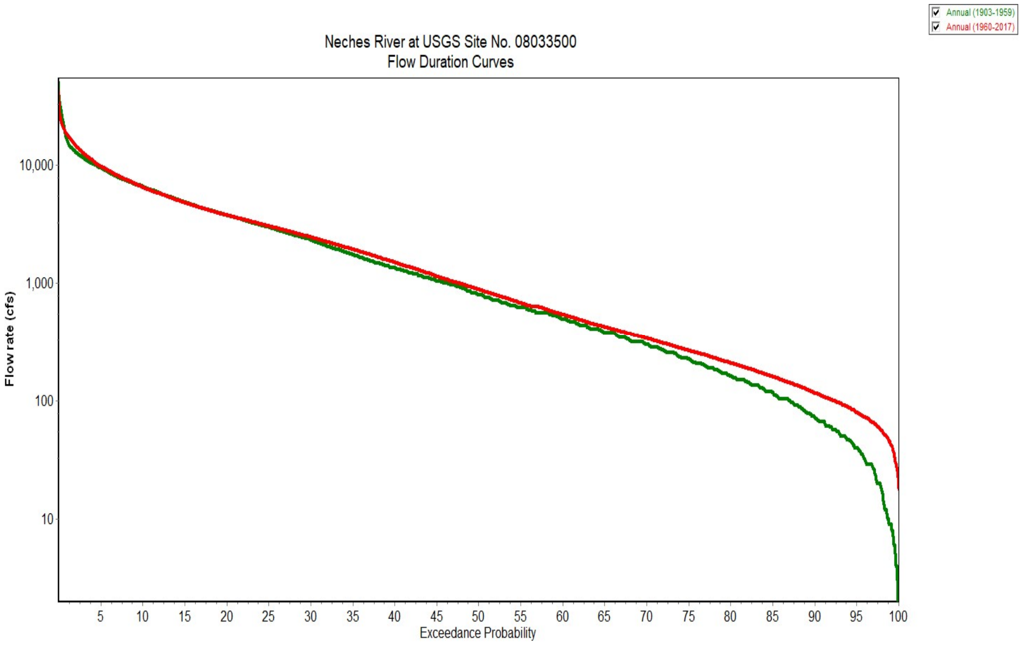
Flow Duration Curves of Trinity River near Romayor



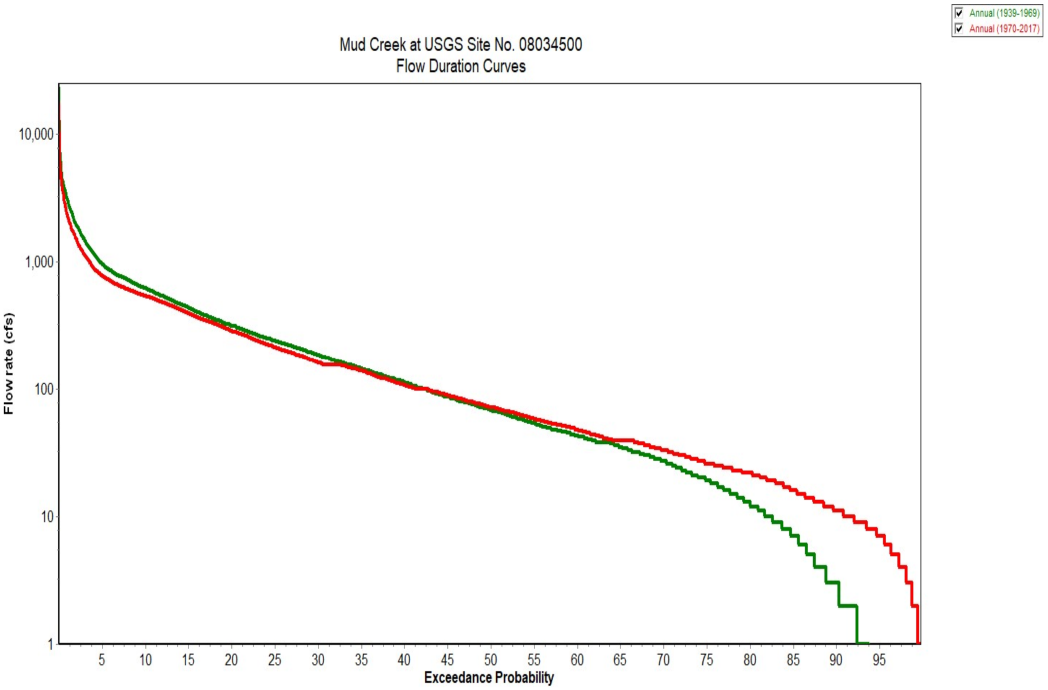
Flow Duration Curves of Neches River near Neches



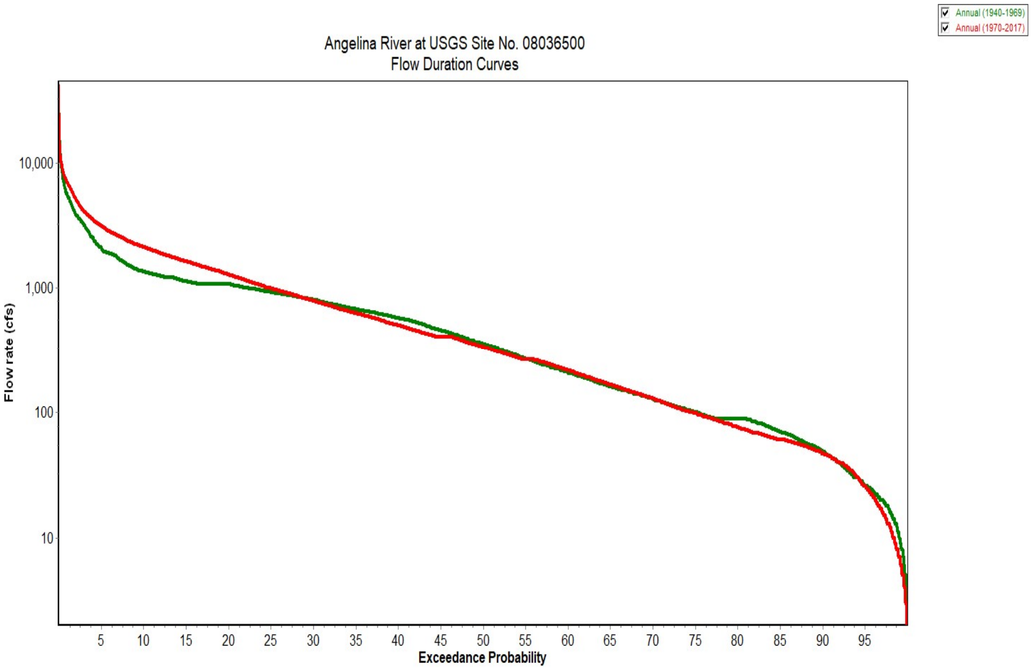
Flow Duration Curves of Neches River near Diboll



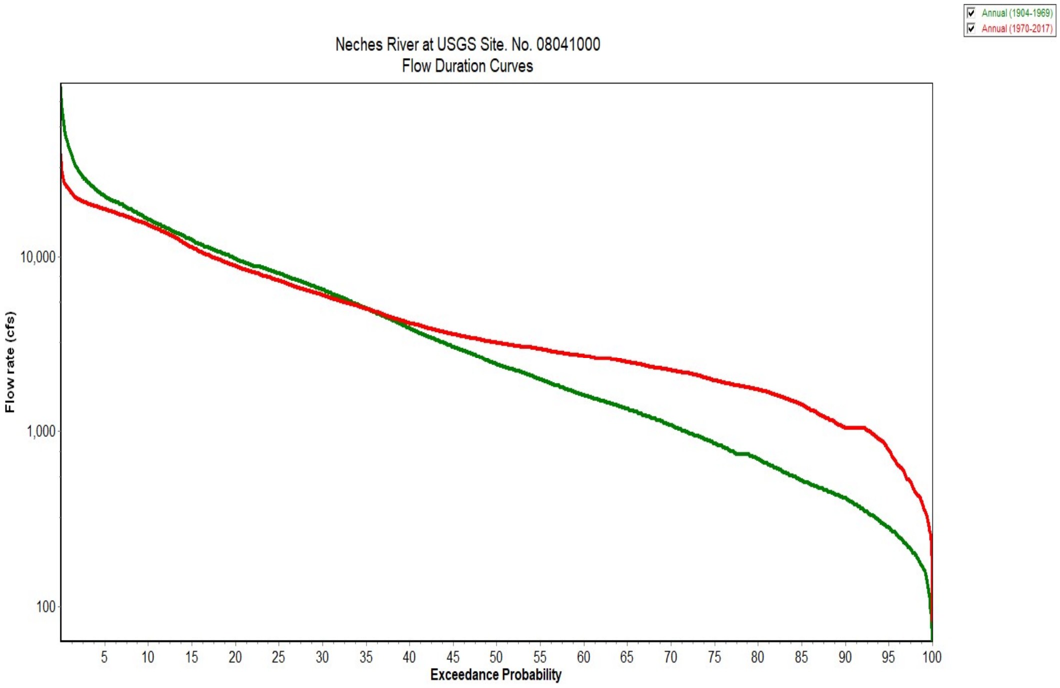
Flow Duration Curves of Neches River near Rockland



Flow Duration Curves of Mud Creek near Jacksonville

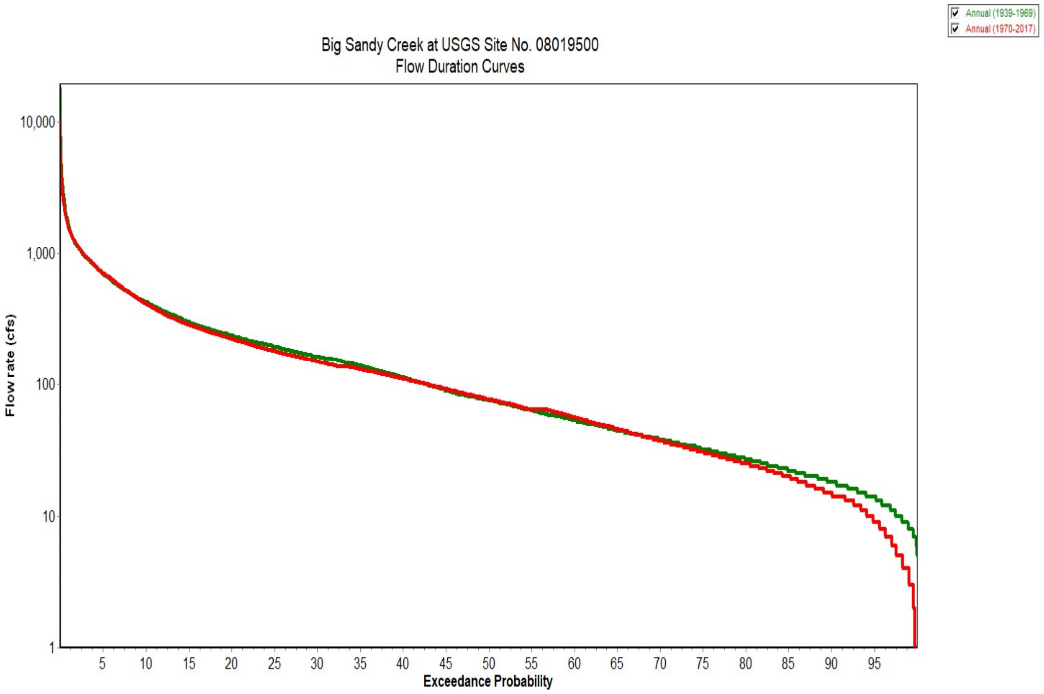


Flow Duration Curves of Angelina River near Alto

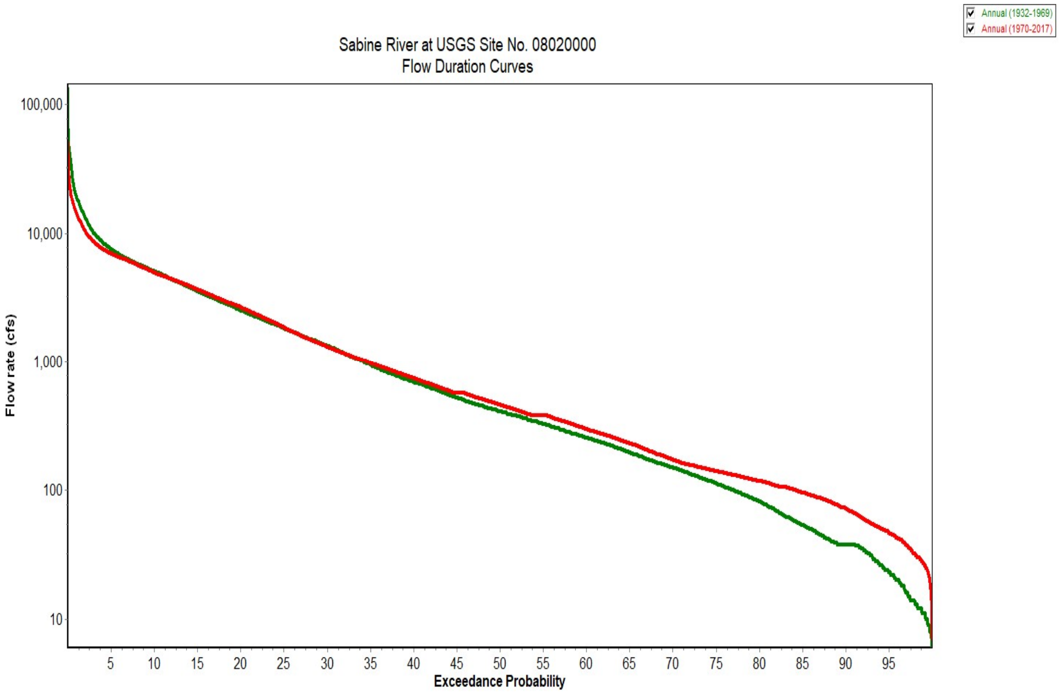


Flow Duration Curves of Neches River at Evadale

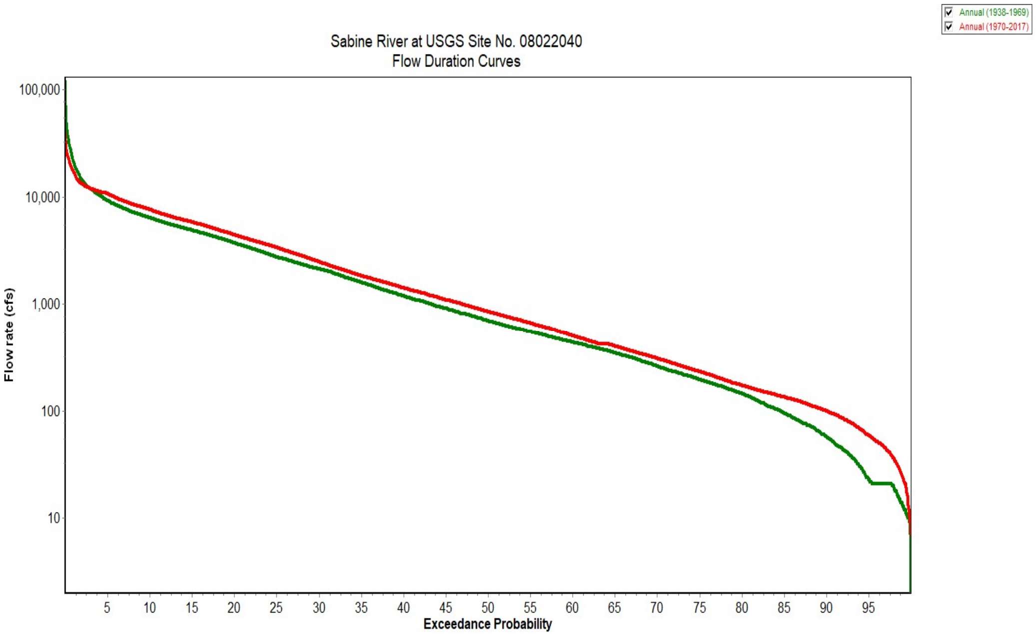
Flow Duration Curves of Village Creek near Kountze



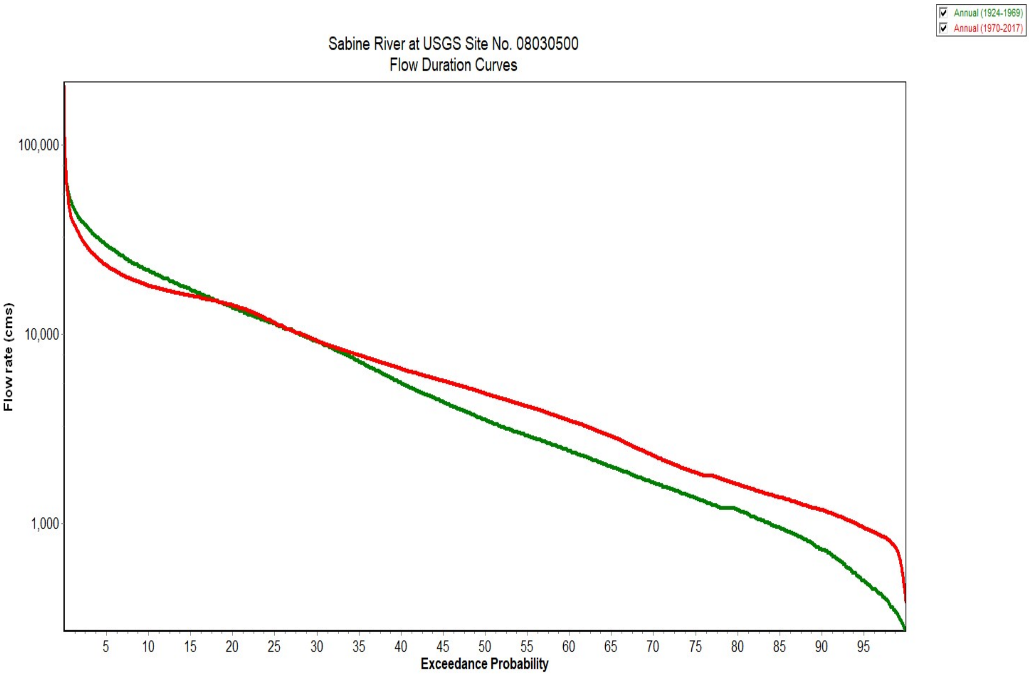
Flow Duration Curves of Big Sandy Creek near Big Sandy



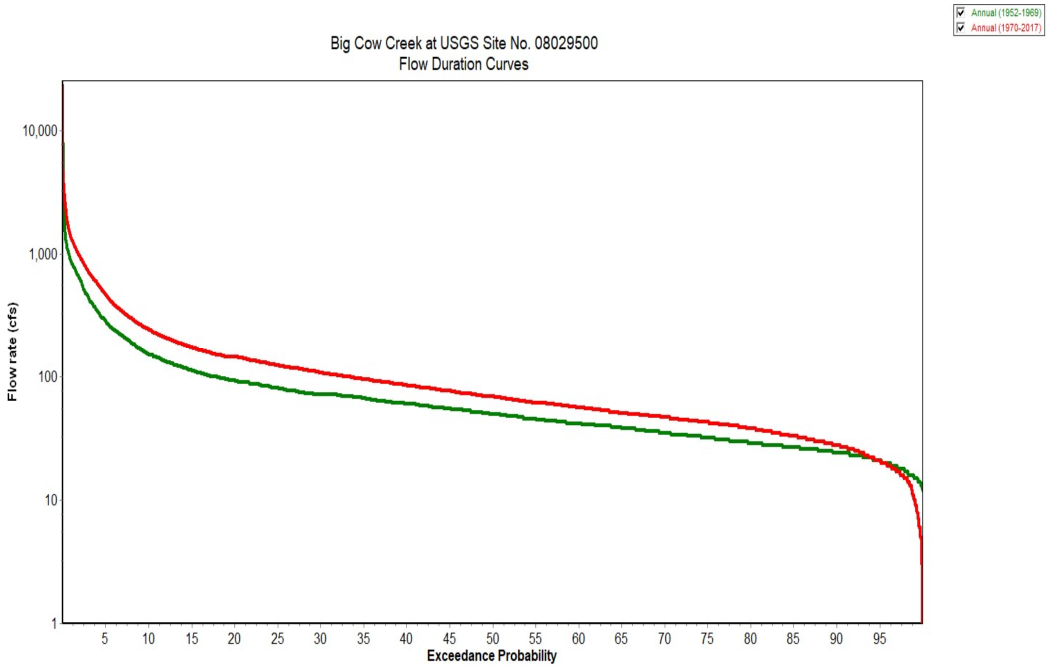
Flow Duration Curves of Sabine River near Gladewater



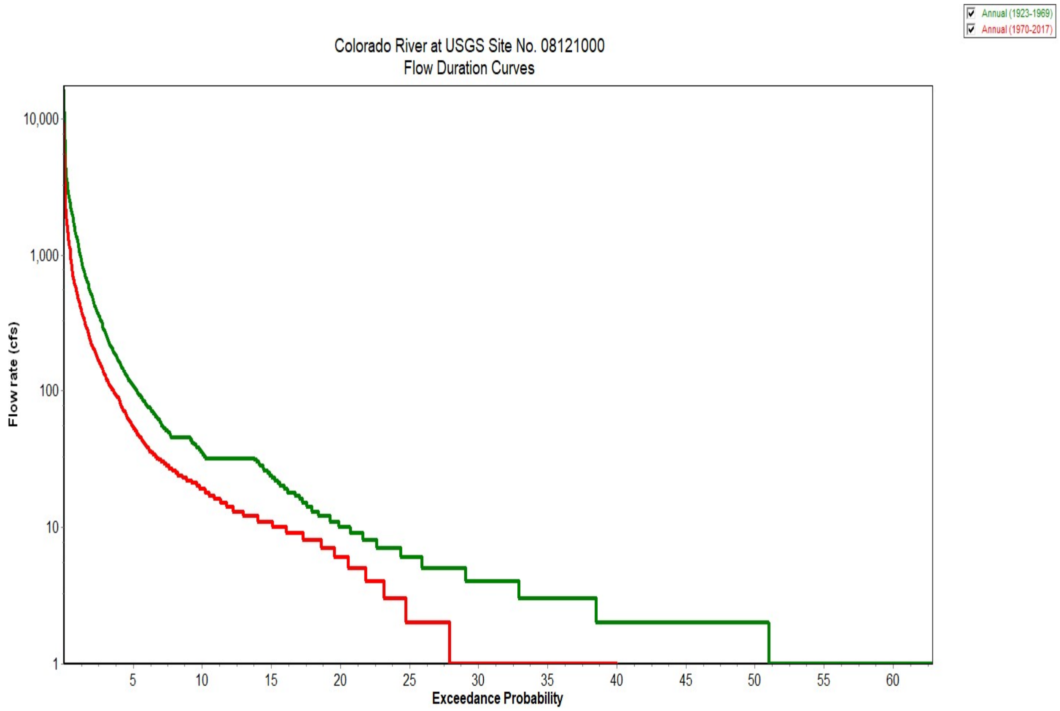
Flow Duration Curves of Sabine River near Beckville



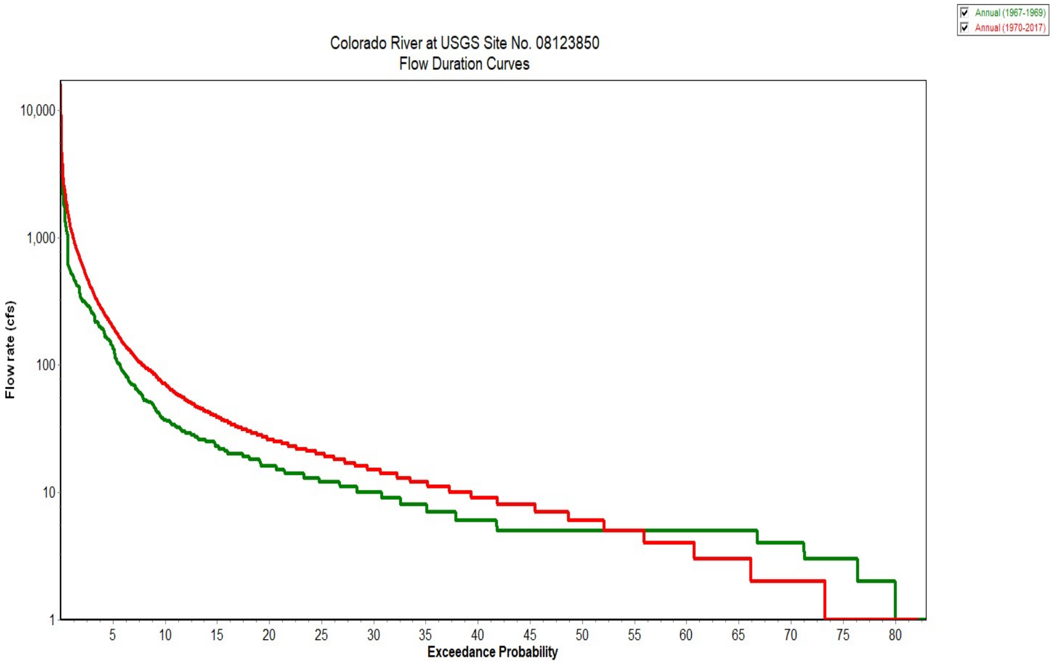
Flow Duration Curves of Sabine River near Ruliff



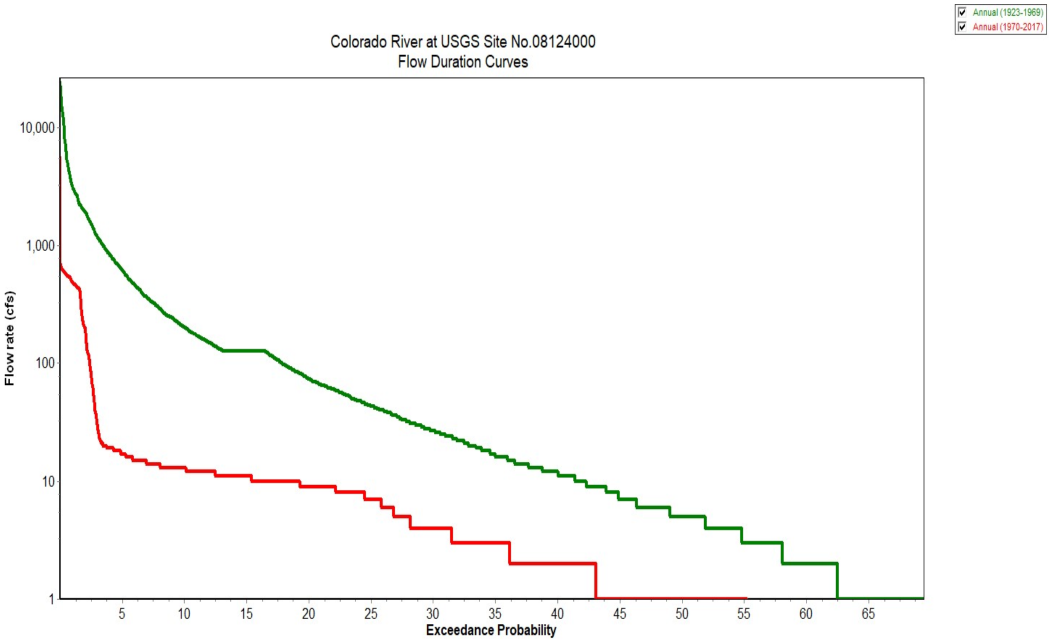
Flow Duration Curves of Big Cow Creek near Newton



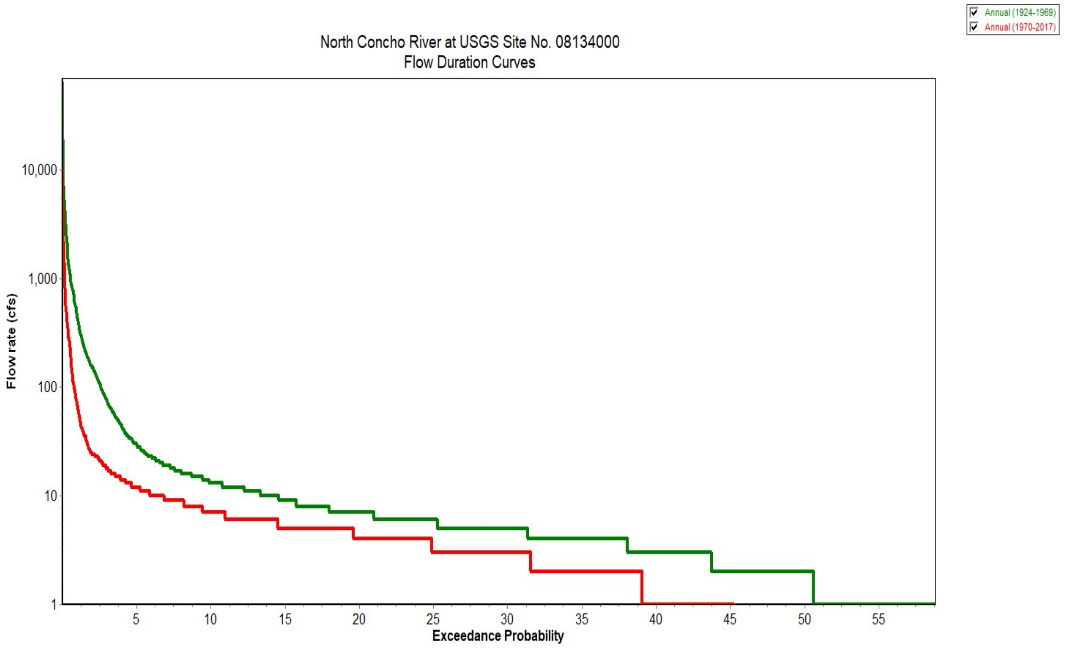
Flow Duration Curves of Colorado River at Colorado City



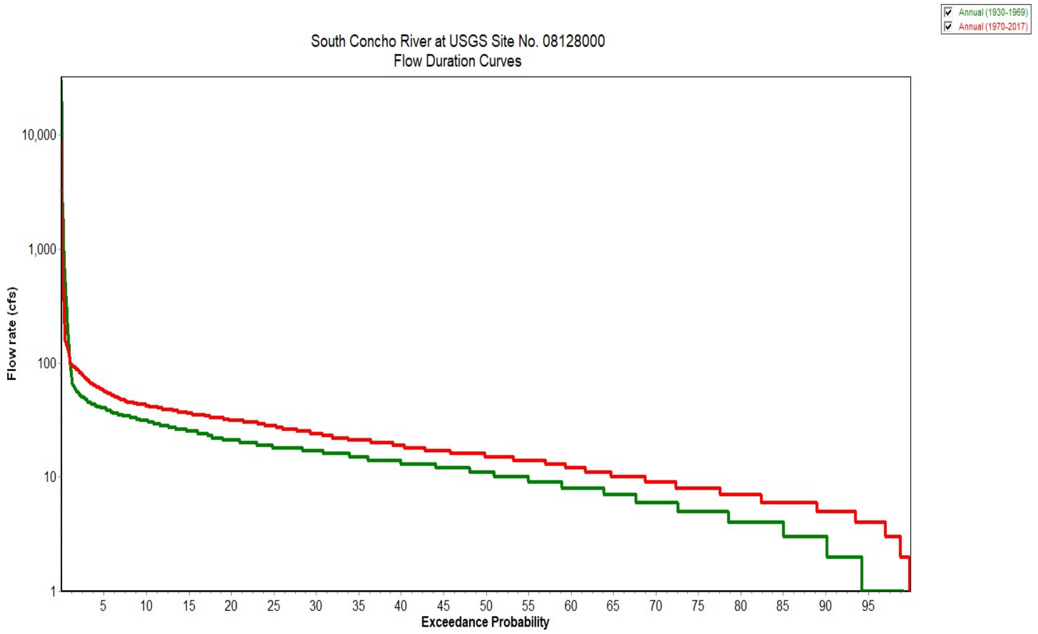
Flow Duration Curves of Colorado River above Silver



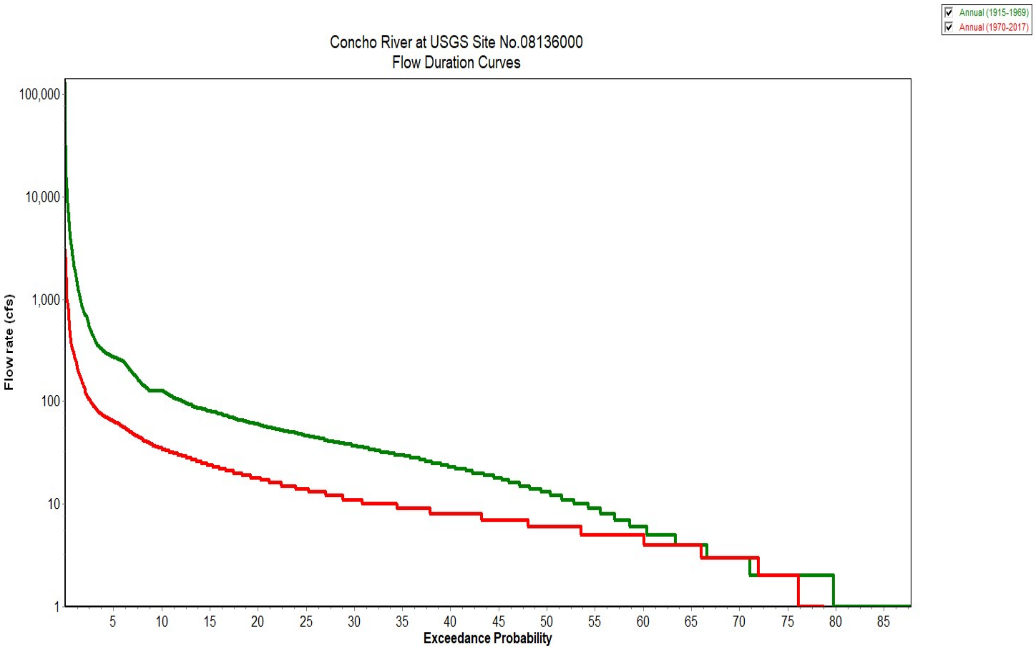
Flow Duration Curves of Colorado River at Robert Lee



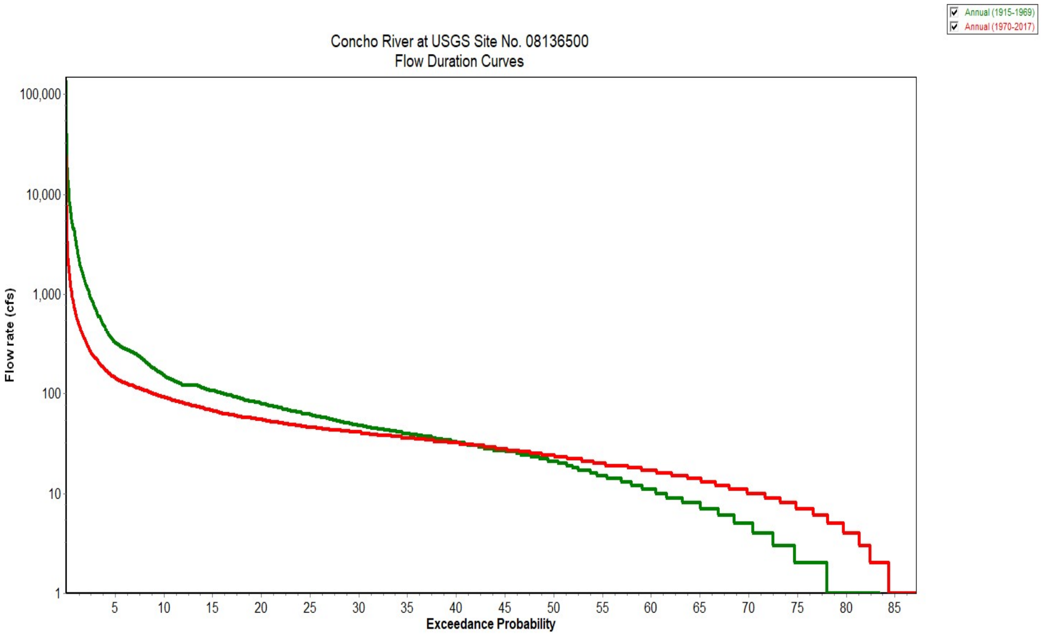
Flow Duration Curves of North Concho River near Carlsbad



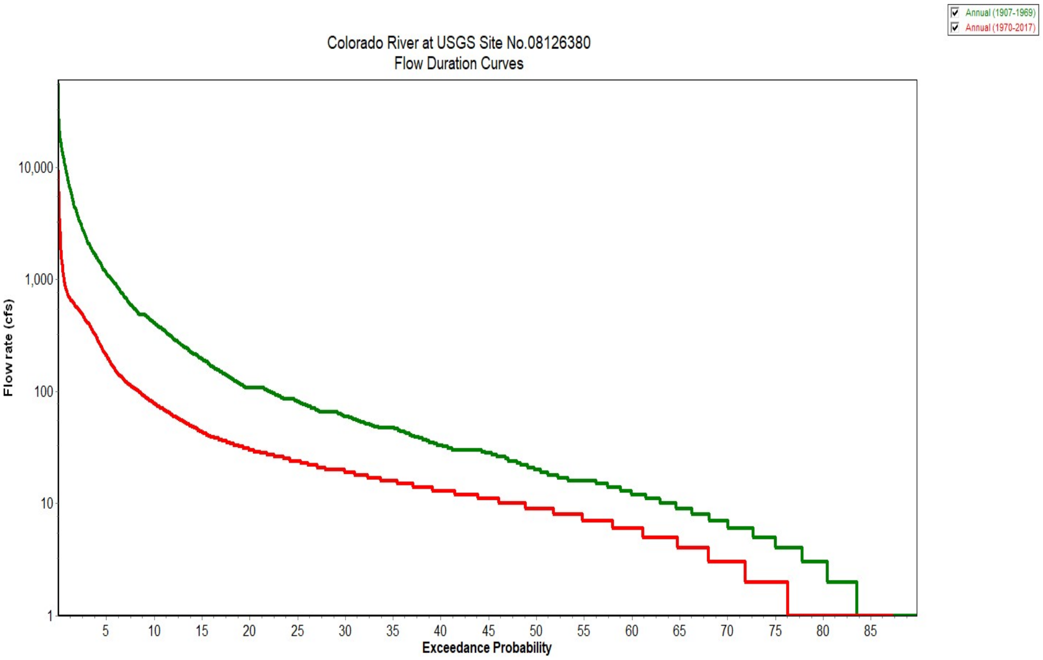
Flow Duration Curves of South Concho River at Christoval



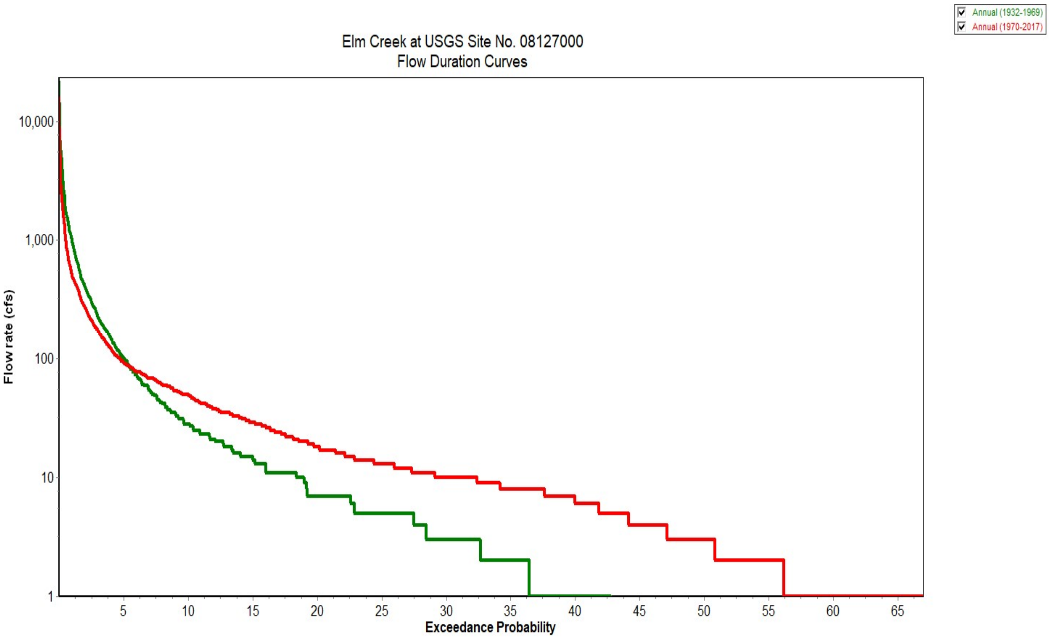
Flow Duration Curves of Concho River at San Angelo



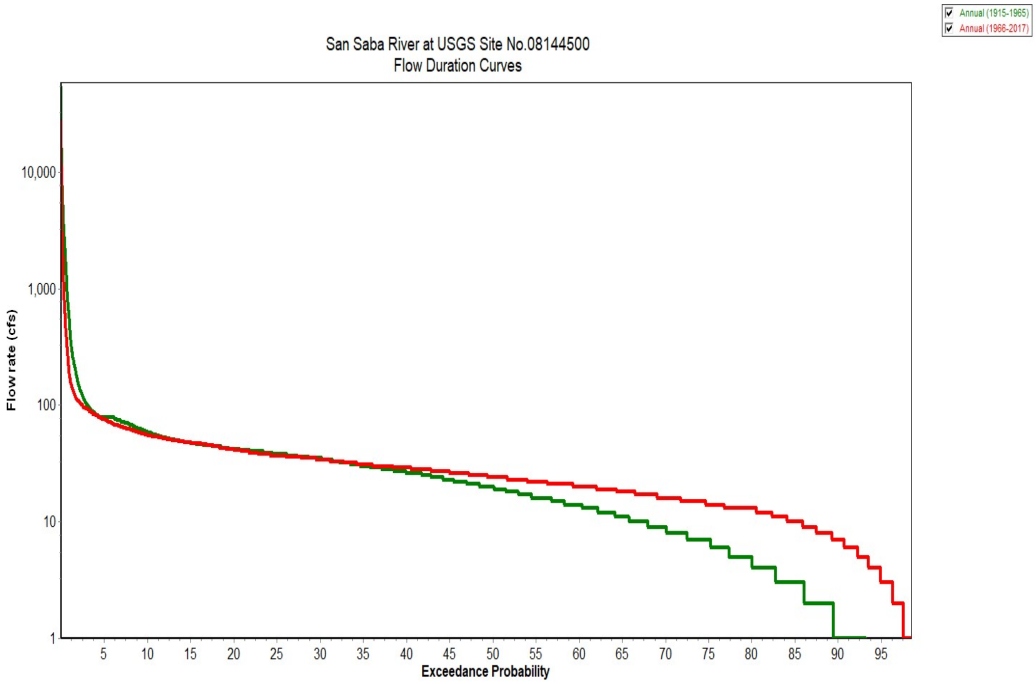
Flow Duration Curves of Concho River at Paint Rock



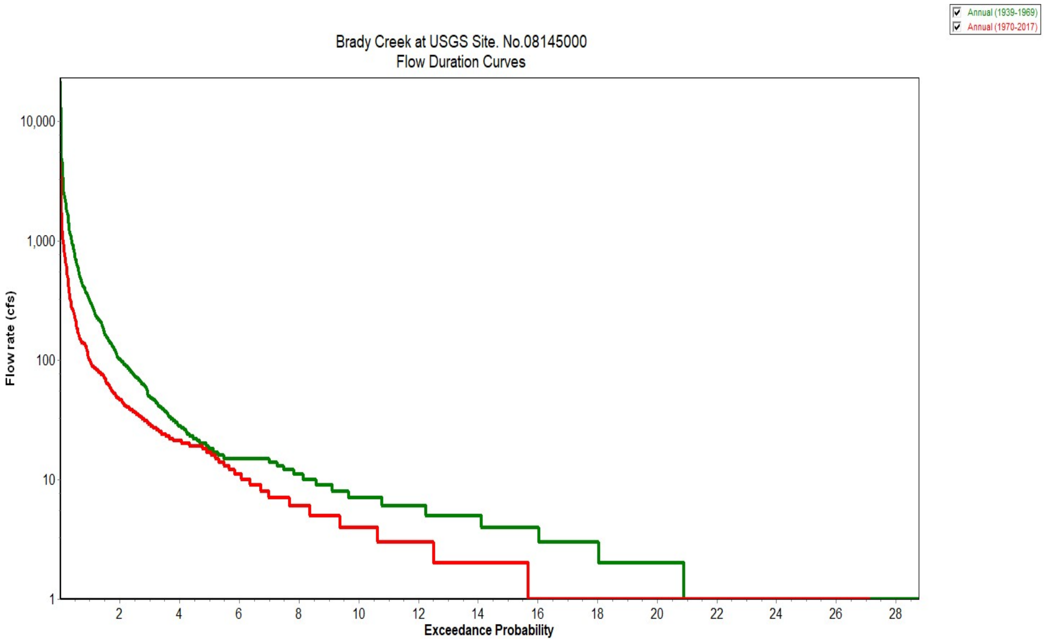
Flow Duration Curves of Colorado River near Ballinger



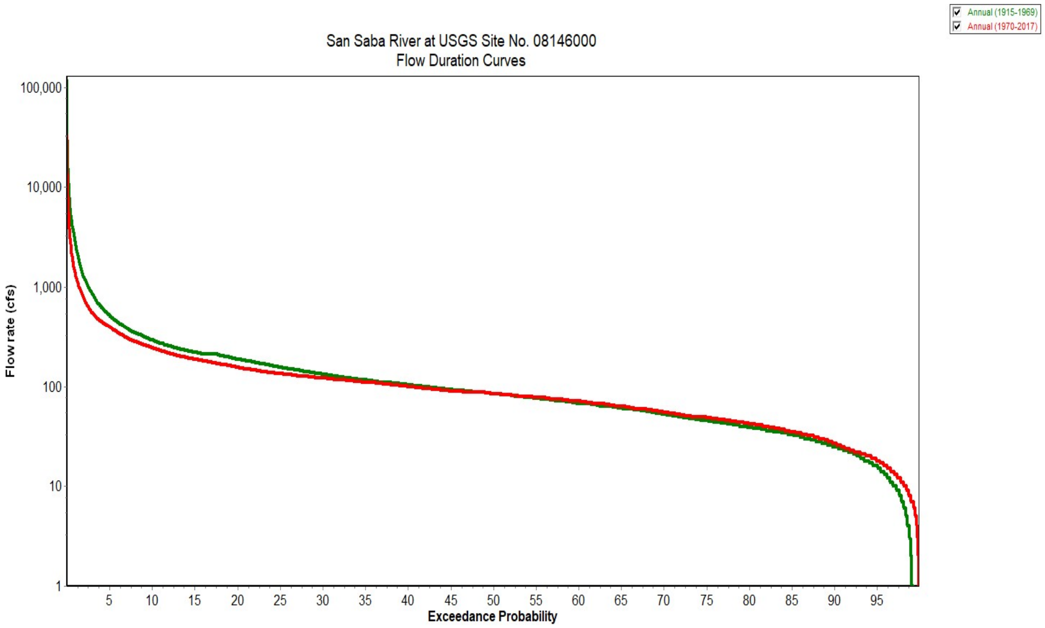
Flow Duration Curves of Elm Creek at Ballinger



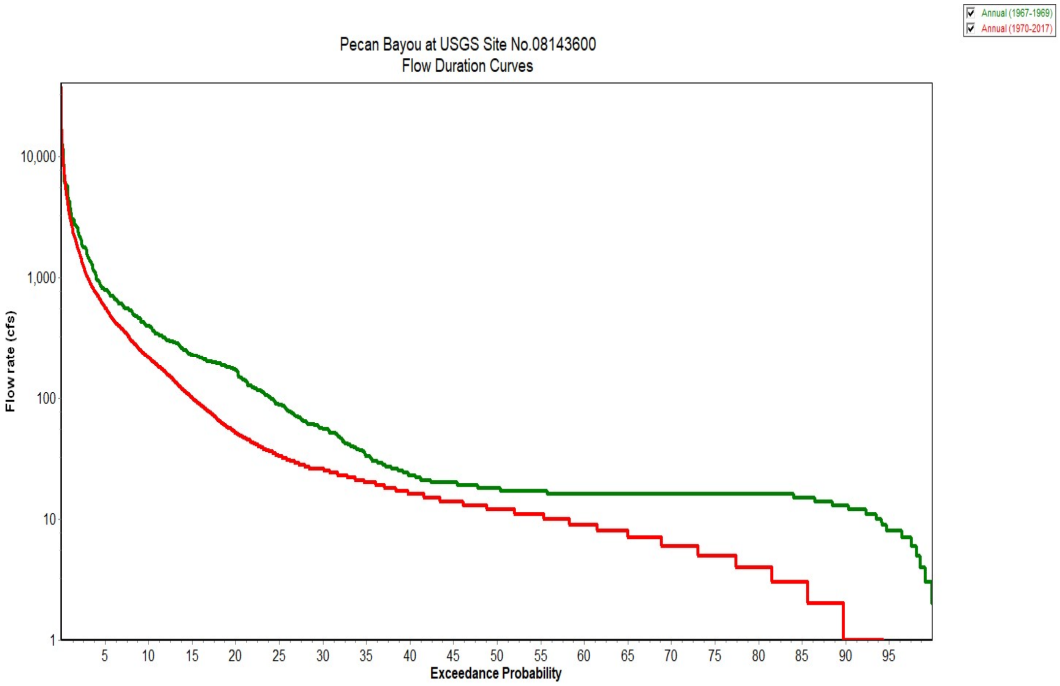
Flow Duration Curves of San Saba River at Menard



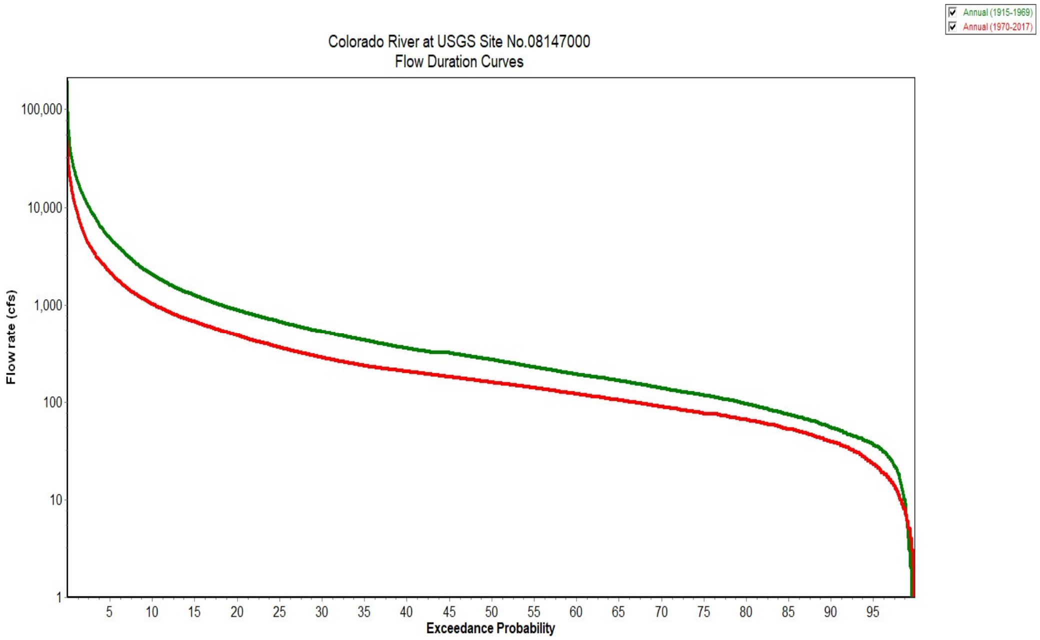
Flow Duration Curves of Brady Creek at Brady



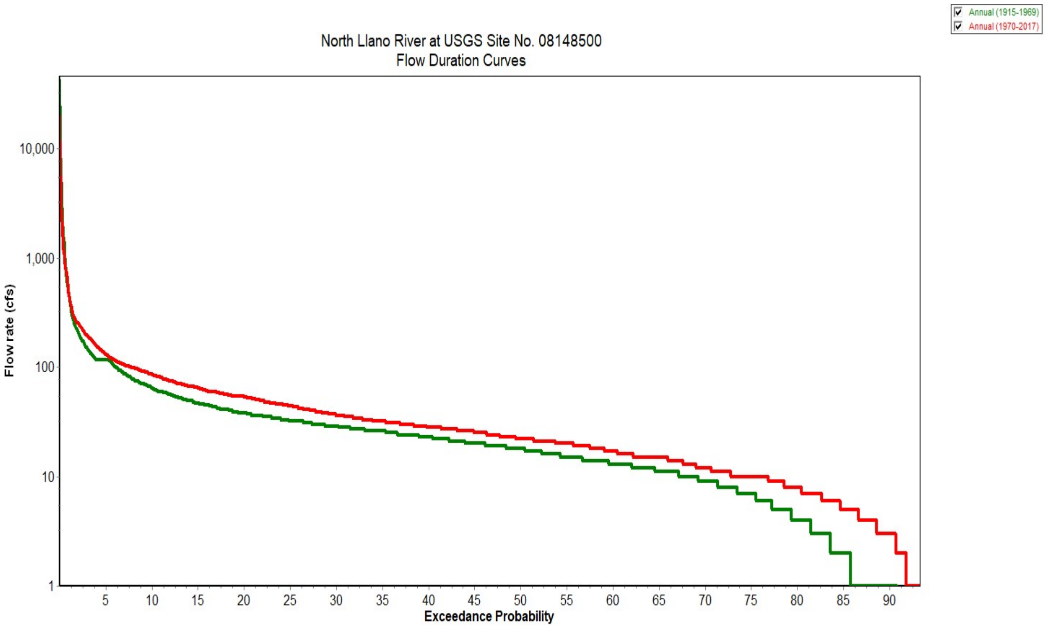
Flow Duration Curves of San Saba River at San Saba



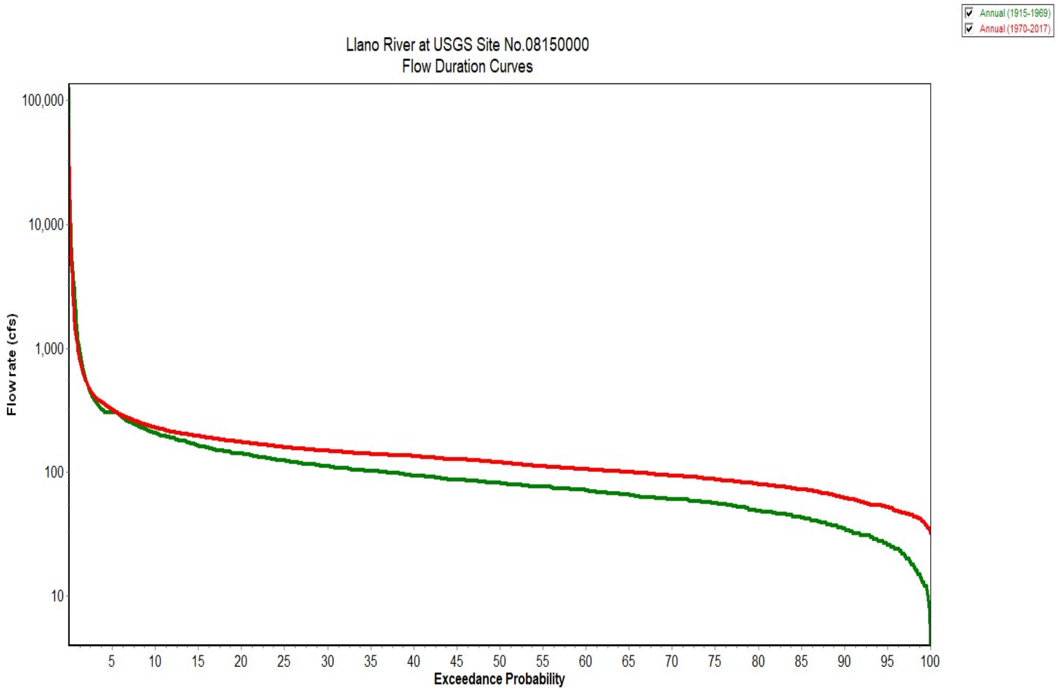
Flow Duration Curves of Pecan Bayou near Mullin



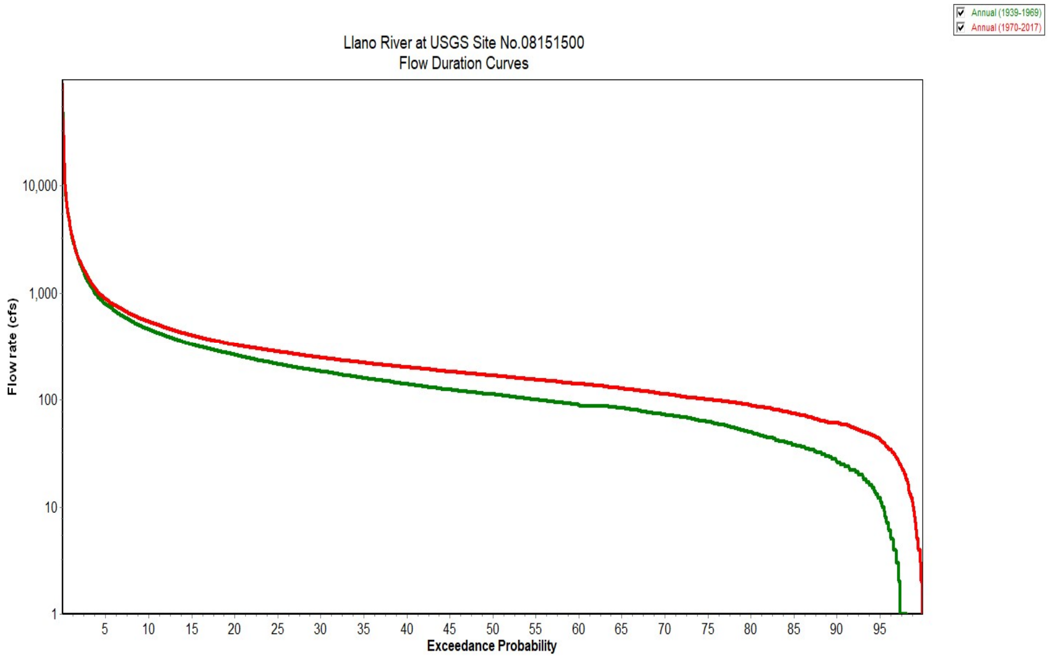
Flow Duration Curves of Colorado River near San Saba



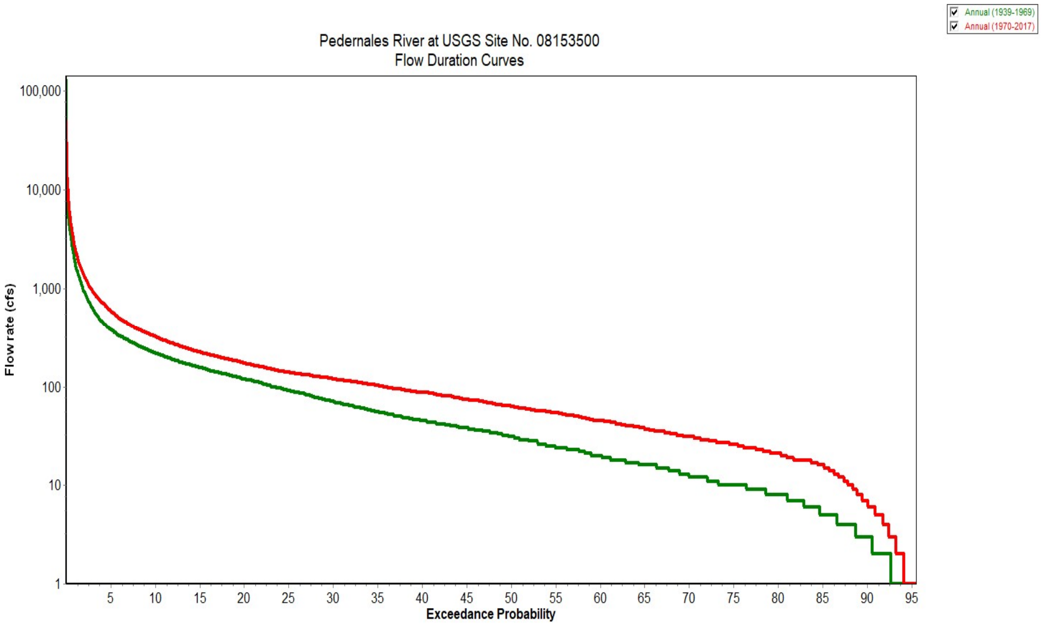
Flow Duration Curves of North Llano River near Junction



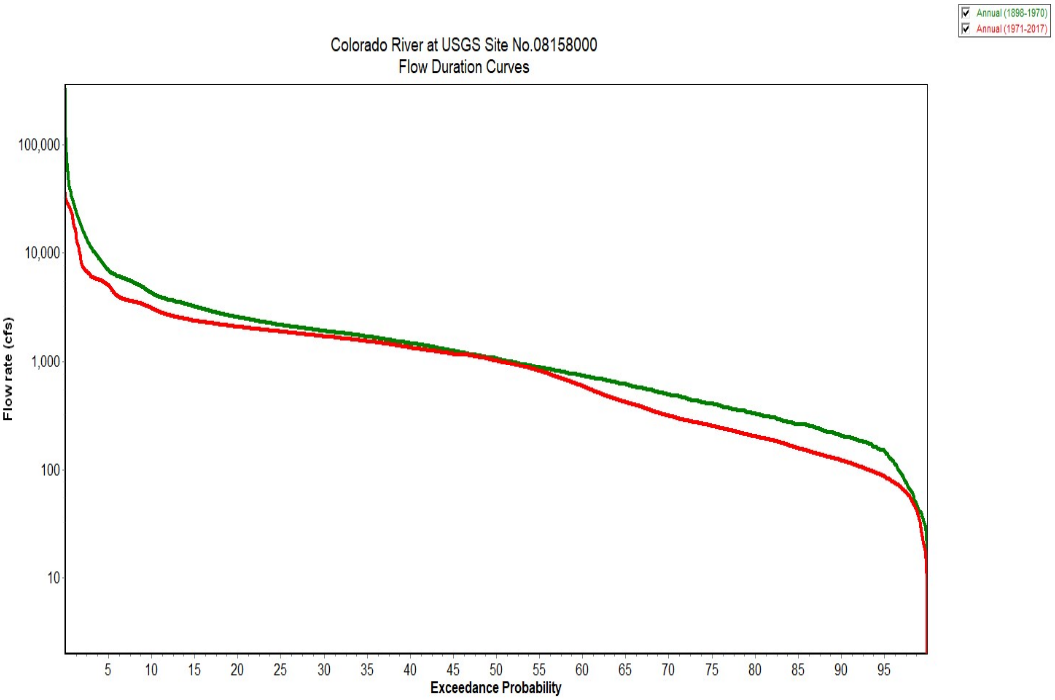
Flow Duration Curves of Llano River near Junction



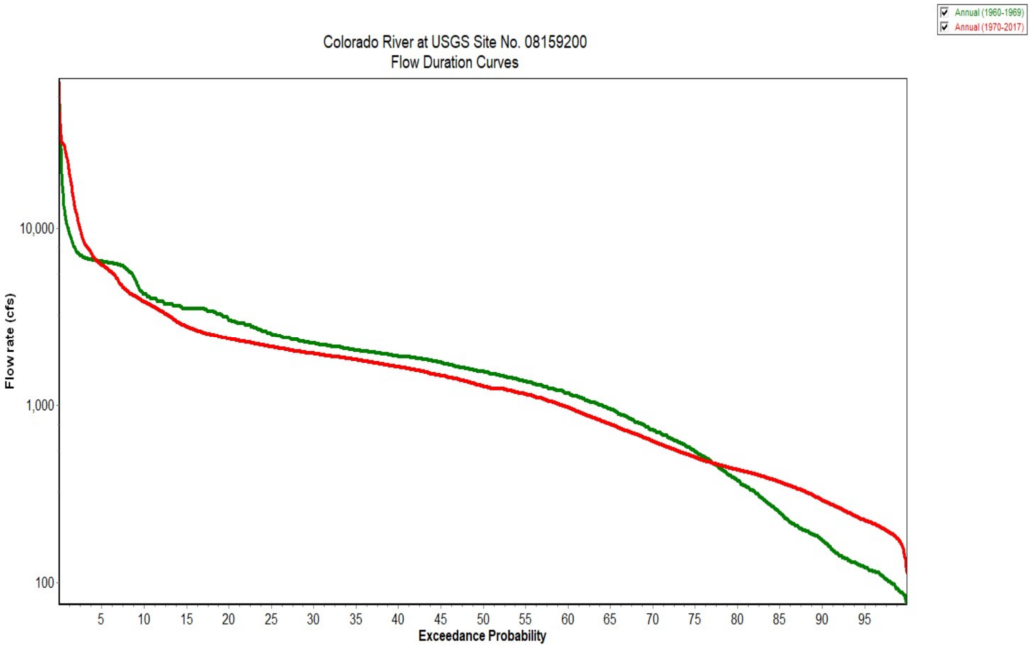
Flow Duration Curves of Llano River at Llano



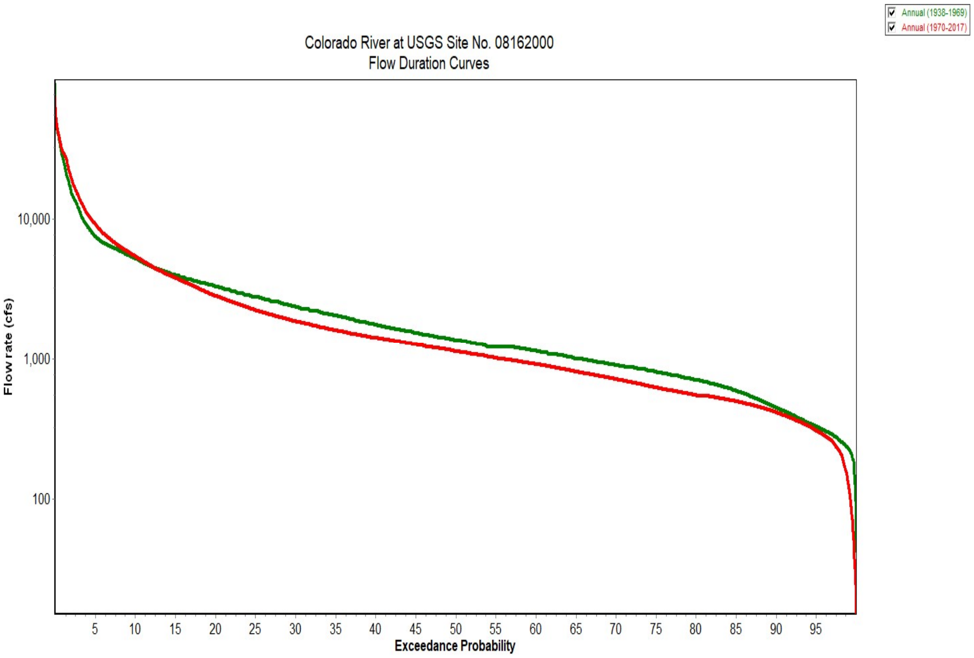
Flow Duration Curves of Pedernales River near Johnson City



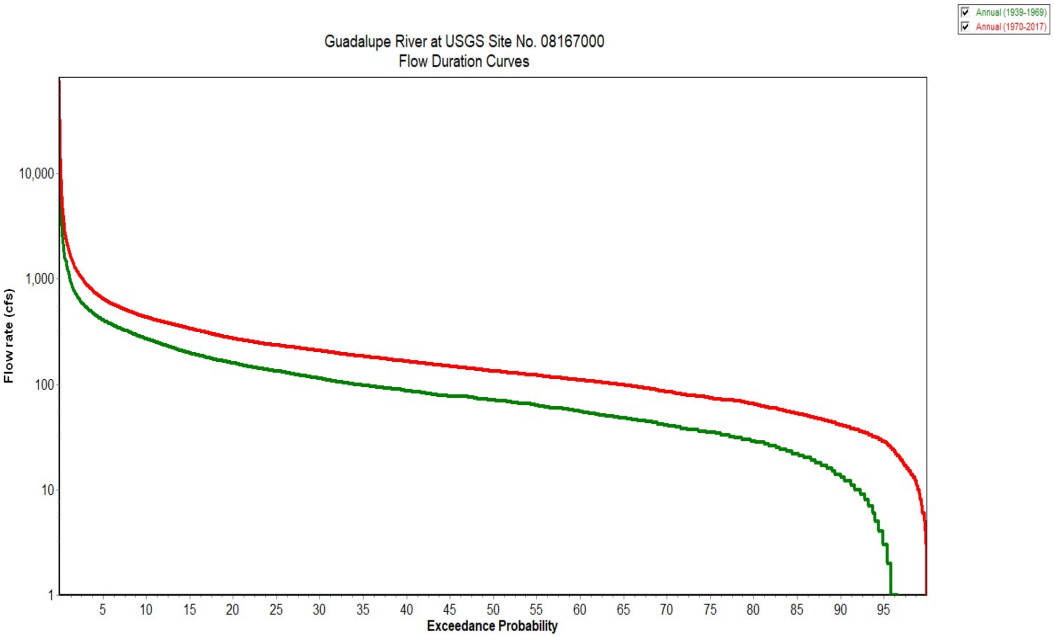
Flow Duration Curves of Colorado River at Austin



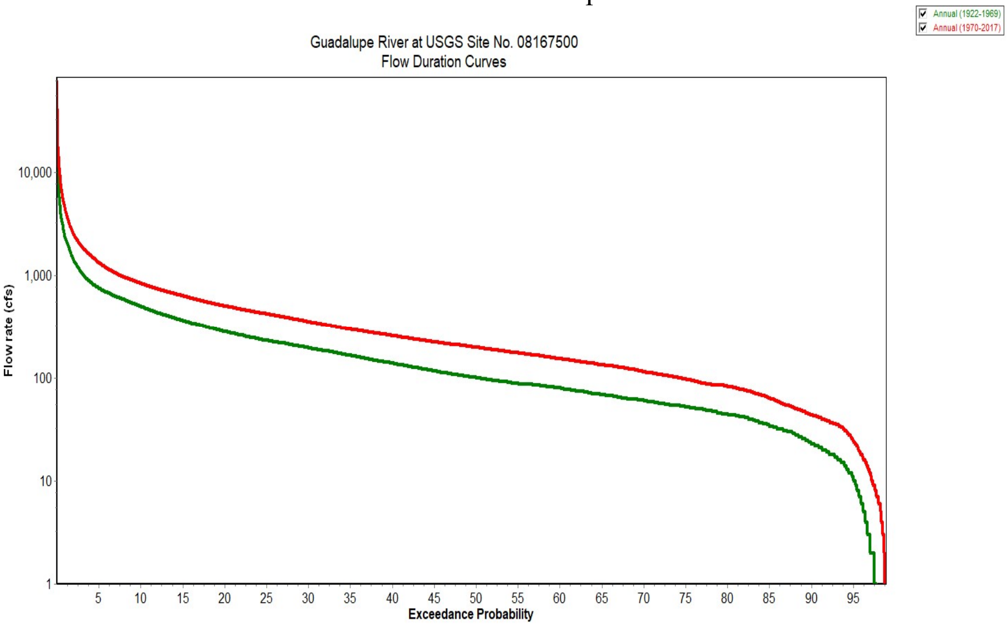
Flow Duration Curves of Colorado River at Bastrop



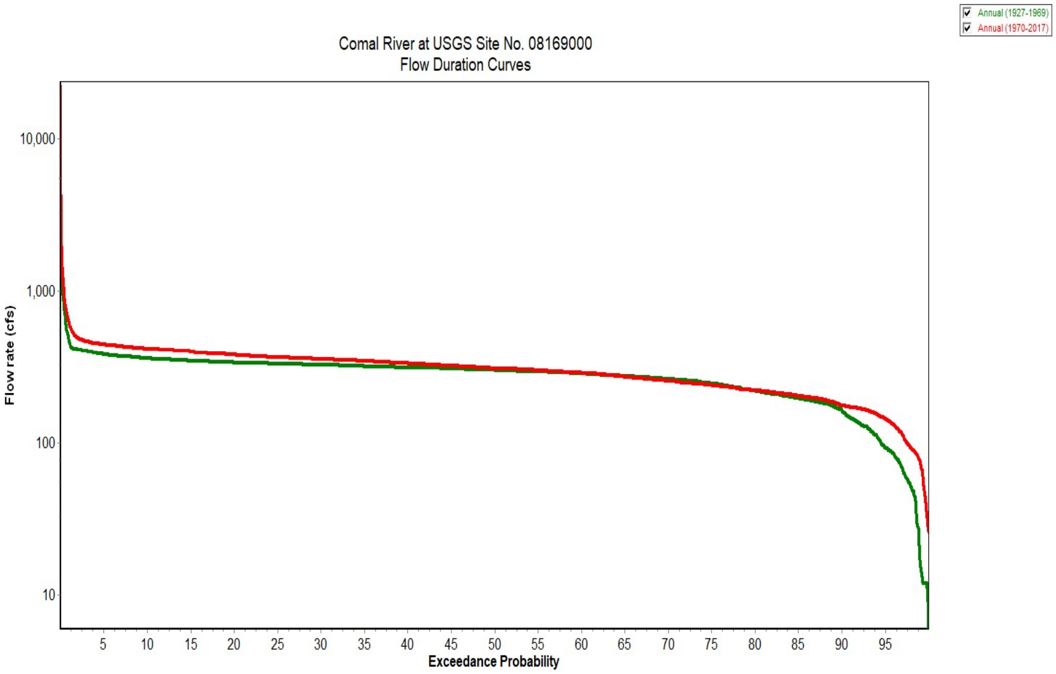
Flow Duration Curves of Colorado River at Wharton



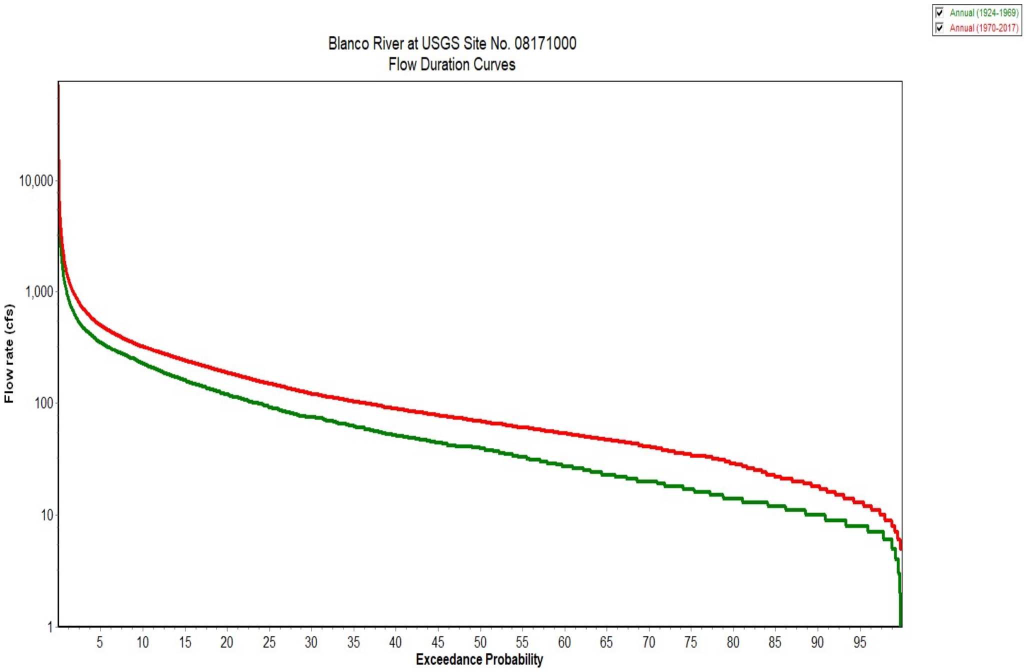
Flow Duration Curves of Guadalupe River at Comfort



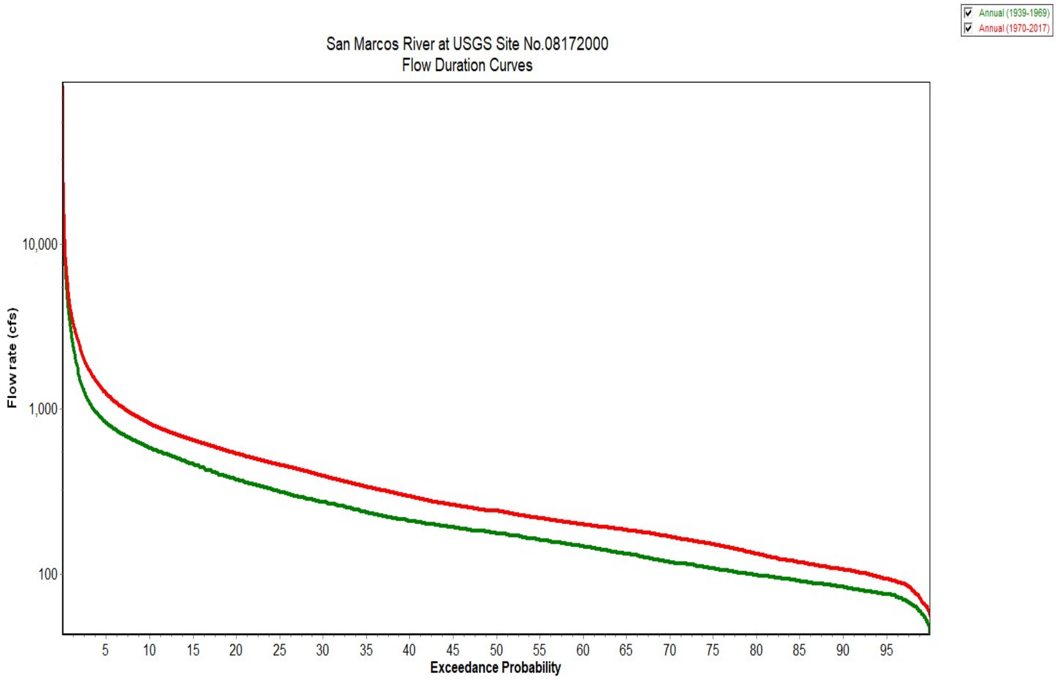
Flow Duration Curves of Guadalupe River near Spring Branch



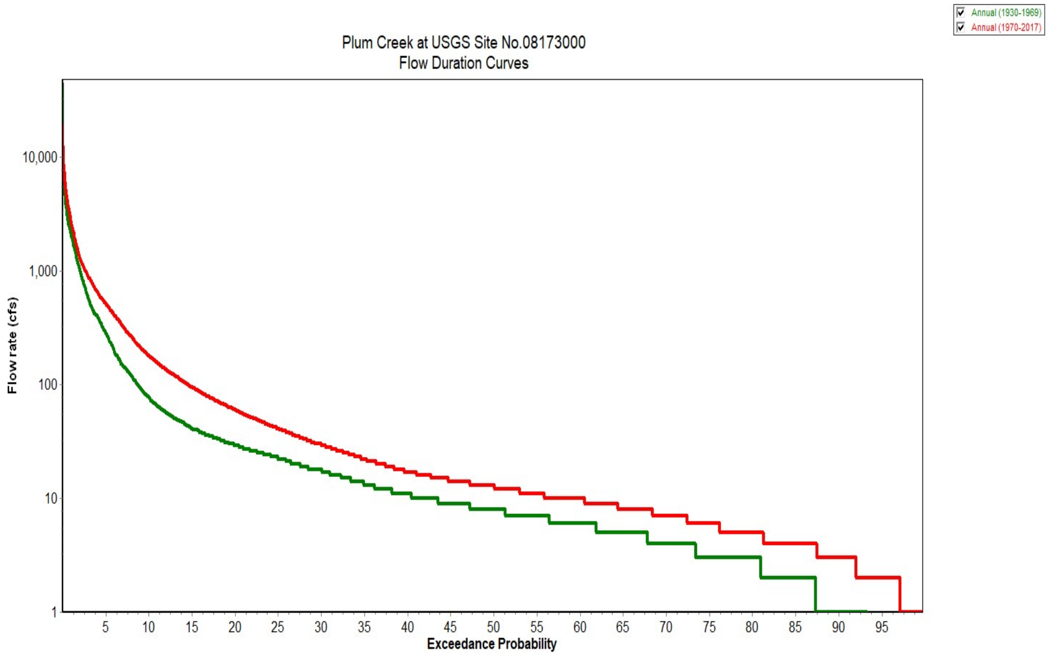
Flow Duration Curves of Comal River at New Braunfels



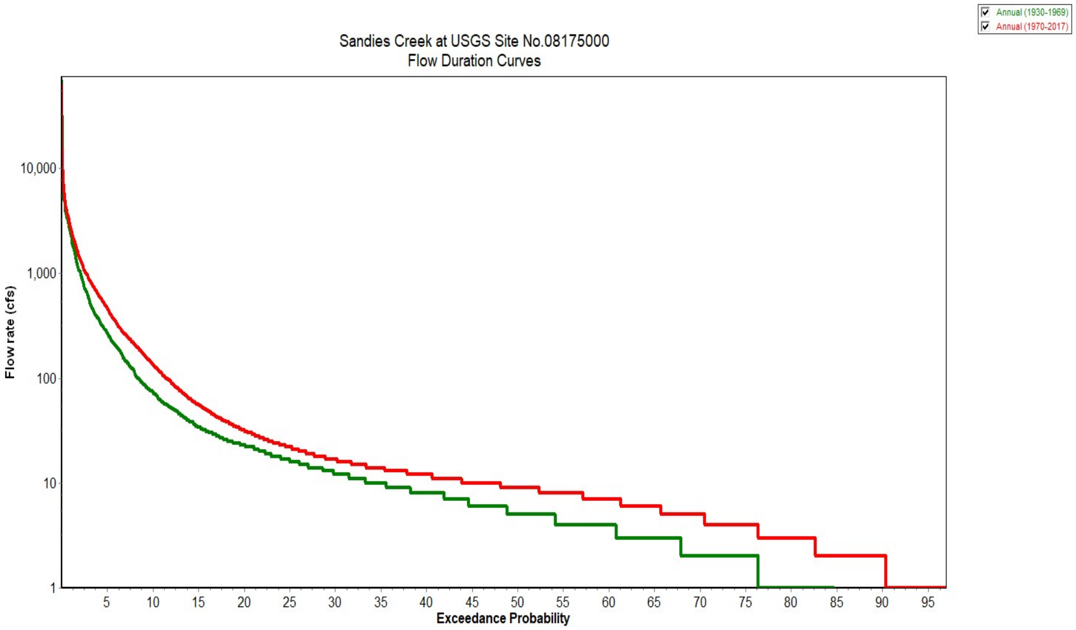
Flow Duration Curves of Blanco River at Wimberley



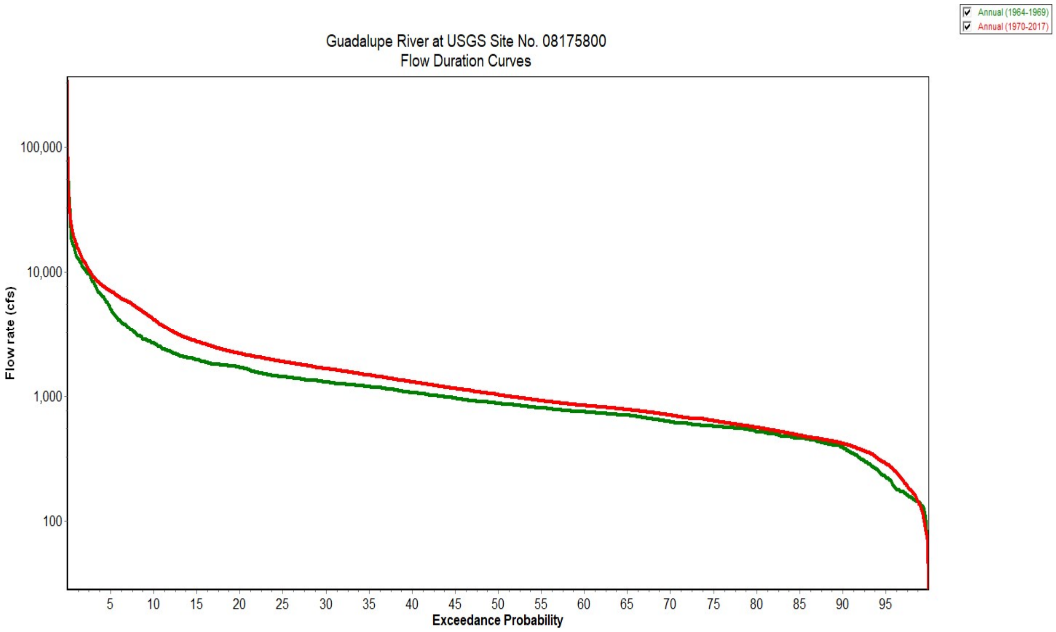
Flow Duration Curves of San Marcos River at Luling



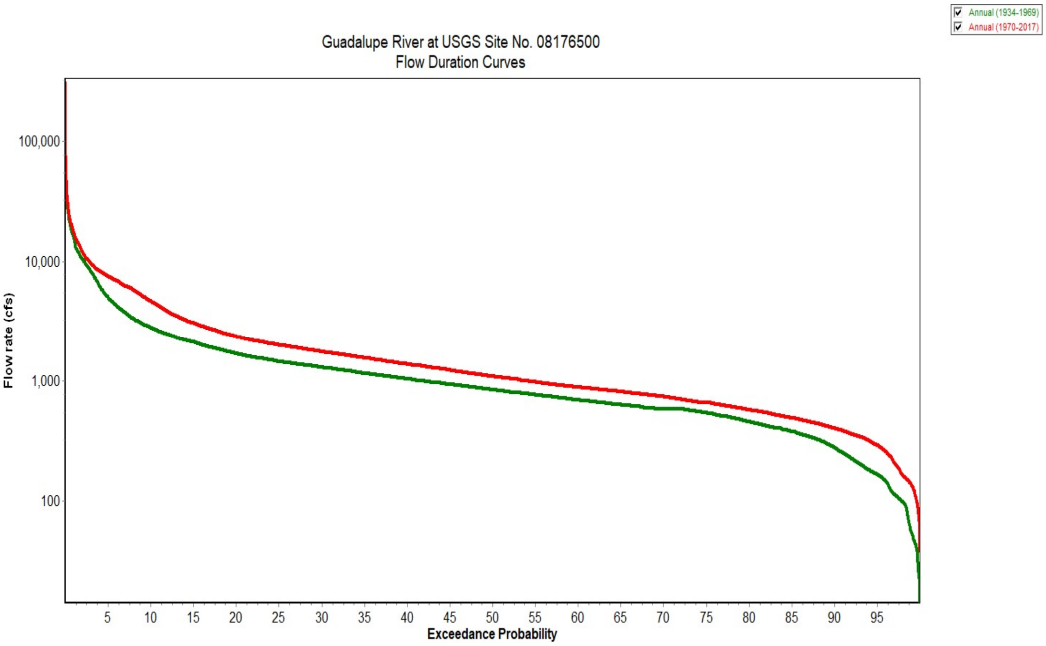
Flow Duration Curves of Plum Creek near Luling



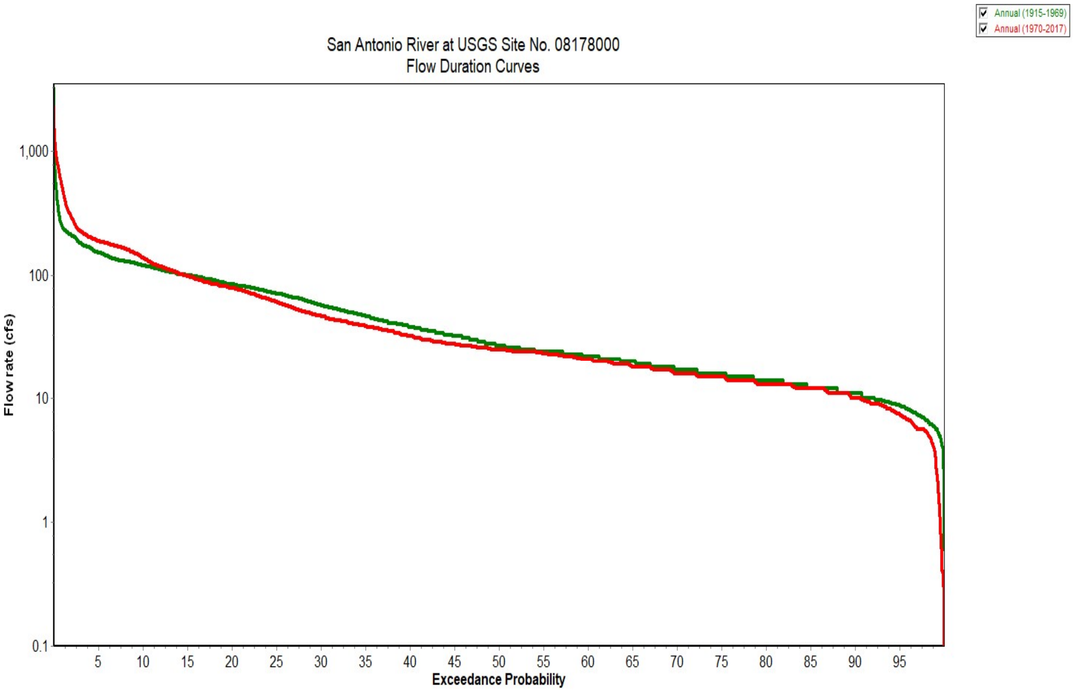
Flow Duration Curves of Sandies Creek near Westhoff



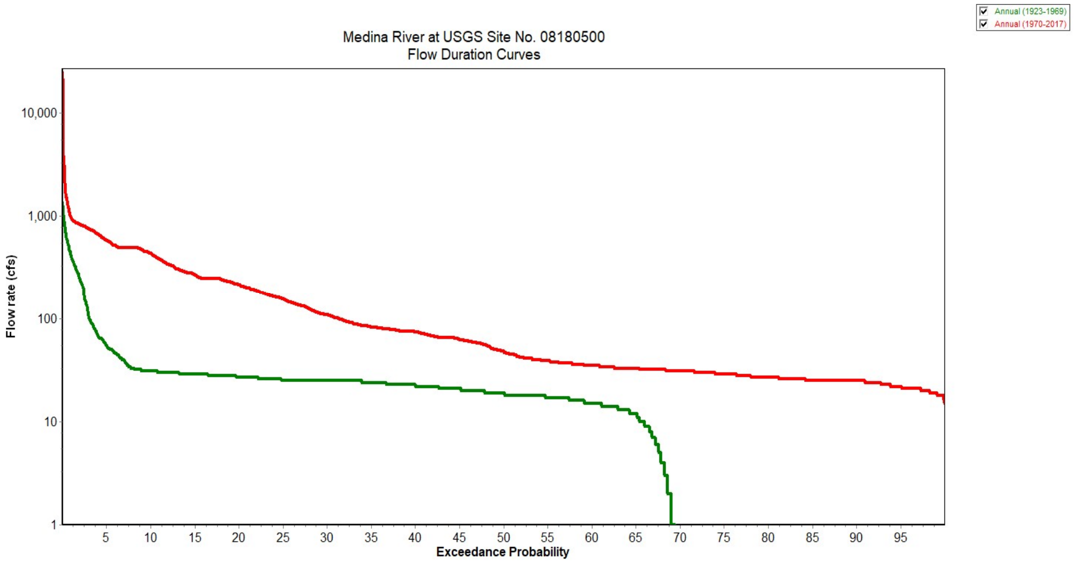
Flow Duration Curves of Guadalupe River at Cuero



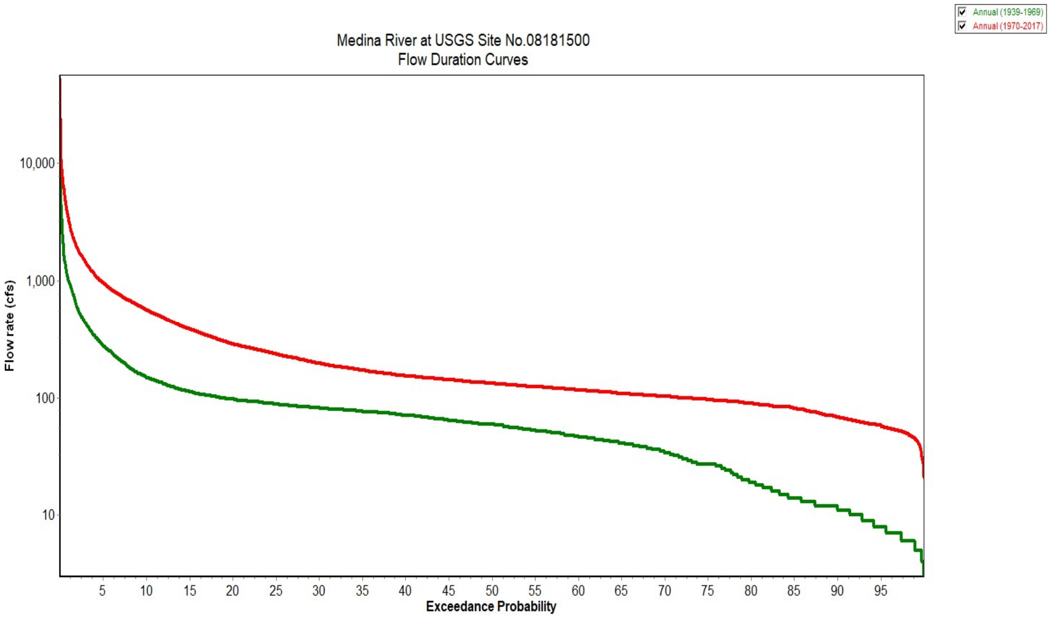
Flow Duration Curves of Guadalupe River at Victoria



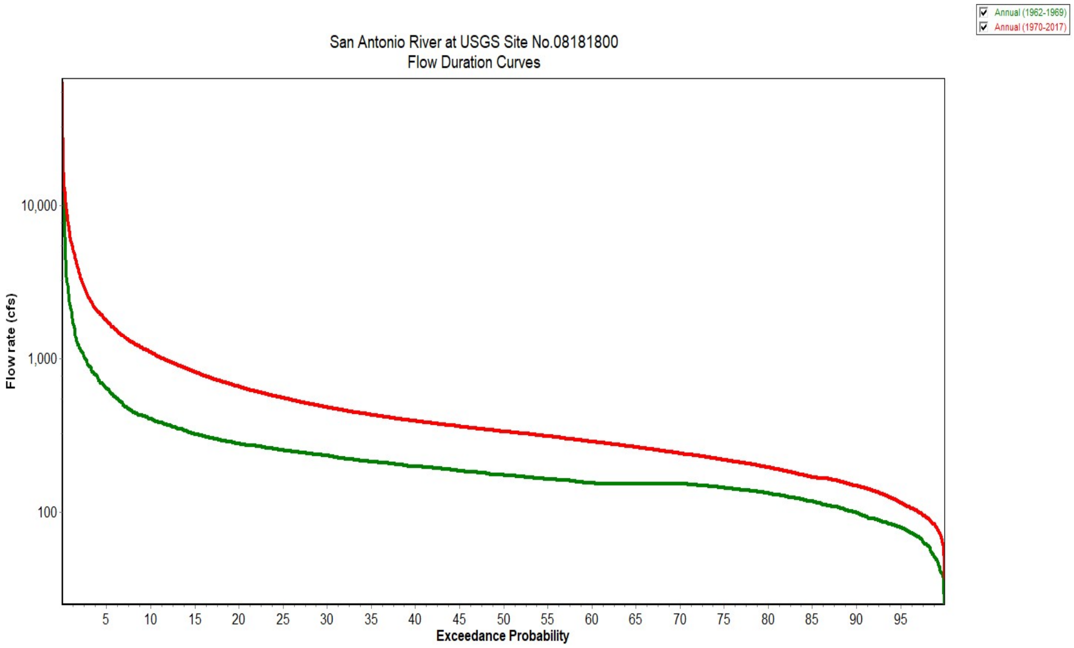
Flow Duration Curves of San Antonio River at San Antonio



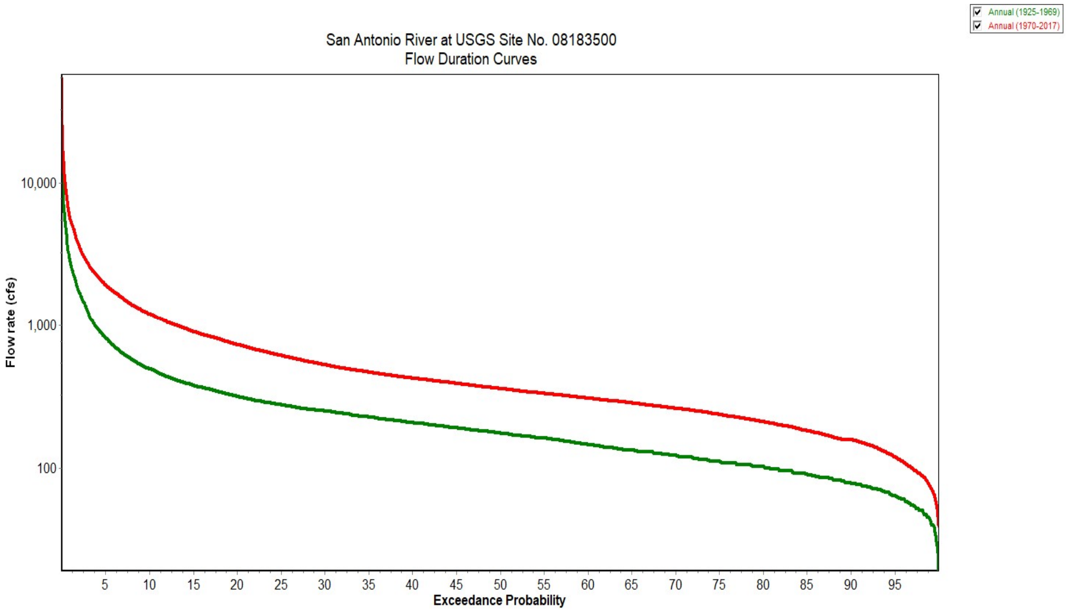
Flow Duration Curves of Medina River near Rio Medina



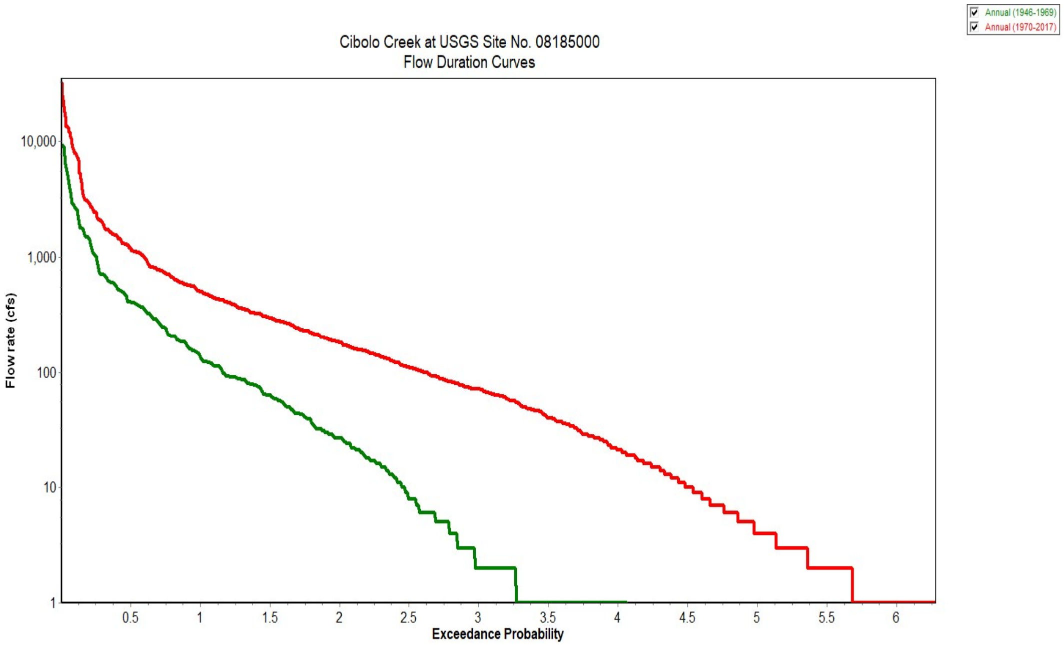
Flow Duration Curves of Medina River at San Antonio



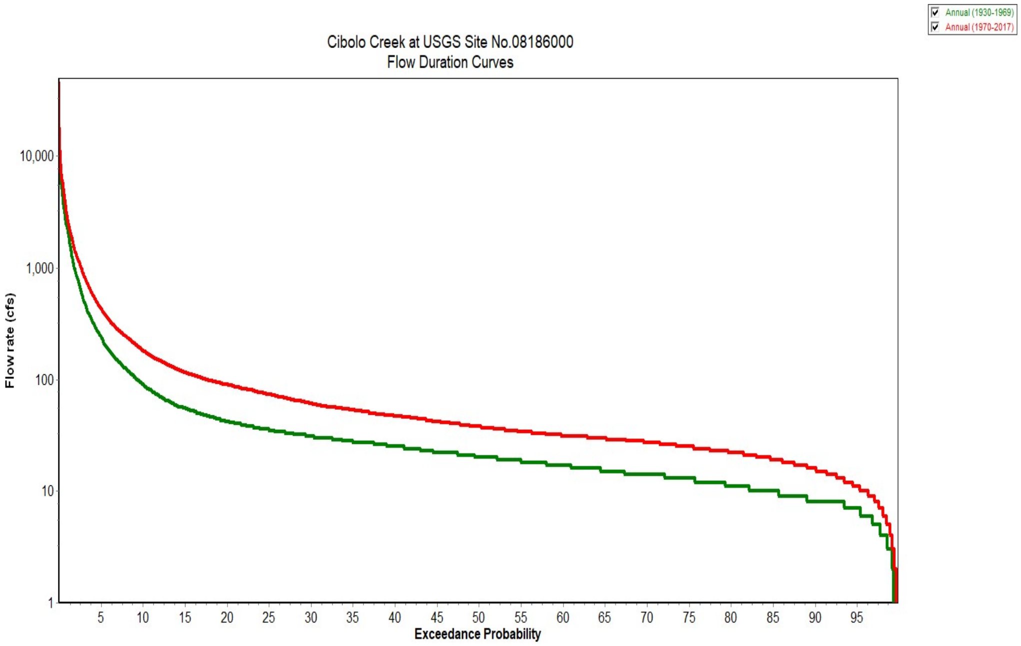
Flow Duration Curves of San Antonio River near Elmendorf



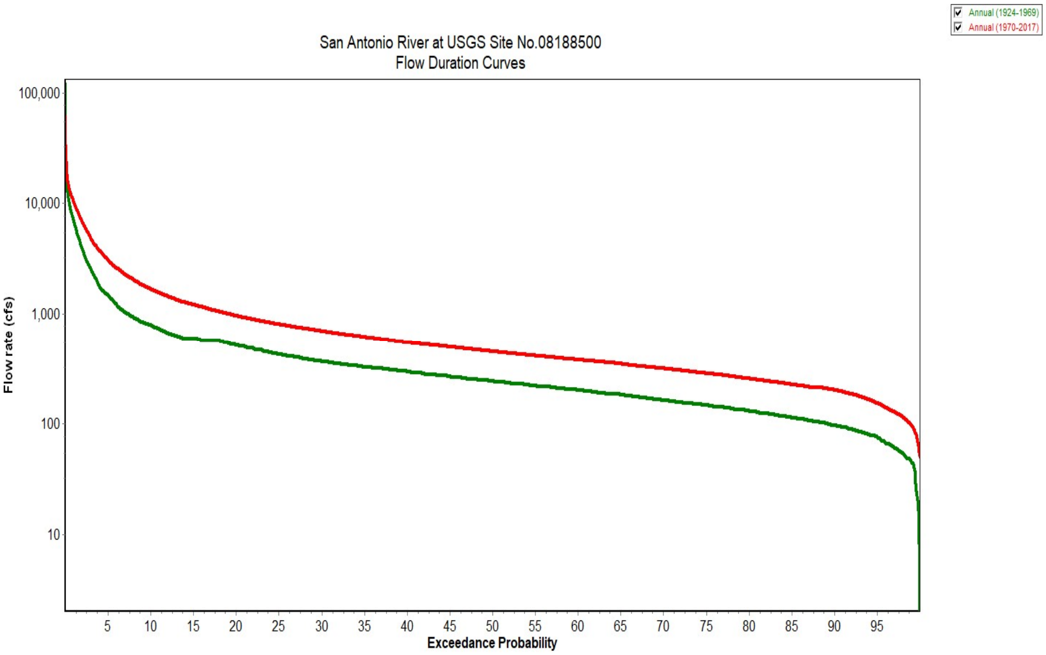
Flow Duration Curves of San Antonio River near Falls City



Flow Duration Curves of Cibolo Creek at Selma

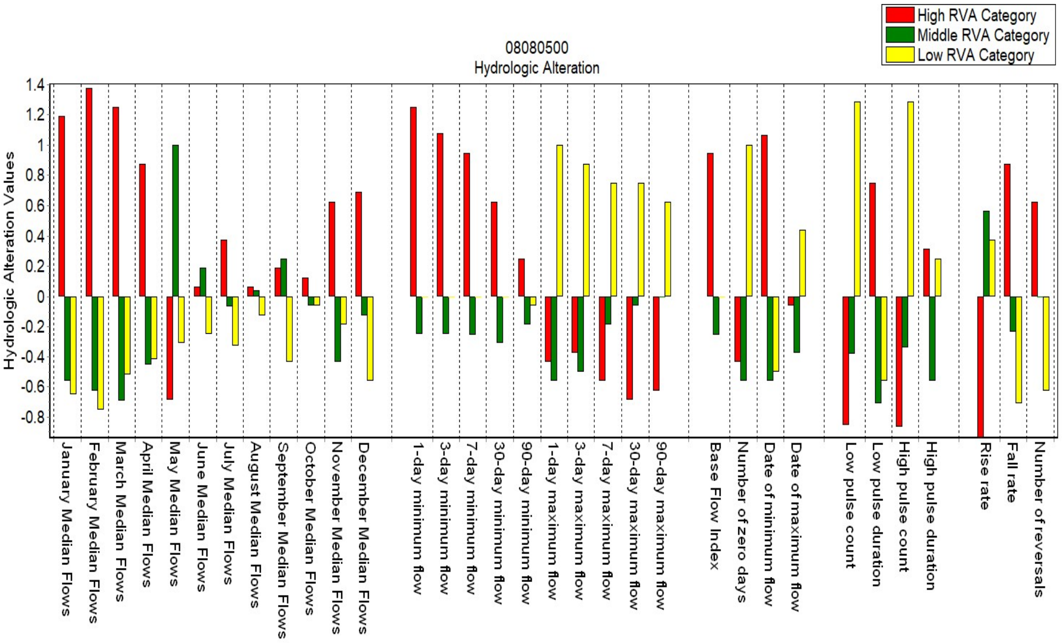


Flow Duration Curves of Cibolo Creek near Falls City

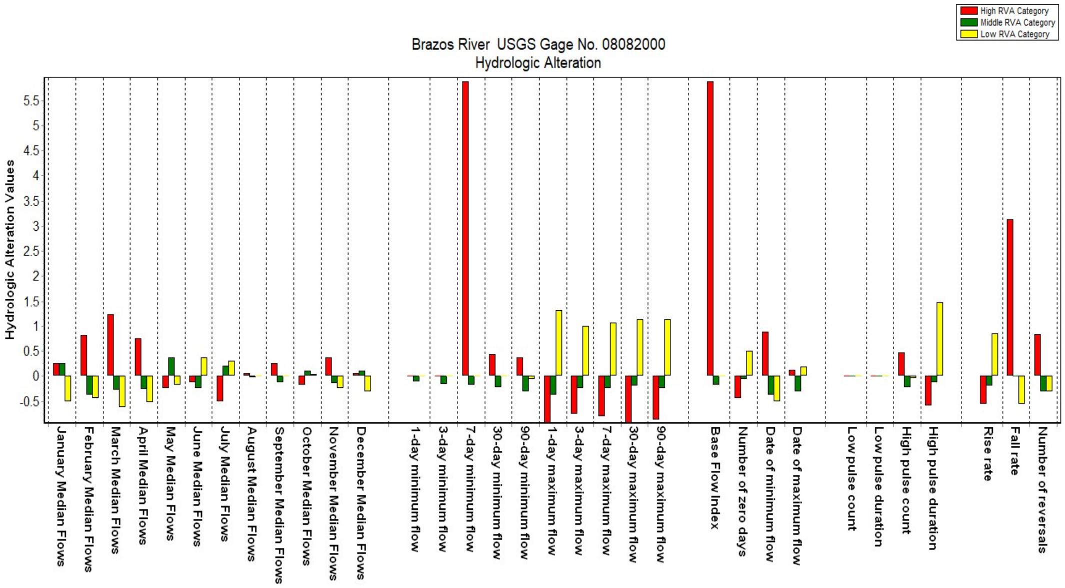


Flow Duration Curves of San Antonio River at Goliad

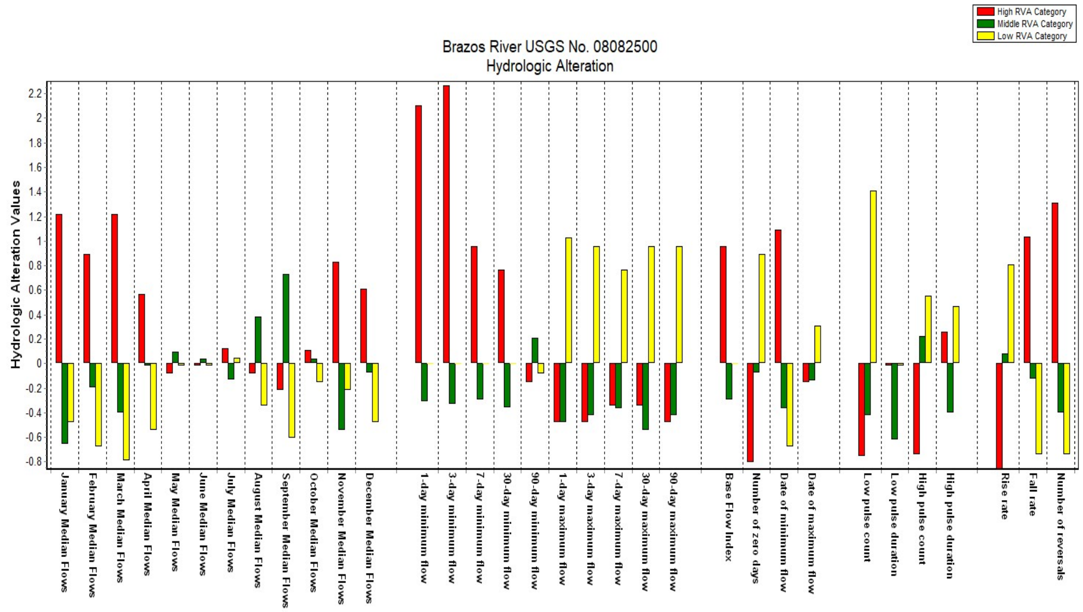
APPENDIX D



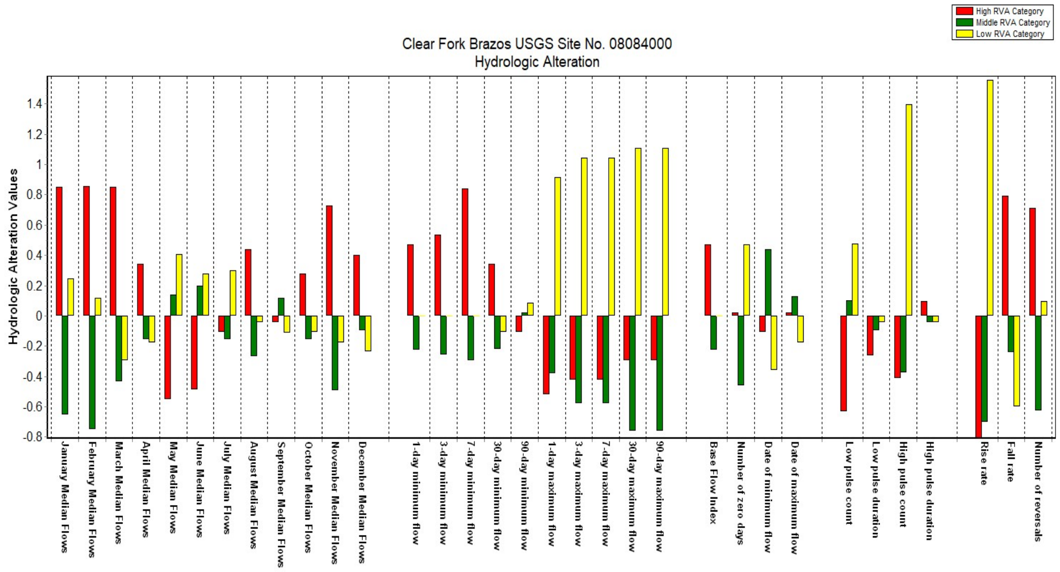
Hydrologic Alteration factors for Double Mountain Fork near Aspermont



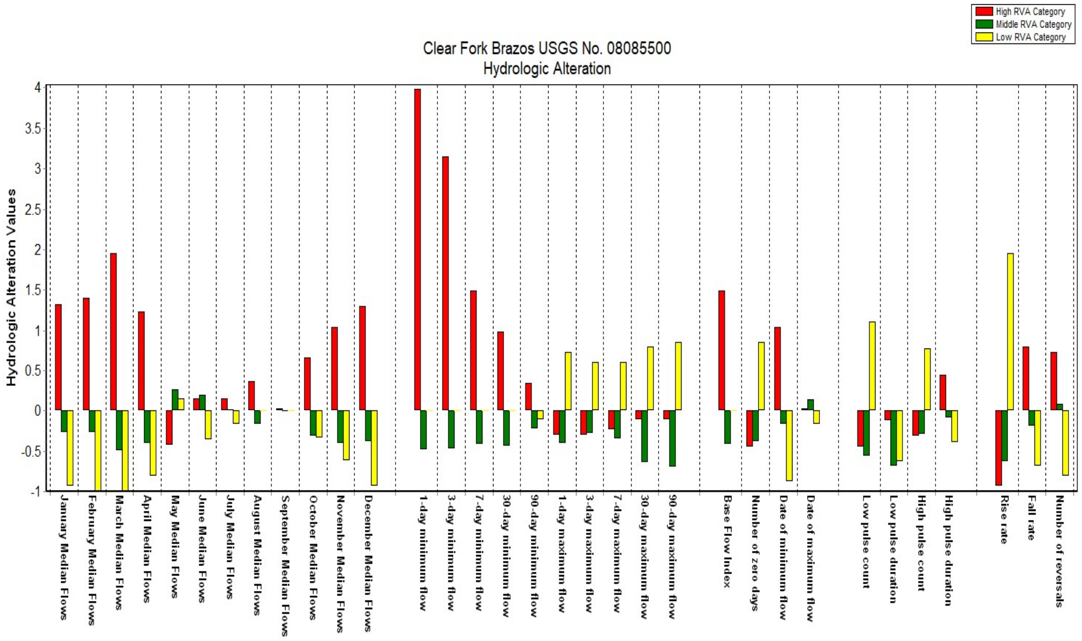
Hydrologic Alteration factors for Salt Fork Brazos River near Aspermont



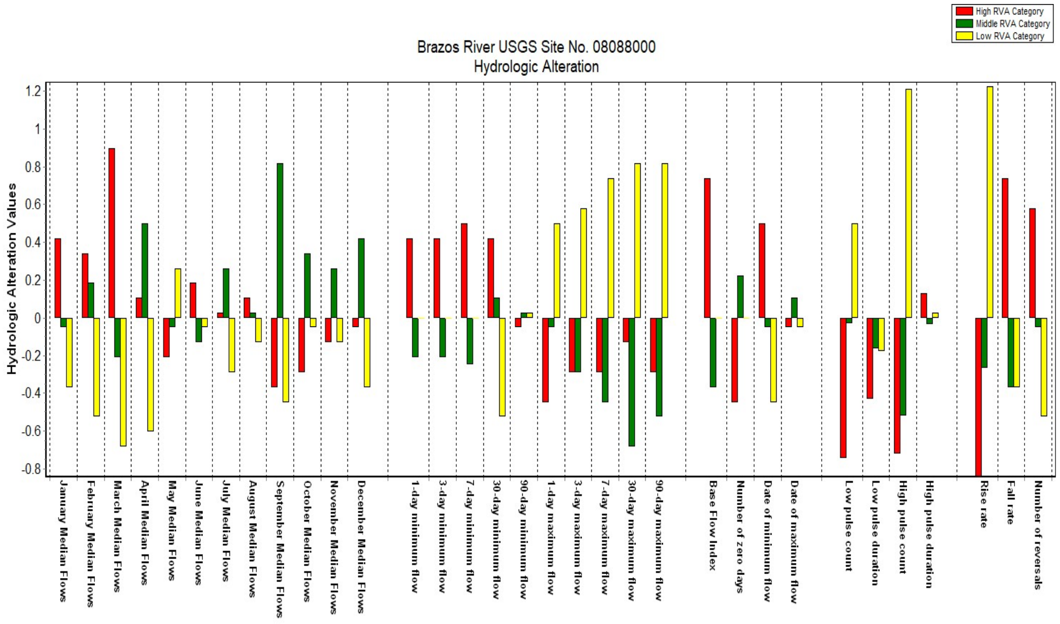
Hydrologic Alteration factors for Brazos River near Seymour



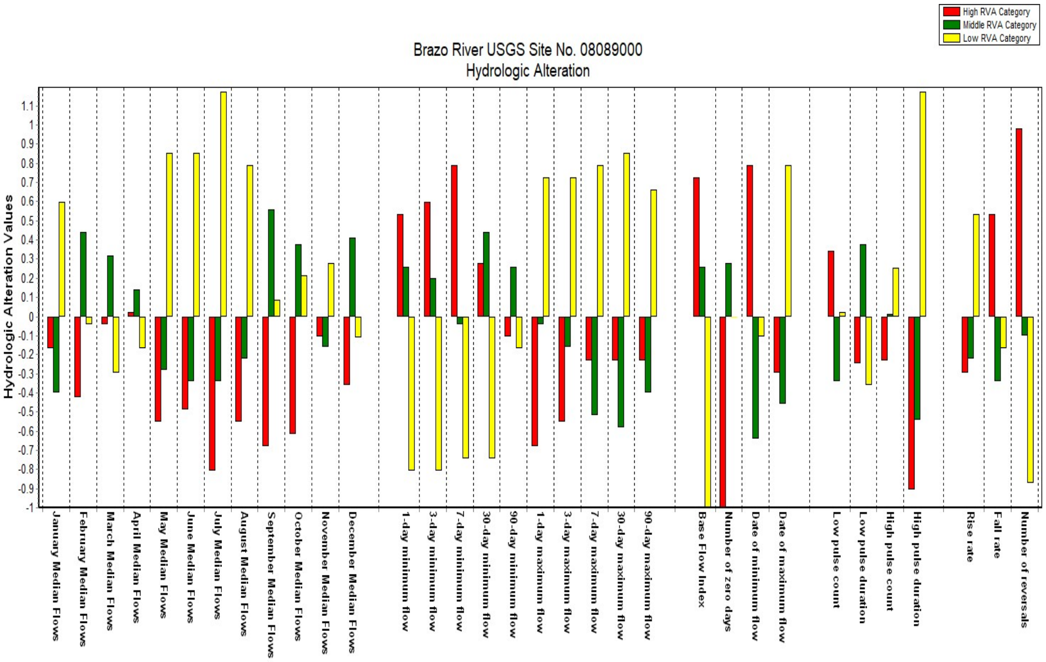
Hydrologic Alteration factors for Clear Fork Brazos near Nugent



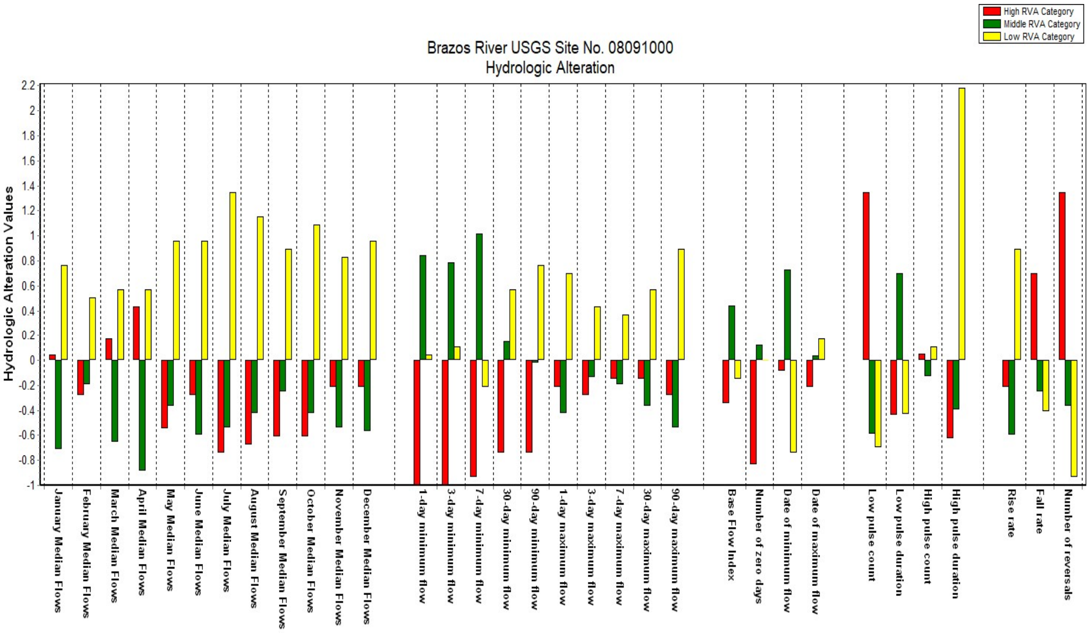
Hydrologic Alteration factors for Clear Fork Brazos near Fort Griffin



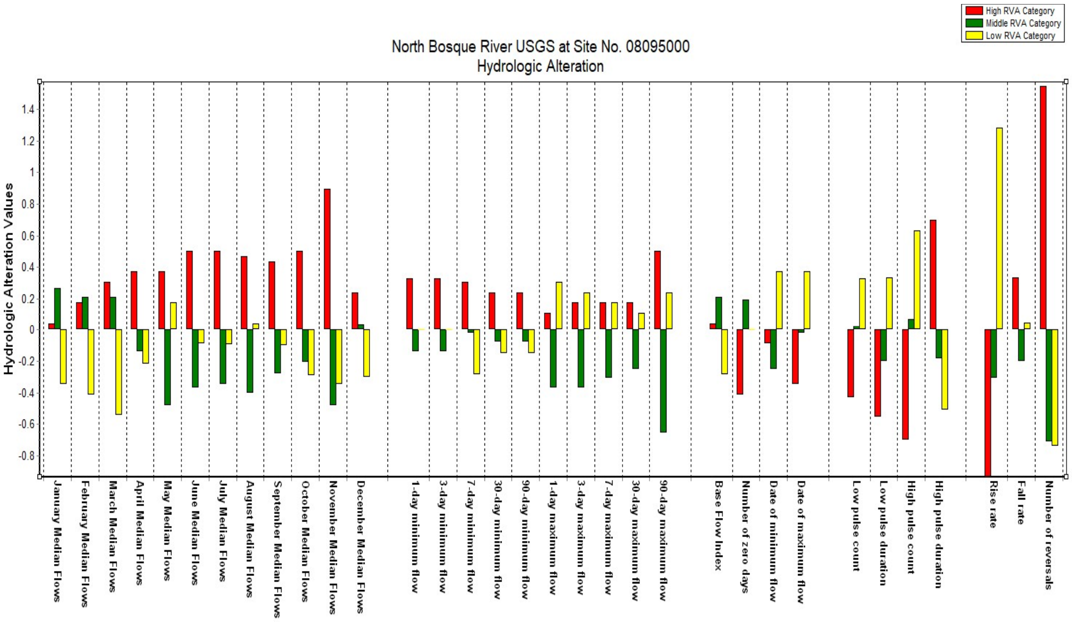
Hydrologic Alteration factors for Brazos River near South Bend



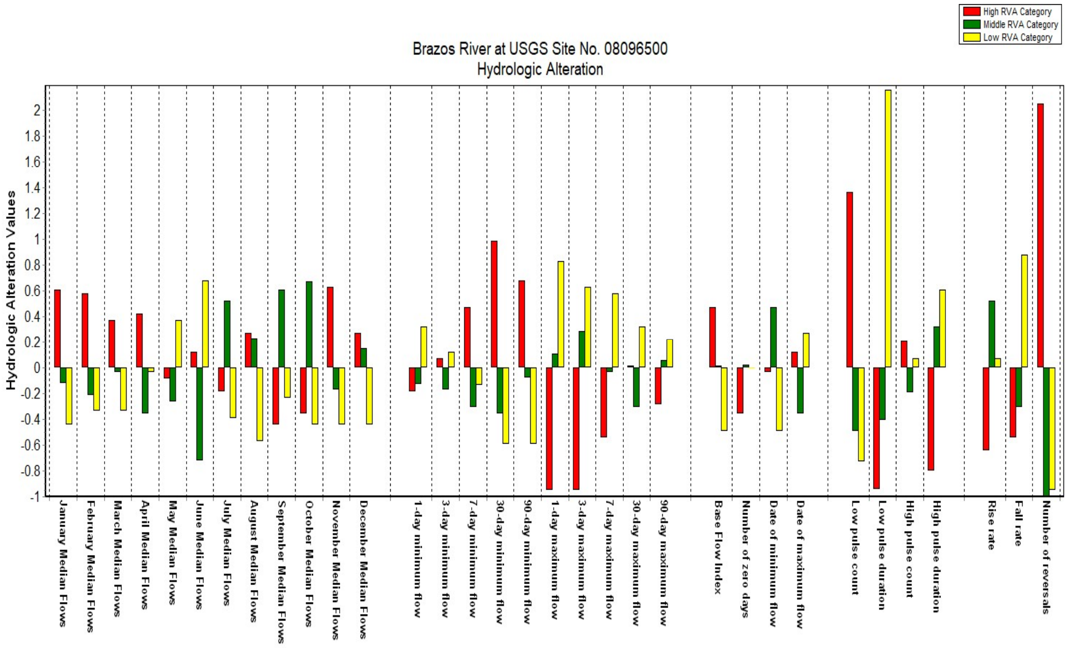
Hydrologic Alteration factors for Brazos River near Palo Pinto



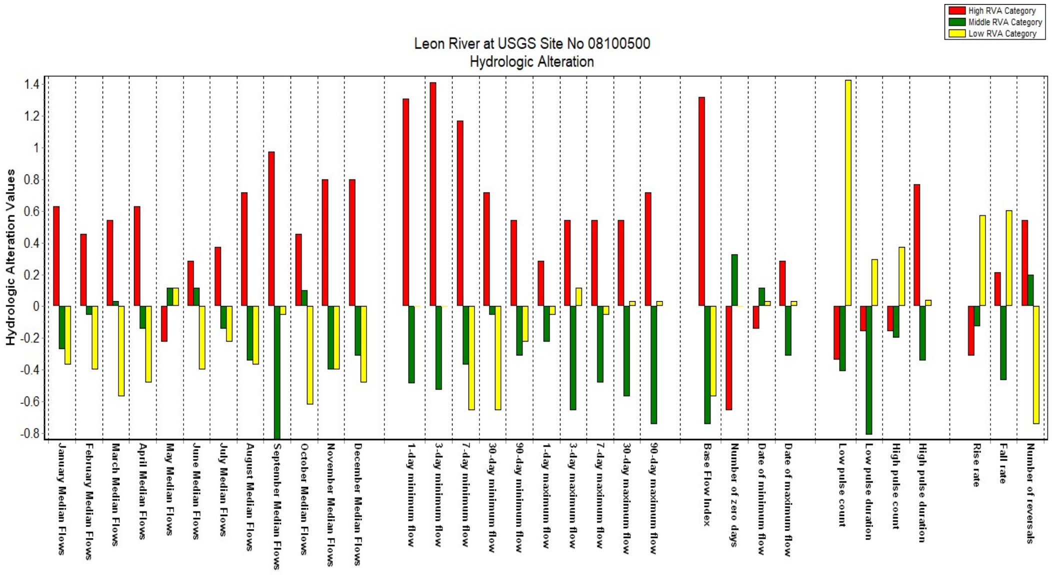
Hydrologic Alteration factors for Brazos River near Glen Rose



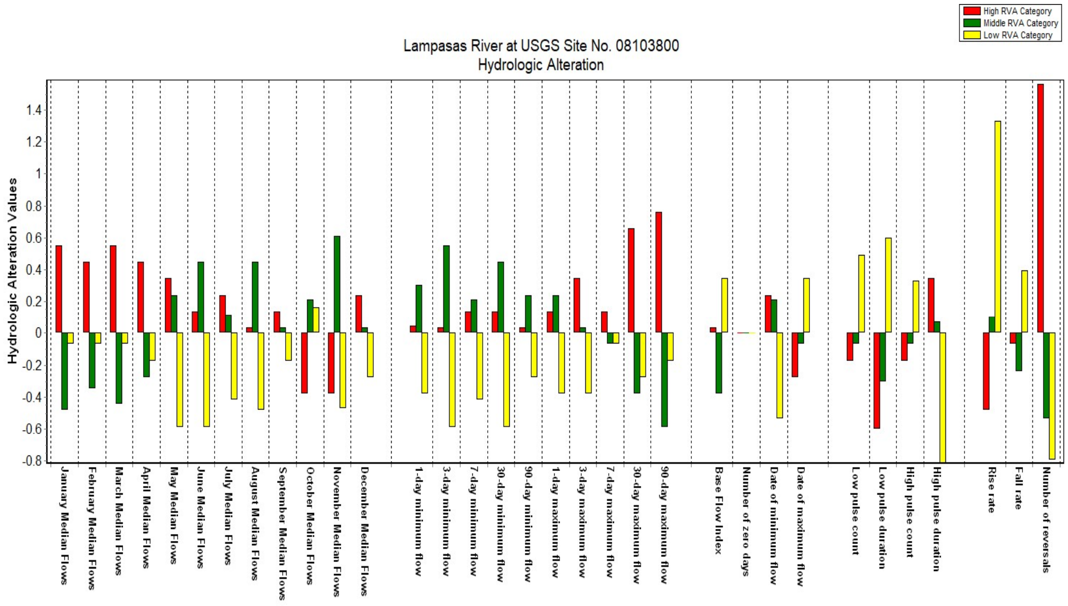
Hydrologic Alteration factors for North Bosque River near Clifton



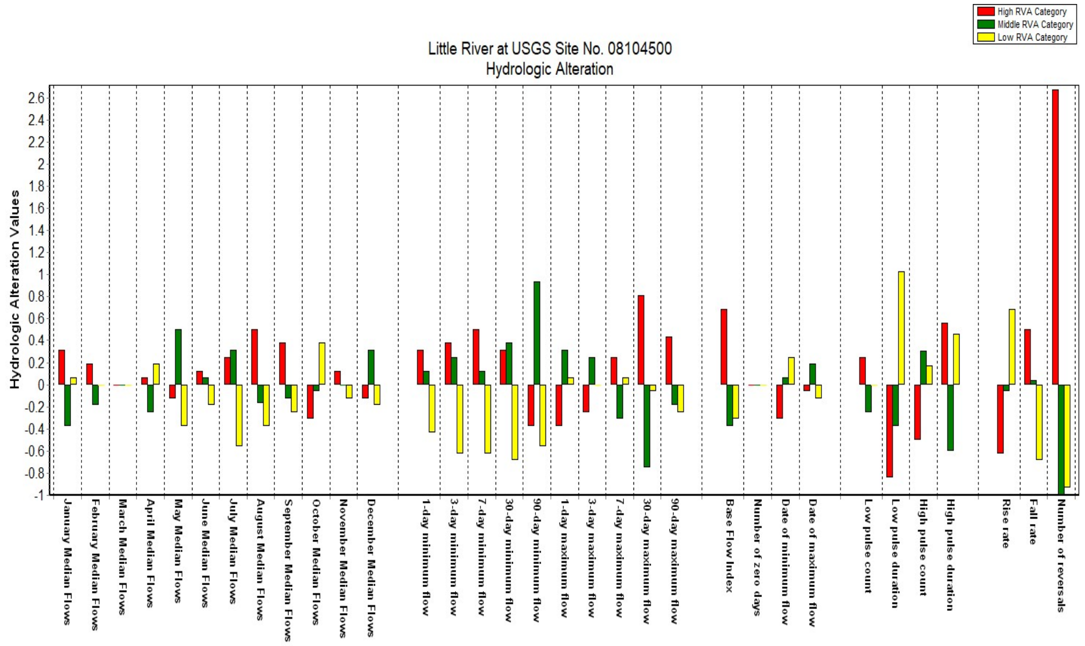
Hydrologic Alteration factors for Brazos River at Waco



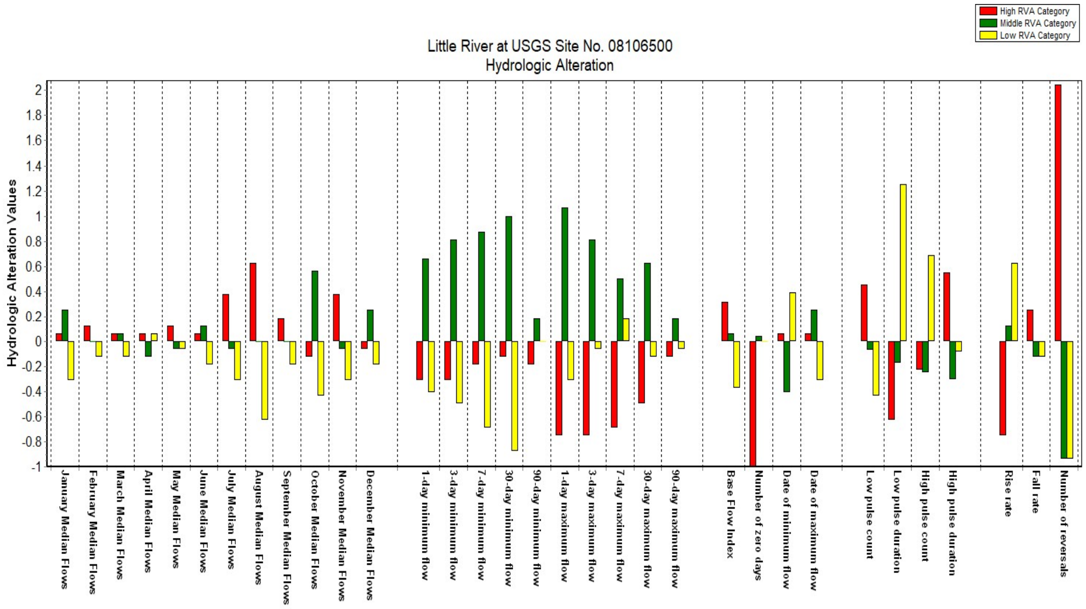
Hydrologic Alteration factors for Leon River near Gatesville



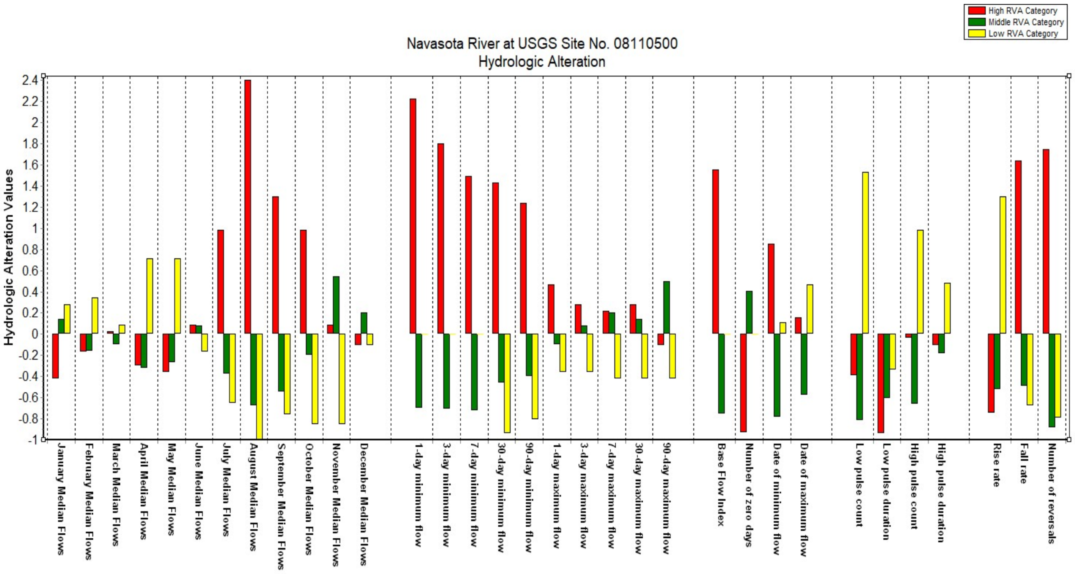
Hydrologic Alteration factors for Lampasas River near Kempner



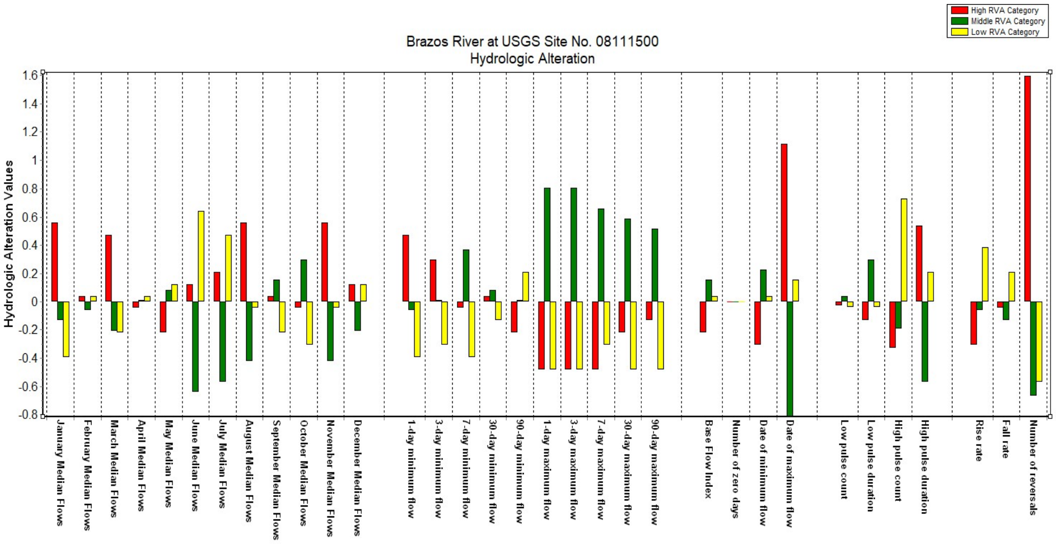
Hydrologic Alteration factors for Little River near Little River



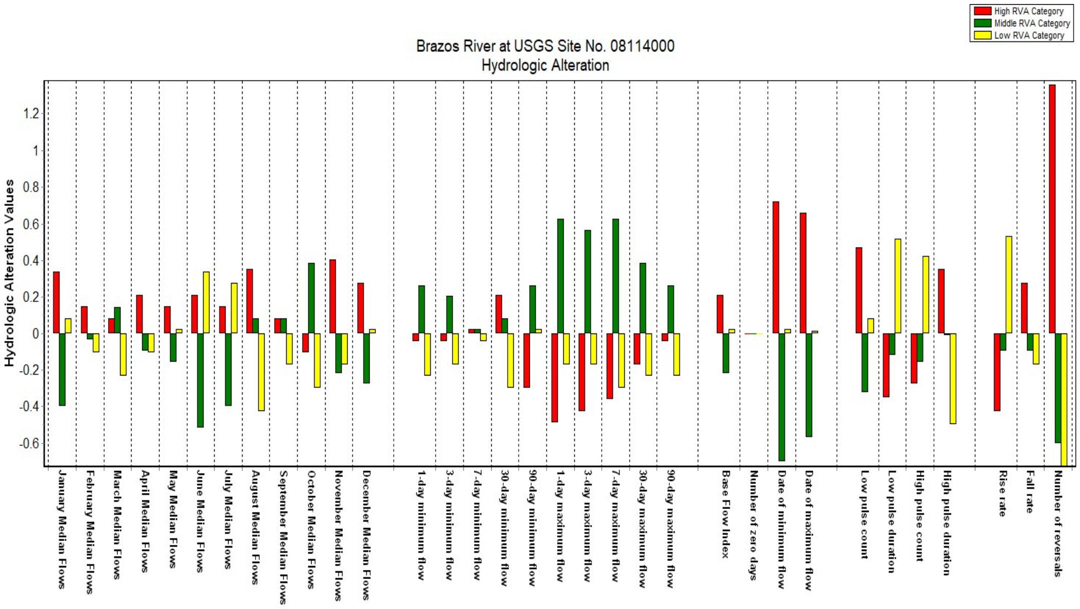
Hydrologic Alteration factors for Little River near Cameron



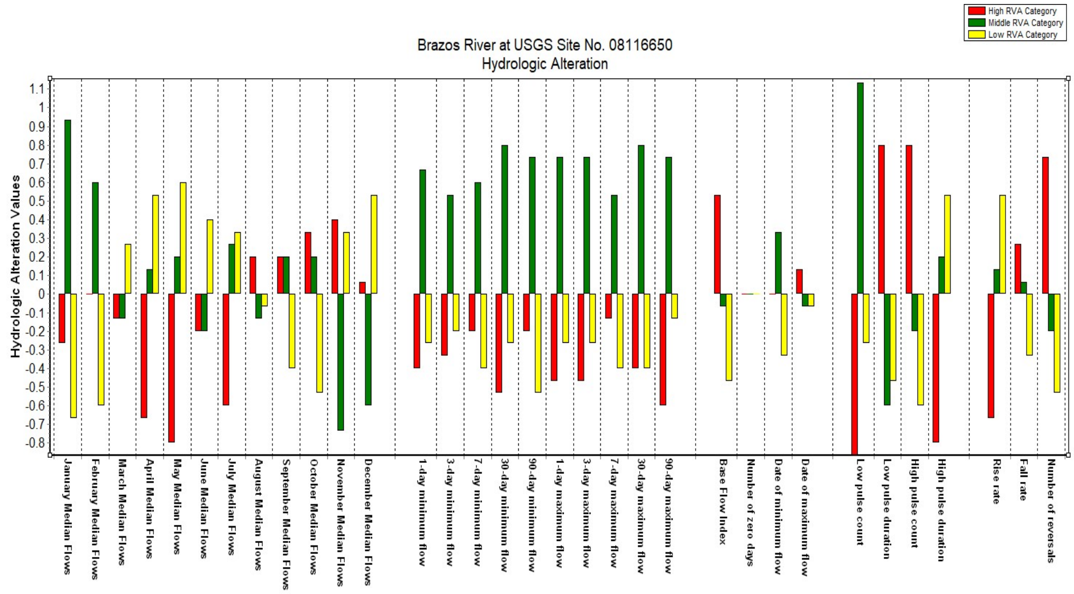
Hydrologic Alteration factors for Navasota River at Easterly



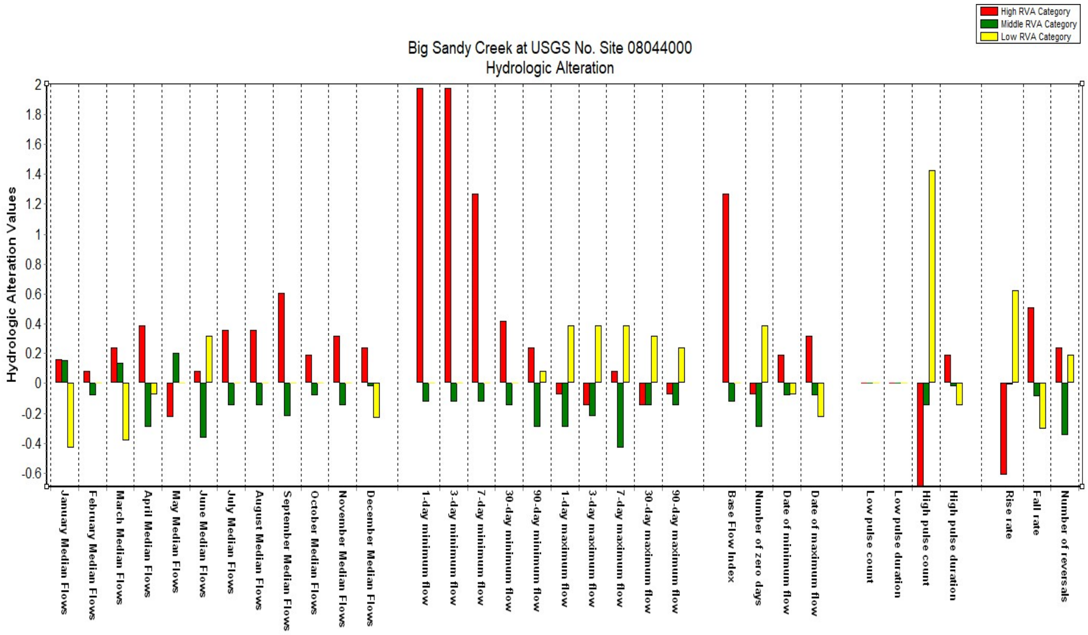
Hydrologic Alteration factors for Brazos River near Hempstead



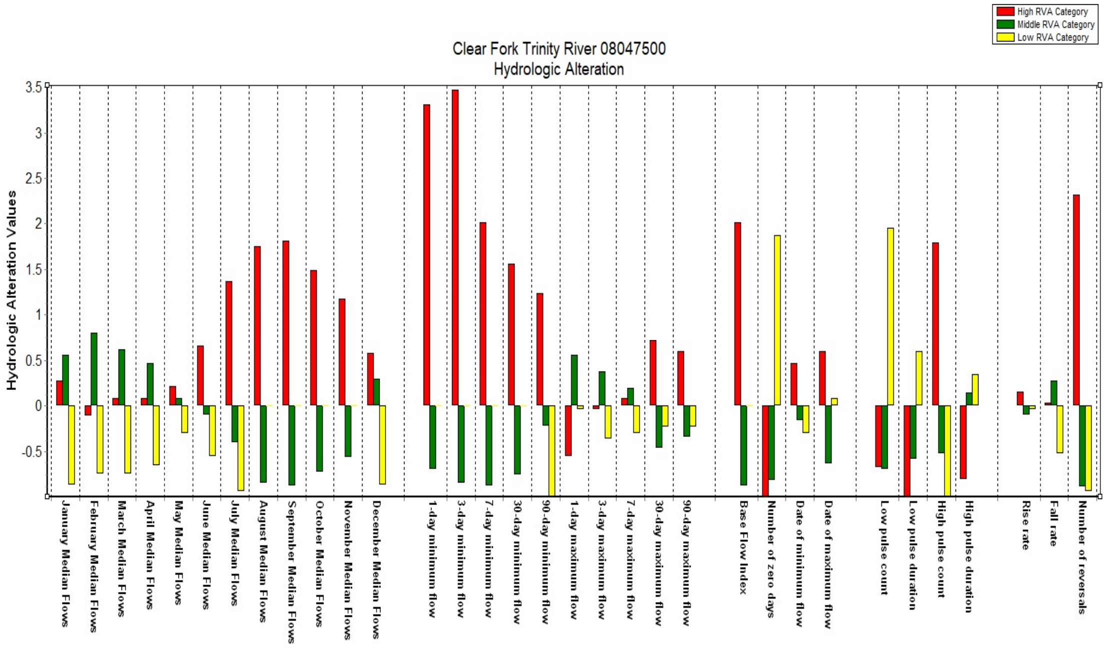
Hydrologic Alteration factors for Brazos River near Richmond



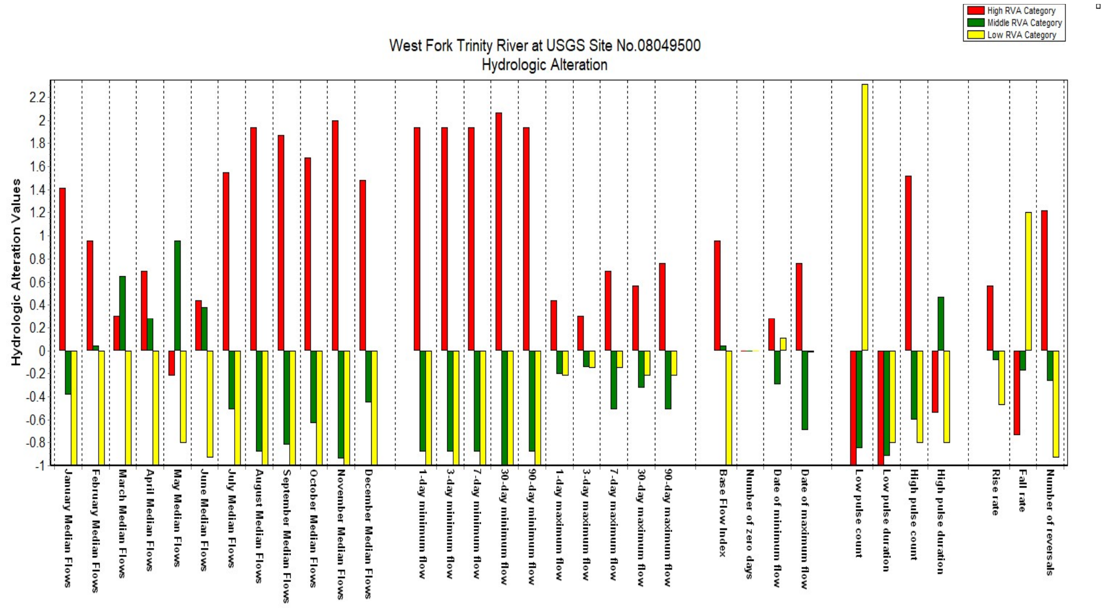
Hydrologic Alteration factors for Brazos River near Rosharon



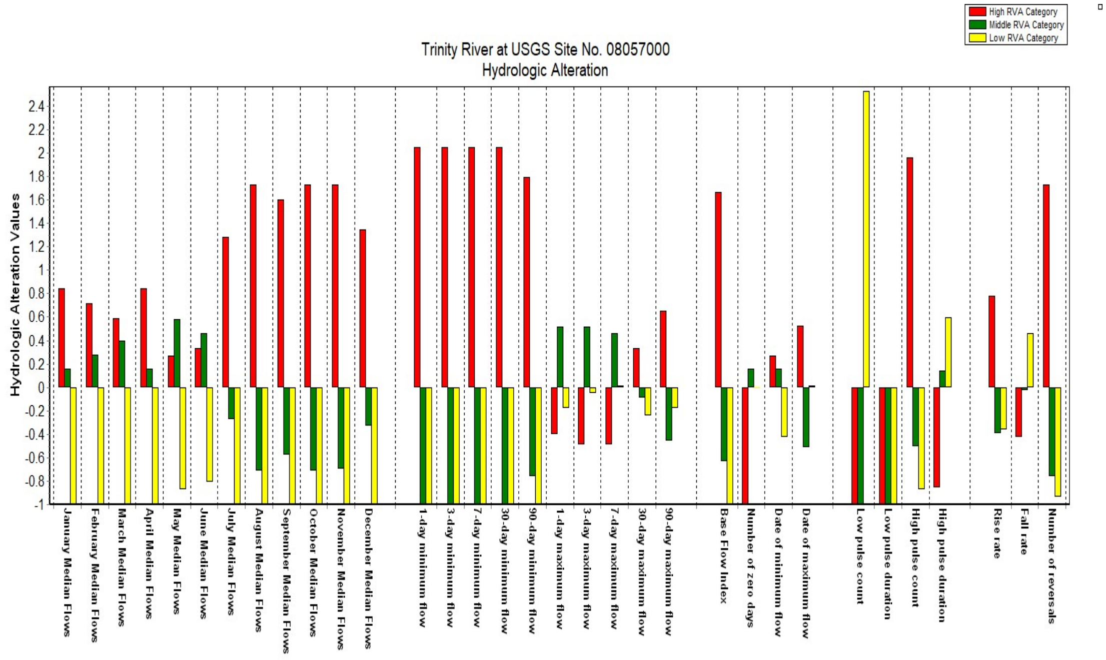
Hydrologic Alteration factors for Big Sandy Creek near Bridgeport



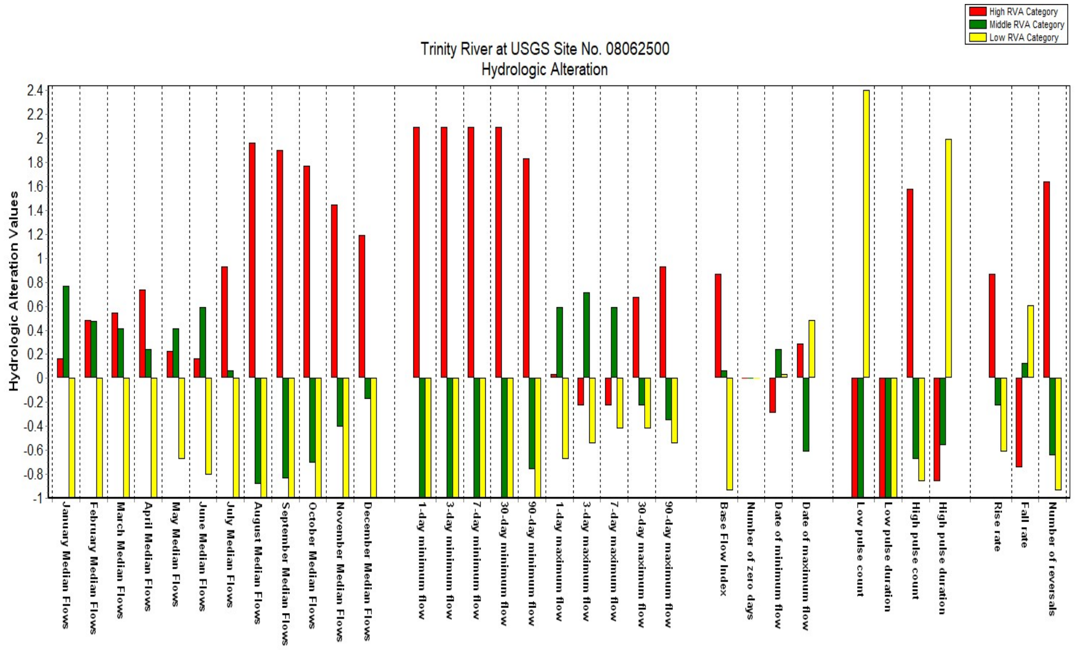
Hydrologic Alteration factors for Clear Fork Trinity River at Fort Worth



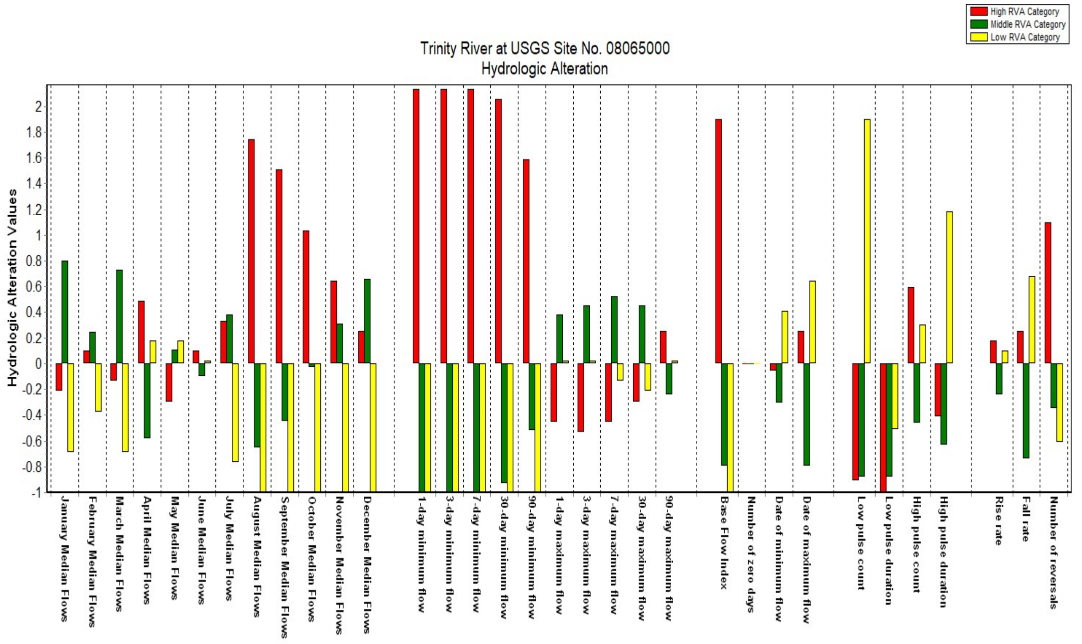
Hydrologic Alteration factors for West Fork Trinity River at Grand Prairie



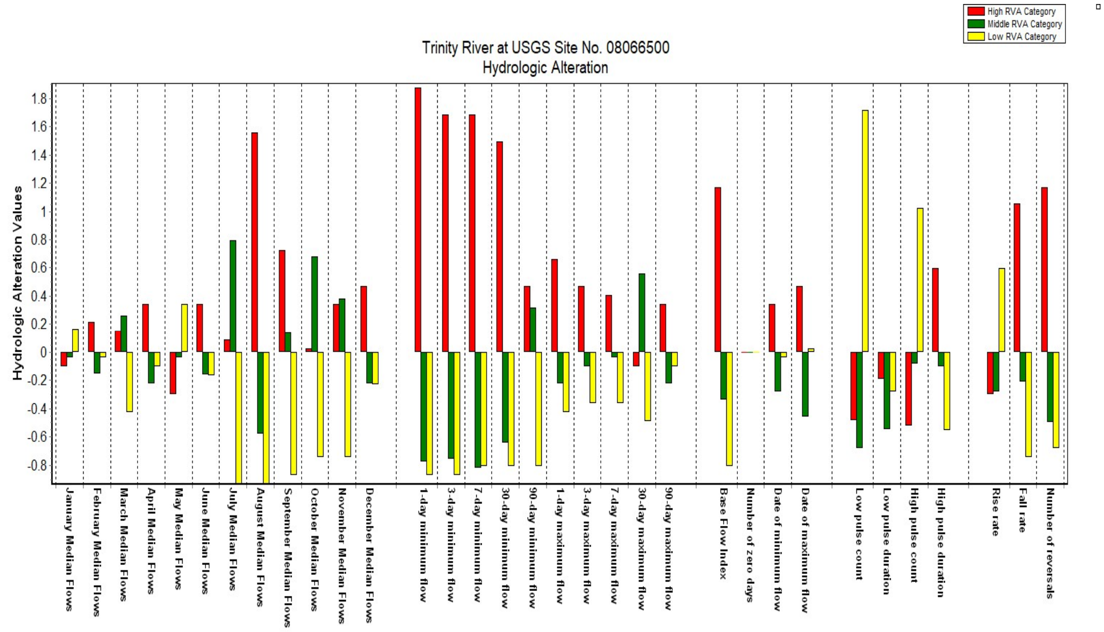
Hydrologic Alteration factors for Trinity River at Dallas



Hydrologic Alteration factors for Trinity River near Rosser



Hydrologic Alteration factors for Trinity River near Oakwood



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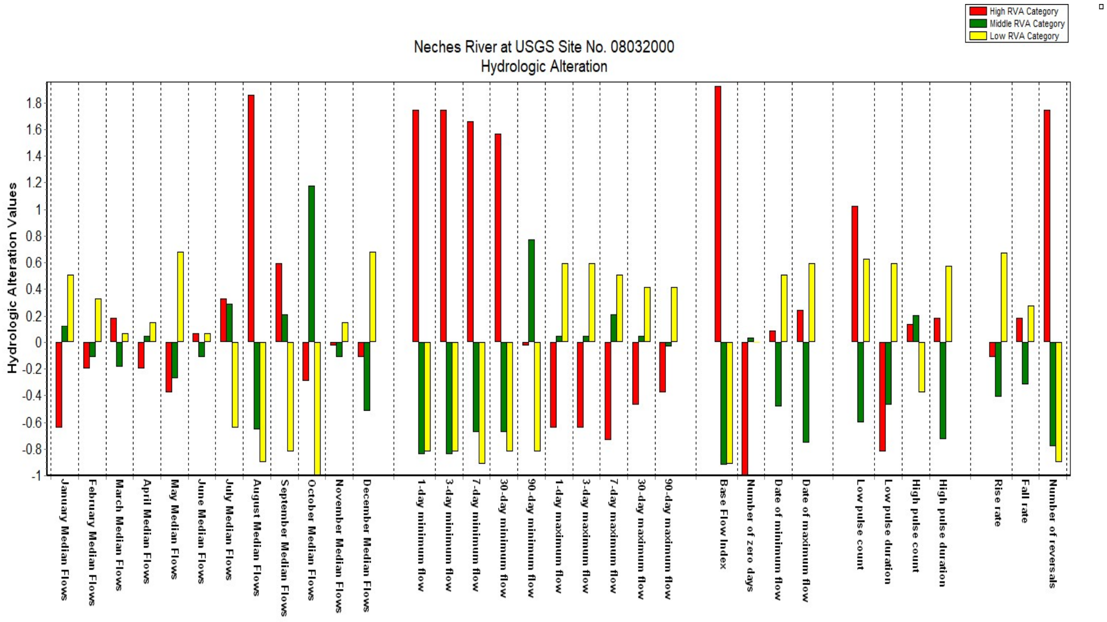
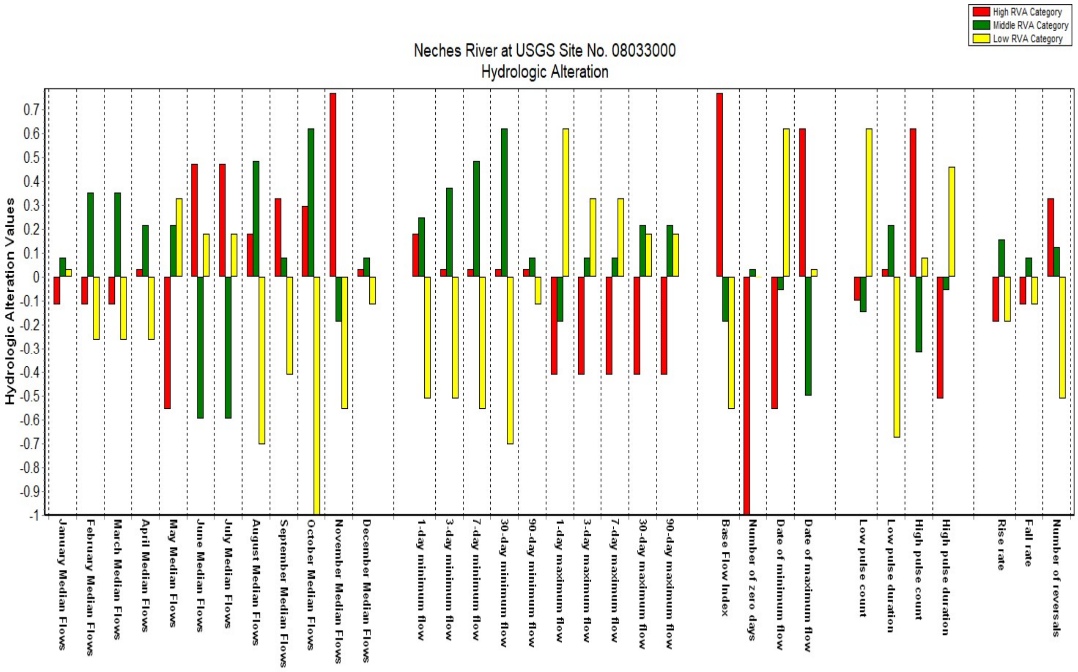
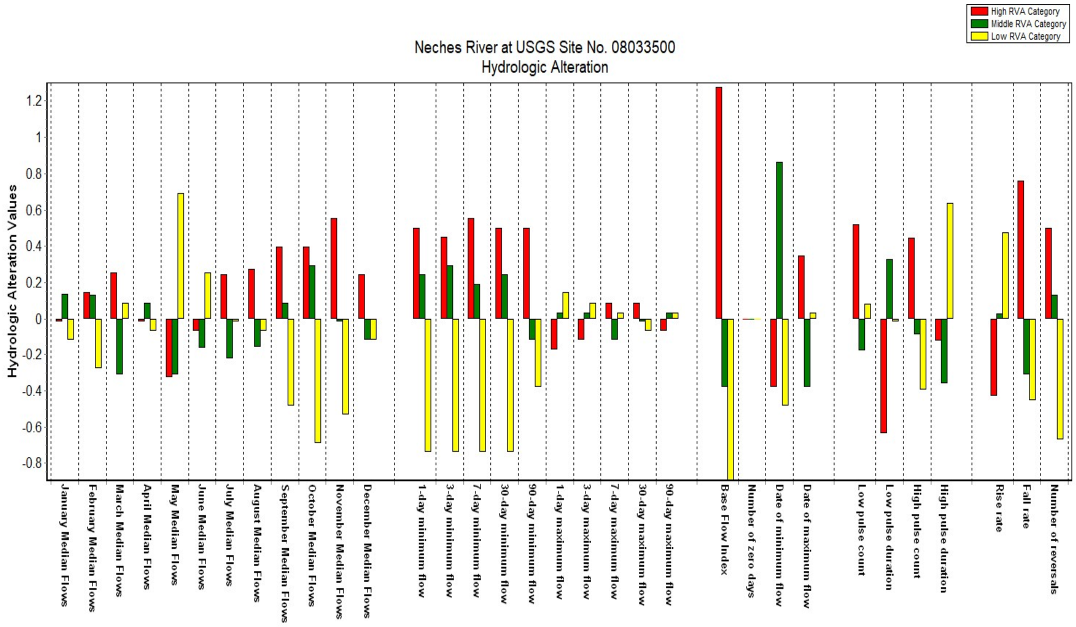


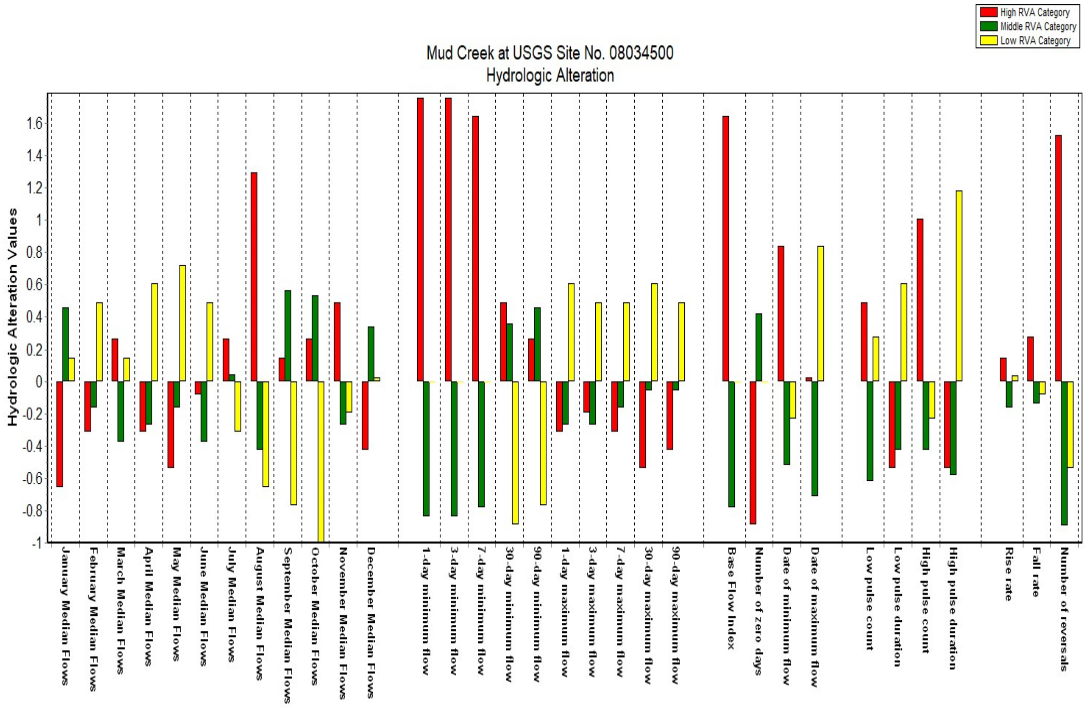
Hydrologic Alteration factors for Neches River near Neches



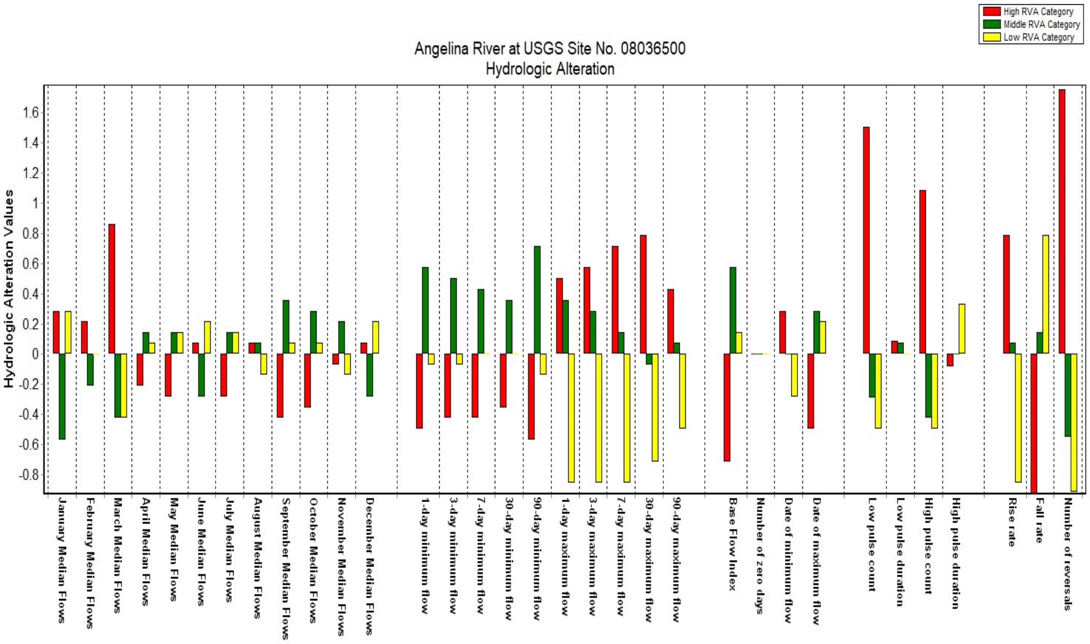
Hydrologic Alteration factors for Neches River near Diboll



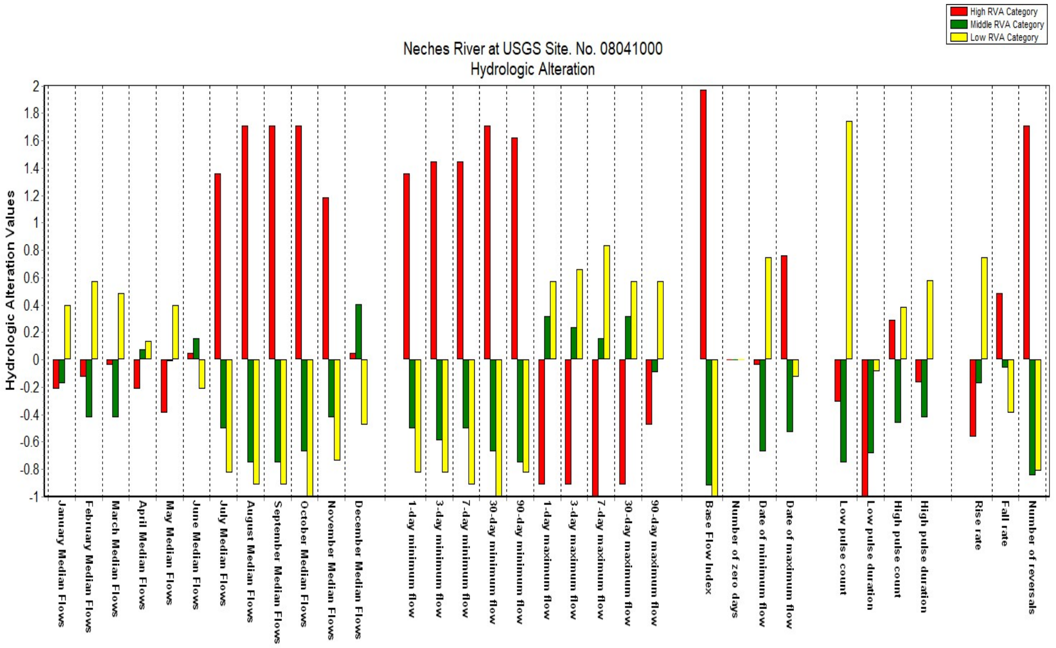
Hydrologic Alteration factors for Neches River near Rockland



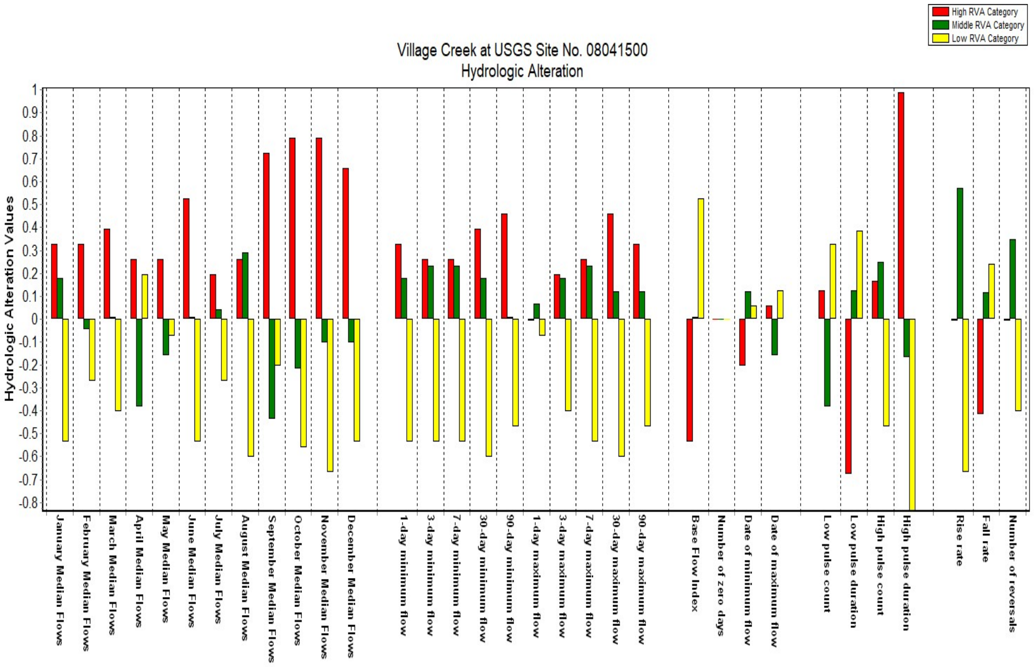
Hydrologic Alteration factors for Mud Creek near Jacksonville



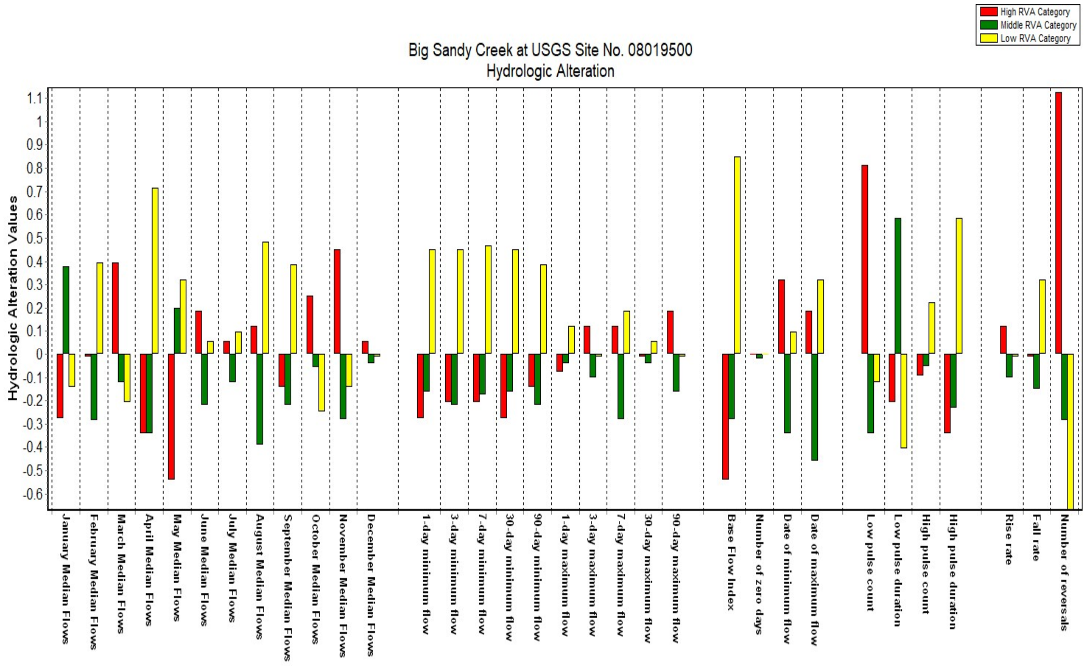
Hydrologic Alteration factors for Angelina River near Alto



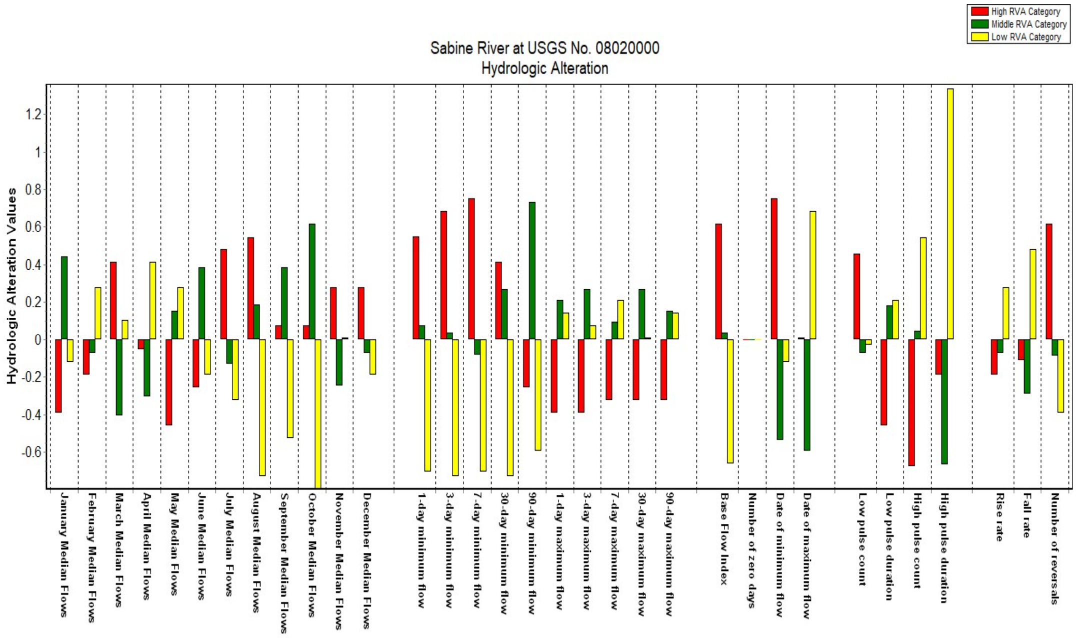
Hydrologic Alteration factors for Neches River at Evadale



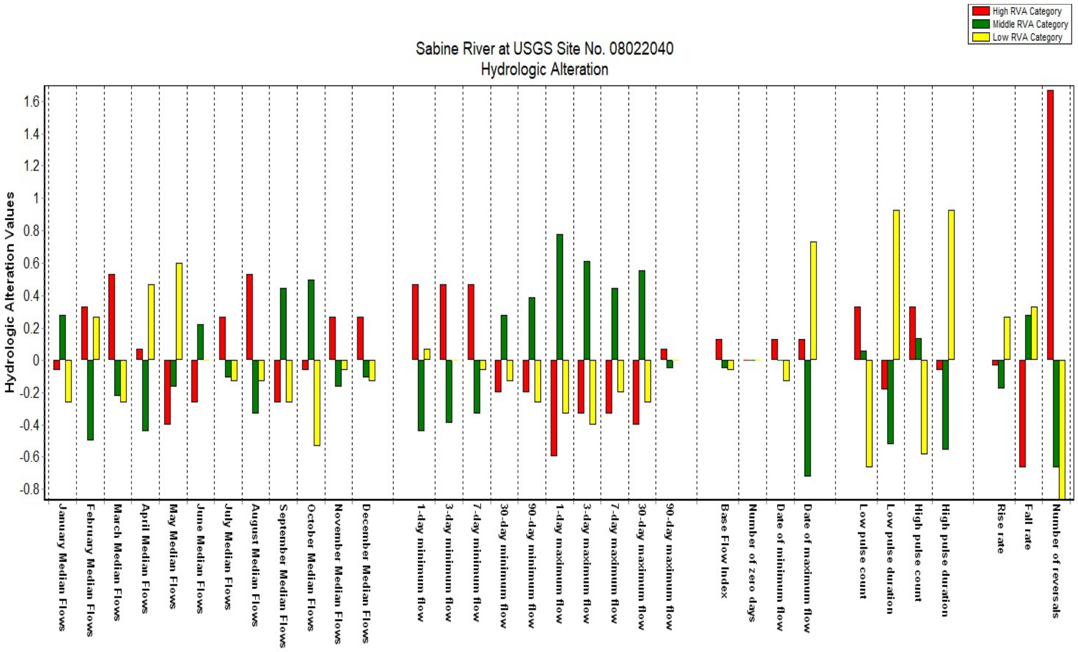
Hydrologic Alteration factors for Village Creek near Kountze



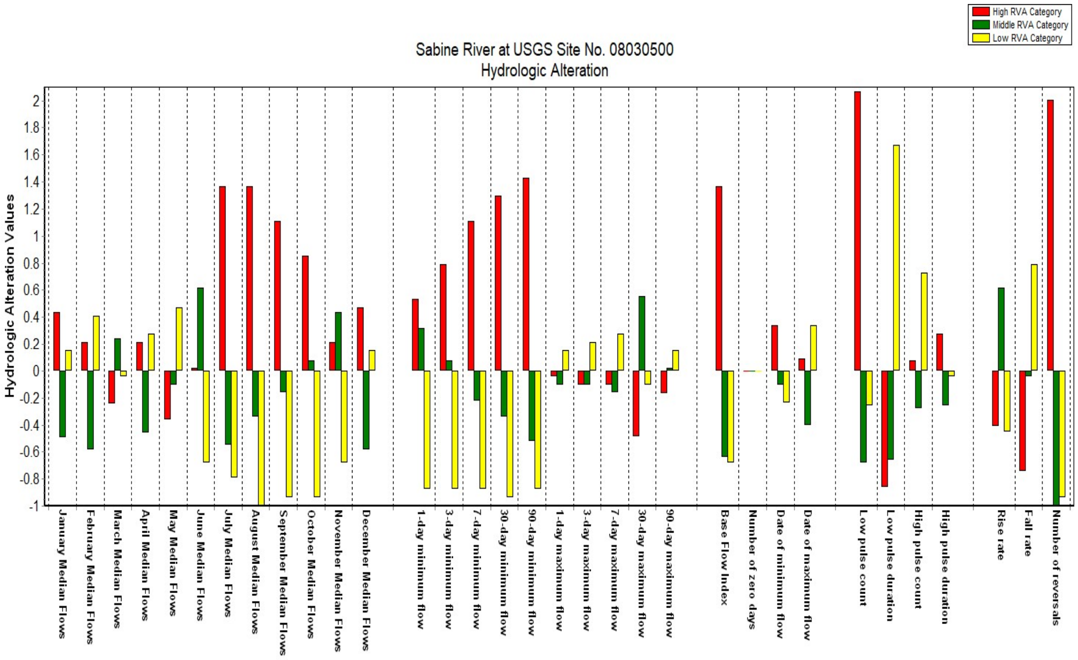
Hydrologic Alteration factors for Big Sandy Creek near Big Sandy



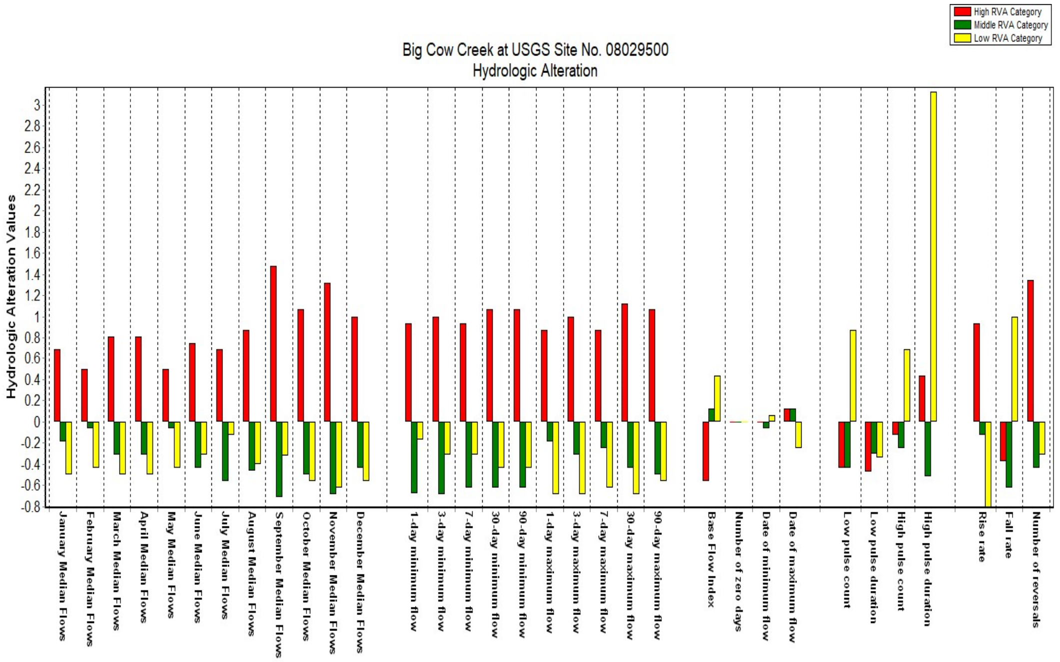
Hydrologic Alteration factors for Sabine River near Gladewater



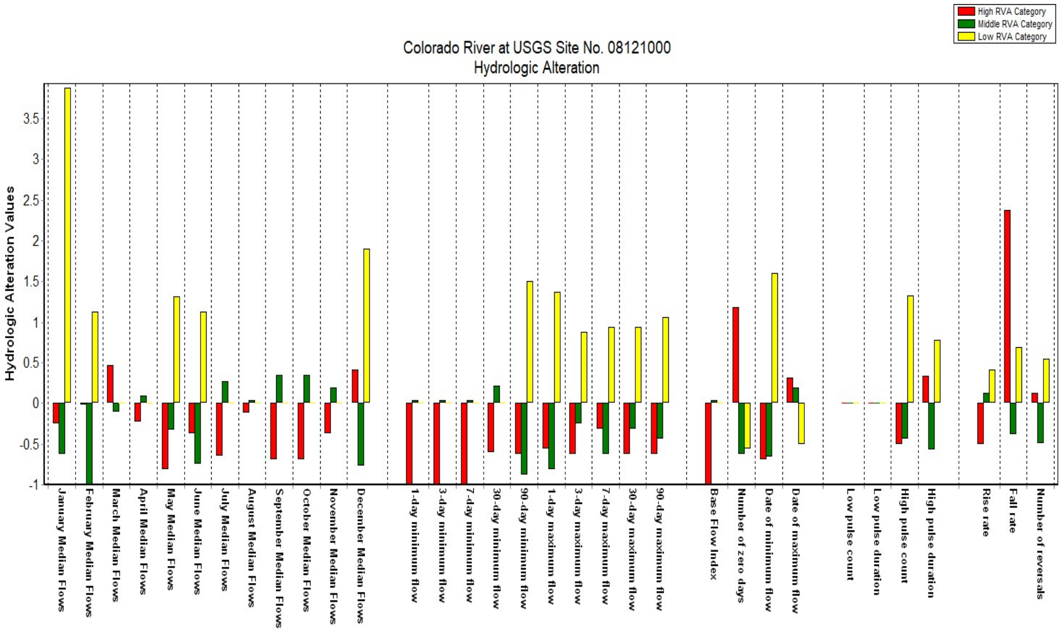
Hydrologic Alteration factors for Sabine River near Beckville



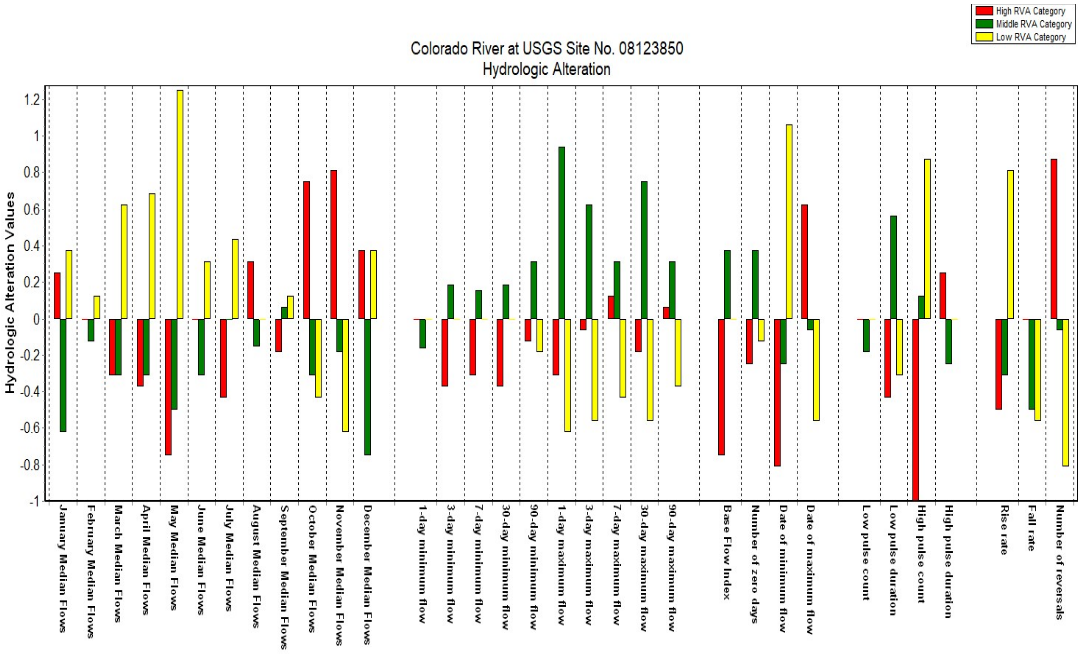
Hydrologic Alteration factors for Sabine River near Ruliff



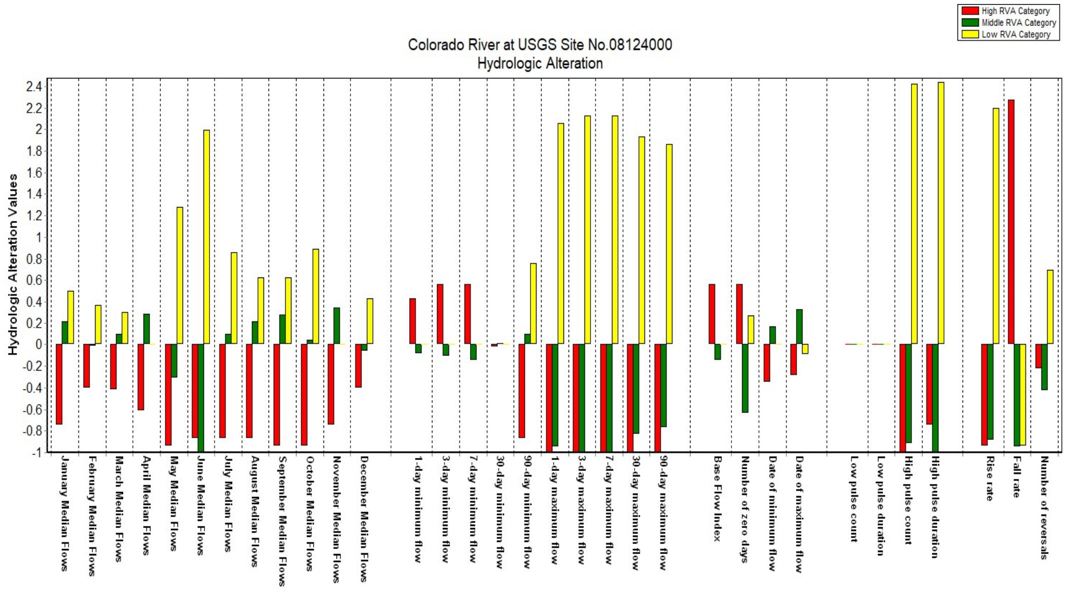
Hydrologic Alteration factors for Big Cow Creek near Newton



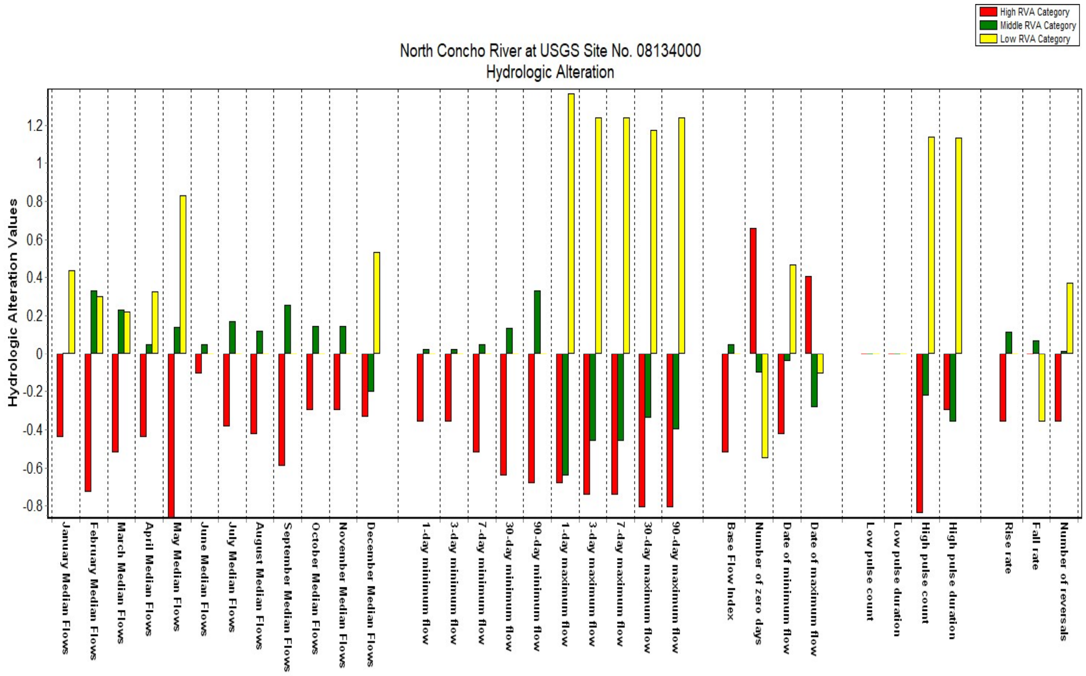
Hydrologic Alteration factors for Colorado River at Colorado City



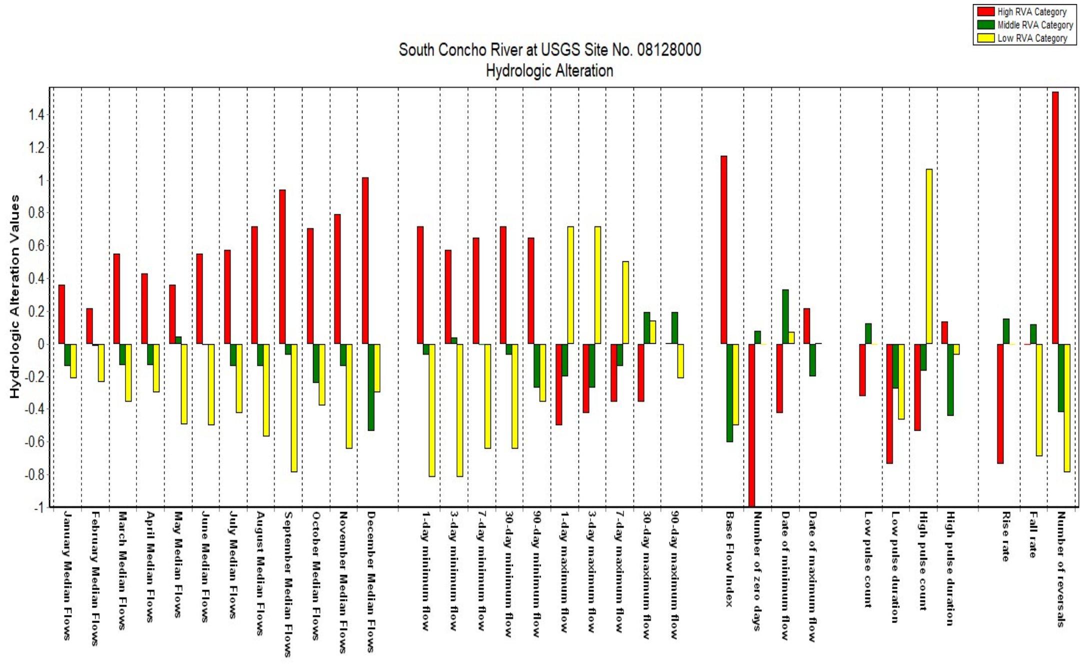
Hydrologic Alteration factors for Colorado River above Silver



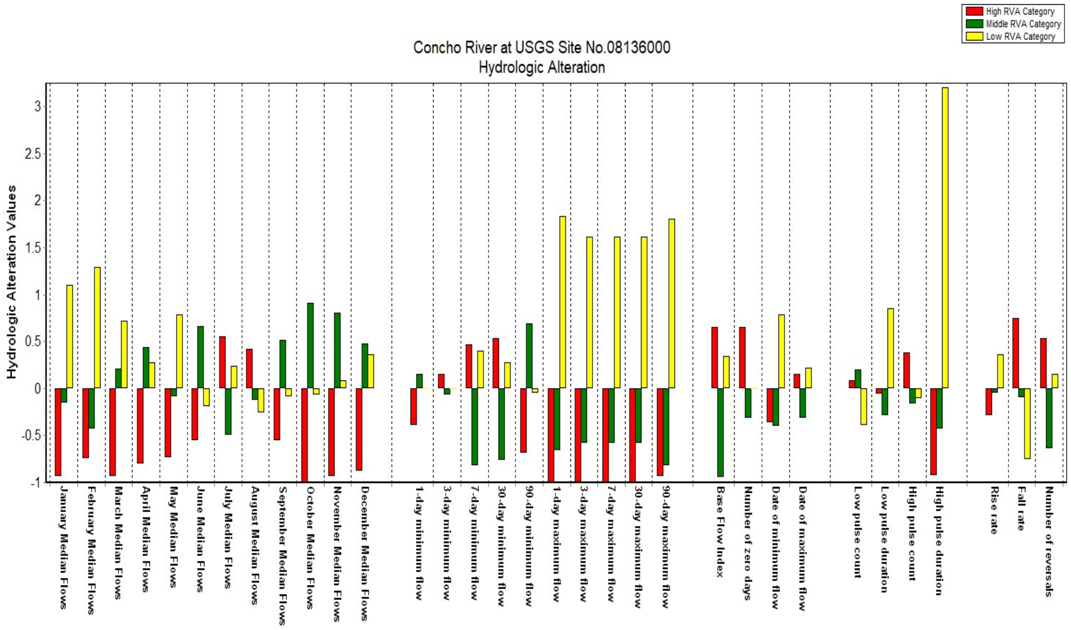
Hydrologic Alteration factors for Colorado River at Robert Lee



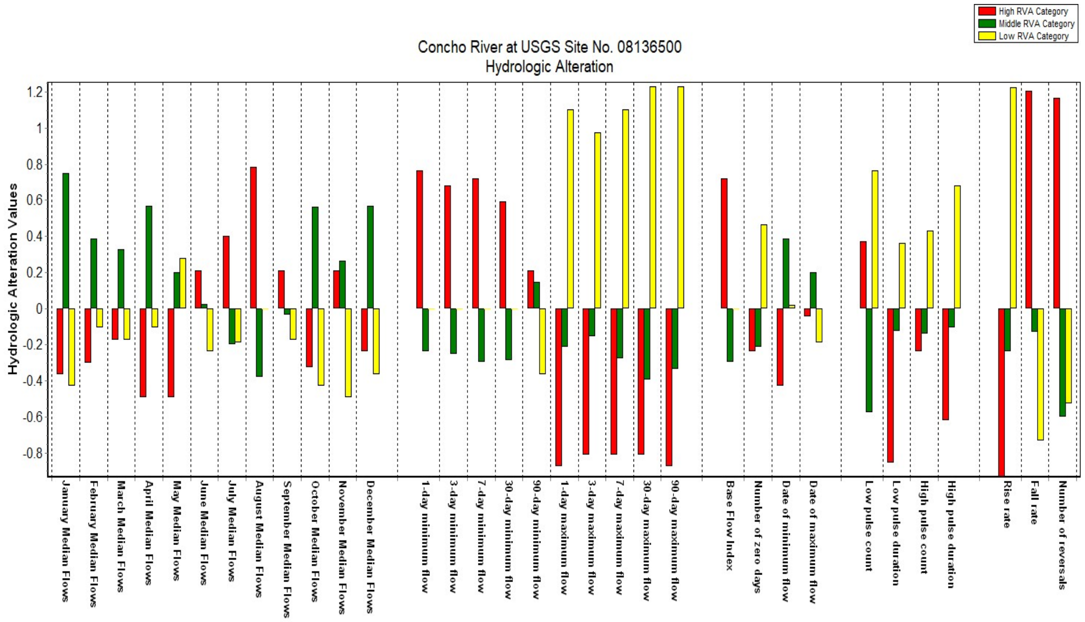
Hydrologic Alteration factors for North Concho River near Carlsbad



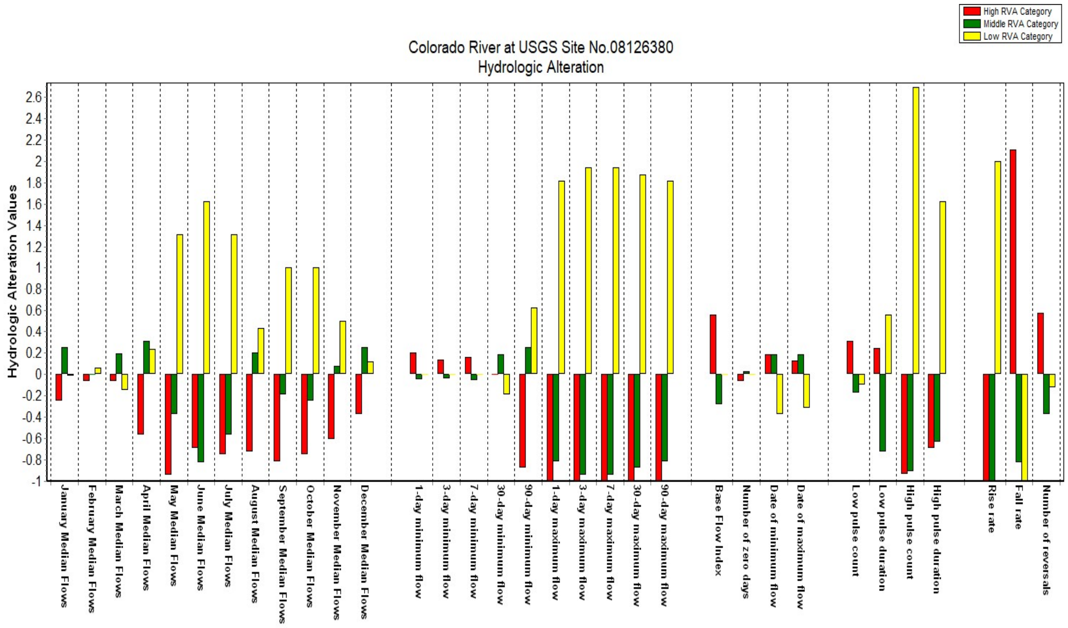
Hydrologic Alteration factors for South Concho River at Christoval



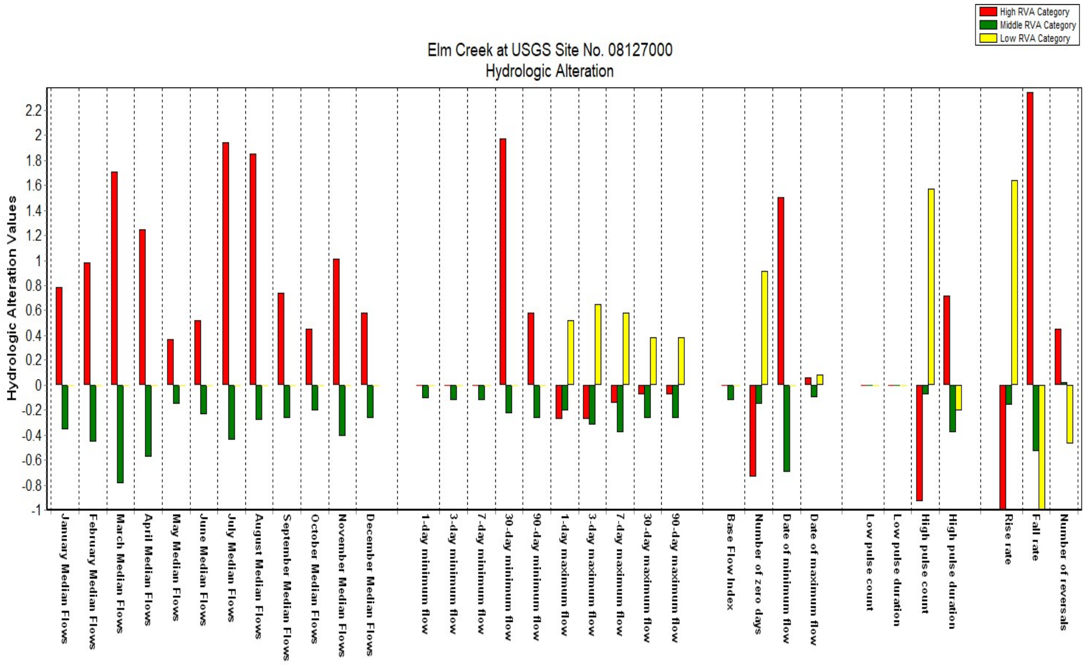
Hydrologic Alteration factors for Concho River at San Angelo



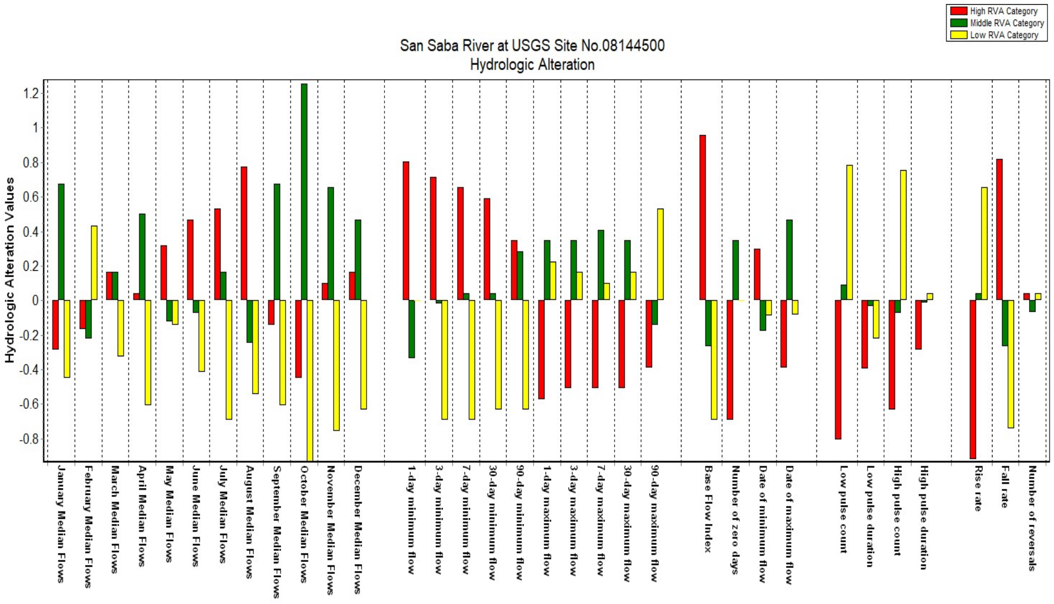
Hydrologic Alteration factors for Concho River at Paint Rock



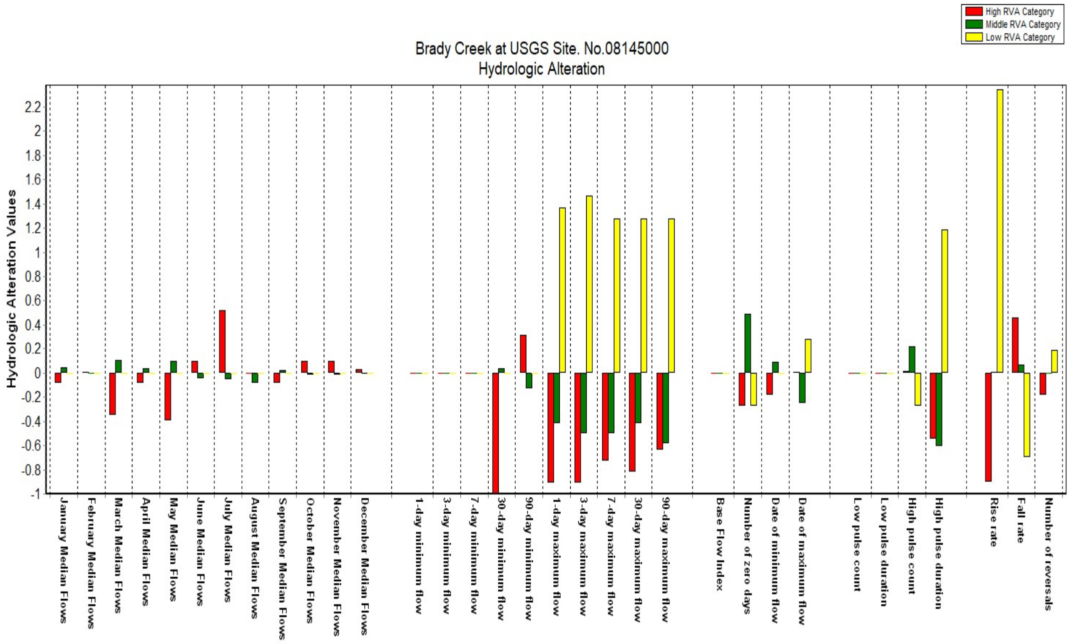
Hydrologic Alteration factors for Colorado River near Ballinger



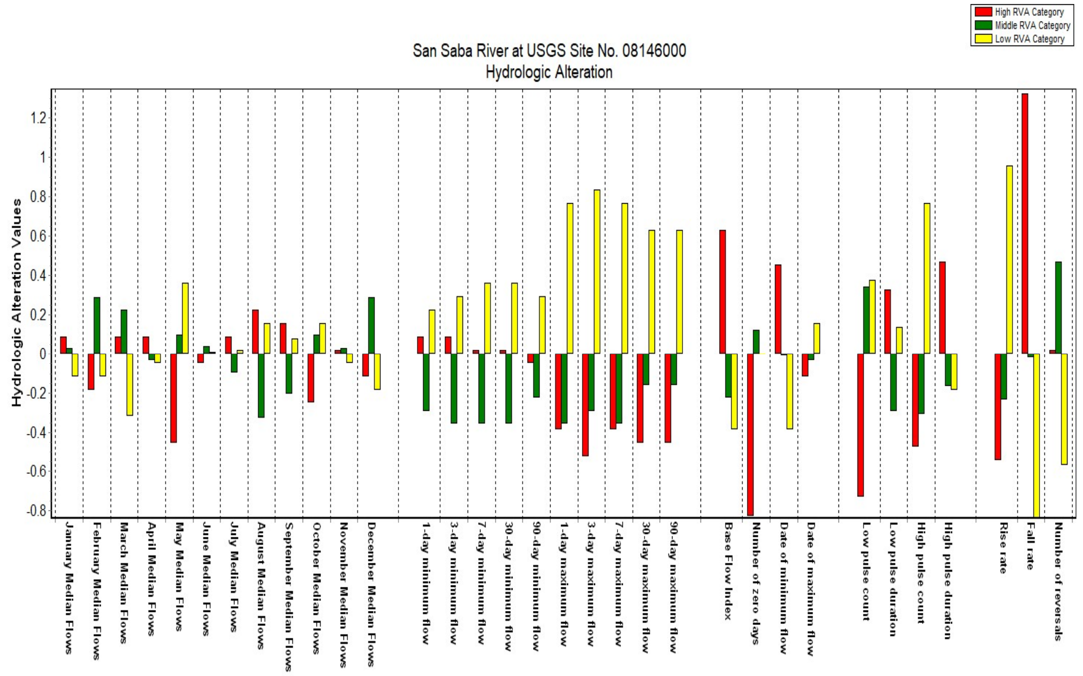
Hydrologic Alteration factors for Elm Creek at Ballinger



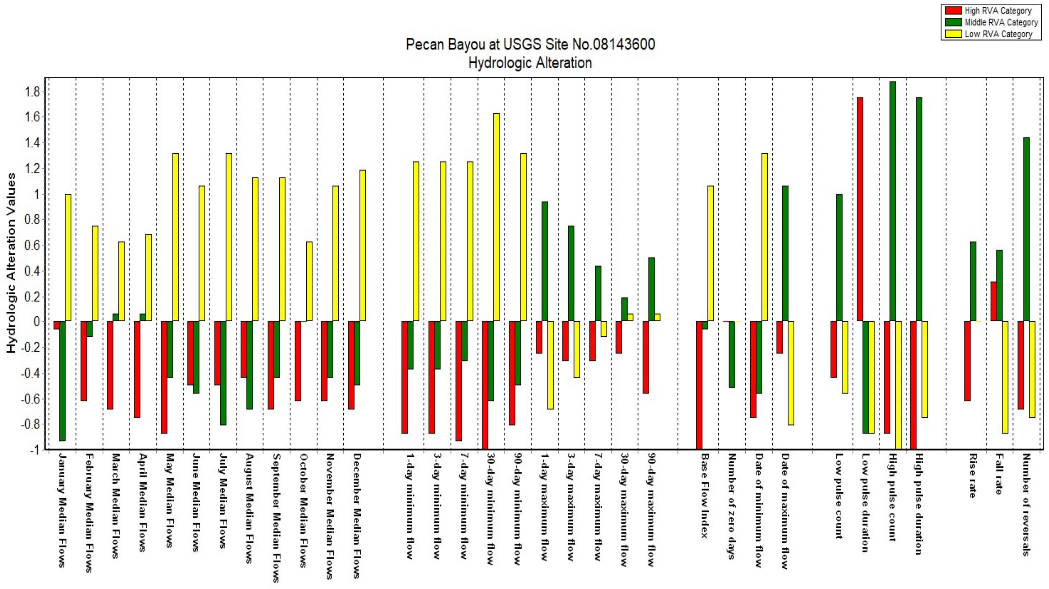
Hydrologic Alteration factors for San Saba River at Menard



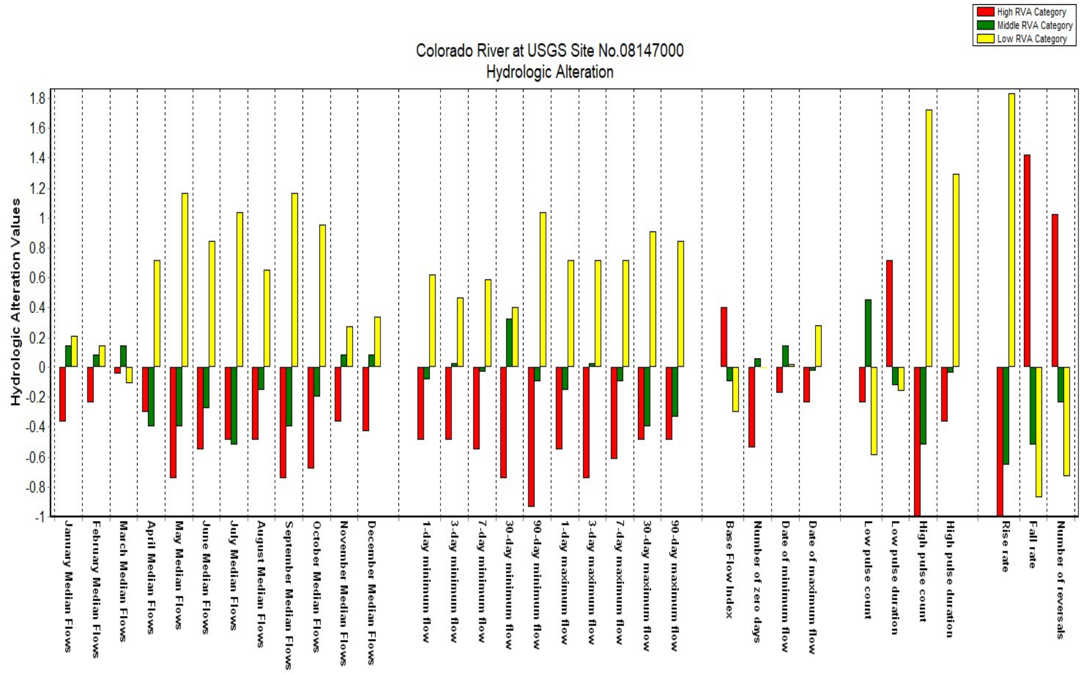
Hydrologic Alteration factors for Brady Creek at Brady



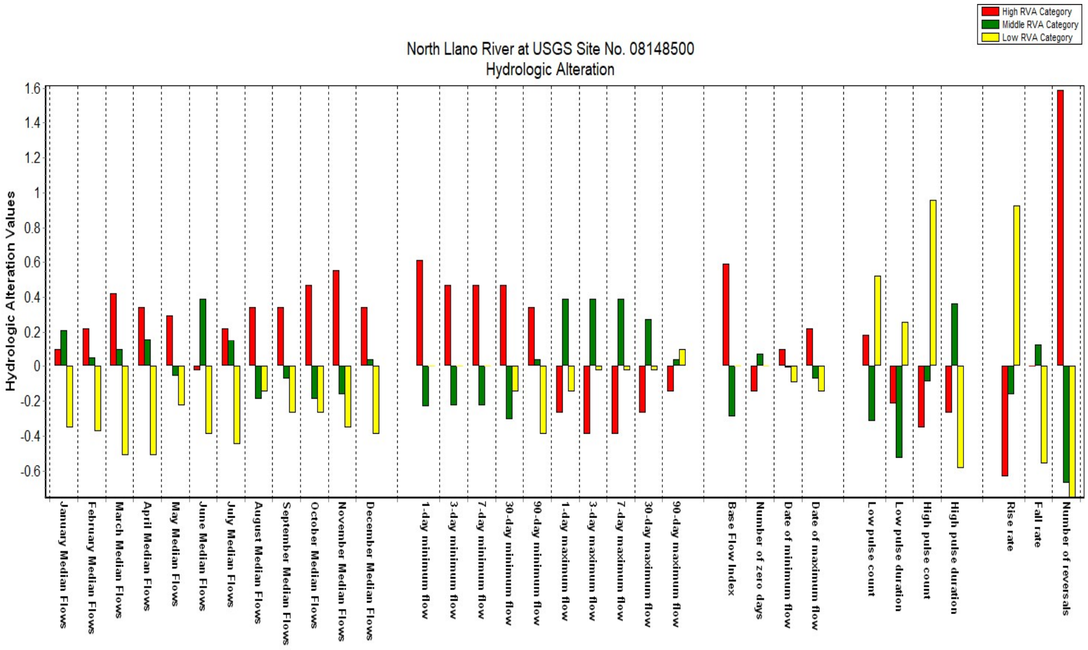
Hydrologic Alteration factors for San Saba River at San Saba



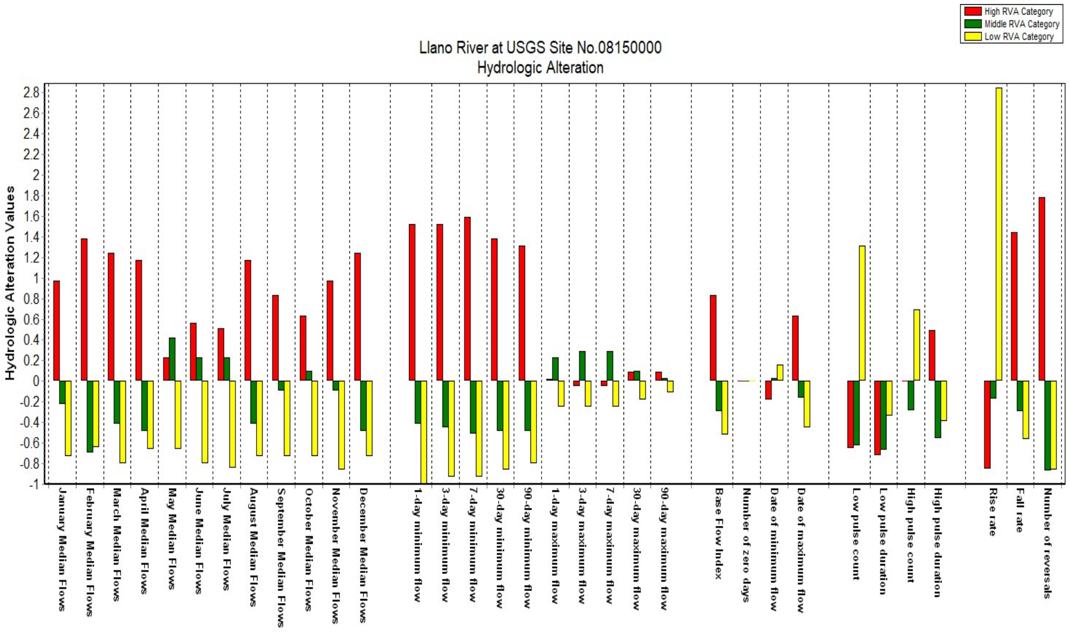
Hydrologic Alteration factors for Pecan Bayou near Mullin



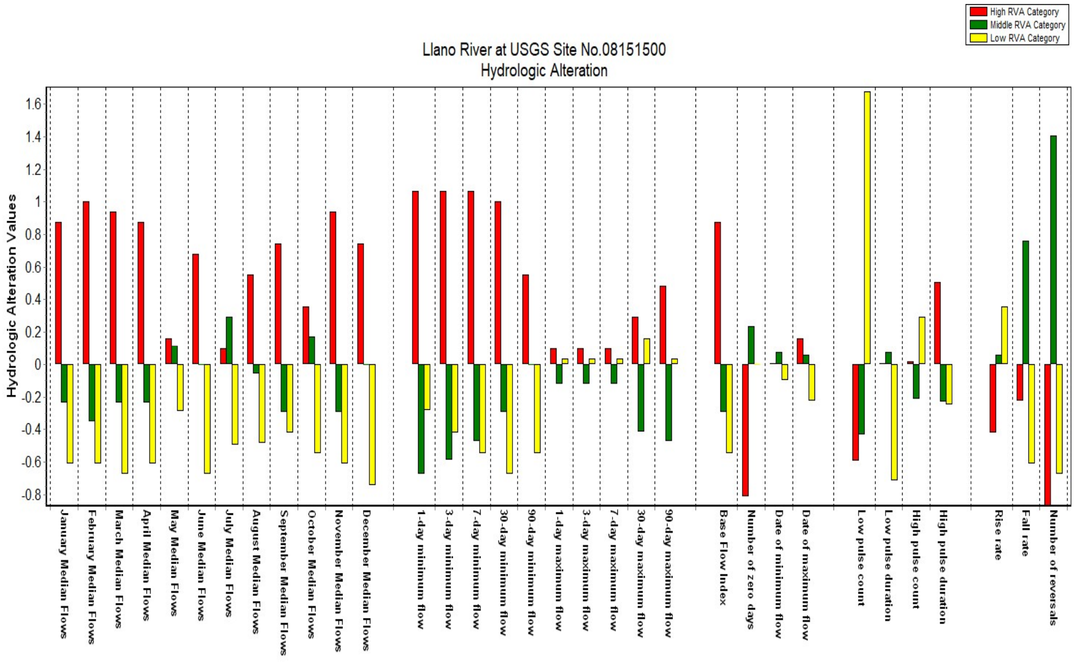
Hydrologic Alteration factors for Colorado River near San Saba



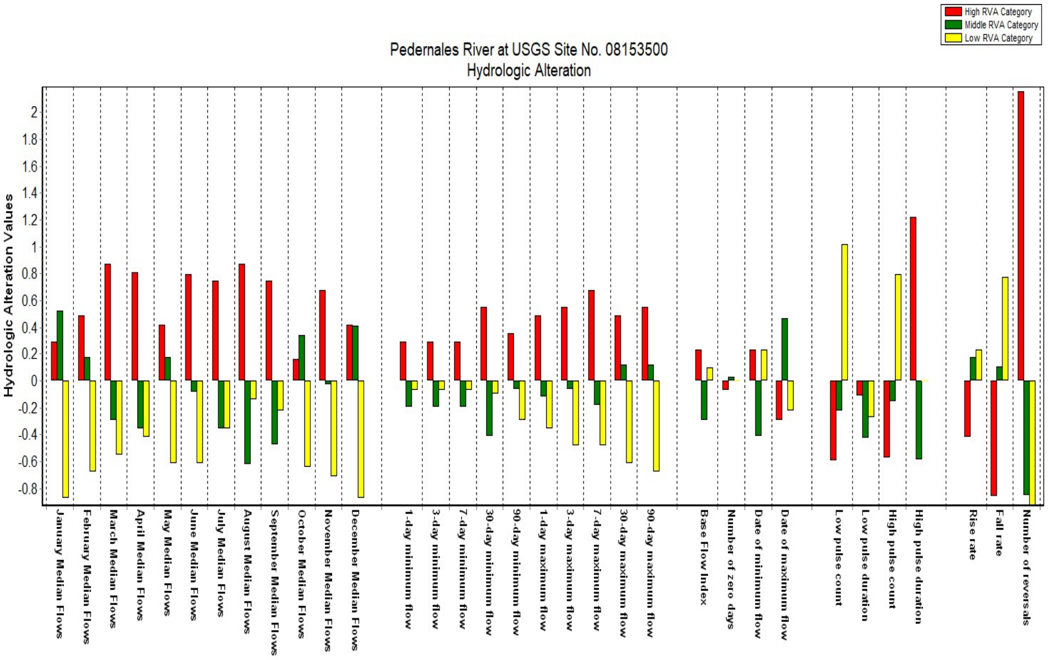
Hydrologic Alteration factors for North Llano River near Junction



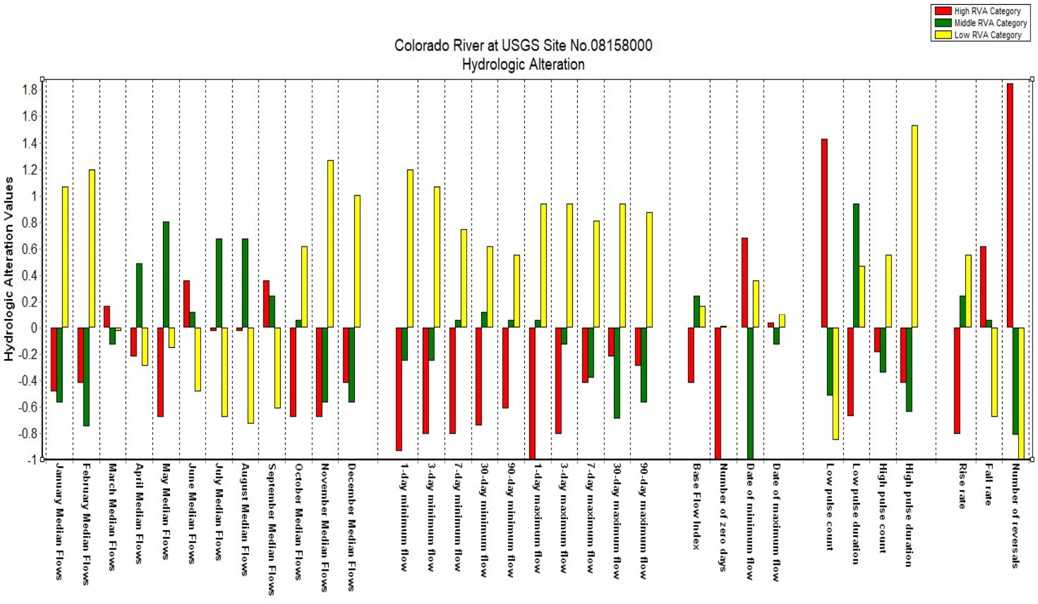
Hydrologic Alteration factors for Llano River near Junction



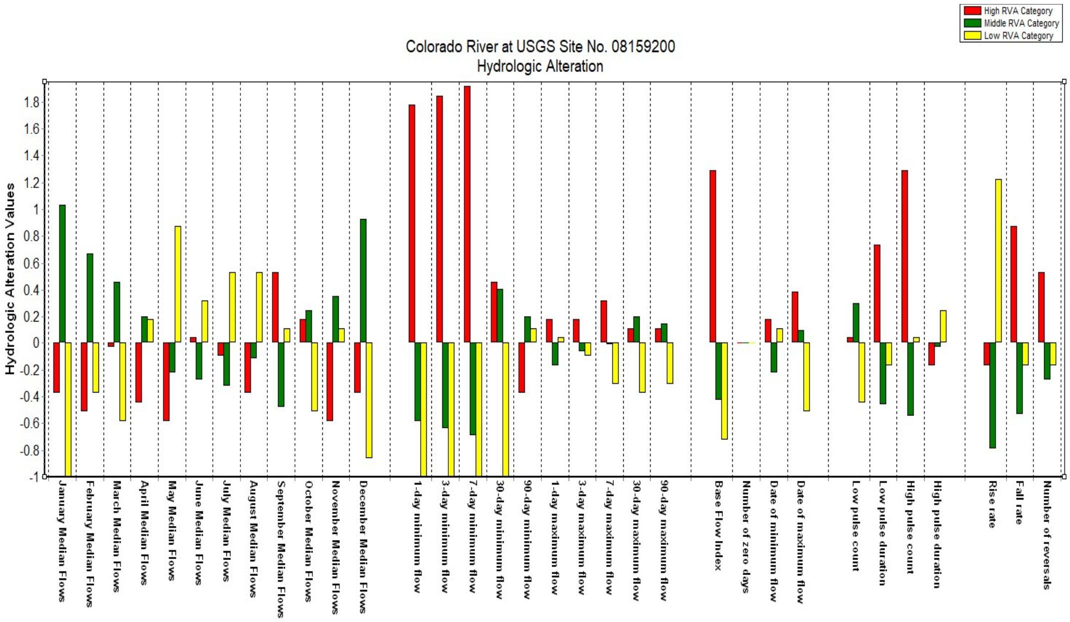
Hydrologic Alteration factors for Llano River at Llano



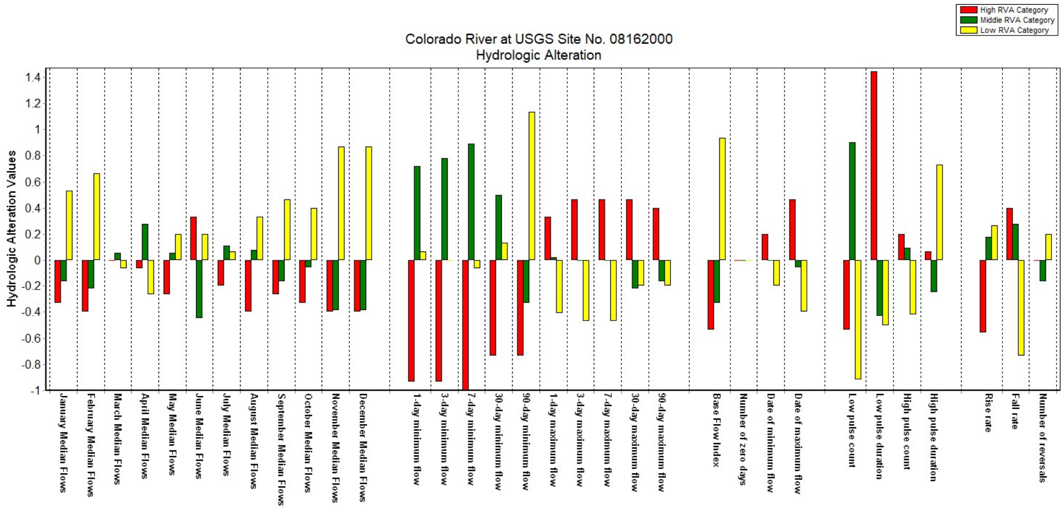
Hydrologic Alteration factors for Pedernales River near Johnson City



Hydrologic Alteration factors for Colorado River at Austin



Hydrologic Alteration factors for Colorado River at Bastrop



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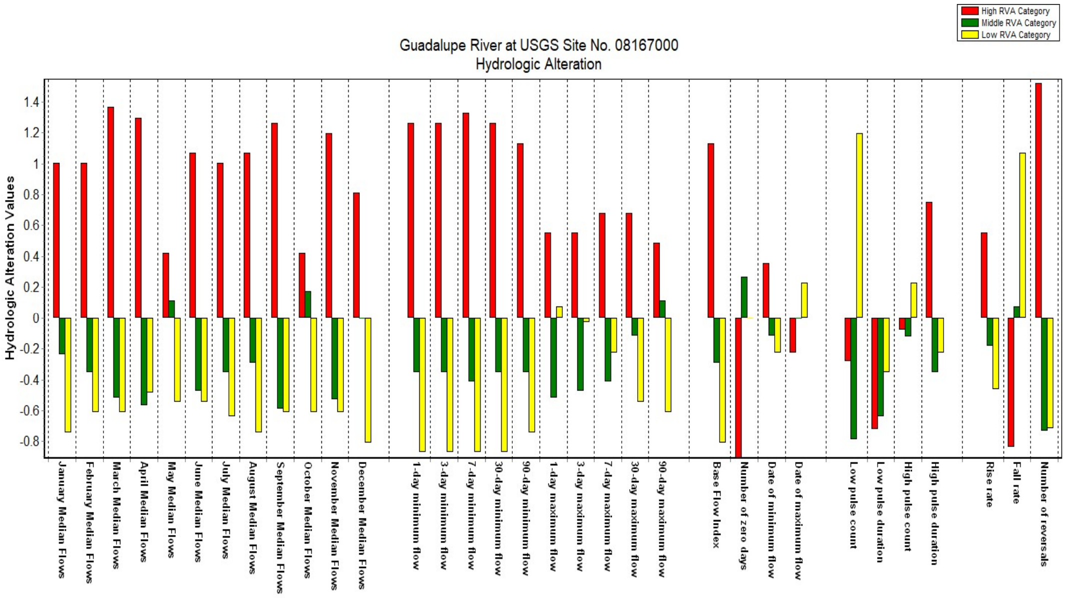
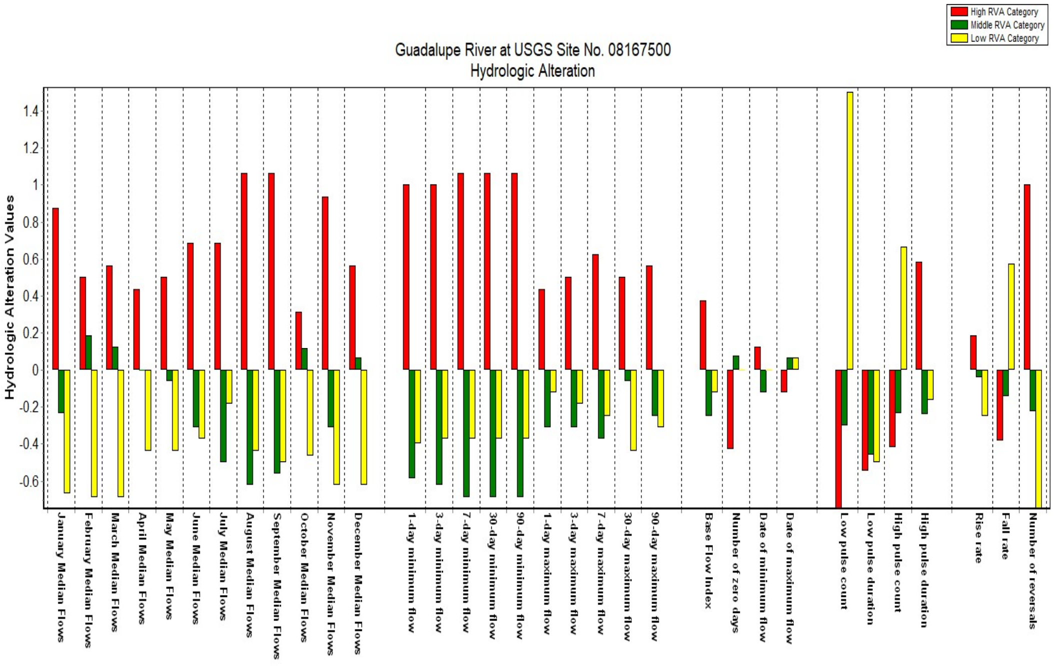
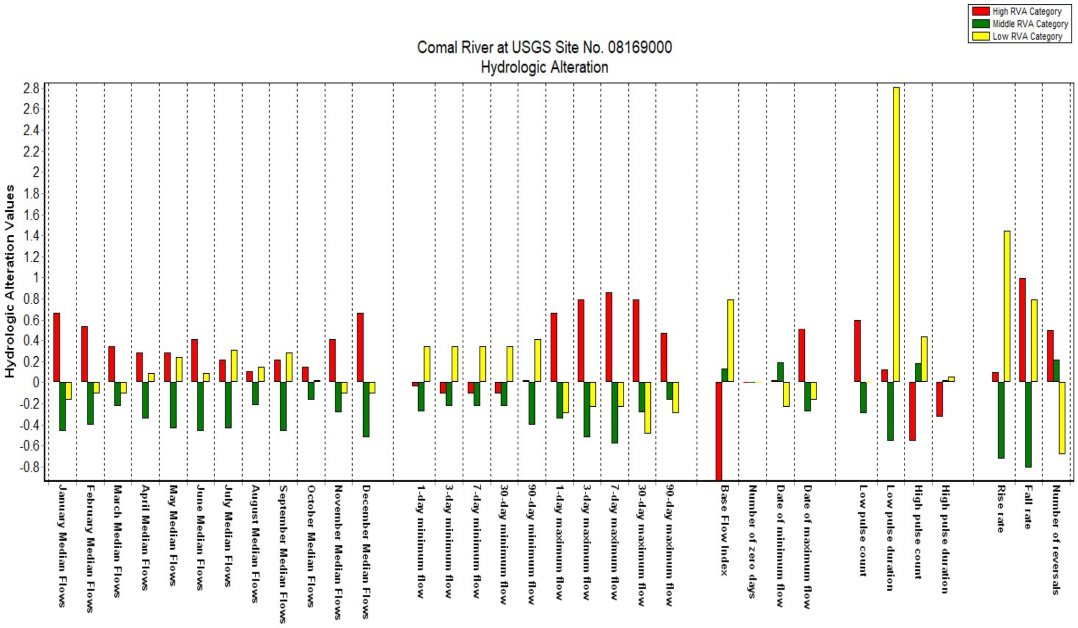


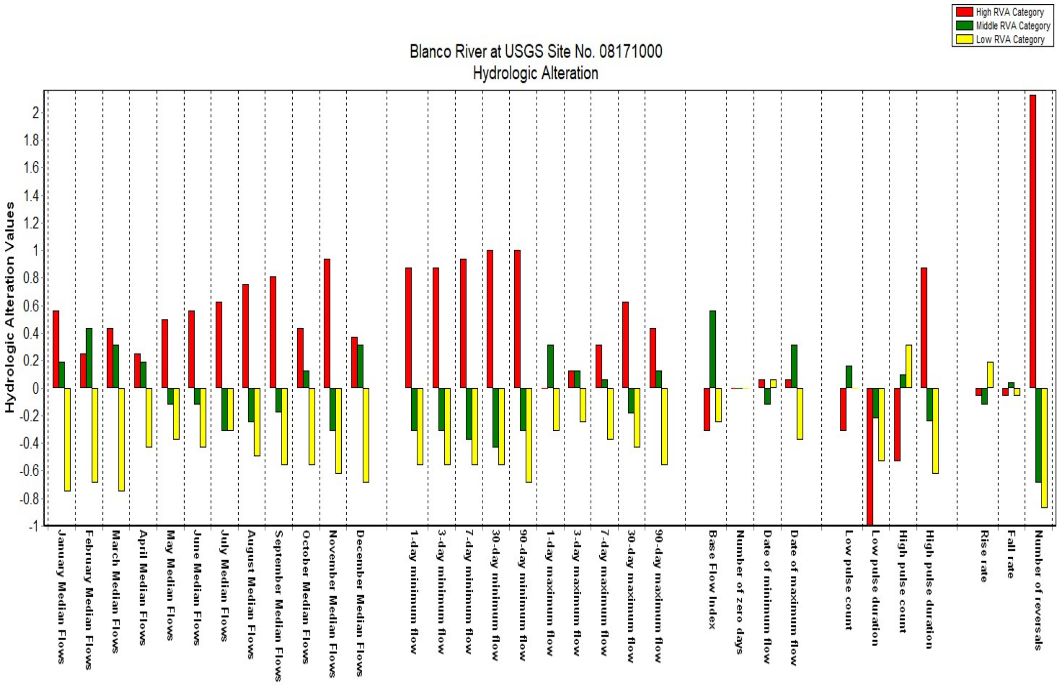
Hydrologic Alteration factors for Guadalupe River at Comfort



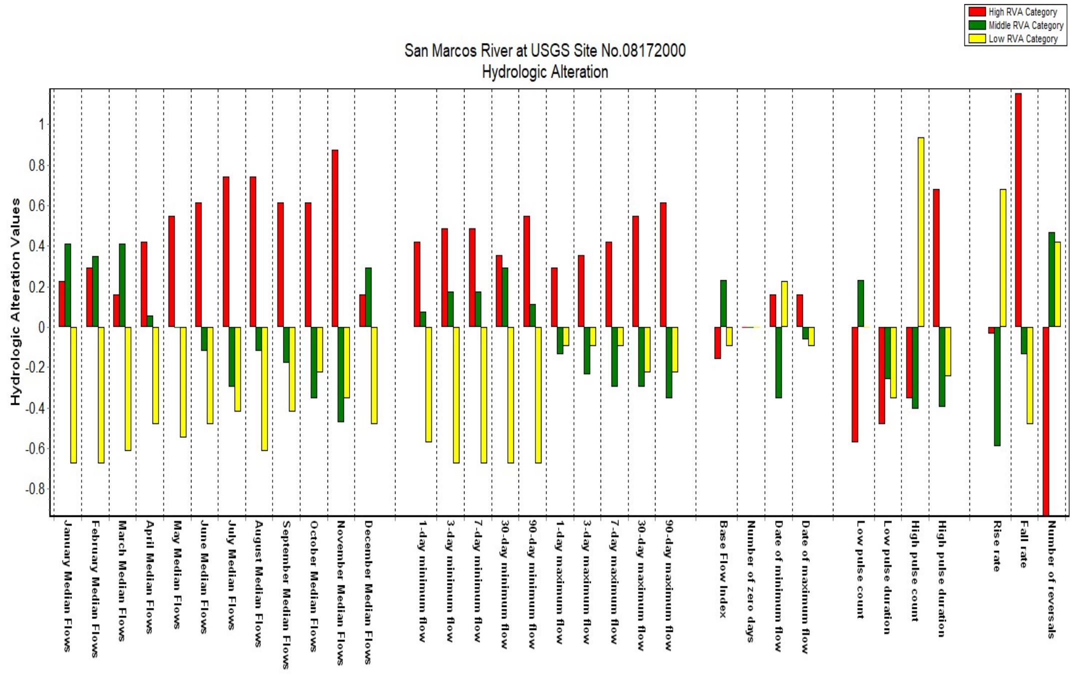
Hydrologic Alteration factors for Guadalupe River near Spring Branch



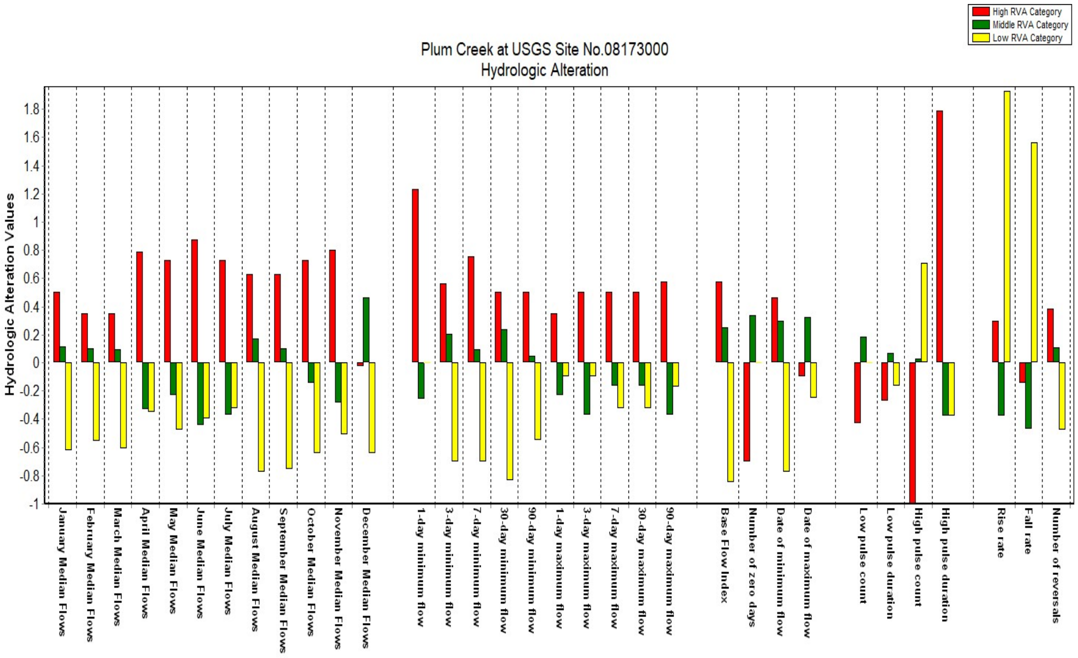
Hydrologic Alteration factors for Comal River at New Braunfels



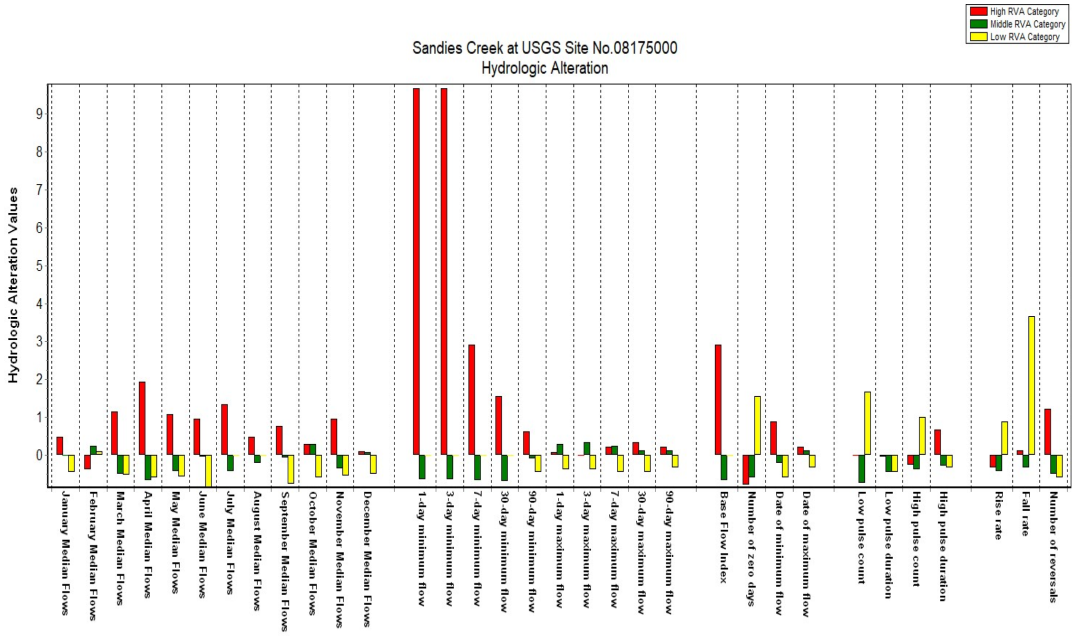
Hydrologic Alteration factors for Blanco River at Wimberley



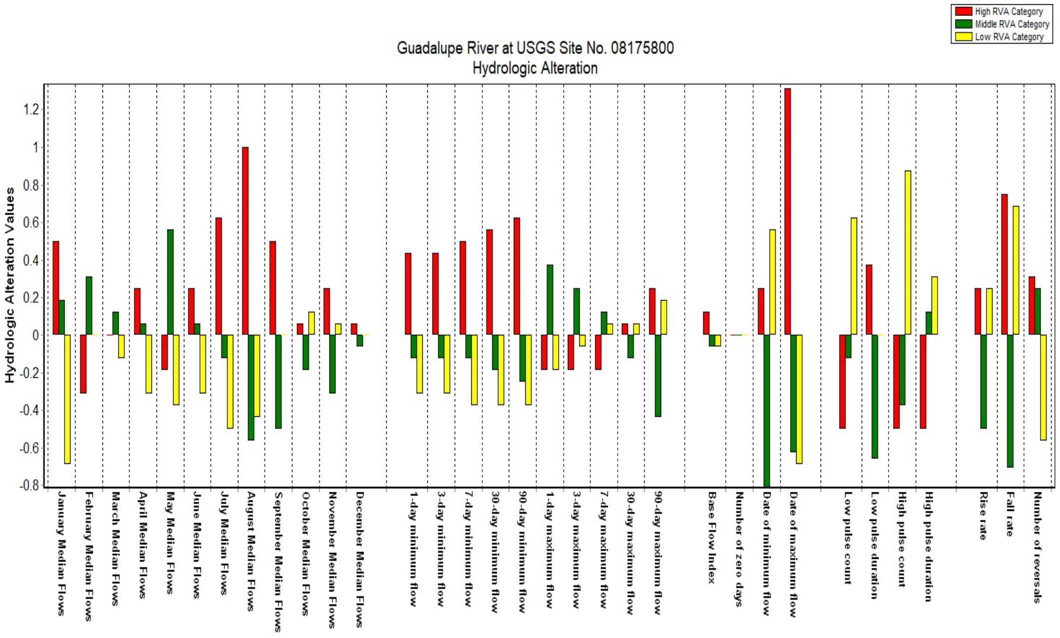
Hydrologic Alteration factors for San Marcos River at Luling



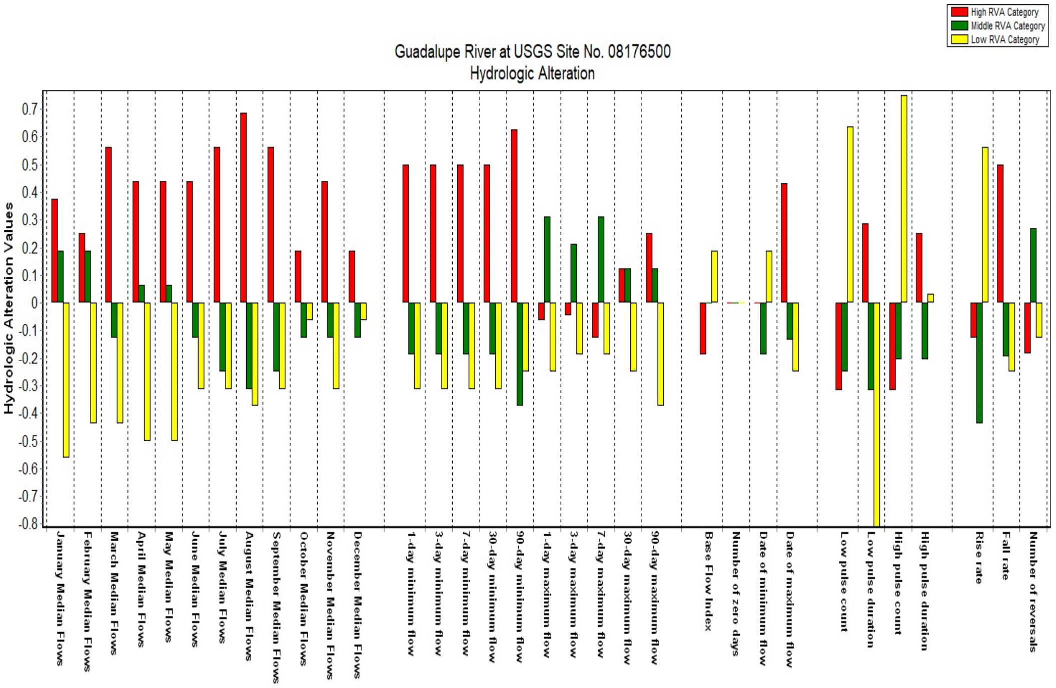
Hydrologic Alteration factors for Plum Creek near Luling



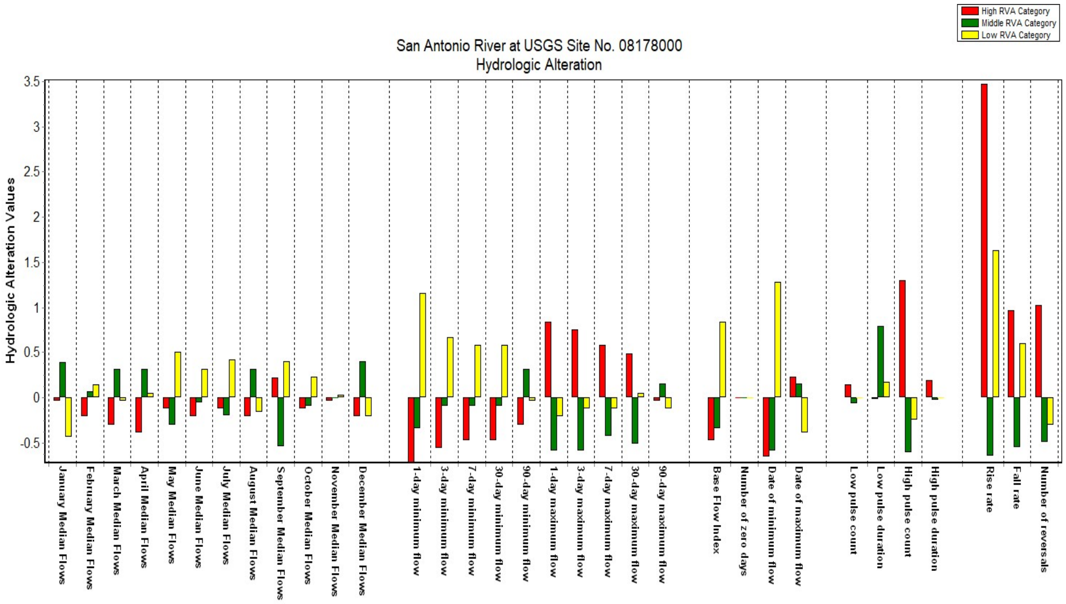
Hydrologic Alteration factors for Sandies Creek near Westhoff



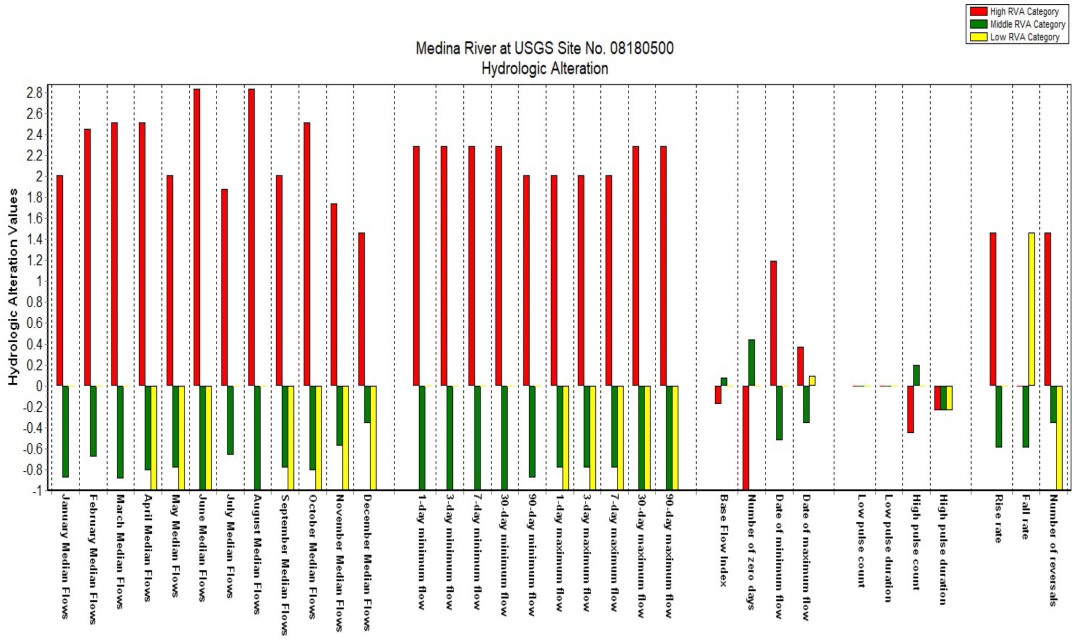
Hydrologic Alteration factors for Guadalupe River at Cuero



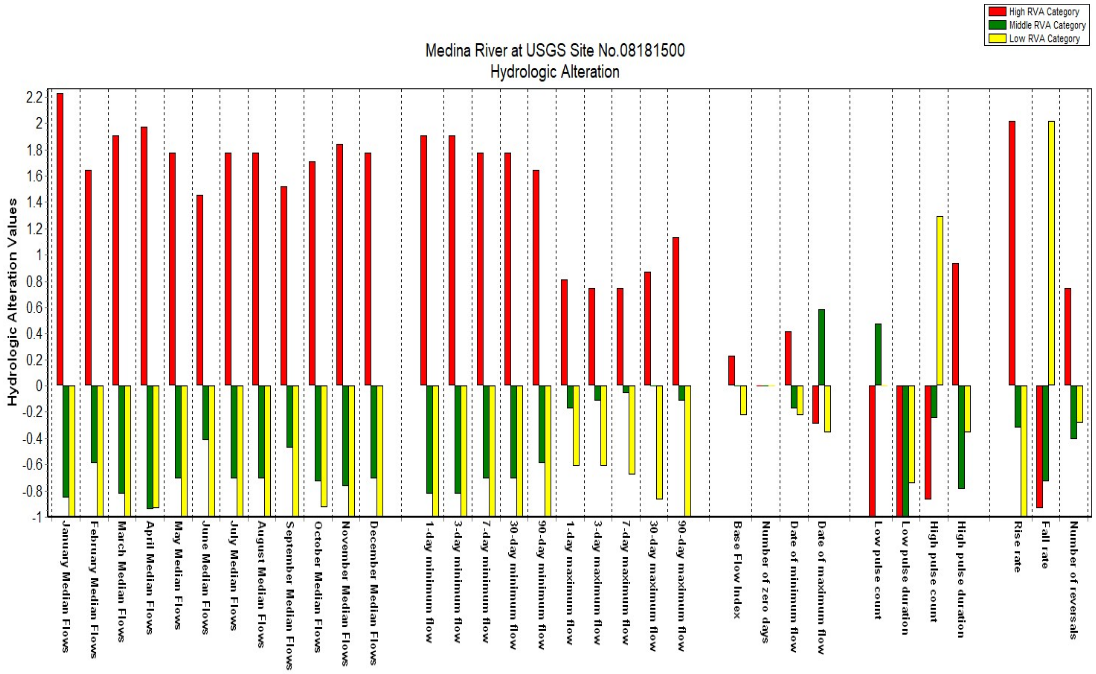
Hydrologic Alteration factors for Guadalupe River at Victoria



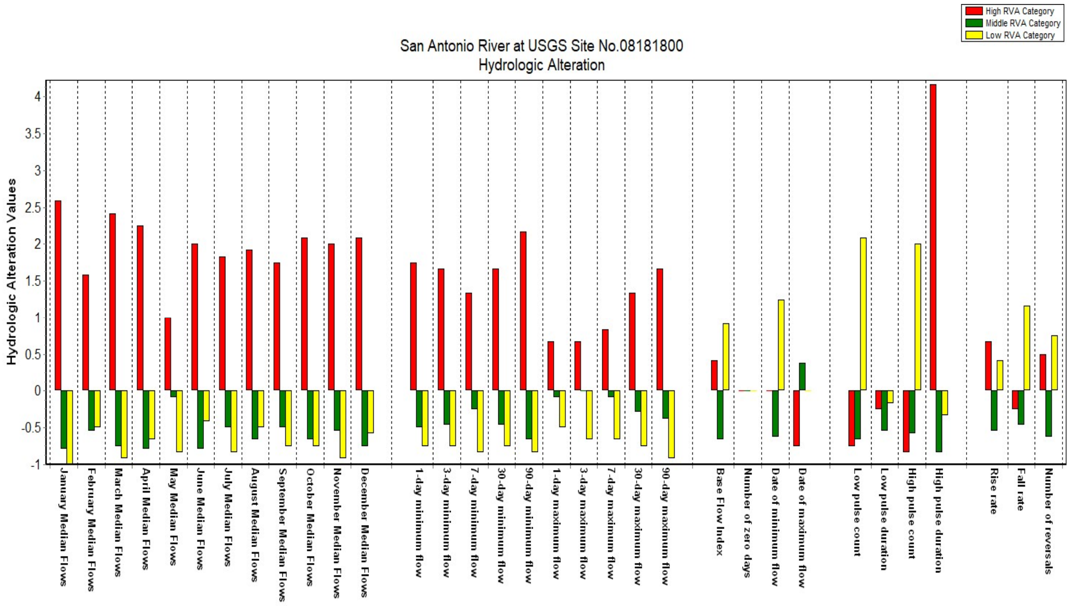
Hydrologic Alteration factors for San Antonio River at San Antonio



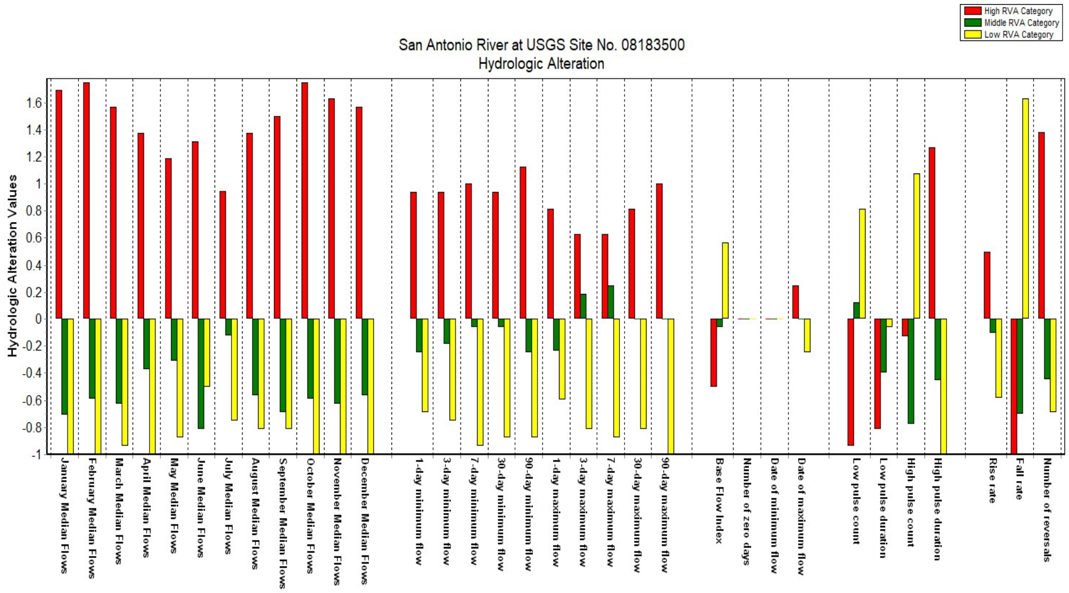
Hydrologic Alteration factors for Medina River near Rio Medina



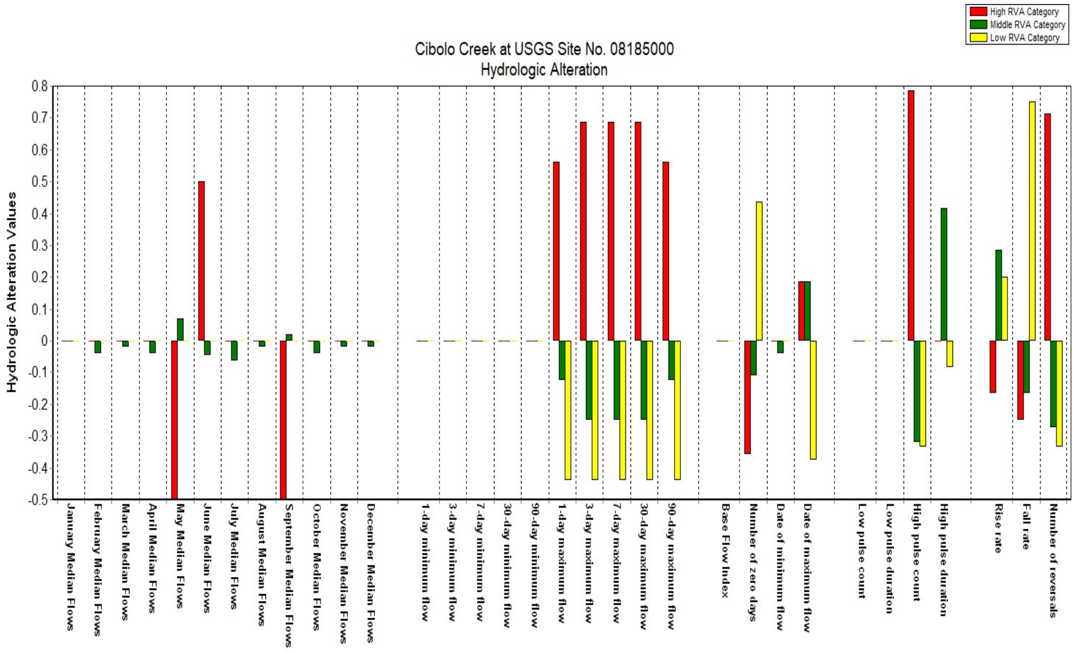
Hydrologic Alteration factors for Medina River at San Antonio



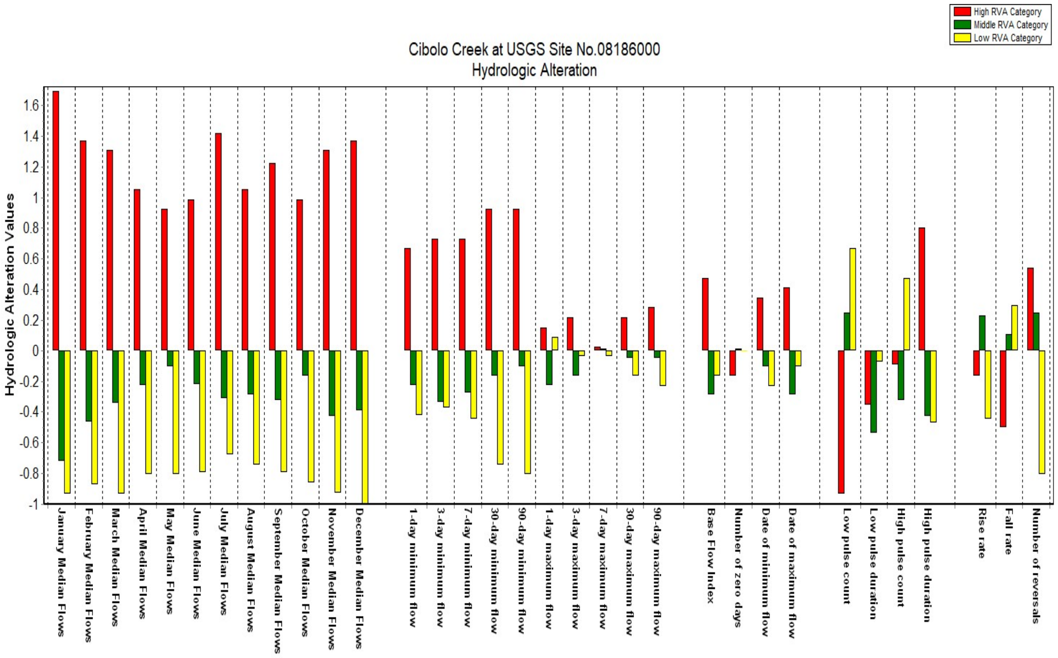
Hydrologic Alteration factors for San Antonio River near Elmendorf



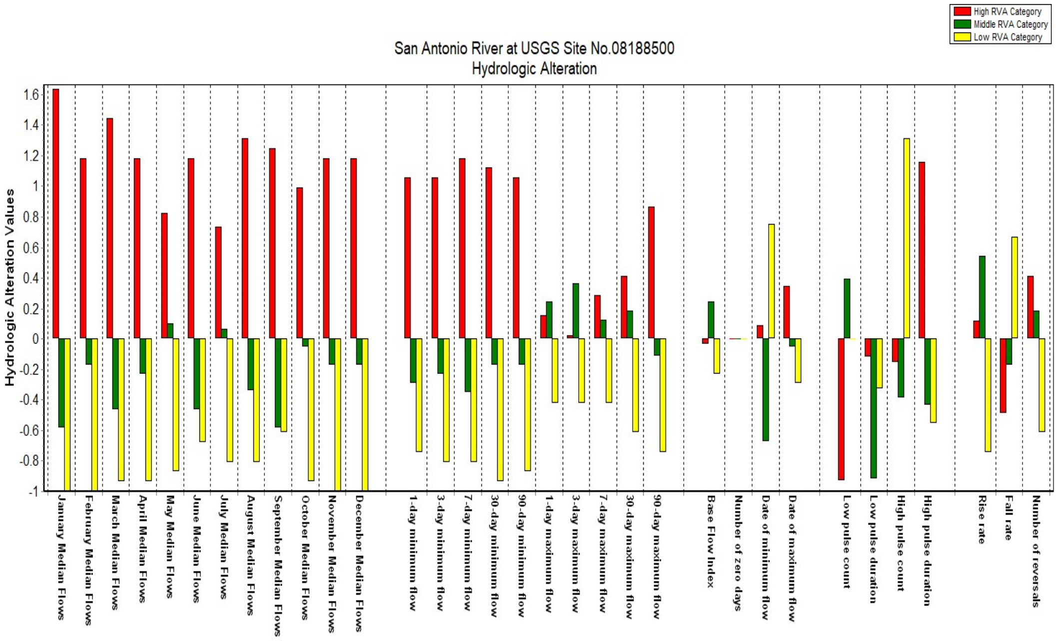
Hydrologic Alteration factors for San Antonio River near Falls City



Hydrologic Alteration factors for Cibolo Creek at Selma



Hydrologic Alteration factors for Cibolo Creek near Falls City



Hydrologic Alteration factors for San Antonio River at Goliad

APPENDIX E

Monthly Target Volume in Acre-Feet for Control Point BRBR59

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940	19,073	24,443	19,195	75,488	38,701	41,792	89,194	56,569	54,744	56,569	102,968	52,879
1941	52,879	47,762	311,104	146,380	151,260	146,380	118,924	90,387	87,471	90,387	174,564	108,218
1942	108,218	97,745	151,260	320,863	151,260	146,380	90,387	116,008	87,471	90,387	167,582	108,218
1943	108,218	97,745	173,137	101,321	77,474	74,975	56,569	56,569	63,794	71,070	18,164	19,591
1944	52,161	31,061	211,978	74,975	77,474	74,975	76,408	59,732	54,744	56,569	107,650	52,879
1945	52,879	47,762	211,978	74,975	77,474	74,975	118,553	90,387	87,471	90,387	115,542	146,627
1946	108,218	97,745	325,742	146,380	151,260	146,380	90,387	90,387	111,845	90,387	107,650	52,879
1947	52,879	47,762	207,210	74,975	77,474	74,975	56,569	78,078	54,744	63,839	20,465	48,476
1948	27,731	26,981	77,474	91,406	163,491	74,975	85,545	56,569	54,744	56,569	17,851	18,446
1949	23,648	42,299	187,611	83,747	77,474	74,975	77,362	56,569	54,744	56,569	62,636	52,879
1950	52,879	78,021	77,474	200,562	77,474	74,975	83,720	56,569	54,744	56,569	51,174	52,879
1951	52,879	47,762	22,170	18,451	81,331	37,766	18,446	22,611	36,754	18,769	17,851	18,458
1952	18,446	18,765	21,107	75,786	37,280	24,206	19,135	18,446	20,215	18,446	39,793	24,727
1953	24,013	19,936	76,118	25,989	36,871	22,233	45,320	21,331	25,243	28,747	51,174	109,356
1954	52,879	47,762	18,446	31,822	86,301	29,483	20,063	21,379	17,851	21,309	37,640	18,446
1955	18,482	23,203	27,671	79,480	36,618	41,630	37,225	29,747	28,430	28,023	23,352	18,632
1956	21,861	22,282	18,644	19,932	83,546	24,852	18,446	18,446	18,560	21,259	39,050	22,255
1957	18,446	21,898	70,799	35,345	43,656	42,248	119,006	90,387	87,471	90,387	174,564	108,218
1958	108,218	97,745	296,466	146,380	151,260	146,380	121,840	90,387	87,471	90,387	104,727	108,218
1959	108,218	129,173	77,474	116,478	147,983	74,975	83,720	56,569	54,744	56,569	105,945	52,879
1960	52,879	49,468	151,260	181,414	193,708	146,380	86,917	56,569	54,744	56,569	105,945	52,879
1961	52,879	47,762	228,742	146,380	151,260	228,742	86,950	56,569	54,744	56,569	107,125	52,879
1962	52,879	47,762	77,474	116,478	112,062	118,977	87,122	56,569	54,744	56,569	97,195	59,923
1963	52,879	47,762	77,474	132,904	144,517	74,975	24,844	18,446	17,851	30,720	26,895	19,230
1964	22,640	24,485	74,839	31,284	32,002	32,136	20,933	26,349	36,891	28,679	105,945	52,879
1965	52,879	47,762	159,825	118,977	77,474	74,975	80,070	56,569	54,744	56,569	104,239	52,879
1966	52,879	47,762	118,977	165,478	77,474	74,975	56,569	89,194	54,744	56,569	51,174	52,879
1967	52,879	47,762	23,059	33,654	88,865	37,664	44,716	25,208	31,688	27,499	103,934	52,879
1968	52,879	49,468	325,742	146,380	151,260	146,380	113,814	90,387	87,471	90,387	104,727	154,663
1969	108,218	97,745	311,575	146,380	151,260	146,380	90,387	101,740	98,824	90,387	99,121	52,879
1970	52,879	47,762	209,479	74,975	77,474	74,975	56,569	56,569	74,511	56,569	51,174	52,879
1971	52,879	47,762	20,809	51,126	35,076	23,945	40,056	36,119	29,035	36,234	104,239	52,879
1972	52,879	49,468	77,474	74,975	147,681	106,512	74,425	65,619	54,744	56,569	102,533	52,879
1973	52,879	47,762	196,983	74,975	77,474	74,975	111,489	90,387	87,471	90,387	164,211	108,218
1974	108,218	97,745	151,260	146,380	199,706	146,380	56,569	87,369	54,744	56,569	181,545	108,218
1975	108,218	97,745	151,260	311,104	151,260	146,380	121,840	90,387	87,471	90,387	51,174	52,879
1976	52,879	49,468	33,970	79,383	43,656	42,248	83,720	56,569	54,744	56,569	167,582	108,218
1977	108,218	97,745	315,984	146,380	151,260	146,380	63,085	56,569	54,744	56,569	21,604	19,191
1978	19,632	43,090	80,363	26,497	31,903	31,947	19,252	38,129	21,768	22,244	25,131	20,064
1979	50,833	29,654	210,419	74,975	77,474	74,975	112,655	90,387	87,471	90,387	104,727	108,218
1980	158,139	101,236	115,933	134,502	80,798	74,975	56,569	56,569	77,765	56,569	31,310	28,294
1981	21,383	24,775	78,745	38,061	41,024	42,248	85,762	56,569	54,744	56,569	163,276	108,218
1982	108,218	97,745	111,079	116,478	115,668	74,975	124,755	90,387	87,471	90,387	51,174	63,185
1983	52,879	81,433	192,922	74,975	77,474	74,975	56,569	76,213	54,744	56,569	51,174	52,879
1984	52,879	49,468	77,474	74,975	77,474	74,975	18,924	19,115	20,527	44,638	83,779	70,568
1985	52,879	47,762	306,225	146,380	151,260	146,380	56,569	56,569	54,744	81,895	109,356	52,879
1986	52,879	47,762	77,474	74,975	201,982	74,975	80,596	56,569	54,744	56,569	102,533	52,879
1987	52,879	47,762	320,863	146,380	151,260	146,380	120,330	90,387	87,471	90,387	51,174	104,239
1988	52,879	49,468	77,474	74,975	77,474	201,982	56,569	56,569	80,187	57,113	51,174	52,879
1989	58,937	93,064	167,977	118,977	77,474	74,975	82,918	56,569	54,744	56,569	51,174	52,879
1990	52,879	77,474	206,980	74,975	77,474	74,975	71,035	63,794	54,744	56,569	83,131	52,879
1991	68,862	47,762	77,474	209,479	77,474	74,975	67,835	65,619	54,744	56,569	181,545	108,218
1992	108,218	101,236	334,742	146,380	151,260	146,380	124,755	90,387	87,471	90,387	132,061	143,136
1993	108,218	97,745	311,104	146,380	151,260	146,380	116,008	90,387	87,471	90,387	51,174	52,879
1994	52,879	104,239	77,474	74,975	211,978	74,975	68,345	56,569	54,744	66,843	99,275	52,879
1995	52,879	47,762	216,977	74,975	77,474	74,975	114,422	90,387	87,471	90,387	51,174	52,879
1996	52,879	49,468	23,105	34,486	25,681	32,145	21,466	46,565	35,802	36,432	102,263	52,879
1997	52,879	47,762	330,622	146,380	151,260	146,380	124,755	90,387	87,471	90,387	104,727	181,545
1998	108,218	97,745	311,104	146,380	151,260	146,380	56,569	56,569	68,737	65,619	107,650	52,879
1999	52,879	47,762	113,006	113,978	121,476	74,975	56,569	56,569	54,744	56,569	51,174	52,879
2000	52,879	67,156	40,537	75,454	35,159	41,739	23,227	18,446	20,900	45,665	51,685	33,203
2001	33,203	29,990	309,972	146,380	151,260	146,380	62,088	61,212	70,026	56,569	105,945	52,879
2002	52,879	47,762	157,980	74,975	112,392	81,560	85,545	56,569	54,744	56,569	180,605	108,218
2003	108,218	97,745	151,260	146,380	151,260	315,026	78,245	56,569	54,744	56,569	86,550	52,879
2004	70,568	49,468	205,268	74,975	77,474	74,975	89,194	56,569	54,744	56,569	178,054	108,218
2005	108,218	97,745	151,260	146,380	151,260	146,380	56,569	89,194	54,744	56,569	18,163	18,511
2006	19,669	47,877	89,840	42,248	34,512	39,583	21,740	19,237	32,535	49,533	31,656	47,255
2007	31,413	29,990	214,478	74,975	77,474	74,975	124,755	90,387	87,471	90,387	104,727	108,218
2008	108,218	101,236	150,922	113,978	77,474	74,975	56,569	88,170	54,744	56,569	51,174	52,879
2009	52,879	47,762	82,541	40,266	38,088	36,835	43,848	19,477	35,524	38,737	109,356	52,879
2010	52,879	47,762	151,260	268,454	155,428	146,380	87,877	56,569	54,744	56,569	51,174	52,879
2011	68,862	61,280	77,474	74,975	77,474	74,975	18,446	18,446	17,851	45,816	30,714	49,779
2012	33,203	31,061	83,733	31,006	43,656	40,276	26,579	19,108	39,341	38,737	17,851	18,446
2013	49,045	29,990	28,271	42,248	81,120	39,988	45,011	36,907	37,488	38,376	109,356	52,879
2014	52,879	47,762	32,682	24,101	75,762	42,248	75,535	56,569	54,744	56,569	105,945	52,879
2015	52,879	47,762	194,476	74,975	77,474	74,975	116,008	90,387	87,471	90,387	181,545	108,218

Monthly Target Volume in Acre-Feet for Control Point BRGR30

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940	2,256	1,660	1,449	1,260	30,564	2,551	36,403	25,226	4,165	4,304	36,371	4,735
1941	4,735	4,276	50,993	146,507	10,453	10,116	84,972	9,838	9,521	9,838	46,051	9,838
1942	9,838	8,886	10,453	148,867	10,453	10,116	9,838	9,838	75,980	9,838	35,308	9,838
1943	9,838	8,886	33,344	18,862	5,657	19,409	4,304	4,304	4,165	4,304	971	1,221
1944	1,499	7,598	45,488	5,474	59,972	5,474	22,511	11,151	17,963	25,088	4,582	4,735
1945	9,676	32,661	151,354	5,474	5,657	5,474	83,988	9,838	9,521	9,838	9,521	9,838
1946	26,263	33,664	5,657	5,474	30,566	33,109	4,304	23,102	41,749	4,304	36,371	4,735
1947	4,735	4,276	19,409	5,474	112,079	5,474	4,304	4,304	4,165	26,968	4,582	33,296
1948	4,735	4,429	5,657	5,474	35,622	72,678	45,732	4,304	4,165	4,304	1,840	1,137
1949	991	12,398	27,184	17,438	104,553	5,474	4,304	4,304	56,549	4,304	8,767	4,735
1950	4,735	9,113	5,657	59,562	65,744	5,474	68,667	4,304	4,165	4,304	4,582	4,735
1951	4,735	4,276	1,869	952	21,030	2,139	1,359	2,007	2,000	1,125	1,452	1,102
1952	1,387	1,360	1,165	1,672	30,869	952	1,962	2,192	1,993	1,108	10,203	3,161
1953	1,356	889	1,310	1,583	16,229	952	17,382	1,275	1,369	1,692	12,395	2,081
1954	2,083	1,580	2,293	30,870	2,767	2,428	1,653	9,334	952	1,829	6,871	997
1955	1,512	1,791	1,622	1,713	30,740	2,735	16,882	2,025	1,868	2,233	2,344	1,860
1956	1,714	1,403	2,046	2,323	30,210	2,144	1,279	1,840	1,148	1,798	11,389	1,758
1957	984	1,353	2,214	31,072	2,767	2,797	23,911	9,838	9,521	77,242	44,424	9,838
1958	9,838	8,886	44,192	53,941	123,108	10,116	79,040	9,838	9,521	9,838	4,582	4,735
1959	4,735	4,276	1,121	1,273	14,045	16,234	17,568	1,903	964	1,876	4,582	13,590
1960	26,401	4,429	10,453	10,116	10,453	10,116	57,292	4,304	4,165	4,304	19,791	4,735
1961	15,229	4,276	19,409	5,474	18,679	104,434	56,206	4,304	4,165	4,304	22,604	4,735
1962	4,735	4,276	5,657	5,474	5,657	115,476	67,052	4,304	4,165	4,304	29,908	15,076
1963	4,735	4,276	5,657	98,327	19,774	5,474	1,716	1,313	1,818	1,645	12,089	1,819
1964	1,364	1,650	2,326	2,137	2,201	2,182	984	1,815	17,350	2,233	39,278	4,735
1965	4,735	4,276	5,657	33,344	109,514	5,474	4,304	14,358	29,357	25,088	4,582	4,735
1966	4,735	8,878	5,657	116,836	5,657	5,474	4,304	32,052	38,248	4,304	4,582	4,735
1967	4,735	4,276	1,529	16,510	2,405	16,849	17,548	1,865	2,035	2,067	972	1,438
1968	12,598	1,127	167,377	10,116	10,453	10,116	54,426	9,838	9,521	9,838	9,521	9,838
1969	9,838	8,886	93,432	51,809	5,657	5,474	4,304	4,304	53,833	4,304	28,843	9,829
1970	4,735	4,276	113,419	5,474	5,657	5,474	4,304	4,304	4,165	4,304	4,582	4,735
1971	4,735	4,276	2,067	1,657	13,620	18,471	4,619	12,043	2,118	2,124	26,286	15,076
1972	4,735	4,429	5,657	5,474	54,319	5,474	1,548	17,270	2,202	2,203	36,218	4,735
1973	4,735	4,276	19,409	92,885	5,657	50,715	35,353	25,088	4,165	4,304	9,521	9,838
1974	9,838	8,886	5,657	27,218	5,657	5,474	1,406	1,923	17,480	1,961	46,051	9,838
1975	9,838	8,886	10,453	55,467	50,142	87,622	42,148	16,806	9,521	9,838	4,582	4,735
1976	4,735	4,429	1,671	2,436	30,663	2,256	16,656	4,304	48,190	4,304	46,051	9,838
1977	9,838	8,886	163,504	10,116	10,453	10,116	4,304	4,304	4,165	4,304	1,048	1,378
1978	1,036	1,644	1,929	29,776	1,107	1,926	1,046	17,176	1,244	2,003	1,636	1,659
1979	1,987	1,495	71,018	20,901	51,992	5,474	4,304	4,304	4,165	4,304	4,582	4,735
1980	4,735	4,429	5,657	5,474	93,217	29,559	4,304	4,304	58,453	4,304	2,201	12,863
1981	2,531	2,197	16,807	16,556	2,337	2,735	4,304	4,304	4,165	58,036	32,712	9,838
1982	9,838	8,886	5,657	5,474	126,197	5,474	79,998	9,838	9,521	9,838	4,582	4,735
1983	4,735	4,276	5,657	5,474	86,683	5,474	4,304	4,304	4,165	52,751	9,524	4,735
1984	4,735	4,429	5,657	5,474	5,657	5,474	1,000	1,746	1,082	16,918	30,464	4,735
1985	4,735	4,276	63,361	10,116	10,453	55,467	4,304	4,304	4,165	57,204	4,582	4,735
1986	4,735	19,046	5,657	5,474	5,657	125,369	53,294	4,304	4,165	4,304	42,312	9,838
1987	9,838	8,886	102,167	10,116	56,479	10,116	9,838	9,838	9,521	9,838	4,582	14,752
1988	9,543	4,429	5,657	5,474	5,657	24,633	4,304	4,304	42,502	4,304	4,582	4,735
1989	4,735	26,538	36,186	7,815	65,669	5,474	9,838	30,916	52,873	9,838	9,521	9,838
1990	13,400	24,333	122,445	5,474	5,657	5,474	4,304	18,904	49,954	4,304	9,218	4,735
1991	19,217	4,276	5,657	5,474	75,485	51,809	11,718	37,756	24,671	4,304	46,051	9,838
1992	9,838	9,203	169,736	10,116	10,453	10,116	58,561	9,838	9,521	9,838	13,635	21,445
1993	13,584	28,582	50,655	10,116	10,453	23,404	9,838	9,838	9,521	72,152	4,582	4,735
1994	4,735	4,276	5,657	5,474	116,714	5,474	4,304	4,304	11,301	57,291	29,777	4,735
1995	4,735	4,276	5,657	18,679	32,615	19,044	9,838	72,169	9,521	9,838	9,521	9,838
1996	9,838	9,203	1,927	1,793	1,353	2,562	1,418	17,205	2,077	1,817	32,716	4,735
1997	4,735	4,276	101,493	56,141	10,453	10,116	43,207	9,838	9,521	9,838	9,521	9,838
1998	9,838	37,452	68,755	10,116	10,453	10,116	4,304	4,304	4,165	4,304	12,668	2,273
1999	2,556	2,023	51,262	64,625	5,657	5,474	4,304	4,304	4,165	4,304	4,582	4,735
2000	4,735	4,429	16,696	1,628	2,031	16,317	4,304	4,304	4,165	75,525	12,998	2,377
2001	2,531	1,946	125,536	10,116	10,453	10,116	4,304	4,304	4,165	4,304	38,333	4,735
2002	4,735	4,276	69,574	5,474	5,657	5,474	61,670	4,304	4,165	4,304	34,598	4,735
2003	4,735	4,276	5,657	5,474	5,657	121,913	17,983	4,304	16,081	4,304	4,582	9,524
2004	11,465	25,724	79,279	51,809	5,657	5,474	61,809	4,304	4,165	4,304	50,942	9,838
2005	9,838	8,886	10,453	10,116	17,160	22,389	11,718	54,118	4,165	4,304	1,825	984
2006	1,195	6,982	15,607	2,495	16,542	1,895	1,159	988	17,048	2,150	12,460	2,221
2007	2,582	2,333	29,934	2,797	2,753	2,735	79,998	9,838	9,521	9,838	9,521	9,838
2008	9,838	9,203	5,657	19,409	47,280	5,474	4,304	28,796	45,038	4,304	12,303	4,735
2009	4,735	4,276	2,890	2,419	2,473	29,844	15,034	1,664	1,952	1,860	21,768	32,491
2010	9,838	8,886	49,981	148,530	10,453	10,116	53,701	4,304	4,165	4,304	4,582	4,735
2011	4,735	6,621	7,342	5,474	5,657	5,474	984	984	1,952	1,650	12,593	1,919
2012	1,571	2,366	27,116	5,474	5,657	18,784	2,163	988	15,868	2,150	952	2,552
2013	5,785	2,333	2,718	2,518	2,543	1,874	17,090	2,275	1,888	2,275	1,983	11,115
2014	2,531	2,333	2,480	2,199	31,056	1,751	4,304	4,304	60,559	4,304	37,696	4,735
2015	4,735	4,276	5,657	113,076	9,543	5,474	48,922	9,838	9,521	30,721	44,055	9,838

Monthly Target Volume in Acre-Feet for Control Point BRHE68

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940	34,285	49,225	33,431	122,815	67,148	67,240	124,864	81,778	79,140	81,778	223,661	88,542
1941	88,542	79,974	588,109	204,694	211,517	204,694	187,519	126,050	121,984	126,050	379,206	177,699
1942	177,699	160,503	211,517	601,755	211,517	204,694	148,886	142,260	121,984	126,050	171,967	177,699
1943	177,699	160,503	186,752	176,947	175,446	113,058	91,605	89,045	88,045	81,778	32,426	40,118
1944	100,894	52,919	349,215	113,058	116,826	113,058	105,226	81,778	79,140	81,778	212,906	88,542
1945	88,542	79,974	347,708	113,058	116,826	113,058	183,453	126,050	121,984	126,050	171,967	381,841
1946	177,699	160,503	608,578	204,694	211,517	204,694	126,050	126,050	175,321	126,050	223,661	88,542
1947	88,542	79,974	337,909	113,058	116,826	113,058	81,778	124,864	79,140	81,778	41,732	90,546
1948	49,051	52,919	177,623	113,058	204,278	161,689	118,798	81,778	79,140	81,778	30,347	31,359
1949	41,323	96,142	334,141	113,058	116,826	113,058	116,950	81,778	79,140	81,778	159,014	124,061
1950	88,542	79,974	116,826	341,678	116,826	113,058	116,950	81,778	79,140	81,778	85,686	88,542
1951	88,542	79,974	35,245	38,462	55,746	133,533	31,359	33,959	48,072	32,733	30,347	31,636
1952	31,359	32,974	43,136	130,676	59,571	48,611	46,226	31,359	32,840	31,359	76,982	44,105
1953	48,319	48,178	132,814	46,322	69,481	43,118	65,711	33,977	41,283	44,736	123,609	176,021
1954	88,542	79,974	31,359	47,425	144,769	48,779	34,289	37,858	30,347	34,859	37,316	31,359
1955	31,744	91,623	43,081	134,315	51,848	65,179	55,714	44,754	40,857	44,450	35,007	31,359
1956	33,211	44,088	35,722	38,303	129,959	40,951	31,359	32,179	30,668	34,999	36,423	76,699
1957	31,359	35,643	111,505	68,189	69,481	67,240	191,585	126,050	121,984	126,050	381,841	177,699
1958	177,699	160,503	401,287	299,352	308,567	204,694	191,585	126,050	121,984	126,050	171,967	177,699
1959	177,699	256,841	116,826	341,678	116,826	113,058	122,226	81,778	79,140	81,778	209,380	88,542
1960	88,542	82,830	211,517	204,694	375,932	355,989	130,108	81,778	79,140	81,778	226,517	88,542
1961	88,542	79,974	522,305	204,694	211,517	204,694	123,133	81,778	79,140	81,778	169,009	126,917
1962	88,542	79,974	116,826	127,405	166,905	258,725	124,864	81,778	79,140	81,778	126,917	171,954
1963	88,542	79,974	116,826	247,501	183,875	113,058	48,117	31,359	30,347	36,748	43,533	37,298
1964	38,794	41,060	121,158	50,885	50,613	48,148	35,974	38,810	54,988	40,862	198,884	88,542
1965	88,542	79,974	182,983	254,952	116,826	113,058	101,073	88,226	79,140	81,778	212,236	88,542
1966	88,542	79,974	260,446	190,521	116,826	113,058	81,778	122,226	79,140	81,778	85,686	88,542
1967	88,542	79,974	32,802	52,910	124,948	60,496	59,391	35,362	47,401	37,580	203,015	88,542
1968	88,542	82,830	588,109	204,694	211,517	204,694	199,717	126,050	121,984	126,050	214,768	338,545
1969	177,699	160,503	571,022	204,694	211,517	204,694	126,050	126,050	150,685	143,863	121,205	173,861
1970	88,542	79,974	341,678	113,058	116,826	113,058	81,778	81,778	113,796	81,778	85,686	88,542
1971	88,542	79,974	37,814	39,453	120,099	38,955	56,080	55,795	43,180	53,000	122,910	173,861
1972	88,542	82,830	116,826	113,058	171,678	133,387	91,921	107,864	79,140	81,778	209,380	88,542
1973	88,542	79,974	330,372	113,058	116,826	113,058	179,387	126,050	121,984	126,050	330,411	194,736
1974	177,699	160,503	211,517	204,694	211,517	204,694	81,778	122,226	79,140	81,778	404,770	177,699
1975	177,699	160,503	211,517	540,347	211,517	204,694	191,585	126,050	121,984	126,050	85,686	88,542
1976	88,542	82,830	60,112	132,068	69,481	67,240	118,181	81,778	79,140	81,778	256,841	274,038
1977	177,699	160,503	410,048	409,442	211,517	204,694	88,426	81,778	79,140	81,778	35,120	38,281
1978	44,358	86,863	58,343	41,956	45,805	48,503	32,042	54,500	45,183	35,733	71,661	48,323
1979	56,569	51,094	326,603	113,058	116,826	113,058	183,021	126,050	121,984	126,050	171,967	177,699
1980	274,038	249,329	190,521	177,584	186,752	113,058	81,778	81,778	105,820	81,778	37,121	43,767
1981	39,664	44,710	58,377	56,545	69,481	145,516	117,602	81,778	79,140	81,778	370,026	177,699
1982	177,699	160,503	116,826	240,545	201,304	113,058	199,717	126,050	121,984	126,050	85,686	120,246
1983	88,542	164,449	315,635	113,058	116,826	113,058	81,778	109,254	79,140	81,778	85,686	88,542
1984	88,542	82,830	148,145	113,058	116,826	113,058	35,104	31,361	31,228	63,951	217,949	88,542
1985	88,542	79,974	506,651	204,694	211,517	204,694	81,778	81,778	79,140	119,588	211,512	88,542
1986	88,542	79,974	116,826	113,058	326,603	113,058	110,884	81,778	79,140	81,778	206,524	88,542
1987	88,542	79,974	594,932	204,694	211,517	204,694	187,519	126,050	121,984	126,050	85,686	182,813
1988	106,656	82,830	116,826	113,058	116,826	240,748	81,778	81,778	94,982	82,849	85,686	88,542
1989	121,388	162,315	194,289	224,243	116,826	113,058	116,950	81,778	79,140	81,778	85,686	88,542
1990	88,542	114,784	337,909	113,058	116,826	113,058	97,984	89,729	79,140	81,778	114,062	88,542
1991	176,717	79,974	116,826	337,893	116,826	113,058	97,312	93,502	79,140	81,778	381,002	177,699
1992	177,699	166,235	622,224	204,694	211,517	204,694	191,235	126,050	121,984	126,050	171,967	387,421
1993	177,699	160,503	574,463	204,694	211,517	204,694	195,651	126,050	121,984	126,050	85,686	88,542
1994	88,542	212,236	241,137	113,058	190,521	113,058	94,601	88,623	79,140	81,778	193,069	88,542
1995	88,542	79,974	345,446	113,058	116,826	113,058	126,050	195,651	121,984	126,050	85,686	126,917
1996	88,542	82,830	32,731	48,142	34,579	45,450	34,713	65,537	53,133	53,177	126,380	171,005
1997	88,542	79,974	615,401	204,694	211,517	204,694	199,717	126,050	121,984	126,050	171,967	399,038
1998	177,699	160,503	565,044	204,694	211,517	204,694	81,778	81,778	114,312	81,778	210,014	88,542
1999	88,542	79,974	182,983	113,058	252,909	113,058	81,778	81,778	79,140	81,778	85,686	88,542
2000	88,542	82,830	66,343	129,144	58,233	67,240	38,119	31,359	32,294	73,529	99,922	56,569
2001	56,569	51,094	540,747	204,694	211,517	204,694	87,203	88,916	95,451	81,778	220,805	88,542
2002	88,542	79,974	318,207	113,058	116,826	113,058	116,950	81,778	79,140	81,778	274,038	274,038
2003	177,699	160,503	211,517	204,694	211,517	588,109	81,778	81,778	118,942	81,778	159,580	88,542
2004	126,917	82,830	116,826	334,140	116,826	113,058	124,864	81,778	79,140	81,778	372,095	177,699
2005	177,699	160,503	211,517	204,694	211,517	204,694	86,119	110,502	79,140	81,778	30,783	31,359
2006	31,409	51,094	143,274	65,715	67,630	64,153	39,565	32,752	62,853	54,050	91,425	56,569
2007	56,569	50,018	356,752	113,058	116,826	113,058	195,356	126,050	121,984	126,050	171,967	177,699
2008	177,699	166,235	332,824	113,058	116,826	113,058	81,778	124,864	79,140	81,778	103,429	88,542
2009	88,542	79,974	143,666	57,148	58,787	42,369	66,679	32,169	56,529	58,413	217,949	88,542
2010	88,542	79,974	211,517	375,932	211,517	204,694	124,864	81,778	79,140	81,778	85,686	88,542
2011	113,493	79,974	116,826	113,058	116,826	113,058	31,372	31,359	30,347	69,899	46,331	100,894
2012	56,569	52,106	147,082	39,852	69,481	64,988	41,422	46,410	69,760	43,945	30,347	31,359
2013	102,719	51,094	45,389	67,240	59,960	53,550	69,760	32,396	53,316	57,815	223,661	88,542
2014	88,542	79,974	53,471	46,203	139,434	67,240	108,230	81,778	79,140	81,778	193,923	88,542
2015	88,542	79,974	308,330	113,058	116,826	113,058	150,685	126,050	121,984	162,883	404,770	177,699

Monthly Target Volume in Acre-Feet for Control Point BRPP27

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940	2,066	1,838	1,117	6,001	8,767	2,059	35,021	4,427	4,284	4,427	21,587	3,751
1941	3,751	3,388	37,465	47,064	7,379	7,140	47,998	7,379	7,140	7,379	30,387	6,149
1942	6,149	5,554	7,379	66,788	7,379	7,140	7,379	7,379	47,956	7,379	9,765	6,149
1943	6,149	5,554	4,612	10,588	4,612	23,122	4,427	4,427	4,284	4,427	1,012	1,045
1944	1,382	5,265	13,452	10,951	13,783	4,463	9,919	4,427	9,776	15,696	3,630	3,751
1945	3,751	3,388	67,470	4,463	4,612	4,463	50,389	7,379	7,140	7,379	5,950	6,149
1946	6,149	11,495	4,612	4,463	10,914	16,919	4,427	25,965	29,713	4,427	22,989	3,751
1947	3,751	3,388	4,612	4,463	54,942	4,463	4,427	4,427	4,284	4,427	3,630	17,030
1948	3,809	3,509	4,612	4,463	10,466	53,205	38,255	4,427	4,284	4,427	1,878	1,452
1949	1,147	4,739	4,612	7,806	44,268	4,463	4,427	4,427	31,672	16,713	3,630	3,751
1950	3,751	3,388	4,612	25,864	33,933	4,463	34,603	4,427	4,284	4,427	3,630	3,751
1951	3,751	3,388	1,265	1,328	15,225	2,190	2,384	2,199	1,559	1,045	1,012	1,045
1952	1,045	978	1,045	1,238	1,625	1,448	2,062	1,935	1,558	1,647	1,695	1,401
1953	1,082	944	1,405	1,099	14,981	1,012	13,389	1,958	1,716	1,958	9,244	1,730
1954	1,690	1,218	1,292	14,896	2,223	1,928	1,922	1,893	1,038	1,111	2,061	1,045
1955	1,838	1,623	1,801	1,404	14,983	2,104	13,324	2,003	2,015	2,223	1,859	1,428
1956	1,773	1,455	1,045	1,614	1,831	1,951	1,045	1,045	1,075	1,319	12,475	5,340
1957	1,045	1,993	1,774	14,493	2,223	2,321	26,399	7,379	7,140	36,799	28,099	6,149
1958	6,149	5,554	13,502	36,733	47,064	7,140	51,346	7,379	7,140	7,379	3,630	3,751
1959	3,751	3,388	1,220	1,012	12,081	2,190	13,834	1,456	1,012	1,912	3,630	13,373
1960	21,075	3,509	7,379	7,140	7,379	7,140	41,553	4,427	4,284	4,427	18,367	3,751
1961	15,797	3,388	4,612	4,463	14,409	56,873	33,601	4,427	4,284	4,427	25,609	3,794
1962	3,751	3,388	4,612	4,463	4,612	56,327	51,077	4,427	4,284	4,427	30,936	3,751
1963	3,751	3,388	4,612	58,309	4,612	4,463	1,170	1,045	1,584	1,821	15,961	1,569
1964	1,605	2,027	1,224	1,274	5,538	8,068	1,676	1,935	13,310	1,045	24,765	3,751
1965	3,751	3,388	4,612	33,184	24,217	4,463	4,427	4,427	25,051	29,570	3,630	3,751
1966	3,751	3,388	4,612	46,873	4,612	4,463	4,427	38,412	4,284	4,427	3,630	3,751
1967	3,751	3,388	1,249	15,019	1,220	2,190	13,447	1,773	1,513	1,787	1,012	1,295
1968	16,137	1,981	81,849	7,140	7,379	7,140	44,651	7,379	7,140	7,379	5,950	6,149
1969	6,149	8,252	43,422	23,919	4,612	4,463	4,427	4,427	49,673	4,427	20,157	3,751
1970	3,751	3,388	53,134	4,463	4,612	4,463	4,427	4,427	4,284	4,427	3,630	3,751
1971	3,751	3,388	1,937	1,640	2,267	14,644	2,332	13,094	1,650	2,368	6,957	12,457
1972	3,751	6,594	4,612	4,463	48,604	4,463	7,035	7,887	2,243	2,294	24,886	3,751
1973	3,751	3,388	29,673	4,463	4,612	4,463	4,427	7,265	6,692	17,141	5,950	6,149
1974	6,149	5,554	4,612	26,966	4,612	15,085	1,045	1,821	13,987	2,049	30,387	6,149
1975	6,149	5,554	7,379	12,813	53,188	25,702	49,033	11,123	7,140	7,379	9,509	4,325
1976	3,751	7,180	1,335	1,777	8,004	1,483	4,427	4,427	34,441	4,427	24,954	6,149
1977	6,149	5,554	45,781	32,512	7,379	7,140	4,427	4,427	4,284	4,427	1,377	1,483
1978	1,340	1,377	1,867	7,760	1,177	1,688	1,045	13,320	1,468	1,582	5,094	1,360
1979	4,135	4,573	37,767	6,014	24,217	4,463	12,918	5,277	4,284	4,427	3,630	3,751
1980	3,751	8,892	4,612	4,463	50,570	4,463	4,427	4,427	33,572	4,427	9,027	8,739
1981	2,236	1,601	14,590	1,868	1,962	2,233	4,427	4,427	4,284	41,696	12,504	12,339
1982	6,149	5,554	4,612	4,463	49,871	4,463	50,870	7,379	7,140	7,379	3,630	7,078
1983	3,751	12,869	4,612	4,463	56,727	4,463	4,427	4,427	4,284	35,504	19,388	3,751
1984	3,751	3,509	4,612	4,463	4,612	4,463	1,045	1,483	1,153	13,617	22,886	10,568
1985	3,751	3,388	28,235	7,140	7,379	46,588	4,427	4,427	4,284	39,610	3,630	3,751
1986	3,751	3,388	4,612	4,463	10,809	50,570	37,302	4,427	4,284	4,427	27,033	6,149
1987	6,149	5,554	52,447	7,140	25,912	7,140	18,950	7,379	7,140	7,379	3,630	26,096
1988	3,767	3,509	4,612	4,463	4,612	10,765	14,784	4,427	23,839	4,427	3,630	3,751
1989	3,751	18,932	4,612	4,463	49,882	4,463	7,379	7,379	50,715	7,379	5,950	6,149
1990	10,980	18,098	50,570	4,463	4,612	4,463	4,427	4,427	34,593	4,427	14,284	3,751
1991	12,747	3,388	4,612	4,463	61,942	4,463	4,427	39,758	4,284	4,427	25,133	6,149
1992	6,149	5,752	73,626	7,140	7,379	7,140	50,605	7,379	7,140	7,379	5,950	19,703
1993	6,205	26,990	33,943	7,140	7,379	7,140	7,379	7,379	7,140	12,584	3,630	9,504
1994	3,751	3,388	4,612	4,463	50,355	4,463	4,427	4,427	4,284	37,202	25,431	3,751
1995	3,751	3,388	4,612	4,463	16,919	46,852	9,200	49,797	7,140	7,379	5,950	6,149
1996	6,149	5,752	2,049	6,733	1,755	8,223	1,610	13,087	1,878	2,368	30,908	3,751
1997	3,751	3,388	43,249	46,112	7,379	7,140	17,312	7,379	7,140	7,379	5,950	6,149
1998	6,149	31,194	33,546	7,140	7,379	7,140	4,427	4,427	4,284	10,361	16,022	1,633
1999	2,435	1,583	26,883	19,640	10,914	4,463	4,427	4,427	4,284	4,427	3,630	3,751
2000	3,751	3,509	2,180	1,928	2,093	14,949	4,427	4,427	4,284	28,867	16,613	1,786
2001	2,460	1,172	63,676	7,140	7,379	7,140	4,427	4,427	15,968	4,427	23,792	3,751
2002	3,751	3,388	30,189	10,617	4,612	4,463	38,852	4,427	4,284	4,427	17,821	12,629
2003	3,751	3,388	4,612	4,463	4,612	57,319	4,427	4,427	8,625	4,427	9,148	3,751
2004	11,171	10,447	28,929	35,440	5,338	4,463	41,090	4,427	4,284	4,427	33,525	6,149
2005	6,149	5,554	7,379	7,140	13,502	7,140	9,919	33,857	4,284	4,427	1,012	1,045
2006	1,045	948	2,243	2,097	14,993	1,874	1,097	1,045	13,720	2,460	7,630	7,353
2007	5,991	1,784	14,973	2,112	2,049	2,015	48,804	7,379	7,140	7,379	5,950	6,149
2008	6,149	5,752	9,184	4,463	19,029	11,000	4,427	4,427	30,693	4,427	9,282	3,751
2009	3,751	3,388	2,398	2,017	2,180	2,321	13,502	1,775	2,335	2,323	9,498	15,830
2010	27,094	5,554	41,738	29,230	7,379	7,140	41,696	4,427	4,284	4,427	3,630	3,751
2011	3,751	3,388	4,612	4,463	4,612	4,463	1,045	1,045	1,012	5,293	1,012	16,371
2012	1,347	2,073	9,476	4,463	4,612	4,463	2,065	2,197	1,377	2,111	1,012	1,045
2013	2,049	1,537	2,354	1,578	1,562	1,492	13,663	2,460	2,152	1,871	1,615	9,260
2014	2,237	1,008	2,398	1,610	2,398	14,959	9,919	4,427	30,232	4,427	10,405	3,751
2015	7,078	3,388	4,612	37,960	24,514	4,463	33,404	7,379	7,140	20,140	32,364	6,149

Monthly Target Volume in Acre-Feet for Control Point BRRI70

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940	39,902	51,709	38,548	134,113	71,427	68,271	123,064	81,778	79,140	81,778	248,517	101,455
1941	101,455	91,636	603,673	236,827	244,721	236,827	205,539	134,658	130,314	134,658	451,001	203,524
1942	203,524	183,828	244,721	619,461	244,721	236,827	196,851	134,658	130,314	134,658	196,959	203,524
1943	203,524	183,828	208,605	257,588	131,583	127,339	106,664	95,393	79,140	81,778	39,111	49,772
1944	113,618	56,945	388,116	127,339	131,583	127,339	107,236	81,778	79,140	81,778	250,527	101,455
1945	101,455	91,636	379,626	127,339	131,583	127,339	205,539	134,658	130,314	134,658	196,959	437,871
1946	203,524	183,828	627,585	236,827	244,721	236,827	202,319	134,658	130,314	134,658	63,197	101,455
1947	101,455	91,636	376,979	127,339	131,583	127,339	87,829	106,664	79,140	81,778	46,959	110,326
1948	53,819	56,945	264,495	127,339	212,850	127,339	117,940	81,778	79,140	81,778	32,978	33,818
1949	43,827	111,010	355,689	127,339	131,583	127,339	122,379	81,778	79,140	81,778	145,691	193,200
1950	101,455	91,636	131,583	379,626	131,583	127,339	112,512	81,778	79,140	81,778	98,182	101,455
1951	101,455	91,636	42,719	45,165	54,740	145,818	33,818	34,609	51,775	36,943	32,727	34,429
1952	33,818	42,228	51,099	137,712	52,621	43,516	50,463	33,818	33,158	33,818	64,428	74,657
1953	54,695	51,987	144,275	43,054	73,170	45,580	61,962	35,326	42,565	47,276	189,876	152,236
1954	101,455	91,636	34,045	48,320	151,999	42,057	36,080	48,957	32,727	37,543	40,227	34,073
1955	35,932	105,744	45,925	143,217	58,059	55,664	51,700	46,880	42,653	46,160	36,237	33,909
1956	38,352	45,374	39,086	41,573	133,431	35,061	33,818	35,189	33,128	37,050	40,712	80,663
1957	33,818	40,145	126,707	66,018	73,170	70,810	210,125	134,658	130,314	134,658	444,436	203,524
1958	203,524	183,828	603,673	236,827	244,721	236,827	209,883	134,658	130,314	134,658	196,959	203,524
1959	203,524	289,813	131,583	379,626	131,583	127,339	123,064	81,778	79,140	81,778	248,910	101,455
1960	101,455	94,909	244,721	265,770	512,532	236,827	123,064	81,778	79,140	81,778	260,346	101,455
1961	101,455	91,636	550,907	236,827	244,721	236,827	123,064	81,778	79,140	81,778	240,043	101,455
1962	101,455	91,636	131,583	127,339	202,438	289,712	120,426	81,778	79,140	81,778	116,574	228,863
1963	101,455	91,636	131,583	257,884	204,360	127,339	54,526	33,818	32,822	37,642	47,893	44,190
1964	43,348	46,867	116,076	52,224	50,842	47,351	40,812	42,054	54,731	39,946	216,162	101,455
1965	101,455	91,636	208,605	281,382	131,583	127,339	115,150	81,778	79,140	81,778	253,800	101,455
1966	101,455	91,636	277,137	212,850	131,583	127,339	81,778	120,426	79,140	81,778	98,182	101,455
1967	101,455	91,636	38,734	54,313	119,833	61,347	59,683	35,368	48,778	41,740	224,967	101,455
1968	101,455	94,909	603,673	236,827	244,721	236,827	218,570	134,658	130,314	134,658	219,030	415,800
1969	203,524	183,828	593,359	236,827	244,721	236,827	134,658	134,658	169,295	152,862	139,145	203,018
1970	101,455	91,636	379,626	127,339	131,583	127,339	96,788	81,778	90,264	81,778	124,193	101,455
1971	101,455	91,636	44,383	41,513	126,454	48,333	52,478	55,649	47,041	51,907	142,418	199,746
1972	101,455	94,909	154,640	127,443	289,871	127,339	98,621	92,902	79,140	81,778	247,255	101,455
1973	101,455	91,636	362,648	127,339	131,583	127,339	189,252	134,658	130,314	134,658	373,385	248,314
1974	203,524	183,828	244,721	236,827	244,721	236,827	81,778	109,874	79,140	81,778	470,697	203,524
1975	203,524	183,828	244,721	573,859	244,721	236,827	209,883	134,658	130,314	134,658	98,182	101,455
1976	101,455	94,909	65,183	141,207	73,170	70,810	116,495	81,778	79,140	81,778	282,546	320,697
1977	203,524	183,828	497,221	326,224	244,721	236,827	100,145	81,778	79,140	81,778	46,466	41,744
1978	105,289	54,982	142,721	44,611	46,856	46,609	38,468	55,684	43,279	40,241	101,314	49,053
1979	60,873	54,982	366,893	127,339	131,583	127,339	195,494	134,658	130,314	134,658	196,959	203,524
1980	386,434	209,004	185,392	219,408	208,605	127,339	81,778	81,778	105,067	81,778	42,208	47,065
1981	45,810	47,159	135,856	54,451	73,170	68,875	123,064	81,778	79,140	81,778	457,567	203,524
1982	203,524	183,828	131,583	275,494	222,982	127,339	218,570	134,658	130,314	134,658	98,182	145,691
1983	145,691	142,418	337,180	127,339	131,583	127,339	89,702	104,026	79,140	81,778	98,182	127,021
1984	101,455	94,909	185,126	130,902	131,583	127,339	42,234	37,092	39,628	64,194	260,346	101,455
1985	101,455	91,636	587,884	236,827	244,721	236,827	91,069	81,778	79,140	90,264	233,211	101,455
1986	101,455	91,636	131,583	127,339	359,125	127,339	107,392	81,778	79,140	81,778	242,064	101,455
1987	101,455	91,636	611,567	236,827	244,721	236,827	209,883	134,658	130,314	134,658	131,660	203,836
1988	101,455	94,909	187,382	127,339	131,583	285,626	81,778	81,778	96,336	82,265	98,182	101,455
1989	158,784	160,601	207,801	258,559	131,583	127,339	118,464	81,778	79,140	81,778	98,182	101,455
1990	101,455	154,430	375,382	127,339	131,583	127,339	109,326	84,242	79,140	81,778	98,182	101,455
1991	260,346	91,636	131,583	361,007	131,583	127,339	107,990	81,778	79,140	81,778	419,811	203,524
1992	203,524	190,393	643,143	236,827	244,721	236,827	209,883	134,658	130,314	134,658	196,959	451,002
1993	203,524	183,828	588,568	236,827	244,721	236,827	218,570	134,658	130,314	134,658	98,182	101,455
1994	116,708	202,232	208,605	127,339	302,605	127,339	104,385	81,778	79,140	81,778	227,618	101,455
1995	101,455	91,636	383,871	127,339	131,583	127,339	153,451	172,270	130,314	134,658	98,182	148,964
1996	101,455	94,909	40,413	48,277	36,653	48,718	43,322	68,050	52,011	54,169	129,249	216,156
1997	101,455	91,636	643,143	236,827	244,721	236,827	218,570	134,658	130,314	134,658	196,959	470,697
1998	203,524	183,828	587,884	236,827	244,721	236,827	81,778	81,778	111,370	81,778	260,346	101,455
1999	101,455	91,636	195,871	127,339	281,382	127,339	81,778	81,778	79,140	81,778	98,182	101,455
2000	141,952	94,909	73,170	124,764	69,248	70,810	37,110	33,818	35,113	69,894	117,545	60,873
2001	60,873	54,982	244,721	236,827	244,721	236,827	90,264	101,388	79,140	81,778	263,618	101,455
2002	101,455	91,636	204,140	127,339	131,583	127,339	114,817	81,778	79,140	81,778	470,102	203,524
2003	203,524	183,828	244,721	236,827	244,721	524,726	81,778	81,778	115,150	81,778	239,634	101,455
2004	101,455	94,909	204,360	289,871	131,583	127,339	123,064	81,778	79,140	81,778	424,215	203,524
2005	203,524	183,828	244,721	236,827	244,721	236,827	88,709	97,271	79,140	81,778	38,343	35,635
2006	57,571	54,982	153,008	64,208	64,346	69,300	45,119	36,607	64,911	50,742	117,545	60,873
2007	60,873	54,982	400,850	127,339	131,583	127,339	214,226	134,658	130,314	134,658	196,959	203,524
2008	203,524	190,393	359,732	127,339	131,583	127,339	81,778	115,141	79,140	81,778	111,260	101,455
2009	101,455	91,636	152,194	48,241	59,021	33,228	61,071	34,101	55,339	57,183	266,891	101,455
2010	101,455	91,636	244,721	236,827	244,721	236,827	123,064	81,778	79,140	81,778	98,182	101,455
2011	146,643	91,636	131,583	127,339	131,583	127,339	34,479	33,818	32,727	63,677	45,978	108,166
2012	60,873	49,964	158,820	41,686	62,391	63,239	55,964	44,876	55,339	43,740	34,929	36,730
2013	113,618	54,982	42,812	69,243	66,906	56,218	66,592	35,728	54,959	57,183	266,891	101,455
2014	101,455	91,636	55,855	47,251	144,856	70,810	105,894	81,778	79,140	81,778	270,164	101,455
2015	101,455	91,636	353,636	127,339	131,583	127,339	134,658	134,658	130,314	199,734	470,697	203,524

Monthly Target Volume in Acre-Feet for Control Point BRRO72

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940	38,840	57,964	31,611	103,323	74,863	71,313	123,563	87,312	84,496	87,312	391,882	128,509
1941	128,509	116,073	592,779	282,050	291,451	282,050	217,073	161,712	156,496	161,712	550,413	288,992
1942	288,992	261,025	291,451	612,443	291,451	282,050	209,110	161,712	156,496	161,712	279,669	288,992
1943	288,992	261,025	239,399	196,836	158,023	152,926	119,367	87,312	84,496	87,312	38,482	47,530
1944	148,968	65,574	318,231	152,926	158,023	152,926	110,583	87,312	84,496	87,312	288,891	202,482
1945	128,509	116,073	308,036	152,926	158,023	152,926	203,397	161,712	156,496	161,712	279,669	410,380
1946	419,702	261,025	612,443	282,050	291,451	82,050	219,256	161,712	156,496	161,712	375,300	128,509
1947	128,509	116,073	302,938	152,926	158,023	152,926	87,312	120,746	84,496	87,312	48,068	66,313
1948	57,144	114,350	276,884	152,926	158,023	152,926	115,427	87,312	84,496	87,312	26,675	26,488
1949	44,689	144,243	292,743	152,926	158,023	152,926	118,930	87,312	84,496	87,312	124,364	192,765
1950	194,191	194,191	158,023	296,551	158,023	152,926	120,672	87,312	84,496	87,312	124,364	128,509
1951	128,509	116,073	38,455	72,448	62,676	72,118	26,440	27,466	46,716	28,370	25,587	27,584
1952	26,663	38,550	50,540	113,761	49,584	39,943	36,698	26,440	26,319	26,440	52,670	115,662
1953	60,788	54,619	114,408	37,331	76,036	46,066	67,781	27,431	37,925	37,605	124,364	358,718
1954	128,509	116,073	27,449	56,651	120,642	48,186	29,054	35,709	25,644	33,249	42,452	27,009
1955	30,796	138,153	44,045	107,295	60,448	56,489	44,761	53,239	55,339	50,396	42,694	27,148
1956	31,685	43,282	34,129	37,496	103,803	35,113	26,440	26,483	25,587	26,609	36,606	66,807
1957	26,440	57,679	105,925	73,518	76,860	74,380	229,479	161,712	156,496	161,712	494,479	288,992
1958	288,992	261,025	555,748	282,050	291,451	282,050	196,388	161,712	156,496	161,712	279,669	288,992
1959	288,992	360,733	158,023	306,838	158,023	152,926	122,628	87,312	84,496	87,312	346,112	128,509
1960	128,509	120,218	291,451	355,692	482,391	282,050	123,563	87,312	84,496	87,312	358,718	128,509
1961	128,509	116,073	527,370	282,050	291,451	282,050	123,563	87,312	84,496	87,312	271,132	206,627
1962	128,509	116,073	158,023	161,961	215,498	196,133	123,563	87,312	84,496	87,312	166,968	240,906
1963	128,509	190,045	158,023	271,254	158,023	152,926	40,201	27,003	26,008	33,692	59,520	43,084
1964	42,916	52,152	112,421	65,453	55,422	58,662	34,566	36,089	59,536	44,702	198,336	128,509
1965	301,327	116,073	231,348	196,133	158,023	152,926	112,692	87,312	84,496	87,312	276,455	206,627
1966	128,509	116,073	286,900	152,926	158,023	152,926	87,312	123,563	84,496	87,312	124,364	128,509
1967	128,509	116,073	35,391	97,237	60,645	58,612	62,492	32,770	49,423	37,860	204,965	128,509
1968	293,036	120,218	572,306	282,050	291,451	282,050	229,479	161,712	156,496	161,712	279,669	480,213
1969	288,992	261,025	595,992	282,050	291,451	282,050	161,712	161,712	174,730	161,712	124,364	276,455
1970	128,509	193,190	302,938	152,926	158,023	152,926	100,752	87,312	92,398	87,312	124,364	128,509
1971	128,509	116,073	41,991	66,063	52,014	45,970	68,394	57,183	45,769	52,467	124,364	374,176
1972	128,509	120,218	188,440	166,158	217,291	152,926	87,312	115,113	84,496	87,312	253,275	128,509
1973	206,627	116,073	269,094	152,926	158,023	152,926	208,780	161,712	156,496	161,712	439,054	325,772
1974	288,992	261,025	291,451	282,050	342,261	282,050	87,312	115,113	84,496	87,312	554,297	288,992
1975	288,992	261,025	291,451	559,579	291,451	282,050	220,167	161,712	156,496	161,712	124,364	128,509
1976	128,509	120,218	67,643	120,483	76,860	74,380	123,354	87,312	84,496	87,312	279,669	552,501
1977	288,992	261,025	519,703	282,050	291,451	282,050	106,426	87,312	84,496	87,312	46,376	38,829
1978	140,201	63,312	115,881	47,300	52,961	44,294	47,539	57,183	42,882	32,811	102,330	63,267
1979	70,096	63,312	287,645	152,926	158,023	152,926	208,613	161,712	156,496	161,712	279,669	288,992
1980	496,252	283,516	206,328	244,438	158,023	152,926	93,979	87,312	100,195	87,312	40,366	50,305
1981	44,346	51,074	117,441	63,373	73,840	74,380	123,563	87,312	84,496	87,312	559,736	288,992
1982	288,992	261,025	187,154	247,903	158,023	152,926	223,980	161,712	156,496	161,712	124,364	165,961
1983	128,509	276,455	277,450	152,926	158,023	152,926	98,525	96,579	84,496	87,312	124,364	153,775
1984	128,509	120,218	232,185	153,021	196,133	152,926	39,242	30,981	32,781	63,016	369,986	128,509
1985	128,509	116,073	593,640	282,050	291,451	282,050	115,113	87,312	84,496	87,312	371,155	128,509
1986	128,509	116,073	190,163	152,926	248,201	152,926	114,342	87,312	84,496	87,312	346,282	128,509
1987	128,509	116,073	569,953	282,050	291,451	282,050	219,046	161,712	156,496	161,712	154,111	235,373
1988	164,836	120,218	201,231	161,082	177,103	171,868	105,287	87,312	84,496	87,312	124,364	128,509
1989	150,285	228,783	206,328	239,340	158,023	152,926	123,563	87,312	84,496	87,312	124,364	128,509
1990	128,509	184,405	291,024	152,926	158,023	152,926	110,560	87,312	84,496	87,312	124,364	128,509
1991	392,929	116,073	196,133	249,535	158,023	152,926	115,542	87,312	84,496	87,312	391,736	410,380
1992	288,992	270,347	621,844	282,050	291,451	282,050	215,719	161,712	156,496	161,712	279,669	514,148
1993	288,992	261,025	532,216	282,050	291,451	282,050	219,046	161,712	156,496	161,712	194,191	128,509
1994	128,509	279,532	283,570	152,926	158,023	152,926	113,396	87,312	84,496	87,312	155,994	331,234
1995	128,509	116,073	277,450	152,926	158,023	152,926	206,731	161,712	156,496	161,712	124,364	206,627
1996	128,509	120,218	34,823	49,919	36,152	40,264	44,962	57,183	55,339	54,440	124,364	272,309
1997	190,045	116,073	619,330	282,050	291,451	282,050	219,046	161,712	156,496	161,712	279,669	569,058
1998	288,992	261,025	546,153	282,050	291,451	282,050	87,312	87,312	113,777	87,312	369,359	128,509
1999	128,509	116,073	229,145	191,036	158,023	152,926	87,312	87,312	84,496	87,312	124,364	128,509
2000	128,509	120,218	114,638	65,608	60,248	74,380	29,461	26,884	29,792	68,394	158,012	70,096
2001	70,096	63,312	291,451	349,242	291,451	282,050	91,949	94,424	96,579	87,312	383,591	128,509
2002	128,509	116,073	191,036	152,926	158,023	152,926	112,311	87,312	84,496	87,312	569,058	288,992
2003	288,992	261,025	394,436	282,050	291,451	412,447	105,325	87,312	84,496	87,312	202,482	128,509
2004	194,175	198,352	286,216	152,926	158,023	152,926	123,563	87,312	84,496	87,312	541,091	288,992
2005	288,992	261,025	291,451	282,050	291,451	282,050	111,723	87,312	84,496	87,312	34,578	34,623
2006	67,010	63,312	125,442	67,981	74,109	70,204	42,397	26,710	54,563	47,266	160,274	70,096
2007	70,096	63,312	313,133	152,926	158,023	152,926	225,951	161,712	156,496	161,712	279,669	288,992
2008	288,992	270,347	277,967	152,926	158,023	152,926	87,312	109,300	84,496	87,312	158,457	128,509
2009	128,509	116,073	117,183	46,642	68,050	35,527	61,143	26,440	55,339	57,183	396,028	128,509
2010	128,509	116,073	291,451	282,050	291,451	282,050	123,563	87,312	84,496	87,312	124,364	128,509
2011	128,509	116,073	158,023	152,926	158,023	152,926	41,581	26,440	27,545	63,378	38,886	155,751
2012	70,096	55,716	127,921	69,144	57,274	62,855	52,300	56,124	55,339	43,630	37,295	33,630
2013	150,902	63,312	33,181	99,775	68,807	49,494	64,336	26,440	55,339	57,183	387,737	128,509
2014	128,509	116,073	36,489	35,072	07,771	74,380	112,537	87,312	84,496	87,312	375,300	128,509
2015	128,509	116,073	280,897	152,926	158,023	152,926	179,946	161,712	156,496	179,946	578,380	288,992

Monthly Target Volume in Acre-Feet for Control Point BRSB23

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940	2,214	969	61	7,919	1,501	1,615	8,743	2,828	2,737	2,828	4,344	4,489
1941	4,489	4,054	21,452	5,950	6,149	5,950	12,514	5,841	5,653	5,841	7,140	7,379
1942	7,379	6,664	6,149	21,254	6,149	5,950	5,841	12,326	5,653	5,841	7,140	7,379
1943	7,379	6,664	16,925	6,441	6,149	5,950	8,561	2,828	2,737	2,828	60	73
1944	719	974	10,612	3,570	10,850	3,570	8,780	2,828	2,737	2,828	4,344	4,489
1945	4,489	4,054	18,011	3,570	3,689	3,570	8,561	2,828	2,737	2,828	4,344	4,489
1946	4,489	4,054	3,689	3,570	10,850	10,612	8,835	2,828	2,737	2,828	4,344	4,489
1947	4,489	4,054	3,689	3,570	17,892	3,570	2,828	2,828	4,880	5,877	893	2,214
1948	1,897	1,295	10,493	3,570	10,850	3,570	8,926	2,828	2,737	2,828	4,344	4,489
1949	4,489	4,054	3,689	9,420	11,685	3,570	7,830	2,828	2,737	2,828	4,344	4,489
1950	4,489	4,054	3,689	17,654	3,689	3,570	8,554	2,828	2,737	2,828	4,344	4,489
1951	4,489	4,054	1,189	862	8,854	1,670	4,060	562	952	230	140	61
1952	82	186	89	670	8,648	1,001	3,750	292	374	61	490	457
1953	98	56	813	4,080	1,261	129	3,891	984	724	846	2,003	2,214
1954	2,214	836	355	8,412	1,672	1,726	742	2,559	60	180	1,191	456
1955	881	1,439	7,882	1,036	1,536	1,670	4,060	984	830	924	2,142	2,214
1956	2,214	2,071	1,632	1,139	8,807	926	78	133	78	528	678	713
1957	206	1,696	1,660	8,556	1,728	1,726	12,326	5,841	5,653	5,841	7,140	7,379
1958	7,379	6,664	6,149	11,708	15,694	5,950	12,703	5,841	5,653	5,841	4,344	4,489
1959	4,489	4,054	161	865	8,565	1,726	4,092	984	639	776	4,344	4,489
1960	4,489	4,199	6,149	5,950	6,149	5,950	8,835	2,828	2,737	2,828	4,344	4,489
1961	4,489	4,054	6,149	5,950	21,452	5,950	12,703	5,841	5,653	5,841	7,140	7,379
1962	7,379	6,664	3,689	3,570	3,689	17,773	8,583	2,828	2,737	2,828	4,344	4,489
1963	4,489	4,054	6,427	14,797	3,689	3,570	2,828	2,828	8,652	2,828	2,142	2,214
1964	2,214	1,793	3,689	3,570	8,093	13,250	309	3,616	578	802	882	61
1965	184	775	3,689	17,535	3,689	3,570	2,828	8,926	2,737	2,828	4,344	4,489
1966	4,489	4,054	3,689	17,773	3,689	3,570	2,828	8,743	2,737	2,828	4,344	4,489
1967	4,489	4,054	1,783	8,948	1,783	1,726	4,092	984	952	984	1,704	1,560
1968	1,728	891	17,535	3,570	3,689	3,570	12,514	5,841	5,653	5,841	4,344	4,489
1969	4,489	4,054	17,535	3,570	3,689	3,570	5,841	5,841	12,326	5,841	7,140	7,379
1970	7,379	6,664	17,773	3,570	3,689	3,570	2,828	2,828	2,737	2,828	4,344	4,489
1971	4,489	4,054	902	441	7,396	1,726	805	4,092	952	955	4,344	4,489
1972	4,489	4,199	3,689	7,299	11,902	3,570	8,287	2,828	2,737	2,828	4,344	4,489
1973	4,489	4,054	21,254	5,950	6,149	5,950	12,514	5,841	5,653	5,841	7,140	7,379
1974	7,379	6,664	3,689	15,274	3,924	3,570	984	3,926	952	924	7,140	7,379
1975	7,379	6,664	6,149	5,950	21,452	5,950	12,514	5,841	5,653	5,841	7,140	7,379
1976	7,379	6,902	3,689	3,570	3,689	3,570	5,666	5,695	2,737	2,828	4,344	4,489
1977	4,489	4,054	18,011	3,570	3,689	3,570	2,828	2,828	2,737	2,828	115	803
1978	694	1,590	1,753	7,948	561	1,614	347	3,886	952	984	2,142	2,214
1979	2,214	1,999	17,773	3,570	3,689	3,570	8,561	2,828	2,737	2,828	4,344	4,489
1980	4,489	4,199	3,689	3,570	17,892	3,570	2,828	2,828	8,835	2,828	4,344	4,489
1981	4,489	4,054	10,612	10,493	3,689	3,570	5,786	5,786	2,737	2,828	4,344	4,489
1982	4,489	4,054	3,689	3,570	17,892	3,570	12,703	5,841	5,653	5,841	4,344	4,489
1983	4,489	4,054	3,689	3,570	17,773	3,570	2,828	2,828	2,737	8,926	4,344	4,489
1984	4,489	4,199	3,689	3,570	3,689	3,570	461	524	495	4,060	4,344	4,489
1985	4,489	4,054	21,452	5,950	6,149	5,950	11,950	6,218	5,653	5,841	7,140	7,379
1986	7,379	6,664	3,689	3,570	9,898	10,493	8,926	2,828	2,737	2,828	7,140	7,379
1987	7,379	6,664	21,452	5,950	6,149	5,950	12,326	5,841	5,653	5,841	7,140	7,379
1988	7,379	6,902	3,689	3,570	3,689	3,570	8,647	2,828	2,737	2,828	4,344	4,489
1989	4,489	4,054	3,689	3,570	15,773	3,570	2,828	8,926	2,737	2,828	4,344	4,489
1990	4,489	4,054	17,773	3,570	3,689	3,570	2,828	8,835	2,737	2,828	4,344	4,489
1991	4,489	4,054	3,689	3,570	17,892	3,570	8,743	2,828	2,737	2,828	7,140	7,379
1992	7,379	6,902	21,650	5,950	6,149	5,950	12,514	5,841	5,653	5,841	7,140	7,379
1993	7,379	6,664	21,254	5,950	6,149	5,950	5,841	5,841	5,653	12,514	7,140	7,379
1994	7,379	6,664	3,689	3,570	18,011	3,570	5,695	2,828	5,695	2,828	4,344	4,489
1995	4,489	4,054	3,689	3,570	17,416	3,570	8,652	2,828	2,737	2,828	7,140	7,379
1996	7,379	6,902	3,689	3,570	3,689	3,570	680	3,387	774	984	4,344	4,489
1997	4,489	4,054	21,452	5,950	6,149	5,950	12,514	5,841	5,653	5,841	7,140	7,379
1998	7,379	6,664	6,149	5,950	6,149	5,950	2,828	2,828	2,737	2,828	60	197
1999	615	811	907	8,891	1,590	874	8,926	2,828	2,737	2,828	4,344	4,489
2000	4,489	4,199	81	8,891	1,783	1,726	8,743	2,828	2,737	2,828	640	2,214
2001	1,966	264	21,452	5,950	6,149	5,950	5,695	2,828	2,737	5,786	4,344	4,489
2002	4,489	4,054	3,689	3,570	17,654	3,570	8,743	2,828	2,737	2,828	4,344	4,489
2003	4,489	4,054	3,689	3,570	3,689	3,570	8,926	2,828	2,737	2,828	4,344	4,489
2004	4,489	4,199	3,689	3,570	3,689	3,570	8,835	2,828	2,737	2,828	7,140	7,379
2005	7,379	6,664	6,149	5,950	6,149	5,950	5,841	5,841	12,514	5,841	4,344	4,489
2006	4,489	4,054	1,459	1,594	1,312	8,891	929	629	60	3,614	2,142	2,214
2007	2,094	1,938	3,689	3,570	3,689	17,654	12,703	5,841	5,653	5,841	7,140	7,379
2008	7,379	6,902	3,689	17,416	3,689	3,570	8,743	2,828	2,737	2,828	4,344	4,489
2009	4,489	4,054	1,783	1,388	832	1,418	4,029	924	812	389	4,344	4,489
2010	4,489	4,054	3,689	15,955	3,689	3,570	8,743	2,828	2,737	2,828	4,344	4,489
2011	4,489	4,054	3,689	3,570	3,689	3,570	61	61	269	61	1,142	1,965
2012	344	2,071	804	1,024	190	649	3,862	121	478	61	1,637	72
2013	61	56	61	176	286	1,148	3,759	984	952	897	517	64
2014	127	200	305	164	69	60	954	677	69	4,029	2,142	1,472
2015	1,282	298	3,689	3,570	3,689	17,773	12,326	5,841	5,653	5,841	7,140	7,379

Monthly Target Volume in Acre-Feet for Control Point BRSE11

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940	61	229	61	3,125	290	336	4,410	799	774	799	1,488	1,537
1941	1,537	1,388	7,814	2,083	2,152	2,083	5,014	1,968	1,904	1,968	2,737	2,828
1942	2,828	2,555	2,152	7,744	2,152	2,083	5,257	1,968	1,904	1,968	2,737	2,828
1943	2,828	2,555	2,152	7,814	2,152	2,083	4,333	799	774	799	75	468
1944	578	575	1,168	1,131	6,938	1,131	4,488	799	774	799	1,488	1,537
1945	1,537	1,388	4,015	1,131	1,168	3,978	4,436	799	774	799	1,488	1,537
1946	1,537	1,388	1,168	1,131	3,385	4,683	4,488	799	774	799	1,488	1,537
1947	1,537	1,388	1,168	1,131	6,938	1,131	799	799	774	799	450	615
1948	482	464	4,015	1,131	3,698	1,335	4,462	799	774	799	1,488	1,537
1949	1,537	1,388	1,168	1,131	7,013	1,131	799	799	4,462	799	1,488	1,537
1950	1,537	1,388	1,168	6,824	1,168	1,131	4,385	799	774	799	1,488	1,537
1951	1,537	1,388	430	376	3,303	417	2,066	165	225	61	110	99
1952	156	245	174	209	3,289	231	2,049	86	65	61	167	258
1953	61	323	348	173	3,168	84	2,056	246	169	234	595	615
1954	615	435	178	3,242	430	417	175	61	60	61	200	265
1955	427	373	3,166	330	430	417	2,074	246	181	246	595	615
1956	615	575	430	371	3,377	351	69	106	60	1,971	138	185
1957	103	496	369	3,234	419	405	5,154	1,968	1,904	1,968	2,737	2,828
1958	2,828	2,555	2,152	2,083	7,814	2,083	4,827	1,968	1,904	1,968	1,488	1,537
1959	1,537	1,388	125	303	405	3,349	2,096	246	110	223	1,488	1,537
1960	1,537	1,438	2,152	2,083	2,152	2,083	4,462	799	774	799	1,488	1,537
1961	1,537	1,388	2,152	2,083	7,953	2,083	5,014	1,968	1,904	1,968	2,737	2,828
1962	2,828	2,555	1,168	3,119	1,627	3,978	4,462	799	774	799	1,488	1,537
1963	1,537	1,388	2,459	5,534	1,168	1,131	799	799	4,462	799	595	615
1964	577	575	1,168	1,131	1,168	6,900	97	91	2,018	221	361	415
1965	424	292	1,168	4,015	4,091	1,131	799	4,462	774	799	1,488	1,537
1966	1,537	1,388	1,168	6,900	1,168	1,131	799	4,462	774	799	1,488	1,537
1967	1,537	1,388	430	3,363	430	417	2,108	246	238	246	586	615
1968	615	575	6,982	1,131	1,168	1,131	5,563	1,968	1,904	1,968	1,488	1,537
1969	1,537	1,388	1,168	1,131	6,975	1,131	1,968	1,968	3,427	1,968	2,737	2,828
1970	2,828	2,555	7,013	1,131	1,168	1,131	799	799	774	799	1,488	1,537
1971	1,537	1,388	257	177	3,049	417	152	2,084	238	246	1,488	1,537
1972	1,537	1,438	1,168	1,131	6,824	1,131	4,436	799	774	799	1,488	1,537
1973	1,537	1,388	7,883	2,083	2,152	2,083	1,968	1,968	4,951	1,968	2,737	2,828
1974	2,828	2,555	1,168	1,131	1,168	6,975	80	1,964	228	246	2,737	2,828
1975	2,828	2,555	2,152	2,083	7,953	2,083	3,491	1,968	1,904	1,968	2,737	2,828
1976	2,828	2,646	1,168	6,900	1,168	1,131	4,410	799	774	799	1,488	1,537
1977	1,537	1,388	1,168	6,900	1,168	1,131	799	4,310	925	799	198	274
1978	538	504	406	155	3,192	348	109	2,108	238	246	595	615
1979	615	555	1,168	1,131	6,900	1,131	4,385	799	774	799	1,488	1,537
1980	1,537	1,438	1,168	1,131	6,975	1,131	799	799	4,149	799	1,488	1,537
1981	1,537	1,388	1,168	6,749	1,168	1,131	799	4,462	774	799	1,488	1,537
1982	1,537	1,388	1,168	1,131	7,013	1,131	4,966	1,968	1,904	1,968	1,488	1,537
1983	1,537	1,388	1,168	1,131	7,013	1,131	799	799	774	4,379	1,488	1,537
1984	1,537	1,438	1,168	1,131	1,168	1,131	115	178	1,991	246	1,488	1,537
1985	1,537	1,388	2,152	7,814	2,152	2,083	4,477	1,968	1,904	1,968	2,737	2,828
1986	2,828	2,555	1,168	3,419	1,614	3,992	4,462	799	774	799	2,737	2,828
1987	2,828	2,555	7,536	2,083	2,152	2,083	5,628	1,968	1,904	1,968	2,737	2,828
1988	2,828	2,646	1,168	1,131	1,168	1,131	4,460	799	774	799	1,488	1,537
1989	1,537	1,388	1,168	1,131	7,013	1,131	799	799	4,462	799	1,488	1,537
1990	1,537	1,388	6,900	1,131	1,168	1,131	2,592	2,618	774	799	1,488	1,537
1991	1,537	1,388	1,168	1,131	7,013	1,131	799	4,462	774	799	2,737	2,828
1992	2,828	2,646	7,744	2,083	2,152	2,083	4,836	1,968	1,904	1,968	2,737	2,828
1993	2,828	2,555	7,883	2,083	2,152	2,083	1,968	1,968	1,904	1,968	2,737	2,828
1994	2,828	2,555	1,168	1,131	7,013	1,131	799	2,307	2,618	799	1,488	1,537
1995	1,537	1,388	1,168	1,131	6,824	1,131	2,592	2,644	774	799	2,737	2,828
1996	2,828	2,646	1,168	1,131	1,168	5,500	2,031	205	238	246	1,488	1,537
1997	1,537	1,388	2,152	7,814	2,152	2,083	5,705	1,968	1,904	1,968	2,737	2,828
1998	2,828	2,555	2,152	2,083	2,152	2,083	799	2,644	774	799	106	318
1999	115	412	312	3,349	421	417	4,488	799	774	799	1,488	1,537
2000	1,537	1,438	122	3,363	430	417	4,488	799	774	799	595	615
2001	615	465	2,152	7,744	2,152	2,083	4,410	799	774	799	1,488	1,537
2002	1,537	1,388	1,168	1,131	6,900	1,131	4,488	799	774	799	1,488	1,537
2003	1,537	1,388	1,168	1,131	1,168	1,131	4,488	799	774	799	1,488	1,537
2004	1,537	1,438	1,168	6,862	1,168	1,131	4,488	799	774	799	2,737	2,828
2005	2,828	2,555	2,152	2,083	2,152	2,083	1,968	4,966	1,904	1,968	1,488	1,537
2006	1,537	1,388	430	417	430	3,349	182	206	112	2,097	595	615
2007	615	555	1,168	1,131	4,015	4,015	3,491	1,968	1,904	1,968	2,737	2,828
2008	2,828	2,646	1,168	1,131	1,168	3,978	799	799	774	4,385	1,488	1,537
2009	1,537	1,388	430	417	430	372	2,100	246	238	246	1,488	1,537
2010	1,537	1,388	1,168	3,978	4,053	1,131	4,436	799	774	799	1,488	1,537
2011	1,537	1,388	1,168	1,131	1,168	1,131	61	64	60	61	280	62
2012	324	184	186	217	78	353	1,979	85	233	203	383	61
2013	66	263	169	198	178	417	2,097	246	238	216	519	62
2014	118	195	275	108	89	368	2,108	190	234	246	595	615
2015	615	555	1,168	1,131	1,168	6,975	5,014	1,968	1,904	1,968	2,737	2,828

Monthly Target Volume in Acre-Feet for Control Point BRWA41

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940	6,054	4,243	4,303	37,550	8,238	8,180	44,888	15,372	14,876	15,372	48,446	12,912
1941	12,912	11,663	136,945	138,952	42,426	41,058	82,056	36,278	35,107	36,278	77,106	29,514
1942	29,514	26,658	42,426	238,215	42,426	41,058	36,278	36,278	84,397	36,278	28,562	29,514
1943	29,514	26,658	16,602	16,066	16,602	16,066	15,372	15,372	22,948	19,541	3,364	4,041
1944	6,657	18,486	71,771	48,231	16,602	16,066	20,953	16,733	33,397	15,372	12,496	23,390
1945	34,939	11,663	110,953	16,066	16,602	16,066	83,226	36,278	35,107	36,278	28,562	47,940
1946	29,514	49,502	138,952	41,058	42,426	41,058	36,278	36,278	82,056	36,278	48,446	12,912
1947	12,912	11,663	47,695	16,066	79,860	16,066	15,372	15,372	14,876	30,635	5,226	18,033
1948	5,963	5,621	16,602	16,066	48,231	47,160	44,393	15,372	14,876	15,372	5,115	4,214
1949	5,032	17,931	16,602	16,066	111,488	16,066	15,372	15,372	44,393	15,372	12,496	12,912
1950	12,912	45,551	16,602	78,788	48,231	16,066	43,897	15,372	14,876	15,372	12,496	12,912
1951	12,912	11,663	5,057	4,625	38,420	7,807	5,177	7,018	13,255	3,891	4,010	5,360
1952	3,549	4,039	3,546	38,652	8,711	3,332	5,060	5,077	6,775	3,462	16,726	5,067
1953	5,635	3,957	38,708	7,448	6,840	3,332	16,958	4,443	4,950	6,442	12,496	12,912
1954	12,912	11,663	4,654	7,788	40,955	8,180	6,511	6,528	3,702	16,327	4,605	3,443
1955	3,443	5,478	6,332	6,053	40,796	8,366	15,289	6,958	7,226	7,442	6,633	5,572
1956	4,969	5,059	4,857	7,455	39,464	5,894	3,577	4,858	4,333	13,112	5,675	16,837
1957	3,443	4,380	7,556	41,142	9,223	8,926	77,669	36,278	35,107	36,278	76,154	29,514
1958	29,514	26,658	42,426	70,705	211,293	41,058	85,567	36,278	35,107	36,278	28,562	29,514
1959	29,514	26,658	16,602	16,066	16,602	109,346	44,393	15,372	14,876	15,372	23,646	36,879
1960	12,912	12,079	42,426	41,058	42,426	41,058	44,888	15,372	14,876	15,372	22,397	36,463
1961	12,912	11,663	42,426	41,058	42,426	235,478	43,897	15,372	14,876	15,372	48,446	12,912
1962	12,912	11,663	16,602	16,066	16,602	110,953	45,384	15,372	14,876	15,372	18,797	29,328
1963	12,912	11,663	16,602	47,695	74,428	16,066	7,131	3,443	4,142	5,299	16,859	3,950
1964	5,279	5,523	8,516	39,501	8,540	7,750	4,336	7,232	18,146	4,789	48,030	12,912
1965	12,912	11,663	36,581	43,841	58,419	16,066	15,372	23,946	33,893	15,372	35,063	12,912
1966	12,912	11,663	16,602	112,560	16,602	16,066	15,372	42,409	14,876	15,372	12,496	12,912
1967	12,912	11,663	5,808	7,923	8,713	39,952	17,720	7,839	7,280	7,314	23,561	12,912
1968	36,463	12,079	236,846	41,058	42,426	41,058	84,397	36,278	35,107	36,278	28,562	29,514
1969	29,514	26,658	42,426	41,058	242,321	41,058	36,278	36,278	83,226	36,278	34,797	24,479
1970	12,912	11,663	110,953	16,066	16,602	16,066	15,372	15,372	14,876	33,397	12,496	12,912
1971	12,912	11,663	7,427	19,957	7,446	5,383	17,085	7,775	6,998	7,942	23,646	36,046
1972	12,912	12,079	16,602	16,066	16,602	16,066	31,515	24,880	14,876	15,372	47,613	12,912
1973	12,912	11,663	48,231	79,324	16,602	16,066	69,658	36,278	35,107	36,278	28,562	29,514
1974	29,514	26,658	42,426	41,058	42,426	41,058	15,372	41,614	16,167	15,372	78,058	29,514
1975	29,514	26,658	42,426	231,168	42,426	41,058	36,278	36,278	35,107	36,278	12,496	12,912
1976	12,912	12,079	5,304	39,909	8,622	8,556	44,888	15,372	14,876	15,372	74,250	29,514
1977	29,514	26,658	240,952	41,058	42,426	41,058	15,372	15,372	14,876	15,372	4,471	3,535
1978	3,985	5,076	7,256	5,555	7,590	5,966	3,686	16,387	3,832	7,009	5,568	4,442
1979	6,733	17,996	109,346	16,066	16,602	16,066	36,278	36,278	35,107	36,278	28,562	29,514
1980	52,358	27,610	16,602	16,066	110,417	16,066	15,372	15,372	43,897	15,372	5,488	6,794
1981	7,017	5,465	8,329	8,191	7,400	41,031	30,790	15,372	14,876	24,384	51,406	29,514
1982	29,514	26,658	44,482	16,066	78,788	16,066	86,737	36,278	35,107	36,278	12,496	12,912
1983	12,912	43,208	16,602	16,066	48,066	16,066	15,372	15,372	14,876	44,393	12,496	12,912
1984	12,912	12,079	16,602	16,066	16,602	16,066	3,680	4,906	4,406	18,053	43,108	12,912
1985	12,912	11,663	42,426	41,058	42,426	41,058	15,372	15,372	14,876	44,888	22,243	36,772
1986	12,912	11,663	16,602	16,066	47,160	79,324	43,962	15,372	14,876	15,372	46,119	12,912
1987	12,912	11,663	138,952	41,058	141,637	41,058	36,278	36,278	35,107	36,278	12,496	46,656
1988	12,912	12,079	16,602	16,066	16,602	79,324	15,372	15,372	43,356	15,372	12,496	12,912
1989	18,958	39,485	98,592	28,963	16,602	16,066	15,372	33,893	24,384	15,372	12,496	12,912
1990	12,912	33,688	110,953	16,066	16,602	16,066	15,372	15,372	43,512	15,372	12,496	12,912
1991	45,947	11,663	16,602	47,695	79,860	16,066	20,697	34,884	14,876	15,372	78,058	29,514
1992	29,514	27,610	239,581	41,058	42,426	41,058	59,167	36,278	35,107	36,278	46,457	53,310
1993	29,514	26,658	42,426	41,058	42,426	41,058	36,278	36,278	35,107	84,397	12,496	12,912
1994	12,912	46,780	16,602	16,066	112,560	16,066	23,061	15,372	14,876	34,884	46,364	12,912
1995	12,912	11,663	112,887	16,066	16,602	16,066	47,856	73,988	35,107	36,278	12,496	12,912
1996	12,912	12,079	5,192	7,769	7,151	7,971	4,973	17,935	7,728	6,844	46,026	12,912
1997	12,912	11,663	239,583	41,058	42,426	41,058	60,337	36,278	35,107	36,278	28,562	79,010
1998	29,514	26,658	42,426	41,058	42,426	41,058	15,372	15,372	14,876	43,066	45,945	12,912
1999	12,912	11,663	108,028	16,066	16,602	16,066	15,372	15,372	14,876	24,880	12,496	12,912
2000	24,479	23,646	7,370	4,824	6,646	40,427	5,815	3,443	3,709	18,126	18,922	6,617
2001	7,379	6,664	42,426	41,058	42,426	41,058	15,372	15,372	42,409	15,372	45,773	12,912
2002	12,912	11,663	98,569	27,877	16,602	16,066	44,888	15,372	14,876	15,372	28,562	63,232
2003	32,720	26,658	42,426	41,058	42,426	238,215	23,393	15,372	29,073	15,372	12,496	12,912
2004	12,912	47,197	47,160	80,395	16,602	16,066	45,384	15,372	14,876	15,372	75,505	29,514
2005	29,514	26,658	42,426	41,058	42,426	41,058	35,125	20,672	14,876	15,372	5,081	3,738
2006	4,145	6,493	36,075	11,048	7,359	7,287	4,678	4,478	15,498	6,124	17,762	6,534
2007	7,379	5,965	106,761	16,066	16,602	16,066	84,397	36,278	35,107	36,278	28,562	29,514
2008	29,514	27,610	77,465	47,160	16,602	16,066	15,372	42,905	14,876	15,372	12,496	12,912
2009	12,912	11,663	6,152	39,929	9,037	8,926	18,553	7,844	7,664	8,108	22,511	12,912
2010	36,879	11,663	42,426	41,058	42,426	41,058	43,901	15,372	14,876	15,372	12,496	12,912
2011	12,912	11,663	16,602	16,066	16,602	16,066	3,528	3,879	7,181	16,831	6,412	18,209
2012	7,125	6,522	39,510	7,286	8,936	7,537	7,866	8,314	18,275	7,609	3,382	3,692
2013	16,639	6,417	5,052	8,926	8,217	7,331	18,497	8,608	6,452	6,045	12,496	24,479
2014	12,912	11,663	4,239	5,128	40,955	6,203	35,100	15,372	23,888	15,372	47,845	12,912
2015	12,912	11,663	46,624	79,860	16,602	16,066	83,226	36,278	35,107	36,278	77,106	29,514

Monthly Target Volume in Acre-Feet for Control Point CFFG18

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940	157	355	188	186	143	220	584	307	298	307	595	615
1941	615	555	2,917	893	922	893	1,434	676	655	676	1,078	984
1942	984	889	922	2,887	922	893	676	676	1,368	676	1,078	984
1943	984	889	922	2,496	922	893	416	307	298	307	60	61
1944	73	81	699	417	430	417	584	307	298	307	595	615
1945	615	555	685	417	430	417	584	307	298	307	595	615
1946	615	555	430	671	430	417	436	446	298	307	595	615
1947	615	555	430	417	699	417	574	307	298	307	60	398
1948	367	352	699	417	430	417	584	307	298	307	595	615
1949	615	555	430	685	430	417	584	307	298	307	595	615
1950	615	555	430	685	430	417	584	307	298	307	595	615
1951	615	555	160	125	127	214	134	61	60	61	60	61
1952	94	106	62	202	251	152	61	132	60	61	345	121
1953	71	56	81	214	208	65	134	61	60	61	60	61
1954	61	56	169	149	222	200	61	61	60	134	191	61
1955	154	243	189	97	151	190	134	61	60	61	60	61
1956	61	58	61	177	174	60	61	61	60	61	60	61
1957	61	294	292	222	246	238	1,434	676	655	676	1,053	984
1958	984	889	922	893	2,917	893	1,434	676	655	676	595	615
1959	615	555	61	60	193	226	134	61	60	61	595	615
1960	615	575	922	893	922	893	584	307	298	307	595	615
1961	615	555	922	893	922	2,917	1,434	676	655	676	1,047	984
1962	984	889	685	417	430	417	584	307	298	307	595	615
1963	615	555	491	611	430	417	307	307	298	307	60	61
1964	61	346	551	537	430	417	132	61	60	61	60	61
1965	61	60	430	671	430	417	574	307	298	307	595	615
1966	615	555	551	551	430	417	307	565	298	307	595	615
1967	615	555	206	60	166	131	134	61	60	61	272	231
1968	326	200	699	417	430	417	1,390	676	655	676	595	615
1969	615	555	664	417	430	417	676	1,111	830	676	1,078	984
1970	984	889	699	417	430	417	307	307	298	307	595	615
1971	615	555	215	190	115	238	132	61	60	61	595	615
1972	615	575	671	417	430	417	584	307	298	307	595	615
1973	615	555	2,917	893	922	893	676	676	1,412	676	952	984
1974	984	889	430	651	430	417	61	134	60	61	1,078	984
1975	984	889	922	893	2,917	893	1,434	676	655	676	1,047	984
1976	984	920	430	653	430	417	584	307	298	307	595	615
1977	615	555	685	417	430	417	421	307	436	307	76	400
1978	346	389	304	60	79	194	61	134	60	61	417	430
1979	430	389	677	417	430	417	574	307	298	307	595	615
1980	615	575	430	417	699	417	307	307	574	307	595	615
1981	615	555	699	417	430	417	584	307	298	307	595	615
1982	615	555	660	417	430	417	1,434	676	655	676	595	615
1983	615	555	671	417	430	417	564	307	298	307	595	615
1984	615	575	430	417	430	417	61	61	60	134	595	615
1985	615	555	2,943	893	922	893	1,412	676	655	676	952	984
1986	1,047	889	430	657	430	417	574	307	298	307	1,078	984
1987	984	889	2,947	893	922	893	1,434	676	655	676	952	1,078
1988	984	920	671	417	430	417	574	307	298	307	595	615
1989	615	555	671	417	430	417	584	307	298	307	595	615
1990	615	555	699	417	430	417	307	584	298	307	595	615
1991	615	555	699	417	430	417	546	307	298	307	1,078	984
1992	984	920	2,947	893	922	893	1,434	676	655	676	1,047	984
1993	984	889	922	2,887	922	893	676	676	655	1,412	1,047	984
1994	984	889	664	417	430	417	307	307	548	307	595	615
1995	615	555	551	534	430	417	584	307	298	307	1,078	984
1996	984	920	430	657	430	417	61	134	60	61	595	615
1997	615	555	2,828	893	922	893	1,434	676	655	676	952	1,047
1998	984	889	922	893	922	893	517	307	298	307	60	134
1999	395	377	304	161	175	83	584	307	298	307	595	615
2000	615	575	140	238	152	77	584	307	298	307	155	430
2001	196	91	2,917	893	922	893	584	307	298	307	595	615
2002	615	555	565	551	430	417	584	307	298	307	595	615
2003	615	555	430	676	430	417	584	307	298	307	595	615
2004	615	575	430	417	699	417	584	307	298	307	952	1,110
2005	984	889	922	893	922	893	1,412	676	655	676	595	615
2006	615	555	207	246	158	238	134	61	60	61	60	61
2007	61	56	430	417	430	685	1,434	676	655	676	1,066	984
2008	984	920	685	417	430	417	584	307	298	307	595	615
2009	615	555	242	238	185	143	134	61	60	61	595	615
2010	615	555	685	417	430	417	584	307	298	307	595	615
2011	615	555	671	417	430	417	61	61	60	61	60	61
2012	61	58	61	173	61	60	61	61	60	61	121	69
2013	62	181	226	241	93	60	134	61	60	61	60	61
2014	61	346	298	112	69	98	134	61	60	61	90	228
2015	61	56	430	417	699	417	1,434	676	655	676	1,078	984

Monthly Target Volume in Acre-Feet for Control Point CFNU16

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940	307	272	177	179	983	163	1,150	246	238	246	476	492
1941	492	444	738	3,490	738	714	2,408	553	536	553	908	799
1942	799	722	738	3,443	738	714	553	2,285	536	553	908	799
1943	799	722	738	714	2,291	753	542	559	238	246	229	255
1944	307	288	826	357	1,193	357	1,142	246	238	246	476	492
1945	492	444	1,181	1,205	369	357	1,150	246	238	246	476	492
1946	492	444	369	1,193	1,169	357	1,150	246	238	246	476	492
1947	492	444	369	357	2,065	357	1,134	246	238	246	258	307
1948	307	283	1,816	357	369	357	1,142	246	238	246	476	492
1949	492	444	369	2,041	369	357	1,150	246	238	246	476	492
1950	492	444	369	842	1,205	357	1,134	246	238	246	476	492
1951	492	444	800	165	184	179	518	61	60	61	137	88
1952	298	273	135	996	127	106	520	61	60	61	151	149
1953	109	56	85	163	920	63	516	61	60	61	141	77
1954	61	159	113	971	148	107	280	61	60	61	130	61
1955	61	79	73	75	1,003	179	518	61	60	61	60	61
1956	61	255	117	820	278	83	61	61	60	520	123	77
1957	61	206	1,030	139	184	179	553	553	536	2,426	882	799
1958	799	722	738	714	738	2,768	1,852	553	536	553	476	492
1959	492	444	184	179	1,024	171	520	61	60	61	476	492
1960	492	460	738	714	738	714	483	246	238	698	476	492
1961	492	444	738	714	2,285	721	2,408	553	536	553	860	799
1962	799	722	1,045	357	369	1,205	1,142	246	238	246	476	492
1963	492	444	369	357	2,053	357	246	627	238	246	60	61
1964	294	283	369	1,845	496	357	520	61	60	61	60	186
1965	303	278	369	1,205	1,205	357	1,083	246	238	246	476	492
1966	492	444	1,205	1,205	369	357	687	690	238	246	476	492
1967	492	444	184	105	997	164	520	61	60	61	298	282
1968	293	288	2,029	357	369	357	2,408	553	536	553	476	492
1969	492	444	369	357	2,065	357	553	2,349	536	553	882	799
1970	799	722	369	2,029	369	357	246	246	238	246	476	492
1971	492	444	184	1,027	180	179	520	61	60	61	476	492
1972	492	460	369	357	369	357	1,150	246	238	246	476	492
1973	492	444	3,490	714	738	714	553	553	2,390	553	774	799
1974	799	722	369	357	369	357	61	520	60	61	908	799
1975	799	722	738	714	738	714	2,408	553	536	553	908	799
1976	799	748	369	2,006	369	357	1,150	246	238	246	476	492
1977	492	444	2,065	357	369	357	682	698	238	246	60	192
1978	123	278	184	171	61	990	445	61	60	61	260	238
1979	290	278	2,053	357	369	357	1,102	246	238	246	476	492
1980	492	460	369	357	2,065	357	1,126	246	238	246	476	492
1981	492	444	1,193	1,169	369	357	1,150	246	238	246	476	492
1982	492	444	369	357	2,065	357	2,390	553	536	553	476	492
1983	492	444	369	357	1,217	1,193	1,150	246	238	246	476	492
1984	492	460	369	357	369	357	361	61	60	61	476	492
1985	492	444	738	714	738	3,181	2,591	553	536	553	826	799
1986	799	722	369	357	731	1,620	1,150	246	238	246	908	799
1987	799	722	3,466	714	738	714	553	553	536	553	774	862
1988	799	748	369	357	369	2,029	1,134	246	238	246	476	492
1989	492	444	369	357	369	2,053	690	246	682	246	476	492
1990	492	444	2,053	357	369	357	246	1,134	238	246	476	492
1991	492	444	369	357	369	2,053	1,126	246	238	246	897	799
1992	799	748	3,490	714	738	714	2,408	553	536	553	881	799
1993	799	722	738	714	738	3,490	553	553	536	553	774	799
1994	872	722	369	357	1,678	357	246	246	1,130	246	476	492
1995	492	444	369	357	1,205	1,181	1,142	246	238	246	899	799
1996	799	748	369	2,018	369	357	61	510	60	61	476	492
1997	492	444	2,765	1,225	738	714	553	553	536	553	774	887
1998	799	722	738	714	738	714	246	246	238	246	293	294
1999	307	100	184	996	162	136	246	246	238	246	476	492
2000	492	460	921	171	61	133	698	246	238	698	298	307
2001	240	278	738	714	738	714	246	1,150	238	246	476	492
2002	492	444	2,053	357	369	357	1,150	246	238	246	476	492
2003	492	444	369	357	369	2,053	666	246	635	246	476	492
2004	492	460	2,053	357	369	357	1,150	246	238	246	908	799
2005	799	722	738	714	2,316	1,143	2,408	553	536	553	476	492
2006	492	444	184	954	172	175	61	61	518	61	298	307
2007	302	207	1,217	1,205	369	357	2,408	553	536	553	856	799
2008	799	748	1,205	1,193	369	357	246	1,150	238	246	476	492
2009	492	444	184	179	184	1,024	518	61	60	61	476	492
2010	492	444	1,217	1,181	369	357	1,142	246	238	246	476	492
2011	492	444	369	357	369	357	61	61	60	520	259	307
2012	307	288	184	1,015	169	140	61	61	518	61	60	61
2013	307	177	178	121	947	160	520	61	60	61	298	307
2014	61	252	176	161	1,014	164	520	61	60	61	289	281
2015	278	254	369	2,006	369	357	2,390	553	536	553	908	799

Monthly Target Volume in Acre-Feet for Control Point DMAS09

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940	61	58	61	1,322	61	60	123	2,095	119	123	238	246
1941	246	222	3,060	476	492	476	2,549	430	417	430	893	922
1942	922	833	492	4,363	492	476	430	2,577	417	430	893	922
1943	922	833	492	1,763	3,044	476	2,091	123	119	123	60	61
1944	61	58	184	578	2,713	179	2,337	123	119	123	238	246
1945	246	222	184	179	184	3,198	2,095	123	119	123	238	246
1946	246	222	184	179	2,139	1,388	671	2,095	119	123	238	246
1947	246	222	184	179	2,713	179	1,268	123	1,105	123	60	61
1948	61	58	184	179	1,449	1,443	2,091	123	119	123	238	246
1949	246	222	184	2,145	1,449	179	123	667	2,087	123	238	246
1950	246	222	184	2,707	184	179	2,087	123	119	123	238	246
1951	246	222	61	60	1,330	60	1,050	61	60	61	60	61
1952	61	58	61	60	955	60	1,499	61	60	61	60	61
1953	61	56	61	1,097	61	60	575	61	60	61	60	61
1954	61	56	61	1,328	61	60	61	61	60	61	60	61
1955	61	56	1,330	60	61	60	1,050	61	60	61	60	61
1956	61	58	61	60	1,833	60	1,046	61	60	61	60	61
1957	61	56	61	1,326	61	60	2,577	430	417	430	893	922
1958	922	833	492	3,060	492	476	1,566	430	417	430	238	246
1959	246	222	61	772	1,330	60	1,050	61	60	61	238	246
1960	246	230	492	476	3,060	476	2,095	123	119	123	238	246
1961	246	222	492	476	492	3,044	2,549	430	417	430	893	922
1962	922	833	184	179	184	2,707	2,426	123	119	123	238	246
1963	246	222	184	2,779	446	179	675	123	2,091	123	60	61
1964	61	58	184	179	1,013	1,437	61	616	1,046	61	60	61
1965	61	56	184	660	2,707	179	123	2,095	119	123	238	246
1966	246	222	184	2,683	184	179	123	2,083	119	123	238	246
1967	246	222	61	1,326	61	60	1,048	61	60	61	60	61
1968	61	58	3,100	179	184	179	2,577	430	417	430	238	246
1969	246	222	1,288	179	2,151	179	430	430	2,549	430	893	922
1970	922	833	2,713	179	184	179	123	123	657	554	238	246
1971	246	222	61	443	1,330	60	1,050	61	60	61	238	246
1972	246	230	184	681	3,095	179	1,227	2,095	119	123	238	246
1973	246	222	3,076	476	492	476	430	430	3,135	430	893	922
1974	922	833	633	2,130	1,443	179	61	1,050	60	61	893	922
1975	922	833	492	476	3,060	476	2,563	430	417	430	893	922
1976	922	863	184	3,211	184	179	2,250	123	119	123	238	246
1977	246	222	184	3,870	184	179	123	2,095	119	123	60	61
1978	61	56	416	60	1,330	60	1,046	61	60	61	60	61
1979	61	56	2,695	179	184	179	2,631	123	119	123	238	246
1980	246	230	184	2,085	1,462	179	123	123	2,643	123	238	246
1981	246	222	1,871	1,437	184	179	2,083	123	119	123	238	246
1982	246	222	184	179	2,713	179	1,479	2,493	417	430	238	246
1983	246	222	184	179	2,707	179	2,545	123	119	123	238	246
1984	246	230	184	179	184	179	61	836	60	61	238	246
1985	246	222	492	3,654	492	476	2,577	430	417	430	893	922
1986	922	833	184	3,032	184	179	2,429	123	119	123	893	922
1987	922	833	1,810	476	3,044	476	3,117	430	417	430	893	922
1988	922	863	184	179	184	2,701	2,095	123	119	123	238	246
1989	246	222	184	179	184	2,707	123	816	1,491	123	238	246
1990	246	222	3,175	179	184	179	595	1,612	119	123	238	246
1991	246	222	184	179	1,407	1,437	671	2,091	119	123	893	922
1992	922	863	492	1,794	3,076	476	430	3,412	417	430	893	922
1993	922	833	492	476	2,469	499	430	1,684	1,268	430	893	922
1994	922	833	184	179	3,721	179	123	123	995	1,089	238	246
1995	246	222	184	179	3,421	179	123	2,095	119	123	893	922
1996	922	863	184	179	184	2,114	61	1,048	60	61	238	246
1997	246	222	492	3,657	492	476	3,611	430	417	430	893	922
1998	922	833	492	476	492	476	1,109	123	119	123	60	61
1999	61	56	61	60	61	1,326	2,095	123	119	123	238	246
2000	246	230	61	1,328	61	60	2,095	123	119	123	60	61
2001	61	56	492	1,778	492	476	123	123	119	123	238	246
2002	246	222	184	179	881	689	123	2,639	119	123	238	246
2003	246	222	184	179	184	179	2,095	123	119	123	238	246
2004	246	230	184	2,701	184	179	2,438	123	119	123	893	922
2005	922	833	492	476	492	476	1,493	430	2,563	430	238	246
2006	246	222	61	60	770	1,326	61	61	60	1,371	60	61
2007	61	56	184	647	1,126	2,695	1,493	2,563	417	430	893	922
2008	922	863	184	179	1,589	1,431	123	123	1,664	1,109	238	246
2009	246	222	61	60	61	60	1,042	61	60	61	238	246
2010	246	222	184	881	2,701	179	2,095	123	119	123	238	246
2011	246	222	184	179	184	179	61	61	60	61	60	61
2012	61	58	61	60	61	60	61	61	60	61	60	61
2013	61	56	61	60	61	1,322	61	1,048	60	61	60	61
2014	61	56	61	60	61	60	1,042	61	60	61	60	61
2015	61	56	184	179	184	2,707	2,563	430	417	430	893	922

Monthly Target Volume in Acre-Feet for Control Point LAKE50

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940	617	1,115	644	1,141	970	4,786	2,087	1,414	1,369	1,414	2,683	1,660
1941	1,660	1,500	15,893	2,559	2,644	2,559	3,197	1,968	1,904	1,968	2,321	2,398
1942	2,398	2,166	2,644	15,767	2,644	2,559	1,968	2,521	2,521	1,968	2,321	3,161
1943	2,398	2,166	1,783	1,726	1,783	1,726	1,414	1,414	2,042	1,414	675	863
1944	1,501	1,035	5,631	5,631	5,746	1,726	2,087	1,414	1,369	1,414	2,530	1,660
1945	1,660	1,500	13,556	1,726	1,783	1,726	2,521	2,521	1,904	1,968	4,252	2,398
1946	2,398	2,166	9,333	2,559	2,644	2,559	1,968	2,364	1,927	1,968	1,930	2,413
1947	1,660	1,500	5,746	1,726	1,783	1,726	1,414	1,414	1,369	1,414	684	760
1948	679	1,110	1,783	1,726	3,719	1,726	2,042	1,414	1,369	1,414	596	673
1949	620	569	5,746	9,593	1,783	1,726	1,620	1,712	1,369	1,414	1,607	1,660
1950	1,660	2,451	1,783	1,726	1,783	1,726	1,414	1,414	2,042	1,414	1,607	1,660
1951	1,660	1,500	638	605	811	725	615	615	898	615	595	615
1952	615	575	660	4,731	1,065	895	904	615	595	615	930	760
1953	1,089	962	1,137	956	5,213	1,065	926	651	696	695	1,607	1,660
1954	1,660	1,500	615	617	818	597	615	615	626	934	1,101	615
1955	704	761	711	763	4,992	1,026	1,002	715	707	616	595	619
1956	617	643	615	595	4,854	643	615	903	613	664	1,058	707
1957	650	640	4,944	965	1,291	1,250	1,968	1,968	1,904	3,201	4,157	2,398
1958	2,398	2,166	2,644	2,559	9,419	9,333	1,968	1,968	1,904	1,968	2,321	2,398
1959	2,398	2,166	1,783	1,726	1,783	9,593	1,777	1,639	1,369	1,414	2,712	1,660
1960	1,660	1,553	2,644	2,559	2,644	2,559	2,057	1,414	1,369	1,414	2,730	1,660
1961	1,660	1,500	2,644	2,559	2,644	2,559	2,087	1,414	1,369	1,414	2,550	1,660
1962	1,660	1,500	1,783	1,726	1,783	4,910	1,863	1,414	1,593	1,414	1,930	2,252
1963	1,660	1,500	1,783	1,726	1,783	1,726	890	621	697	639	1,111	682
1964	704	939	4,706	1,238	1,095	868	627	1,029	774	792	2,667	1,660
1965	1,660	1,500	1,783	1,726	13,556	1,726	1,414	1,593	1,817	1,414	2,736	1,660
1966	1,660	1,500	5,631	9,536	1,783	1,726	1,414	2,042	1,369	1,414	1,607	1,660
1967	1,660	1,500	1,137	1,132	994	650	922	641	816	977	1,607	1,660
1968	2,790	1,553	16,108	2,559	2,644	2,559	3,137	1,968	1,904	1,968	2,321	2,398
1969	2,398	2,166	2,644	9,248	9,419	2,559	1,968	2,457	1,904	2,584	2,575	1,660
1970	1,660	1,500	13,556	1,726	1,783	1,726	1,414	1,568	1,799	1,414	1,607	1,660
1971	1,660	1,500	1,291	1,033	1,043	813	964	984	952	984	2,444	1,660
1972	1,660	1,553	1,783	1,726	9,363	1,726	1,863	1,576	1,369	1,414	1,607	1,660
1973	1,660	1,500	1,783	1,726	1,783	5,573	2,584	1,968	1,904	2,521	2,321	2,398
1974	2,398	2,166	2,644	2,559	2,644	2,559	1,639	1,806	1,369	1,414	4,339	2,398
1975	2,398	2,166	2,644	9,333	9,333	2,559	3,137	1,968	1,904	1,968	1,607	1,660
1976	1,660	1,553	1,138	1,122	1,291	4,938	2,087	1,414	1,369	1,414	2,321	2,398
1977	2,398	2,166	9,248	9,333	2,644	2,559	1,414	1,414	1,593	1,414	1,071	1,107
1978	1,107	1,321	921	819	807	790	665	746	721	697	756	882
1979	1,137	975	1,783	1,726	9,420	5,631	3,156	1,968	1,904	1,968	2,321	2,398
1980	2,398	2,243	1,783	1,726	9,651	1,726	1,414	1,414	1,369	1,414	896	874
1981	789	798	3,812	1,764	1,136	1,207	1,772	1,639	1,369	1,414	3,317	2,398
1982	2,398	2,166	1,783	1,726	5,573	1,726	1,968	1,968	1,904	1,968	1,607	1,660
1983	1,660	1,635	1,783	1,726	1,783	1,726	1,414	1,414	1,369	1,414	1,607	1,660
1984	1,660	1,553	1,783	1,726	1,783	1,726	892	659	642	827	1,607	2,037
1985	1,660	1,825	8,992	6,380	4,469	2,559	1,414	1,414	1,369	2,042	1,607	1,983
1986	1,660	2,092	1,783	1,726	1,783	13,556	1,772	1,414	1,593	1,414	2,736	1,660
1987	1,660	1,500	2,644	2,559	9,333	9,333	3,121	1,968	1,904	1,968	2,104	1,983
1988	1,660	1,553	1,783	1,726	1,783	4,734	1,414	1,414	1,369	1,414	1,607	1,660
1989	1,660	1,500	1,783	1,726	5,573	5,516	1,414	1,414	1,369	1,414	1,607	1,660
1990	1,660	1,500	5,746	9,303	1,783	1,726	1,639	1,593	1,593	1,414	1,779	1,660
1991	2,195	1,500	1,783	1,726	1,783	5,400	1,593	1,414	1,369	1,863	2,321	4,543
1992	2,398	2,243	16,023	2,559	2,644	2,559	3,137	1,968	1,904	1,968	3,393	3,285
1993	2,398	2,166	9,333	2,559	9,248	2,559	1,968	1,968	1,904	1,968	1,607	1,660
1994	1,660	2,158	1,783	1,726	9,536	4,685	1,585	1,414	1,786	1,414	1,760	2,359
1995	1,660	1,500	5,631	9,536	1,783	1,726	1,968	3,097	1,904	1,968	1,607	1,660
1996	1,660	1,553	1,291	1,250	1,291	3,773	1,068	864	849	802	2,462	1,660
1997	1,660	1,500	16,108	2,559	2,644	2,559	3,201	1,968	1,904	1,968	2,321	4,466
1998	2,398	2,166	9,419	9,248	2,644	2,559	1,863	1,639	1,369	1,414	2,252	1,930
1999	1,660	1,500	1,783	9,478	5,631	1,726	1,967	1,414	1,369	1,414	1,607	1,660
2000	1,660	1,553	1,268	639	5,108	744	1,190	652	602	670	1,050	1,107
2001	1,004	1,000	2,644	2,559	2,644	2,559	1,593	1,863	1,369	1,414	2,210	1,903
2002	1,660	1,500	1,783	1,726	1,783	1,726	2,087	1,414	1,369	1,414	2,321	2,398
2003	2,398	3,161	2,644	2,559	2,644	2,559	2,087	1,414	1,369	1,414	1,607	1,660
2004	1,892	1,846	1,783	1,726	1,783	4,483	2,087	1,414	1,369	1,414	3,393	3,471
2005	2,398	2,166	2,644	2,559	2,644	2,559	2,060	1,414	1,369	1,414	973	1,051
2006	1,086	969	697	3,419	2,490	1,250	1,190	780	670	682	792	875
2007	1,000	975	1,783	13,498	1,783	1,726	3,201	1,968	1,904	1,968	2,321	2,398
2008	2,398	2,243	1,783	1,726	4,329	1,726	1,414	1,414	1,369	1,414	1,607	1,660
2009	1,660	1,500	690	2,378	3,407	783	1,190	984	835	719	2,736	1,660
2010	1,660	1,500	15,852	2,559	2,644	2,559	2,042	1,414	1,369	1,414	1,607	1,660
2011	1,660	1,500	1,783	1,726	1,783	1,726	616	616	595	877	1,394	638
2012	666	699	4,978	1,250	1,198	1,250	894	670	630	615	654	620
2013	733	889	1,020	768	699	690	653	709	635	664	1,607	2,231
2014	1,660	1,500	804	697	735	5,186	1,984	1,414	1,369	1,414	1,607	1,660
2015	1,660	1,500	1,783	1,726	1,783	13,498	3,201	1,968	1,904	1,968	4,466	2,398

Monthly Target Volume in Acre-Feet for Control Point LEGT47

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940	238	441	271	2,268	568	428	1,326	738	714	738	1,190	1,230
1941	1,230	1,111	11,188	3,213	3,320	3,213	2,753	1,660	1,607	1,660	3,784	3,197
1942	3,197	2,888	3,320	10,992	3,320	3,213	2,646	1,660	1,607	1,660	3,968	3,197
1943	3,197	2,888	6,385	1,916	1,476	1,428	934	738	1,083	738	399	545
1944	553	518	7,063	1,428	1,476	1,428	1,326	738	714	738	1,190	1,230
1945	1,230	1,111	7,063	1,428	1,476	1,428	2,646	1,660	1,607	1,660	3,887	3,197
1946	3,197	2,888	11,206	3,213	3,320	3,213	1,660	2,153	2,112	1,660	1,190	1,230
1947	1,230	1,111	7,015	1,428	1,476	1,428	1,083	738	714	910	362	389
1948	466	518	1,476	1,428	6,968	1,428	1,326	738	714	738	60	73
1949	239	465	5,999	1,428	1,476	1,428	1,295	738	714	738	1,190	1,230
1950	1,230	1,111	1,476	5,058	3,338	1,428	1,326	738	714	738	1,190	1,230
1951	1,230	1,111	371	339	2,269	472	79	61	60	61	60	61
1952	61	58	61	2,118	334	357	390	61	60	61	155	221
1953	298	219	2,395	423	383	245	361	151	101	172	1,190	1,230
1954	1,230	1,111	111	2,071	523	94	61	61	60	381	279	61
1955	61	196	208	2,111	341	577	436	87	132	186	67	61
1956	74	399	94	167	2,434	480	77	285	60	61	109	173
1957	114	115	2,241	488	615	595	2,646	1,660	1,607	1,660	3,865	3,197
1958	3,197	2,888	10,992	3,213	3,320	3,213	2,646	1,660	1,607	1,660	3,094	3,197
1959	3,197	3,222	1,476	1,428	1,476	6,698	1,303	738	714	738	1,190	1,230
1960	1,230	1,150	3,320	3,213	3,320	3,213	1,116	934	714	738	1,190	1,230
1961	1,230	1,111	10,992	3,213	3,320	3,213	1,326	738	714	738	1,190	1,230
1962	1,230	1,111	1,476	1,428	1,476	3,195	1,216	738	714	738	1,190	1,230
1963	1,230	1,111	1,476	1,428	6,682	1,428	399	91	165	61	250	226
1964	378	503	2,485	595	615	400	61	363	137	234	1,190	1,230
1965	1,230	1,111	1,476	1,428	7,063	1,428	1,326	738	714	738	1,190	1,230
1966	1,230	1,111	1,476	7,015	1,476	1,428	1,326	738	714	738	1,190	1,230
1967	1,230	1,111	584	2,435	561	388	454	85	129	132	1,190	1,230
1968	1,230	1,150	11,099	3,213	3,320	3,213	2,646	1,660	1,607	1,660	3,094	3,197
1969	3,197	2,888	7,049	7,049	3,320	3,213	2,530	1,723	1,607	1,660	1,190	1,230
1970	1,230	1,111	7,063	1,428	1,476	1,428	1,326	738	714	738	1,190	1,230
1971	1,230	1,111	615	495	2,454	95	313	198	138	228	1,190	1,230
1972	1,230	1,150	1,476	3,243	5,083	1,428	1,326	738	714	738	1,190	1,230
1973	1,230	1,111	3,243	5,010	1,476	1,428	2,646	1,660	1,607	1,660	3,572	3,197
1974	3,197	2,888	3,320	3,213	3,320	3,213	738	1,279	714	738	3,968	3,197
1975	3,197	2,888	3,320	10,992	3,320	3,213	2,646	1,660	1,607	1,660	1,190	1,230
1976	1,230	1,150	400	2,256	520	392	1,303	738	714	738	3,205	3,531
1977	3,197	2,888	11,099	3,213	3,320	3,213	1,326	738	714	738	60	98
1978	524	414	431	258	289	135	246	411	202	61	60	61
1979	286	423	7,015	1,428	1,476	1,428	2,649	1,660	1,607	1,660	3,094	3,197
1980	3,375	2,991	1,476	1,428	7,063	1,428	738	738	886	738	60	170
1981	134	236	417	463	361	2,485	1,326	738	714	738	3,094	3,197
1982	3,197	3,119	5,105	1,428	3,338	1,428	2,753	1,660	1,607	1,660	1,190	1,230
1983	1,230	1,111	1,476	1,428	1,476	1,428	1,119	916	714	738	1,190	1,230
1984	1,230	1,150	5,105	1,428	1,476	3,228	301	246	82	200	1,190	1,230
1985	1,230	1,111	10,214	3,242	3,320	3,213	1,248	738	714	738	1,190	1,230
1986	1,230	1,111	1,476	1,428	7,063	1,428	1,326	738	714	738	1,190	1,230
1987	1,230	1,111	11,099	3,213	3,320	3,213	2,753	1,660	1,607	1,660	1,190	1,230
1988	1,230	1,150	1,476	1,428	1,476	6,968	1,326	738	714	738	1,190	1,230
1989	1,230	1,111	7,015	1,428	1,476	1,428	1,326	738	714	738	1,190	1,230
1990	1,230	1,111	6,872	1,428	1,476	1,428	1,326	738	714	738	1,190	1,230
1991	1,230	1,111	1,476	4,933	3,338	1,428	1,326	738	714	738	3,968	3,197
1992	3,197	2,991	11,206	3,213	3,320	3,213	2,753	1,660	1,607	1,660	3,865	3,197
1993	3,197	2,888	11,099	3,213	3,320	3,213	2,716	1,660	1,607	1,660	1,190	1,230
1994	1,230	1,111	1,476	1,428	7,015	1,428	1,326	738	714	738	1,190	1,230
1995	1,230	1,111	6,920	1,428	1,476	1,428	2,646	1,660	1,607	1,660	1,190	1,230
1996	1,230	1,150	615	2,446	615	586	297	219	238	246	1,190	1,230
1997	1,230	1,111	11,206	3,213	3,320	3,213	2,753	1,660	1,607	1,660	3,094	3,865
1998	3,197	2,888	11,206	3,213	3,320	3,213	738	738	714	1,326	1,190	1,230
1999	1,230	1,111	3,290	5,058	1,476	1,428	738	738	714	738	1,190	1,230
2000	1,230	1,150	61	336	2,366	533	61	61	60	361	536	553
2001	494	500	10,885	3,213	3,320	3,213	738	738	1,303	738	1,190	1,230
2002	1,230	1,111	6,799	1,428	1,476	1,428	1,326	738	714	738	3,968	3,197
2003	3,197	2,888	3,320	3,213	3,320	11,099	738	738	1,255	738	1,190	1,230
2004	1,230	1,150	1,476	6,870	1,476	1,428	1,326	738	714	738	3,968	3,197
2005	3,197	2,888	7,049	3,213	3,320	3,213	738	1,298	714	738	60	61
2006	61	500	2,485	595	585	595	61	61	60	453	536	553
2007	553	500	6,968	1,428	1,476	1,428	2,753	1,660	1,607	1,660	3,094	3,197
2008	3,197	2,991	3,170	5,058	1,476	1,428	738	738	1,229	738	1,190	1,230
2009	1,230	1,111	2,453	595	615	505	458	61	238	234	1,190	1,230
2010	1,230	1,111	6,942	6,167	3,560	3,213	1,326	738	714	738	1,190	1,230
2011	1,230	1,111	1,476	1,428	4,896	1,428	61	61	60	413	536	553
2012	535	518	2,485	492	596	573	61	61	450	246	60	61
2013	538	500	61	2,222	409	518	455	61	88	204	1,190	1,230
2014	1,230	1,111	61	531	2,427	577	738	738	714	1,261	1,190	1,230
2015	1,230	1,111	5,058	3,290	1,476	1,428	1,660	1,660	1,607	2,753	3,968	3,197

Monthly Target Volume in Acre-Feet for Control Point LRCA58

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940	2,205	11,190	2,449	28,858	6,982	7,140	94,686	9,838	9,521	9,838	29,838	11,683
1941	11,683	10,552	114,486	45,223	46,731	45,223	102,241	20,291	19,636	20,291	27,372	28,284
1942	28,284	25,547	46,731	112,979	46,731	45,223	36,373	20,291	19,636	20,291	51,027	28,284
1943	28,284	25,547	41,117	40,502	19,061	18,446	13,622	9,838	14,296	12,439	3,174	5,779
1944	13,007	6,327	85,842	18,446	19,061	18,446	31,688	9,838	9,521	9,838	29,838	11,683
1945	11,683	10,552	87,072	18,446	19,061	18,446	54,666	20,291	19,636	20,291	35,360	41,360
1946	28,284	25,547	117,501	45,223	46,731	45,223	20,291	20,291	41,747	20,291	29,838	11,683
1947	11,683	10,552	86,457	18,446	19,061	18,446	9,838	9,838	9,521	9,838	4,567	5,419
1948	5,356	9,790	19,061	30,596	59,349	21,040	22,678	13,470	9,521	9,838	1,904	2,015
1949	6,411	3,222	57,099	43,239	19,061	18,446	11,394	9,838	9,521	12,675	14,604	11,683
1950	11,683	23,158	19,061	57,416	38,402	18,446	24,512	9,838	36,534	9,838	11,306	11,683
1951	11,683	10,552	3,239	3,019	6,918	26,996	2,000	1,968	7,893	1,968	1,913	1,968
1952	1,968	1,945	2,678	28,216	6,074	4,575	2,799	1,968	1,904	1,968	5,168	6,678
1953	3,991	4,127	4,824	13,130	18,841	4,884	3,762	3,185	16,155	3,987	22,405	17,986
1954	11,683	10,552	2,419	3,292	5,024	1,913	1,968	1,968	2,137	2,556	9,616	1,970
1955	2,505	3,963	3,520	28,059	6,808	8,116	14,637	3,968	3,475	3,182	1,952	2,351
1956	2,584	7,333	1,968	2,450	28,781	3,440	1,968	2,540	1,904	1,971	9,113	3,725
1957	2,526	3,000	28,123	6,360	8,608	8,331	39,703	25,990	19,636	20,291	50,880	28,284
1958	28,284	25,547	112,979	45,223	46,731	45,223	30,025	20,291	66,421	20,291	27,372	28,284
1959	28,284	35,717	19,061	40,502	30,266	40,727	37,554	10,804	9,521	9,838	29,461	11,683
1960	11,683	10,929	46,731	45,223	46,731	45,223	15,329	9,838	9,521	57,342	28,708	11,683
1961	11,683	10,552	80,608	45,223	46,731	80,608	90,228	9,838	9,521	9,838	29,461	11,683
1962	11,683	10,552	19,061	39,800	19,148	39,272	23,605	14,158	33,258	9,838	30,215	11,683
1963	11,683	10,552	19,061	18,446	19,061	18,446	9,240	1,971	2,699	2,627	4,657	3,152
1964	6,256	10,171	27,899	7,392	8,291	8,213	9,098	3,843	3,923	5,873	30,215	11,683
1965	11,683	10,552	59,498	43,175	19,061	18,446	51,209	9,838	9,521	9,838	29,461	11,683
1966	11,683	10,552	39,887	64,402	19,061	18,446	13,427	55,254	9,521	9,838	11,306	11,683
1967	11,683	10,552	4,422	7,523	31,595	4,176	11,950	2,874	4,547	4,356	30,215	11,683
1968	11,683	10,929	119,008	45,223	46,731	45,223	91,800	20,291	19,636	20,291	37,612	43,282
1969	28,284	25,547	100,802	45,223	46,731	45,223	20,291	31,386	20,471	28,120	11,306	30,592
1970	11,683	10,552	86,457	18,446	19,061	18,446	14,180	9,838	31,193	9,838	11,306	11,683
1971	11,683	10,552	5,784	6,602	8,088	3,288	31,693	5,533	3,764	5,829	27,577	11,683
1972	11,683	10,929	19,061	18,446	38,657	40,502	16,813	9,838	9,521	57,749	28,217	11,683
1973	11,683	10,552	83,383	18,446	19,061	18,446	51,617	20,291	37,664	21,997	52,298	28,284
1974	28,284	25,547	46,731	45,223	80,608	45,223	9,838	55,858	29,683	9,838	55,347	28,284
1975	28,284	25,547	46,731	109,964	46,731	45,223	97,888	20,291	19,636	20,291	11,306	11,683
1976	11,683	10,929	7,724	31,675	8,608	8,331	93,099	9,838	9,521	9,838	38,622	40,036
1977	28,284	25,547	92,439	67,270	46,731	45,223	16,845	9,838	9,521	9,838	3,664	3,568
1978	4,482	11,164	5,691	5,403	4,703	4,999	3,030	4,120	3,190	2,299	5,034	6,057
1979	10,595	6,109	87,315	18,446	19,061	18,446	55,883	20,291	19,636	20,291	27,372	28,284
1980	28,284	37,638	41,117	18,446	63,787	18,446	9,838	9,838	9,521	9,838	3,802	5,481
1981	5,099	6,109	30,113	8,331	8,132	8,331	62,142	9,838	9,521	9,838	39,141	28,284
1982	28,284	25,547	19,061	56,260	45,209	18,446	36,757	20,291	19,636	20,291	11,306	11,683
1983	11,683	28,331	82,768	18,446	19,061	18,446	9,838	23,639	9,521	9,838	11,306	11,683
1984	11,683	10,929	19,061	18,446	19,061	18,446	2,560	2,195	2,391	16,651	16,855	23,535
1985	11,683	10,552	109,964	45,223	46,731	45,223	11,925	9,838	9,521	38,687	29,949	11,683
1986	11,683	10,552	19,061	18,446	79,729	18,446	20,260	12,162	9,521	9,838	29,129	11,683
1987	11,683	10,552	111,471	45,223	46,731	45,223	89,339	20,291	19,636	20,291	16,855	23,158
1988	11,683	10,929	19,061	18,446	19,061	84,612	9,838	9,838	9,521	9,838	11,306	11,683
1989	14,952	22,693	41,117	18,446	64,402	18,446	22,172	13,885	9,521	9,838	11,306	11,683
1990	11,683	10,552	41,117	64,402	19,061	18,446	34,927	9,838	9,521	9,838	16,855	11,683
1991	24,049	10,552	19,061	62,895	41,444	18,446	19,960	24,767	9,521	9,838	53,522	28,284
1992	28,284	26,460	119,008	45,223	46,731	45,223	87,527	20,291	19,636	20,291	39,535	41,360
1993	28,284	25,547	114,486	45,223	46,731	45,223	47,814	20,291	19,636	20,291	11,306	11,683
1994	11,683	27,893	19,061	18,446	87,687	18,446	19,152	9,838	12,944	32,477	27,116	12,265
1995	11,683	10,552	86,567	18,446	19,061	18,446	39,183	20,291	19,636	20,291	11,306	11,683
1996	11,683	10,929	3,122	5,038	4,703	6,548	4,819	4,774	5,772	5,879	27,671	11,683
1997	11,683	10,552	117,501	45,223	46,731	45,223	115,171	20,291	19,636	20,291	27,372	55,347
1998	28,284	25,547	46,731	45,223	46,731	45,223	9,838	9,838	54,148	9,838	30,215	11,683
1999	11,683	10,552	39,272	18,446	40,728	18,446	14,491	9,838	9,521	9,838	11,306	11,683
2000	28,708	10,929	8,608	18,632	6,037	8,215	5,894	1,968	1,989	32,920	12,876	6,764
2001	6,764	6,109	112,851	45,223	46,731	45,223	18,792	37,169	29,542	9,838	30,215	11,683
2002	11,683	10,552	19,061	18,446	19,061	18,446	88,975	9,838	9,521	9,838	53,522	28,284
2003	28,284	25,547	46,731	45,223	46,731	45,223	9,838	9,838	41,717	9,838	16,495	11,683
2004	23,912	10,929	19,061	85,842	19,061	18,446	93,099	9,838	9,521	9,838	54,493	28,284
2005	28,284	25,547	46,731	45,223	46,731	45,223	12,639	35,435	9,521	9,838	1,916	1,968
2006	5,865	12,434	22,689	10,485	7,476	8,075	11,589	1,977	5,772	5,842	6,372	12,950
2007	6,764	6,109	88,917	18,446	19,061	18,446	128,018	20,291	19,636	20,291	27,372	28,284
2008	28,284	26,460	19,061	18,446	38,193	18,446	9,838	9,838	9,521	9,838	11,306	11,683
2009	11,683	10,552	8,608	30,073	7,346	5,229	5,506	3,191	10,645	5,964	30,215	11,683
2010	11,683	10,552	46,731	45,223	46,731	45,223	32,981	9,838	9,521	9,838	11,306	11,683
2011	29,085	10,552	19,061	18,446	19,061	18,446	1,968	1,968	1,904	9,079	12,789	6,764
2012	6,764	6,115	32,035	5,258	8,608	7,665	16,020	2,731	5,772	3,212	1,904	1,968
2013	13,072	6,109	7,666	8,331	8,608	7,708	25,127	3,075	5,643	5,964	30,215	11,683
2014	11,683	10,552	8,608	7,126	30,984	8,331	18,958	9,838	40,242	9,838	27,694	11,683
2015	11,683	10,552	84,612	18,446	19,061	18,446	20,291	20,291	19,636	129,327	55,347	28,284

Monthly Target Volume in Acre-Feet for Control Point LRLR53

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940	3,382	3,518	3,395	13,736	4,036	5,018	11,344	7,379	7,140	7,379	12,723	6,764
1941	6,764	6,109	86,060	25,587	26,440	25,587	22,094	12,298	11,901	12,298	11,306	11,683
1942	11,683	10,552	26,440	84,017	26,440	25,587	12,298	22,491	11,901	12,298	32,268	11,683
1943	11,683	10,552	17,758	24,578	9,223	8,926	7,379	7,379	10,813	7,379	3,458	4,037
1944	7,127	4,717	36,788	8,926	9,223	8,926	11,106	7,379	7,140	7,379	12,505	6,764
1945	6,764	6,109	37,313	8,926	9,223	8,926	22,491	12,298	11,901	12,298	21,598	22,729
1946	11,683	10,552	87,428	25,587	26,440	25,587	12,298	12,298	11,901	12,298	12,377	6,764
1947	6,764	6,109	37,313	8,926	9,223	8,926	7,379	7,379	7,140	7,379	5,391	3,992
1948	3,654	3,458	9,223	8,926	32,662	11,197	10,887	7,379	7,140	7,379	3,273	3,382
1949	3,783	5,347	36,680	8,926	9,223	8,926	8,462	7,379	7,140	9,784	8,283	6,764
1950	6,764	10,155	9,223	8,926	17,847	16,805	11,344	7,379	7,140	7,379	6,545	6,764
1951	6,764	6,109	3,549	3,448	14,217	4,624	3,382	3,382	4,575	3,382	3,273	3,382
1952	3,382	3,164	3,546	13,626	4,778	4,019	4,839	3,382	3,273	3,382	5,619	3,970
1953	3,713	3,162	13,261	3,878	5,299	4,032	5,414	3,970	3,642	4,146	7,696	8,464
1954	6,764	6,109	3,382	3,762	4,233	3,273	3,382	3,382	3,281	3,915	5,996	3,382
1955	3,445	3,590	3,858	13,608	4,961	5,357	5,473	3,957	3,974	3,799	3,326	3,435
1956	3,596	3,271	3,382	3,590	14,082	3,523	3,382	5,060	3,273	3,554	5,789	3,957
1957	3,542	3,315	13,587	4,776	5,841	5,653	16,997	12,298	11,901	17,394	32,645	11,683
1958	11,683	10,552	83,164	25,587	26,440	25,587	12,298	12,298	11,901	12,298	11,306	11,683
1959	11,683	10,552	9,223	8,926	9,223	34,068	10,659	7,379	7,140	7,379	12,941	6,764
1960	6,764	6,327	26,440	25,587	26,440	25,587	8,462	7,379	7,140	10,022	12,723	6,764
1961	6,764	6,109	55,228	25,587	26,440	55,228	11,344	7,379	7,140	7,379	12,362	6,764
1962	6,764	6,109	9,223	14,306	16,730	17,317	9,380	8,462	7,140	7,379	8,459	10,830
1963	6,764	6,109	9,223	8,926	22,400	21,424	5,373	3,382	3,631	3,641	5,885	3,401
1964	3,697	4,473	14,419	5,018	5,715	5,653	3,854	5,414	4,056	5,082	12,941	6,764
1965	6,764	6,109	35,483	8,926	9,223	8,926	11,344	7,379	7,140	7,379	12,116	6,764
1966	6,764	6,109	24,800	19,595	9,223	8,926	8,332	10,022	7,140	7,379	6,545	6,764
1967	6,764	6,109	3,783	5,452	13,582	3,963	6,240	3,569	4,140	4,213	8,459	8,241
1968	8,895	6,327	86,575	25,587	26,440	25,587	22,413	12,298	11,901	12,298	11,306	11,683
1969	11,683	10,552	26,440	84,869	26,440	25,587	12,298	12,298	11,901	12,298	10,116	8,677
1970	6,764	6,109	37,313	8,926	9,223	8,926	7,379	7,379	11,106	7,379	6,545	6,764
1971	6,764	6,109	4,894	4,920	11,082	3,620	5,394	4,820	3,970	5,165	12,723	6,764
1972	6,764	6,327	9,223	8,926	34,958	8,926	11,106	7,379	7,140	7,379	10,809	8,677
1973	6,764	6,109	35,528	8,926	9,223	8,926	22,604	12,298	11,901	12,298	11,306	11,683
1974	11,683	10,552	26,440	25,587	26,440	25,587	7,379	11,106	7,140	7,379	34,152	11,683
1975	11,683	10,552	26,440	84,046	26,440	25,587	22,491	12,298	11,901	12,298	6,545	6,764
1976	6,764	6,327	4,709	15,036	5,841	5,653	11,215	7,379	7,140	7,379	11,306	33,021
1977	11,683	10,552	80,921	30,389	26,440	25,587	9,308	7,379	7,140	7,379	3,457	3,533
1978	3,618	5,979	4,243	4,240	4,200	5,080	4,208	4,099	3,619	3,454	3,759	4,495
1979	5,882	4,554	36,420	8,926	9,223	8,926	21,697	12,298	11,901	12,298	11,306	11,683
1980	11,683	10,929	9,223	8,926	37,313	8,926	7,379	7,379	7,140	7,379	3,641	5,491
1981	3,705	3,716	5,028	5,653	14,216	5,653	11,096	7,379	7,140	7,379	19,337	11,683
1982	11,683	10,552	17,496	17,496	17,756	8,926	21,386	12,298	11,901	12,298	6,545	6,764
1983	6,764	12,286	36,123	8,926	9,223	8,926	7,379	8,462	7,140	7,379	6,545	6,764
1984	6,764	6,327	9,223	8,926	9,223	15,864	5,047	3,502	3,427	4,675	9,936	8,677
1985	6,764	6,109	56,081	25,587	26,440	55,228	7,379	7,379	8,224	9,630	12,505	6,764
1986	6,764	6,109	9,223	8,926	36,718	8,926	11,344	7,379	7,140	7,379	12,723	6,764
1987	6,764	6,109	81,458	25,587	26,440	25,587	22,491	12,298	11,901	12,298	8,241	10,591
1988	6,764	6,327	9,223	8,926	9,223	37,016	8,462	7,379	8,037	7,566	6,545	6,764
1989	11,426	6,570	27,553	17,388	9,223	8,926	10,704	7,379	7,140	7,379	6,545	6,764
1990	6,764	6,109	33,995	8,926	9,223	8,926	10,630	7,379	7,140	7,379	10,155	6,764
1991	8,604	6,109	9,223	8,926	36,718	8,926	10,633	7,379	7,140	7,379	34,152	11,683
1992	11,683	10,929	87,428	25,587	26,440	25,587	22,094	12,298	11,901	12,298	21,938	22,729
1993	11,683	10,552	84,016	25,587	26,440	25,587	17,241	12,298	16,613	12,298	8,459	6,764
1994	6,764	10,155	9,223	8,926	36,725	8,926	10,804	7,379	7,140	7,379	11,850	6,764
1995	6,764	6,109	37,313	8,926	9,223	8,926	17,394	17,394	11,901	12,298	6,545	7,589
1996	6,764	6,327	3,513	4,177	4,873	5,593	5,266	4,290	4,998	4,839	12,505	6,764
1997	6,764	6,109	87,428	25,587	26,440	25,587	23,284	12,298	11,901	12,298	11,306	34,529
1998	11,683	10,552	82,687	25,587	26,440	25,587	7,379	7,379	10,300	7,379	12,941	6,764
1999	6,764	6,109	31,625	12,233	9,223	8,926	8,525	7,379	7,140	7,379	6,545	6,764
2000	8,344	10,373	5,434	9,239	5,620	5,653	4,358	3,382	3,330	6,334	6,741	5,042
2001	5,042	4,554	26,440	25,587	26,440	25,587	8,377	8,237	8,688	7,379	12,723	6,764
2002	6,764	6,109	35,746	8,926	9,223	8,926	11,344	7,379	7,140	7,379	21,221	21,598
2003	11,683	10,552	26,440	25,587	26,440	84,017	10,599	7,379	7,140	7,379	7,931	6,764
2004	8,552	8,425	26,661	17,496	9,223	8,926	11,344	7,379	7,140	7,379	33,775	11,683
2005	11,683	10,552	26,440	25,587	26,440	25,587	7,379	11,344	7,140	7,379	3,273	3,382
2006	4,360	5,972	14,287	5,111	5,512	5,553	4,928	3,382	4,998	4,935	4,828	6,451
2007	4,506	4,554	37,611	8,926	9,223	8,926	23,284	12,298	11,901	12,298	11,306	11,683
2008	11,683	10,929	9,223	35,528	9,223	8,926	7,379	11,106	7,140	7,379	6,545	6,764
2009	6,764	6,109	9,937	5,574	5,841	4,197	6,392	4,524	4,712	5,165	12,941	6,764
2010	6,764	6,109	26,440	25,587	26,440	25,587	11,344	7,379	7,140	7,379	6,545	6,764
2011	12,723	6,109	9,223	8,926	14,642	8,926	3,382	3,382	3,273	6,558	5,991	4,387
2012	5,042	4,717	13,452	4,207	5,841	5,653	6,392	3,962	4,998	5,165	3,273	3,382
2013	6,741	4,554	3,588	13,944	5,841	5,323	5,983	5,165	4,518	5,050	12,505	6,764
2014	6,764	6,109	3,466	3,471	15,413	5,653	10,885	7,379	7,140	7,379	12,286	6,764
2015	6,764	6,109	18,185	26,958	9,223	8,926	12,298	12,298	11,901	22,887	33,775	11,683

Monthly Target Volume in Acre-Feet for Control Point NAEA66

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940	67	502	73	5,034	568	595	492	492	476	492	5,580	861
1941	861	778	19,361	1,726	1,783	1,726	1,266	984	952	984	1,369	1,414
1942	1,414	1,277	1,783	19,476	1,783	1,726	984	984	1,297	984	5,579	6,763
1943	1,414	1,277	5,645	1,131	1,168	1,131	492	492	476	492	212	183
1944	2,017	518	14,825	1,131	1,168	1,131	492	492	476	492	3,942	2,415
1945	861	778	14,788	1,131	1,168	1,131	1,360	984	952	984	1,369	12,203
1946	1,414	1,277	19,073	1,726	1,783	1,726	984	984	1,252	984	5,580	861
1947	861	778	14,750	1,131	1,168	1,131	492	492	476	492	104	283
1948	409	1,989	5,645	5,532	5,683	1,131	492	492	476	492	67	130
1949	1,778	292	14,750	1,131	1,168	1,131	492	492	476	492	833	861
1950	5,552	778	1,168	14,750	1,168	1,131	492	492	476	492	833	861
1951	861	778	157	179	463	189	61	61	83	61	60	118
1952	266	1,528	491	434	5,025	181	61	80	67	61	1,029	789
1953	463	310	5,066	595	589	149	109	149	90	82	2,388	4,025
1954	861	778	169	250	5,128	86	61	73	60	81	161	127
1955	141	1,757	186	5,014	574	550	100	95	60	84	61	62
1956	123	1,311	192	169	4,952	214	110	65	80	61	1,686	61
1957	67	393	5,145	559	615	559	984	984	952	1,360	11,975	1,414
1958	1,414	1,277	1,783	1,726	19,533	1,726	984	1,360	952	984	1,369	1,414
1959	1,414	11,975	1,168	14,750	1,168	1,131	492	492	476	492	5,524	861
1960	861	805	10,370	1,726	10,601	1,726	492	492	476	492	5,524	861
1961	861	778	1,783	1,726	1,783	19,533	492	492	476	492	3,289	2,930
1962	861	778	1,168	10,122	5,683	1,131	492	492	476	492	833	861
1963	861	778	1,168	1,131	1,168	1,131	61	61	60	61	60	130
1964	306	381	351	206	97	60	61	105	119	63	833	861
1965	5,517	778	10,047	5,683	1,168	1,131	492	492	476	492	833	861
1966	861	5,441	5,645	10,198	1,168	1,131	492	492	476	492	833	861
1967	861	778	276	426	4,899	371	99	76	123	184	5,552	861
1968	861	805	19,591	1,726	1,783	1,726	1,360	984	952	984	1,369	6,717
1969	6,672	1,277	19,591	1,726	1,783	1,726	984	1,223	952	984	2,332	3,998
1970	861	778	14,825	1,131	1,168	1,131	492	492	476	492	833	861
1971	861	4,947	620	133	155	60	121	137	71	109	3,970	2,415
1972	861	805	1,168	1,131	1,168	1,131	492	492	476	492	2,388	3,970
1973	861	778	14,712	1,131	1,168	1,131	1,360	984	952	984	12,066	1,414
1974	1,414	1,277	10,543	1,726	10,543	1,726	492	492	476	492	12,112	1,414
1975	1,414	1,277	1,783	13,343	7,800	1,726	1,360	984	952	984	833	861
1976	861	805	361	5,108	615	559	492	492	476	492	10,570	1,414
1977	1,414	1,277	19,533	1,726	1,783	1,726	492	492	476	492	214	161
1978	221	1,961	5,123	554	480	297	64	61	174	75	1,841	506
1979	507	500	14,750	1,131	1,168	1,131	1,297	984	952	984	1,369	12,112
1980	1,414	1,323	4,826	10,904	1,168	1,131	492	492	476	492	335	134
1981	304	1,916	404	488	4,798	524	492	492	476	492	1,369	1,414
1982	1,414	1,277	10,122	5,608	1,168	1,131	984	984	952	984	833	5,608
1983	861	778	14,788	1,131	1,168	1,131	492	492	476	492	833	861
1984	861	2,360	14,637	1,131	1,168	1,131	61	61	60	141	5,580	861
1985	861	778	19,130	1,726	1,783	1,726	492	492	476	492	5,496	861
1986	861	778	1,168	7,889	7,992	1,131	492	492	476	492	5,580	861
1987	861	778	19,418	1,726	1,783	1,726	984	984	952	984	833	5,580
1988	861	805	14,524	1,131	1,168	1,131	492	492	476	492	833	861
1989	861	2,124	1,284	1,131	14,788	1,131	492	492	476	492	833	861
1990	2,341	3,826	14,788	1,131	1,168	1,131	492	492	476	492	5,552	861
1991	861	778	14,674	1,131	1,168	1,131	492	492	476	492	6,672	6,763
1992	1,414	1,323	19,418	1,726	1,783	1,726	984	984	952	984	1,369	12,066
1993	1,414	1,277	19,476	1,726	1,783	1,726	1,297	984	952	984	833	861
1994	861	5,524	1,168	1,131	14,599	1,131	492	492	476	492	3,942	2,443
1995	861	778	14,617	1,131	1,168	1,131	1,297	984	952	984	833	861
1996	861	805	360	187	452	60	161	61	60	61	833	2,118
1997	1,733	2,900	19,476	1,726	1,783	1,726	1,211	984	952	984	1,369	12,203
1998	1,414	1,277	19,591	1,726	1,783	1,726	492	492	476	492	5,479	861
1999	861	778	14,750	1,131	1,168	1,131	492	492	476	492	833	861
2000	861	805	174	276	241	260	157	61	60	118	397	1,901
2001	553	500	19,533	1,726	1,783	1,726	492	492	476	492	833	861
2002	5,608	778	14,524	1,131	1,168	1,131	492	492	476	492	1,369	1,414
2003	12,203	1,277	19,591	1,726	1,783	1,726	492	492	476	492	833	861
2004	861	805	14,750	1,131	1,168	1,131	492	492	476	492	1,369	12,203
2005	1,414	1,277	19,591	1,726	1,783	1,726	492	492	476	492	178	181
2006	229	153	198	60	61	381	182	184	172	184	536	113
2007	61	2,074	1,168	14,788	1,168	1,131	1,360	984	952	984	1,369	1,414
2008	1,414	1,323	1,168	14,788	1,168	1,131	492	492	476	492	833	861
2009	861	778	186	60	4,993	595	145	184	179	114	5,552	861
2010	861	778	19,591	1,726	1,783	1,726	492	492	476	492	833	861
2011	861	778	1,168	1,131	1,168	1,131	61	61	179	184	161	126
2012	143	1,989	67	5,165	615	213	137	184	179	184	536	168
2013	147	56	61	60	61	60	61	61	60	61	833	5,608
2014	861	778	315	69	61	4,521	926	492	476	492	833	861
2015	861	778	1,168	14,599	1,168	1,131	1,360	984	952	984	1,369	12,066

Monthly Target Volume in Acre-Feet for Control Point NBCL36

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940	70	77	62	3,660	169	329	492	492	476	492	714	738
1941	738	666	12,041	1,964	2,029	1,964	1,910	1,045	1,012	1,045	2,089	2,138
1942	1,537	1,388	2,029	12,106	2,029	1,964	1,910	1,045	1,012	1,045	2,852	1,537
1943	1,537	1,388	3,752	4,720	4,232	952	492	492	476	492	60	269
1944	307	288	984	7,837	4,442	952	492	492	476	492	714	738
1945	738	666	11,295	952	984	952	1,978	1,045	1,012	1,045	2,089	1,537
1946	2,188	1,388	12,237	1,964	2,029	1,964	1,045	1,045	1,910	1,045	714	738
1947	738	666	7,869	952	984	952	492	492	476	492	209	307
1948	302	280	984	952	11,327	952	492	492	476	492	117	209
1949	255	278	984	11,232	984	952	492	492	476	492	714	738
1950	738	666	984	952	984	952	492	492	476	492	714	738
1951	738	666	245	220	403	3,820	72	61	60	61	60	61
1952	61	58	61	3,609	284	211	63	61	60	61	105	162
1953	254	257	391	367	3,893	88	130	138	77	131	714	738
1954	738	666	62	212	151	3,211	61	61	60	112	231	61
1955	61	104	111	242	3,695	367	97	61	91	103	60	61
1956	61	186	61	121	3,823	133	61	61	60	61	87	124
1957	61	79	156	3,760	430	417	1,978	1,045	1,012	1,045	2,888	1,537
1958	1,537	1,388	11,995	1,964	2,029	1,964	1,978	1,045	1,012	1,045	1,488	1,537
1959	1,537	1,388	984	952	984	7,773	492	492	476	492	714	738
1960	738	690	2,029	6,805	6,815	1,964	492	492	476	492	714	738
1961	738	666	2,029	1,964	2,029	8,682	492	492	476	492	714	738
1962	738	666	984	2,360	2,939	952	492	492	476	492	714	738
1963	738	666	984	952	984	952	84	61	60	61	234	137
1964	228	288	3,907	417	422	268	61	81	111	170	714	738
1965	738	666	984	952	11,295	952	492	492	476	492	714	738
1966	738	666	984	11,263	984	952	492	492	476	492	714	738
1967	738	666	345	3,847	349	194	152	84	104	127	714	738
1968	738	690	12,303	1,964	2,029	1,964	1,910	1,045	1,012	1,045	1,488	1,537
1969	1,537	1,388	2,029	11,975	2,029	1,964	1,978	1,045	1,012	1,045	714	738
1970	738	666	11,263	952	984	952	492	492	476	492	714	738
1971	738	666	409	350	2,886	1,085	82	174	104	184	714	738
1972	738	690	984	952	984	952	492	492	476	492	714	738
1973	738	666	984	11,232	984	952	1,944	1,045	1,012	1,045	1,488	1,537
1974	2,188	1,388	2,029	1,964	2,029	1,964	492	492	476	492	2,888	1,537
1975	1,537	1,388	2,029	12,106	2,029	1,964	1,976	1,045	1,012	1,045	714	738
1976	738	690	177	417	3,893	393	492	492	476	492	1,863	2,089
1977	1,537	1,388	12,041	1,964	2,029	1,964	492	492	476	492	298	307
1978	307	278	423	411	356	170	132	70	60	61	83	93
1979	143	278	11,263	952	984	952	1,045	1,944	1,012	1,045	1,488	1,537
1980	2,138	1,438	984	952	4,379	952	492	492	476	492	129	285
1981	307	278	430	417	430	3,893	492	492	476	492	1,488	1,537
1982	1,537	2,368	1,260	952	11,232	952	1,978	1,045	1,012	1,045	714	738
1983	738	666	984	952	984	952	492	492	476	492	714	738
1984	738	690	4,058	953	984	952	83	61	60	135	714	738
1985	738	666	5,323	3,612	3,675	1,964	492	492	476	492	714	738
1986	738	666	984	952	4,379	7,805	492	492	476	492	714	738
1987	738	666	5,388	1,964	8,616	1,964	1,934	1,045	1,012	1,045	714	738
1988	738	690	984	952	984	11,295	492	492	476	492	714	738
1989	738	666	11,359	952	984	952	492	492	476	492	714	738
1990	738	666	4,410	7,869	984	952	492	492	476	492	714	738
1991	738	666	984	4,283	4,379	4,410	492	492	476	492	2,888	1,537
1992	1,537	1,438	12,172	1,964	2,029	1,964	1,966	1,045	1,012	1,045	2,669	1,537
1993	1,537	1,388	12,041	1,964	2,029	1,964	1,448	1,045	1,478	1,045	714	738
1994	738	666	984	952	11,359	952	492	492	476	492	714	738
1995	738	666	11,232	952	984	952	1,910	1,045	1,012	1,045	714	738
1996	738	690	430	387	282	3,837	168	184	179	184	714	738
1997	738	666	12,303	1,964	2,029	1,964	1,978	1,045	1,012	1,045	1,488	2,888
1998	1,537	1,388	12,237	1,964	2,029	1,964	492	492	476	492	714	738
1999	738	666	984	952	984	952	492	492	476	492	714	738
2000	738	690	419	417	288	3,694	153	61	60	77	293	307
2001	307	278	8,813	1,964	2,029	1,964	492	492	476	492	714	738
2002	738	666	5,821	2,177	984	952	492	492	476	492	2,888	1,537
2003	1,537	1,388	2,029	1,964	2,029	4,774	492	492	476	492	714	738
2004	738	690	984	7,534	4,555	952	492	492	476	492	2,832	1,537
2005	1,537	1,388	2,029	1,964	2,029	1,964	492	492	476	492	60	61
2006	61	262	2,321	417	348	274	173	61	60	150	250	212
2007	300	278	7,869	4,410	984	952	1,978	1,045	1,012	1,045	1,488	1,537
2008	1,537	1,438	984	10,787	1,302	952	492	492	476	492	714	738
2009	738	666	328	3,851	430	323	163	61	135	184	714	738
2010	738	666	2,029	1,964	2,029	1,964	492	492	476	492	714	738
2011	738	666	984	952	984	952	89	61	60	123	226	307
2012	267	288	3,907	417	376	409	157	61	63	121	60	61
2013	261	278	419	2,740	252	338	131	61	98	145	714	738
2014	738	666	286	225	2,816	773	492	492	476	492	714	738
2015	738	666	984	10,964	1,252	952	1,877	1,045	1,012	1,045	2,888	1,537

Monthly Target Volume in Acre-Feet for Control Point SFAS06

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1940	61	58	61	60	61	60	61	61	60	61	238	246
1941	246	222	307	298	307	298	184	184	179	184	536	553
1942	553	500	307	298	307	298	184	184	179	184	536	553
1943	553	500	307	298	307	298	61	61	60	61	60	61
1944	61	58	123	119	123	119	61	61	60	61	238	246
1945	246	222	123	119	123	119	61	61	60	61	238	246
1946	246	222	123	119	123	119	61	61	60	61	238	246
1947	246	222	123	119	123	119	61	61	60	61	60	61
1948	61	58	123	119	123	119	61	61	60	61	238	246
1949	246	222	123	119	123	119	61	61	60	61	238	246
1950	246	222	123	119	123	119	61	61	60	61	238	246
1951	246	222	61	60	61	60	61	61	60	61	60	61
1952	61	58	61	60	61	60	61	61	60	61	60	61
1953	61	56	61	60	61	60	61	61	60	61	60	61
1954	61	56	61	60	61	60	61	61	60	61	60	61
1955	61	56	61	60	61	60	61	61	60	61	60	61
1956	61	58	61	60	61	60	61	61	60	61	60	61
1957	61	56	61	60	61	60	184	184	179	184	536	553
1958	553	500	307	298	307	298	184	184	179	184	238	246
1959	246	222	61	60	61	60	61	61	60	61	238	246
1960	246	230	307	298	307	298	61	61	60	61	238	246
1961	246	222	307	298	307	298	184	184	179	184	536	553
1962	553	500	123	119	123	119	61	61	60	61	238	246
1963	246	222	123	119	123	119	61	61	60	61	60	61
1964	61	58	123	119	123	119	61	61	60	61	60	61
1965	61	56	123	119	123	119	61	61	60	61	238	246
1966	246	222	123	119	123	119	61	61	60	61	238	246
1967	246	222	61	60	61	60	61	61	60	61	60	61
1968	61	58	123	119	123	119	184	184	179	184	238	246
1969	246	222	123	119	123	119	184	184	179	184	536	553
1970	553	500	123	119	123	119	61	61	60	61	238	246
1971	246	222	61	60	61	60	61	61	60	61	238	246
1972	246	230	123	119	123	119	61	61	60	61	238	246
1973	246	222	307	298	307	298	184	184	179	184	536	553
1974	553	500	123	119	123	119	61	61	60	61	536	553
1975	553	500	307	298	307	298	184	184	179	184	536	553
1976	553	518	123	119	123	119	61	61	60	61	238	246
1977	246	222	123	119	123	119	61	61	60	61	60	61
1978	61	56	61	60	61	60	61	61	60	61	60	61
1979	61	56	123	119	123	119	61	61	60	61	238	246
1980	246	230	123	119	123	119	61	61	60	61	238	246
1981	246	222	123	119	123	119	61	61	60	61	238	246
1982	246	222	123	119	123	119	184	184	179	184	238	246
1983	246	222	123	119	123	119	61	61	60	61	238	246
1984	246	230	123	119	123	119	61	61	60	61	238	246
1985	246	222	307	298	307	298	184	184	179	184	536	553
1986	553	500	123	119	123	119	61	61	60	61	536	553
1987	553	500	307	298	307	298	184	184	179	184	536	553
1988	553	518	123	119	123	119	61	61	60	61	238	246
1989	246	222	123	119	123	119	61	61	60	61	238	246
1990	246	222	123	119	123	119	61	61	60	61	238	246
1991	246	222	123	119	123	119	61	61	60	61	536	553
1992	553	518	307	298	307	298	184	184	179	184	536	553
1993	553	500	307	298	307	298	184	184	179	184	536	553
1994	553	500	123	119	123	119	61	61	60	61	238	246
1995	246	222	123	119	123	119	61	61	60	61	536	553
1996	553	518	123	119	123	119	61	61	60	61	238	246
1997	246	222	307	298	307	298	184	184	179	184	536	553
1998	553	500	307	298	307	298	61	61	60	61	60	61
1999	61	56	61	60	61	60	61	61	60	61	238	246
2000	246	230	61	60	61	60	61	61	60	61	60	61
2001	61	56	307	298	307	298	61	61	60	61	238	246
2002	246	222	123	119	123	119	61	61	60	61	238	246
2003	246	222	123	119	123	119	61	61	60	61	238	246
2004	246	230	123	119	123	119	61	61	60	61	536	553
2005	553	500	307	298	307	298	184	184	179	184	238	246
2006	246	222	61	60	61	60	61	61	60	61	60	61
2007	61	56	123	119	123	119	184	184	179	184	536	553
2008	553	518	123	119	123	119	61	61	60	61	238	246
2009	246	222	61	60	61	60	61	61	60	61	238	246
2010	246	222	123	119	123	119	61	61	60	61	238	246
2011	246	222	123	119	123	119	61	61	60	61	60	61
2012	61	58	61	60	61	60	61	61	60	61	60	61
2013	61	56	61	60	61	60	61	61	60	61	60	61
2014	61	56	61	60	61	60	61	61	60	61	60	61
2015	61	56	123	119	123	119	184	184	179	184	536	553