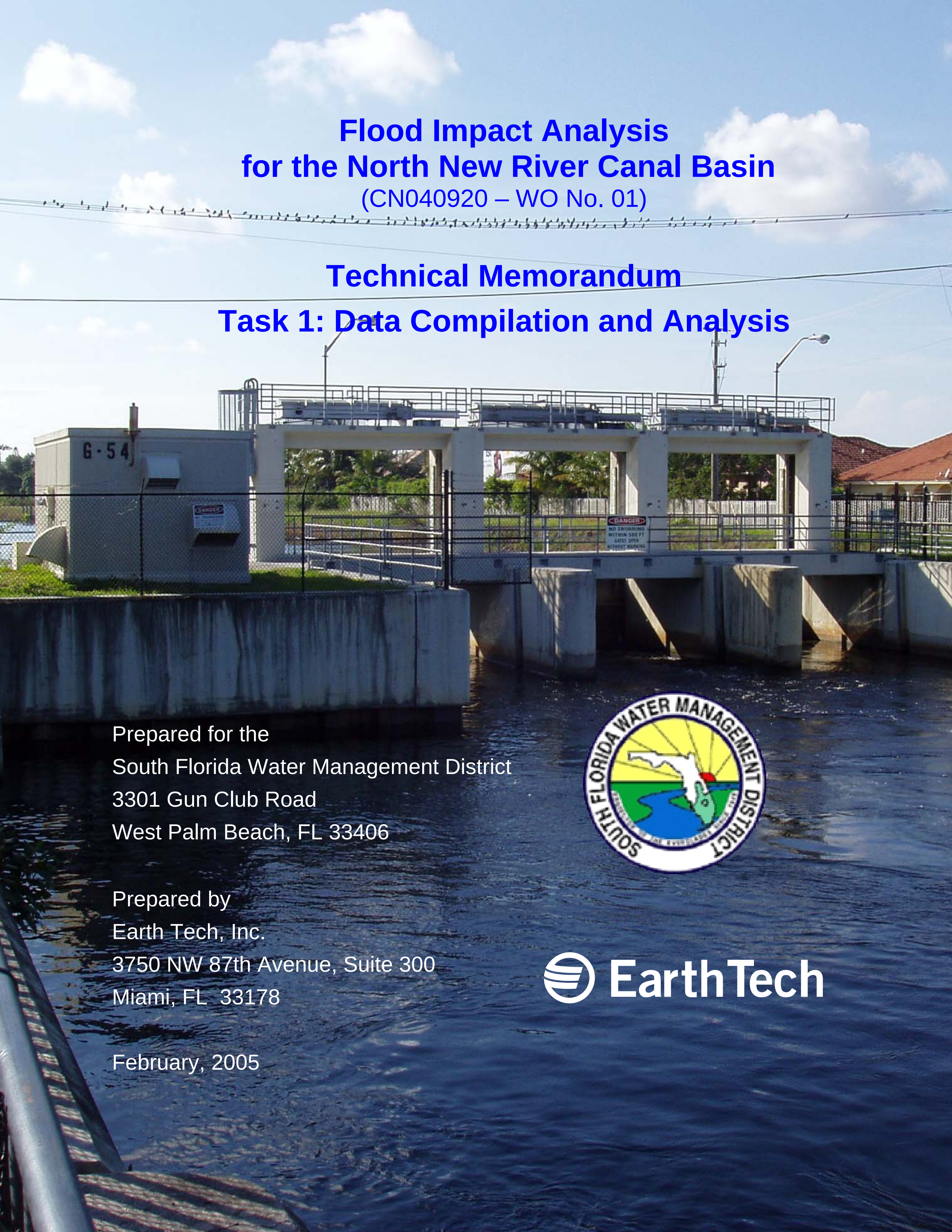

Flood Impact Analysis for the North New River Canal Basin

(CN040920 – WO No. 01)

Technical Memorandum

Task 1: Data Compilation and Analysis

Prepared for the
South Florida Water Management District
3301 Gun Club Road
West Palm Beach, FL 33406

Prepared by
Earth Tech, Inc.
3750 NW 87th Avenue, Suite 300
Miami, FL 33178

February, 2005

Flood Impact Analysis for the North New River Canal Basin

Technical Memorandum

Task 1 – Data Compilation and Analysis

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1 Introduction

This technical memorandum was prepared in accordance with Task 1 of Work Order CN040920-WO01 with the South Florida Water Management District (SFWMD). This memorandum documents the available data pertaining to the North New River Canal (NNRC) Basin and analyzes the historical records of water levels, runoff volumes and peak discharges at various structures within the project area. The data review will help determine if adequate data is available to support the construction of a hydraulic model of the NNRC, as part of the flood impact analysis for the NNRC Basin.

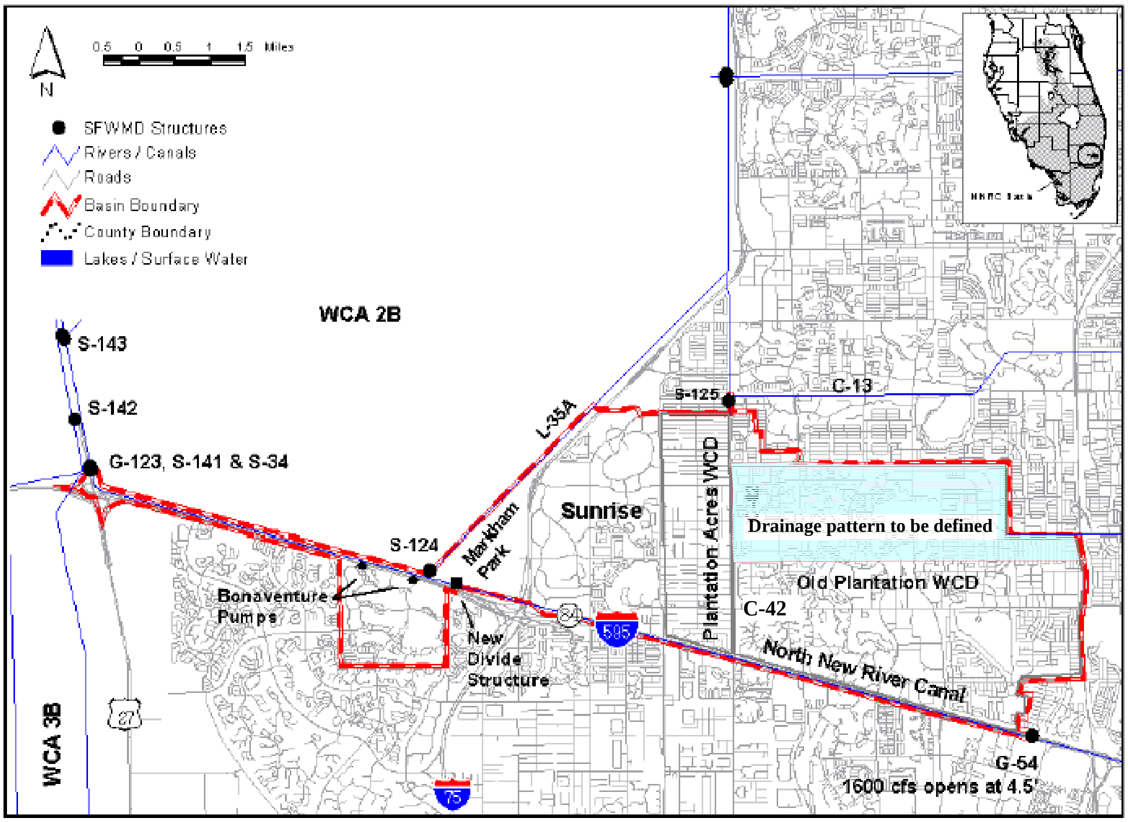


Figure 1-1 NNR Canal Basin Map

The NNRC Basin covers an area of about 19,000 acres (30 square miles) in eastern Broward County. The basin is located southeast of Water Conservation Area (WCA) 2B, west of the Florida Turnpike and north of Interstate Highway 595. The NNRC Basin is located immediately to the north of the C-11 West Basin, separated only by the NNRC. A map of the NNRC Basin is presented on Figure 1-1.

The project canals and control structures in the NNRC have four functions:

- To provide flood protection and drainage for the NNRC Basin
- To supply water to the basin during periods of low natural flow

- To convey excess water from Water Conservation Areas to tidewater
- To intercept and control seepage from WCA 2A

There are eight project control structures regulating flow in the NNRC Basin. The two major control structures are the Sewell Lock (G-54) and G-123. The Sewell Lock (G-54) is a spillway and lock structure along the NNRC and it regulates discharges from the NNRC to tidewater. G-123 is a pumping station located on the NNRC. During the dry season, G-123 discharges water, which would be otherwise discharged to tidewater from the NNRC into the WCA 3A. The pumping station is also used as flood protection for the NNRC Basin.

The long-term plan for achieving EPA water quality goals recommends that discontinuing the use of G-123 pump station is the most cost-effective means of diverting NNRC's stormwater runoff away from the Everglades. The plan also recognizes that a flood impact analysis must be performed to ensure the NNRC Basin's current level of flood protection will be maintained after discontinuing the use of G-123. The flood impact analysis will include the following tasks:

- Review and analysis of historical data
- Hydraulic analysis of selected storm events to evaluate the potential impacts of discontinuing the use of G-123 pump station during flood events
- Evaluations of alternatives capable of reducing or eliminating the negative impacts of discontinuing the use of G-123 pump station

The following sections describe the review of the available data provided by the SFWMD pertaining to NNRC Basin, the data needed to construct a hydraulic model of the NNRC Basin, and conclusions of the data review and recommendations for additional data to support the flood impact analysis of the NNRC Basin.

2 Available Data

2.1 Introduction

This section describes the data collected by SFWMD for the Consultant. An initial package of electronic files, hardcopy drawings and report was provided during the kickoff meeting. Additional information, reports and permit documentation were subsequently collected from the various municipal water districts and provided to the Consultant. With regards to the hydrological data, after an initial review and discussions with the District, additional flow records for the G-54 structures and the operating for the G-123 pump station were collected to attempt to complement some missing records within the database.

2.2 River Cross-Sections and Profile

River cross-sections are a key element in developing the NNRC hydraulic model. A review of the data revealed that three cross-section surveys and one river profile had been conducted on the NNRC. The data also includes one cross-section survey and one river profile along C-42 Canal. The following is a summary of these surveys:

- 34 cross-sections along the NNRC starting from Levee L-35A to the railroad (RR) in Fort Lauderdale. The cross-sections had been surveyed on December 22-23, 1958
- 14 cross-sections along the NNRC between Pine Island Road and University Drive surveyed on December 12, 1973
- 22 cross-sections along the NNRC surveyed between September 25 – October 15, 1974
- 32 cross-sections along the NNRC surveyed on June 9, 1979
- 13 cross-sections along the NNRC from Sewell Locks to University Drive surveyed on January 18, 1973
- NNRC profile along centerline dated October 2004
- Six (6) cross-section surveys along C-42 dated February 1951
- C-42 canal profile along centerline dated October 2004

The October 2004 centerline survey of the North New River Canal and C-42 Canal was performed by SFWMD staff from a boat utilizing the following survey echo-sounder and Global Positioning Satellite technology:

- Survey echo-sounder: Odom Hydrotrack
- GPS receiver: Trimble HYDRO
- Software: Hypack Max Hydrographic

A comparison between the NNRC 1979 cross-section survey and the 2004 river profile showed that the river reach upstream of the Sewell Lock (G-54), approximately three miles in length, has accumulated up to five feet of sediment between 1979 and 2004. Figure 2-1 shows the recently surveyed profile of the NNRC, as well as the profiles of the centerline of the canal drawn from the surveyed cross-sections collected for this evaluation. Since the river profile was not necessarily taken at the lowest point of the canal, it is only a preliminary indication of a possible conveyance reduction of the canal. This sediment accumulation should be verified by a cross-section survey.

2.3 Pumped Flows into the North New River Canal Basin

This subsection documents available data pertaining to pump stations that discharge into the NNRC Basin. Based on available discharge permits, maps, and schematics, the following is a summary of pumped flow information data found in the data set:

- **Plantation Acres Improvement District (PAID) Discharge Permit**: The permit authorizes the operation of a water management system serving 2,065 acres of residential and commercial lands by the improvement of canals and the use of six (6) 20,000 gallon-per-minute (gpm) pumps discharging into C-42 Canal and then into the NNRC. The control elevation of these pumps is 4.0 feet relative to the National Geodetic Vertical Datum (ft NGVD). The pump elevation is permitted at elevation 4.5 ft NGVD and OFF at elevation 3.5 ft NVGD. The locations of these pumps were shown on the available facility map provided with the set of maps/schematics.

- **Lago Mar Development Discharge Permit:** This permit is for a surface water management system to serve a 318.4-acre residential development. The development has an on-site lake and canal that discharges into the NNRC. The discharge structure consists of two pumps with a total capacity of 45,000 gpm.

- **G-123 Pump Station**: SFWMD structure on the NNRC that discharges the excess flow in the NNRC into the WCA 2A. The total capacity of the pump is 400 cfs.

- **Old Plantation Water Control District (OPWCD):** The OPWCD owns three pump stations; two of these stations, 180,000 gpm each, discharge into the NNRC between the G-54 structure and the confluence of the C-42 Canal with the NNRC.

- **Bonaventure Drainage District (BDD):** The BDD owns two pumps, 100,000 gpm in combined capacity, that discharge into the NNRC just west of the confluence point of the C-42 canal with the NNRC.

- **City of Sunrise Drainage District:** The City of Sunrise owns a pump that is 150,000 gpm in capacity and discharges into the NNRC, midway between the confluence point of C-42 Canal with the NNRC and the confluence point of the L-35A Canal with the NNRC.

- **Water Control District's Pump Records Summary:** The pumping records data was provided for major pumps in the study area during selected storm events.

Table 2-1 presents a summary of the available data pertaining to pumped flows into the NNRC Basin.

Table 2-1 - Summary of Available Pump Station Data

Pump Owner	Pump Name	Pump Size	Receiving Water	Rainfall Events Where Pump Records are Available
Old Plantation Water Control District	Station #2	180,000 gpm	NNRC	11/1998, 06/1999, 10/1999, 10/2000, 08/2001, 05/2003
	Station #3	180,000 gpm	NNRC	11/1998, 06/1999, 10/1999, 10/2000, 08/2001, 05/2003
Bonaventure Drainage District	Station #1	55,000 gpm	NNRC	06/1999, 10/1999, 10/2000, 08/2001, 05/2003
	Station #2	45,000 gpm	NNRC	06/1999, 10/1999, 10/2000, 08/2001, 05/2003
City of Sunrise Drainage District	Station #8	150,000 gpm	NNRC	10/1999, 08/2000, 10/2000
Plantation Acres Improvement District (PAID)	Pump #1	20,000 gpm	C-42 Canal	None
	Pump #2	20,000 gpm	C-42 Canal	None
	Pump #3	20,000 gpm	C-42 Canal	None
	Pump #4	20,000 gpm	C-42 Canal	None
	Pump #5	20,000 gpm	C-42 Canal	None
	Pump #6	20,000 gpm	C-42 Canal	None
Lago Mar Development	NA	45,000 gpm	NNRC	None
SFWMD	G-123	400 cfs	NNRC	11/1994, 11/1998, 06/1999, 10/1999, 10/2000

2.4 Gravity Flows into the North New River Canal Basin

This subsection documents available data on gravity sub-basin runoff flows into the NNRC Basin. Table 2-2 summarizes the gravity flow information with the details described below:

- **City of Sunrise Drainage Basin #7:** Basin #7 is located north of the Plantation Canal and east of the C-42 Canal. The basin has a total area of 293 acres, 79% of which is categorized as single and multi family residential. The stormwater system consists of a series of interconnected canals and Lake Edwards, and discharge by way of gravity into the C-42 Canal through a 54-inch outfall. The input and the results of sub-basin simulations, using Advanced Interconnected Channel and Pond (ICRP) Routing, are included in the data set.

- **Markham Park:** The park area is 665 acres, of which 38 acres are impervious. The park has an on-site lake that provides surface water management and recreation that retain the runoff from the park and discharge into the NNRC through a V-notch weir. The discharge permit includes a stage-storage-discharge curve for the on-site lake. The allowable discharge into the NNRC is 152 cfs. However, since this park site is mostly pervious, the actual discharge will be less than the maximum allowable.

- **Plantation Lakeside Development:** The available data includes a copy of permit information for the gravity flow from the proposed (marked as undeveloped) Plantation Lakeside development into the NNRC. The total area is 7.01 acres with 56%

imperviousness. The maximum allowable discharge into the NNRC is 13 cfs. The permit also shows information on an on-site canal for water management and discharge into the NNRC through a weir-orifice discharge structure. The permit also includes a stage-storage-discharge curve of the on-site canal.

- **D&C Barnett Plaza:** This plaza includes a 9.28-acre commercial development with 61% imperviousness. The allowable discharge into the NNRC is 1.03 cfs. The runoff is routed to a 0.9-acre on-site lake for water management and discharge into the NNRC through a bleeder and weir structure. The permit also includes a stage-storage-discharge curve of the on-site lake.

- **Florida Department of Transportation (FDOT) permit:** This permit proposed surface water management to serve the interchange of I-75 and SR25. A total of 275 acres are drained into the NNRC through nineteen 24-inch RCPs and two 48-inch RCPs. The applicant has requested an outfall capacity of 460 cfs. The permit shows the locations of all the RCPs.

- **FDOT permit for the construction of one 36-inch outfall into the NNRC**. The outfall will serve a total of 7.7 acres of public highway. It has been recommended by SFWMD to modify the permit to include construction and operation authority for a 36-inch outfall serving a 1.7-acre parcel of I-75 to the NNRC. The permit shows the locations of all outfalls.

- **FDOT permit for construction and operation of a 6-lane interstate highway and a water management system**: This system will serve 84.2 acres of road improvement area with eight outfalls to the NNRC. The permit shows the location of the eight outfalls.

- **FDOT proposed permit for slip ramp connection to SR-84:** For traffic capacity improvements and travel delay reduction, FDOT is requesting a permit for a slip ramp connection from eastbound SR-84 to eastbound I-595, and modifications to the existing S-E connector and the existing N-E connector. These new modifications will result in increased highway runoff flow into the NNRC. The FDOT permit shows a map of the study area and location of outfalls.

The data review identified gravity flows into upstream C-42 Canal and L-35A. There is no information found for these discharges. However, the flows will be accounted for in the boundary conditions of the hydraulic model of the NNRC Basin. Table 2-2 presents a summary of the available data pertaining to gravity flows into the NNRC Basin.

Table 2-2 - Summary of Gravity Flow Data

Name	Basin Area (acres)	% Imperviousness	Receiving Water	Water Management	Comments
City of Sunrise Basin #7	293	79%	C-42	Canals and Lake Edwards	% Imperviousness estimated from land use
City of Sunrise Basin 17A	223	NA	L-35A Canal	NA	Upstream of S-124 Structure. The area was estimated as 40% of Basin 17. Not included in the model.
City of Sunrise Basin 17B	334	NA	C-42 Canal	NA	Upstream of S-125 structure. The area was estimated as 60% of Basin 17. Not included in the model.
Markham Park	665	6%	NNRC	On-site Lake	
Plantation Lakeside Development	7	56%	NNRC	On-site Canal	This was marked as "undeveloped"
D&C Barnet Plaza	9	61%	NNRC	On-site Lake	
DOT Highway Runoff (I-75 and SR-25)	275	70% Approx.	NNRC	Grassed swales	4.5 miles along I-75 19x24" outfalls; 2x48" outfalls 460 cfs discharge capacity
DOT Highway Runoff	8	NA	NNRC	Grassed swales, baffled catch basins	36" outfall
DOT Highway Runoff	84	60% approx.	NNRC	Include retention	I-595 - 2.45 miles between Hiatus Rd and University Drive: 8 outfalls
DOT Highway Runoff	60	NA	NNRC	Dry retention, for percolation	Slip ramp connection to SR-84

2.5 Bridge Construction Permits

Copies of right of way and cross-section information are available for the following NNRC bridges:

- Markham Park Bridge
- I-75 Crossing (6 bridges)
- Stile Bridge
- SW 136th Avenue Bridge
- Flamingo Road Bridge
- Hiatus Road Bridge
- Nob Hill Road Bridge
- Pine Island Road Bridge

There are three bridges that were listed in the data, but no permit or information has been provided. The three bridges are:

- Commodore Drive Bridge
- SW 125th Avenue Bridge
- University Drive Bridge

2.6 NNRC Basin Studies and Report

This subsection describes available studies and reports that pertain to the NNRC Basin and may provide information to support the North New River Flood Impact Analysis.

- Atlas of Flow Computations at District Hydraulic Structures - SFWMD, April 2003. This electronic document provides current flow computation procedures for the District's hydraulic structures. Also available are the 1994 and 2000 versions of the SFWMD Structure Book that includes information on the following structures in the NNRC Basin: G-54, G-123, S-123, S-124, S-125, S-34, S-141.
- Basin-Specific Feasibility Studies - Everglades Stormwater Program Basin - Brown and Caldwell, October 2002. This report includes a section on the "Evaluation of Alternatives Water Quality Conditions for North New River Canal Basin." This section presents results of the evaluation of alternative water quality strategies for the NNRC Basin.
- An Atlas of Eastern Broward County Surface Water Management Basins SFWMD, November 1987. This technical memorandum contains information about the surface water management basins in Broward County. There is a section on the NNRC Basin that provides a description of the basin three canals (NNRC, L-35A, and C-42), the basin control structures (S-34, S-124, S-125, S-141, S-142, S-143, G-54, and G-123).
- Everglades Protection Area Tributary Basins - Long Term Plan for Achieving Water Quality Goals - Burns & McDonnell, October 2003: This report includes two sections that describe pre-2006 and post-2006 strategies for NNRC Basin.
- Central and Southern Florida Project Water Preserve Areas - Draft Integrated Feasibility Report - Supplemental Environmental Impact Statement – USACE & SFWMD, October 2001. The report includes the following sections that relate to the NNRC:
  - Hazardous Toxic and Radioactive Waste in NNR Project Area
  - Formulation of the Preliminary Plan of NNR Improvements (US 27 Conveyance)
  - Evaluation of the Alternative Plans and the PSP for NNR Improvements
  - NNR Impoundments
  - Recommended Plan for NNR Improvements
- Hurricane Irene – SFWMD after Action Assessment (Hard Copy) - SFWMD, December 9, 1999. A report of the assessment of the District operations and operation criteria during Hurricane Irene to identify possible system improvements. One section in the report describes findings, conclusions, and recommendations in the assessment of the operation of structures in South New River.
- Canal Conveyance Capacity Program - Windshield Evaluation: Documentation of visual observations of the North New River Canal from G-54 structure to the east side of US 441. The document describes bank and overbank conditions, water quality observations, navigation activity, and access constraints.

2.7 Maps and Schematics

The following is a list of maps and schematics provided in the data set:

- Plantation Acres Improvement District (PAID) Facilities Map

- Tributary Basin Map – North New River Canal Basin
- City of Sunrise Basin Boundary Sketch
- North New River Canal – Approximate Profile along Centerline, November 2004
- C-42 Canal – Approximate Profile along Centerline, November 2004
- C-42 Canal Plan and Cross-sections drawings, 1950-1951
- NNRC Cross-Sections Drawings, 12/1958
- NNRC Cross-Sections Drawings, 01/1973
- NNRC Cross-Section Drawings, 10/1974
- NNRC Cross-Sections Drawings, 06/1979

2.8 Aerial Photographs and Pictures

The data set includes copies of aerial photographs showing bridge locations on the NNRC. The photographs show street names, water bodies, and highways, which will help to identify the exact bridge location and support the river simulation in the flood impact analysis. The data also include a number of electronic "snap shots" taken at bridges across the NNRC and C-42 Canal. The pictures provide a better understanding of the geometry and structure of the bridges.

2.9 Historical Records

Records of water levels, flows and rainfall were either provided by SFWMD or directly collected from DBHDRO Website. These records are for varying time periods and include the following stations:

- Daily headwater (HW) levels for G-54 from October 1960 to November 2004
- Daily tailwater (TW) levels for G-54 from January 1990 to November 2004
- Daily flows for G-54 from January 1940 to November 2004
- Daily headwater levels for G-123 from January 1983 to November 2004
- Daily tailwater levels for G-123 from January 1990 to November 2004
- Daily flows for G-123 from June 1985 to November 2004
- Daily headwater levels for S-124 from January 1990 to November 2004
- Daily tailwater (TW) level for S-124 from June 1985 to November 2004
- Daily flow for S-124 from November 1986 to November 2004
- Daily tailwater levels for S-125 from August 1997 to November 2004
- Daily flow for S-125 from August 1997 to November 2004
- Daily rainfall for S-9 from January 1991 to January 2004
- Daily rainfall for G-54 from January 1990 to January 2004
- Daily rainfall for S-124 from January 1991 to January 2004
- Daily rainfall for S-34 from October 1994 to January 2004
- Daily rainfall for S-125 from January 1999 to January 2004
- Daily rainfall for 3A-36 from January 1960 to January 2004

Daily water levels in the NNR Canal and the C-42 Canal have been plotted for the period from January 1993 to October 2003 on Figure 2-2. The figure compares four sets of records: headwater levels at G-123, tailwater levels at S-124, tailwater levels at S-125 and headwater levels at G-54.

Preliminary observation of the records indicates that, in general, the lowering of the water level at the control structure G-54 by one to two feet does not always result in a significant lowering of the water level upstream at S-124 or S-125 or G-123. Although details of the gate operation at G-54 have not been collected and evaluated, the observation is consistent with a reduction of the conveyance capacity of the NNR canal.

Headwater and tailwater levels at the G-54 structure have been plotted on Figure 2-3 for the period from February 1982 to the present. Also shown on the figure are the long-term average levels for the periods prior to, and after the reconstruction of G-54 structure. It appears that on average there is a significant difference (approximately 0.4 foot) between the two periods. This difference is observed on both sets of records, headwater and tailwater levels. This is further demonstrated on Figure 2-4, which shows the average difference between these levels (i.e., the head losses created by the structure). It is recommended that these observations be further investigated as there are several possible explanations, including: changed datum, changed locations of gauge station, increased head losses due to the remnants of the old structure, changed operating rules, etc. This review should take place in the next phase of this study as the ability of G-54 to effectively control the water level in the NNR Canal is an important component of flood impact analysis.

Figure 2-1 NNR Canal Profile

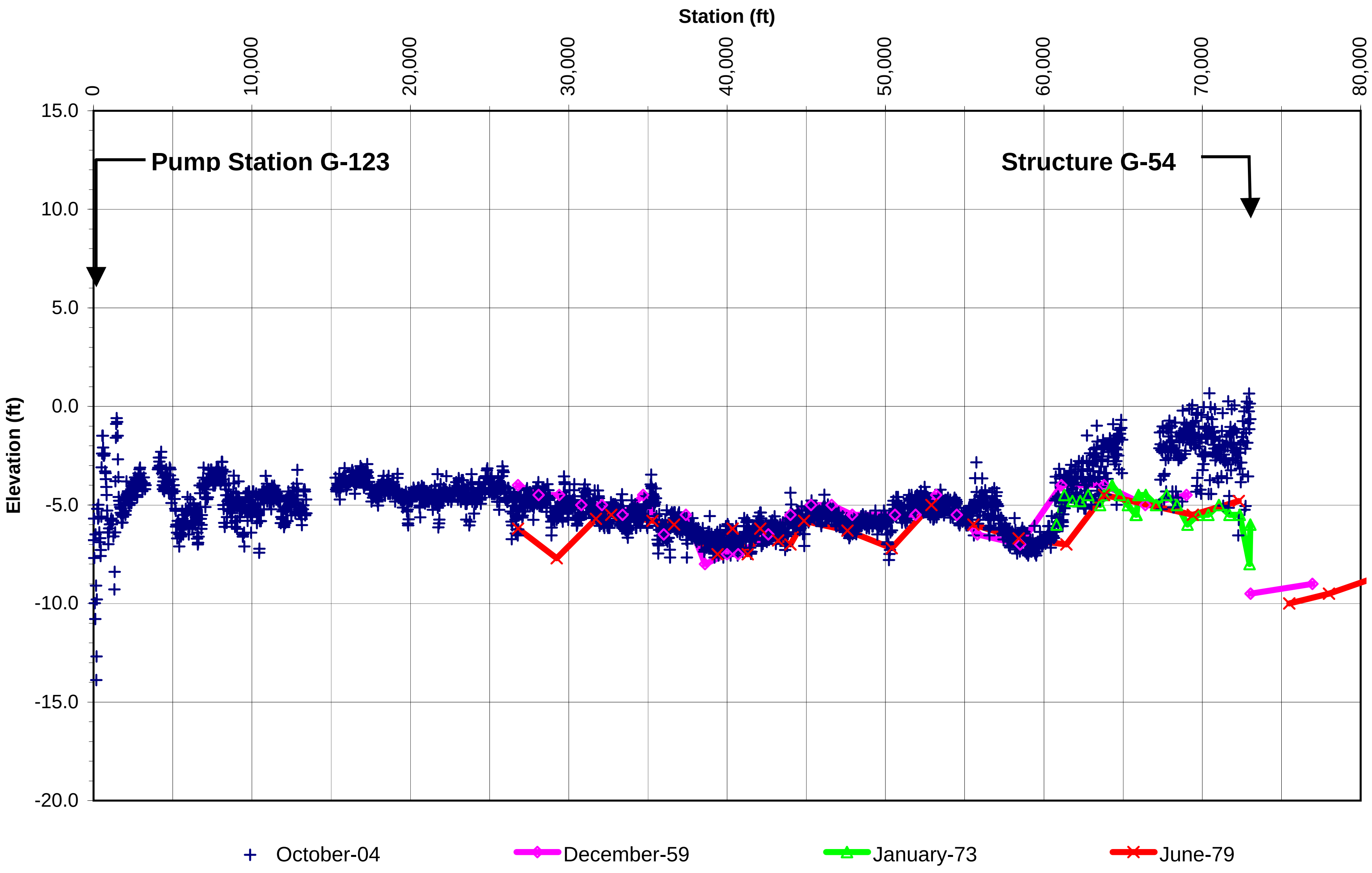


Figure 2-2 NNR Canal Detailed Profile (page 1 of 5)

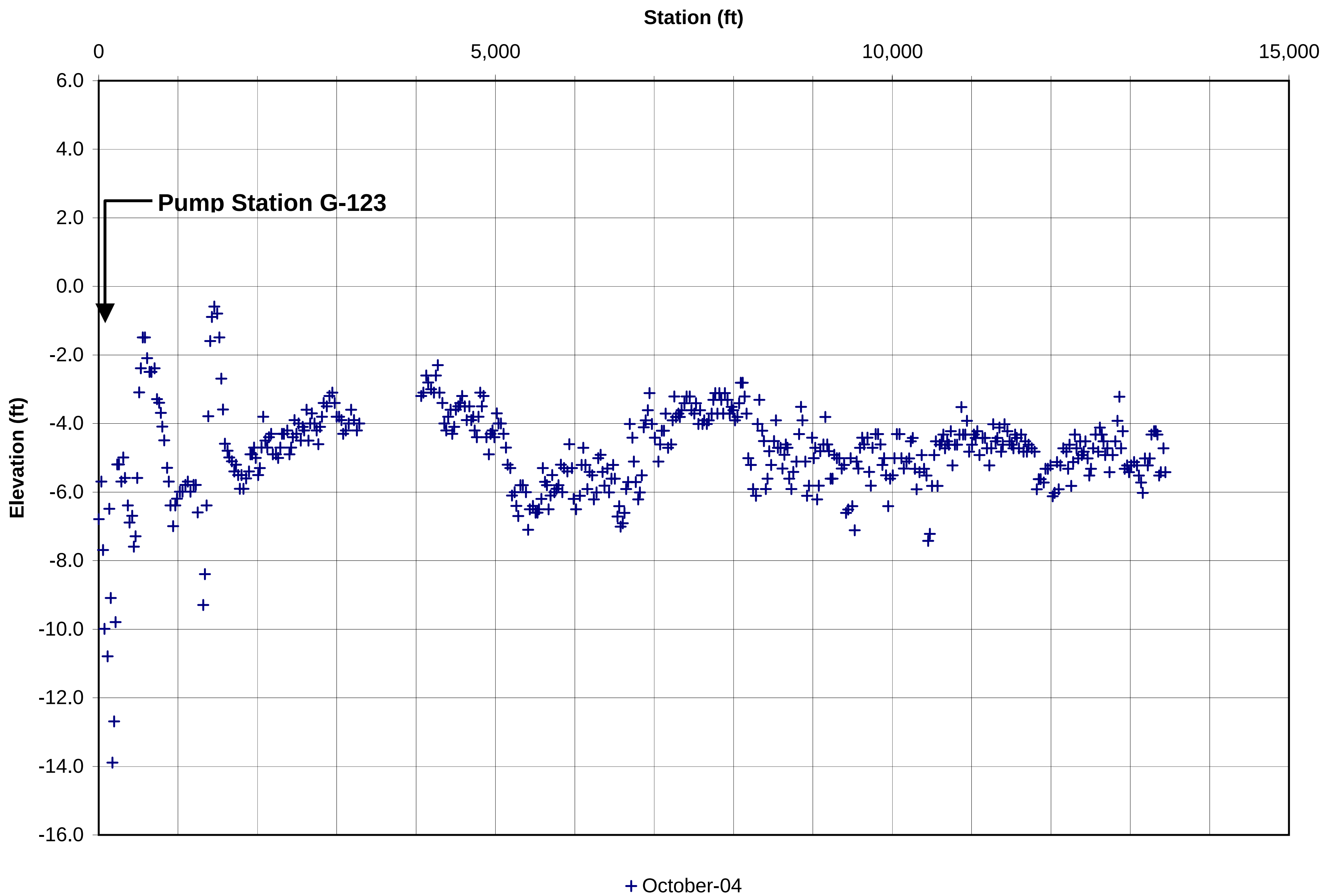


Figure 2-2 NNR Canal Detailed Profile (page 2 of 5)

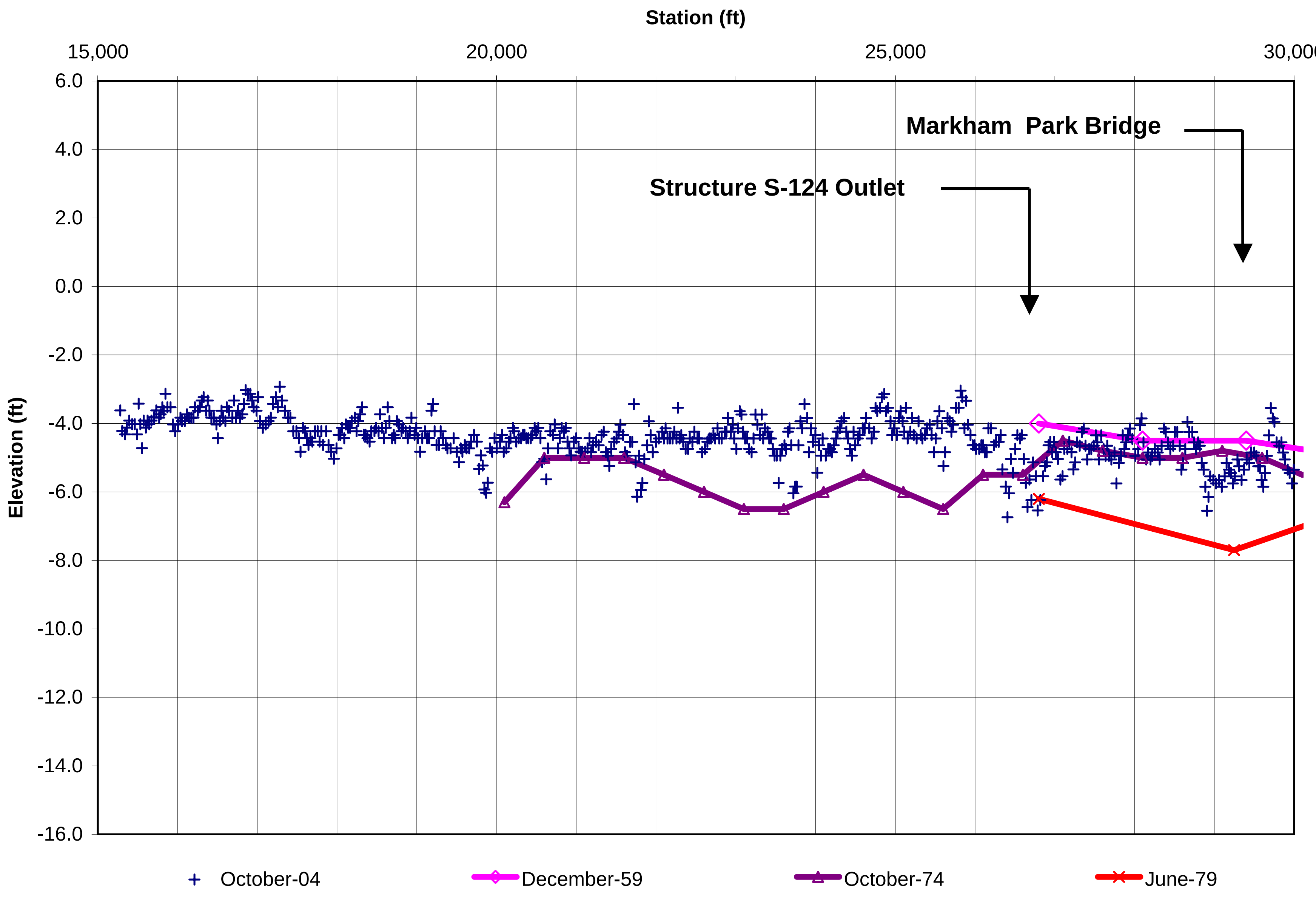


Figure 2-2 NNR Canal Detailed Profile (page 3 of 5)

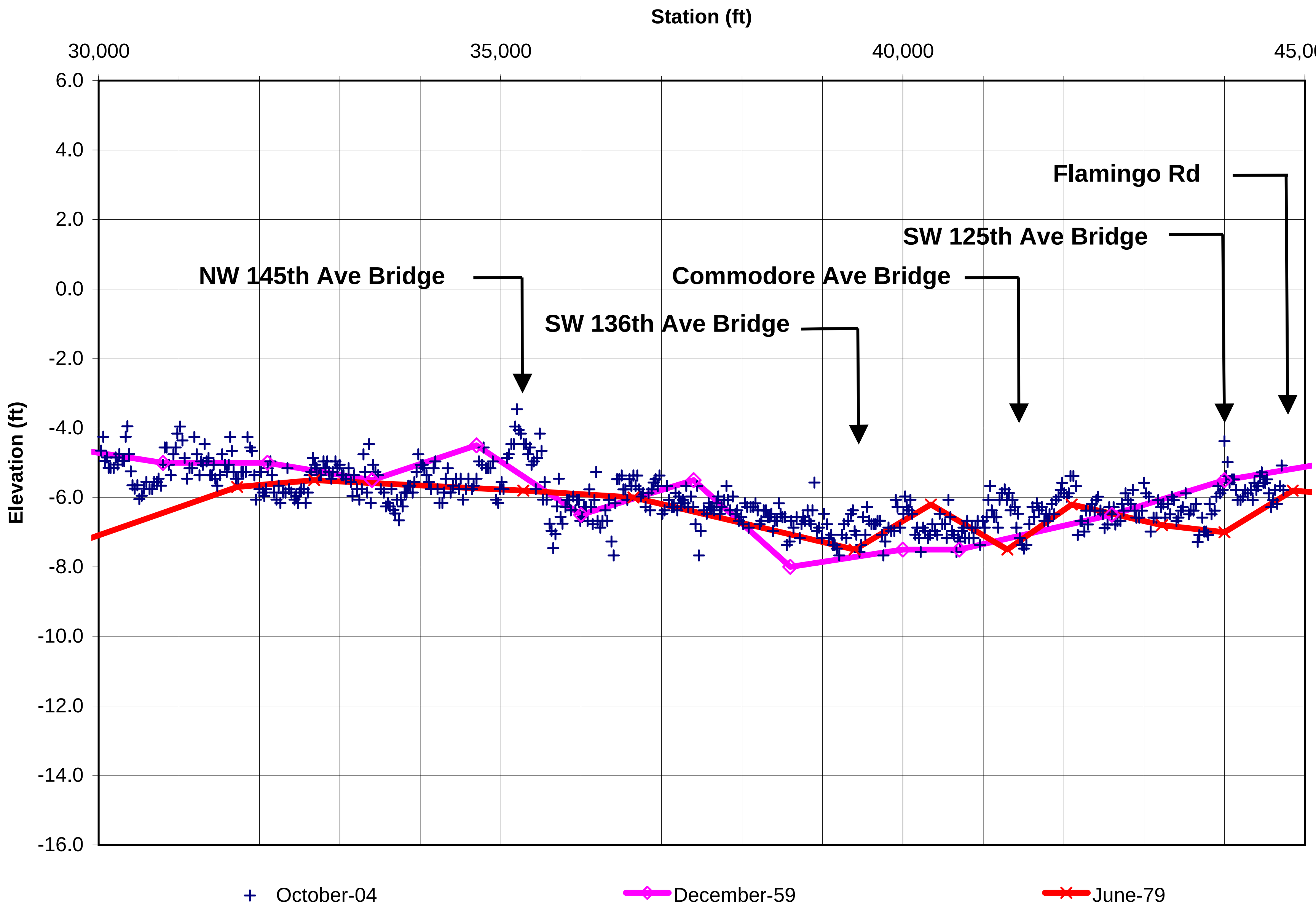


Figure 2-2 NNR Canal Detailed Profile (page 4 of 5)

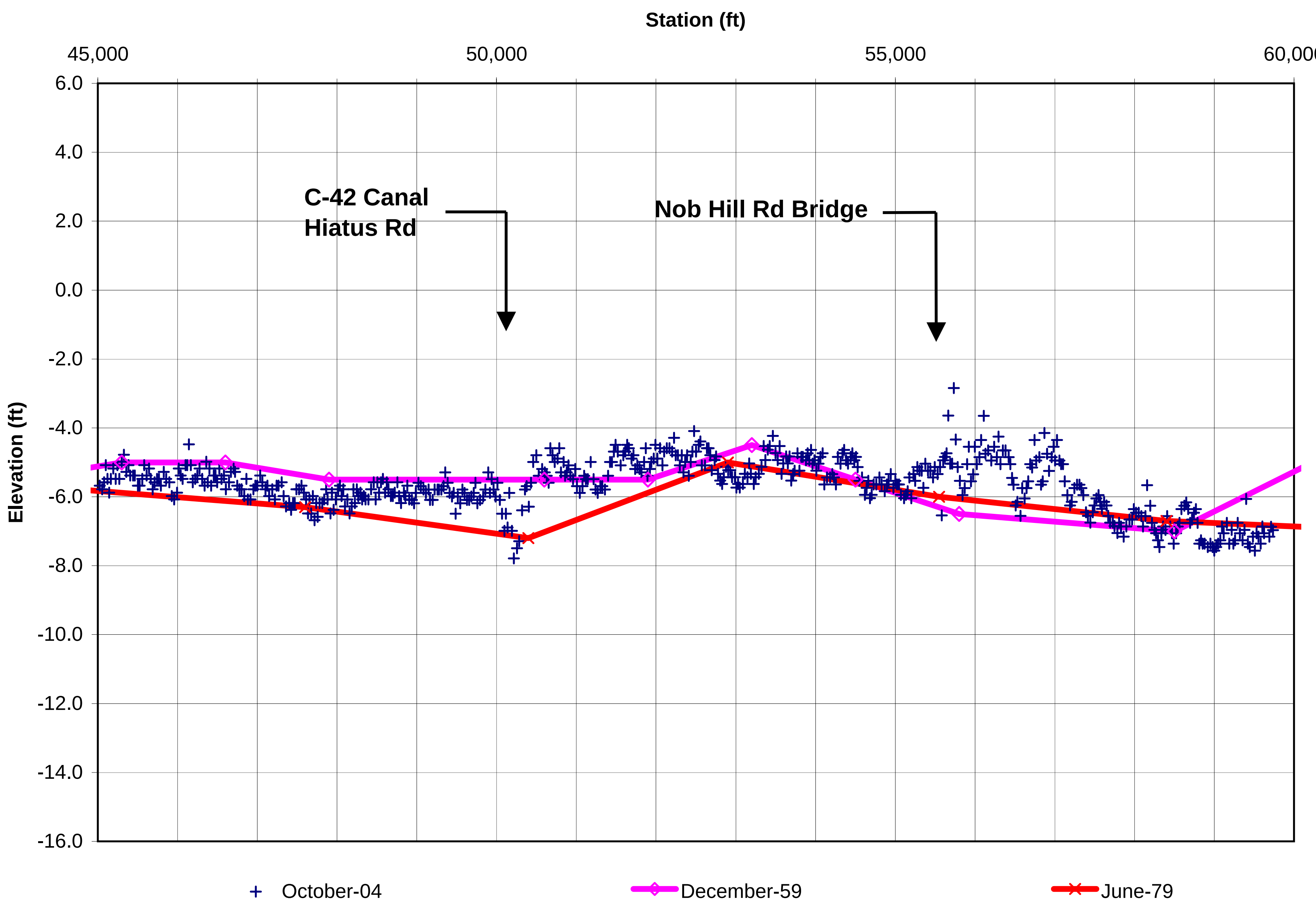


Figure 2-2 NNR Canal Detailed Profile (page 5 of 5)

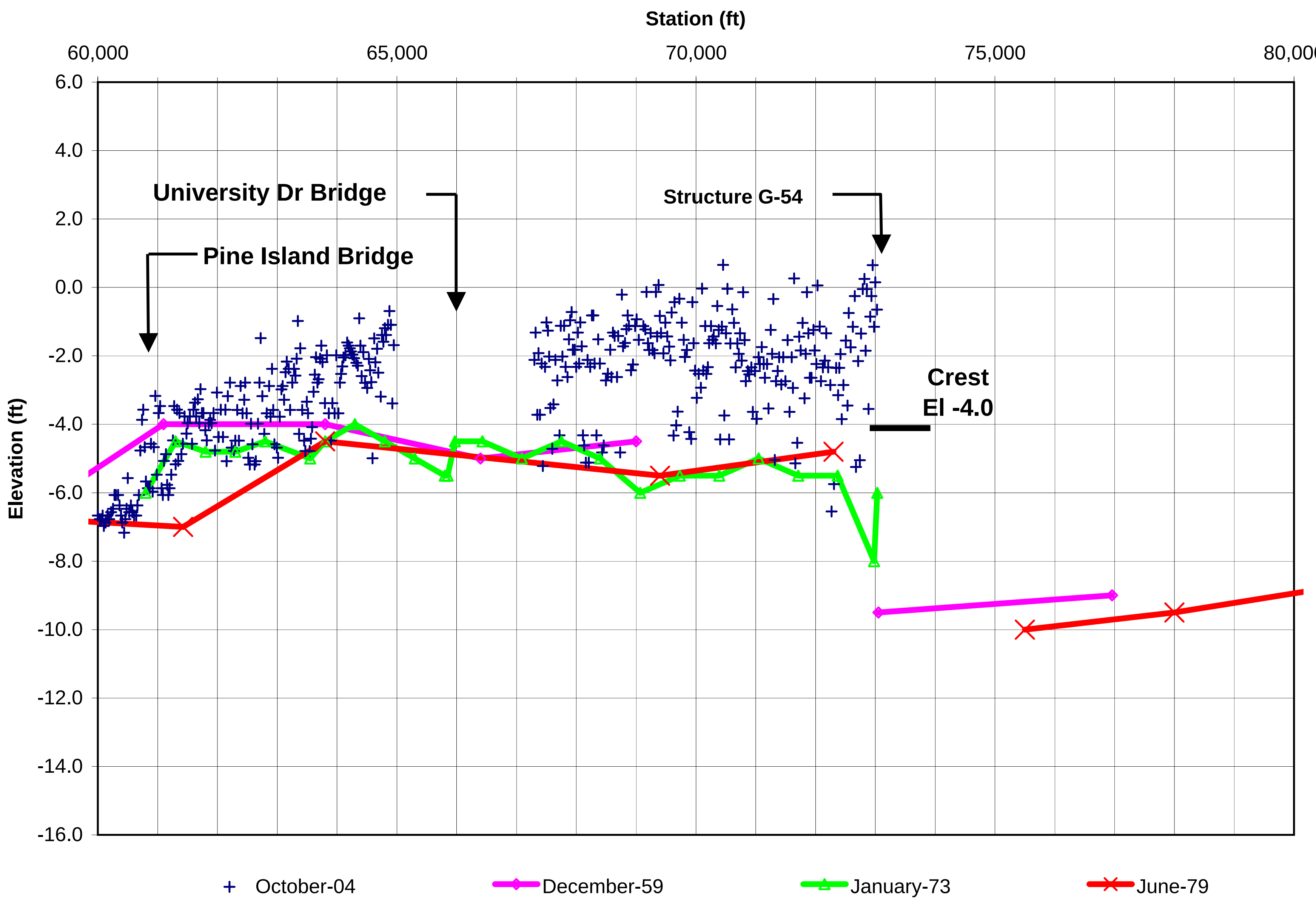


Figure 2-3 C-42 Canal Profile

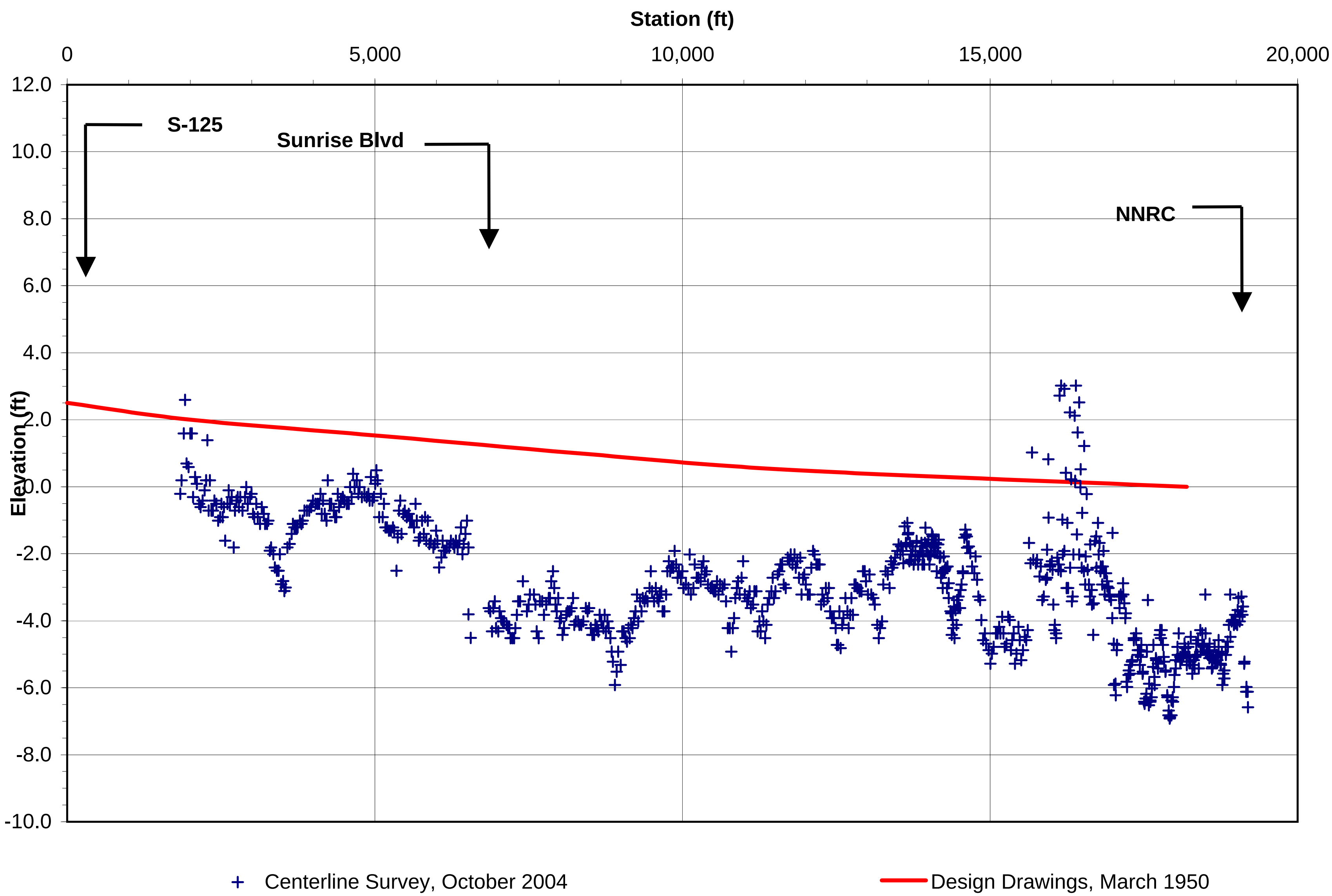


Figure 2-4 NNRC and C-42 Water Levels (page 1 of 11)

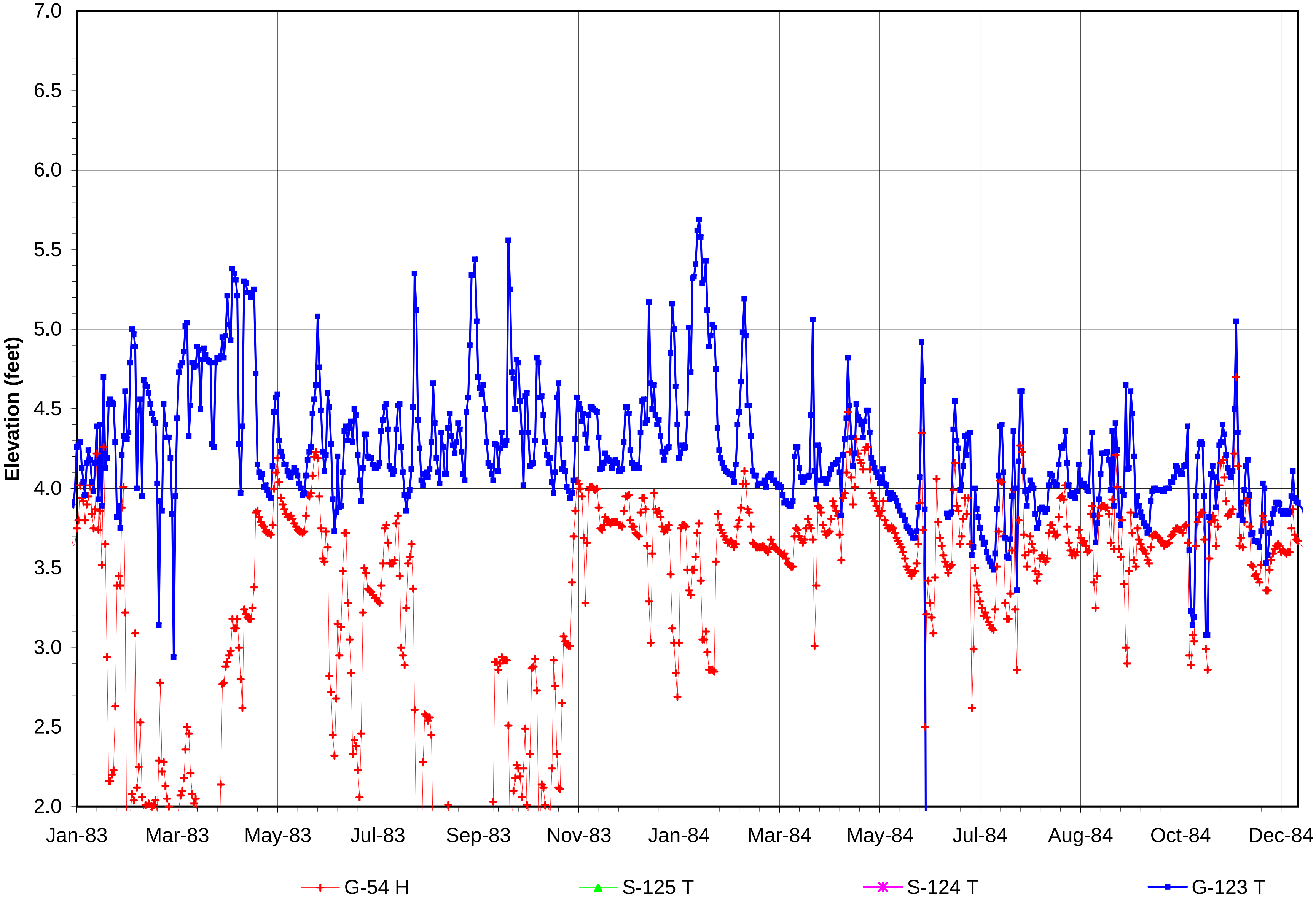


Figure 2-4 NNRC and C-42 Water Levels (page 2 of 11)

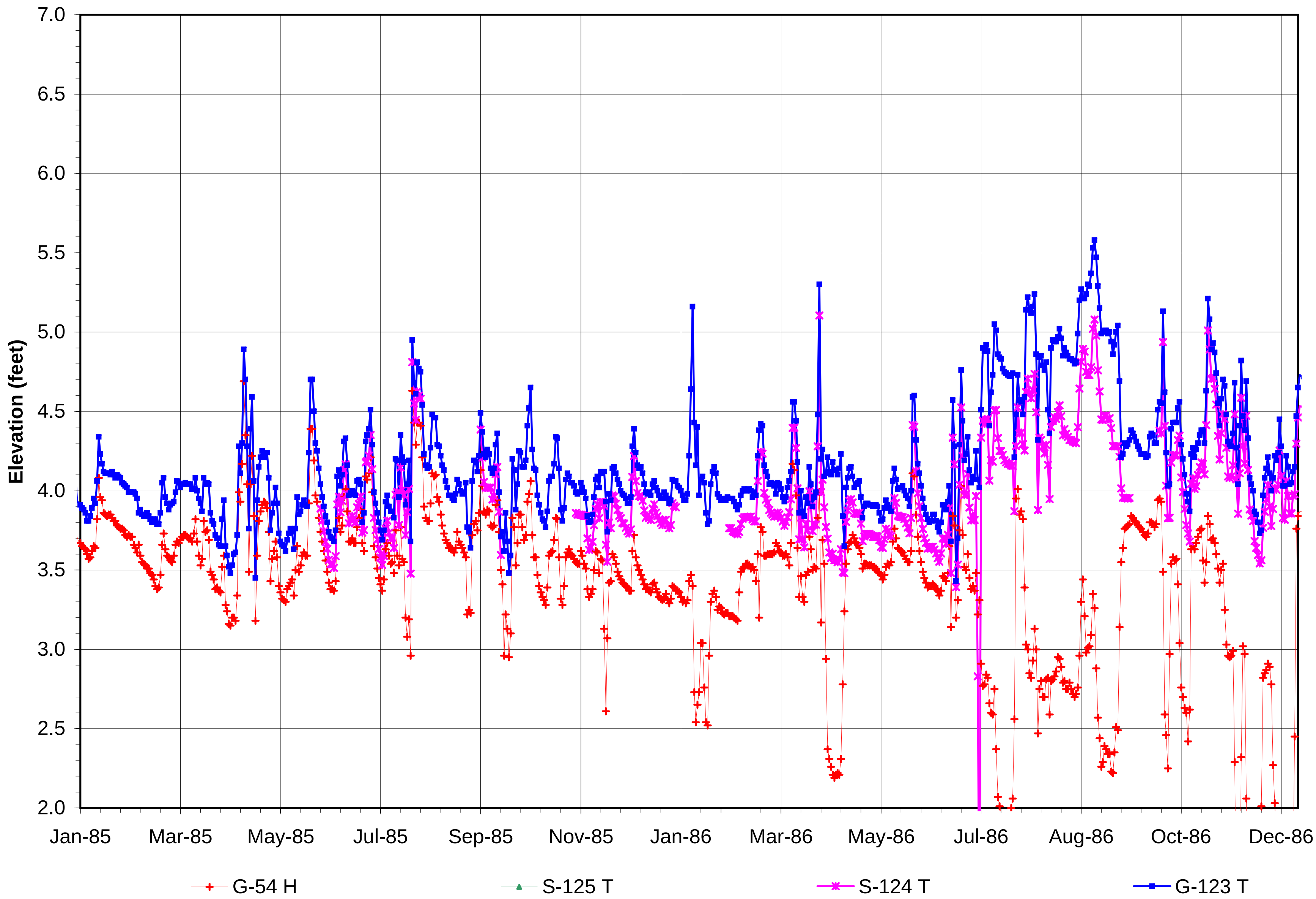


Figure 2-4 NNRC and C-42 Water Levels (page 3 of 11)

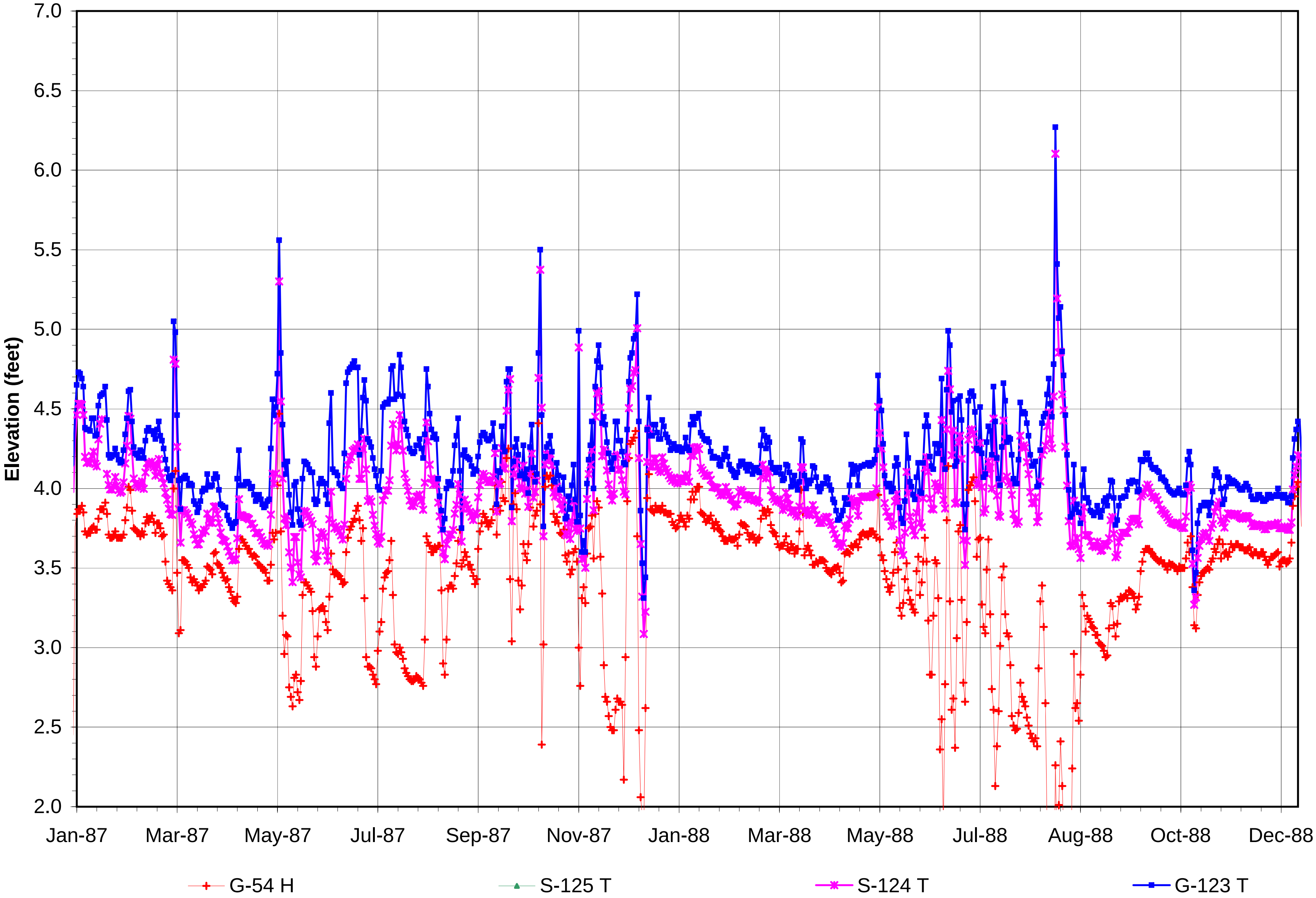


Figure 2-4 NNRC and C-42 Water Levels (page 4 of 11)

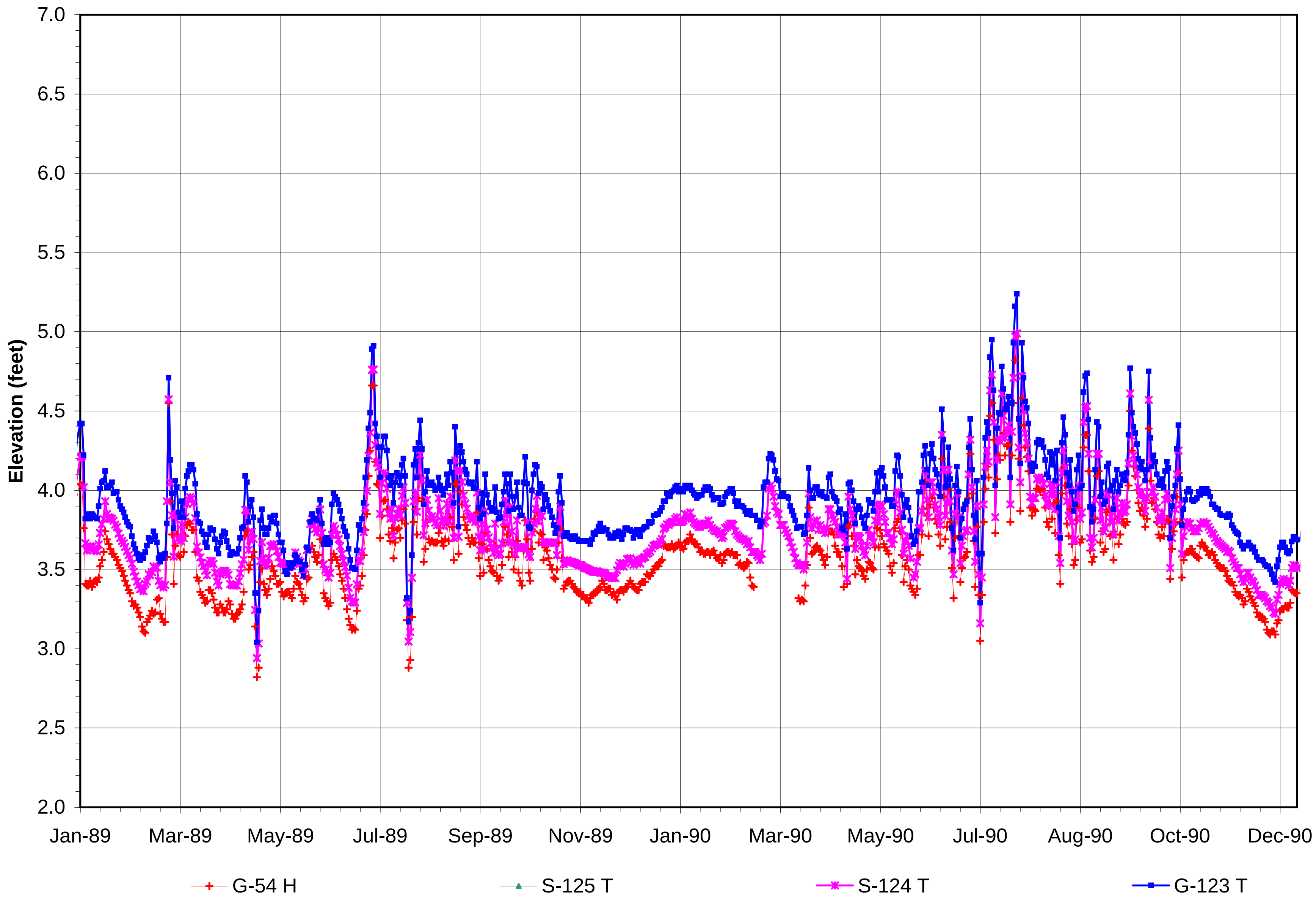


Figure 2-4 NNRC and C-42 Water Levels (page 5 of 11)

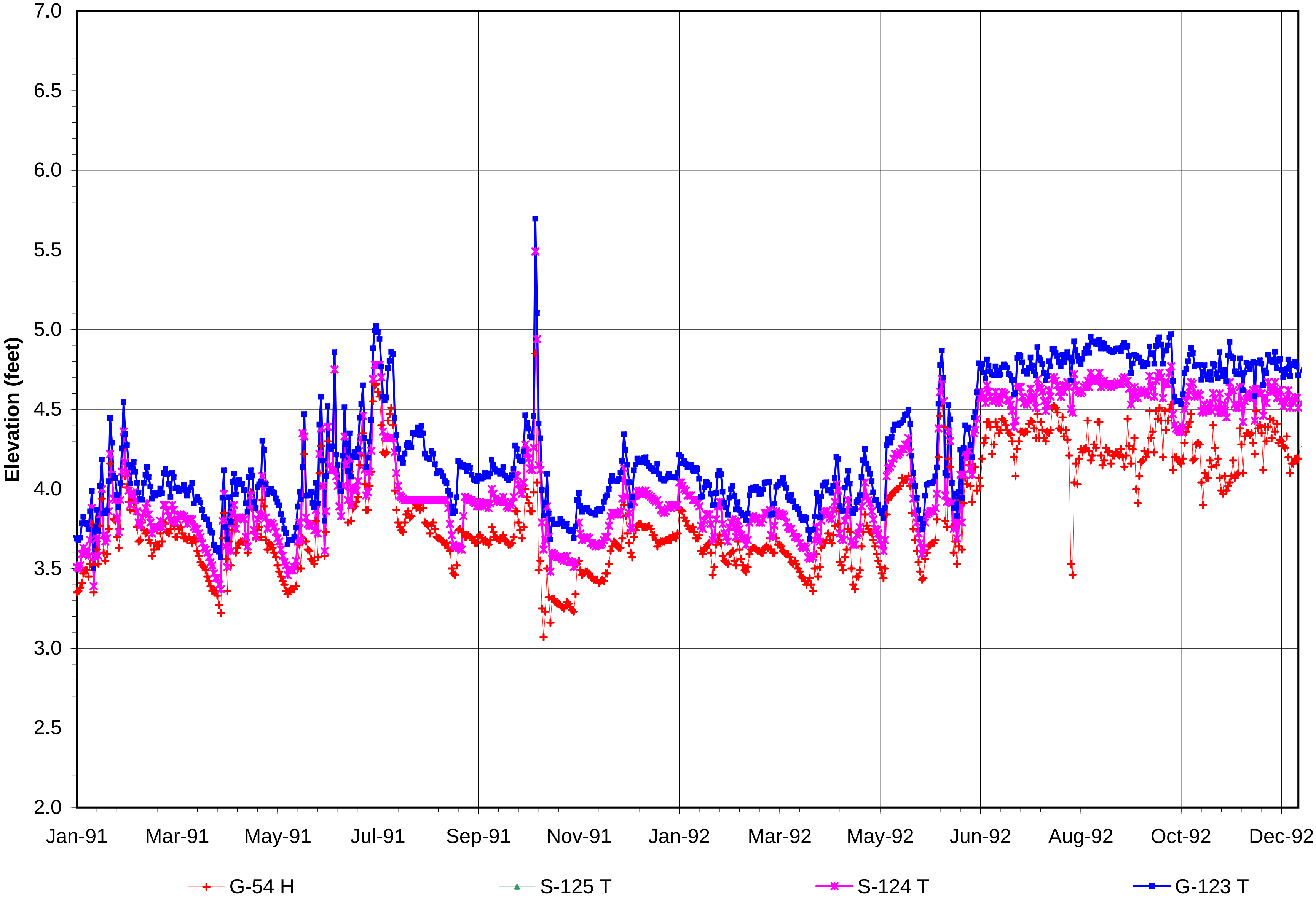


Figure 2-4 NNRC and C-42 Water Levels (page 6 of 11)

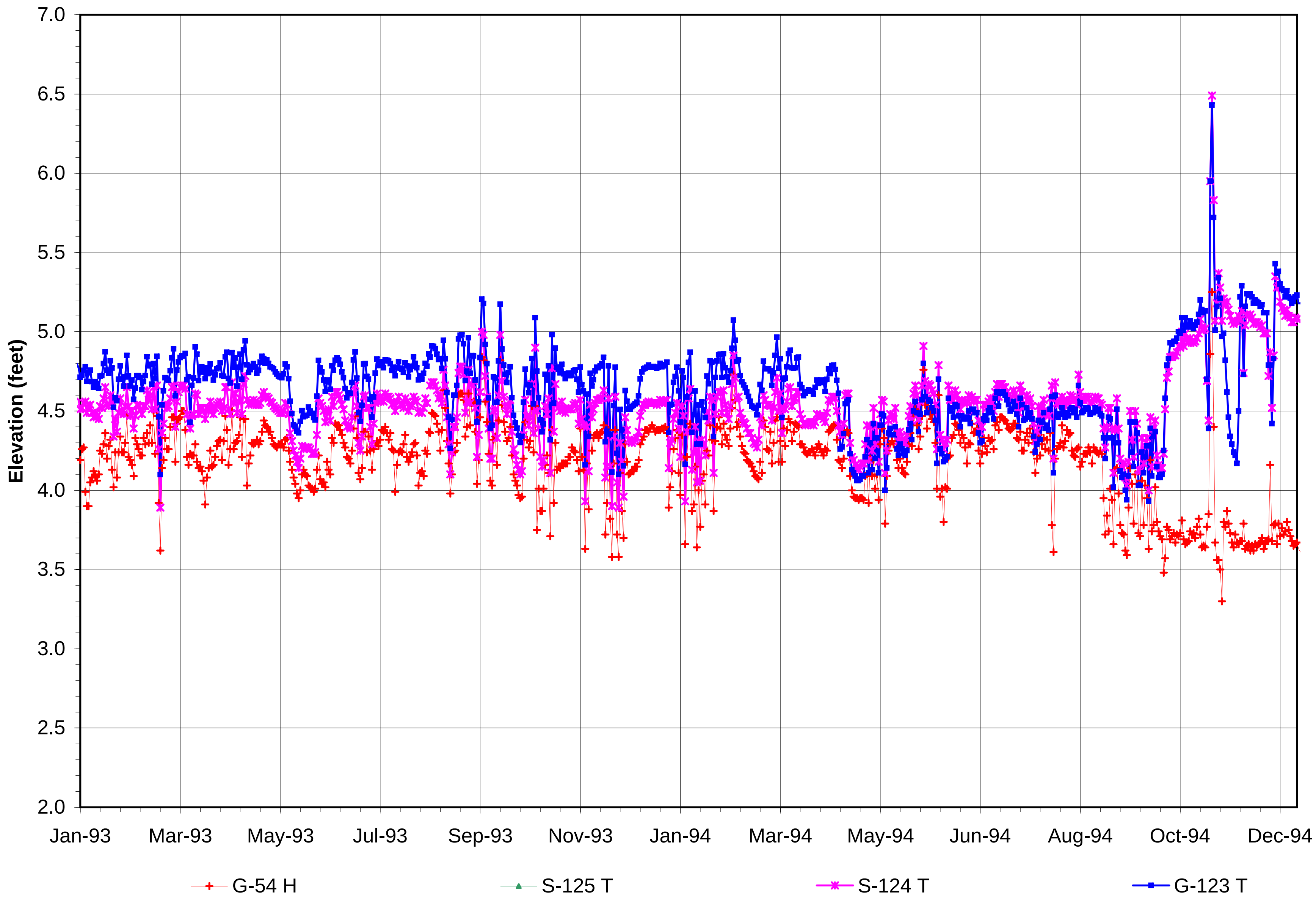


Figure 2-4 NNRC and C-42 Water Levels (page 7 of 11)

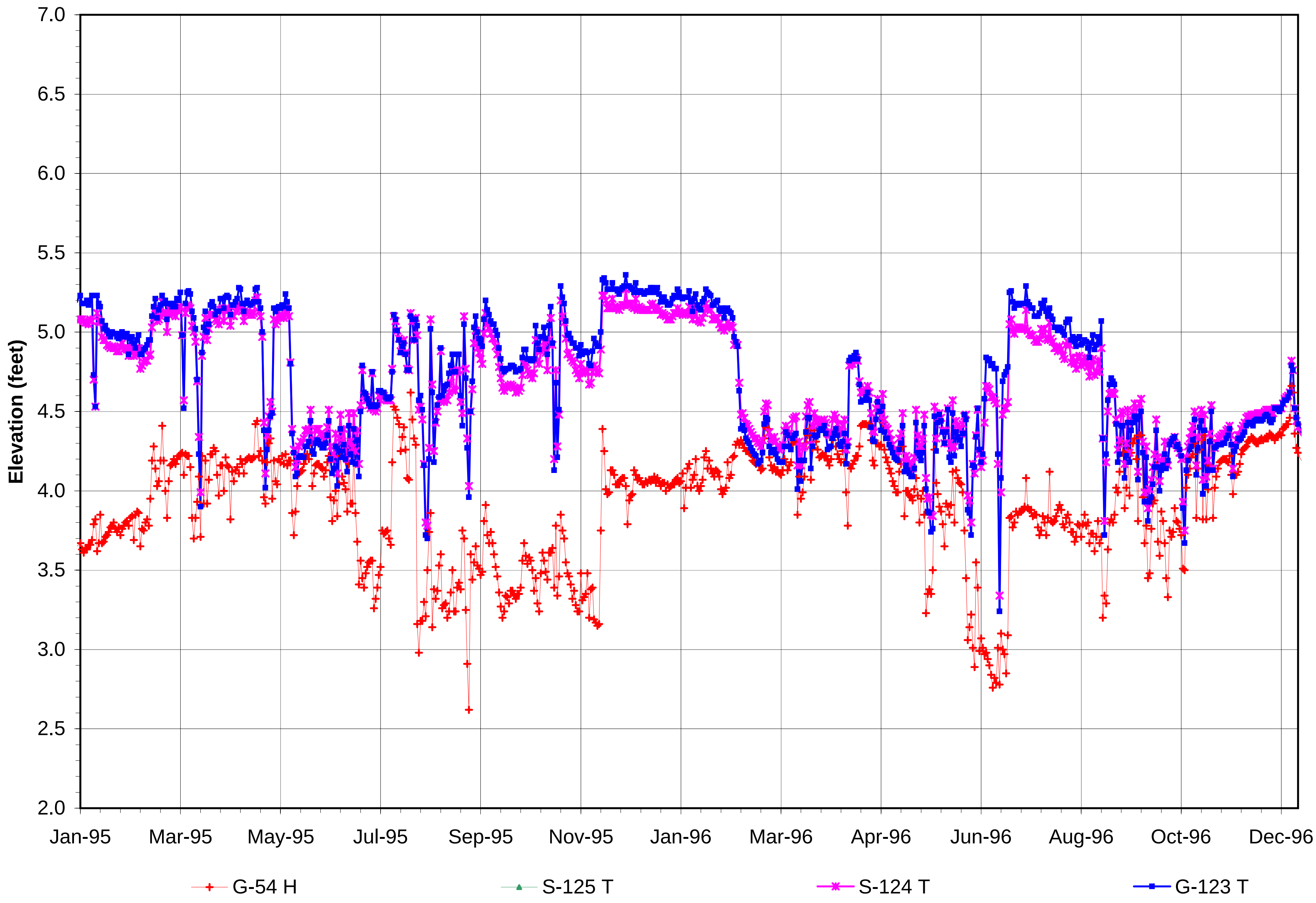


Figure 2-4 NNRC and C-42 Water Levels (page 8 of 11)

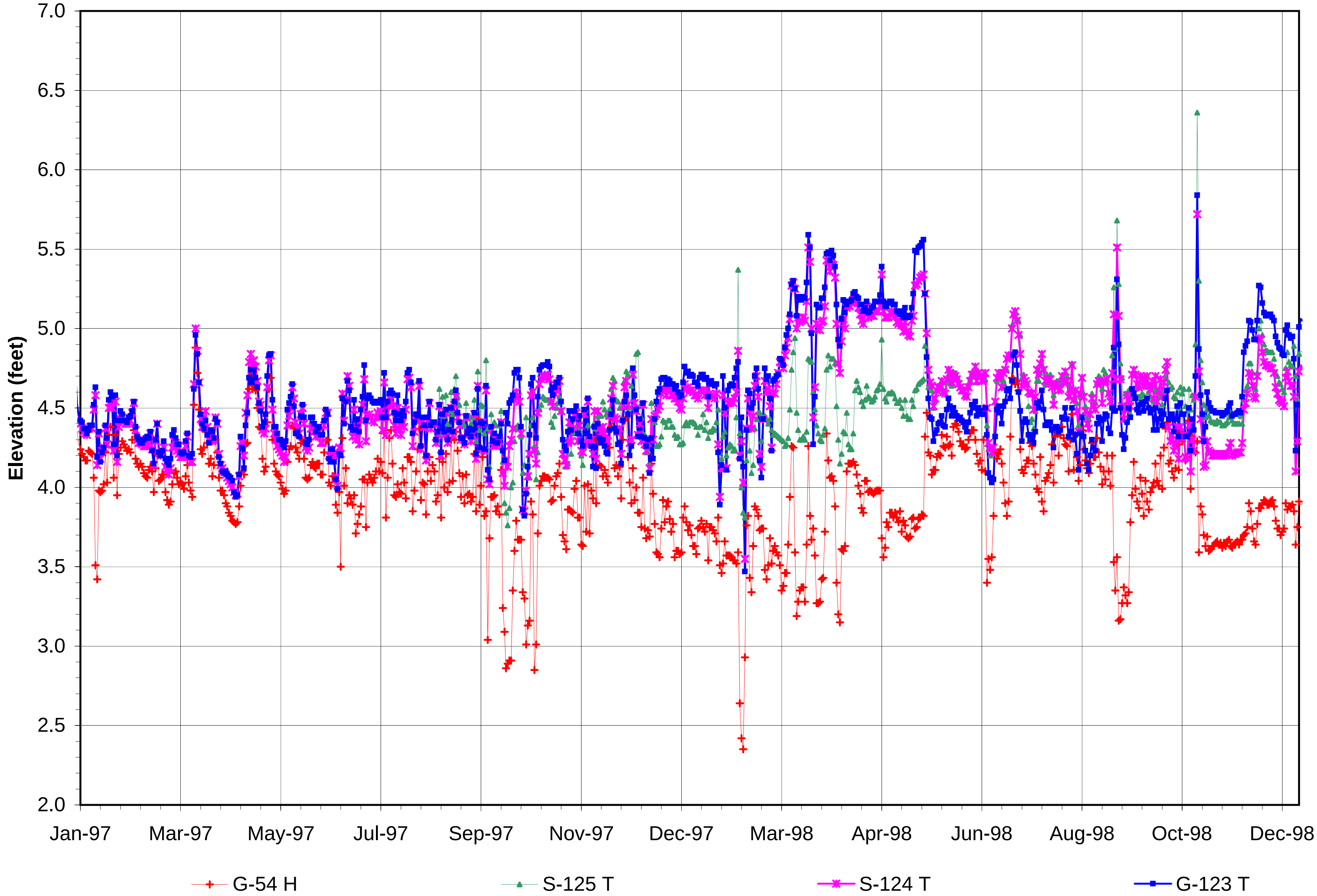


Figure 2-4 NNRC and C-42 Water Levels (page 9 of 11)

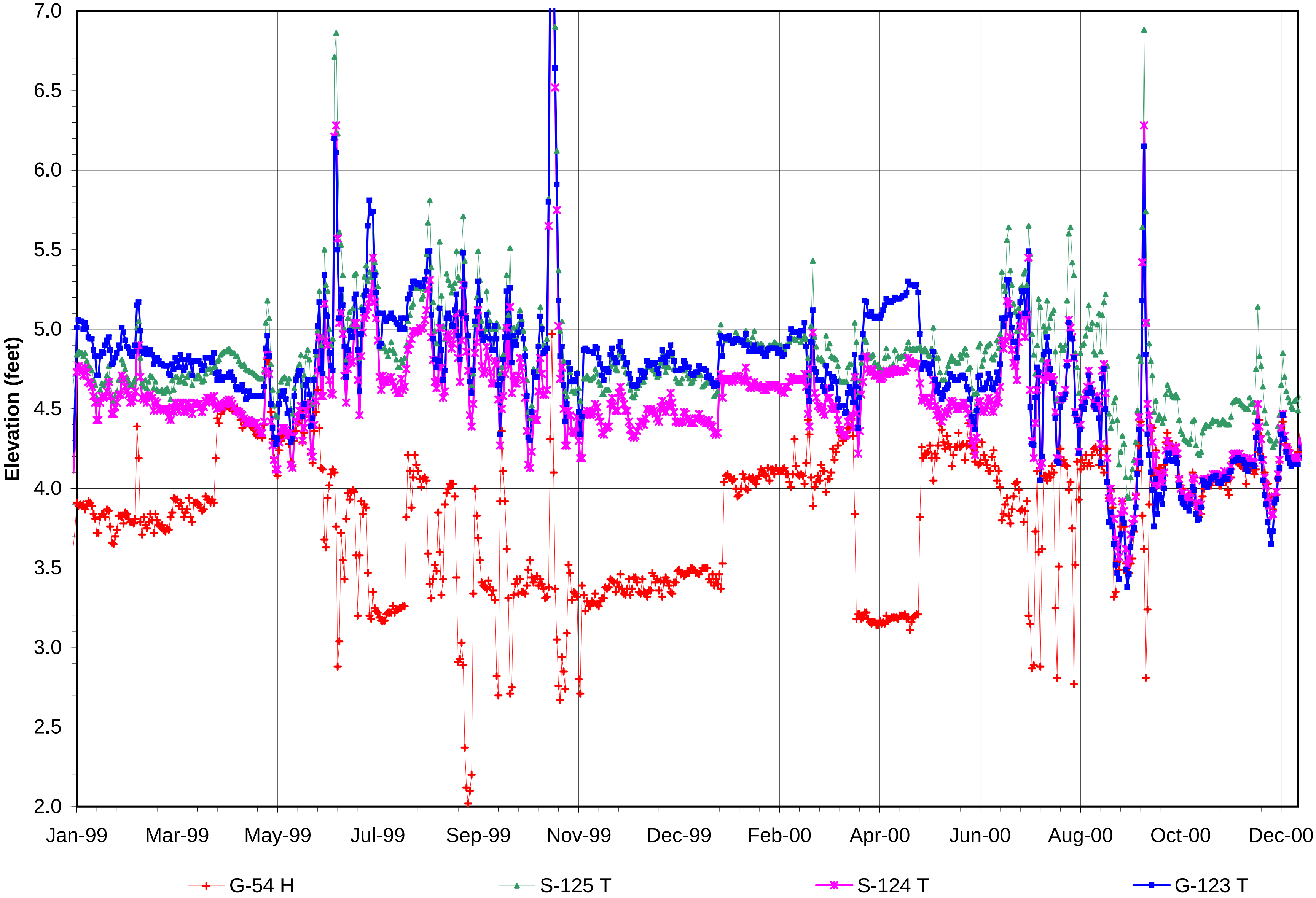


Figure 2-4 NNRC and C-42 Water Levels (page 10 of 11)

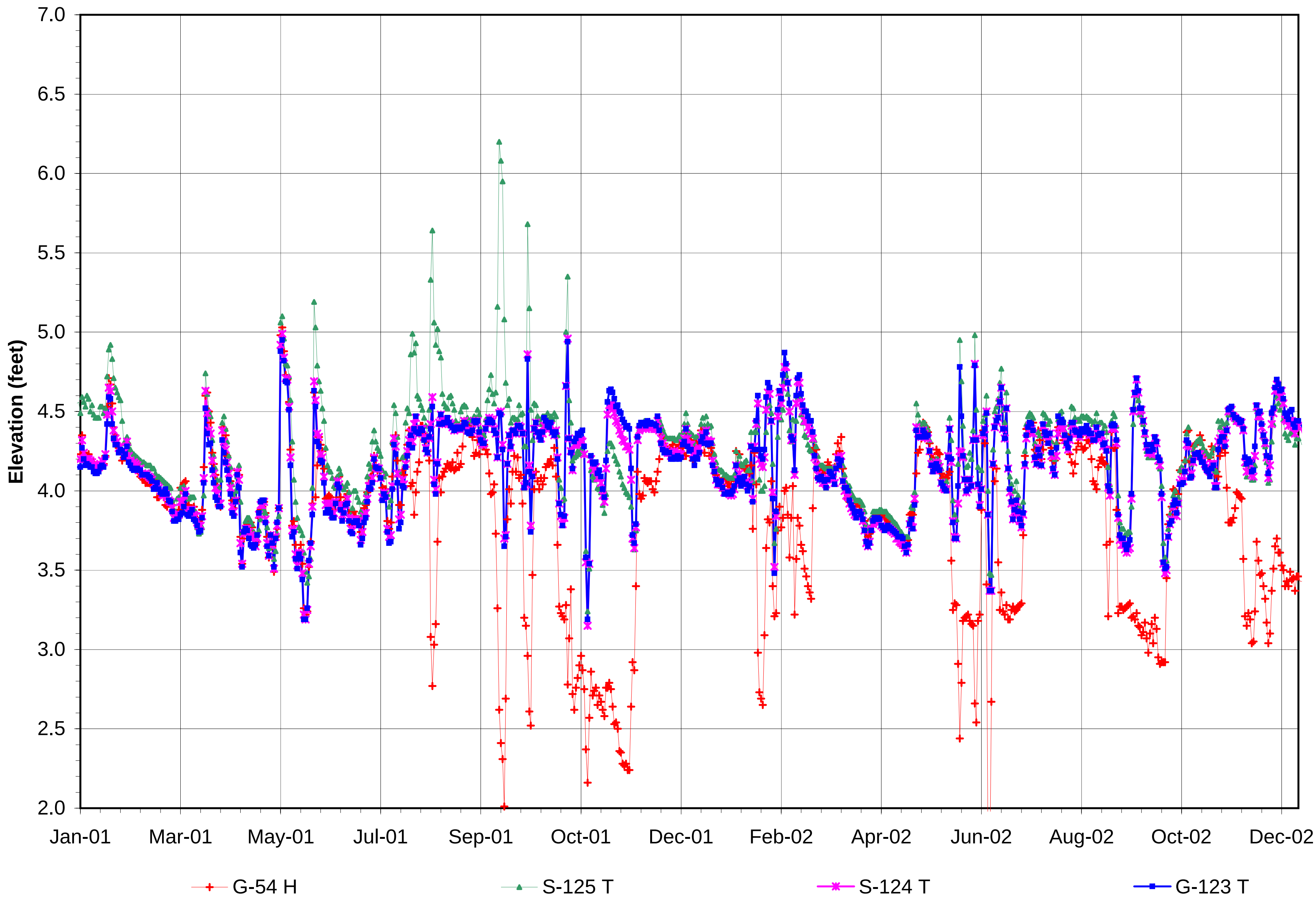


Figure 2-4 NNRC and C-42 Water Levels (page 11 of 11)

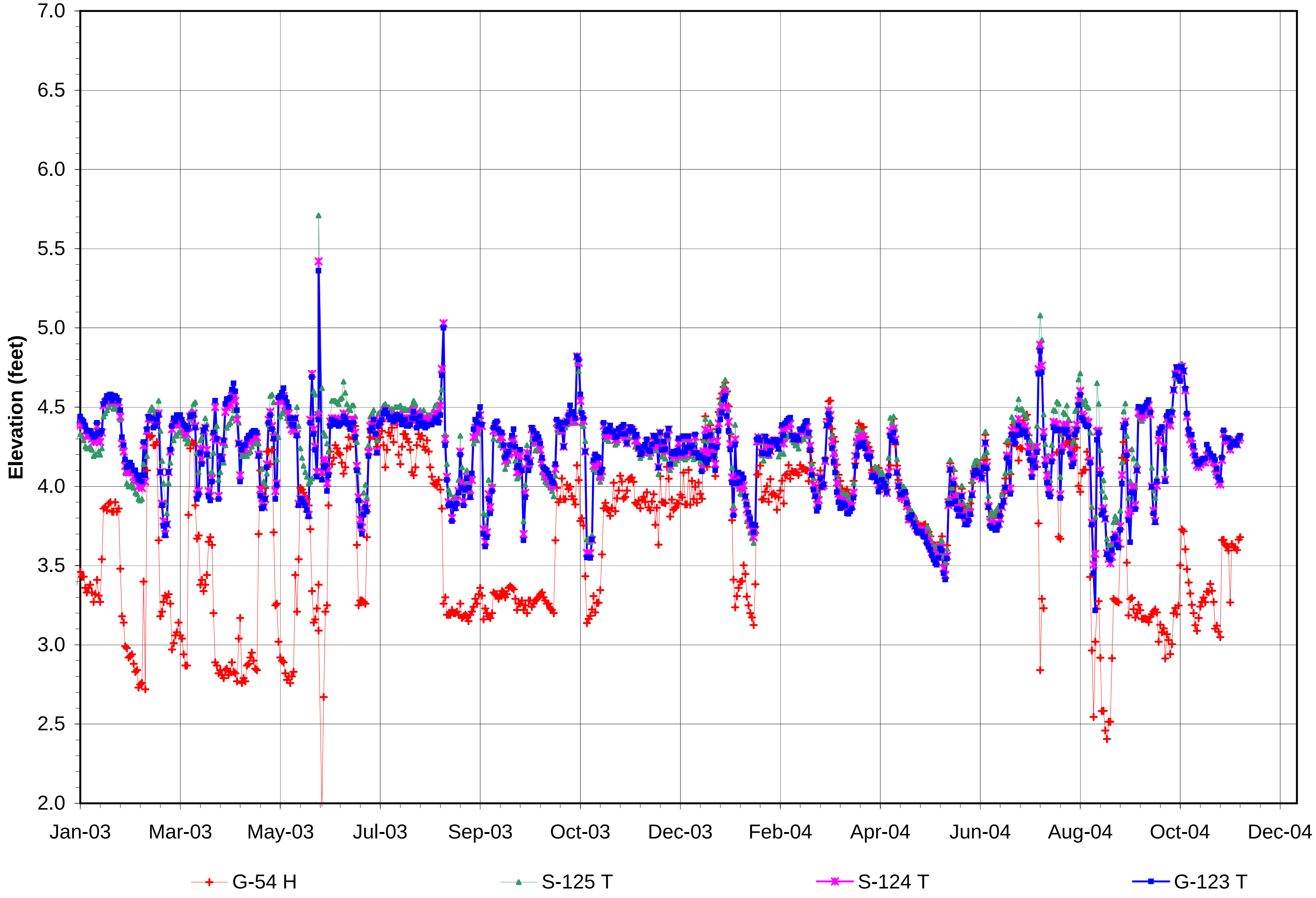


Figure 2-5 Headwater and Tailwater Stages at G-54

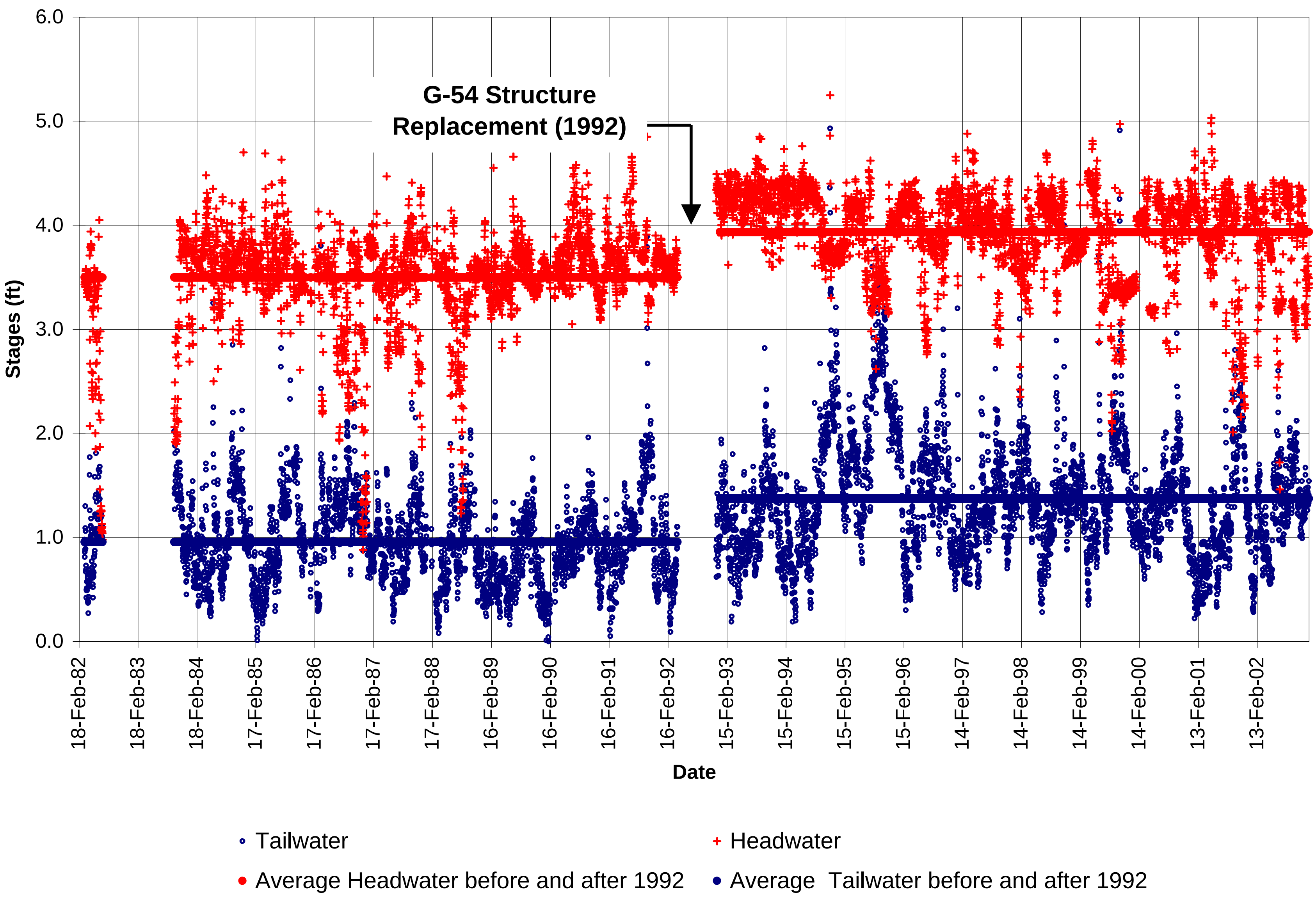
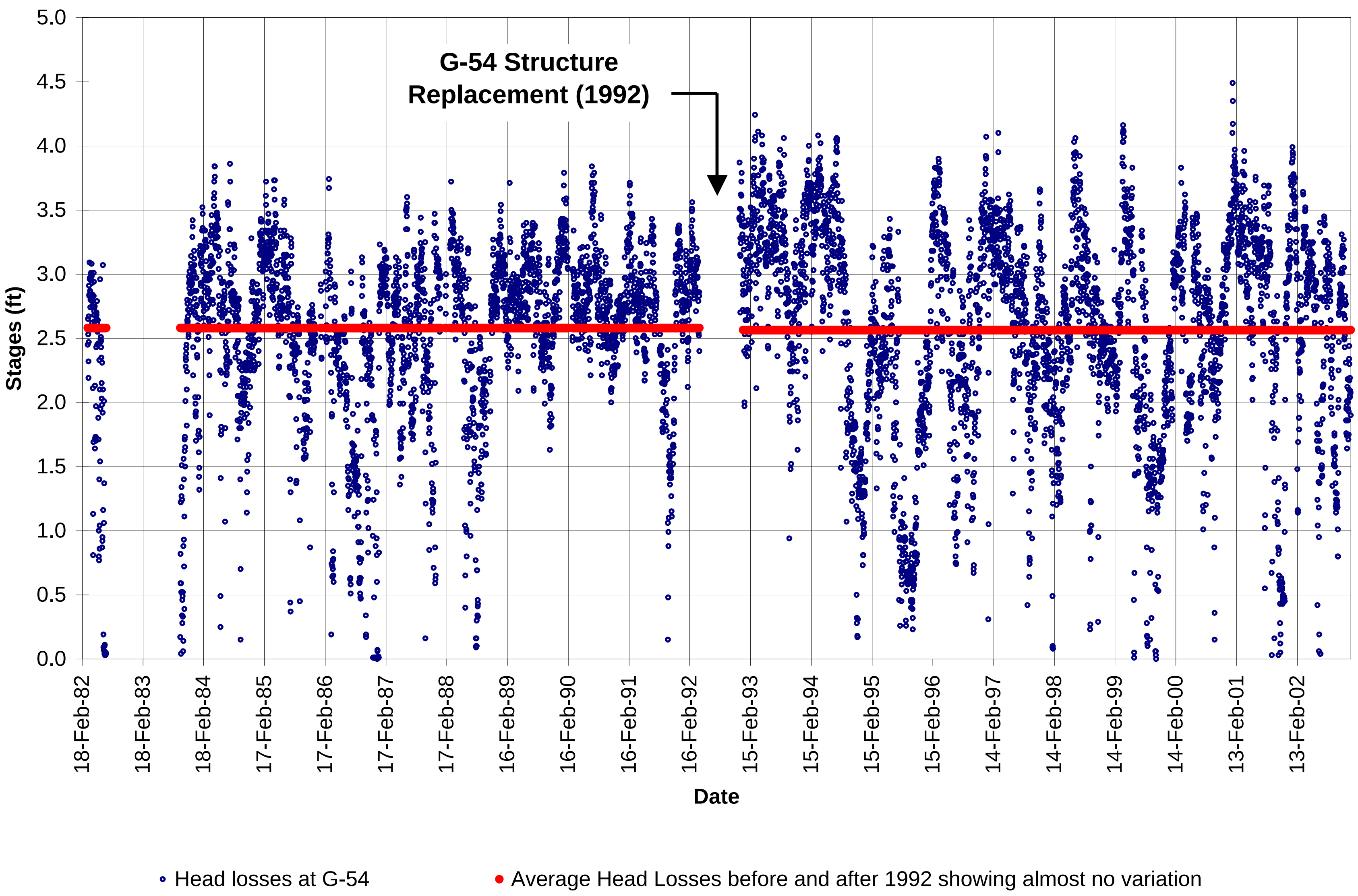


Figure 2-6 Head losses at Structure G-54



3 XP-SWMM Model for the NNRC Basin

3.1 Introduction

The main objective of the NNRC Flood Impact Analysis is to perform a hydraulic analysis of selected storm events to evaluate the potential impacts of discontinuing the use of the G-123 pump station during flood events. The hydraulic analysis requires construction of an XP-SWMM model of the NNRC and C-42 Canal using readily available information. The model will extend along the NNRC from G-54 upstream to the to the G-123 pump station, and along the C-42 Canal from S-125 structure downstream to its confluence with the NNRC. Figure 3-1 presents a schematic of the model domain and inflow points. The following subsection describes the steps required to build the NNRC hydraulic model.

3.2 Hydraulic Network

The scope of work requires the development of a model network that includes the NNRC and C-42 Canal. To build the hydraulic network, one needs the following key model input parameters for the NNRC and C-42 Canals:

- Culvert and canal invert elevations
- Canal cross-sections
- Bridges information
- Drainage structure and canal length
- Drainage structure and canal slope
- Manning roughness coefficient

3.3 Runoff Flows

For the NNRC Basin, the basin runoff flow enters the hydraulic network in two ways:

1. **Pumped Flows:** Basin runoff flows are pumped into the model's river and canals. Pumping records for selected storms and pump design/permitted flow are required for each pump in the model domain.

2. **Gravity Flows:** Basin runoff flows are calculated in the model and discharged into the network of river and canals. Detailed meteorological data and surface characteristics are required as input to generate a runoff hydrograph from each of the sub-basin areas. The following information is required for each gravity flow sub-basin:
    - Drainage Area
    - % Imperviousness
    - Width of Overland Flow
    - Land slope
    - Rainfall during selected storms
    - Depression storage
    - Soil type for infiltration parameters

- Groundwater parameters
- Stage-area-volume for on-site water management facilities (lake, canal, swale)
- Discharge structure information

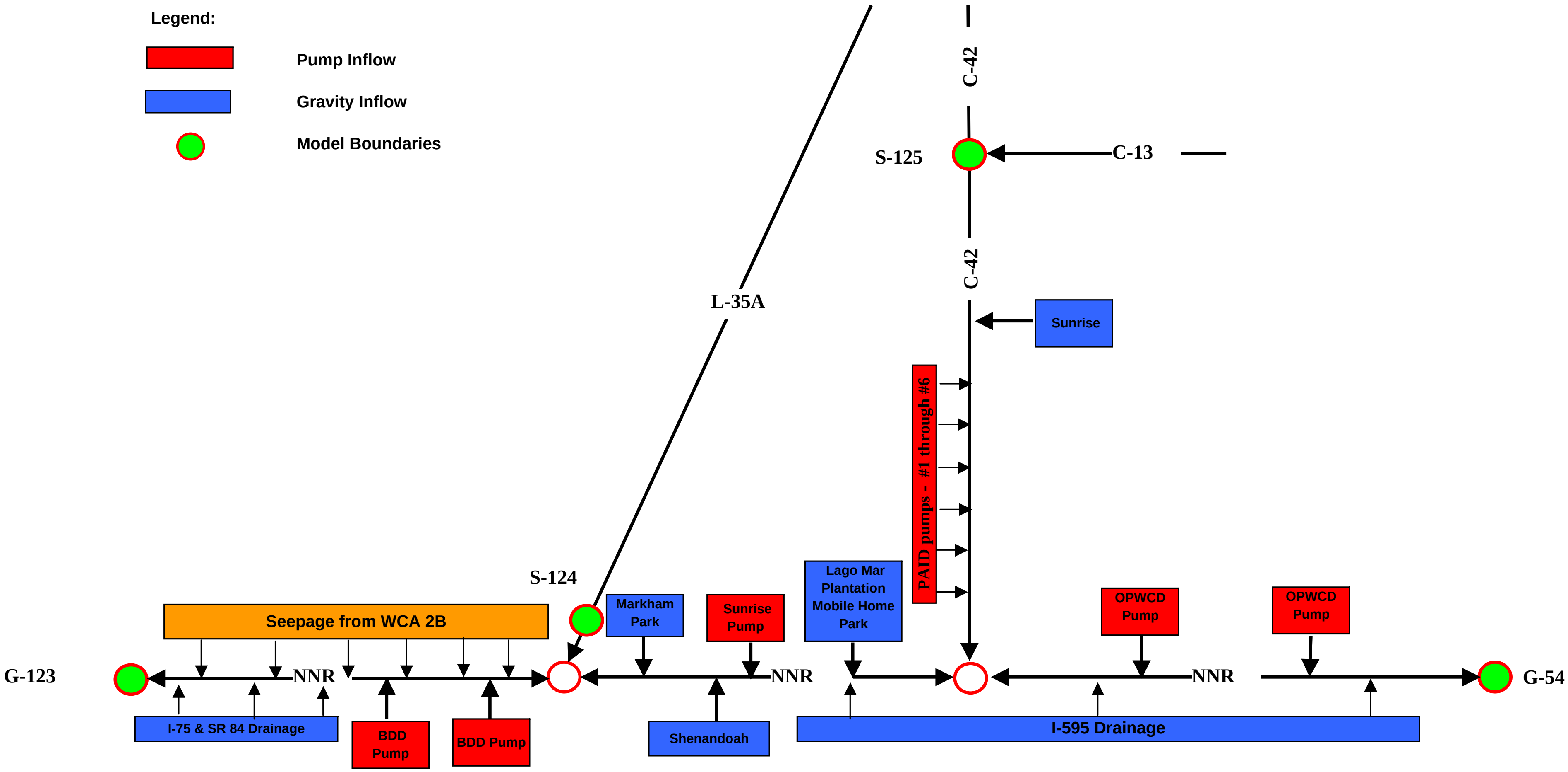
3.4 Boundary Conditions

Surface water boundary conditions are specified at upstream and downstream ends of the NNRC and C-42 canals network. The following is a list of boundary points required in the NNRC model:

- S-124 structure on the L-35A Canal
- S-125 structure on the C-42 Canal
- G-123 structure on the NNRC
- G-54 structure on the NNRC

The stage-flow, time-flow or time-stage data are required for all four boundary-points for the duration of the selected rainfall events. It is expected that the 15-minute interval records will be available for these simulations.

Figure 3-1 Schematic of the NNR Canal XP-SWMM Model



OPWCD = Old Plantation Water Control District
BDD = Bonnaventure Development District
PAID= Plantation Acres Improvement District

4 Frequency Analysis

4.1 Methodology

Seven series of hydrological data were analyzed using the Log-Pearson Type III distribution as documented in the HEC-FFA program package (Version 3.1, February 1995). This program was developed by the Hydrologic Engineering Center of the US Army Corps of Engineers and uses the techniques described in the “Guidelines for Determining Flood Flow Frequency,” Bulletin 17B, Water Resource Council, September 1981.

Annual maximums of each data series were extracted, ranked and assigned a plotting position based on the Weibull formula. The Log-Pearson Type III distribution was used to best fit the collected data. The results of the analysis for each series are presented in the form of probability plots of the datasets along with the 5% and 95% confidence limit plots, as well as tables of recurrence interval values.

4.2 Headwater Levels at Structure G-54

Daily records extend from October 1960 to November 2004. Annual peak levels are presented in Table 4-1. The results of the analysis for the entire period of records are presented in Table 4-2 and Figure 4-1. It should be noted that the drainage area of the contributing watershed has been reduced from approximately 40 sq. miles to 30 sq. miles, some time in the period 1975 to 1985; the exact year was not available for this analysis. A second computation was performed using only data from 1985 to 2004; the results are also shown in Table 4-2. A new G-54 structure was built in 1992 to replace the older one. It is not anticipated that the new structure would significantly affect the water levels upstream of the structure; it is, however, prudent to see if the frequency analysis results would be affected by this change. Although the period of records is short, a third computation was performed using data from the period of 1992 to 2004. The results are also presented in Table 4-2.

Table 4-1 G-54 Structure – Annual Maximum Headwater Levels

Date	Elev. (Ft)	Rank	Date	Elev. (Ft)	Rank	Date	Elev. (Ft)	Rank
December 24, 1960	4.17	44	May 10, 1975	5.00	12	July 23, 1990	4.97	16
November 8, 1961	4.96	17	May 3, 1976	4.90	19	October 8, 1991	4.85	21
April 12, 1962	4.97	14	December 11, 1977	4.51	35	June 7, 1992	4.54	33
January 16, 1963	4.63	30	February 9, 1978	4.80	23	September 4, 1993	4.84	22
October 12, 1964	4.23	42	April 25, 1979	4.51	34	November 16, 1994	5.25	7
December 20, 1965	4.95	18	October 25, 1980	4.63	31	July 23, 1995	4.62	32
January 26, 1966	5.00	13	May 30, 1981	5.69	2	December 31, 1996	4.46	37
March 30, 1967	5.22	8	November 11, 1982	4.75	24	March 15, 1997	4.88	20
February 24, 1968	5.33	6	January 25, 1983	4.26	41	July 17, 1998	4.69	27
November 1, 1969	5.16	10	December 2, 1984	4.70	25	October 16, 1999	4.97	15
September 15, 1970	5.21	9	April 16, 1985	4.69	26	April 12, 2000	4.44	38
October 8, 1971	5.54	4	March 11, 1986	4.17	43	May 5, 2001	5.03	11
January 25, 1972	5.74	1	May 9, 1987	4.47	36	May 24, 2002	4.43	39
January 12, 1973	5.52	5	June 12, 1988	4.14	45	July 12, 2003	4.42	40
December 15, 1974	5.66	3	July 1, 1989	4.66	28	January 26, 2004	4.65	29

Table 4-2 G-54 Structure – Headwater Levels Frequency Analysis

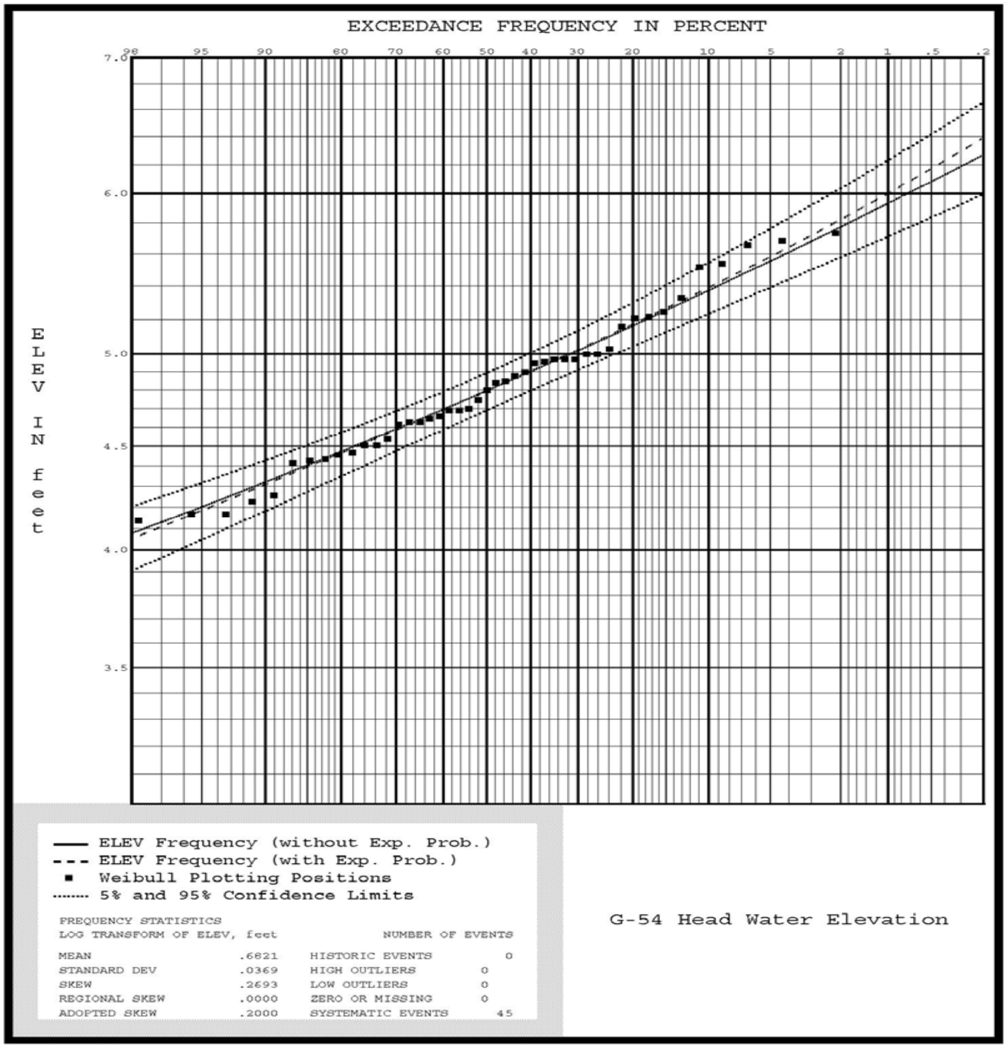
Return Period (yr)	1960 – 2004			1985 – 2004			1992 - 2004		
	Expected Levels (ft)	Confidence Limits		Expected Levels (ft)	Confidence Limits		Expected Levels (ft)	Confidence Limits	
		5%	95%		5%	95%		5%	95%
500	6.40	6.67	6.00	5.84	6.07	5.39	6.20	6.39	5.44
200	6.17	6.43	5.84	5.66	5.90	5.29	5.90	6.14	5.33
100	6.00	6.24	5.72	5.52	5.76	5.21	5.70	5.96	5.24
50	5.83	6.05	5.59	5.39	5.61	5.13	5.51	5.77	5.15
20	5.59	5.77	5.40	5.21	5.41	5.01	5.28	5.51	5.02
10	5.39	5.55	5.24	5.06	5.24	4.90	5.11	5.31	4.92
5	5.17	5.30	5.05	4.91	5.05	4.78	4.94	5.10	4.79
2	4.80	4.90	4.70	4.64	4.75	4.53	4.68	4.80	4.55

The results of the frequency analysis, presented in Table 4-2, indicate that the flood levels predicted using the long-term records are significantly higher than those using the shorter, more recent records (20 years from 1985 to 2004). A comparison of the 1985-2004 records with the even shorter period (1992-2004) indicates that the flood levels do not appear to be significantly different in the latter period. Therefore the analysis performed using the period 1985-2004 can be used to evaluate recent events.

The frequency analysis of the long-term headwater levels at the G-54 structure is presented in Figure 4-1. Over the last twenty years, the largest observed event took place on November 16, 1994, when the water level reached El. 5.25. Based on the frequency analysis performed with the records of the last twenty years, this event would approximately correspond to a 30-year event.

The second largest event in recent years occurred on May 5, 2001, when the water levels reached El. 5.03, approximately corresponding to a 10-year flood.

Figure 4-1 G-54 Structure – Headwater Frequency Analysis



4.3 Headwater Levels at G-123 Pump Station

Daily records extend from January 1983 to November 2004. Annual peak levels are presented in Table 4-3. The results of the frequency analysis for the period of record are presented in Table 4-4 and Figure 4-2.

Table 4-3 G-123 Pump Station – Annual Maximum Headwater Levels

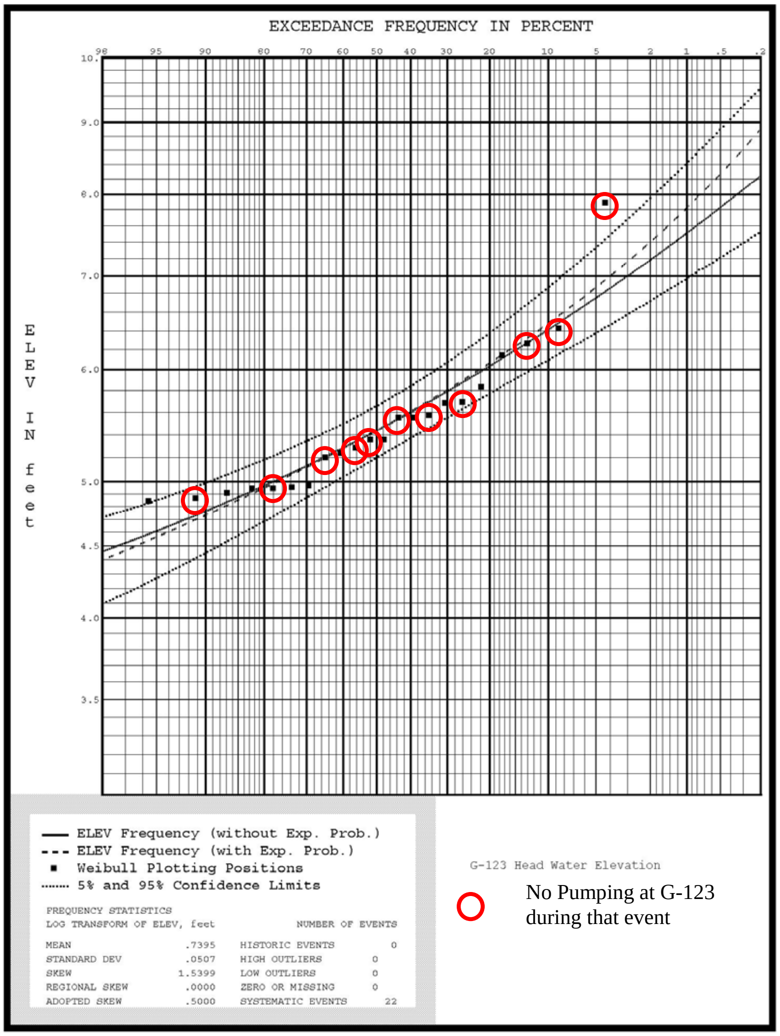
Date	Elev. (Ft)	Rank	Date	Elev. (Ft)	Rank
September 24, 1983	5.56	9	November 16, 1994	6.43	2
January 16, 1984	5.69	7	November 29, 1995	5.36	12
July 26, 1985	4.95	18	July 26, 1996	5.29	13
September 8, 1986	5.58	8	March 15, 1997	4.96	17
May 9, 1987	5.56	10	November 5, 1998	5.84	5
August 15, 1988	6.27	3	October 16, 1999	7.90	1
July 2, 1989	4.91	20	October 4, 2000	6.15	4
July 23, 1990	5.24	14	May 5, 2001	4.95	19
October 8, 1991	5.70	6	March 2, 2002	4.87	21
October 22, 1992	4.97	16	May 28, 2003	5.36	11
September 4, 1993	5.21	15	August 2, 2004	4.85	22

Table 4-4 G-123 Pump Station – Headwater Level Frequency Analysis

Return Period (yr)	Expected Levels (ft)	Confidence Limits	
		5%	95%
500	8.91	9.55	7.54
200	8.27	8.91	7.22
100	7.83	8.44	6.98
50	7.41	7.97	6.73
20	6.87	7.35	6.38
10	6.47	6.87	6.10
5	6.06	6.38	5.78
2	5.44	5.67	5.21

The maximum observed water level occurred on October 16, 1999 when it reached El. 7.90, which, according to this analysis, approximately corresponds to a 110-year flood event. The second highest level was recorded on November 16, 1994 when it reached El. 6.43; this approximately corresponds to a 10-year event.

Figure 4-2 G-123 Pump Station – Headwater Frequency Analysis



4.4 Tailwater Levels at S-124 Structure

Daily records extend from June 1985 to November 2004. Annual peak levels are presented in Table 4-5. The results of the frequency analysis for this period of record are presented in Table 4-6 and Figure 4-3.

Table 4-5 S-124 Structure – Annual Maximum Tailwater Levels

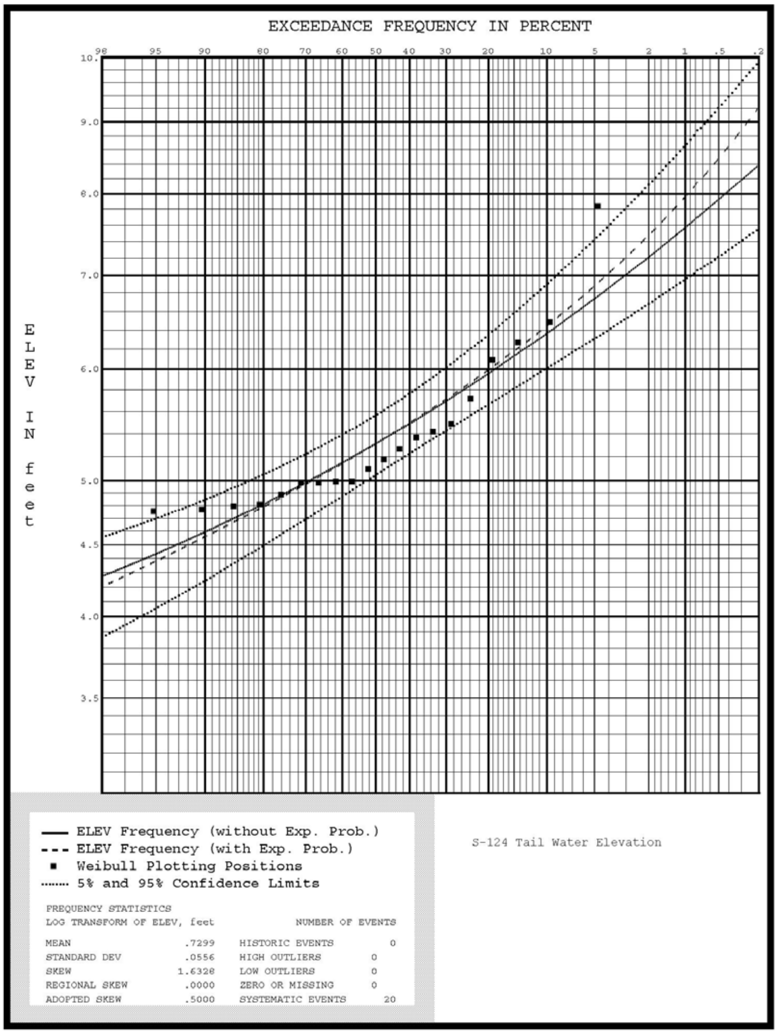
Date	Elev. (ft)	Rank	Date	Elev. (ft)	Rank
July 26, 1985	4.81	17	November 29, 1995	5.27	9
March 27, 1986	5.10	11	January 16, 1996	5.18	10
October 12, 1987	5.37	8	March 15, 1997	5.00	12
August 15, 1988	6.10	4	November 5, 1998	5.72	5
July 2, 1989	4.76	20	October 16, 1999	7.84	1
July 23, 1990	4.99	14	October 4, 2000	6.28	3
October 8, 1991	5.49	6	May 5, 2001	4.99	15
October 22, 1992	4.77	19	June 24, 2002	4.80	18
September 4, 1993	5.00	13	May 28, 2003	5.42	7
November 16, 1994	6.49	2	August 2, 2004	4.89	16

Table 4-6 S-124 Structure – Tailwater Level Frequency Analysis

Return Period (yr)	Expected Levels (ft)	Confidence Limits	
		5%	95%
500	9.23	9.96	7.57
200	8.48	9.23	7.32
100	7.97	8.68	6.96
50	7.48	8.14	6.69
20	6.88	7.44	6.32
10	6.44	6.90	6.01
5	5.99	6.36	5.67
2	5.31	5.70	5.05

The maximum water level was also observed on October 16 1999, when it reached El.7.84, which at this location, approximately corresponds to 90-year event. Similarly, the second highest level observed was on November 16, 1994, when the water level reached El.6.49, which approximately corresponds to a 10-year event.

Figure 4-3 S-124 Structure – Tailwater Frequency Analysis



4.5 Tailwater Levels at S-125 Structure

Daily records extend from August 1997 to November 2004. Annual peak levels are presented in Table 4-7. This series has only eight events. No conclusion could be reasonably made regarding the return period of any flooding event based on a frequency analysis at that location and therefore no analysis was performed.

Table 4-7 S-125 Structure – Annual Maximum Tailwater Levels

Date	Elev. (ft)	Rank
December 5, 1997	4.60	8
November 5, 1998	6.11	4
October 16, 1999	7.93	1
October 4, 2000	6.63	2
September 12, 2001	6.20	3
June 24, 2002	4.98	7
May 28, 2003	5.71	5
August 2, 2004	5.08	6

4.6 Event Volume for Pump Station G-123

Daily records extend from June 1985 to November 2004. The maximum daily flows are limited by the pumping capacity of the station (approximately 400 cfs); furthermore the operation of the pumps is occasionally limited by the maintenance or availability of the pumps. For these reasons, this type of daily records statistical analysis would not be appropriate for this type of data. An event volume analysis was performed and presented in the Section 5.

4.7 Daily Flows for Structure S-124

Daily records extend from June 1987 to November 2004. Annual maximum daily volumes are presented in Table 4-8. The results of the frequency analysis for this period of record are presented in Table 4-9 and Figure 4-4.

Table 4-8 S-124 Structure – Annual Maximum Daily Flows

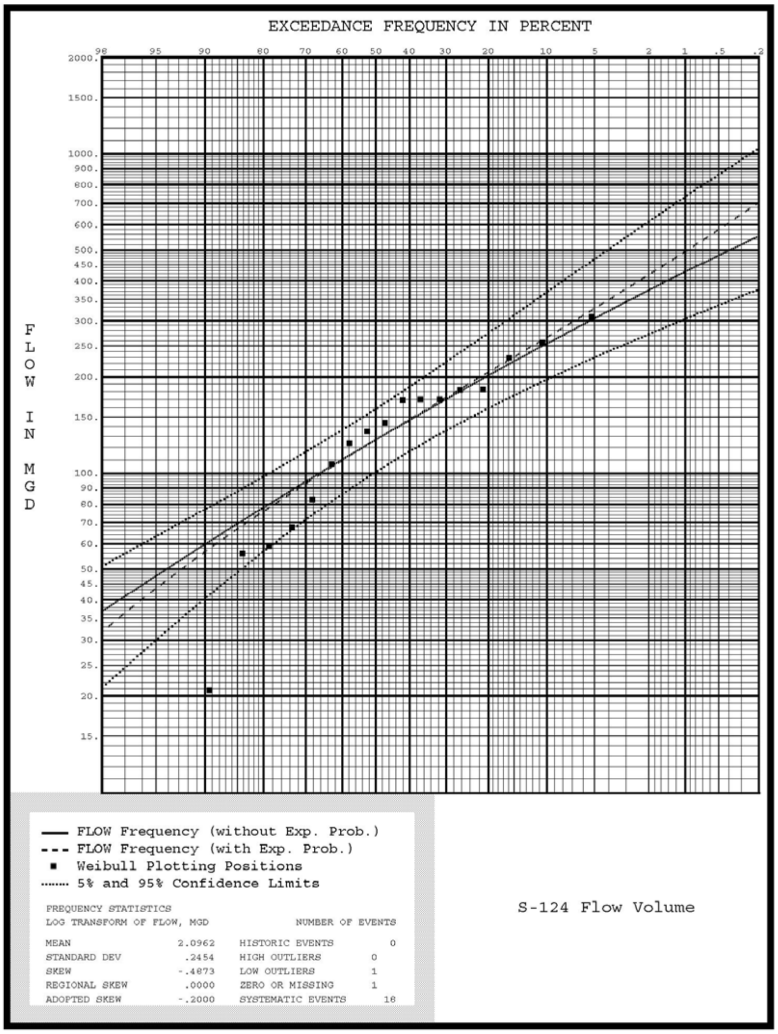
Date	Volume (MGD)	Rank	Date	Volume (MGD)	Rank
October 10, 1987	124	11	April 10, 1996	68	14
November 15, 1988	83	13	April 15, 1997	171	6
August 22, 1989	59	15	February 4, 1998	183	5
July 2, 1990	183	4	June 18, 1999	231	3
April 24, 1991	171	7	December 11, 2000	56	16
September 11, 1992	144	9	September 14, 2001	136	10
October 7, 1993	257	2	January 1, 2002	0	18
November 17, 1994	170	8	May 29, 2003	21	17
August 25, 1995	310	1	January 31, 2004	107	12

Table 4-9 S-124 Structure – Daily Flow Frequency Analysis

Return Period (yr)	Expected Volumes (MGD)	Confidence Limits	
		5%	95%
500	705	1050	378
200	579	867	337
100	495	739	306
50	419	619	274
20	328	472	231
10	266	370	197
5	207	276	160
2	127	160	101

The largest daily flows observed at that location occurred on August 25, 1995, approximately corresponding to a 17-year event. The event of November 17, 1994 has a surprisingly low return period at that location (in the order of 4-year) when compared to the return period of water levels at G-123 and S-124. A possible explanation is that the high tailwater level in the NNRC limited the capacity of the culverts, as there was little difference between headwater and tailwater levels.

Figure 4-4 S-124 Structure – Daily Flow Frequency Analysis



4.8 Peak Flow for Structure G-54

Daily records extend from January 1940 to November 2004. Annual peak flows are presented in Table 4-10. The results of the frequency analysis for the entire period of record are presented in Table 4-11 and Figure 4-5. As previously indicated, the drainage area of the contributing watershed has been reduced from approximately 40 sq. miles to 30 sq. miles at some time within the period of 1975 to 1985. The results of the second analysis are also shown in Table 4-11. The G-54 structure was rebuilt in 1992. It is not anticipated that the new structure would affect the discharge of the NNR Canal; however, it is prudent to see if the frequency analysis results would be affected by this change. A third computation was performed using data from the period of 1992 to 2004, the results of which are also presented in Table 4-11.

Table 4-10 G-54 Structure – Annual Maximum Daily Flows

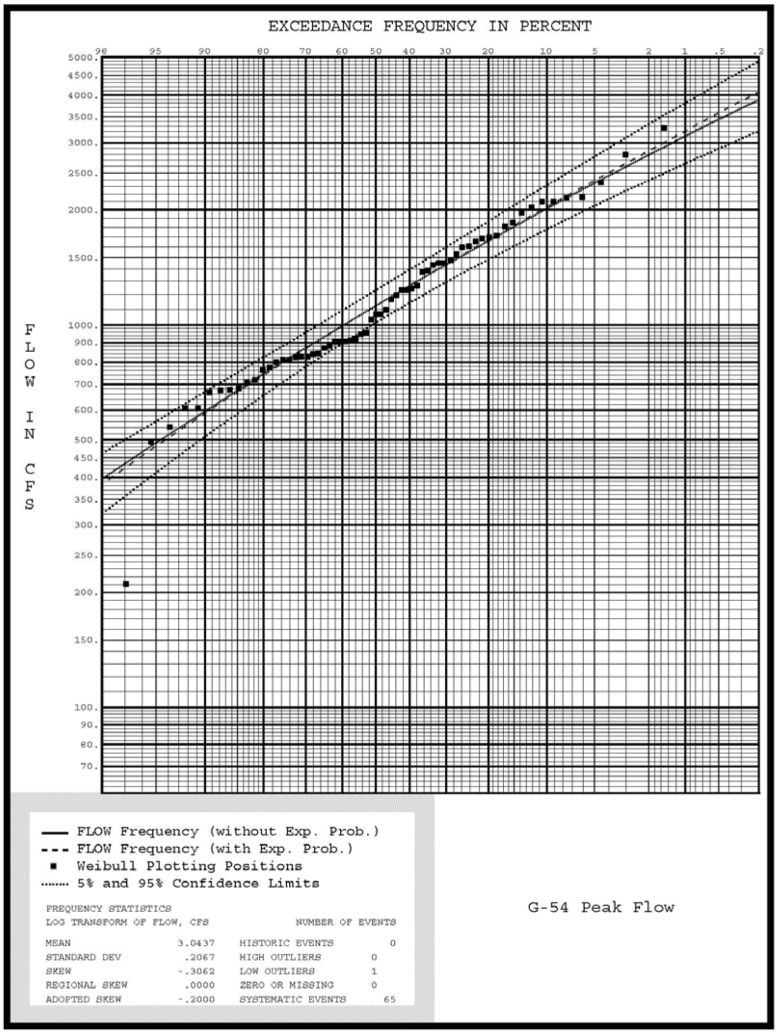
Date	Flow (cfs)	Rank	Date	Flow (cfs)	Rank	Date	Flow (cfs)	Rank
September 12, 1940	1440	22	August 30, 1962	495	63	May 29, 1984	1250	26
August 8, 1941	1970	9	October 4, 1963	907	40	July 24, 1985	840	45
June 12, 1942	1820	11	October 13, 1964	1380	24	March 27, 1986	2370	3
September 13, 1943	608	61	November 1, 1965	764	53	January 1, 1987	1270	25
October 23, 1944	1070	33	June 9, 1966	1200	29	June 8, 1988	712	55
November 13, 1945	1390	23	June 14, 1967	1610	16	July 2, 1989	64	65
September 19, 1946	1070	32	July 9, 1968	1240	28	June 9, 1990	211	64
November 19, 1947	3280	1	November 4, 1969	2160	4	October 8, 1991	843	44
October 5, 1948	2800	2	March 8, 1970	2110	7	August 23, 1992	826	48
October 1, 1949	2110	6	November 10, 1971	1170	30	October 7, 1993	915	38
October 19, 1950	1690	14	June 18, 1972	1480	19	November 16, 1994	2155	5
October 23, 1951	1460	20	November 19, 1973	675	58	August 25, 1995	1100	31
October 29, 1952	1860	10	October 7, 1974	828	47	October 17, 1996	719	54
October 20, 1953	1700	13	October 2, 1975	679	57	January 14, 1997	813	49
July 26, 1954	1660	15	August 19, 1976	1240	27	November 5, 1998	873	43
October 13, 1955	923	37	June 3, 1977	909	39	October 20, 1999	884	42
October 17, 1956	811	50	October 24, 1978	960	35	October 4, 2000	543	62
October 16, 1957	1460	21	April 25, 1979	828	46	September 15, 2001	800	51
January 3, 1958	1600	17	April 11, 1980	778	52	February 14, 2002	608	60
June 19, 1959	2040	8	August 20, 1981	1720	12	May 28, 2003	667	59
September 24, 1960	1540	18	November 9, 1982	906	41	February 1, 2004	684	56
January 14, 1961	952	36	February 13, 1983	1040	34			

The maximum peak flow observed in the period since 1985 occurred on March 27, 1986, with 2,370 cfs; it approximately corresponds to 35-year event. The second largest flow was recorded on November 16, 1994; it is approximately a 25-year event, i.e., a return period significantly higher than those of the observed water levels in the watershed (G-123 and S-124) on that date.

Table 4-11 G-54 Structure – Daily Flows Frequency Analysis

Return Period (yr)	1960 – 2004			1985 – 2004			1992 - 2004		
	Expected Flows (cfs)	Confidence Limits		Expected Flows (cfs)	Confidence Limits		Expected Flows (cfs)	Confidence Limits	
		5%	95%		5%	95%		5%	95%
500	4080	4920	3220	4990	6970	2630	5720	6550	2240
200	3580	4290	2910	3920	5540	2290	3930	4920	1930
100	3220	3830	2660	3250	4600	2040	3030	3930	1720
50	2860	3370	2400	2680	3770	1800	2380	3130	1520
20	2390	2780	2060	2050	2810	1490	1750	2280	1280
10	2030	2330	1790	1640	2188	1260	1400	1770	1100
5	1670	1880	1490	1270	1620	1020	1120	1360	926
2	1120	1240	1020	798	972	655	795	932	669

Figure 4-5G-54 Structure – Flood Frequency Analysis



5 G-123 Operation

5.1 Collected Data

In order to evaluate the storm event that historically triggered the use of the G-123 pump station, operation logs were provided by SFWMD; the logs cover the period from January 1993 to June 2000. These logs are the records of operation; they report the cumulative hours of operation for each pump, the periods of operation, i.e., starting and ending times for each pump as well as headwater and tailwater levels at each change of operation (starting or ending). The range of annual pumped volume is also estimated for each water year.

In addition to these operating logs, SFWMD provided the daily flow records as reported on the DBHYDRO website: these records extend from 1985 to the present with periods of missing data. The combined records have been plotted and are shown on Figure 5-1.

5.2 Event Volume Statistical Analysis

To perform the frequency analysis for the event volume, a minimum inter-event time (IET) must be established so that event independence is assured. The selected minimum IET will be the value that assures that the Coefficient of Variation (COV) (defined as the standard deviation divided by the mean) of the time between midpoint of independent events series is equal to one. The detailed operation logs provided the basis for calculating the IET. The usable data for that purpose extend only over a two-year period (1993-1994). Based on the limited amount of information available, it was determined that the IET was approximately 1.5 day. Using that value, the entire period of records from 1985 to 2004 was reviewed to calculate the pumped volumes of each independent event. Figure 5-2 shows the magnitude of each of these events. The maximum annual events are presented on Table 5-1.

Water can be pumped at G-123 during the dry season for water supply of the WCA, as well as to control water levels in the NNRC Basin during the rainy season. In order to visually separate theses types of events, rainfall at G-54 and the headwater level at the S-124 structure are also indicated on Figure 5-2.

Table 5-1 G-123 Pump Station – Annual Maximum Volume Events

Year	Volume (cfs-day)	Remarks	Year	Volume (cfs-day)	Remarks
1985	1,720		1993	7,110	Not a single flood event
1986	1,939		1994	7,725	Not a single flood event
1987	14,278	Not a single flood event	1997	3,276	
1988	2.020		1998	9,679	Not a single flood event
1989	3,944	Not a single flood event	2000	9,889	Not a single flood event
1990	14,612	Not a single flood event	2001	21,580	Not a single flood event
1991	3,693	Not a single flood event	2002	0	
1992	1,557		2003	1,138	

As indicated on the above table, some of the maximum annual events are related to continuous pumping for an extended period of time (sometimes more than a month); these events may cover more than one single flood event, and therefore they were excluded from the frequency analysis. As a result only six events can be used for the frequency analysis of the event volume, the results of which are presented in Table 5-2.

Table 5-2 G-123 Pump Station –Event Volume Frequency Analysis

Return Period (yr)	Expected Volumes (cfs-day)	Confidence Limits	
		5%	95%
100	4,244	N/A	N/A
50	3,792	N/A	N/A
20	3,223	N/A	N/A
10	2,807	3,974	1,640
5	2,394	3,181	1,606
2	1,806	2,311	1,301

5.3 Analysis of G-123 Operation

The records obtained from the operation logs along with the other hydrological data provided by the SFWMD were used to develop Table 5-3, which includes the following information:

- Date and time when the G-123 pumps were turned on
- Date and time when the G-123 pumps were turn off
- G-123 Headwater stage at the time the pumps were turned on
- G-123 Headwater peak stage during the event and its associated return period
- G-123 Headwater stage at the time pumps were turned off
- G-123 pumped event flow volume during the event and its Return Period.
- Rainfall volume (inches) recorded during the event at G-54, S-124 and 3A-36 stations and their return periods obtained by comparison with the latest isohyetal maximum rainfall maps published by the SFWMD.
- Tailwater peak stage at S-124 and its associated return period
- Event flow volume at S-124 during the event and its associated return period
- Peak discharge at G-54 during the event and its associated return period

The G-123 pump station has the dual purpose of supplying water to the Water Conservation Area No.3A (WCA 3A) and providing water level control during storm events. The SFWMD structure book outlines operating rules for the control structures in the District. For the G123 pump station, the document indicates that subject to tailwater stages, pumping to supply water to the WCA 3A is a function of the headwater stage. Regardless of the headwater stage, pumping must be curtailed if the tailwater stage rises to 11.5. The pump station is also operated in conjunction with structures S-124 and S-125. In particular, it is reported that a stage of about 5.50 at the headwater of the S-124 structure has triggered operation of the pump station during storm events.

On that basis, Table 5.4 was developed to separate the pumping events for the purpose of water supply from events to control water levels during storm events.

Table 5-4 Events with S-124 Headwater Levels above 5.50

Date	S-124 HW	G-123 HW	G-123 TW	G-123 Oper.	Date	S-124 HW	G-123 HW	G-123 TW	G-123 Oper.
Nov 15, 1994	6.84	6.43	11.97	No	Jul 21, 1997	6.02	4.74	10.76	No
Dec 21, 1994	5.96	4.79	11.80	No	Sep 6, 1997	6.11	4.11	10.91	No
Feb 27, 1995	5.73	5.20	9.37	No	Oct 29, 1997	5.72	4.51	9.49	No
Mar 14, 1995	5.72	5.24	9.44	No	Feb 3, 1998	5.84	4.79	11.18	No
May 4, 1995	5.62	5.15	9.74	No	Mar 16, 1998	5.69	5.29	10.04	No
May 10, 1995	5.65	5.19	9.64	No	Apr 5, 1998	6.16	5.06	8.72	No
July 26, 1995	5.72	5.08	9.66	No	Apr 24, 1998	5.87	5.13	8.52	No
Aug 3, 1995	6.26	5.02	11.31	No	May 7, 1998	5.78	5.15	8.30	No
Aug 23, 1995	6.39	5.05	11.52	No	Sep 17, 1998	5.51	5.31	10.48	Yes
Oct 18, 1995	5.99	4.68	10.73	No	Nov 4, 1998	6.20	5.84	10.88	No
Feb 3, 1996	5.63	4.94	7.78	No	Nov 27, 1998	5.60	4.41	10.51	No
Feb 25, 1996	5.77	4.25	9.89	No	Dec 20, 1998	5.59	5.07	10.04	No
Apr 8, 1996	5.85	4.36	9.43	No	Jan 2, 1999	5.81	4.81	9.36	No
Apr 25, 1996	5.65	4.32	9.54	No	Jun 2, 1999	5.84	5.34	9.04	No
May 22, 1996	5.58	4.24	9.49	No	Jun 9, 1999	7.02	6.11	10.01	No
Jun 21, 1996	5.80	3.88	10.87	No	Jun 24, 1999	5.88	4.97	10.48	No
Jul 17, 1996	5.74	5.26	8.76	No	Jul 1, 1999	5.88	5.74	10.82	No
Aug 20, 1996	5.56	5.08	7.93	No	Aug 24, 1999	5.77	5.48	10.64	No
Sep 3, 1996	5.50	4.93	8.15	No	Oct 16, 1999	8.11	7.90	11.63	No
Sep 10, 1996	5.70	4.33	10.00	No	Mar 20, 2000	5.85	5.12	11.23	No
Oct 6, 1996	5.67	4.21	10.42	No	Jun 7, 2000	5.50	4.62	9.18	No
Oct 17, 1996	5.89	4.23	11.36	No	Jul 26, 2000	5.75	5.49	10.16	Yes
Nov 3, 1996	5.58	4.28	10.76	No	Oct 03, 2000	6.59	6.15	10.56	Yes
Jan 14,1997	5.99	4.63	10.04	No	Sep 13, 2001	6.12	4.48	10.63	No
Jan 22, 1996	5.53	4.55	9.93	No	Sep 30, 2001	6.11	4.12	11.68	No
Feb 17, 1997	5.86	4.23	10.02	Yes	Oct 23, 2001	6.59	4.94	11.32	No
Mar 13, 1997	5.56	4.21	9.45	Yes	May 28, 2003	5.74	5.36	10.55	Yes
Apr 13, 1997	5.54	4.12	9.66	Yes	Aug 10, 2003	5.55	5.00	11.03	No
Jul 14, 1997	6.03	4.58	10.78	No					

Based on Figure 5-2, the table reports all the events for which the S-124 structure headwater is above stage 5.50 during the period from January 1993 to November 2003. Of these 57 events, only 7 triggered the use of G-123, and only four correspond to a flood situation with the water level in the NNRC above 5.30 (the 2-year stage is El. 5.44).

In addition, of the 50 events when the pumps were not in operation, the stage at the headwater of G-123 reached a level in excess of the 2-year event six times. Of these six events only two occurred when the tailwater stage of G-123 was above El. 11.50.

Additional analysis, including consideration of the rainfall amount and operating rules of the Water Conservation Areas, in conjunction with hydrologic\hydraulics simulation, are required to evaluate the impact of the G-123 pump station operation on flooding in the NNRC Basin.

Figure 5-1 Flows at G-123 in cfs

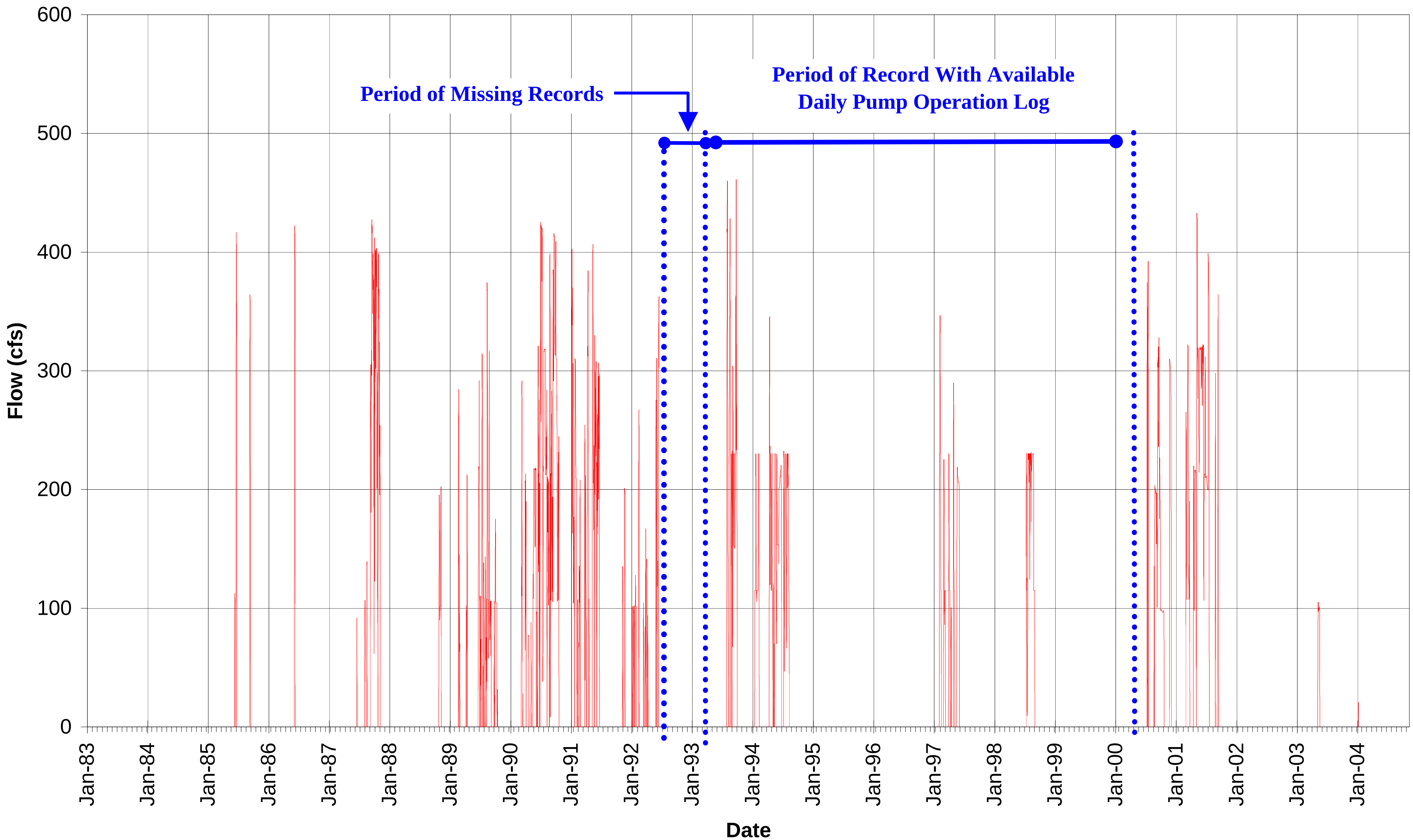


Figure 5-2 G-123 Event Volume, Rainfall at G-54 and Headwater Stages at S-124, (page 1 of 11)

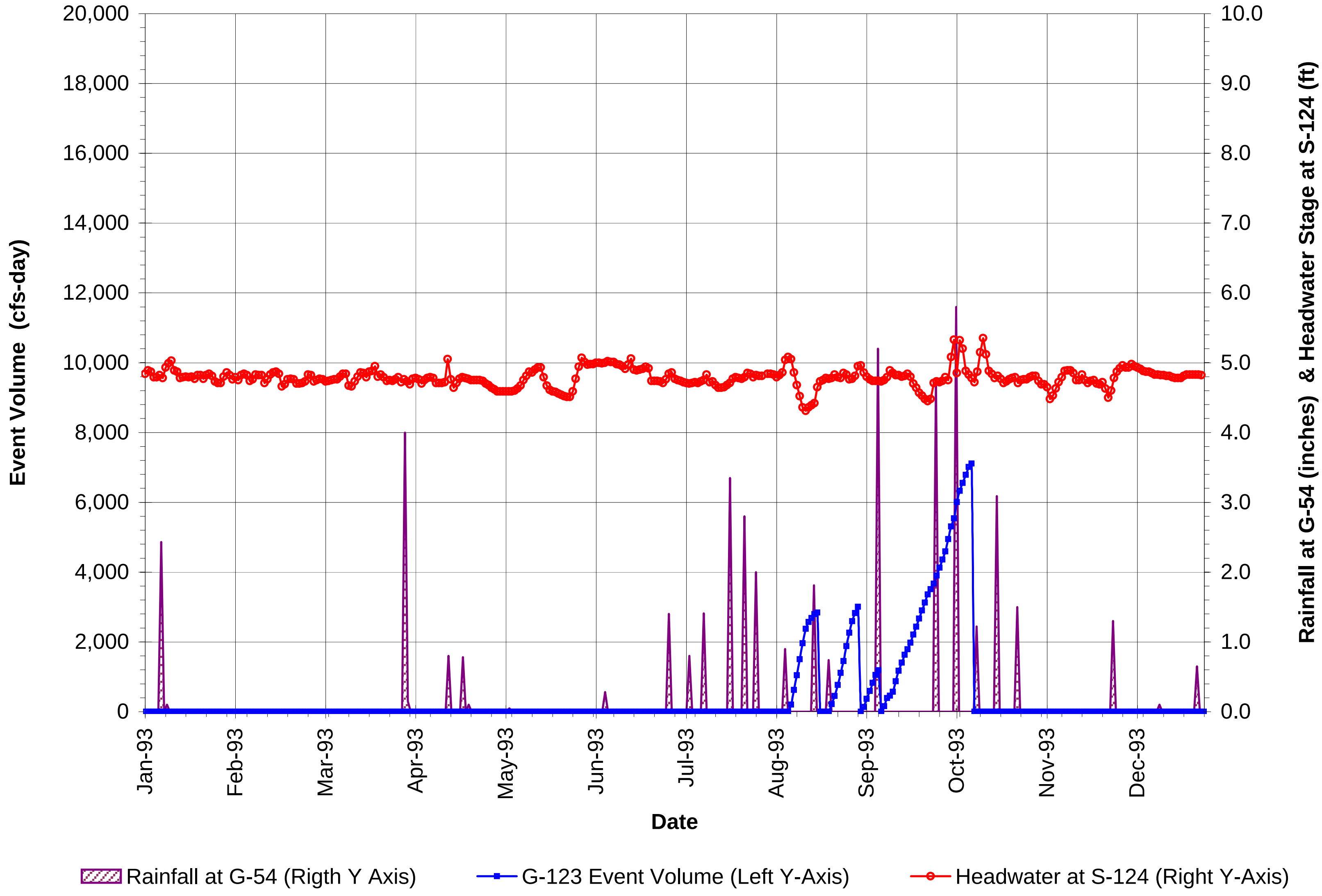


Figure 5-2 G-123 Event Volume, Rainfall at G-54 and Headwater Stages at S-124, (page 2 of 11)

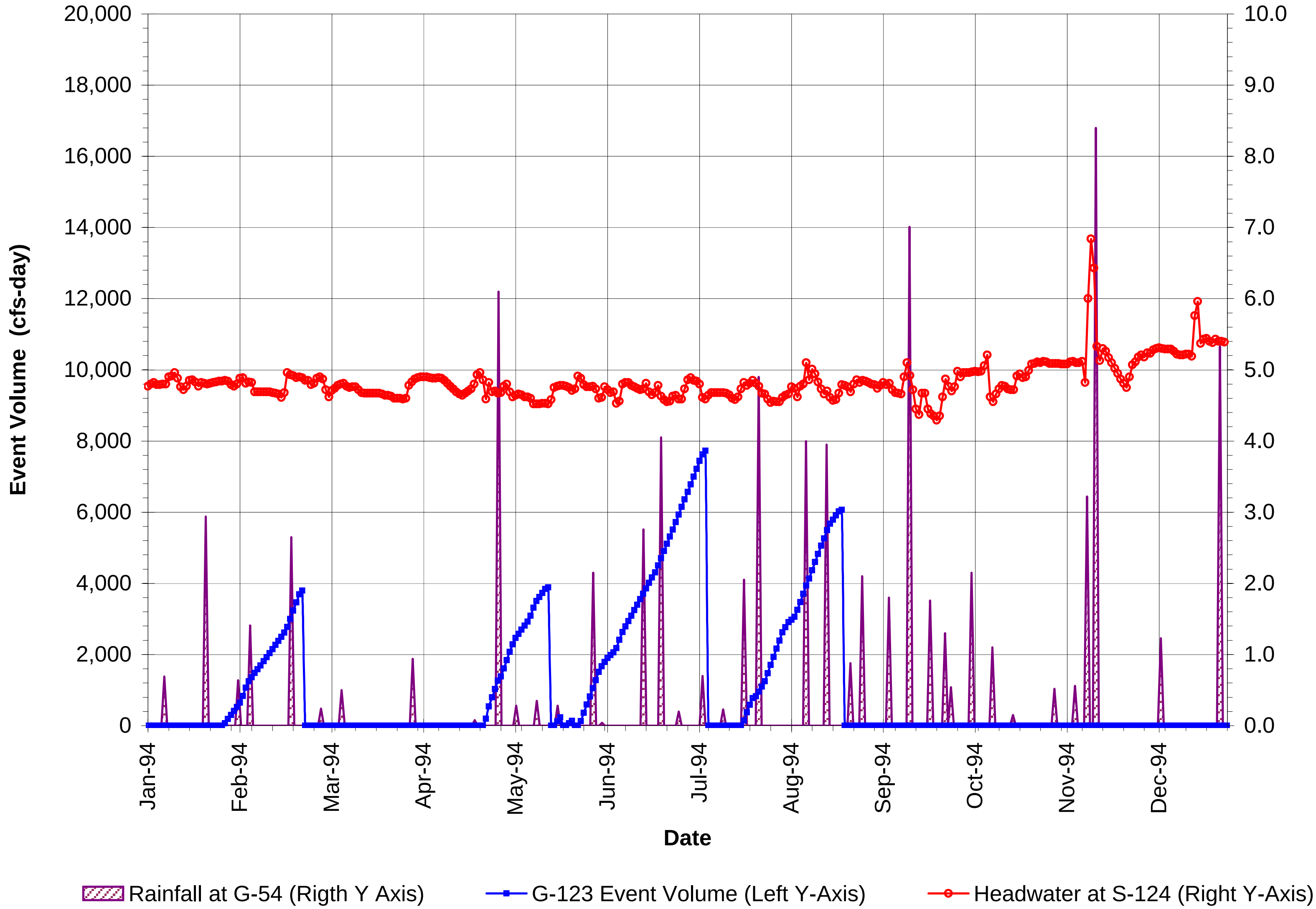


Figure 5-2 G-123 Event Volume, Rainfall at G-54 and Headwater Stages at S-124, (page 3 of 11)

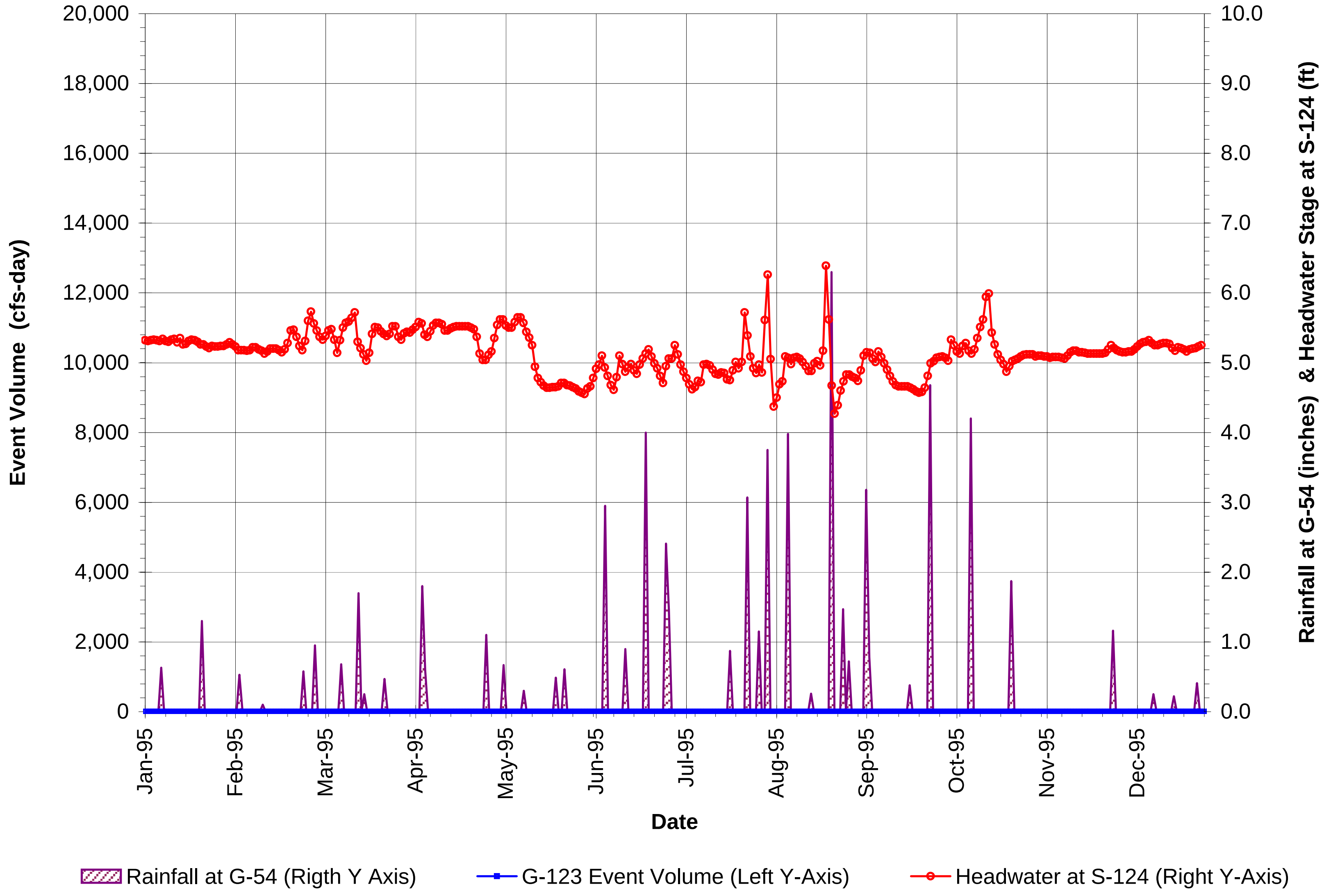


Figure 5-2 G-123 Event Volume, Rainfall at G-54 and Headwater Stages at S-124, (page 4 of 11)

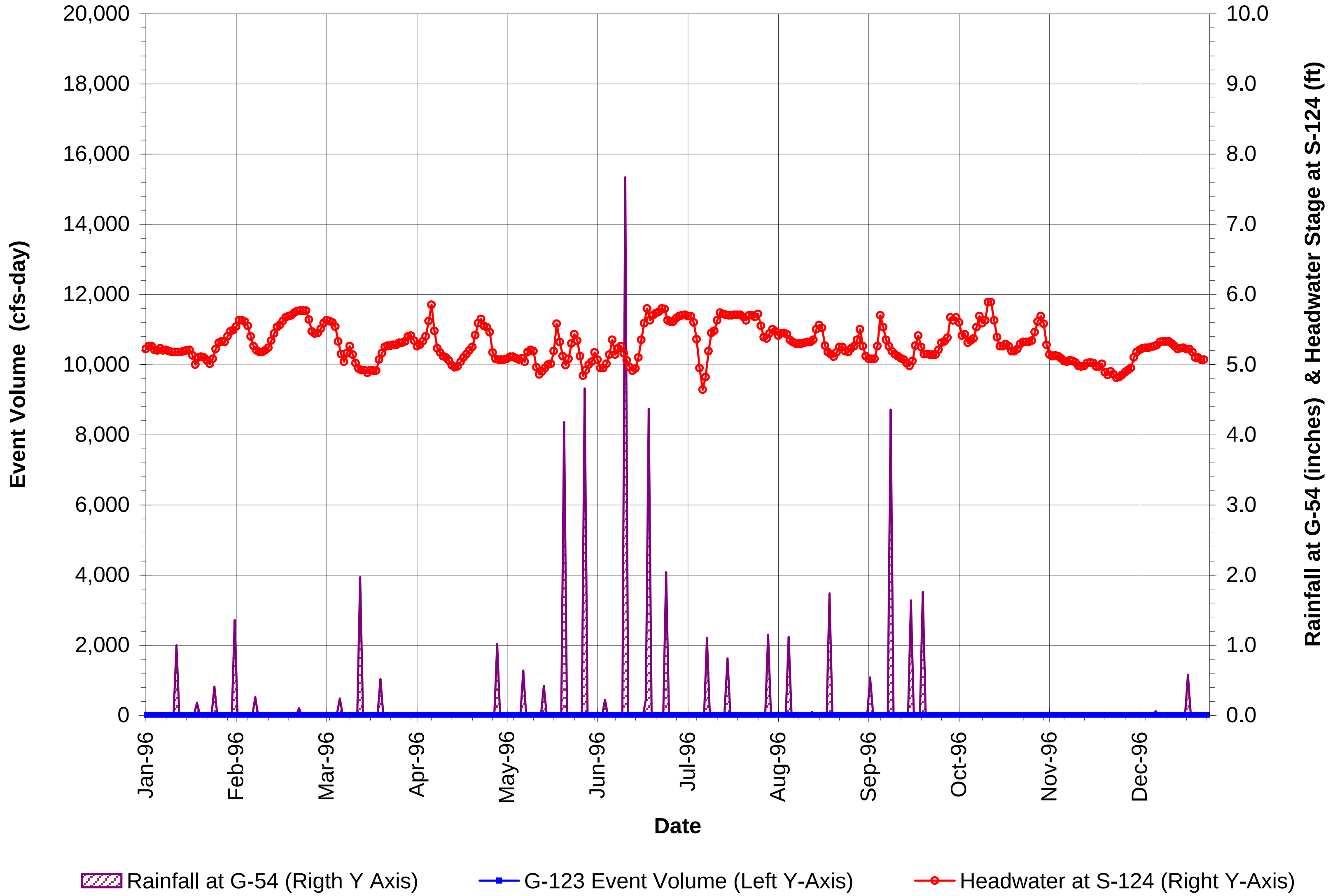


Figure 5-2 G-123 Event Volume, Rainfall at G-54 and Headwater Stages at S-124, (page 5 of 11)

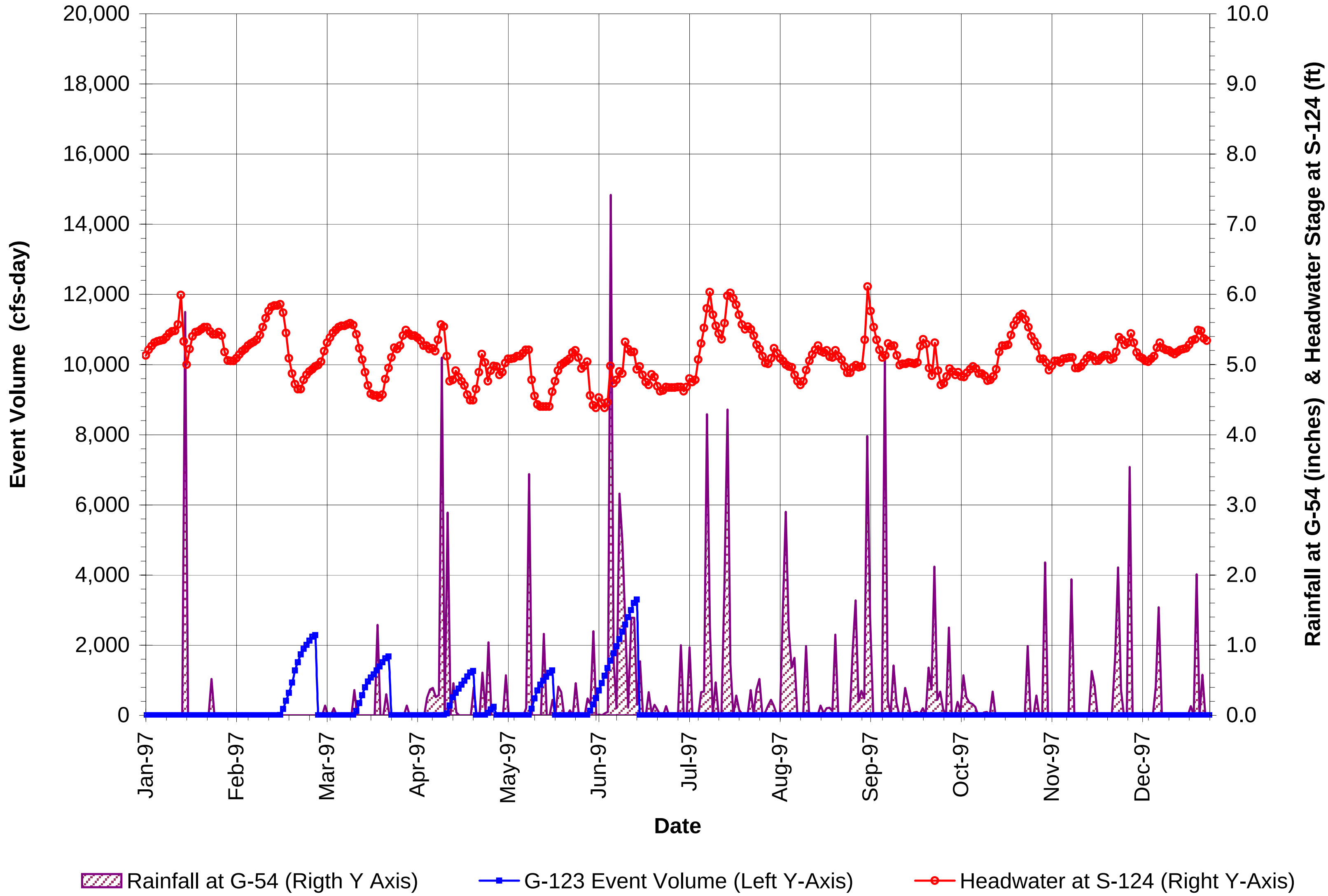


Figure 5-2 G-123 Event Volume, Rainfall at G-54 and Headwater Stages at S-124, (page 6 of 11)

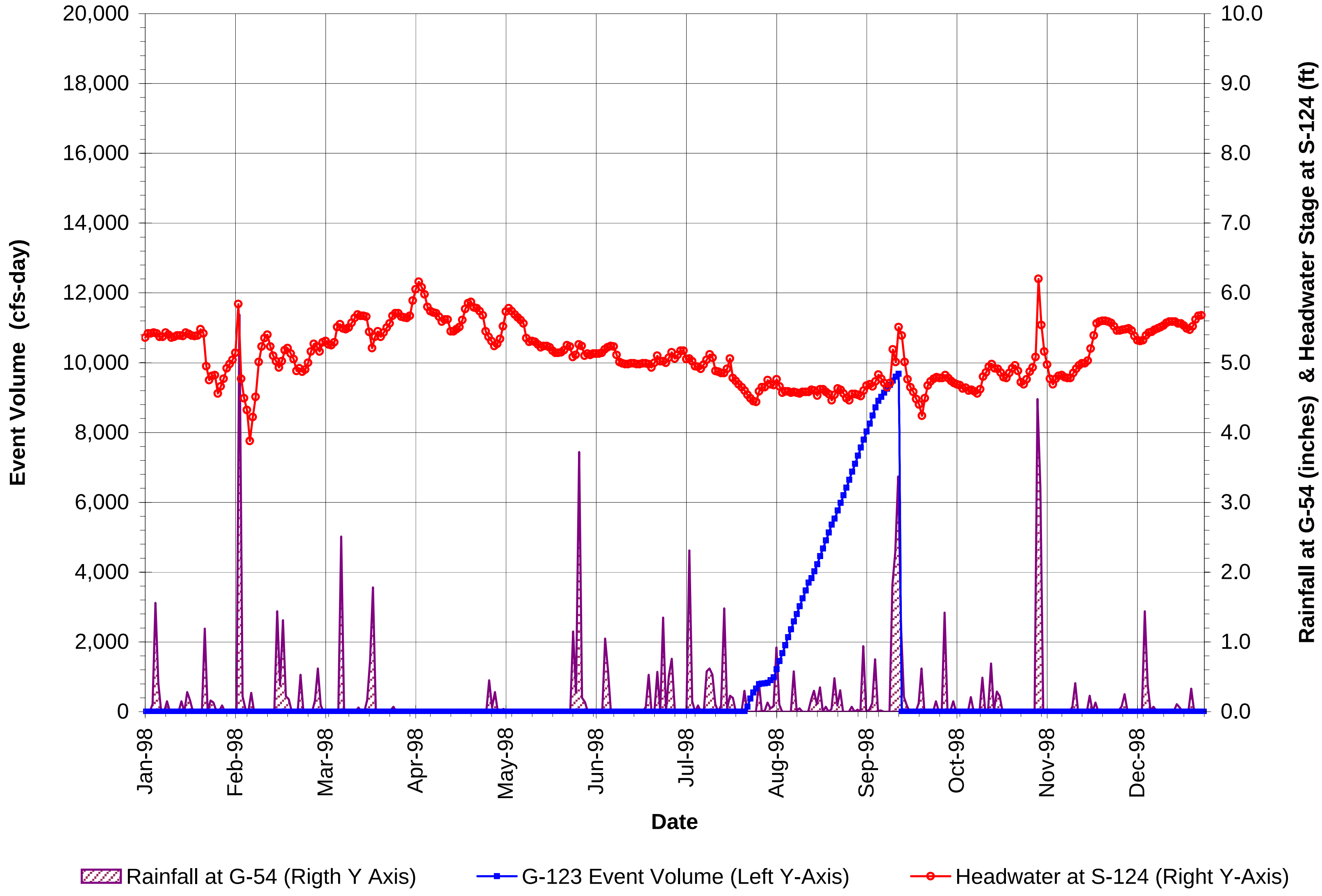


Figure 5-2 G-123 Event Volume, Rainfall at G-54 and Headwater Stages at S-124, (page 7 of 11)

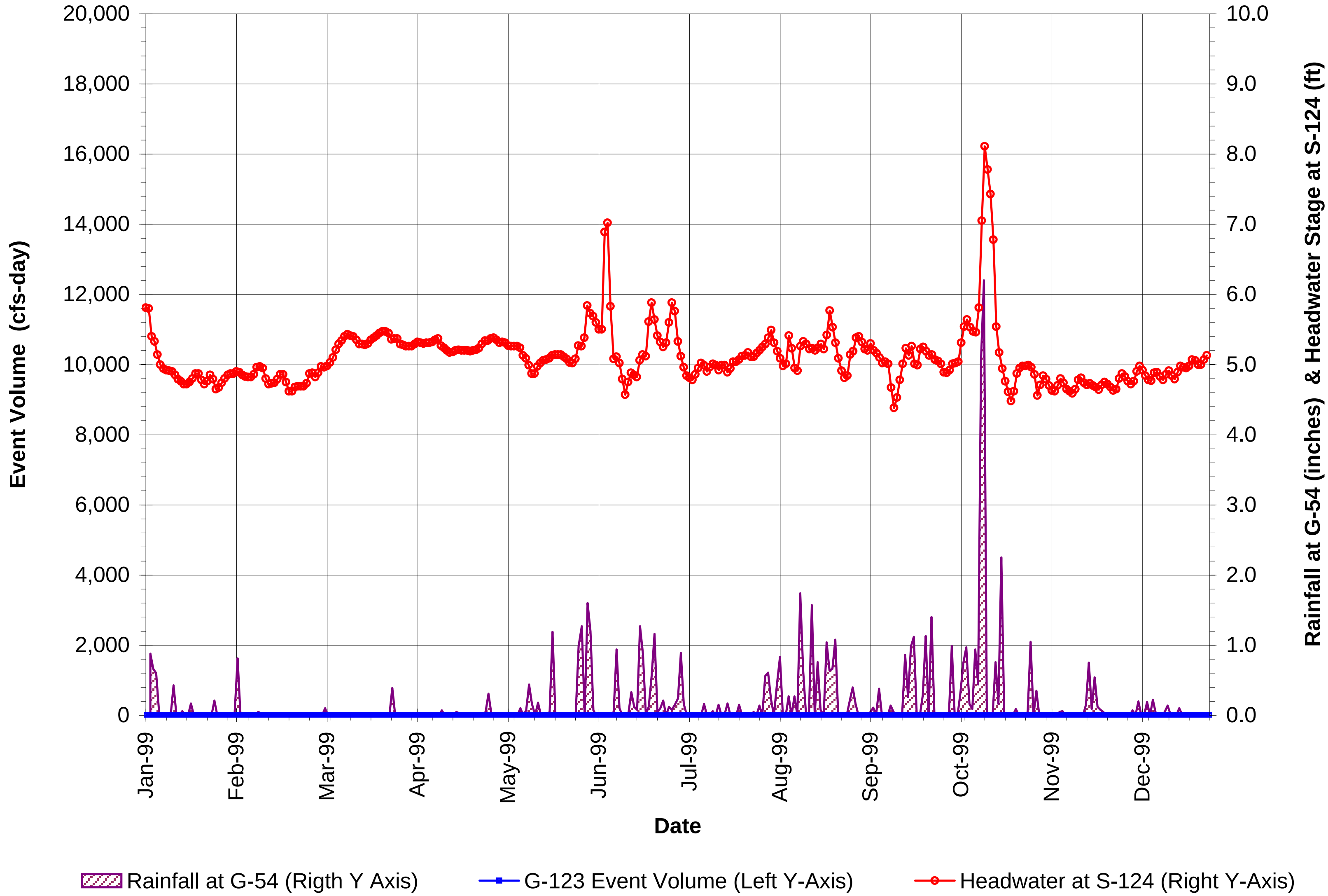


Figure 5-2 G-123 Event Volume, Rainfall at G-54 and Headwater Stages at S-124, (page 8 of 11)

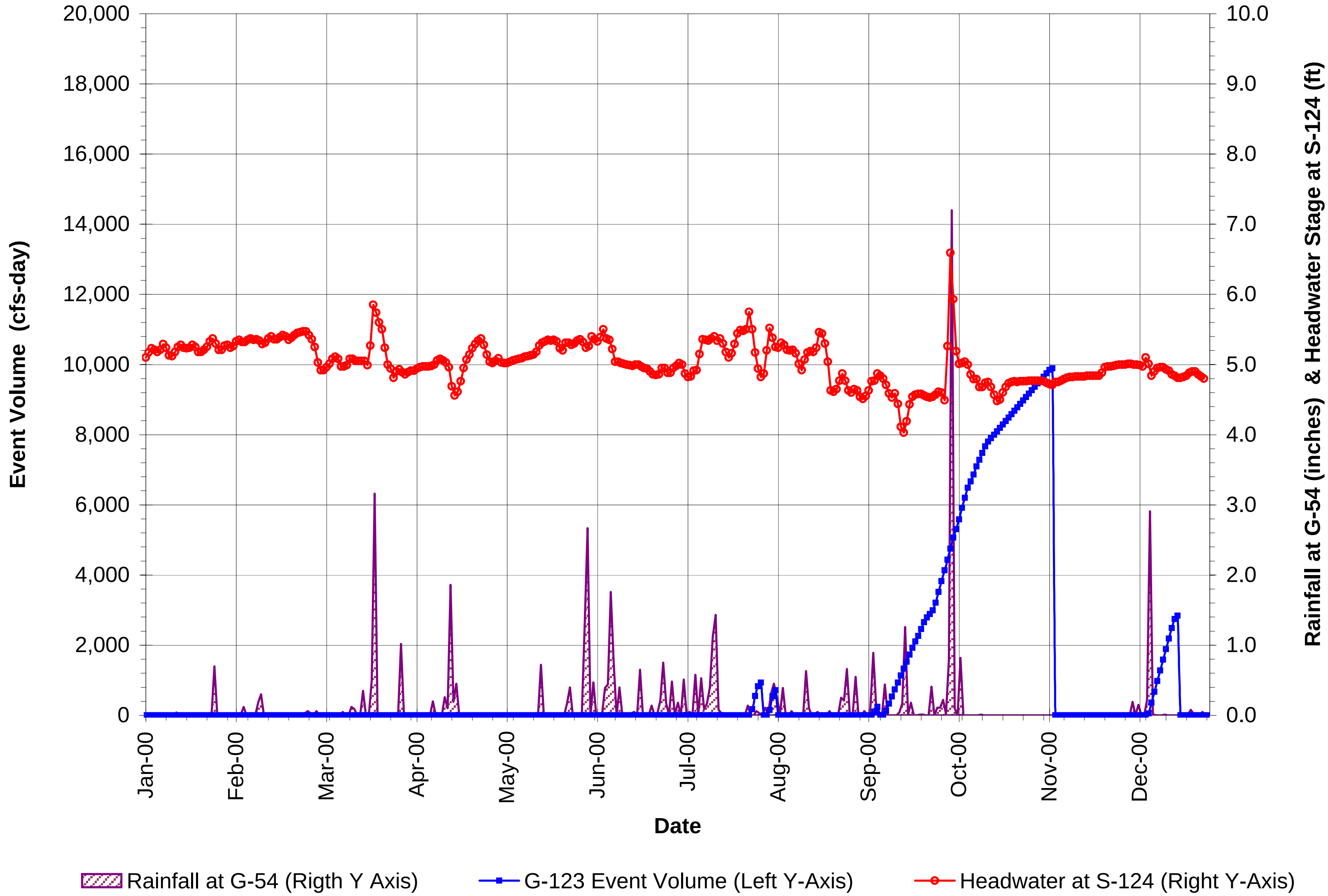


Figure 5-2 G-123 Event Volume, Rainfall at G-54 and Headwater Stages at S-124, (page 9 of 11)

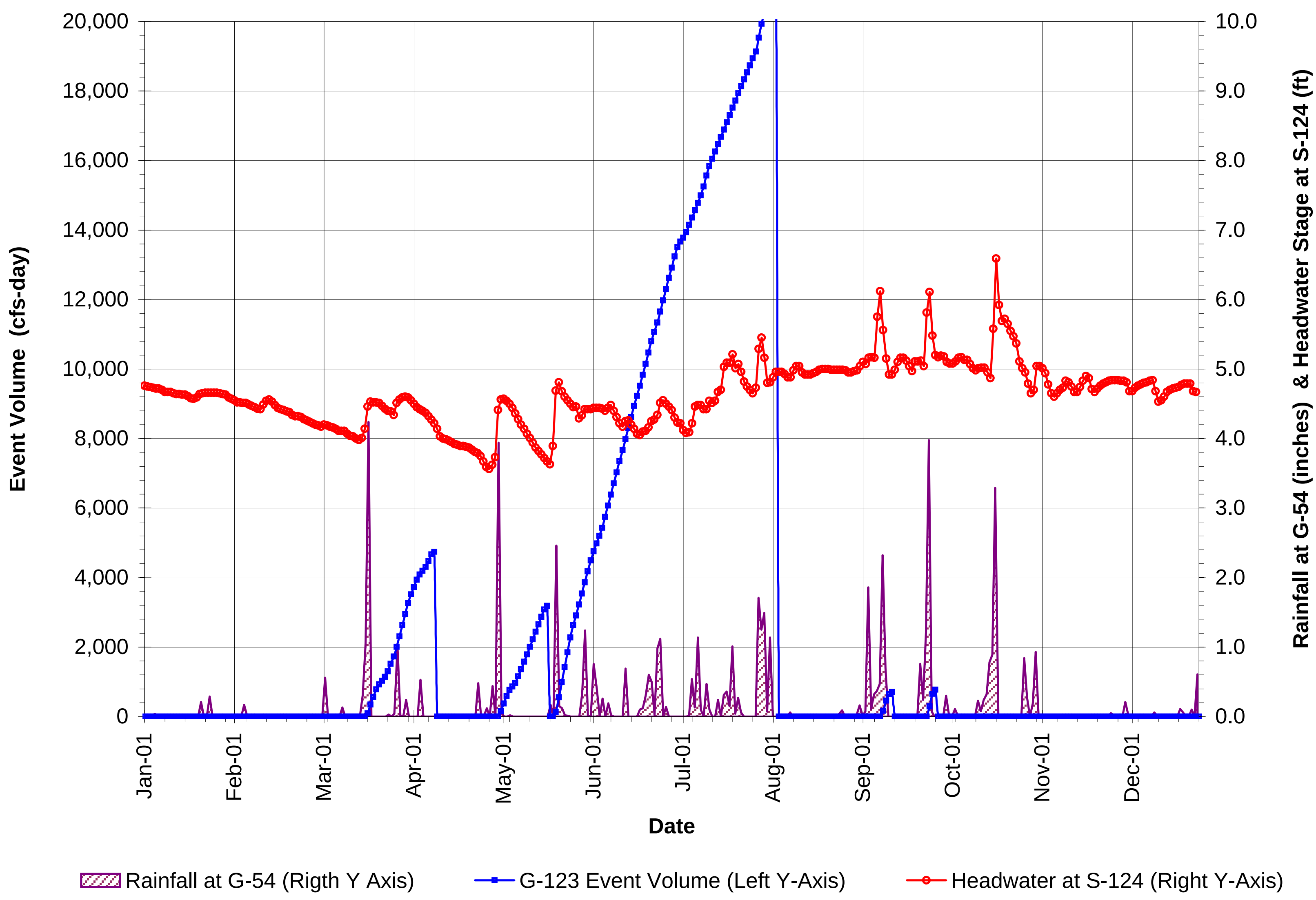


Figure 5-2 G-123 Event Volume, Rainfall at G-54 and Headwater Stages at S-124, (page 10 of 11)

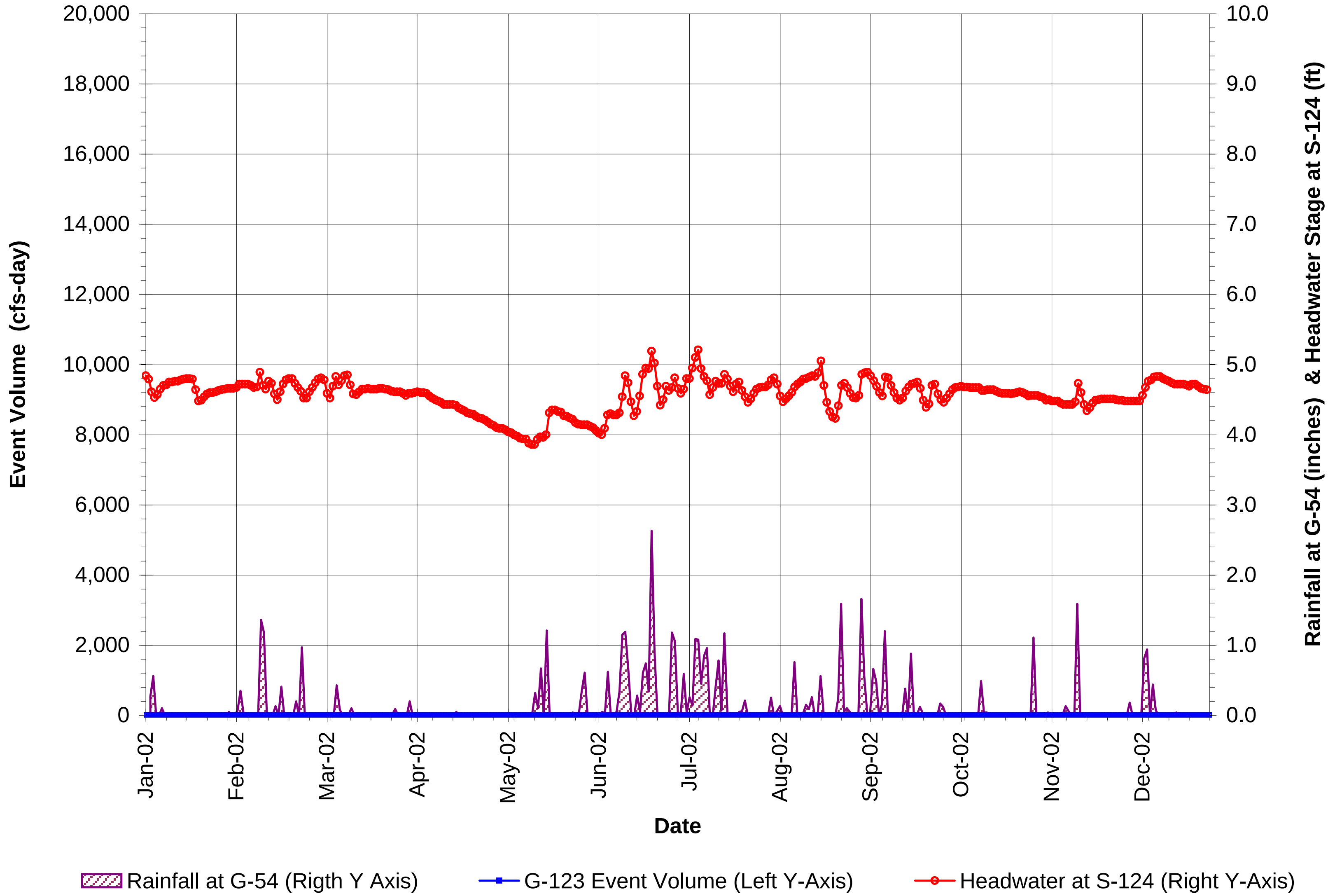


Figure 5-2 G-123 Event Volume, Rainfall at G-54 and Headwater Stages at S-124, (page 11 of 11)

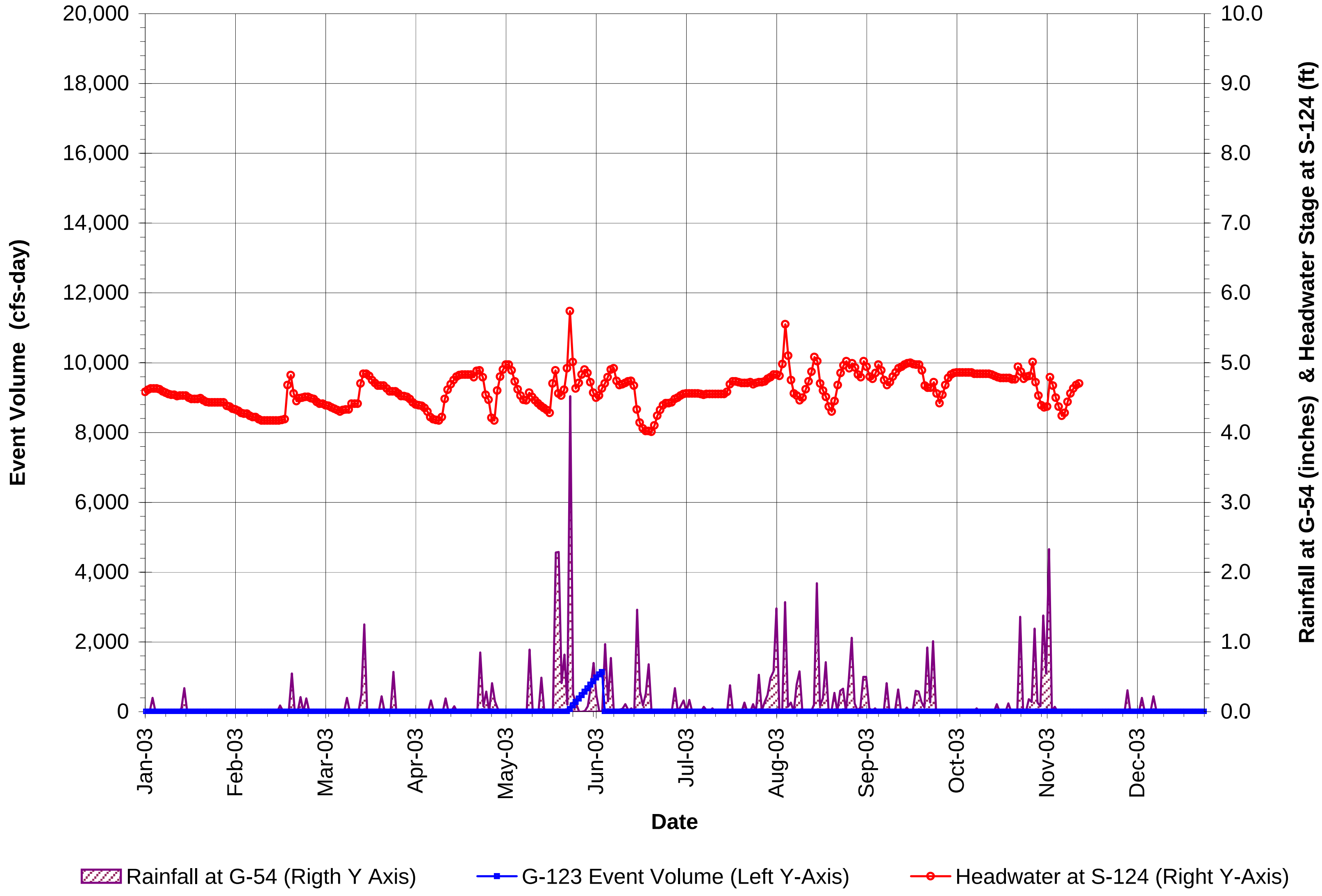


Table 5-3 . Analysis of the Operation of G-123 for the Period with Available Daily Pump Log

	G-123 Pump Records						G-123					S-124					G-54		Rainfall (1-day Event)					
	Pump On			Pump Off																				
Event	Day	Time	HW Stage	Day	Time	HW Stage	HW Peak Stage	Return Period (Years)	Peak Discharge (cfs)	Total Pumped Volume (cfs-day)	Return Period (Years)	HW Stage	TW Stage	Return Period (Years)	Daily Flow (MGD)	Return Period (Years)	Peak Discharge (cfs)	Return Period (Years)	G-54	Return Period (Years)	S-124	Return Period (Years)	3A-36	Return Period (Years)
1	11-Aug-93	7:50 AM	4.98	11-Aug-93	11:00 AM	4.60	4.80	1.15	206	2841	10.0	5.1	4.6	1.10	584	250	65	<1.01	0.00	N/A	1.44	<2	2.80	<2
	11-Aug-93	12:50 PM	4.68	13-Aug-93	9:15 AM	4.86	4.90	1.25	419			5.1	4.8	1.18	152	2.70	65	<1.01	0.00	N/A	0.87	<2	0.53	<2
	13-Aug-93	9:30 AM	4.86	20-Aug-93	9:15 AM	4.62	4.80	1.15	460			4.9	4.7	1.12	54	1.10	13	<1.01	0.26	<2	0.02	<2	0.12	<2
2	24-Aug-93	7:55 AM	5.10	27-Aug-93	8:40 AM	5.16	5.00	1.28	313	3009	15.0	4.8	4.8	1.18	39	1.04	10	<1.01	0.24	<2	0.36	<2	0.22	<2
	27-Aug-93	8:40 AM	5.16	31-Aug-93	9:50 AM	4.72	5.00	1.28	428			4.8	4.8	1.18	50	1.08	11	<1.01	0.00	N/A	0.60	<2	0.08	<2
	31-Aug-93	2:00 AM	4.94	3-Sep-93	3:15 AM	4.78	4.80	1.15	380			4.8	4.6	1.12	85	1.35	10	<1.01	0.00	N/A	0.15	<2	0.45	<2
3	5-Sep-93	9:50 AM	5.35	10-Sep-93	1:45 AM	4.32	5.20	1.52	230	1187	1.05	5.0	5.0	1.32	49	1.07	11	<1.01	1.01	<2	0.05	<2	0.27	<2
4	12-Sep-93	7:30 AM	4.86	14-Sep-93	1:44 AM	4.54	4.80	1.15	230	7110	Continuous operation, not related with a particular flood event	4.7	4.6	1.12	58	1.12	7	<1.01	0.00	N/A	0.05	<2	0.00	
	15-Sep-93	8:15 AM	5.24	15-Sep-93	1:44 AM	5.32	5.20	1.52	113			4.9	5.0	1.32	-152	N/A	6	<1.01	0.00	N/A	2.41	<2	0.00	N/A
	15-Sep-93	3:16 AM	5.28	12-Oct-93	12:20 PM	4.88	5.20	1.52	460			4.9	5.0	1.32	65	1.16	915	1.49	0.39	<2	0.28	<2	0.08	<2
5	27-Jan-94	9:30 AM	4.93	8-Feb-94	12:28 PM		5.10	1.43	230	3797	Continuous operation, not related with a particular flood event	4.9	4.8	1.25	61	1.13	0	N/A	0.17	<2	0.10	<2	0.13	<2
	8-Feb-94	2:30 AM	4.70	22-Feb-94	11:05 AM	4.80	4.80	1.15	230			4.7	4.6	1.12	65	1.16	136	<1.01	0.19	<2	0.16	<2	0.24	<2
6	25-Apr-94	10:10 AM	4.50	27-Apr-94	2:30 AM	5.04	4.40	1.03	345	3884	Continuous operation, not related with a particular flood event	5.0	4.5	1.10	150	2.53	227	<1.01	0.00	N/A	0.29	<2	1.07	<2
	27-Apr-94	2:45 AM	4.81	29-Apr-94	8:15 AM	4.90	4.40	1.04	253			4.8	4.5	1.10	253	8.70	241	<1.01	3.53		1.30	<2	0.46	<2
	29-Apr-94	8:30 AM	4.80	4-May-94	11:02 AM	4.40	4.50	1.04	236			4.7	4.6	1.10	181	3.77	274	<1.01	1.19	<2	0.14	<2	0.25	<2
	4-May-94	12:55 PM	4.40	9-May-94	1:30 AM	4.70	4.40	1.03	211			4.7	4.5	1.06	186	4.08	274	<1.01	0.06	<2	0.11	<2	0.00	N/A
	9-May-94	1:40 AM	4.68	16-May-94	8:20 AM	4.50	4.40	1.03	230			4.6	4.5	1.10	150	2.53	4	<1.01	0.05	<2	0.05	<2	0.00	N/A
7	19-May-94	9:05 AM	4.50	20-May-94	2:10 AM	4.22	4.40	1.03	120	233	< 1.01	4.8	4.5	1.10	151	2.53	0	<1.01	0.23	<2	0.54	<2	0.00	N/A
8	23-May-94	9:25 AM	4.57	24-May-94	2:48 AM	4.36	4.50	1.04	70	137	< 1.01	4.8	4.6	1.10	149	2.53	0	<1.01	0.00	N/A	0.00	N/A	0.00	N/A
9	27-May-94	10:20 AM	4.90	6-Jun-94	2:15 AM	4.20	4.80	1.15	230	7726	Continuous operation, not related with a particular flood event	4.9	4.9	1.32	121	1.90	348	1.02	0.22	<2	0.32	<2	0.20	<2
	6-Jun-94	2:25 AM	4.13	9-Jun-94	10:00 AM	4.16	4.30	<1.01	229			4.7	4.4	1.04	193	4.55	407	1.03	0.00	N/A	0.91	<2	0.71	<2
	9-Jun-94	10:15 AM	4.08	10-Jun-94	9:00 AM	4.36	4.20	<1.01	229			4.6	4.3	1.04	158	2.94	218	<1.01	0.00	N/A	1.07	<2	2.00	<2
	10-Jun-94	9:20 AM	4.30	21-Jun-94	2:30 AM	4.56	4.60	1.06	220			4.7	4.7	1.12	153	2.67	424	1.03	0.25	<2	0.41	<2	0.40	<2
	21-Jun-94	2:35 AM	4.50	7-Jul-94	8:20 AM	4.58	4.50	1.04	220			4.7	4.6	1.10	107	1.67	265	<1.01	0.31	<2	0.23	<2	0.14	<2
	7-Jul-94	9:00 AM	4.52	8-Jul-94	11:00 AM	4.35	4.50	1.04	182			4.8	4.5	1.10	268	10.53	2	<1.01	0.65	<2	0.12	<2	0.00	<2
10	21-Jul-94	9:00 AM	4.60	25-Jul-94	8:50 AM	4.62	4.60	1.06	230	6065	Continuous operation, not related with a particular flood event	4.7	4.7	1.12	194	4.55	359	1.02	0.51	<2	0.30	<2	0.69	<2
	25-Jul-94	9:00 AM	4.55	26-Jul-94	10:30 AM	4.60	4.50	1.04	127			4.9	4.6	1.12	299	14.29	359	1.02	4.61		0.84	<2	0.00	<2
	26-Jul-94	10:45 AM	4.52	29-Jul-94	8:20 AM	4.58	4.50	1.04	225			4.8	4.6	1.12	200	4.88	170	<1.01	1.69	<2	0.52	<2	1.01	<2
	29-Jul-94	8:50 AM	4.54	4-Aug-94	10:00 AM	4.46	4.50	1.04	230			4.7	4.6	1.10	98	1.52	129	<1.01	0.15	<2	0.29	<2	0.07	<2
	4-Aug-94	1:50 AM	4.58	8-Aug-94	7:00 AM	4.48	4.50	1.04	190			4.6	4.6	1.10	204	5.00	111	<1.01	0.24	<2	0.11	<2	0.55	<2
	8-Aug-94	7:16 AM	4.44	12-Aug-94	10:40 AM	4.90	4.60	1.06	230			4.7	4.7	1.12	184	3.85	824	N/A	0.97	<2	0.34	<2	0.85	<2
	12-Aug-94	10:45 AM	4.90	17-Aug-94	8:50 AM	4.30	4.60	1.06	230			4.7	4.7	1.12	191	4.44	824	N/A	0.00	N/A	0.85	<2	0.60	<2
	17-Aug-94	11:25 AM	4.40	23-Aug-94	9:18 AM	4.50	4.50	1.04	230			4.7	4.6	1.10	111	1.72	166	<1.01	0.67	<2	0.01	<2	0.10	<2
11	16-Feb-97	11:00 AM	9.61	24-Feb-97	11:15 AM	4.40	4.40	1.03	345	2284	5.0	5.8	4.4	1.06	70	1.20	139	<1.01	0.00	N/A	0.14	<2	0.06	<2
	24-Feb-97	11:15 AM	4.40	28-Feb-97	9:20 AM	4.38	4.30	1.01	156			4.7	4.3	1.02	53	1.10	0	<1.01	0.00	N/A	0.08	<2	0.01	<2
12	14-Mar-97	11:00 AM	5.06	20-Mar-97	10:45 AM	4.05	5.00	1.28	225	1675	2.5	5.6	5.0	1.43	98	1.55	1	<1.01	0.00	N/A	0.35	<2	0.18	<2
	20-Mar-97	12:15 PM	4.36	24-Mar-97	8:54 AM	4.60	4.40	1.03	115			4.6	4.5	1.06	102	1.56	0	<1.01	0.41	<2	0.02	<2	0.01	<2
13	14-Apr-97	6:45 AM	5.40	17-Apr-97	10:09 AM	5.04	4.70	1.10	230	1260	1.1	5.5	4.8	1.25	8	N/A	250	<1.01	0.57	<2	0.34	<2	0.40	<2
	17-Apr-97	2:50 AM	5.08	23-Apr-97	9:05 AM	4.58	4.70	1.10	132			4.8	4.8	1.25	-16	N/A	0	<1.01	0.08	<2	0.01	<2	0.01	<2
14	28-Apr-97	10:10 AM	4.90	30-Apr-97	2:40 AM	4.64	4.80	1.15	101	237	<1.01	5.2	4.8	1.25	-15	N/A	0	<1.01	0.48	<2	0.11	<2	0.18	<2
15	13-May-97	7:35 AM	4.61	20-May-97	2:10 AM	4.46	4.50	1.04	289	1281	1.1	5.2	4.6	1.10	29	1.02	86	<1.01	0.19	<2	0.27	<2	0.05	<2
16	2-Jun-97	10:30 AM	4.68	12-Jun-97	8:00 AM	4.60	4.60	1.06	218	3296	20.0	5.0	4.6	1.10	95	1.44	354	1.02	1.30	<2	0.67	<2	0.53	<2
	12-Jun-97	8:15 AM	4.51	18-Jun-97	10:21 AM	4.80	4.70	1.10	206			4.8	4.7	1.12	98	1.52	733	1.23	1.64	<2	1.05	<2	0.50	<2
17	27-Jul-98	9:00 AM	4.12	18-Sep-98	12:00 PM	N/A	5.30	1.72	230	9678	Continuous Op.	5.5	5.5	2.50	85	1.35	728	1.23	0.28	<2	0.35	<2	0.10	<2

6 Conclusion and Recommendations

- The review of the NNRC Basin data concludes that the presently available data is sufficient to construct a screening-level XP-SWMM for the NNRC. Engineering judgment and conservative assumptions will compensate for missing data.
- For a detailed hydraulic model, the following information will be required, but this information is currently not available:
  - Commodore Drive Bridge Permit (or related information)
  - SW 125th Avenue Bridge Permit (or related information)
  - University Drive Bridge Permit (or related information)
  - Pumping records during selected storm events for all pumps that discharge into the river/canal network (pump design/permit will be used for missing pumping records)
  - Sub-basin characteristics for Shenandoah and Mobile Home Park gravity flows that were identified during the data review
  - Gage data for Staff Gage #13 along the C-42 Canal that was identified during data review. This gage will support calibration of the C-42 Canal
- Additional information regarding the G-123 operation will be necessary to assess the impact that the removal of these pumps will have on flood events. In particular, the detailed logs of pump operation during flood events will be needed; these logs should include hourly pumped flows (based on tailwater and headwater levels, and pump characteristics). The analysis of the pump station operation should be finalized.
- For the purpose of simulating flood events, the recorded water levels and flows (on an hourly basis) at the various structures in the system will be needed, as well as precipitation records at all the rainfall stations in basin.
- A preliminary evaluation of the hydraulic performance of the G-54 structure should be conducted: for that purpose the design and construction (as-built) drawings should be reviewed. If available, the design memorandum for the new structure should also be reviewed.
- It is recommended to survey the area immediately downstream of the structure to assess the possible impact of the remnants of the old G-54 structure.
- As indicated by the preliminary survey of the NNRC, it appears that the approximately 3-mile long reach immediately upstream of G-54 may be subject to severe sediment accumulation. If accurate, it may have a significant impact on the NNRC capacity, and it would be preferable to use recently surveyed canal cross-sections in the simulation model.