US Army Corps
of Engineers
Buffalo District

Reservoir Regulation Manual

Keuka Lake Outlet
Penn Yan, New York

Prepared by:
U.S. Army Corps of Engineers Buffalo District
Hydrologic Investigation Section
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Photograph

NOTICE TO USERS OF THIS MANUAL

Regulations specify that this Water Control Manual be published in loose leaf form, and only those sections, or parts thereof, requiring changes will be revised and printed. Therefore, this copy should be preserved in good condition so that inserts can be made to keep the manual current. Changes to individual pages must carry the date of revision, which is the Divisions's approval date.

This water control manual assumes the following editorial guidance for the terms regulation and operations:

1. Use of the term "Regulation" is restricted to either: (1) water control procedures and decisions that normally are determined by regulating engineers (hydrologic or hydraulic), (2) legal rules, agreements, or contracts, FERC licenses, water supply contracts, and ruling of interstate compacts.

2. Use of the term "Operations" refers to physical manipulation of outlet works or other instrumentation and computers associated with Keuka Lake Outlet.

3. Use of the term "damtender" refers to the individual who has the responsibility for the physical "operation" of the project.

EMERGENCY REGULATION ASSISTANCE PROCEDURES

In the event that unusual conditions arise during duty or non duty hours, one or more of the people listed in Chapter V in the paragraph *"Warning"* should be contacted.

Table of Contents

PLATES

PERTINENT DATA

A. General

Location	Penn Yan, Yates County, New York from Keuka Lake, 1.0 mile downstream to dam and control structure near Main Street Bridge. The structure is 6.7 miles upstream of Seneca Lake.
Type of Project	Natural Lake with gated outlet
Purpose	Flood Control authorized by Section 205 of the 1948 Flood Control Act (Public Law 80-845, 30 June 1948)
Drainage Area	183 sq. mi. (Keuka Lake)
Project Owner	New York State
Operating Agency	Village of Penn Yan
Regulating Agency	New York State Dept. of Environmental Conservation, and Keuka Lake Outlet Compact (KLOC)

B. Reservoir (Keuka Lake)

Maximum water surface elevation (design surcharge pool)	725.52
Total capacity at maximum water surface elevation (acre-feet)	216,690
Total capacity at maximum water surface elevation (inches)	25.26
Top of Conservation Pool*	See Table 1 (Paragraph 7-04)
Top of Flood Control Pool*	715.0
Top of the Inactive Pool*	709.0

**All elevations are in feet NGVD*

C. Outlet Structure

Type	Masonry with concrete cap and Aluminum, Steel, and Wood slide gates Federal project completed November 1993
Top of Dam, Elevation	716.0
Type	Aluminum, Steel, Wood slide gates, and sheetpile sidewalls
Number of Gates	6
Size of Gates:	6' X 7' (3 Main Gates) 4.5' X 4.5' (2 Andrews Gates) 5.4' x 4.0' (Birkett Gate)

D. Spillway

Dam Length - feet (Federal Project)	52.2
Fixed Elevation	716.0
Top of Gates (When open)	723.0

E. Channel

Type	15 foot grout mat and 50 feet of rip rap
Maximum Channel Capacity (cfs) at Spillway Elevation (716.0)	1040

CHAPTER I: INTRODUCTION

1-01 Authorization

This manual has been prepared following directives and guidance contained in:

a. EM 1110-2-3600, Management of Water Control Systems, dated 30 November 1987.

b. ER 1110-2-240, Water Control Management, dated 8 October 1982, change # 1 dated 30 April 1987, and change # 2 dated 1 March 1994.

c. ER 1110-2-241, Use of Storage Allocated for Flood Control and Navigation at Non-Corps Projects, dated 27 May 1990.

d. ER 1110-2-248, Requirements for Water Data Transmission Using GOES/DCS, dated 13 March 1981.

e. ER 1110-2-249, Management of Water Control Data Systems, dated 31 August 1994.

f. ER 1110-2-1400, Reservoir/Water Control Centers, dated 30 September 1993.

g. ER 1110-2-1941, Drought Contingency Plans, dated 15 September 1981.

h. ER 1110-2-8156, Preparation of Water Control Manuals, dated 31 August 1995.

i. ER 1130-2-419, Dam Operations Management Policy, dated 18 May 1978, change # 1 dated 9 April 1982.

1-02 Purpose and Scope

This manual contains a description of the Keuka Lake Outlet control structure. The manual has pertinent information concerning project features, regulation and operation of the control structure.

1-03 Related manuals and reports

The Buffalo District prepared a Detailed Project Report and Environmental Assessment in October 1987 for the new outlet structure constructed in 1993. The Buffalo District prepared an Operation and Maintenance Manual for the completed structure in March 1994.

Another related report is the Oswego River Basin Management Plan Analysis prepared by the Buffalo District Corps of Engineers in January 1984. This report provided an assessment and evaluation of feasible lake management plans, and structural improvements to the outlet. The study included the effects of several lake level management plans on flood protection, hydropower generation, fish and wildlife management, municipal water supply, water quality, and water-based recreation around the lake. The detailed project report was the continuation of the 1984 study report.

1-04 Project Owner

New York State owns the project.

1-05 Operating Agency

Keuka Lake Outlet structure is operated by the Village of Penn Yan. In 1990 the towns and villages that border the lake formed the "Keuka Lake Outlet Compact" (KLOC). The towns include Penn Yan, Jerusalem, Pultney, Barrington, Hammondsport, Milo, Wayne, and Urbana. The KLOC will undertake the responsibilities associated with controlling the lake level, channel maintenance (from control structure to Keuka Lake), and maintaining and managing the control structure. A Board of Commissioners, composed of eight members who represent the six towns and two villages, governs the KLOC.

The KLOC appointed the village of Penn Yan as control structure manager. The village of Penn Yan, in turn appointed the Penn Yan Municipal Utilities Operations Supervisor as the Manager. The manager shall oversee the day-to-day operation and maintenance of the outlet control structure. He or she may delegate duties associated with said day-to-day operation to one or more employees of Penn Yan Municipal.

It is the responsibility of the Manager to assure harmony with other agencies concerning gate regulation. During periods of high water it is necessary for the Manager to communicate with the agencies responsible for downstream areas and KLOC. Notification of downstream areas will limit or prevent any unnecessary or avoidable damage downstream.

1-06 Regulating Agencies

The New York State Department of Environmental Conservation and the Keuka Lake Outlet Compact regulate the project.

CHAPTER II: DESCRIPTION OF PROJECT

2-01 Location

Keuka Lake is a "Y" shaped lake located in the southwestern part of the Oswego River Basin, between Canandaigua and Seneca Lakes (Plates 1&2). The outlet drains east from Keuka Lake and discharges into Seneca Lake at Dresden, New York. The project is located in Yates County in the Village of Penn Yan. A dam and control structure about 1 mile downstream from the lake on the Keuka Lake Outlet near the Main Street Bridge in Penn Yan regulate the outflow.

2-02 Purpose

The purpose of the federal project is to reduce the damages that result from periodic flooding along Keuka Lake by allowing greater winter drawdown. This includes the danger of death, injury, disease, and human suffering associated with periodic flooding along Keuka Lake. The project should also preserve, protect or enhance the quality of the fish and wildlife habitat in the Keuka Lake vicinity, and preserve cultural resources in the project area. Lastly, it will encourage sound community planning concerning the flood hazard.

2-03 Physical Components

A. Control Structure

The control structure at Penn Yan consists of six sluice gates (See Plates 3A and 3B). Two of the gates, (Andrews Gates) are located on the right side of the dam (looking downstream). A third gate (Birkett Gate) is on the left side. These gates were installed around 1929, and were originally constructed of wood. The Andrew Gates were replaced with the existing steel gates in 1966; however, the Birkett Gate retains the original wood.

The three gates installed in 1993 are between the Birkett Gate and the Andrews Gates. These gates are the primary control structures. Each aluminum slide gate is six feet wide by seven feet high. A walkway attached to the control structure provides access to the slide gate control mechanisms.

The primary control structure spans the stream located approximately 20 feet upstream of the Main Street bridge. It includes three aluminum slide gates and a galvanized sheet pile wall.

B. Spillway

The control structure provides a spillway of approximately 52 feet. The sheet pile wall joins the Birkett Mill Race on the left bank and the Andrews Mill Race on the right bank.

C. Channel (Downstream of Structure)

Two concrete walls channel the flow from the control structure to the center arch opening of the Main Street Bridge. A grout-mat covers the channel bottom starting at the control structure and continuing underneath the center arch stopping at the downstream face. Rip-rap and bedding stone cap the channel bottom starting at the downstream face of the mat and continuing 50 feet downstream. A concrete wall extends 60 feet downstream of the Main Street Bridge on the left side of the center arch.

2-04 Related control facilities

There are no related control facilities at this site.

2-05 Real estate acquisition

Permanent easements for project operation and maintenance are located on the east bank of the outlet channel. This land is presently Village of Penn Yan park land.

2-06 Public Facilities

There are no public facilities associated with this project.

CHAPTER III - HISTORY OF PROJECT

3-01 Authorization

Construction of the Keuka Lake Flood Control Project on the Keuka Lake Outlet, Village of Penn Yan, Yates County New York was completed under the authority of Section 205 of the 1948 Flood Control Act (Public Law 80-845, June 1948), as amended.

3-02 Planning and Design

This section presents a brief summary of prior studies and reports dealing with Keuka Lake.

A survey report of the Oswego River Basin, submitted to Congress on 17 June 1940 considered improvements of Keuka Outlet to provide flood control for properties on the lake shore. The plan of improvement made several recommendations. These recommendations included removal of shoals in the channel upstream of the dam, replacement of the small gates in the Andrews raceway with a single modern structure, lowering the sill 1.7 feet, and channel excavation downstream from the new gate to reduce tailwater elevations. These recommendations would allow more effective control of lake levels by regulation at the dam. The recommended plan was authorized as a Federal project by the Flood Control Act approved 18 August 1941. Syracuse District completed the Plans and specifications, however this plan proposed an entirely new gate near the center of the spillway rather than replacement of the existing gates.

This plan was never constructed because of high estimated cost of rights-of-way, and local opposition to the proposed range of regulated lake levels. In 1959 the Buffalo District submitted a reconnaissance report on Keuka Outlet at Penn Yan, New York. This report detailed improvements for flood control. A Detailed Report was completed by the Buffalo District in 1960. This report concluded that reduction of flood damages would be best accomplished through regulation of lake levels so as to have available storage during flood periods. The report recommended that no structural project for flood protection be adopted.

As part of the National Dam Safety Act, Public Law 92-367, a Phase I inspection report was prepared in August 1980. This inspection was conducted to evaluate the existing condition of the dam, to identify deficiencies and hazardous conditions, to determine if those deficiencies constituted hazards to life and property, and to recommend remedial measures.

As part of the Oswego River Basin Study, a Management Plan Analysis (Final Feasibility Report) for Keuka Lake was completed in January 1984. This report recommended construction of additional gates at the existing control structure. This report served as the basis for preparation of a Detailed Project Report.

The Detailed Project Report (DPR) included a comprehensive outline of the project conditions and a discussion of feasible and economically justified improvements. The cost and benefits of the various alternatives were outlined. The divisions of project responsibilities between Federal and non-Federal interests in the Selected Plan were also presented in summary form.

3-03 Construction

The control structure at Penn Yan has six gates. Three of the gates (Andrews Gates and Birkett Gate) were installed around 1929. The Andrews Gates were originally constructed of wood, but they were replaced with steel gates in 1966. The Birkett gate remains built of wood.

Between December 1992 and November 1993 three aluminum slide gates were installed after removing an existing earth and masonry dam in the center of the stream. The channel bottom just downstream of the control structure was paved with a grout-filled mat. The grout mat extends approximately 15 feet downstream of the center arch of the Main Street bridge. Rip-rap was placed on the channel bottom 50 feet downstream of the grout-filled mat. Lastly, a concrete wall extending 60 feet was constructed downstream of the main Street Bridge on the left side of the center arch.

3-04 Related projects

There is a controlled diversion of water from Waneta and Lamoka Lakes which have a drainage area of 45.3 square miles (In Chemung Basin) to Keuka Lake, the long-term average flow at the diversion (from 1966-1994) is 19.9 cfs.

3-05 Modifications to regulations

A draft water control plan was completed to operate the newly constructed federal project. The regulation plan was modified in 1997 modified since the federal project was completed in 1992. The new regulation plan is presented in Chapter VII. Regulation plans existed prior to the federal project, a history of these policies are detailed below. Note that all elevations given in this report are in feet NGVD.

During the period WY 1930 through WY 1979, various operating policies were in place on Keuka Lake. Throughout this period, changing channel conditions affected the operation of the structure. These different operating policies and outlet capacities would create different lake levels than those in existence today.

Before 1963, NYSEG managed the control gates. This was primarily to provide regulation for the benefit of hydro production at their Waterloo and Seneca Falls plants (on the Seneca River downstream of Seneca Lake). During this period, a rule curve was used which provided an annual range of target levels which varied from a low of 711.0 on February 20 to a peak of 714.2 on May 20. To account for variations in inflows during the spring runoff period a reasonable range of levels on May 1 would be 713.0 to 715.5 with the target being 713.8.

In 1963, NYSEG sold their control rights to Penn Yan Municipality and for the next four years, responsibility for lake regulation rested with the Village Highway Department. Lake level control during this period was generally unsatisfactory.

After 1967, responsibility transferred to the Penn Yan Municipal Water Supply Department. Shortly after that, local officials working in collaboration with the Keuka Lake Shore Property Committee, established a revised rule curve. This curve had an annual range of target levels varying from a low of 712.0 on March 1 to a peak of 714.7 on May 15. These levels were generally about 0.5 to 1 foot higher than the previous NYSEG curve.

In 1977, the rule curve was subject to further adjustment. The main adjustment was for the fall-winter period. After September 1, the lake was lowered as quickly as possible from 714.0 to 713.0. The reason for this was to provide an opportunity for cottagers along the lake to carry out annual maintenance and repairs on their dwellings, grounds, and beaches. After November 1, the lake rule curve was lowered again to a winter target level of 712.0. Prior to the spring runoff, the operators set a target lake level. In a year of heavy snow pack the level was set at 712.0, a light snowpack would warrant early filling. This decision was not formal, but based on experience and judgment. During high flow periods the old gate structures (Andrews and Birkett gates) were opened fully, primarily because of their limited discharge capacity.

3-06 Principle regulation problems.

There have not been any regulation problems to date.

CHAPTER IV: WATERSHED CHARACTERISTICS

4-01 General Characteristics

Keuka Lake has a length of 21 miles and maximum depth of approximately 185 feet. The Keuka Lake drainage area shown on Plate 2, is 183 square miles and the surface area of the lake (at elevation 715.0) is approximately 18.3 square miles. Keuka Outlet drains east from Keuka Lake and discharges into Seneca Lake at Dresden. The average slope of the outlet is 43.8 ft/mi. A USGS stream gaging site (No. 04232482) is located approximately 0.4 miles upstream from Seneca Lake at Dresden. The average discharge at this gage is 196 cfs for 29 years of data. The drainage area at the gage is 207 square miles.

There is a controlled diversion of water from Waneta and Lamoka Lakes (Gage No. 01528700) that have a drainage area of 45.3 square miles (in Chemung river Basin), into Keuka Lake. The long-term average flow at the diversion (from 1966-1974) is 19.9 cfs.

4-02 Topography

Keuka Lake occupies a long narrow basin tending in a north-south direction. The shore of the lake is smooth and regular and has a steep slope.

4-03 Geology and soil

The finger lakes were part of an inland sea during the Paleozoic Age. Upper Devonian sandstones and shales are to be found in the southern portion of the basins, changing to Middle Devonian limestones northward. The most dramatic landform features in the Finger Lakes basins are the results of glacial action, the lakes are rock scoured basins.

In general the northern portions of the basins contain moderately coarse-textured soils with calcareous substrata, giving way southwardly to complex assemblages of more acid, less well-drained types.

4-04 Sediment

This topic is not applicable at this site.

4-05 Climate

The closest first-order weather station for climatological data is at the Rochester-Monroe County Airport near Rochester, NY approximately 45 miles from the control structure. Records have been kept since 1872 for temperature, 1829 for precipitation, and 1941 for snowfall. Temperature and precipitation information reported here include records through the 1981 calendar year. The precipitation gage locations are presented on Figure 4.

A. Temperature - The normal annual temperature is 47.9 °F, with July being the warmest month (71.3 °F) and February the coldest month (24.5°F). The highest recorded temperature was 102 °F in July 1936 and the lowest was -22 °F in February 1934.

B. Precipitation - The 40-year normal annual precipitation is 32.67 inches, with monthly averages ranging from 2.39 inches (water equivalent) in February to 3.09 inches in June. The maximum monthly recorded precipitation is 9.70 inches and the minimum monthly recorded precipitation is 0.22 inches. The maximum 24-hour value is 3.85 inches. The normal annual snowfall is 89.1 inches with the maximum monthly average occurring in January (22.8 inches). The maximum monthly snowfall is 64.8 inches.

C. Snow Evaporation - Evapotranspiration losses average about 20 inches per year throughout the Oswego River Basin.

D. Wind - No information available on wind at this site.

4-06 Storms and floods

The majority of high lake levels in the Keuka Lake Basin occur during the spring months. For Keuka Lake 48 of the 64 annual peaks occurred in the months of March, April, or May. The flood damage threshold above which significant damages occur is at elevation 715.0 feet NGVD. This is the lake level at which nominal amounts of flood damages begin.

In the 64 years of record, 46 events have exceeded the flood damage stage of 715 feet NGVD, 18 events have exceeded elevation 716.00 feet NGVD, and three events have exceeded elevation 718.00 feet NGVD. The three events that exceeded elevation 718.00 feet NGVD occurred in water years 1935, 1936, 1972. Tropical storm Agnes (June 1972) was the largest recorded event on Keuka Lake and reached an elevation of 719.3 feet.

Keuka Lake has a long history of flooding. Inadequate gate capacity prevented winter drawdown to provide increased storage for the spring runoff. Tropical Storm Agnes, which hit the basin in June 1972, left approximately $1.2 million worth of damages in the Keuka Lake watershed (1972 dollars).

Floods of the same or larger magnitude as previous floods are possible. Proportionally, larger floods have been experienced in areas with characteristics similar to those found in the Keuka Lake watershed area. Combinations of rainfall and runoff that have occurred in those areas are possible in the Keuka Lake watershed.

4-07 Runoff characteristics

The runoff from the watershed is passed directly to the lake by overland flow from the steep valley slopes and by many small tributaries. The largest tributary to Keuka Lake is Sugar Creek with a drainage area of 36.2 square miles. Other tributaries to Keuka Lake include Keuka Inlet (25.0 square miles), Waneta Lake Outlet (3.2 square miles), and other minor tributaries.

4-08 Water Quality

The New York State Department of Environmental Conservation (NYSDEC) classification for Keuka Lake is AA. This means that the lake waters are suitable for drinking water, culinary or food processing purposes, or any other use. Keuka Outlet is classified as C and C(t) from the lake downstream to Seneca Lake. Class C is suitable for fishing and other uses except as a source of potable water, and for primary contact recreation. Sub-classification (t) recognizes that the outlet waters are suitable for trout survival and spawning. The Keuka Inlet has a classification of B where it empties into Keuka Lake. Class B is suitable for primary contact, drinking, culinary, or food processing purposes.

4-09 Channel and floodway characteristics

Keuka Lake Outlet flows from the lake at Penn Yan, 7.7 miles to Seneca Lake at Dresden. The channel has a relatively steep bank and mild channel slope the first 1,100 feet downstream from the dam. The channel has a capacity of 1000 cfs. From there, the river drops 270 feet to Seneca Lake . There are several drops along the river where critical flow occurs. These sites were old mills that, although currently not in use, act as a control to flow. Some of these sites have been partially removed.

4-10 Upstream structures

The outlet from Keuka Lake flows through a marsh area and through the Village of Penn Yan. The outlet control structure stands approximately one mile downstream from the lake. An abandoned railroad trestle stands just upstream of the structure.

4-11 Downstream structures

The control structure is at the Main Street Bridge. The Main Street Bridge is an old multiple arch masonry structure built about 1880 and refurbished several times. An abandoned railroad trestle stands just downstream of the structure. There are several old mills downstream of the control structure including Cascade Mills (River Mile 2.7), Mays Mills (River Mile 3.2), Seneca Mills (River Mile 3.9), Milo Mills (River Mile 5.0), and Keuka Mills (River Mile 5.8).

4-12 Economic data

a. Population

In 1980, the resident population for the townships which perimeter the lake was 22, 897. Moderate growth is expected. Area population expands during the summer months. In 1980 the population of the Village of Penn Yan was 4,779.

b. Agriculture

Agriculture is a vital economic activity in Yates and Steuben County where one out of four acres is harvested cropland. Grapes are the major products produced along with wheat, corn, beans, and tomatoes.

c. Industry

Manufacturing is a significant sector in the economic activity of Yates county. The resulting products of the manufacturing sector are men's apparel, food products, fruit juice concentrates, and pleasure boats.

Steuben county is the regional center for the wine industry. The Taylor Wine Company Inc., is a major employer along with several smaller wineries. Most of the wineries are near Hammondsport at the southern end of Keuka Lake. In addition the other major employers are Corning Community College, Corning Glass Works, Ingersoll-Rand Company, and Mercury Aircraft, Inc.

d. Flood Damages

Flood losses around Keuka Lake include damages to residential and commercial structures and their contents, damages to docking facilities, and related cleanup costs. Agricultural damages are negligible in the floodplain. The average annual flood damages are $160,050 computed in March 1996 price levels.

CHAPTER V: DATA COLLECTION AND COMMUNICATION NETWORKS

5-01 Hydrometeorological stations

a. Facilities

Discharges from Keuka Lake are measured at a gage located at Dresden, NY (Gage No. 04232482). The gage is located on the right embankment upstream of the Milo Street bridge, that is 0.4 miles upstream from Seneca Lake, and approximately 6.1 miles downstream from the Keuka Lake control structure. The drainage area at the gage measures 207 square miles versus 182 square miles for Keuka Lake at its mouth. Diversions from Waneta and Lamoka Lake into Keuka Lake are measured at the entrance to the diversion canal. (Gage No. 01528700). Records at Keuka Lake Outlet gage have been kept since April 1965. The average discharge for 29 years of record is 196 ft^3/sec (through water year 1994). The maximum daily discharge was 4,000 ft^3/sec on 22 June 1972 and the minimum daily discharge was 11 ft^3/sec on 27 June 1980.

The average discharge for the diversions from Lamoka and Waneta lakes (Gage No. 01528700) over 28 years of record (up to WY 1994) is 19.9 ft^3/sec. The maximum discharge recorded was 73 ft^3/sec on 23 June 1972, and there is no flow for many days during the year.

Keuka Lake water surface elevations are measured by a gage on the left bank of Keuka Inlet, 300 feet upstream from Keuka Lake at Hammondsport, NY (Gage No. 04232450). Records have been kept at this gage since August 1960. The maximum elevation of record was 719.35 feet NGVD on 24 June 1972, and the minimum daily elevation was 711.40 feet NGVD on 2 and 3 February 1961.

b. Reporting

A gage at the Village of Penn Yan Water Treatment Plant on West Lake Road monitors lake level. The lake level is monitored daily (hourly, if required) by the water plant operator. Recorded lake levels are phoned into the Municipal Office. The Manager has a daily log of all lake levels. The Manager records the lake levels on the target curve and adjusts the gate structures as required. The gate operator records all gate adjustments in the log book.

c. Maintenance

The United States Geological Survey (USGS) maintains the gages on Keuka Lake and Keuka Lake Outlet.

5-02 Water quality stations

There are no water quality stations in this reservoir.

5-03 Sediment stations

There are no sediment stations in this reservoir.

5-04 Recording Hydrologic Data

This topic is not applicable at this site.

5-05 Communication Network

There is no communication network at this project.

5-06 Communication with the project

This project is not manned, and there is no direct communication with the project.

a. Regulating Office with Project Office

This topic is not applicable at this site.

b. Between Project Office and Others

Interested parties can call the Penn Yan Municipal Utilities Office during normal working hours ((315) 536-3374) to obtain the lake level.

It will be the responsibility of the Manager to assure harmony with other agencies concerning gate regulation. The Manager should communicate with those agencies during periods of high water in Keuka Lake, Seneca Lake, or Seneca River and downstream. It will be necessary for the Manager to talk with those agencies to limit or prevent any unnecessary or avoidable damage downstream.

5-07 Project Reporting Instructions

The project operators report any conditions affecting downstream areas to the New York State Thruway Authority and the Seneca Lake Pure Waters Association.

5-08 Warning

In case of a flood emergency, the Manger of the gates will contact local and downstream agencies to assure that safety and property damages are high priority until the flood emergency has subsided:

Yates County Sheriff Dept.	(315) 536-4438
John Zmarthie, NYS Thruway Authority Keuka Lake Outlet Compact, Chairman Seneca Lake Pure Waters Assoc.	(315) 437-2741

Local Media:

Radio: WYLF	536-0850
Newspaper: Chronicle Express	536-4422

CHAPTER VI: HYDROLOGIC FORECAST

6-01 General

There are no hydrologic forecasts for this project.

a. Role of Corps

The Corps of Engineers does not provide any hydrologic forecasts at this project.

b. Role of Other Agencies

Other agencies do not provide any hydrologic forecasts at this site, except the general flood warning systems of the National Weather Service.

6-02 Flood Condition Forecasts

There are no flood condition forecasts at this site.

a. Requirements

This topic is not applicable at this site.

b. Methods

This topic is not applicable at this site.

6-03 Conservation Purpose Forecasts

There are no conservation purpose forecasts at this site.

a. Requirements

This topic is not applicable at this site.

b. Methods

This topic is not applicable at this site.

6-04 Long range forecasts

There are no long range forecasts done at this site.

a. Requirements

This topic is not applicable at this site.

b. Methods

This topic is not applicable at this site.

6-05 Drought Forecast

There is no drought forecast done at this site.

a. Requirements

This topic is not applicable at this site.

b. Methods

This topic is not applicable at this site.

c. Reference Documents

This topic is not applicable at this site.

CHAPTER VII: WATER CONTROL PLAN

7-01 General objectives

Keuka Lake is operated to control flooding on the lake perimeter, downstream reaches, and to maintain a summer pool level. The operation of the Keuka Lake control structure will be different from the operation of a typical flood control reservoir. The control structure is operated to control flooding around the perimeter of Keuka Lake, upstream of the structure, unlike a typical flood control reservoir which controls downstream flooding.

7-02 Constraints

The first priority of reservoir operation is to keep the reservoir near the top of the conservation level (See Plate 5). The volume of storage represented by the zone between conservation zone and the flood control zone is the flood storage area. Inflows greater than the release capacity of the control structure or the outlet capacity can be stored safely without creating flood damages below the top of flood control (715 NGVD).

The Municipal board of the Village of Penn Yan requires a release of approximately 13 mgd (20 cfs) at the control structure. This is to maintain sufficient assimilative capacity for waste dilution in Keuka Outlet. This condition is specified in the city sewage treatment plant's effluent discharge permit. There is generally no problem meeting this requirement. The Village of Penn Yan usually manipulates the Andrews Gate to maintain the low flow requirement.

The physical constraints of the outlet structure determine the top of the inactive zone. The sill level of the Birkett gate is at elevation 709.0 feet NGVD. The sill level of the Andrew gates is at elevation 709.10 feet NGVD. Thus the top of the inactive zone would be at elevation 709.0 feet NGVD. (See Plate 5)

The top of the flood control zone is set at elevation 715 feet NGVD. This is the elevation on Keuka Lake at which flooding begins. (See Plate 5)

The top of the conservation zone varies by month throughout the year. The requirements of flood control, recreation, fish and wildlife, hydropower, and water supply create the constraints imposed on this level. The top of the conservation zone has to be below the elevation where flooding begins (elevation 715.15 feet NGVD). At least a 1/2 foot flood storage area between the top of conservation and the top of the flood control zone is desired. In addition, during the winter months, lake levels should be kept as low as possible to accept the spring runoff without causing flooding.

During the boating season a lake level of 714.7 feet NGVD will satisfy the needs of recreational boaters. The operational ranges of lake levels are well within the range of lake levels required for environmental considerations. Any operating policy carried out will satisfy environmental concerns.

7-03 <u>Overall plan for water control</u>

The Keuka Lake outlet structure operates to control flooding on the lake perimeter and to some extent on Keuka Outlet. In the operation of the control structure at Penn Yan, consideration is given to downstream flooding during high flow periods. However, downstream flood damage is quite small in relation to the flood damage potential around Keuka Lake. There is a small tributary which may impact downstream flooding during significant rainfall events located about 1/4 of a mile downstream of Cascade Mill, the tributary is located approximately at river mile 2.45. The dam operator should check this tributary during heavy precipitation. If the flow in the tributary is heavy, the operator should commence further checking for downstream flooding. The gate settings should be adjusted to minimize downstream flooding. This tributary and the associated check point are presented on Plate 6. After topping the conservation zone, the policy will be to make releases up to channel capacity (about 1,000 cfs) or the outlet control structure's capacity, whichever is less. This release policy would be followed up to the elevation 716.0 feet NGVD. Once 716.0 feet NGVD is exceeded, the release policy will be to maintain an outflow of 1000 cfs by gradually closing gates, the gates should be fully closed at elevation 718.0 NGVD (See section 7-04 for gate settings).

The lake level is the primary indicator for operating the structure. If the level is above the target, gates must be opened to reduce or reverse the rise. If the level is below the target, gates must be closed (if they are not already all closed) to let the natural inflow raise the lake level. The effectiveness of a particular operation procedure depends on the uncontrolled (natural) rate of inflow to the lake and on the structure's outflow capacity. Note that there is a difference in elevation between the lake and the control structure. Also there is a difference in readings taken at Penn Yan municipal and the USGS gage No. 0432450 at Hammondsport. Historical data indicates a discrepancy in readings during higher flows, Plate 17presents data taken during a high flow event in 1993 this data illustrates the discrepancy between gages. All elevations sited in this water control plan are lake elevations indexed to the USGS gage.

Overcompensating (opening too many gates) for a rise in level could result in unwanted evacuation of water, and a drop in levels below the target. If the natural inflow then dropped off, it might be difficult to restore the target level. If too few gates were opened, the lake might continue to rise above the target to damaging elevations.

Large changes in gate settings (either opening or closing) may also result in a need for frequent adjustment because of too-rapid fluctuations in level. The procedures described in paragraph 7-04 should adequately respond to lake level changes without requiring unreasonable frequency of gate manipulations.

Use the Birkett Gate only in emergencies because of its ratchet wheel operation.

described in paragraph 7-04 should adequately respond to lake level changes without requiring unreasonable frequency of gate manipulations.

Use the Birkett Gate only in emergencies because of its ratchet wheel operation.

The early summer target level for Keuka Lake is 714.5 feet NGVD on April 30. The lake is then drawn down progressively during the summer months to 713.7 feet NGVD on August 31. Maintaining the 20 cfs low flow requirement and normal evaporation losses during the summer months usually produces the fall target level. During fall, the lake is brought down quickly to 712.0 by November 30. The winter level is held until the end of February. The end of February lake level is 712.0 feet NGVD. Filling then begins on March 1 to reach the summer target level of 714.5 NGVD by April 30.

7-04 Standing instructions to damtender

These instructions assume a downstream channel capacity of 1,000 cfs, and a downstream low flow requirement of 20 cfs.

The time of the year (Target Rule Curve as shown on Table 1 and Plate 5) and the levels of Keuka Lake determine the gate settings.

The two elevations used in deciding gate settings are the conservation lake elevations as determined from Table 1 and elevation 714.5 feet (NGVD).

Conservation Level < 714.5 FT.-NGVD

When the Conservation Level of Keuka Lake is less than 714.5 FT.-NGVD but greater than or equal to 712 FT.-NGVD and the Keuka Lake level is above the Conservation Level as determined by Table 1: Conservation Lake Level by Day of the Year, pg. 7-4; open ALL 6 Gates Fully as indicated in Table 2a (i.e. 3 New Center Gates, 2 Andrews Race Gates and 1 Birkett Gate).

* If Keuka Lake rises above 714.5 FT.-NGVD, follow the operating plan for Keuka Lake Level > 714.5 FT.-NGVD (Flood Control Operation) in Table 2c.

(**Special Note** : If the Keuka Lake level is below the Conservation Level as determined by Table 1: Conservation Lake Level by Day of the Year, pg. 7-4, use the gate operations from Table 2b - Gate Operation if Conservation Level is 714.5 FT.-NGVD.)

Conservation Level is 714.5 FT.-NGVD

When the Conservation Level of Keuka Lake is 714.5 FT.-NGVD, the intent is to release a minimum of 20 cfs downstream. Therefore follow the operation of gates as stated in Table 2b, for the various range of Keuka Lake elevations. During this operation, only the 3 New Center Gates and the 2 Andrews Race Gates will be used.

* Note: The historical minimum for Keuka Lake is 711.40 FT.-NGVD for a period of record from 1960 to the present.

** If Keuka Lake rises above 714.5 FT.-NGVD, follow the operating plan for Keuka Lake Level > 714.5 FT.-NGVD (Flood Control Operation) in Table 2c.

Keuka Lake Level > 714.5 FT.-NGVD: (Flood Control Operation)

When the Level of Keuka Lake is greater than 714.5 FT.-NGVD open all 6 gates fully (i.e. 3 New Center Gates, 2 Andrews Gates, and 1 Birkett Gate) until the level reaches 716.0 FT.-NGVD. Then proceed to close the 3 New Center gates, as indicated in Table 2c, while keeping the 2 Andrews Gates and 1 Birkett Gate fully open to maintain a maximum of 1000 CFS. When all 3 New Center Gates are closed completely, while both Andrews Gates and Birkett Gate remain fully open, the pre-construction rating curve will be achieved. This operating plan is for both rising and receding Keuka Lake Levels above 714.5 FT.-NGVD.

* When Keuka Lake reaches 718.0 FT.-NGVD, all 3 Center Gates should be closed while 2 Andrews Gates and 1 Birkett Gate remain fully open. This operation should continue for Keuka Lake > 718.0 FT.-NGVD.

Lake level measurements should be made on a daily basis, during times of heavy runoff from snowmelt or rain they should be taken at least twice a day.

Note: The elevation of Keuka Outlet at the control structure is not necessarily the same as the surface elevation of the lake. All water surface elevations used in this water control manual are measured at the lake.

TABLE 1: CONSERVATION LAKE LEVEL BY DAY OF THE YEAR

	MONTH											
DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	712.0	712.0	712.0	713.3	714.5	714.5	714.5	714.0	713.7	713.0	713.0	712.0
2	712.0	712.0	712.0	713.3	714.5	714.5	714.5	714.0	713.7	713.0	713.0	712.0
3	712.0	712.0	712.1	713.4	714.5	714.5	714.5	714.0	713.7	713.0	712.9	712.0
4	712.0	712.0	712.1	713.4	714.5	714.5	714.5	714.0	713.6	713.0	712.9	712.0
5	712.0	712.0	712.2	713.5	714.5	714.5	714.4	714.0	713.6	713.0	712.9	712.0
6	712.0	712.0	712.2	713.5	714.5	714.5	714.4	714.0	713.6	713.0	712.8	712.0
7	712.0	712.0	712.3	713.5	714.5	714.5	714.4	713.9	713.6	713.0	712.8	712.0
8	712.0	712.0	712.3	713.6	714.5	714.5	714.4	713.9	713.5	713.0	712.8	712.0
9	712.0	712.0	712.3	713.6	714.5	714.5	714.4	713.9	713.5	713.0	712.7	712.0
10	712.0	712.0	712.4	713.7	714.5	714.5	714.4	713.9	713.5	713.0	712.7	712.0
11	712.0	712.0	712.4	713.7	714.5	714.5	714.4	713.9	713.5	713.0	712.7	712.0
12	712.0	712.0	712.5	713.7	714.5	714.5	714.3	713.9	713.4	713.0	712.6	712.0
13	712.0	712.0	712.5	713.8	714.5	714.5	714.3	713.9	713.4	713.0	712.6	712.0
14	712.0	712.0	712.5	713.8	714.5	714.5	714.3	713.9	713.4	713.0	712.6	712.0
15	712.0	712.0	712.6	713.9	714.5	714.5	714.3	713.9	713.4	713.0	712.5	712.0
16	712.0	712.0	712.6	713.9	714.5	714.5	714.3	713.9	713.4	713.0	712.5	712.0
17	712.0	712.0	712.7	713.9	714.5	714.5	714.3	713.8	713.3	713.0	712.5	712.0
18	712.0	712.0	712.7	714.0	714.5	714.5	714.2	713.8	713.3	713.0	712.4	712.0
19	712.0	712.0	712.8	714.0	714.5	714.5	714.2	713.8	713.3	713.0	712.4	712.0
20	712.0	712.0	712.8	714.1	714.5	714.5	714.2	713.8	713.3	713.0	712.4	712.0
21	712.0	712.0	712.8	714.1	714.5	714.5	714.2	713.8	713.2	713.0	712.3	712.0
22	712.0	712.0	712.9	714.1	714.5	714.5	714.2	713.8	713.2	713.0	712.3	712.0
23	712.0	712.0	712.9	714.2	714.5	714.5	714.2	713.8	713.2	713.0	712.3	712.0
24	712.0	712.0	713.0	714.2	714.5	714.5	714.1	713.8	713.2	713.0	712.2	712.0
25	712.0	712.0	713.0	714.3	714.5	714.5	714.1	713.8	713.1	713.0	712.2	712.0
26	712.0	712.0	713.0	714.3	714.5	714.5	714.1	713.8	713.1	713.0	712.2	712.0
27	712.0	712.0	713.1	714.3	714.5	714.5	714.1	713.7	713.1	713.0	712.1	712.0
28	712.0	712.0	713.1	714.4	714.5	714.5	714.1	713.7	713.1	713.0	712.1	712.0
29	712.0	712.0	713.2	714.4	714.5	714.5	714.1	713.7	713.0	713.0	712.1	712.0
30	712.0		713.2	714.5	714.5	714.5	714.0	713.7	713.0	713.0	712.0	712.0
31	712.0		713.3		714.5		714.0	713.7		713.0		712.0

7-05 Flood control

***** **NOTE: Operator MUST first Refer to Page 7-5 and 7-6 to properly use these tables.** *****

Table 2a - Gate Operation if Conservation Level < 714.5 FT.-NGVD

Elev. @ Keuka Lake (FT.-NGVD)	Gate(s) Operation
712 to ≤ 714.5*	Open ALL 6 Gates Fully.

Table 2b - Gate Operation if Conservation Level is 714.5 FT.-NGVD

>709.0* to 709.7*	Open all 5 Gates.
>709.7* to ≤ 709.9*	2 Andrews Gates Open 0.5 FT each and 2 Center New Gates Open 0.5 FT each.
>709.9* to ≤ 710.2*	2 Andrews Gates Open 0.5 FT each and 1 Center New Gate Open 0.5 FT.
>710.2* to ≤ 710.8*	2 Andrews Gates Open 0.5 FT each.
>710.8* to ≤ 711.1*	1 Andrews Gate Open 0.8 FT.
>711.1* to ≤ 711.6	1 Andrews Gate Open 0.7 FT.
>711.6 to ≤ 712.5	1 Andrews Gate Open 0.6 FT.
>712.5 to ≤ 714.3	1 Andrews Gate Open 0.5 FT.
>714.3 to ≤ 714.5**	1 Andrews Gate Open 0.4 FT.

Table 2c - Gate Operation if Keuka Lake Level > 714.5 FT.-NGVD (Flood Control Operation)

>714.5 to 716.0	Open ALL 6 Gates Fully.
>716.0 to ≤ 716.3	1 Birkett and 2 Andrews Gates Opened Fully 2 Center Gates Opened Fully 1 Center Gate Opened 2 FT
>716.3 to ≤ 716.6	1 Birkett and 2 Andrews Gates Opened Fully 1 Center Gate Opened Fully 1 Center Gate Opened 5.3 FT 1 Center Gate Opened 2 FT
>716.6 to ≤ 717.0	1 Birkett and 2 Andrews Gates Opened Fully 1 Center Gate Opened Fully 1 Center Gate Opened 2.9 FT **Close 1 Center Gate**
>717.0 to ≤ 717.4	1 Birkett and 2 Andrews Gates Opened Fully 1 Center Gate Opened 4.7 FT 1 Center Gate Opened 2.9 FT **Close 1 Center Gate**
>717.4 to ≤ 717.9	1 Birkett and 2 Andrews Gates Opened Fully 1 Center Gate Opened 3.5 FT **Close 2 Center Gates**
>717.9 to ≤ 718.0	1 Birkett and 2 Andrews Gates Opened Fully 1 Center Gate Opened 2 FT **Close 2 Center Gates**
>718.0*	1 Birkett and 2 Andrews Gates Opened Fully **Close 3 Center Gates**

Also see Plate 10 - Rating Curve for Keuka Lake

7-06 Recreation

Keuka Lake supports many water oriented recreational activities including swimming, boating, water skiing, and fishing. Many private and commercial developments perimeter the Lake and most have their own docking facilities. There are approximately 2,620 docks around the Lake. Most recreational boating on Keuka Lake takes place from May to October.

Keuka Lake has nine commercial marinas, one public marina, and a private yacht club. Launches are available at all but one commercial facility. Two public launch ramps and five launch lanes are available. About 88 percent of the 210 pier moorings available are found at commercial marinas.

There are four public beaches (Champlin, Indian Pines, Keuka Lake State park, and Red Jacket) on Keuka Lake.

There are no special releases for recreational activities at the present time, however the town of Pen Yan is currently researching the possibility of special releases for canoeing.

7-07 Water quality

The Municipal board of the Village of Penn Yan requires a flow in the outlet of at least 13 mgd (20 cfs) to maintain sufficient assimilative capacity for waste dilution. This condition is specified in the city sewage treatment plant's effluent discharge permit. There is generally no problem meeting this requirement.

7-08 Fish and wildlife

The main lake level consideration for fish and wildlife is not to expose the productive littoral zone. The steep-sided nature of the shoreline limits the extent of the littoral zone, and lake conditions favor a coldwater fishery. However, a warmwater fishery also exists in the lake with small mouth bass being the most important warm water game species. The NYSDEC lists lake trout as the most dominant and important fish in Keuka Lake. Lake Trout have had a self-sustaining natural population for the last 50 years. Bath Hatchery stocks Brown Trout. Rainbow trout are present in limited numbers, due to the unavailability of rearing areas in the tributaries. An exception is Cold Brook, which drains into the south end of the lake and provides excellent habitat for production and rearing of rainbow trout. Weedy areas at the north and south end of the lake provide a good habitat for rearing large mouth bass and chain pickerel. Landlocked salmon were introduced to the lake in 1976, but are currently uncommon.

When developing lake level regulation plans for Keuka Lake, special consideration must be given to the lake trout. Currently, lake trout spawn on the submerged rocky shoal areas off the Bluffs (lake area directly south of the junction of two forks of the lake). This species spawns in November and December in water that is usually three to six meters in depth. These are the only known areas where natural lake trout reproduction takes place. Currently there is a limited smelt fishery in the Hammondsport area at the southern end of the lake.

7-09 Water supply

Keuka Lake satisfies the municipal and industrial water supply needs for the villages of Penn Yan and Hammondsport, Keuka College, and the Country Club. The current average withdrawal rate is approximately 0.9 mgd (1.4 cfs), with most of the return flow going into Keuka Outlet, downstream of the control structure. This usage should increase in proportion to the minimal expected population growth.

Water supply usage causes a drop in lake level of 0.09 inches over one month (neglecting any inflows or outflows during that period). Note that this is not a cumulative process. This is a negligible effect and should remain that way. The population would have to increase substantially before there would be a significant effect on lake levels.

Private water intakes around the lake should be considered when manipulating the lake level. For many families living year-round along the lake, these are the sole source of water. Lake elevations below 712 feet (NGVD), and the right snow and temperature conditions, could freeze some of these water lines.

7-10 Hydroelectric power

Keuka Lake has played a significant role in the development of the area because of the excellent mill sites available. Between 1790 and 1860, 32 to 40 mills operated along the 7.5 mile outlet which drops approximately 270 feet between Keuka Lake and Seneca Lake. With industrialization and time, the mills were abandoned or burned and not rebuilt. The last to close was Milo Mills in 1962.

The Village of Penn Yan was issued a preliminary permit, Project Number 8599-000, on 14 September 1984, for the development of the retired New York State Electric and Gas (NYSE&G) Seneca Mills site. Subsequently, the permit to the village has been dismissed for failure to substantiate its proposal. A competing development permit was issued to upstate Hydro Associates, Project Number 9273-000 for development of the same site.

7-11 Navigation

There is not any commercial navigation on Keuka Lake and the lake outflows do not significantly affect levels elsewhere in the system. This conservation need does not impose constraints on the lake management plan.

7-12 Drought Contingency Plans

There are no drought contingency plans at this site.

7-13 Flood Emergency Action Plans

There are no formal flood emergency action plans at this site. The Village of Penn Yan receives flood emergency guidance from the New York State Thruway Authority. The NYS Thruway Authority has flood emergency action plans which cover the entire Oswego River Basin.

7-14 Other

There are no formal plans for water control for other interests.

7-15 Deviation from Normal Regulation

There is no formal procedure for approval of, and notification of deviations from the normal regulation of the Keuka Lake Outlet structure. The KLOC generally notifies the New York State Thruway Authority and the Seneca Lake Pure Waters Association of water control deviations that may affect downstream conditions. The KLOC should also notify the NYS Department of Environmental Conservation of any significant deviations.

a. Emergencies

The water level in Keuka Lake Outlet may be varied for emergencies such as drowning. There is no formal plan for these deviations; they are done at the operators discretion on a case by case basis.

b. Unplanned Minor Deviations

The water level in Keuka Lake Outlet may be varied for activities such as construction activities, and log jams. There is no formal plan for these deviations; they are performed at the operators discretion on a case by case basis.

c. Planned Deviations

The water level in Keuka Lake Outlet is lowered for inspections and maintenance activities on the control structure. There is no formal plan for these deviations; they are done at the operators discretion on a case by case basis.

7-16 Rate of Release Change

There are no restrictions on the normal allowable rate of increase and decrease in releases.

CHAPTER VIII: EFFECT OF WATER CONTROL PLAN

8-01 General

This control structure provides flood damage reduction and recreational boating benefits. Flood losses around Keuka Lake include damages to residential and commercial structures and their contents, damage to docking facilities, and related cleanup costs. Keuka Lake supports many water-oriented recreational activities including swimming, boating, water skiing, and fishing. The control structure provides benefits for recreational boaters by providing higher water levels in the summer months.

Benefit Category	Average Annual Benefits
Flood Damage	$124,100
Recreational Boating	$12,200
Total	$136,300

March 1996 Price Levels

8-02 Flood control

a. Spillway design flood

The spillway design flood or the Probable Maximum Flood (PMF) is a hypothetical storm based on " the most severe meteorological event reasonably possible in the geographic region involved." The Probable Maximum Storm (PMS) rainfall over the Keuka Lake Watershed is 25.26 inches, with runoff of 22.29 inches. The peak PMF inflow would be 200,000 cfs or 1,000 cfs/sq. mi. The PMF would produce a lake elevation of 734.56 feet NGVD, and a discharge of 13,300 cfs.

b. Standard Project Flood

The Standard Project Flood (SPF) is a hypothetical storm based on "the most severe meteorological conditions considered characteristic of the geographic region involved." An SPF peak inflow can be about 40-60 percent of a PMF. The SPF index is the amount of Standard Project Storm (SPS) rainfall that will fall over a 200-square mile watershed in 24 hours. Using a SPS index of 9.08 inches, the total computed rainfall over the Keuka Lake watershed would be 12.46 inches, with 9.79 inches of runoff. The peak SPF inflow calculated would be 89,000 cfs, or 492 cfs/sq.mi. The SPF would produce a lake elevation of 725.52 feet NGVD and a discharge of 5,500 cfs.

c. Other floods

No other floods were modeled for this project.

8-03 Recreation

Lake management produces recreation benefits. The average annual recreational boating benefits produced are $12,200 which are 9 percent of the total benefits.

8-04 Water Quality

There are no appreciable effects on water quality due to the control structure.

8-05 Fish and wildlife

There are no appreciable effects on fish and wild life due to the control structure.

8-06 Water Supply

There are no appreciable effects on water supply due to the control structure.

8-07 Hydroelectric power

There are no appreciable effects on hydroelectric power due to the control structure.

8-08 Navigation

There are no appreciable effects on navigation due to the control structure.

8-09 Drought Contingency Plans

There are no drought contingency plans associated with this structure.

8-10 Flood Emergency Action Plans

The water control plan does not significantly affect flood emergency action plans at this site.

8-11 Frequencies

a. Peak inflow probability

This information is not available for this site.

b. Pool Elevation Duration and Frequency

A graph of stage-frequency is presented in Plate 9. A graph of pool elevation duration is not available at this site.

TABLE 3: ANNUAL PEAK DISCHARGES
KEUKA LAKE AT DRESDEN (GAGE #04232482)

Water Year	Date	Discharge (cfs)
1966	2-13-1966	640
1967	8-4-1967	620
1968	3-22-1968	850
1969	6-23-1969	1,080
1970	4-02-1970	849
1971	3-15-1971	2,320
1972	6-22-1972	4,000
1973	12-06-1973	2,270
1974	2-22-1974	724
1975	9-26-1975	2,150
1976	3-03-1976	2,360
1977	9-20-1977	2,580
1978	3-21-1978	1,460
1979	9-06-1979	1,550
1980	11-26-1980	2,020
1981	2-11-1981	692
1982	6-06-1982	982
1983	5-11-1983	828
1984	8-11-1984	1,820
1985	2-2-1985	985
1986	7-19-1986	2,600
1987	9-13-1987	2,810
1988	7-27-1988	446
1989	5-11-1989	1,040
1990	2-16-1990	1,360
1991	4-21-1991	1,390
1992	7-31-1992	1,730

Also, see Plate 8. Historical data for the period after 1992 was not added to this table because the flow profile will change due to the federal project therefore these values will not be used to complete the flood frequency analysis.

Table 4: ANNUAL PEAK LAKE ELEVATIONS
KEUKA LAKE AT HAMMONDSPORT (GAGE #04232450)

Water Year	Date	Elevation (Feet-
1931	6-08-1931	715.70
1932	5-12-1932	716.95
1933	5-10-1933	716.00
1934	4-26-1934	714.36
1935	7-08-1935	719.00
1936	3-28-1936	718.35
1937	6-22-1937	716.32
1938	5-24-1938	714.74
1939	4-19-1939	715.75
1940	4-24-1940	715.92
1941	10-01-1941	713.40
1942	4-08-1942	716.05
1943	6-02-1943	717.60
1944	5-24-1944	715.05
1945	5-19-1945	716.68
1946	1-06-1946	715.23
1947	6-06-1947	717.22
1948	5-25-1948	715.78
1949	5-25-1949	713.82
1950	4-06-1950	716.07
1951	4-14-1951	715.72
1952	4-10-1952	716.09
1953	3-25-1953	716.06
1954	5-03-1954	715.67
1955	3-25-1955	715.55
1956	3-13-1956	717.47
1957	4-13-1957	715.61
1958	4-23-1958	715.75
1959	4-09-1959	714.98
1960	5-25-1960	715.50
1961	4-27-1961	715.78
1962	4-16-1962	714.30
1963	4-04-1963	714.67
1964	4-23-1964	715.71
1965	6-10-1965	714.74
1966	5-13-1966	714.91
1967	5-20-1967	715.30

1968	6-28-1968	715.01
1969	5-09-1969	714.91
1970	4-10-1970	714.91
1971	4-14-1971	715.13
1972	6-24-1972	719.30
1973	4-07-1973	715.31
1974	4-17-1974	714.37
1975	9-27-1975	715.4
1976	3-05-1976	716.24
1977	9-26-1977	715.66
1978	4-08-1978	716.25
1979	8-10-1979	715.09
1980	4-15-1980	715.00
1981	5-31-1981	714.68
1982	6-07-1982	715.01
1983	5-03-1983	715.58
1984	5-15-1984	716.21
1985	6-12-1985	714.50
1986	4-21-1986	715.00
1987	4-14-1987	714.92
1988	7-21-1988	714.54
1989	5-17-1989	715.81
1990	5-21-1990	715.16
1991	4-24-1991	714.62
1992	4-01-1992	714.98
1993	4-26-1993	716.97
1994	4-20-1994	715.04
1995	6-26-1995	714.03

Also, see Plate 9, for Stage-Frequency Curve.

c. Key Control Points 1997

There are no key control points downstream. The flood flow frequency curve for the stream gage at Dresden is show on Plate 8 . The annual peak discharges are presented in Table 3 .

8-12 Other studies

a. Examples of Regulation

None.

b. Channel and Floodway Improvement

None.

CHAPTER IX: WATER CONTROL MANAGEMENT

9-01 Responsibilities and Organization

a. Corps of Engineers - None.

b. Other Federal Agencies - None.

c. State and County Agencies

The local cooperative for federal flood control projects in New York State is the Department of Environmental Conservation.

d. Private Organization - None.

9-02 Interagency coordination

a. Local Press and Corps Bulletins - Provide public press releases.

b. National Weather Service - Provide general flood warnings.

c. U.S. Geological Survey - None.

d. Power Marketing Agency - None.

e. Other Federal, State, or Local Agencies - The KLOC coordinates with the New York State Thruway Authority during flood emergencies. The KLOC also coordinates with the Seneca Lake Pure Waters Association on release activities that would affect downstream conditions.

9-03 Interagency agreements

The US Army Corps of Engineers and the New York State Department of Conservation signed a Local Cost Agreement. This agreement said that the local sponsor (NYSDEC) would be solely responsible for operating, repairing, maintaining, replacing, and rehabilitating the project.

9-04 Commissions, river authorities, compacts and committees

The Keuka Lake Outlet Compact (KLOC) regulates Keuka Lake.

9-05 Non-Federal Hydropower

There is no non-Federal hydropower at this site.

9-06 Reports

No reports are necessary for water control management at this site.

PLATES

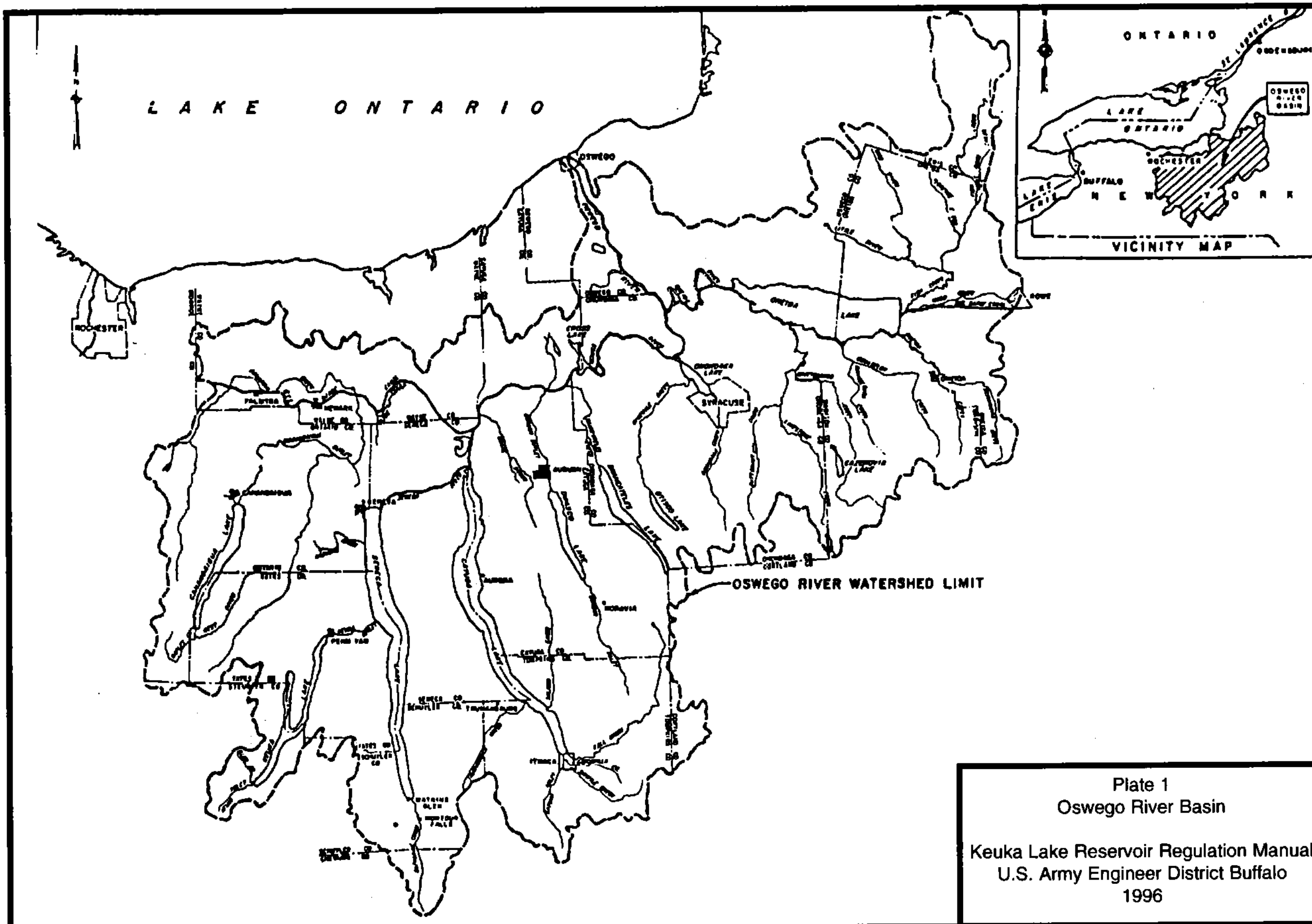


Plate 1
Oswego River Basin

Keuka Lake Reservoir Regulation Manual
U.S. Army Engineer District Buffalo
1996

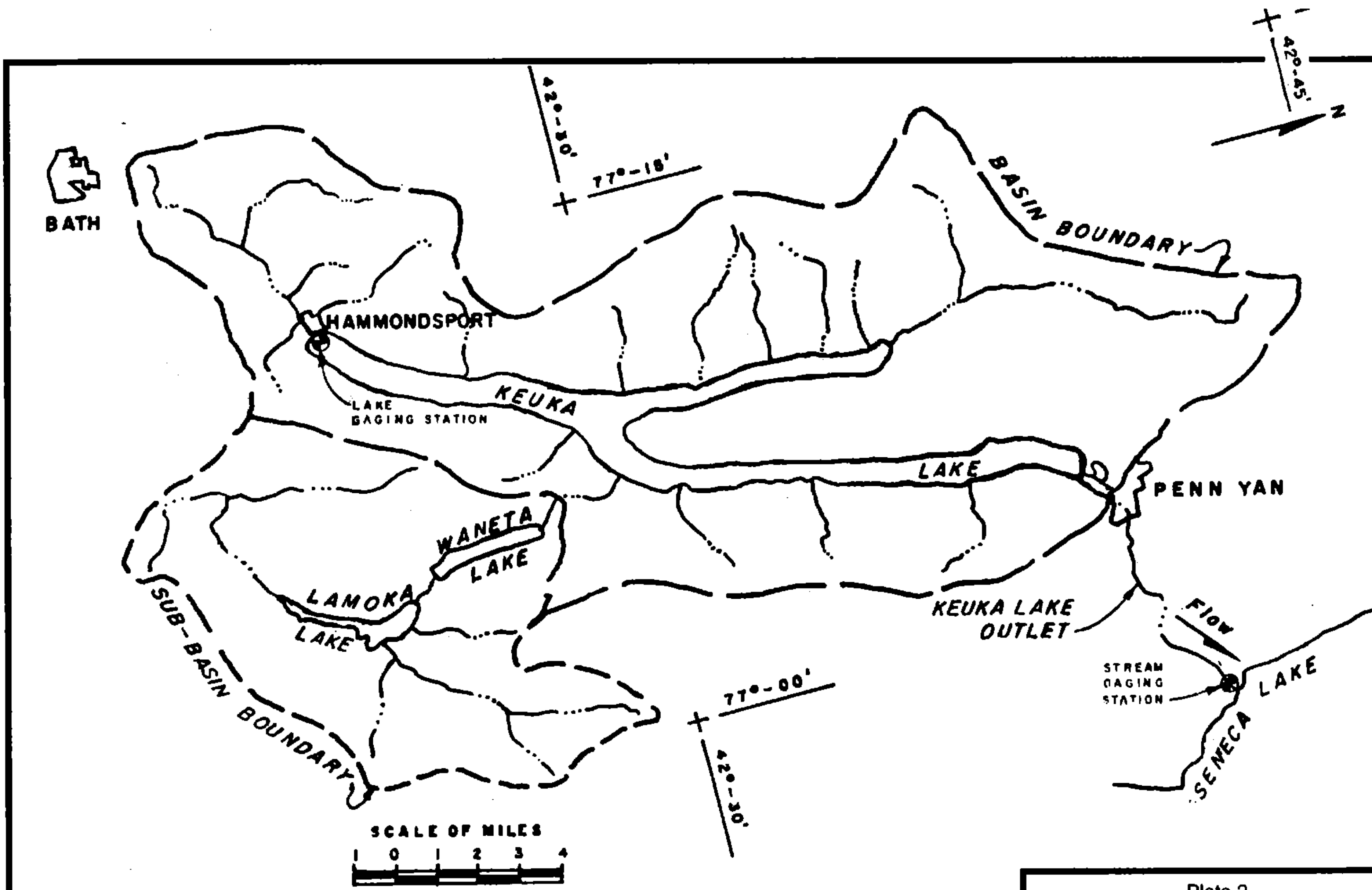


Plate 2
Keuka Lake Watershed

Keuka Lake Reservoir Regulation Manual
U.S. Army Engineer District Buffalo
1996

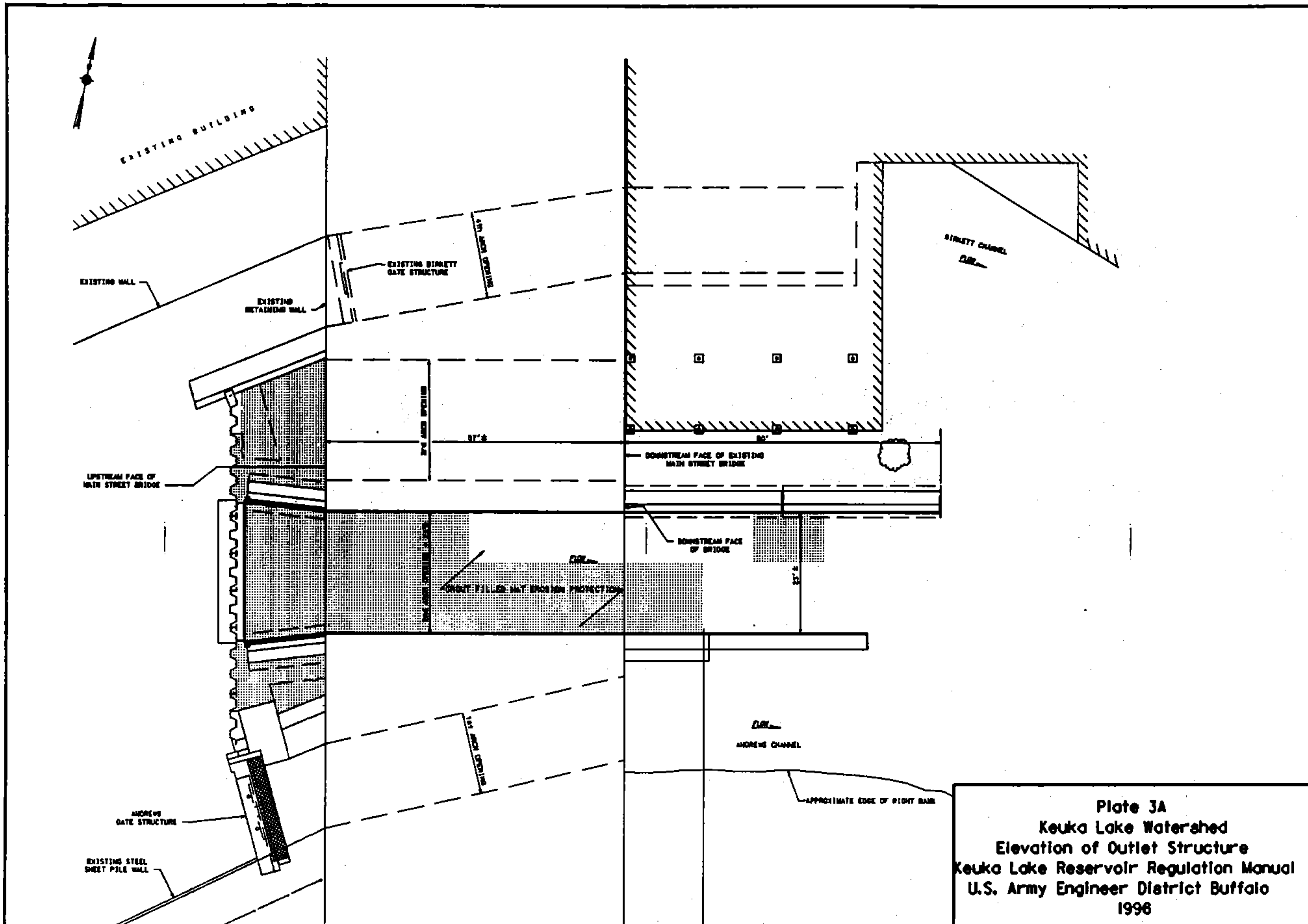
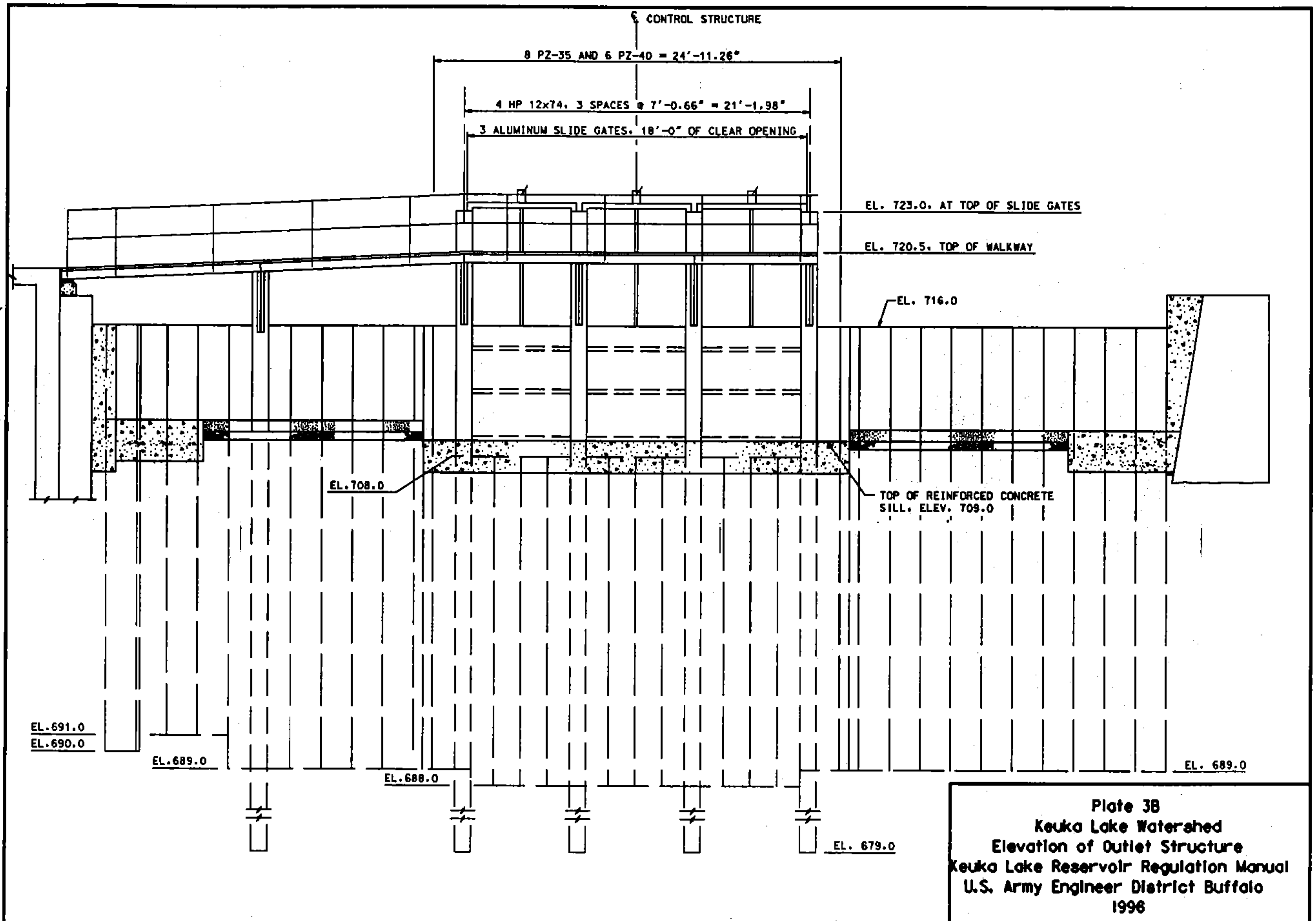


Plate 3A
Keuka Lake Watershed
Elevation of Outlet Structure
Keuka Lake Reservoir Regulation Manual
U.S. Army Engineer District Buffalo
1996



℄ CONTROL STRUCTURE
8 PZ-35 AND 6 PZ-40 = 24'-11.26"
4 HP 12x74, 3 SPACES @ 7'-0.66" = 21'-1.98"
3 ALUMINUM SLIDE GATES, 18'-0" OF CLEAR OPENING
EL. 723.0, AT TOP OF SLIDE GATES
EL. 720.5, TOP OF WALKWAY
EL. 716.0
EL. 708.0
TOP OF REINFORCED CONCRETE SILL, ELEV. 709.0
EL. 691.0
EL. 690.0
EL. 689.0
EL. 688.0
EL. 679.0
EL. 689.0
Plate 3B
Keuka Lake Watershed
Elevation of Outlet Structure
Keuka Lake Reservoir Regulation Manual
U.S. Army Engineer District Buffalo
1996

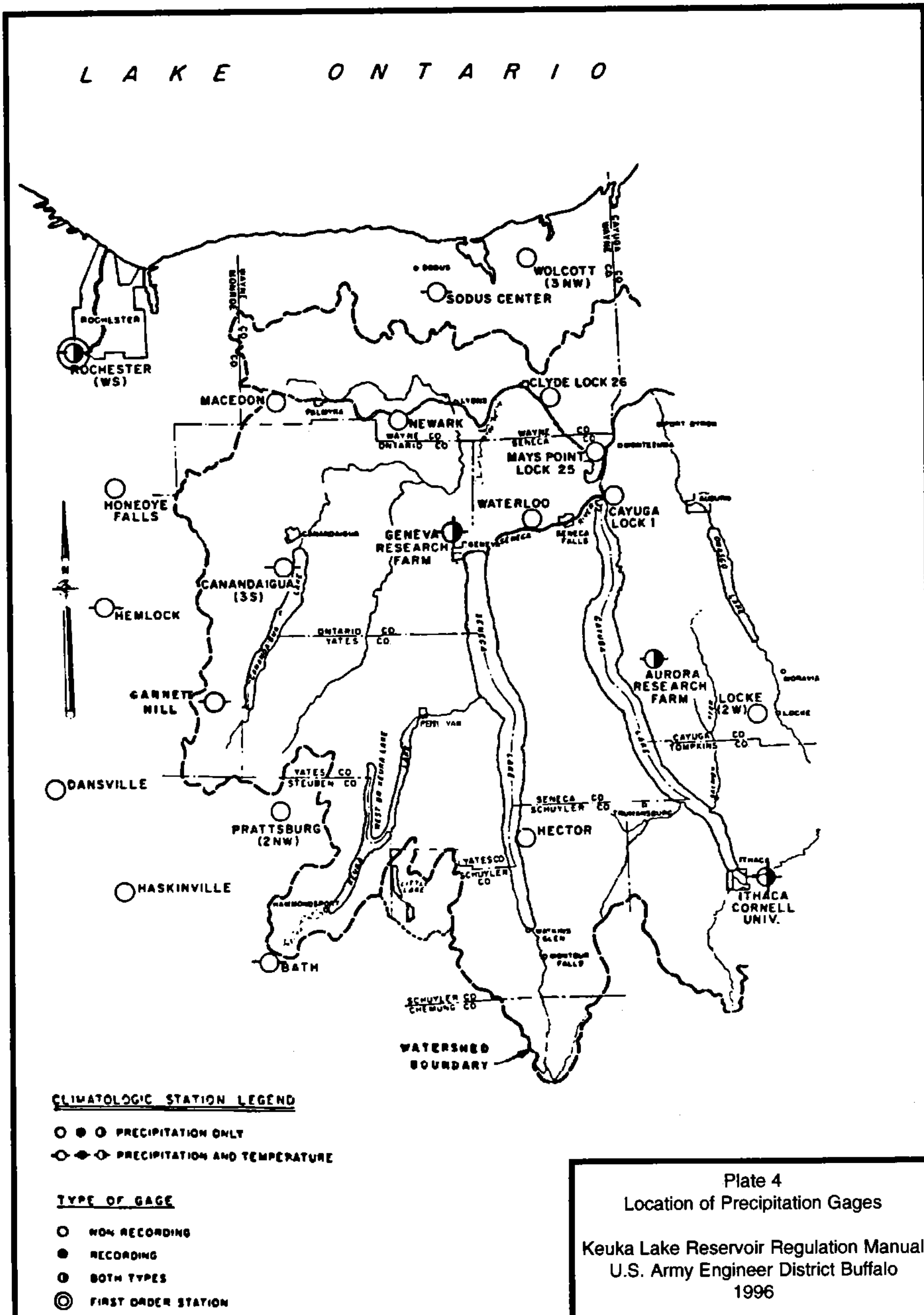


Plate 4
Location of Precipitation Gages

Keuka Lake Reservoir Regulation Manual
U.S. Army Engineer District Buffalo
1996

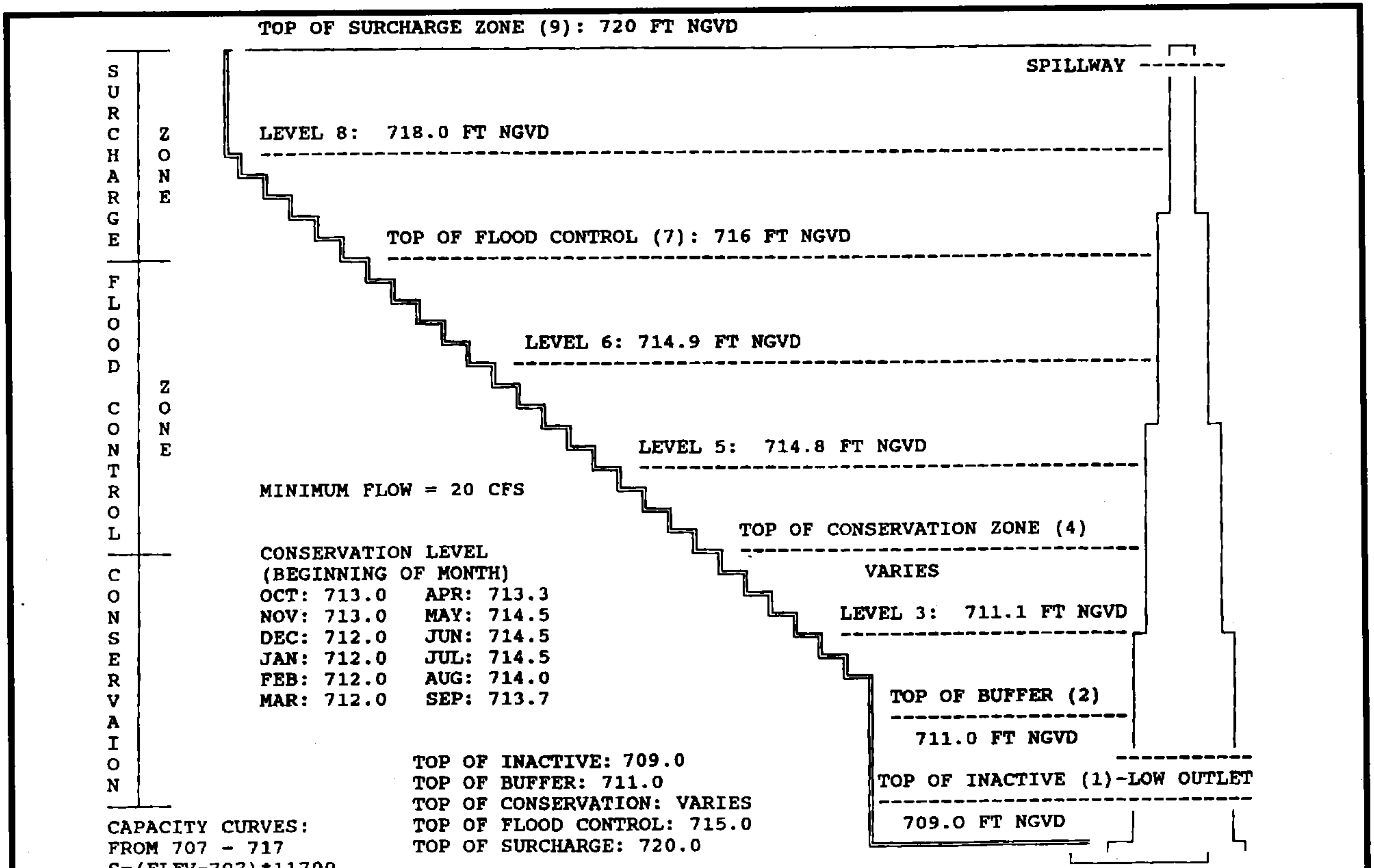


Plate 5
Keuka Lake Basic of Comparison (BOC)

Keuka Lake Reservoir Regulation Manual
U.S. Army Engineer District Buffalo
1996

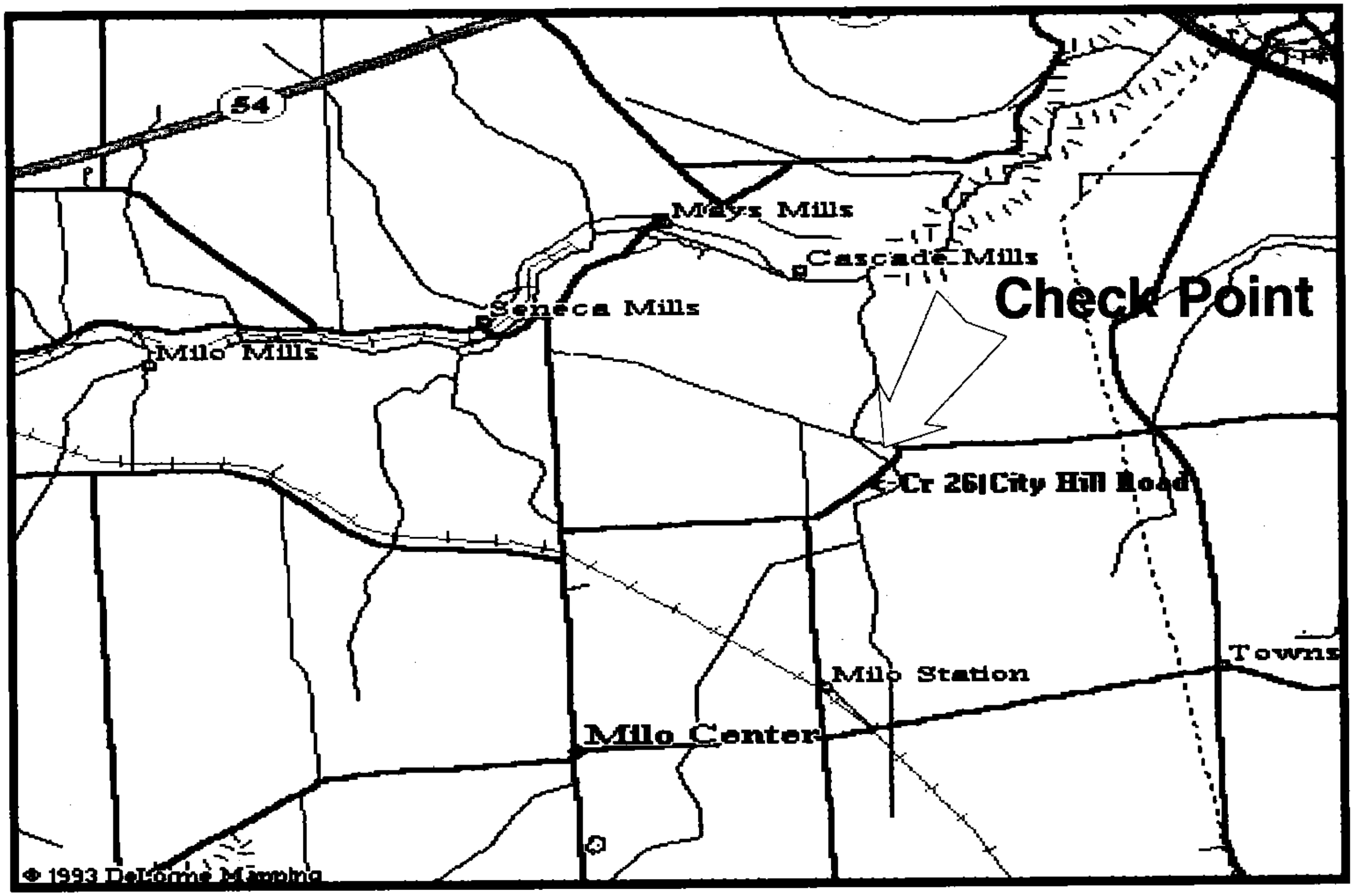


Plate 6
Downstream Tributary Location

Keuka Lake Reservoir Regulation Manual
U.S. Army Corps of Engineer District Buffalo
1996

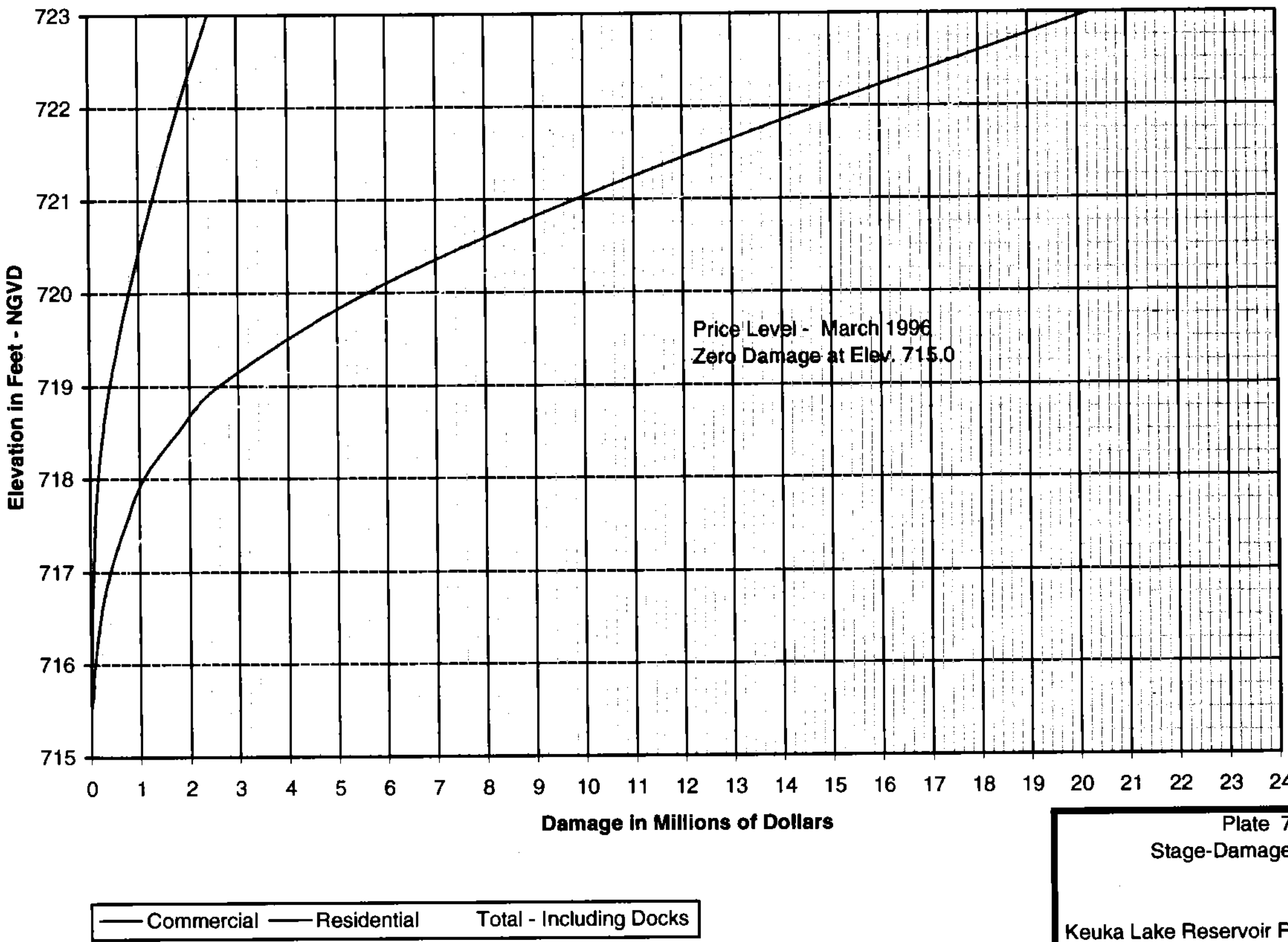


Plate 7
Stage-Damage Curves

Keuka Lake Reservoir Regulation Manual
U.S. Army Engineer District Buffalo
1996

Figure 8: Discharge Frequency Curve

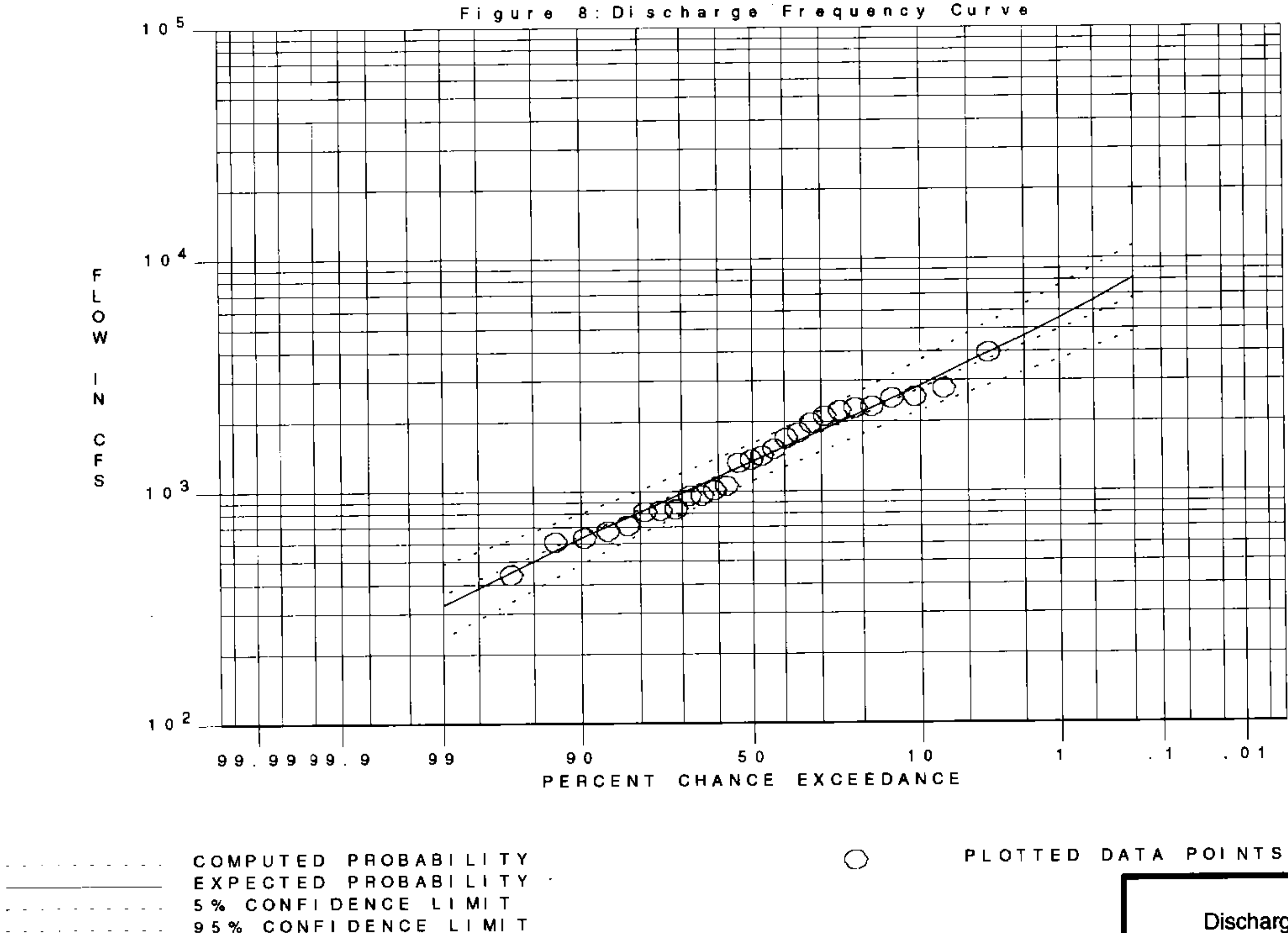


Plate 8
Discharge Frequency Curve
(Historical and BOC)

Keuka Lake Reservoir Regulation Manual
U.S. Army Engineer District Buffalo
1996

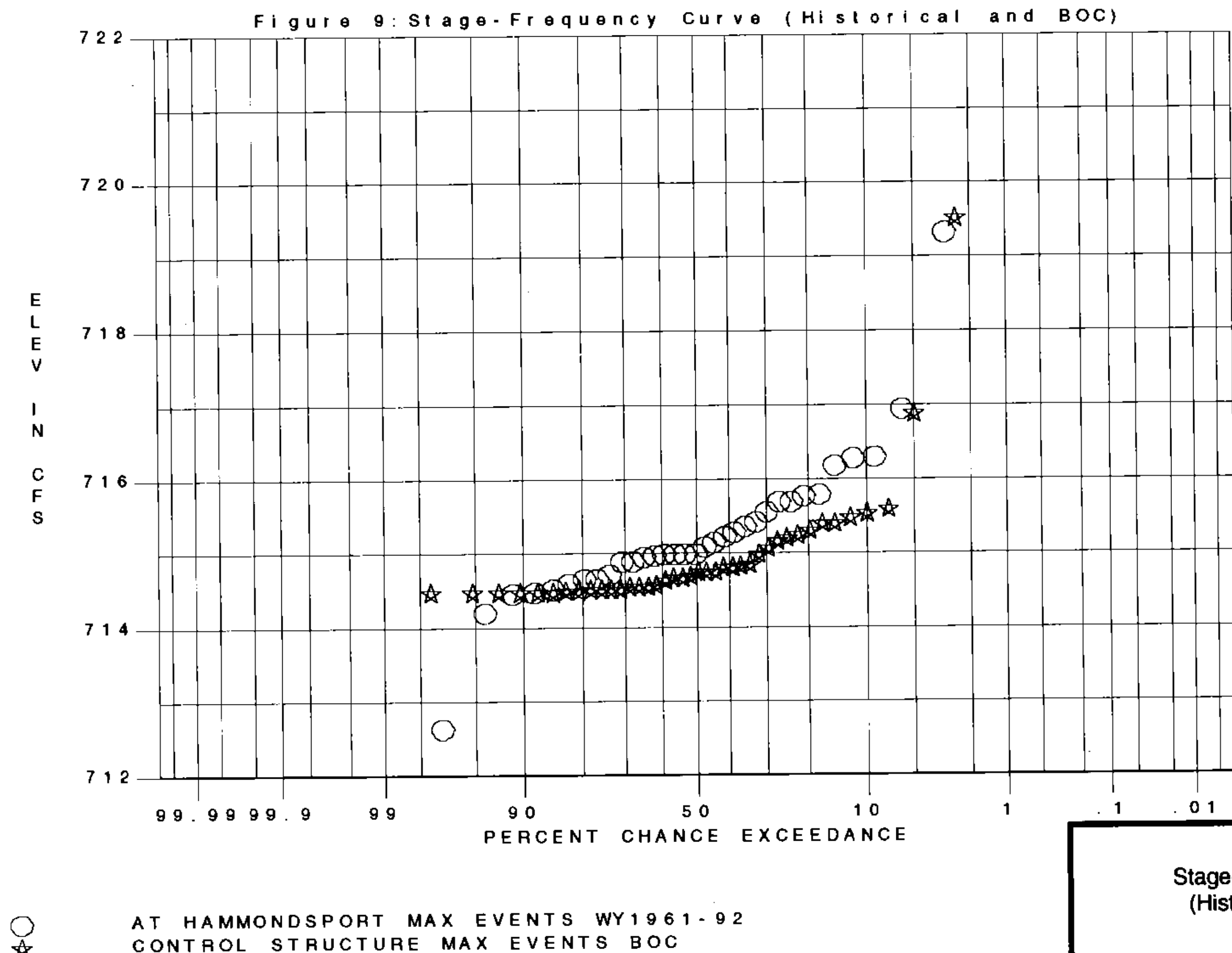


Plate 9
Stage-Frequency Curve
(Historical and BOC)

Keuka Lake Reservoir Regulation Manual
U.S. Army Engineer District Buffalo
1996

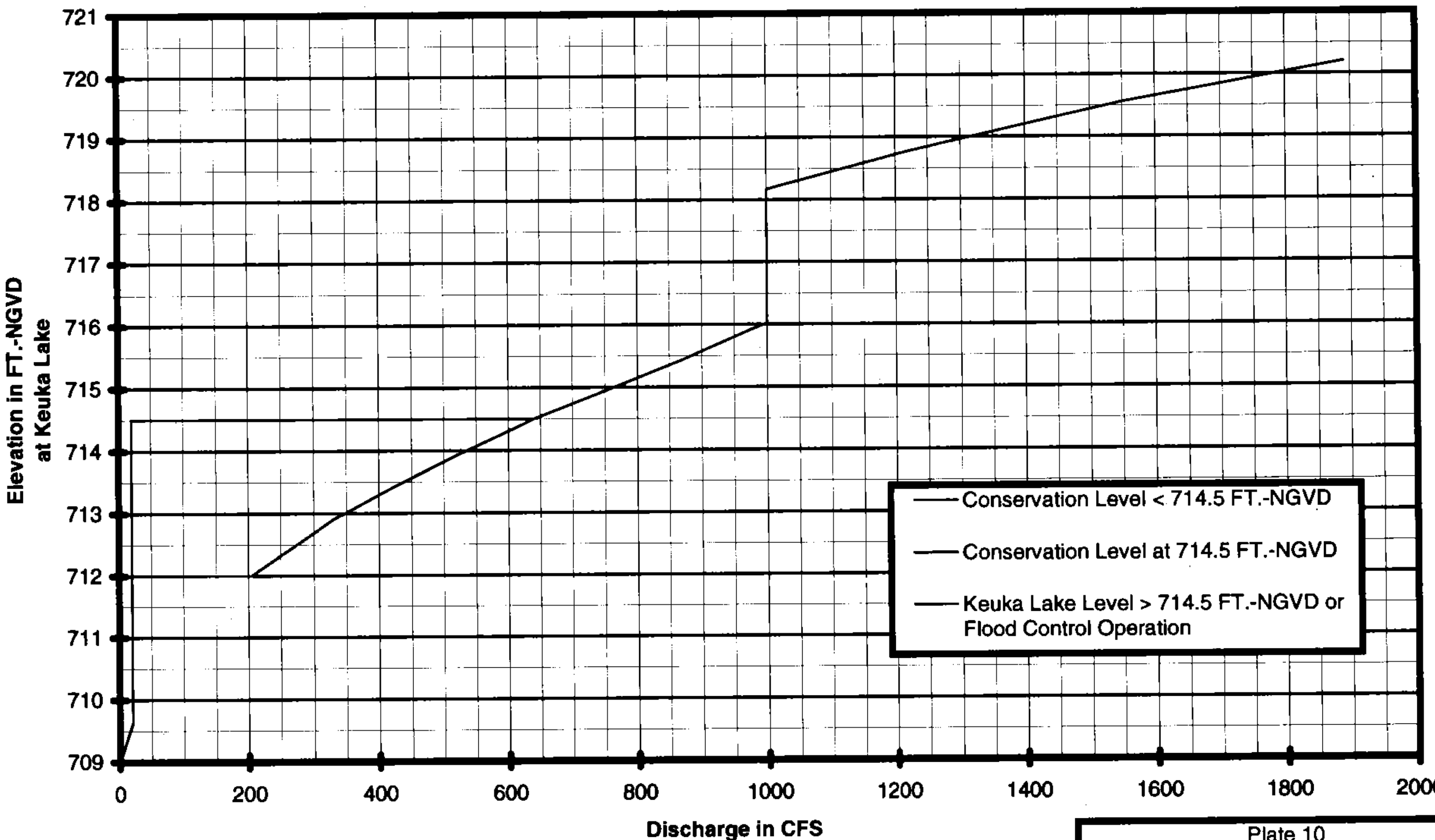


Plate 10
Rating Curve at Keuka Lake

Keuka Lake Reservoir Regulation Manual
U.S. Army Engineer District Buffalo
1996

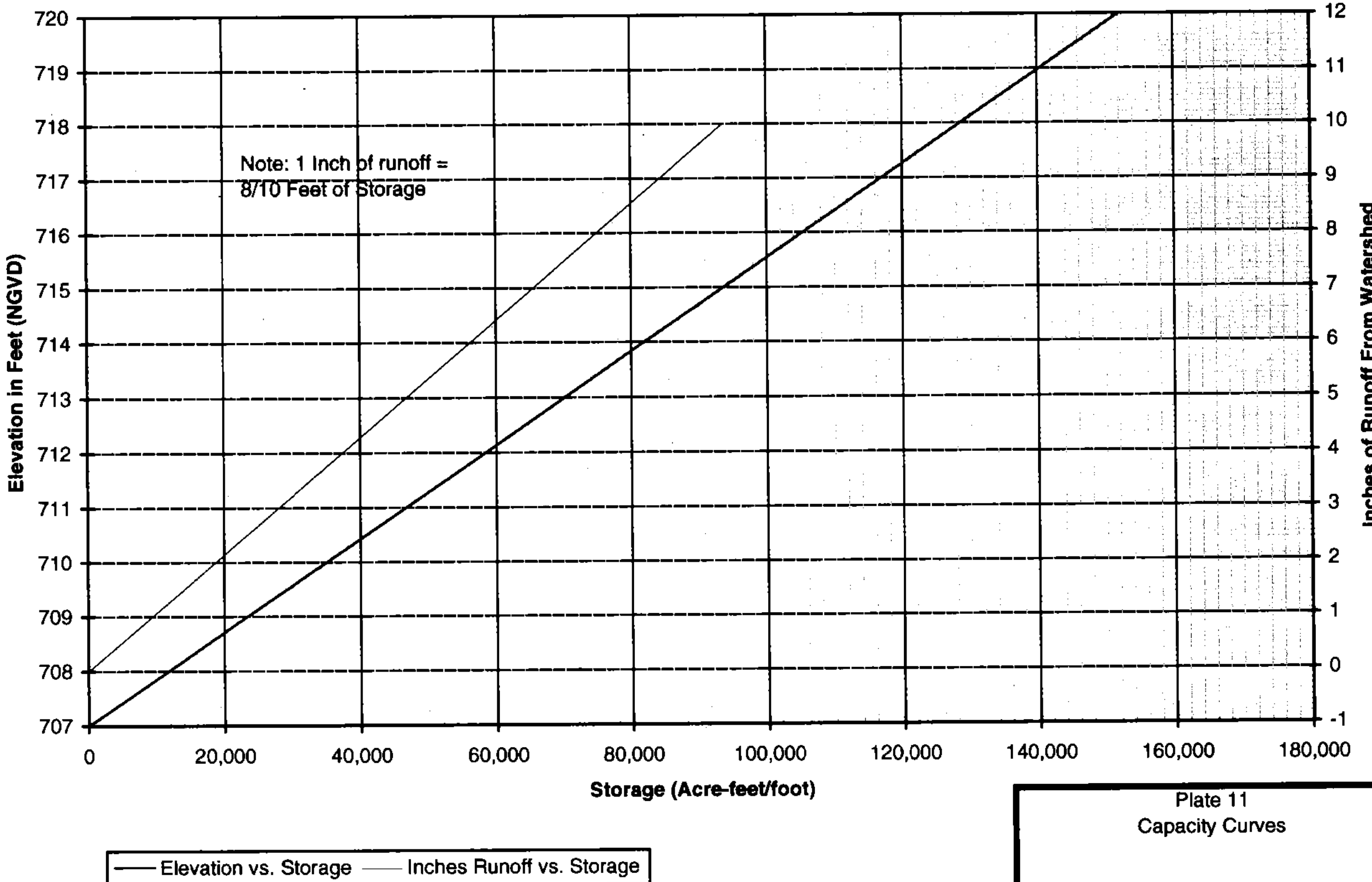


Plate 11
Capacity Curves

Keuka Lake Reservoir Regulation Manual
U.S. Army Engineer District Buffalo
1996

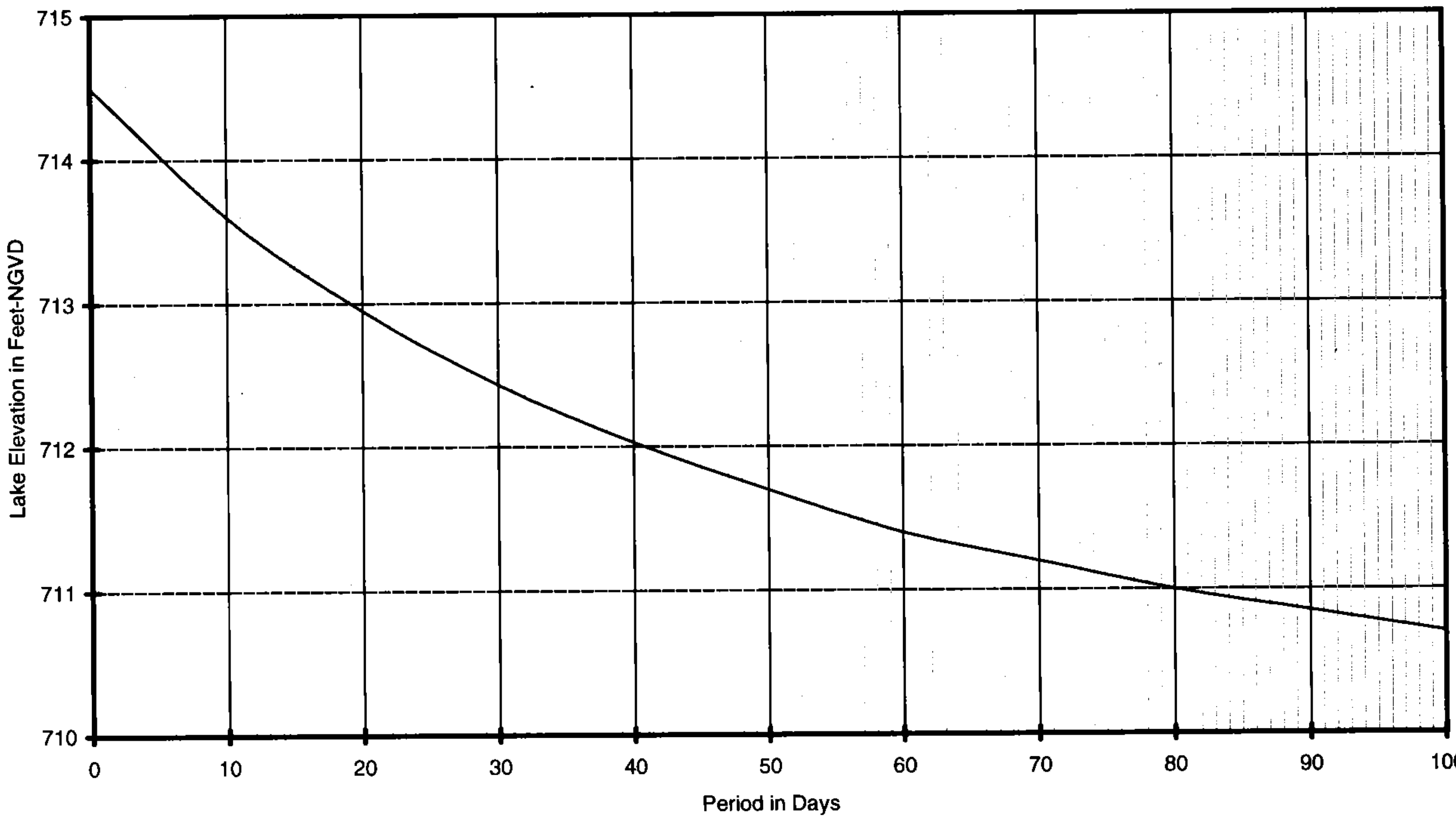


Plate 12
Drawdown Curves
Inflow = 0 cfs

Keuka Lake Reservoir Regulation Manual
U.S. Army Engineer District Buffalo
1996

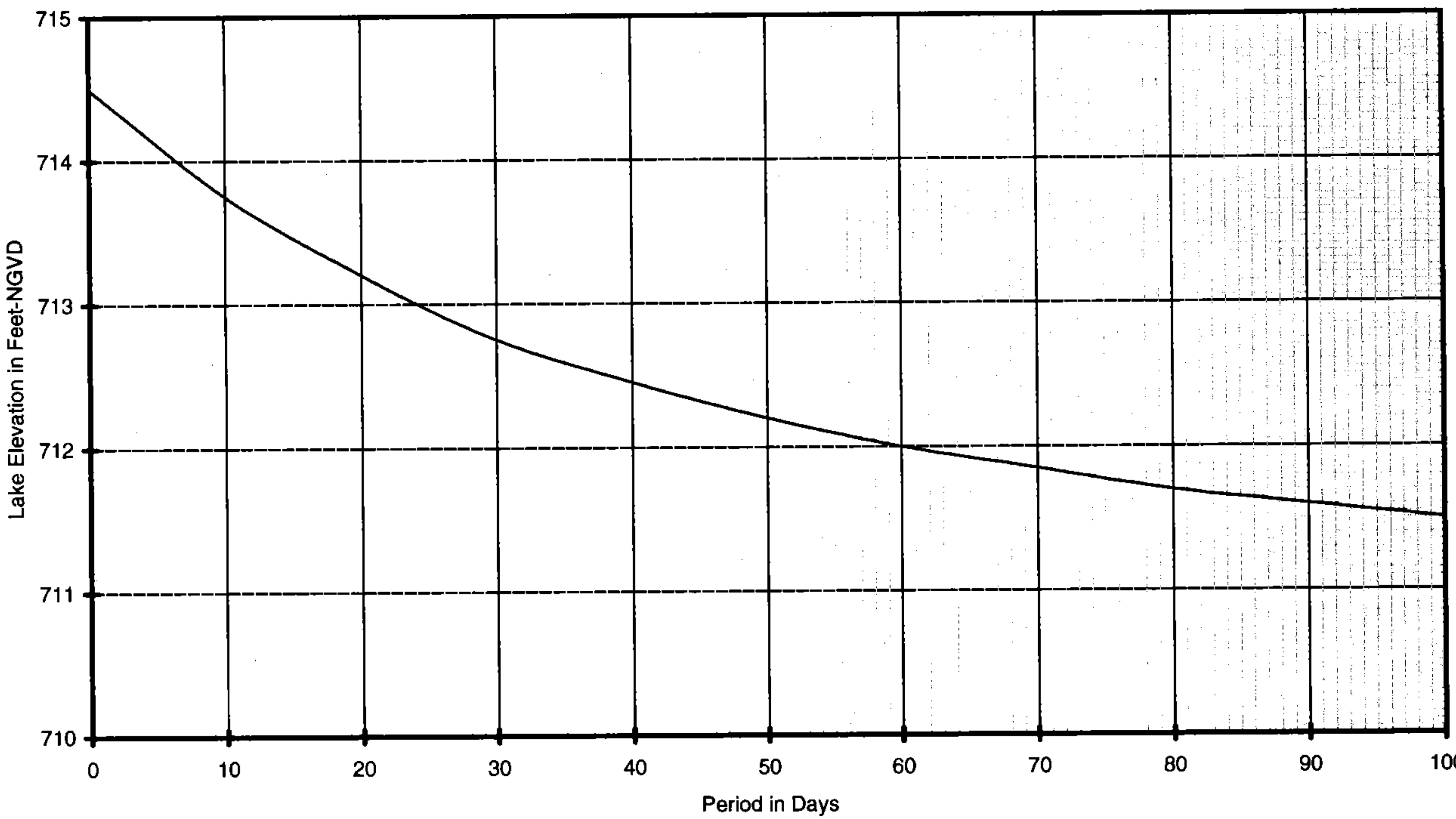


Plate 13
Drawdown Curves
Inflow = 100 cfs

Keuka Lake Reservoir Regulation Manual
U.S. Army Engineer District Buffalo
1996

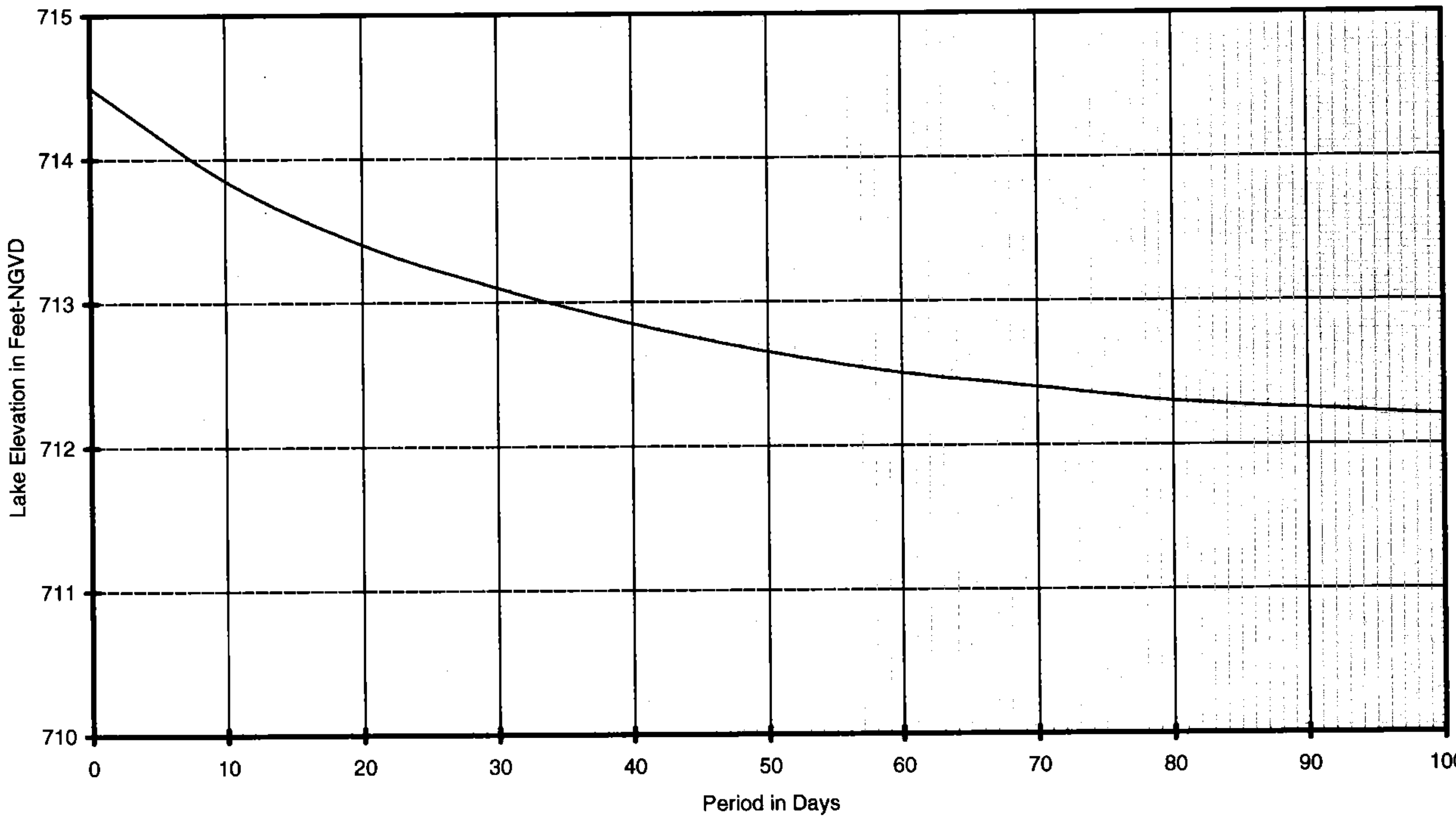


Plate 14
Drawdown Curves
Inflow = 200 cfs

Keuka Lake Reservoir Regulation Manual
U.S. Army Engineer District Buffalo
1996

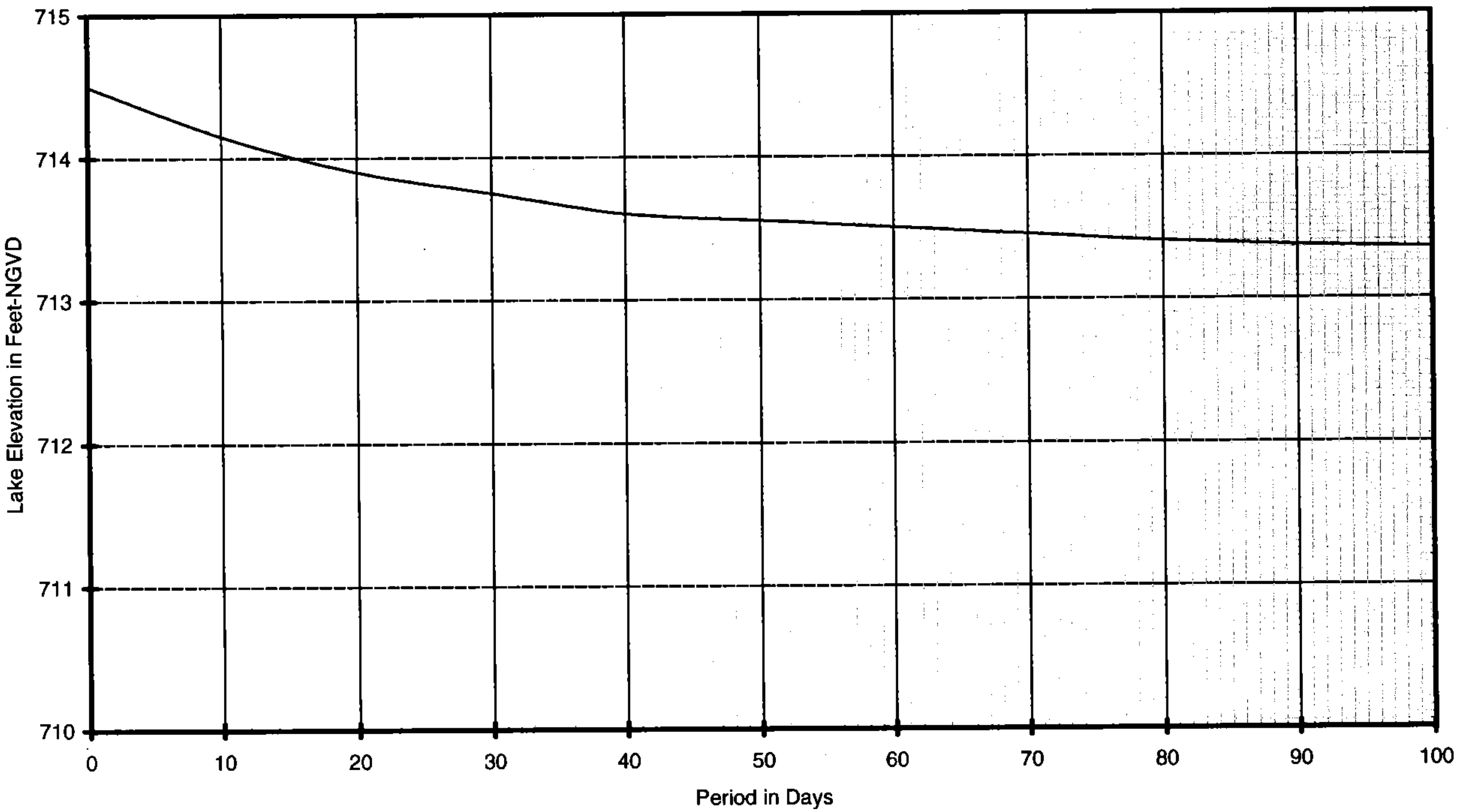


Plate 15
Drawdown Curves
Inflow = 400 cfs

Keuka Lake Reservoir Regulation Manual
U.S. Army Engineer District Buffalo
1996

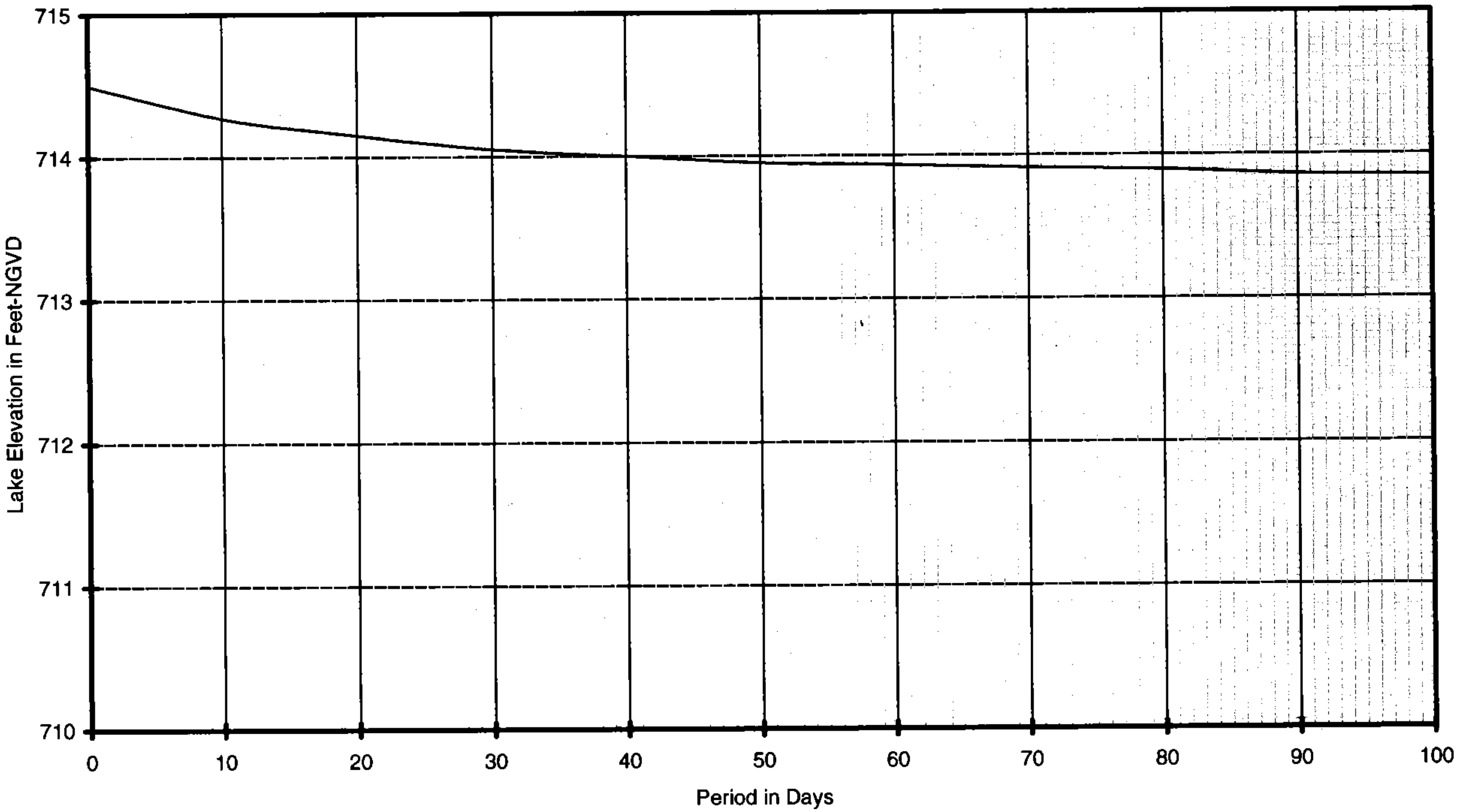


Plate 16
Drawdown Curves
Inflow =500 cfs

Keuka Lake Reservoir Regulation Manual
U.S. Army Engineer District Buffalo
1996

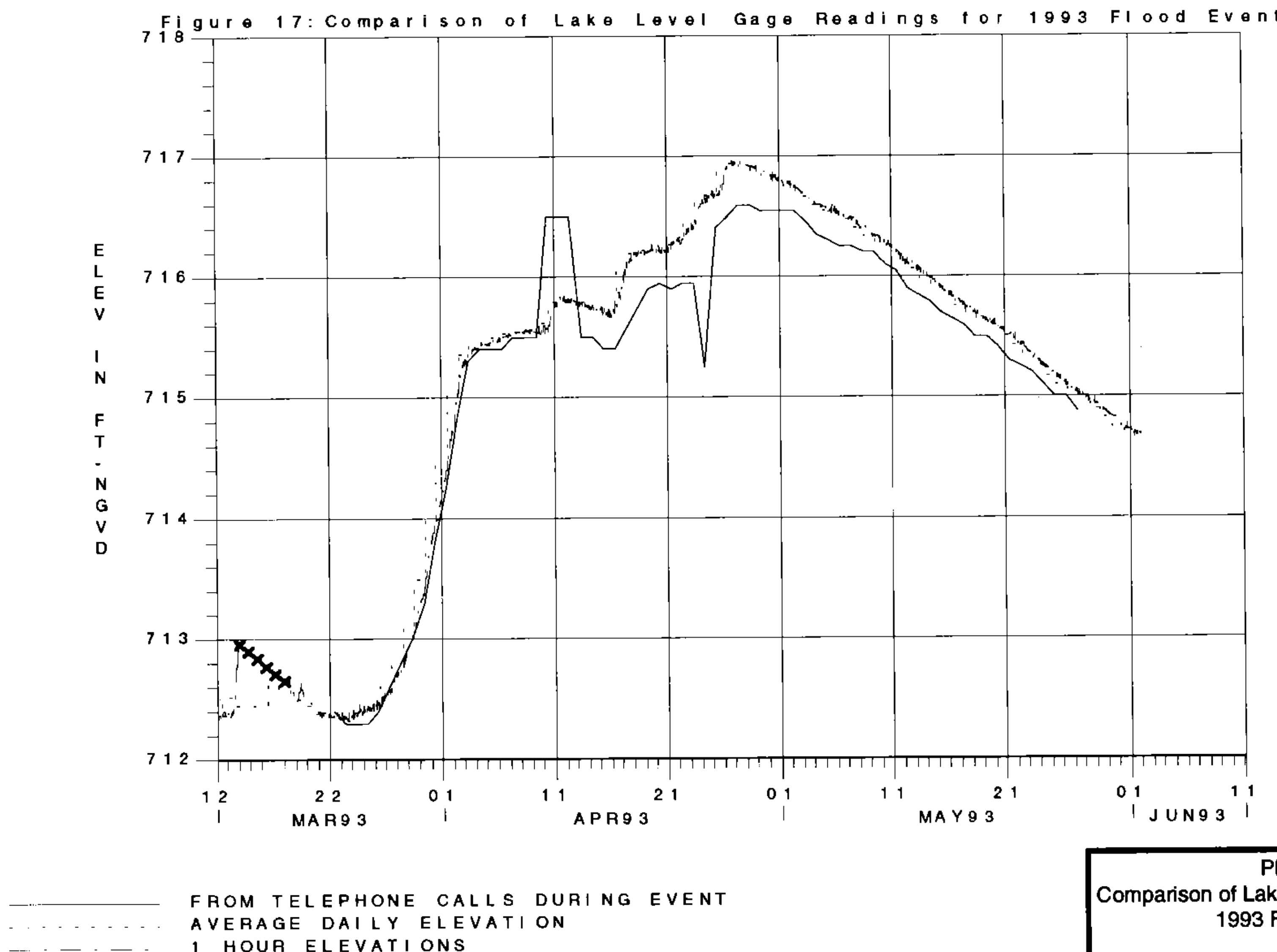


Plate 17
Comparison of Lake Level Gage Readings
1993 Flood Event

Keuka Lake Reservoir Regulation Manual
U.S. Army Engineer District Buffalo
1996

EXHIBIT A

Supplementary Pertinent Data

Operation of Control Structure

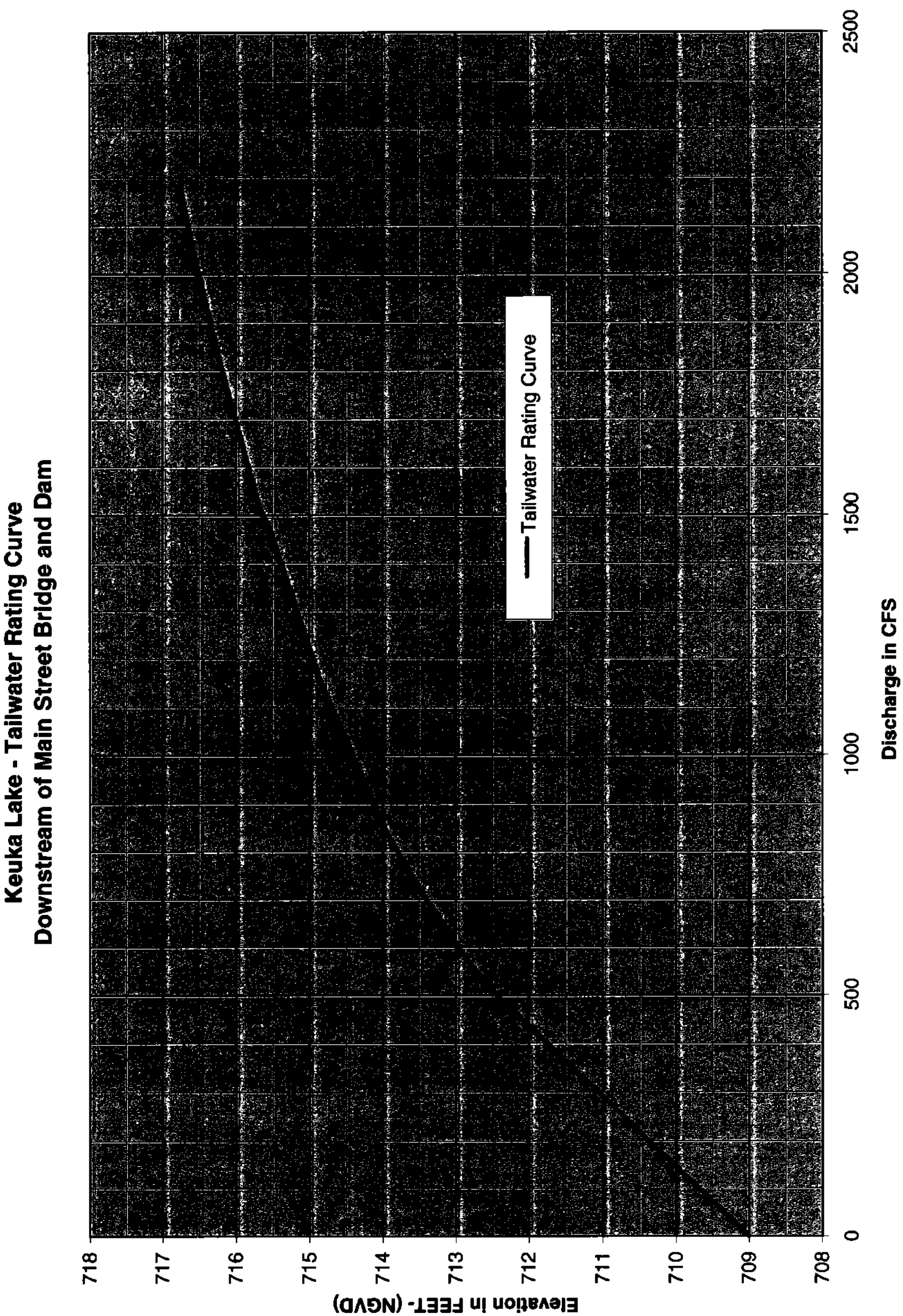
The operation of the Keuka Lake control structure will be somewhat different from the operation of a typical flood control reservoir. Normally, a flood control reservoir is operated to reduce flood damages on downstream reaches of the outlet only. In that type of operation, when inflows to the reservoir exceed the downstream channel capacity (and/or structure capacity), the reservoir (taking into account downstream flow conditions) will store the excess floodwaters. When the inflows becomes less than the channel capacity, water in the flood control pool will be released to bring the reservoir back down to the conservation pool level as soon as possible.

However, Keuka Lake will be operated to control flooding on the lake perimeter as well as downstream reaches. Once the top of conservation zone Elev. 714.5 feet, is exceeded, the policy will be to make releases through the dam up to 1000 CFS or the outlet control structure's capacity, whichever is less. This maximum release capacity of 1000 CFS will be allowed when lake levels are between 716.0 and 718.2 feet. When lake levels exceed Elev. 718.2 feet, discharges will be in accordance with the pre-project rating curve. This policy will not induce additional adverse downstream flood impacts.

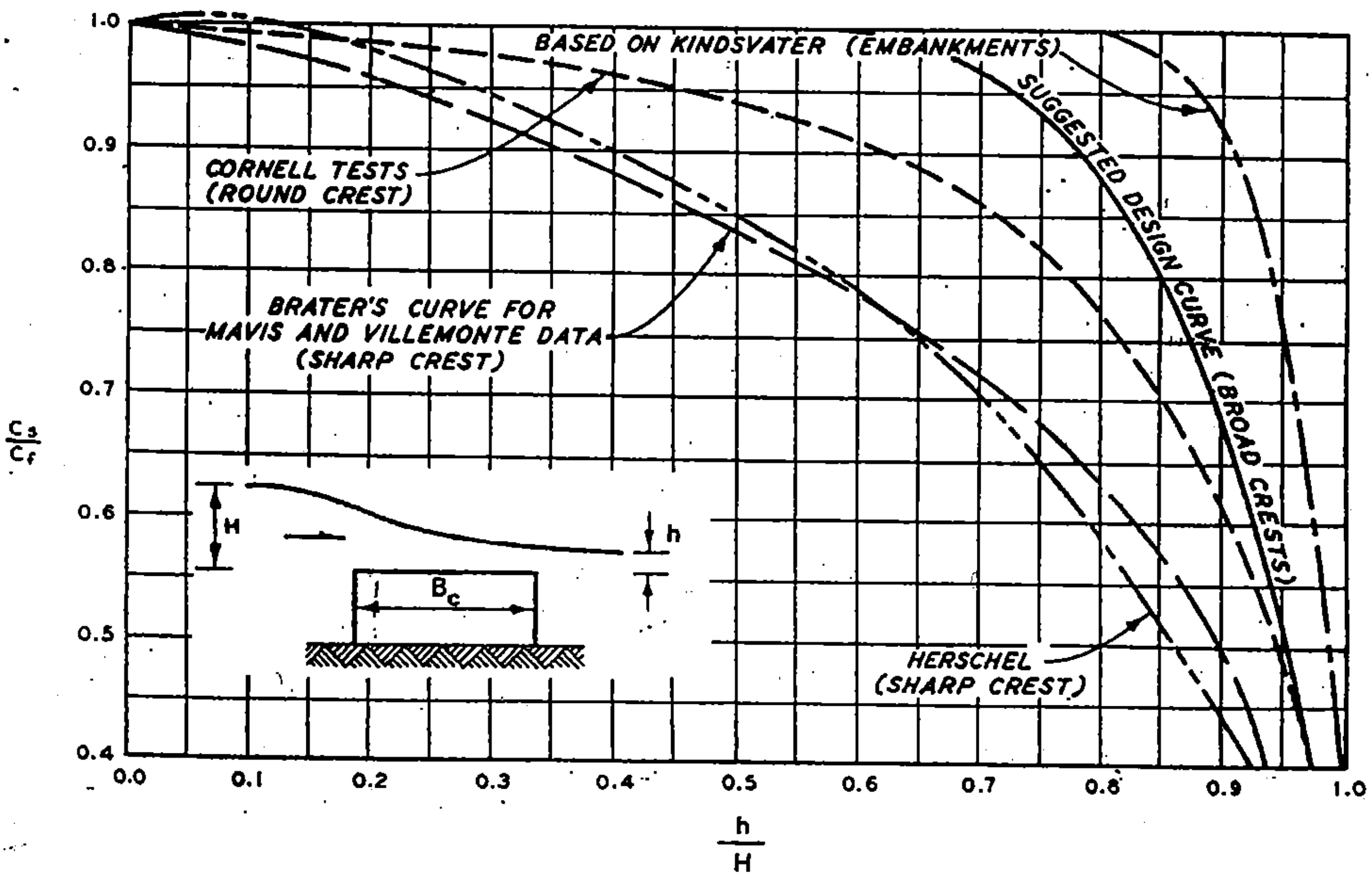
Development of Improved Rating Curve

Flow through the 2 Andrews Race, 1 Birkett and 3 New Center Gates can occur either as weir flow or orifice flow, depending on the gate openings and on the elevation of Keuka Lake. Discharge under weir flow conditions was determined using the equation $Q=CLH^{3/2}$, where C is the weir flow coefficient, L is the length of weir opening (in this case width of the gate), and H is the depth of water over the weir crest. Discharge under orifice flow conditions was computed using the equation $Q=C_dA\ \sqrt{2gH}$, where C_d is the discharge coefficient, A is the area of the opening, H is the head on the orifice (distance from the water surface to the midpoint of the orifice opening), and g is acceleration due to gravity.

A tailwater rating curve, as shown on Figure 1 (pg. A-2), was established downstream of the Main St. Bridge and Dam using the HEC-2 computer program . When weir flow (i.e. free flow) conditions exist under an open gate, and a tailwater effect is present, the "Suggested Design Curve (Broad Crests)" on Figure 5-15 b. Submerged Flow from the EM-1110-2-1605 Hydraulic Design of Navigation Dams, dated 12 May 1987 was used to establish a tailwater correction factor. This curve is shown on Figure 2 (pg. A-3). The tailwater correction factor was determined from the curve after establishing h/H which is the tailwater stage divided by the headwater stage at the gate. The correction factor c_s/c_f was then multiplied by the computed weir flow discharge to determine the corrected discharge, assuming tailwater effects presents. The following is an example calculation computing the flow through the 3 New Center gates, fully open, with 1000 CFS as the tailwater discharge and a head at the gates of elevation 715 ft.-NGVD.


Keuka Lake - Tailwater Rating Curve
Downstream of Main Street Bridge and Dam
Tailwater Rating Curve
Elevation in FEET - (NGVD)
718
717
716
715
714
713
712
711
710
709
708
Discharge in CFS
0
500
1000
1500
2000
2500

 (Figure 1)



b. SUBMERGED FLOW

NOTE: C_f = FREE-FLOW COEFFICIENT
C_s = SUBMERGED-FLOW COEFFICIENT
NEGLIGIBLE VELOCITY OF APPROACH

Figure 5-15. Low-monolith diversion, discharge coefficients (from HDC 711)

Known: Tailwater elev. = 714.35 ft.-NGVD from tailwater rating curve for Q=1000 CFS.
Headwater at Gates = 715.0 ft.-NGVD
Bottom of Sill at Gates = 709.0 ft.-NGVD

Calculation: h/H=(714.35-709)/(715-709)=0.89 ; from Fig. 5-15b "Suggested Design Curve (Broad Crests)" of EM-1110-2-1605, the Correction factor is 0.70. The weir flow (i.e. free flow) discharge through one New Center gate assuming C = 3.16 is $Q = CLH^{3/2} = (3.16)(6)(715-709)^{3/2} = 279$ CFS. The corrected discharge due to tailwater effect is (0.70)(279 CFS) = 195 CFS. Therefore, for 3 New Center gates, the discharge Q = (3)(195 CFS) = 585 CFS. The remainder of the 1000 CFS downstream discharge would be comprised of flow through the Birkett and Andrews Race gates.

Under orifice flow conditions, especially when high lake levels occur, partial gate openings will produce submerged orifice flow conditions. Under these conditions, computation of the total discharge involves trial and error computations using the tailwater rating curve to determine whether the tailwater is high enough to produce submergence. The following is an example calculation of orifice flow with a tailwater effect of 1 New Center gate opened 2.9 feet with a headwater at the gate of 716.5 ft.-NGVD and a tailwater discharge of 1000 CFS.

Known: Tailwater elev. = 714.35 ft.-NGVD from tailwater rating curve for Q=1000 CFS.
Headwater at Gate = 716.5 ft.-NGVD
Bottom of Sill at Gates = 709.0 ft.-NGVD

Calculation: Orifice Flow = $Q = C_d A \sqrt{2gH}$, $= (0.62)(2.9)(6)\sqrt{2(32.2)(716.5-714.35)}$; where C_d=0.62, A=(2.9 ft. high)(6 ft. wide), g =32.2 ft/s^2, and H = (716.5 - 714.35). Therefore, Q = 127 CFS. The remainder of the 1000 CFS downstream discharge would be comprised of flow through the remaining 2 New Center gates as well as the Birkett and Andrews Race gates.

For aid in determining the operator's rating curve, the following computations, assuming NO TAILWATER, have been included on Pages A-6 through A-13: Center New Gates, Andrews Race Gates and Birkett Gate (Computations for only 1 specific type gate each, assuming NO TAILWATER for a range of gate openings, including fully open). These computations depict where the change between weir flow under the gate and orifice flow is assumed to take place depending upon the height of the gate opening. Corresponding to these computations, Figures 3 through 5 (pgs. A-14 thru A-16) depict the rating curves, assuming NO TAILWATER, for various height of gate openings ranging from 0.5' to fully open, for 1 Center New Gate, 1 Andrews Race Gate and the sole Birkett Gate, respectively.

As noted before, during flood control operation, when the Keuka Lake elevation exceeds 718.2 ft.-NGVD, all three New Center gates should be fully closed. At this time, uncontrolled weir flow over the top of the structure will exist. For additional information, Page A-17 contains uncontrolled weir flow computations over the dam structure upstream of the Main Street Bridge. These computations begin at water surface elevation 716 ft.-NGVD at the gate, are based on ALL gates being closed, and are broken down into separate portions of the structure. Figure 6 (pg. A-18) depicts the rating curves for uncontrolled weir flow, with ALL gates closed, over various portions of the dam structure and Figure 7 (pg. A-19) depicts solely the sum Total Weir Flow over the entire structure with ALL gates closed.

CENTER NEW GATES: 3 gates each 6 FT. wide and 7 FT. high. Bottom of Sill= 709.0 ft.

COMPUTATIONS FOR **1 GATE ONLY**- FULLY OPENED

These computations assume NO Tailwater.

ELEV.	H (ft.)	Q(weir)CFS	Q(orifice)CFS
709	0	0	
709.35	0.35	4	
709.5	0.5	7	
710	1	19	
710.5	1.5	35	
711	2	54	
711.5	2.5	75	
712	3	99	
712.5	3.5	124	
713	4	152	
713.5	4.5	181	
714	5	212	
714.5	5.5	245	
715	6	279	
715.5	6.5	314	
716	7	351	
716.5	7.5	389	
717	8	429	
717.5	8.5		467
718	9		490
718.33	9.33		505
718.5	9.5		512
719	10		533
719.5	10.5		553
720	11		572
720.5	11.5		591
721	12		609
721.5	12.5		627
722	13		644
722.5	13.5		661
723	14		677

$Q_{(weir)} = CLH^{3/2}$

where:
C=3.16
L=6ft.
H=varies (ft.)

NOTE: The transition from weir flow to orifice flow occurs between 1.2 to 1.33 (Ht. of Gate Opening).
For a conservative approach we assume orifice flow will occur at 1.2 Ht. of Gate Opening.

$Q_{(orifice)} = C_d A(2gH)^{1/2}$

where:
C_d=0.62
g=32.2 ft. per second squared.
H=varies (ft.) (For example: With a full gate open 7 ft., and a Head of 720, H=720-712.5)
A= 6' x 7' = 42 sq. ft. for full gate opening.

CENTER NEW GATES: 3 gates each 6 FT. wide and 7 FT. high. Bottom of Sill =709.0 ft.

**** COMPUTATIONS FOR **1 GATE ONLY** - **various** gate openings.****

		.5 ft open	.5 ft open	1 ft. open	1 ft. open	2 ft. open	2 ft. open	3 ft. open	3 ft. open
ELEV.	H (ft.)	Q(weir)	Q(orifice)	Q(weir)	Q(orifice)	Q(weir)	Q(orifice)	Q(weir)	Q(orifice)
709	0	0		0		0		0	
709.4	0.35	4		4		4		4	
709.5	0.5	7		7		7		7	
709.7	0.67		10	10		10		10	
710	1		13	19		19		19	
710.3	1.33		16		27	29		29	
710.5	1.5		17		30	35		35	
711	2		20		37	54		54	
711.5	2.5		22		42		73	75	
711.7	2.67		23		44		77	83	
712	3		25		47		84	99	
712.5	3.5		27		52		94	124	
713	4		29		56		103		142
713.5	4.5		31		60		112		155
714	5		33		63		119		168
714.5	5.5		34		67		127		179
715	6		36		70		134		190
715.5	6.5		37		73		140		200
715.7	6.67		38		74		142		204
716	7		39		76		146		210
716.5	7.5		40		79		152		219
717	8		42		82		158		228
717.5	8.5		43		84		164		237
718	9		44		87		169		245
718.3	9.33		45		89		172		251
718.5	9.5		45		90		174		253
719	10		47		92		179		261
719.5	10.5		48		94		184		269
720	11		49		97		189		276
720.5	11.5		50		99		193		283
721	12		51		101		198		290
721.5	12.5		52		103		202		297
722	13		53		106		207		304
722.5	13.5		54		108		211		310
723	14		55		110		215		317

These computations assume
NO Tallwater.

$Q_{(weir)} = CLH^{3/2}$

where: C=3.16
L=6ft.
H=varies (ft.)

NOTE: The transition from weir flow to orifice flow occurs between 1.2 to 1.33 (Ht. of gate opening). For a conservative approach, we assume orifice flow will occur at 1.2 (Ht. of gate opening).

$Q_{(orifice)} = C_dA(2gH)^{1/2}$

where: C_d=0.62
g=32.2 ft. per second squared.
H=varies (ft.)
A= 6' x Ht.of gate opening (sq. ft.)

CENTER NEW GATES: 3 gates each 6 FT. wide and 7 FT. high.

Bottom of Sill=709.0 ft.

**** COMPUTATIONS FOR **1 GATE ONLY** - **various** gate openings. ****

ELEV.	H (ft.)	4 ft. open Q(weir)	4 ft. open Q(orifice)	5 ft. open Q(weir)	5 ft. open Q(orifice)	6 ft. open Q(weir)	6 ft. open Q(orifice)	7 ft. open Q(weir)	7 ft. open Q(orifice)
709	0	0		0		0		0	
709.4	0.35	4		4		4		4	
709.5	0.5	7		7		7		7	
709.7	0.67	10		10		10		10	
710	1	19		19		19		19	
710.5	1.5	35		35		35		35	
711	2	54		54		54		54	
711.5	2.5	75		75		75		75	
711.7	2.67	83		83		83		83	
712	3	99		99		99		99	
712.5	3.5	124		124		124		124	
713	4	152		152		152		152	
713.5	4.5	181		181		181		181	
714	5		207	212		212		212	
714.3	5.33		218	233		233		233	
714.5	5.5		223	245		245		245	
715	6		239	279		279		279	
715.5	6.5		253		299	314		314	
715.7	6.67		258		305	327		327	
716	7		267		317	351		351	
716.5	7.5		280		334		380	389	
717	8		292		350		401	429	
717.5	8.5		304		366		420		467
718	9		316		381		439		490
718.3	9.33		323		390		451		505
718.5	9.5		327		395		457		512
719	10		338		409		474		533
719.5	10.5		348		422		491		553
720	11		358		435		507		572
720.5	11.5		368		448		522		591
721	12		378		460		537		609
721.5	12.5		387		472		552		627
722	13		396		484		566		644
722.5	13.5		405		495		580		661
723	14		414		506		594		677

These computations assume
<u>NO</u> Tailwater.

$Q_{(weir)} = CLH^{3/2}$

<u>where:</u> C=3.16
L=6ft.
H=varies (ft.)

<u>**NOTE:**</u> The transition from weir flow to orifice flow occurs between 1.2 to 1.33 (Ht. of gate opening). For a conservative approach, we assume orifice flow will occur at 1.2 (Ht. of gate opening).

$Q_{(orifice)} = C_dA(2gH)^{1/2}$

<u>where:</u> C_d=0.62
g=32.2 ft. per second squared.
H=varies (ft.)
A= 6' x Ht.of gate opening (sq. ft.)

ANDREWS RACE GATES: 2 gates each 4.5 FT. wide and 4.5 FT.high. Bottom of Sill= 709.1 ft.

COMPUTATIONS FOR **1 GATE ONLY**- FULLY OPENED

These computations assume NO Tailwater.

ELEV.	H (ft.)	Q(weir)CFS	Q(orifice)CFS
709.1	0	0	
709.5	0.4	4	
710	0.9	12	
710.5	1.4	24	
711	1.9	37	
711.5	2.4	53	
712	2.9	70	
712.5	3.4	89	
713	3.9	110	
713.5	4.4	131	
714	4.9	154	
714.5	5.4	178	
715	5.9		192
715.1	6		195
715.5	6.4		205
716	6.9		217
716.5	7.4		229
717	7.9		239
717.5	8.4		250
718	8.9		260
718.1	9		262
718.5	9.4		269
719	9.9		279
719.1	10		280

$Q_{(weir)} = CLH^{3/2}$

where: C=3.16
L=4.5ft.
H=varies (ft.)

NOTE: The transition from weir flow to orifice flow occurs between 1.2 to 1.33 (Ht. of Gate Opening).
For a conservative approach we assume orifice flow will occur at 1.2 Ht. of Gate Opening.

$Q_{(orifice)} = C_dA(2gH)^{1/2}$

where: C_d=0.62
g=32.2 ft. per second squared
H=varies (ft.) (For example: With a full gate open 4.5 ft., and a Head of 718, H=718-711.35)
A=4.5' x 4.5' = 20.25 sq. ft. for full gate opening.

ANDREWS RACE GATES: 2 gates each 4.5 FT. wide and 4.5 FT. high. Bottom of Sill =709.1 ft.

***COMPUTATIONS FOR **1 GATE ONLY**- **various** gate openings. ***

		.5 ft open	.5 ft open	1 ft. open	1 ft. open	2 ft. open	2 ft. open	3 ft. open	3 ft. open	4 ft open	4 ft open
ELEV.	H (ft.)	Q(weir)	Q(orifice)	Q(weir)	Q(orifice)	Q(weir)	Q(orifice)	Q(weir)	Q(orifice)	Q(weir)	Q(orifice)
709.1	0	0		0		0		0		0	
709.5	0.4	4		4		4		4		4	
709.8	0.67		7	8		8		8		8	
710	0.9		9	12		12		12		12	
710.4	1.33		12		20	22		22		22	
710.5	1.4		12		21	24		24		24	
711	1.9		14		26	37		37		37	
711.5	2.4		16		31	53		53		53	
711.8	2.67		17		33		58	62		62	
712	2.9		18		35		62	70		70	
712.5	3.4		20		38		69	89		89	
713	3.9		21		41		76		104	110	
713.1	4		22		42		78		106	114	
713.5	4.4		23		44		83		114	131	
714	4.9		24		47		88		124		153
714.4	5.33		25		49		93		131		163
714.5	5.4		25		50		94		133		165
715	5.9		27		52		99		141		177
715.1	6		27		53		100		142		179
715.5	6.4		28		54		104		149		188
716	6.9		29		57		109		156		198
716.5	7.4		30		59		113		163		208
717	7.9		31		61		118		170		218
717.5	8.4		32		63		122		176		227
718	8.9		33		65		126		183		235
718.5	9.4		34		67		130		189		244
719	9.9		35		69		134		195		252
719.1	10		35		69		134		196		253

These computations assume
NO Tailwater.

For equations, see previous
computations for 1 Center gate
at various gate openings, using
L = 4.5 ft. & A=4.5 ft. x HT. of gate opening

ANDREWS RACE GATES; 2 gates each 4.5 FT. wide and 4.5 FT. high.								Bottom of Sill =709.1 ft.			These computations assume NO Tailwater.					
COMPUTATIONS FOR 1 GATE ONLY- various gate openings																
		.2 ft open	.2 ft open	.3 ft open	.3 ft open	.4 ft open	.4 ft open	.5 ft open	.5 ft open	.6 ft open	.6 ft open	.7 ft open	.7 ft open	.8 ft open	.8 ft open	
ELEV. (ft.)	H (ft.)	Q(weir)	Q(orifice)	Q(weir)	Q(orifice)	Q(weir)	Q(orifice)	Q(weir)	Q(orifice)	Q(weir)	Q(orifice)	Q(weir)	Q(orifice)	Q(weir)	Q(orifice)	
709.1	0	0.0		0.0		0.0		0.0		0.0		0.0		0.0		
709.3	0.2	1.3		1.3		1.3		1.3		1.3		1.3		1.3		
709.37	0.27		1.8	2.0		2.0		2.0		2.0		2.0		2.0		For equations, see previous
709.5	0.4		2.5		3.4	3.6		3.6		3.6		3.6		3.6		computations for 1 Center gate
709.63	0.53		2.9		4.1		5.1	5.5		5.5		5.5		5.5		at various gate openings, using
709.7	0.6		3.2		4.5		5.7	6.6		6.6		6.6		6.6		L = 4.5 ft. & A=4.5 ft. x HT. of gate opening
709.77	0.67		3.4		4.8		6.1		7.3	7.8		7.8		7.8		
709.9	0.8		3.7		5.4		6.9		8.3		9.5	10.2		10.2		
710	0.9		4.0		5.8		7.5		9.0		10.4		11.6	12.1		
710.03	0.93		4.1		5.9		7.7		9.2		10.7		11.9	12.8		
710.17	1.07		4.4		6.4		8.4		10.1		11.8		13.3		14.7	
710.2	1.1		4.5		6.5		8.5		10.3		12.0		13.6		15.0	
710.3	1.2		4.7		6.9		9.0		10.9		12.7		14.4		16.0	
710.4	1.3		4.9		7.2		9.4		11.5		13.4		15.3		17.0	
710.43	1.33		5.0		7.3		9.5		11.6		13.6		15.5		17.3	
710.5	1.4		5.1		7.5		9.8		12.0		14.1		16.1		17.9	
710.6	1.5		5.3		7.8		10.2		12.5		14.7		16.8		18.8	
710.7	1.6		5.5		8.1		10.6		13.0		15.3		17.5		19.6	
710.8	1.7		5.7		8.4		11.0		13.5		15.9		18.2		20.4	
711	1.9		6.0		8.9		11.7		14.4		17.0		19.5		21.9	
711.3	2.2		6.5		9.6		12.7		15.6		18.5		21.3		24.0	
711.4	2.3		6.6		9.8		13.0		16.0		19.0		21.9		24.7	
711.5	2.4		6.8		10.1		13.3		16.4		19.5		22.4		25.3	
711.77	2.67		7.2		10.7		14.1		17.4		20.7		23.9		27.0	
712	2.9		7.5		11.1		14.7		18.2		21.7		25.0		28.3	
712.1	3		7.6		11.3		15.0		18.6		22.1		25.5		28.9	
712.2	3.1		7.8		11.5		15.3		18.9		22.5		26.0		29.4	
712.3	3.2		7.9		11.7		15.5		19.2		22.9		26.5		30.0	
712.5	3.4		8.1		12.1		16.0		19.9		23.7		27.4		31.0	
713	3.9		8.7		13.0		17.2		21.4		25.5		29.5		33.5	
713.1	4		8.8		13.2		17.5		21.7		25.8		29.9		34.0	
713.5	4.4		9.3		13.8		18.4		22.8		27.2		31.5		35.8	
714	4.9		9.8		14.6		19.4		24.1		28.8		33.4		38.0	
714.1	5		9.9		14.8		19.6		24.4		29.1		33.8		38.4	
714.43	5.33		10.2		15.3		20.3		25.2		30.1		35.0		39.8	
714.5	5.4		10.3		15.4		20.4		25.4		30.3		35.2		40.1	
715	5.9		10.8		16.1		21.4		26.6		31.8		36.9		42.0	
715.1	6		10.9		16.2		21.6		26.8		32.1		37.3		42.4	
715.5	6.4		11.2		16.8		22.3		27.8		33.2		38.5		43.9	
716	6.9		11.7		17.5		23.2		28.9		34.5		40.1		45.7	
716.5	7.4		12.1		18.1		24.0		29.9		35.8		41.6		47.4	
717	7.9		12.5		18.7		24.9		31.0		37.0		43.1		49.1	
717.5	8.4		12.9		19.3		25.6		32.0		38.2		44.5		50.7	
718	8.9		13.3		19.9		26.4		32.9		39.4		45.8		52.2	
718.5	9.4		13.7		20.4		27.2		33.9		40.5		47.1		53.7	
719	9.9		14.0		21.0		27.9		34.8		41.6		48.4		55.2	
719.1	10		14.1		21.1		28.0		35.0		41.8		48.7		55.5	

BIRKETT GATE: 1 gate 4.0 FT. wide and 5.4 FT. high — Bottom of Sill = 709.0 ft.

COMPUTATIONS FOR **1 GATE ONLY** - **various** gate openings.

Per Mike Smith after conversation with Mr. Webster of Keuka Lake, Birkett Gate is fully operational.

It was fixed recently and can be opened to a full height of 5.4 feet to aid in passage of 1000 cfs.

These computations assume NO Tailwater.

ELEV. (	H (ft.	FULLY OPEN Q(weir)CFS	FULLY OPEN Q(orifice)CFS	.5 ft open Q(weir)	.5 ft open Q(orifice)	1 ft open Q(weir)	1 ft open Q(orifice)	2 ft open Q(weir)	2 ft open Q(orifice)	3 ft open Q(weir)	3 ft open Q(orifice)
709	0	0		0		0		0		0	
709.5	0.5	4		4		4		4		4	
709.67	0.67	7			6	7		7		7	
710	1	13			9	13		13		13	
710.33	1.33	19			10		18	19		19	
710.5	1.5	23			11		20	23		23	
711	2	36			13		24	36		36	
711.5	2.5	50			15		28		49	50	
711.67	2.67	55			15		29		51	55	
712	3	66			17		31		56	66	
712.5	3.5	83			18		34		63	83	
713	4	101			19		37		69		94
713.5	4.5	121			21		40		74		103
714	5	141			22		42		80		112
714.33	5.33	156			22		44		83		117
714.5	5.5	163			23		45		84		119
715	6	186			24		47		89		127
715.5	6.5	209			25		49		93		134
715.67	6.67		214		25		49		95		136
716	7		223		26		51		97		140
716.2	7.2		228		26		52		99		143
716.5	7.5		235		27		53		101		146
716.7	7.7		240		27		53		103		149
717	8		247		28		55		105		152
717.2	8.2		252		28		55		107		155
717.5	8.5		259		29		56		109		158
717.7	8.7		263		29		57		110		160
718	9		270		29		58		113		164

$Q_{(weir)} = CLH^{3/2}$

where: $C=3.16$

$L=4ft.$

H=varies (ft.)

NOTE: The transition from weir flow to orifice flow occurs between 1.2 to 1.33 (Ht. of gate opening). For a conservative approach, we assume orifice flow will occur at 1.2 (Ht. of gate opening).

$Q_{(orifice)} = C_dA(2gH)^{1/2}$

where: $C_d=0.62$

g=32.2 ft. per second squared.

H=varies (ft.)

A= 4' x Ht.of gate opening (sq. ft.)

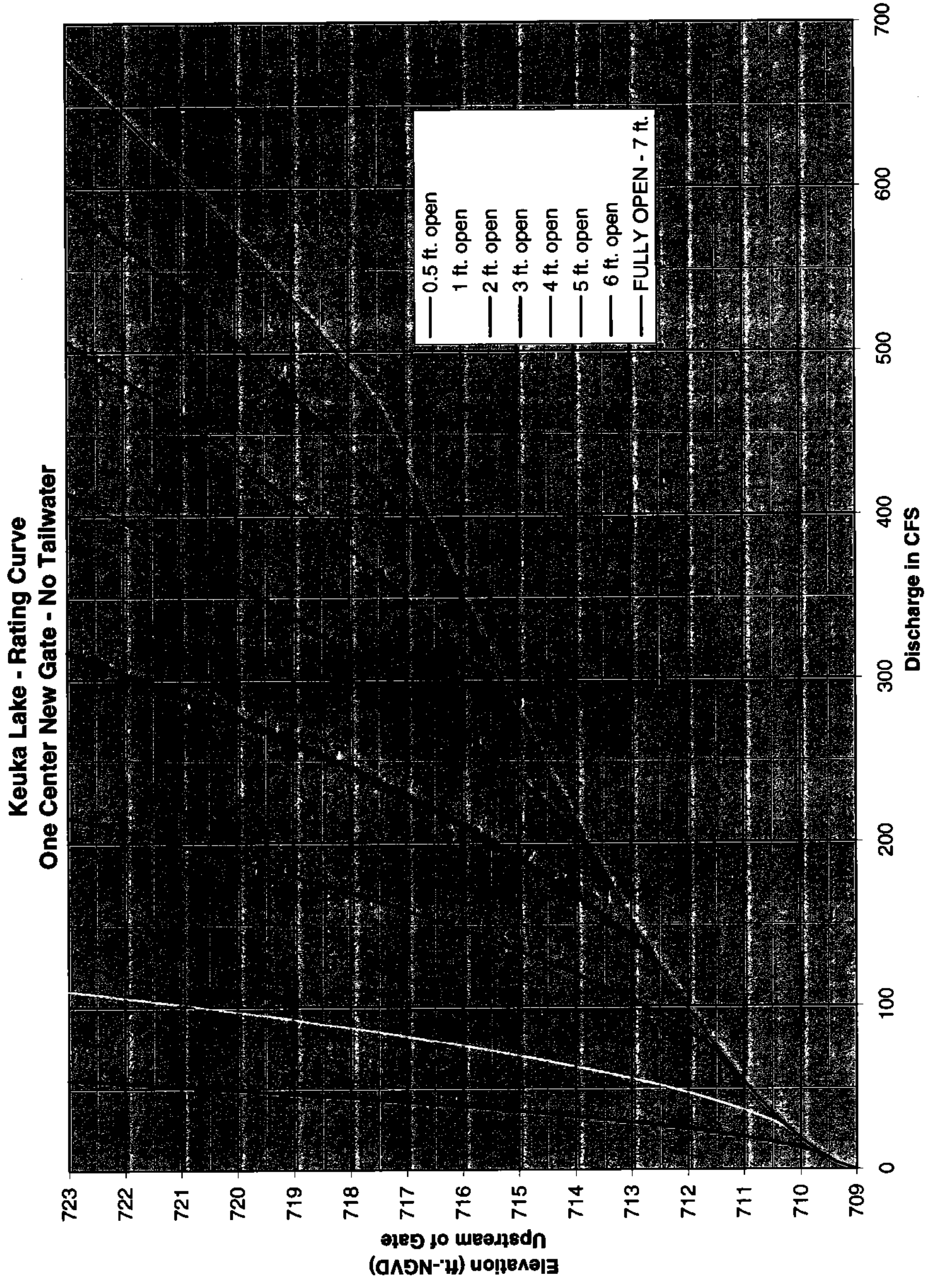
BIRKETT GATE: 1 gate 4.0 FT. wide and 5.4 FT. high — Bottom of Sill = 709.0 ft.

COMPUTATIONS FOR **1 GATE ONLY** - **various** gate openings.

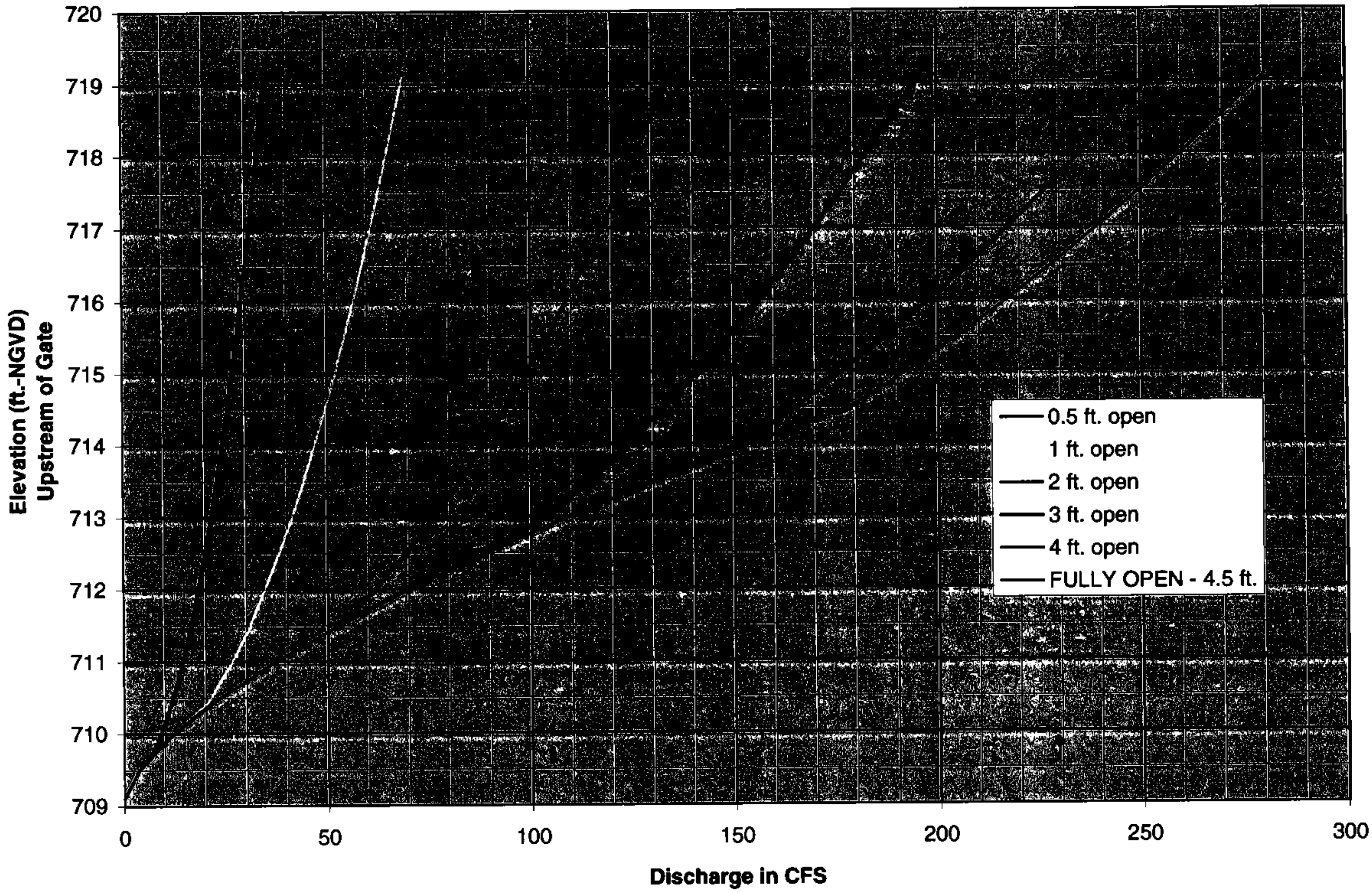
Per Mike Smith after conversation with Mr. Webster of Keuka Lake, Birkett Gate is fully operational.

It was fixed recently and can be opened to a full height of 5.4 feet to aid in passage of 1000 cfs.

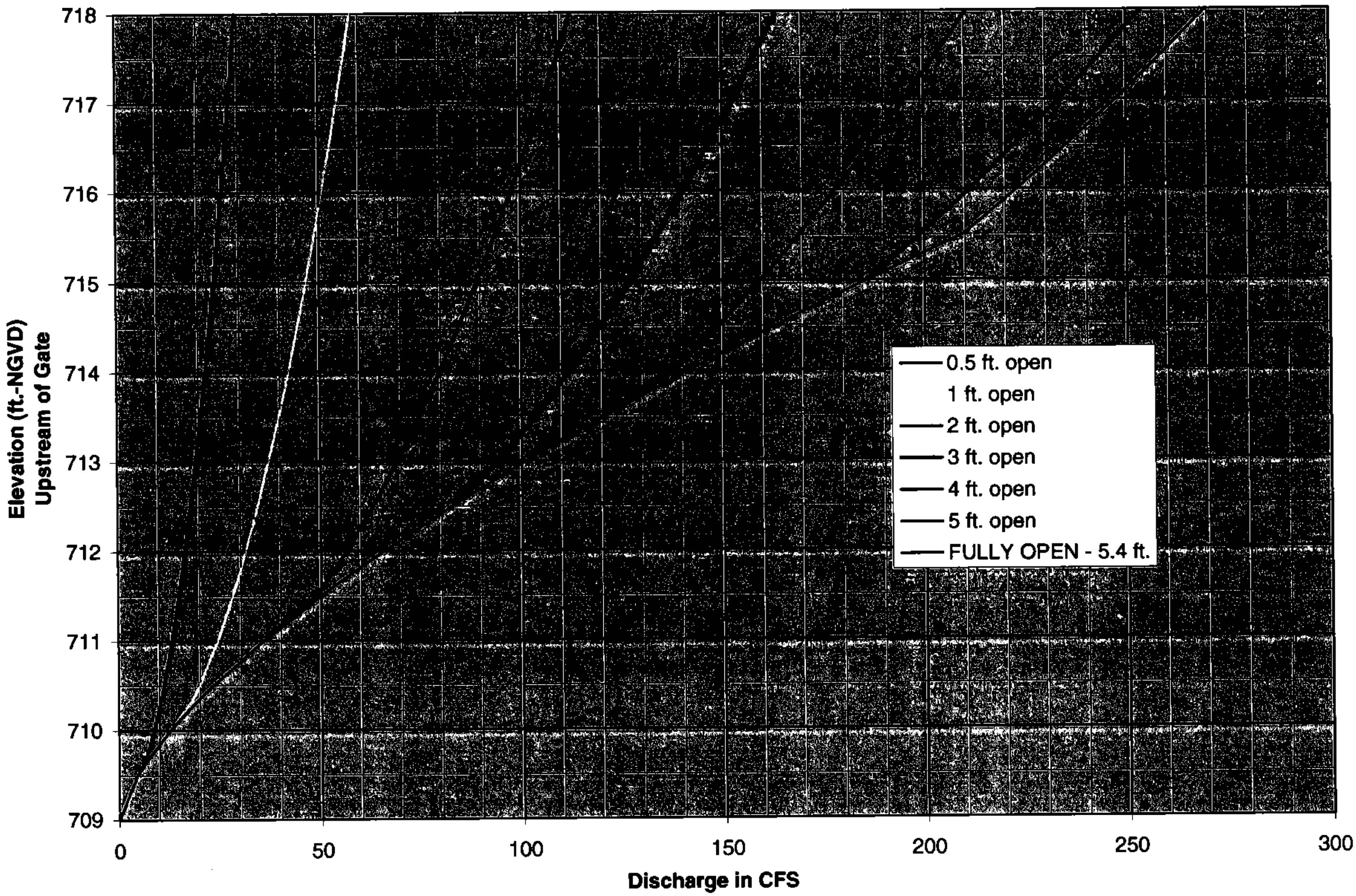
		4 ft open	4 ft. open	5 ft open	5 ft open		
ELEV. (ft.)	H (ft.)	Q(weir)CFS	Q(orifice)CF	Q(weir)	Q(orifice)		These computations assume
709	0	0		0			**NO** Tailwater.
709.5	0.5	4		4			
709.67	0.67	7		7			
710	1	13		13			$Q_{(weir)} = CLH^{3/2}$
710.33	1.33	19		19		where:	C=3.16
710.5	1.5	23		23			L=4 ft.
711	2	36		36			H=varies (ft.)
711.5	2.5	50		50			
711.67	2.67	55		55		NOTE:	The transition from weir flow to orifice flow
712	3	66		66			occurs between 1.2 to 1.33 (Ht. of gate opening).
712.5	3.5	83		83			For a conservative approach, we assume
713	4	101		101			orifice flow will occur at 1.2 (Ht. of gate opening).
713.5	4.5	121		121			
714	5		138	141			
714.33	5.33		145	156			
714.5	5.5		149	163			
715	6		159	186			
715.5	6.5		169		199		$Q_{(orifice)} = C_dA(2gH)^{1/2}$
715.67	6.67		172		203	where:	C_d=0.62
716	7		178		211		g=32.2 ft. per second squared.
716.2	7.2		182		216		H=varies (ft.)
716.5	7.5		187		223		A= 4' x Ht.of gate opening (sq. ft.)
716.7	7.7		190		227		
717	8		195		233		
717.2	8.2		198		238		
717.5	8.5		203		244		
717.7	8.7		206		248		
718	9		211		254		


Keuka Lake - Rating Curve
One Center New Gate - No Tailwater
Elevation (ft.-NGVD)
Upstream of Gate
Discharge in CFS
723
722
721
720
719
718
717
716
715
714
713
712
711
710
709
0
100
200
300
400
500
600
700
0.5 ft. open
1 ft. open
2 ft. open
3 ft. open
4 ft. open
5 ft. open
6 ft. open
FULLY OPEN - 7 ft.

Keuka Lake - Rating Curve
One Andrews Race Gate - No Tailwater



Keuka Lake - Rating Curve
Birkett Gate - No Tailwater



 (Figure 5)

Assume ALL Gates Closed

Uncontrolled Weir Flow OVER THE NEW CENTER GATE STRUCTURE

NEW WEIR LENGTH = 57.2 ft. from AS-BUILTS, however subtract 5 feet for H-pilings, therefore weir length = 52.2 ft.

		New Center Structure		**Near Birkett**		**Birkett Gate**	**Sum-Total of**		**Over Andrews Race Gates**	Total Weir Flow	ELEV. (ft.)
ELEV. (ft.)	H (ft.)	Q(weir)CFS	H (ft.)	Q(weir)CFS	H (ft.)	Q(weir)CFS	**Birkett Gate Area** Q(weir)CFS	H (ft.)	Q(weir)CFS	Q(weir)CFS	
716	0	0								0	716
716.5	0.5	58								58	716.5
717	1	165								165	717
717.5	1.5	303								303	717.5
718	2	467	0	0	0	0	0			467	718
718.2	2.2	538	0.2	8	0.2	4	12			551	718.2
718.4	2.4	613	0.4	22	0.4	13	35			648	718.4
718.5	2.5	652	0.5	31	0.5	18	49			701	718.5
718.6	2.6	692	0.6	41	0.6	23	64			756	718.6
718.7	2.7	732	0.7	52	0.7	29	81			813	718.7
718.8	2.8	773	0.8	63	0.8	36	99			872	718.8
718.9	2.9	815	0.9	76	0.9	43	118			933	718.9
719	3	857	1	88	1	50	138	0	0	996	719
719.1	3.1	900	1.1	102	1.1	58	160	0.1	3	1063	719.1
719.2	3.2	944	1.2	116	1.2	66	182	0.2	8	1134	719.2
719.3	3.3	989	1.3	131	1.3	74	205	0.3	14	1208	719.3
719.4	3.4	1034	1.4	147	1.4	83	229	0.4	22	1285	719.4

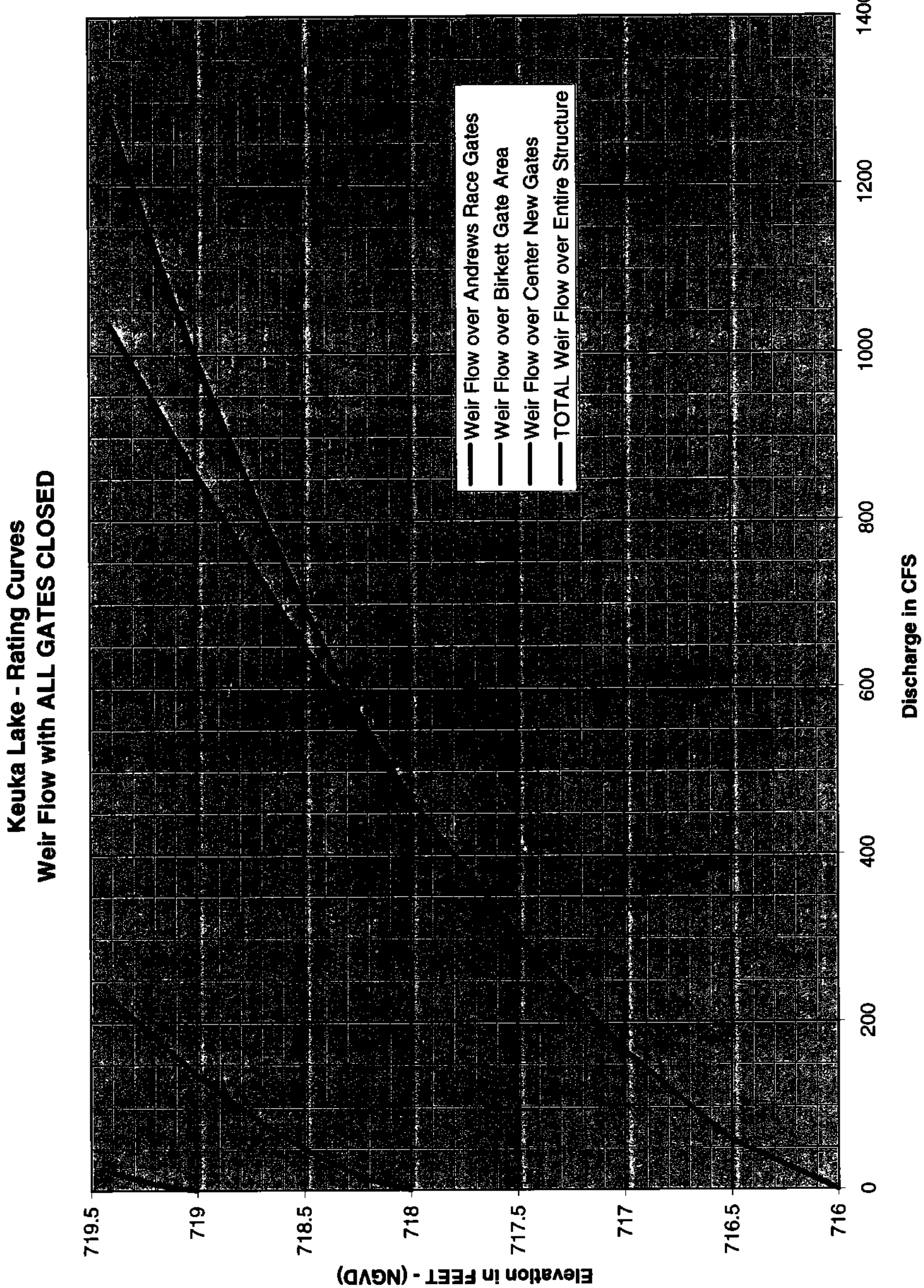
For Example: Over New Center Structure:

These computations assume NO Tailwater.

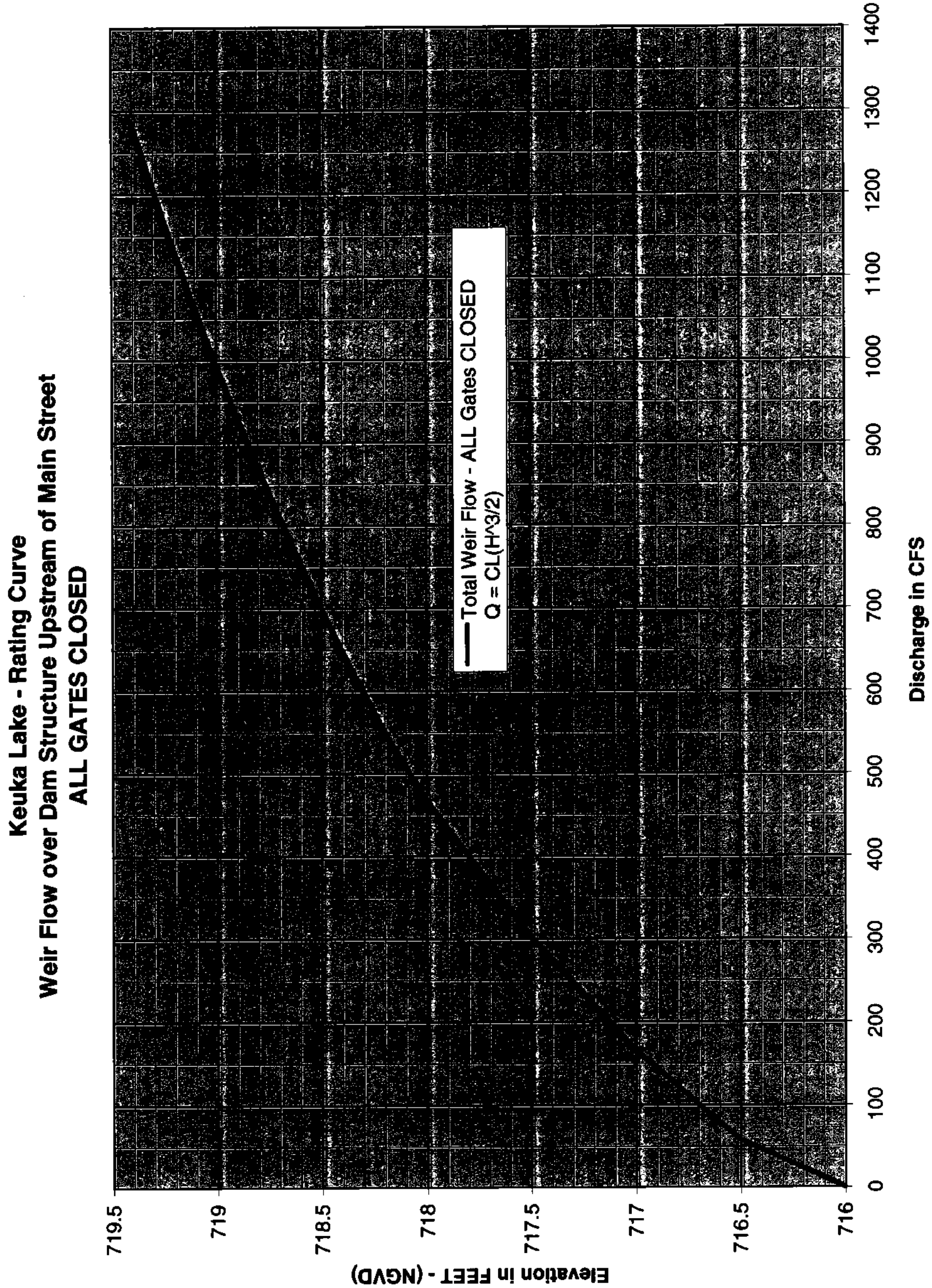
$Q_{(weir)}=CLH^{3/2}$

where:
C=3.16
L=52.2 ft.
H=varies (ft.)

NOTE: Weir flow begins at Elev. 716 for 52.2 foot long weir over new gates excluding 5 H-piling widths.
Weir flow begins at Elev. 718 for 28 foot long weir near Birkett Gate.
Weir flow begins at Elev. 718 for 15.8 ft over Birkett Gate.
Weir flow begins at Elev. 719 for 27 feet over Andrews Race Gates and adjacent abutment.


Keuka Lake - Rating Curves
Weir Flow with ALL GATES CLOSED
Weir Flow over Andrews Race Gates
Weir Flow over Birkett Gate Area
Weir Flow over Center New Gates
TOTAL Weir Flow over Entire Structure
Elevation in FEET - (NGVD)
719.5
719
718.5
718
717.5
717
716.5
716
Discharge in CFS
0
200
400
600
800
1000
1200
1400

 (Figure 6)


Keuka Lake - Rating Curve
Weir Flow over Dam Structure Upstream of Main Street
ALL GATES CLOSED
Total Weir Flow - ALL Gates CLOSED
Q = CL(H^3/2)
Elevation in FEET - (NGVD)
719.5
719
718.5
718
717.5
717
716.5
716
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
Discharge in CFS

The calculations and results as referred to above were all made at the gated structure itself. An HEC-2 "Water Surface Profiles" computer model generated from the gated structure upstream to Keuka Lake was used in order to determine the corresponding elevations at Keuka Lake. The rating curve generated at the gated structure can be found on Figure 8 (pg. A-24) with the corresponding rating curve at Keuka Lake on Figure 9 (pg. A-25). A more detailed summary description and table for the three different scenarios: Conservation Level < 714.5 ft.-NGVD, Conservation Level is 714.5 ft.-NGVD and Keuka Lake Level > 714.5 ft.-NGVD depicting the elevation at Keuka Lake, corresponding elevation at the gated structure, discharge in CFS, and gate operation can be found below.

*** <u>**NOTE:**</u> Operator <u>**MUST**</u> first Refer to corresponding descriptions to properly use the tables below.***

<u>Conservation Level < 714.5 FT.-NGVD</u>

When the Conservation Level of Keuka Lake is less than 714.5 FT.-NGVD but greater than or equal to 712 FT.-NGVD and the Keuka Lake level is <u>above</u> the Conservation Level as determined by <u>Table 1: Conservation Lake Level by Day of the Year, pg. 7-4</u>; open ALL <u>6</u> Gates Fully as indicated in **Table 2a** (i.e. 3 New Center Gates, 2 Andrews Race Gates and 1 Birkett Gate).

Table 2a - Gate Operation if Conservation Level < 714.5 ft.-NGVD

Elev.@ Keuka Lake (ft.-NGVD)	Elev.@Gates (ft.-NGVD)	Discharge (CFS)	Gate(s) Operation
712	711.15	205	Open ALL 6 Gates Fully
712.9	712	330	Open ALL 6 Gates Fully
713.4	712.5	420	Open ALL 6 Gates Fully
713.9	713	515	Open ALL 6 Gates Fully
714.4	713.5	620	Open ALL 6 Gates Fully
714.5*	713.58	640	Open ALL 6 Gates Fully

* If Keuka Lake rises above 714.5 FT.-NGVD, follow the operating plan for Keuka Lake Level > 714.5 FT.-NGVD (Flood Control Operation) in **Table 2c**.

(<u>**Special Note**</u>: If the Keuka Lake level is <u>below</u> the Conservation Level as determined by <u>Table 1: Conservation Lake Level by Day of the Year, pg. 7-4</u>, use the gate operations from <u>**Table 2b** - Gate Operation if Conservation Level is 714.5 FT.-NGVD.</u>)

Conservation Level is 714.5 FT.-NGVD

When the Conservation Level of Keuka Lake is 714.5 FT.-NGVD, the intent is to release a minimum of 20 CFS downstream. Therefore follow the operation of gates as stated in **Table 2b**, for the various range of Keuka Lake elevations. During this operation, only the 3 New Center Gates and the 2 Andrews Race Gates will be used.

Table 2b - Gate Operation if Conservation Level is 714.5 ft.-NGVD

Elev.@ Keuka Lake (ft.-NGVD)	Elev.@Gates (ft.-NGVD)	Discharge (CFS)	Gate(s) Operation
>709* to 709.74*	709 to ≤709.5	≤20	Open ALL 5 Gates
>709.74* to ≤709.85*	>709.5 to ≤709.7	≥20	2 Andrews Gates Open 0.5 FT. each and 2 Center New Gates Open 0.5 FT. each.
>709.85* to ≤710.25*	>709.7 to ≤710.2	≥20	2 Andrews Gates Open 0.5 FT. each and 1 Center New Gate Open 0.5 FT.
>710.25* to ≤ 710.8*	>710.2 to ≤710.8	≥20	2 Andrews Gates Open 0.5 FT. each.
>710.8* to ≤711.1*	>710.8 to ≤711.1	≥20	1 Andrews Gate Open 0.8 FT.
>711.1* to ≤711.6	>711.1 to ≤711.6	≥20	1 Andrews Gate Open 0.7 FT.
>711.6 to ≤712.5	>711.6 to ≤712.5	≥20	1 Andrews Gate Open 0.6 FT.
>712.5 to ≤ 714.3	>712.5 to ≤714.3	≥20	1 Andrews Gate Open 0.5 FT.
>714.3 to ≤714.5**	>714.3 to ≤714.5	≥20	1 Andrews Gate Open 0.4 FT.

* Note: The historical minimum for Keuka Lake is 711.40 FT.-NGVD for a period of record from 1960 to the present.

** If Keuka Lake rises above 714.5 FT.-NGVD, follow the operating plan for Keuka Lake Level > 714.5 FT.-NGVD (Flood Control Operation) in **Table 2c**.

Keuka Lake Level > 714.5 FT.-NGVD: Flood Control Operation

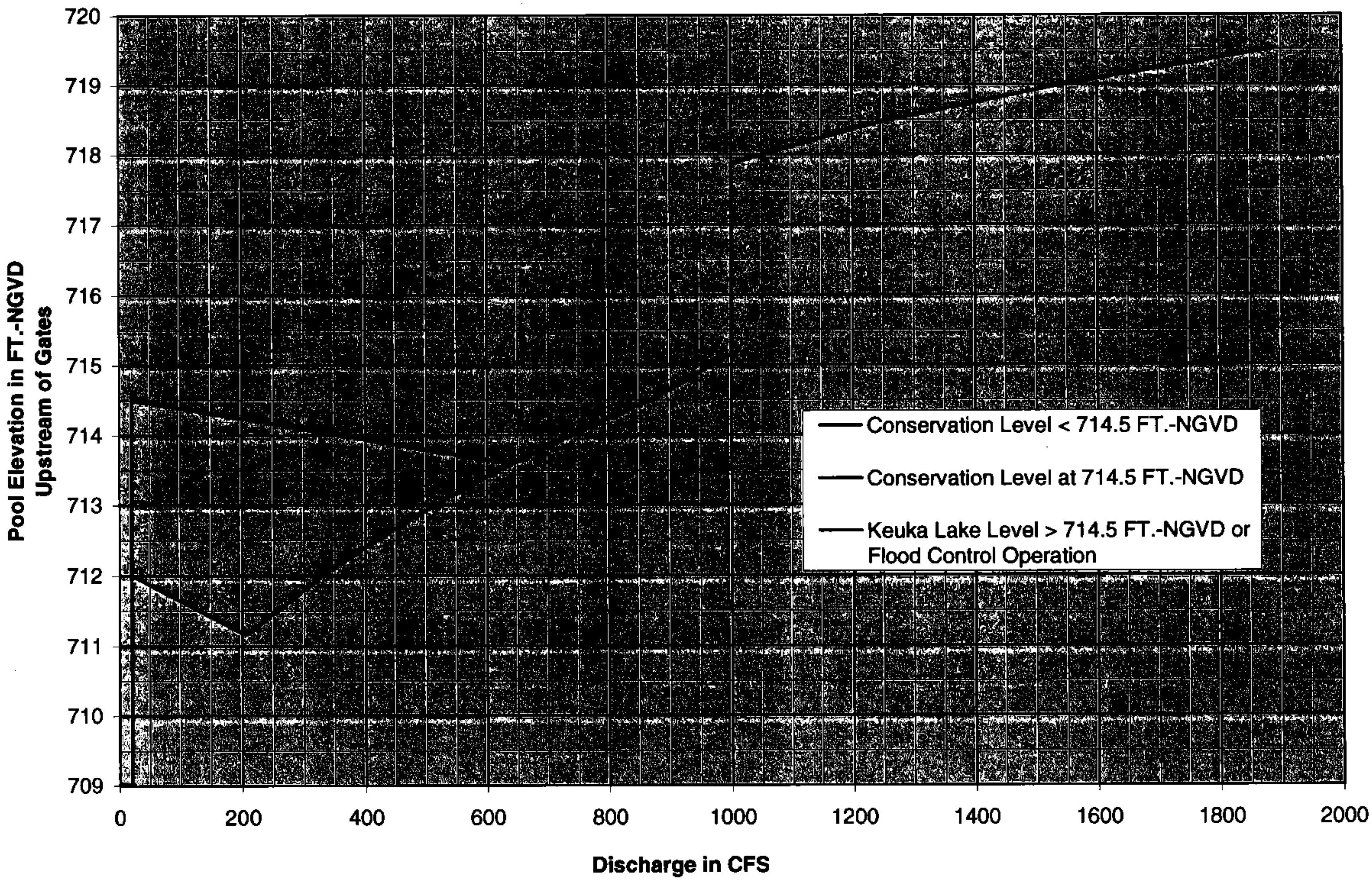
When the Level of Keuka Lake is greater than 714.5 FT.-NGVD open all 6 gates fully (i.e. 3 New Center Gates, 2 Andrews Gates, and 1 Birkett Gate) until 1000 CFS is passed through the gates. Then proceed to close the 3 New Center gates, as indicated in **Table 2c**, while keeping the 2 Andrews Gates and 1 Birkett Gate fully open to maintain a maximum of 1000 CFS. When all 3 New Center Gates are closed completely, while both Andrews Gates and Birkett Gate remain fully open, the pre-construction rating curve will be achieved. This operating plan is for both rising and receding Keuka Lake Levels above 714.5 FT.-NGVD.

Table 2c - Gate Operation if Keuka Lake Level > 714.5 (Flood Control Operation)

Elev.@ Keuka Lake (ft.-NGVD)	Elev.@Gates (ft.-NGVD)	Discharge (CFS)	Gate(s) Operation
714.5	713.58	640	Open ALL 6 Gates Fully
714.9	714	740	Open ALL 6 Gates Fully
715.43	714.5	870	Open ALL 6 Gates Fully
715.89	715	970	Open ALL 6 Gates Fully
716.03	715.15	1000	Open ALL 6 Gates Fully
>716.03 to ≤716.26	>715.15 to ≤715.5	≤1000	1 Birkett and 2 Andrews Gates Opened Fully 2 Center Gates Opened Fully 1 Center Gate Opened 2 FT
>716.26 to ≤716.62	>715.5 to ≤716	≤1000	1 Birkett and 2 Andrews Gates Opened Fully 1 Center Gates Opened Fully 1 Center Gate Opened 5.3 FT 1 Center Gate Opened 2 FT
>716.62 to ≤717.01	>716 to ≤716.5	≤1000	1 Birkett and 2 Andrews Gates Opened Fully 1 Center Gates Opened Fully 1 Center Gate Opened 2.9 FT **Close 1 Center Gate**
>717.01 to ≤717.42	>716.5 to ≤717	≤1000	1 Birkett and 2 Andrews Gates Opened Fully 1 Center Gates Opened 4.7 FT 1 Center Gate Opened 2.9 FT **Close 1 Center Gate**
>717.42 to ≤717.85	>717 to ≤717.5	≤1000	1 Birkett and 2 Andrews Gates Opened Fully 1 Center Gate Opened 3.5 FT **Close 2 Center Gates**
>717.85 to ≤718.03	>717.5 to ≤717.7	≤1000	1 Birkett and 2 Andrews Gates Opened Fully 1 Center Gate Opened 2 FT **Close 2 Center Gates**
>718.03 to ≤718.17*	>717.7 to ≤717.86	≤1000	1 Birkett and 2 Andrews Gates Opened Fully **Close 3 Center Gates**
718.21	717.9	1014	1 Birkett and 2 Andrews Gates Opened Fully **Close 3 Center Gates**
718.72	718.35	1200	1 Birkett and 2 Andrews Gates Opened Fully **Close 3 Center Gates**
718.89	718.5	1270	1 Birkett and 2 Andrews Gates Opened Fully **Close 3 Center Gates**
719.55	719	1550	1 Birkett and 2 Andrews Gates Opened Fully **Close 3 Center Gates**
720.2	719.5	1890	1 Birkett and 2 Andrews Gates Opened Fully **Close 3 Center Gates**

* When Keuka Lake reaches 718.17 FT.-NGVD, all 3 Center Gates should be closed while 2 Andrews Gates and 1 Birkett Gate remain fully open. This operation should continue for Keuka Lake > 718.17 FT.-NGVD.

Keuka Lake - Rating Curve at Gated Structure



 (Figure 8)

Keuka Lake - Rating Curve
at Keuka Lake