WATER CONTROL MANUAL

CENTER HILL DAM AND RESERVOIR

Cumberland River Basin

U.S. Army Corps of Engineers
Great Lakes and Ohio River Division
Nashville District
Lancaster, Tennessee

April 2024

Project Photo

RECORD OF CHANGES

Date of Change	Section Number of Change/ Complete Update	Summary of Change
December 1998	Administrative Update	Change from Regulation Manual to Water Control Manual.
21 September 2017	Administrative Update	Added fuse plug information.
13 April 2024	Complete Update	Minimum flow, ramp rates, reformatting, removal of crop season, terminology update.

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NOTICE TO USERS OF THIS MANUAL

Regulations specify that this water control manual be published in digital form in the central repository located at the following link:

https://cwbi-int.sec.usace.army.mil/dcp

The water control manual at the central repository will be considered the official manual and will always be kept current. Instructions and information to upload or document the review status of the water control manual, as per ER 1110-2-240, in the central repository portal can be found under the help tab in the portal.

It is not unexpected that USACE Corporate Information may move the central repository link to a new location. This information will be shared with all offices if a situation occurs by the HQUSACE.

REGULATION ASSISTANCE PROCEDURES

In the event that unusual conditions arise during nonduty hours, communication can be achieved by contacting, in the order listed, one of the following personnel:

- Cordell Hull Powerhouse (remote plant)

[redacted]

- [redacted], Center Hill Maintenance Supervisor:

[redacted]

- [redacted], Center Hill Resource Manager:

[redacted]

- [redacted], Water Management:

[redacted]

- [redacted], Water Management:

[redacted]

- [redacted], Water Management Section Chief:

[redacted]

- [redacted], Water Management Streamgaging:

[redacted]

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VERTICAL DATUM CONVERSIONS

All elevations in this report are referenced to NGVD29 feet. At the dam site, the NGVD29 to NAVD88 offset is -0.203 feet i.e., 648.0 NGVD29 = 647.8 NAVD88.

CENTER HILL PERTINENT DATA

a. Location. Center Hill Dam is located on the Caney Fork River, at river mile 26.6, in DeKalb County, Tennessee (TN), 14 miles southeast of the city of Carthage (North 36°05′48", West 85°49′38").

b. Drainage Area. The Center Hill drainage basin encompasses 2,174 square miles (mi^2). One inch (") of runoff in the basin equates to a change of storage of 58,456 day-second-feet (dsf) (115,950 acre-feet). The Great Falls Dam is located 64.5 river miles upstream from Center Hill Dam on the Caney Fork River and its drainage basin encompasses 1,675 mi^2.

c. Physical Components. Center Hill is a combination of a concrete gravity dam and a rolled earthfill embankment. The concrete gravity dam has a total length of 2,160 feet (’). The spillway section is 470’, the power section is 267’, the left side, non-overflow section is 400’, the right-side non-overflow section is 245’, and the rolled earthfill embankment section is 778’. Center Hill is outfitted with eight Tainter gates on a concrete gravity ogee spillway with a spillway crest at elevation 648.0. The spillway has a bucket stilling basin. The effective spillway width is 400’ (eight gates, 50’ wide each) and each gate is 37’ high. The spillway design discharge is 458,000 cubic feet per second (cfs). Center Hill is also outfitted with six cast iron, slide, hydraulically operated sluice gates each 4’ wide by 6’ tall. The sluice gates have a total discharge capacity with a pool at spillway crest (elevation 648.0) of 9,600 cfs. Center Hill has a rolled-fill dike saddle dam approximately 0.5 mile east of the main dam that is 770’ long by 35’ wide. The top of the saddle dam is at elevation 696.6. The saddle dam is equipped with a fuse plug and rolled compacted concrete (RCC) berm downstream. The fuse plug was added within the saddle dam and is 600’ in width and 34.4’ high. The RCC berm immediately downstream of the saddle dam is an 850’ long and 750’ wide weir. The fuse plug has a design discharge of approximately 400,000 cfs. Center Hill has three Francis turbines with three 20’ diameter penstocks. The nominal head is 160’, the nominal discharge is 3,950 cfs per unit, and the nameplate power rating is 57 megawatts (MW) each (171 MW total).

d. Real Estate. Real estate fee holdings total approximately 38,551 acres and easement holdings total approximately 102 acres above the dam and 427 acres below the dam. The guideline for acquisition is elevation 690.0; however, additional lands at the damsite and upstream which were deemed necessary to avoid paying excessive severance or incidental damages due to isolation were acquired.

e. Pertinent Elevations. Pertinent elevations are displayed in Table P-1 below.

Table P-1. Pertinent Elevations

			Reservoir Capacity			
	Elevation (feet, NGVD)	Reservoir Area (acres)	Cumulative Volume (acre-feet)	Cumulative Volume (dsf)	Incremental Volume (acre-feet)	Incremental Runoff (inches)
Top of Dam	696.0	-	-	-	-	-
Top of Fuse Plug	692.0					
Maximum Pool	685.0[1]	-	-	-	-	-
Top of Surcharge Pool	686.0	23,190	2,114,380	1,067,860	22,380	0.20
Top of Flood Control Pool (Top of Gates)	685.0	20,060	2,092,000	1,054,000	762,000	6.58
Top of Conservation Pool (Spillway Crest)	648.0	18,220	1,330,000	671,000	492,000	4.24
SEPA Band	623.5-648.0	-	-	-	411,221	3.53
Top of Inactive Pool	618.0	14,590	838,000	422,500	838,000	10.82
Turbine Penstock Centerline	549.9	5,400	148,500	75,000	-	-
Sluice Invert	496.0	680	5,970	3,010	-	-
Streambed	470.0[2]	-	-	-	-	-

[1]Maximum Pool elevation taken from the Spillway Design Flood
[2]Approximate Elevation

I - INTRODUCTION

1-01 Authorization

This manual is prepared in accordance with the following regulations:

ER 1110-2-240, “Water Control Management,” dated 30 May 2016, which assigns to District Engineers the responsibility for development of plans and manuals for operation of reservoirs.

ER 1110-2-1400, "Reservoir/Water Control Management," which describes the delegated responsibilities Water Management Divisions for water management activities. New water control manuals or revised water control manuals which contain a change to the water control plan must be developed with full public involvement as required by WRDA 1990, Sec. 310, must comply with the National Environmental Policy Act (NEPA) per ER 200- 2-2, and must be sent to CECW-CE for review and comment prior to MSC approval, in accordance with ER 1110-2-240.

EM 1110-2-3600, “Management of Water Control Systems,” dated 10 October 2017, which provides technical guidance on management and operation of water control systems and general guidance on the content of Water Control Manuals.

ER 1110-2-8156, “Preparation of Water Control Manuals,” dated 30 September 2018, which provides specifications on Water Control Manual content and format.

ER 1110-2-1156, “Safety of Dams – Policy and Procedures,” dated 31 March 2014, which prescribes the guiding principles, policy, organization, responsibilities, and procedures for implementation of risk-informed dam safety program activities and a dam safety portfolio risk management process within the USACE.

ER 1110-2-8154, "Water Quality Management," dated 31 May 2018, which provides direction for the water quality management of U.S. Army Corps of Engineers' (Corps) Civil Works projects including the Corps policy to comply with requirements of the Clean Water Act not to degrade existing water quality to the maximum extent that is practicable, consistent with project authorities, Federal legal and regulatory requirements, the public interest, and water control manuals.

1-02 Purpose and Scope

The purpose of this manual is to serve as a guide for the day-to-day and emergency regulation of the Center Hill project, and to provide background information on the project. This manual presents the plan of regulation for the Center Hill project and furnishes information pertinent to its operation.

1-03 Related Manuals and Reports

This manual supersedes the previous manual "Center Hill Dam Water Control Manual", dated December 1998.

a. Original Water Control Manuals.

Table 1-1. Original Water Control Manuals

Master Regulation Manual for Reservoirs in the Cumberland River Basin Revised March, 1954		
	Appendices	Date
A:	Regulation Manual for Wolf Creek	March 1954
B:	Regulation Manual for Dale Hollow	March 1954
C:	Regulation Manual for Center Hill	March 1954
D:	Regulation Manual for Old Hickory	November 1959
E:	Regulation Manual for Cheatham	November 1959
F:	Regulation Manual for Barkley Reservoir	April 1969
G:	Regulation Manual for J. Percy Priest Reservoir	April 1977

b. Revised Water Control Manuals.

Table 1-2. Revised Water Control Manuals

Cumberland River Basin Water Control Manuals		Published
Volume I	Master Water Control Reference Manual	April 1990
Volume II	Master Water Control Plan	December 1998
Volume III	Barkley Water Control Manual	December 1998
Volume IV	Cheatham Water Control Manual	December 1998
Volume V	Old Hickory Water Control Manual	December 1998
Volume VI	Cordell Hull Water Control Manual	January 2022
Volume VII	J. Percy Priest Water Control Manual	December 1998
Volume VIII	Center Hill Water Control Manual	December 1998
Volume IX	Dale Hollow Water Control Manual	February 2021
Volume X	Wolf Creek Water Control Manual	December 1998
Volume XI	Laurel Water Control Manual	May 2017
Volume XII	Martins Fork Water Control Manual	May 2017

c. Related Manuals.

- Center Hill Dam Instructions for Reservoir Regulation – Revised December 1998.
- Cumberland River Basin Drought Contingency Plan – November 1994.
- The Emergency Action Plan - April 2020

1-04 Project Owner

The owner is the U.S. Army Corps of Engineers (USACE), an agency of the United States

Government.

1-05 Operating Agency

The operating agency is the U.S. Army Corps of Engineers, Nashville District (LRN). At the powerhouse, there are twelve full time employees: one senior electrician, three journeyman electricians, one senior mechanic, three journeyman mechanics, and two maintenance mechanics who work 10-hour shifts Monday-Thursday. One office assistant and one powerhouse maintenance supervisor work 8-hour shifts Monday-Friday. Center Hill Dam operations were remoted to Cordell Dam on 16 October 1973. Cordell Hull operators are responsible for generator and gate operations and are on shift 24/7.

At the resource manager's office, there are 12 full time employees: one resource manager, one environmental protection specialist, one conservation biologist, three natural resource specialists, three civil engineer technicians, one park contract inspector, one maintenance mechanic, and one office administrator.

1-06 Regulating Agencies

LRN is the regulating agency for Center Hill Dam. The Water Management Section of the Hydrology and Hydraulics Branch is responsible for directing the regulation of the dam. The project staff at Center Hill Dam are responsible for executing those directions. The hydropower marketing agency is the Southeastern Power Administration (SEPA), and the hydropower scheduling agency is the Tennessee Valley Authority (TVA).

LRN maintains a network of rain gages, as well as stream gages, in the Center Hill basin. Stream gages are on the Collins River at McMinnville, the Falling Water River near Cookeville, and the Calfkiller River at HWY 70 at Sparta. Additionally, rain gages are located at Statesville, Cookeville, Monterey, and Great Falls. Additionally, LRN maintains redundant headwater and tailwater gages near the damsite. TVA maintains headwater and tailwater gages at Great Falls Dam.

Weather and river information are provided to LRN from the National Weather Service (NWS). Radar rainfall and downstream river forecasts for Carthage on the Cumberland River are provided by the National Weather Service.

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II - DESCRIPTION OF PROJECT

2-01 Location

Center Hill Dam is located at North 36°05′48", West 85°49′38"on Caney Fork River mile 26.6 in DeKalb County, TN, 14 miles southeast of the city of Carthage.

2-02 Purpose

Initial primary authorizing purposes include flood control (PL 75-761, Flood Control Act of 1938) and hydropower (PL 79-525, River and Harbor Act of 1946). Additional authorized operating purposes include recreation (PL 78-534, Flood Control Act of 1944), fish and wildlife (PL 85-624, Fish and Wildlife Coordination Act of 1958, PL 93-205, Endangered Species Act of 1973), water quality (PL 92-500, Federal Water Pollution Control Act Amendments 1972) and water supply (PL 85-500, Water Supply Act of 1958).

2-03 Physical Components

Plate II-1, Plate II-2, and Plate II-3 in the Plates Appendix show a general plan view and the physical components of Center Hill Dam.

a. Dam. Combination concrete gravity and rolled earthfill embankment with a total length of 2,160’. This includes: concrete spillway section 470’ long; concrete power section 267’ long; concrete left side, non-overflow section 400’ long; concrete right side, non-overflow section 245’ long; and rolled earthfill embankment section 778’ long. Top of dam, roadway, and embankment elevation is at 696.0.

b. Spillway. Concrete gravity Ogee with 400’ long effective width. Controlled by eight 50’ wide by 37’ high Tainter gates. Spillway crest elevation is at 648.0.

c. Sluices. Six 4’ x 6’ cast iron sluice gates (two per conduit) are operated hydraulically. One of these gates is modified with a restrictor plate to limit the flow to approximately 250 cfs, this gate is referred to as the orifice gate.

d. Power Plant. Three Francis turbines with 57 MW nameplate power rating. Three 20’ diameter penstocks with a penstock intake centerline elevation of 549.9.

e. Saddle Dam & Fuse Plug. Approximately 0.5 mile east of the main dam is a 125’ tall and 800’ long earthen embankment, most often referred to as a “saddle dam”. A fuse plug was added to the existing saddle dam to provide additional spillway capacity to pass the design storm. The fuse plug is primarily made of homogenous sand grain material. Water is prevented from going through the sand by an impervious geomembrane located in parallel to the upstream face of the fuse plug. The fuse plug is separated from the existing saddle dam by a non-erodible concrete slab. The fuse plug is 600’ wide and 35’ high. Further description of the saddle dam and fuse plug can be found in Section 7-12

Dam Safety. Top of saddle dam embankment elevation is 658.0. Top of fuse plug elevation is 692.0.

f. RCC Berm. Immediately downstream of the saddle dam is a concrete gravity berm with a top elevation of 658.0. The berm is 850’ long, 130’ high, with a 750’ wide weir.

2-04 Related Control Facilities

Center Hill Dam is located upstream of Old Hickory Dam. Great Falls Dam, operated by TVA, is located upstream of Center Hill Dam. Plate II-4 in the Plates Appendix shows a detailed map of the Center Hill Reservoir. Plate II-5 is a map showing where Center Hill is located in reference to the other reservoirs in the Cumberland River Basin. Plate II-6 shows a schematic of the dams in the Cumberland River Basin and how they align in the system. Plate II-7 shows the profile of the Cumberland River with the existing projects labeled.

2-05 Real Estate Acquisition

Fee holdings at the project include 38,551 acres and easement holdings total 102 acres above the dam and 427 acres below the dam. The guideline used for acquisition was elevation 690.0; however, additional lands at the damsite and upstream which were deemed necessary to avoid paying excessive severance or incidental damages due to isolation.

2-06 Public Facilities

Multiple access locations and public facilities are associated with Center Hill Dam. These are listed in Exhibit A and include private facilities (commercial docks), USACE recreation areas and state park facilities.

III - HISTORY OF PROJECT

3-01 Authorization

The initial purposes for which Center Hill Dam and Reservoir was authorized include flood control (PL 75-761, Flood Control Act of 1938) and hydropower (PL 79-525, River and Harbor Act of 1946).

Additional authorized purposes for which the project is operated include recreation (PL 78-534, Flood Control Act of 1944), fish and wildlife (PL 85-624, Fish and Wildlife Coordination Act of 1958, PL 93-205, Endangered Species Act of 1973), water quality (PL 92-500, Federal Water Pollution Control Act Amendments of 1972), and water supply (PL 85-500, Water Supply Act of 1958).

3-02 Planning and Design

Center Hill Reservoir is a major unit in the comprehensive plan for the development of the Cumberland River Basin. It was authorized for construction by the Flood Control Act of 1938 and the River and Harbor Act of 1946.

Subsequent Congressional authorizations expanded project purposes to include recreation, water supply, fish and wildlife conservation, and water quality. Section 4 of the Flood Control Act of 1944 authorized the Corps to construct, maintain, and operate public parks and recreational facilities in reservoir areas under the control of the Department of the Army. Storage space in the reservoir is allocated for water supply on a permanent basis in accordance with the Water Supply Act of 1958 (PL 85-500). The Fish and Wildlife Coordination Act (FWCA) of 1958 (PL 85-624) authorized specific project authority to evaluate, protect, and enhance fish and wildlife resources. Section 661 of the FWCA provides that fish and wildlife conservation shall receive equal consideration with other project purposes. Additionally, water quality was added as an authorized purpose by the Federal Water Pollution Control Act Amendments of 1972 (PL 92-500, commonly known as the Clean Water Act). The objective of the Clean Water Act was to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters".

3-03 Construction

Construction of Center Hill Dam began 18 March 1942. Construction was suspended due to WWII in October 1943, but work resumed in January 1946 and closure was achieved 27 November 1948. Impoundment was achieved on 11 January 1949. Hydropower units 1, 2, and 3 were placed in service in December 1950, January 1951, and April 1951, respectively. Installation of new auto-venting hydropower units started in 2015 and hydropower units 2, 3 and 1 were placed in service in August 2017, July 2020, and March 2021, respectively.

3-04 Related Projects

Center Hill Dam is located upstream of Old Hickory Dam, which is located at Cumberland River mile 216.2, 92 miles downstream of Carthage. Great Falls Dam, operated by TVA, is located at Caney Fork River mile 91.1, 64.5 miles upstream of Center Hill Dam.

Center Hill Dam is part of the comprehensive development plan for the Cumberland River Basin. Including Center Hill, there are ten multipurpose reservoirs on the Cumberland River and its tributaries operated and constructed by LRN. These ten reservoirs are operated as a system of reservoirs to best optimize prescribed project benefits.

3-05 Dam Safety

The Dam Safety Action Classification System (DSAC) is intended to provide consistent and systematic guidelines for appropriate actions to address the dam safety issues and deficiencies of USACE dams. USACE dams are given a DSAC rating based on their individual dam safety risk, considered as a combination of probability of failure and potential life safety, economic, environmental, or other consequences. Center Hill was reclassified from a DSAC I to a DSAC III dam in 2020 as the result of placing a grout curtain and concrete barrier wall in the main embankment in 2012 and 2015 and a RCC berm downstream of the saddle dam embankment in 2020. USACE considers this level of life-risk to be in a tolerable range, but the dam does not meet all essential USACE guidelines. In 1992, a phase 1 dam safety evaluation ruled that Center Hill Dam would not pass the full probable maximum flood and remedial work on the saddle dam was necessary. The existing saddle dam and fuse plug were added to help pass the necessary flows to prevent overtopping of Center Hill Dam. The fuse plug is a water retaining embankment and was added on top of the existing saddle dam to increase the spillway capacity. The fuse plug is an erodible structure with concrete base that will act as a concrete spillway if it is overtopped and washed out. After heavy rains or at elevations above 658.0, the fuse plug will require monitoring since this structure is designed to activate automatically without operator instruction. Minor repairs are required immediately to correct faults related to settling, sloughing, seepage, and erosion.

On 18 July 2023, a flow measurement was taken to record the estimated discharge from the leakage at the right abutment of Center Hill Dam, which has been deemed to not be a dam safety risk. The range of flows recorded were from 58 cfs to 78 cfs.

USACE is continuing to attempt to lower the life-safety risk at Center Hill with a Tainter gate replacement project. Failure of a Tainter gate is one such potential life-loss failure mode and is why Center Hill is still a DSAC III. As part of the periodic inspection, powerhouse personnel are required to take Center Hill specific dam safety training with an emphasis to continually survey the site for warning signs or impacts to dam safety. The last periodic inspection at Center Hill Dam was in 2021. Periodic Assessments are conducted on a ten-year recurring interval and in conjunction with the periodic inspection. During the periodic assessment, a potential failure

mode analysis and risk assessment of the entire structure will be reviewed. The next periodic assessment shall be in 2026. The DSAC rating could be changed then if the Tainter gate rehabilitation has been completed.

3-06 Principal Regulation Problems

Interim Risk Reduction Measures (IRRM) were initiated on 21 December 2006 to lower the pool for Dam Safety after Center Hill Dam was rated as a DSAC I, which categorizes the potential failure modes as urgent and compelling. The lowering of the Conservation Pool to the lowest practical level reduced the level of pressure on the foundation and reduced the probability of failure to protect the public upstream and downstream of the project. This drawdown of the pool lasted until February 2020 and mainly consisted of repairs to multiple areas of active piping and sinkholes in the left rim abutment, right rim abutment, and main dam embankment.

3-07 Modifications to Regulations

This 2024 manual replaces the Center Hill Water Control Manual dated December 1998. This manual primarily consists of a stylistic update to comply with current regulations and to update plots and data; however, the following changes were implemented in this manual:

- The control flow at Carthage does not vary seasonably based on crop or flood season. It is now 72,000 cfs year-round. The previous control flows were lowered during crop season to 45,000 cfs or a 20’ stage, typically 15 April to 15 December. This modification is first mentioned in Section 4-09.
- Hydropower ramp rates are limited to a max of one unit up in the first hour and a max of two units up in the second hour. Ramp rates down will remain at a max of two units per hour. This modification is first mentioned in Section 7-02.
- The minimum flow requirement from Center Hill Dam varies seasonally. During the non-low flow season, the minimum flow is one unit hour of generation every eight hours. During the low flow season, the minimum flow is 250 cfs continuous, typically through the orifice gate, and one unit hour of generation at least every 48 hours. The low flow season is generally understood to be between 01 June through 30 November but can be modified based on hydrologic conditions. The non-low flow season is understood to be any period outside of the low flow season, generally defined as 01 December through 31 May. This is first mentioned in Section 7-02.
- The pool between elevations 618.0-648.0 is now known as the Conservation Pool. This pool was formerly known as the Power Pool. This change is addressed in Section 7-03(c).

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IV - WATERSHED CHARACTERISTICS

4-01 General Characteristics

Center Hill Dam lies in the middle of the Cumberland River Basin, located in Dekalb County, TN, at Caney Fork River mile 26.6. At elevation 648.0, Center Hill Reservoir has a surface area of 28.47 mi^2 (18,220 acres) and encompasses parts of DeKalb, Putnam, and White Counties in TN. Center Hill Reservoir is LRN's second largest storage reservoir with a storage volume at the top of Flood Control Pool of just over two million acre-feet.

The Caney Fork River, the largest tributary of the Cumberland River, drains a fan-shaped area of 2,585 square miles lying entirely within the State of Tennessee. The drainage area above the Center Hill dam is 2,174 square miles. The length of the river is approximately 145 miles, while the basin has a length of 70 miles and a maximum width of 60 miles. The Caney Fork rises in Cumberland County to approximately elevation 2000, flows westerly to its junction with the Collins and Rocky Rivers, and then flows northwesterly to join the Cumberland River at Carthage, TN (mile 309.2). The other principal tributary is the Falling Water River which joins approximately 27 miles above the dam. All streams in the basin flow through narrow valleys and gorges.

4-02 Topography

The Center Hill Reservoir area is dominated by two Level IV sub-ecoregions: the Eastern Highland Rim (71g) and the Outer Nashville Basin (71h). Stream dissection along tributary streams of the Caney Fork has created a steep ridge and valley topography.

Center Hill Reservoir covers a deeply carved meandering Caney Fork River valley. The rough terrain surrounding the reservoir has slopes often exceeding forty-five percent, and the irregular shoreline forms many deep narrow coves. In the lower section of the reservoir, however, some open areas are found with gradual slopes leading from the surrounding hillsides to the edge of the water (OMP 2004). Plate IV-1 shows the elevation map for the Center Hill Basin. Plate IV-2 shows the stream profile for the Caney Fork River.

Eastern Highland Rim (71g) has level terrain, with landforms characterized as tablelands of moderate relief and irregular plains. Numerous springs and spring-associated fish fauna also typify the region. Natural vegetation for the region is transitional between the oak-hickory type to the west and the mixed mesophytic forests of the Appalachian ecoregions to the east. Bottomland hardwood forests were once abundant in some areas, although much of the original bottomland forest has been inundated by several large impoundments. Barrens and former prairie areas are now mostly oak thickets or pasture and cropland.

Outer Nashville Basin (71h) is a heterogeneous region, with rolling and hilly topography and slightly higher elevations. Deciduous forests with pasture and cropland are the dominant land covers. Streams are low to moderate gradient, with productive, nutrient-rich waters, resulting in

algae, rooted vegetation, and occasionally high densities of fish. The Nashville Basin as a whole has a distinctive fish fauna, notable for fish that avoid the region, as well as those that are present.

4-03 Geology and Soils

Eastern Highland Rim (71g) is composed of Mississippian-age limestone, chert, shale and dolomite predominate, and karst terrain sinkholes and depressions.

Outer Nashville Basin (71h) region encompasses most all the outer areas of the generally no-cherty Mississippian-age formations, and some Devonian-age Chattanooga shale, remnants of the Highland Rim. The region's limestone rocks and soils are high in phosphorus, and commercial phosphate is mined.

4-04 Sediment

In the Center Hill Definite Project Report, dated September 1941, silt deposits were estimated to be approximately 260 ac-ft/year. Sediment surveys were completed in 1942, 1965, 1984, and 2022. The 1942 survey has not been used to determine sedimentation rates due to an insufficient number of original ranges for accurate definition of volumes. A 1986 Report discusses the sedimentation rate between 1965 and 1984 as below the spillway crest elevation 648 is a rate of 902 af/yr. The 2022 survey indicated a reduced sedimentation rate 330 ac-ft/yr using better bathymetry mapping technology. The 2022 survey was utilized to update the stage-storage curve.

4-05 Climate

The climate of the Center Hill Basin is distinctly continental with moderate temperatures averaging approximately 60 degrees Fahrenheit and on occasion, exceeding 100 degrees or falling below zero Fahrenheit (NOAA 2014). See Table 4-1 below for monthly average rainfall in inches. Table 4-2 contains the mean pan evaporation rates for Center Hill Reservoir. Table 4-3 contains the monthly average mean temperatures since 1980. Plate IV-3 contains a climatological survey of McMinnville, TN.

Table 4-1. Average Monthly Rainfall (inches)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4.65	4.76	5.89	4.5	5.27	4.5	5.27	4.34	4.5	3.72	4.5	5.58

Table 4-2. Mean Pan Evaporation (inches)

Apr	May	Jun	Jul	Aug	Sep	Oct
0.17	0.2	0.24	0.23	0.22	0.19	0.12

Table 4-3. Monthly Average Mean Temperatures (°F) at McMinnville, TN

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
1980	39.7	35.7	46.3	57.3	67.8	75.5	82.8	81.7	76.0	57.8	48.5	41.0	**59.2**
1981	35.5	42.6	47.5	64.0	64.2	77.5	79.8	76.6	68.1	60.4	49.9	38.3	**58.7**
1982	34.0	39.5	52.5	54.6	71.0	73.3	79.8	76.1	69.6	61.1	51.4	48.2	**59.3**
1983	38.8	42.7	50.3	54.5	64.8	75.5	80.5	83.2	73.7	62.4	49.9	34.0	**59.2**
1984	32.2	43.4	46.1	58.2	64.2	77.4	76.1	76.5	68.6	66.7	46.0	49.6	**58.8**
1985	27.8	36.5	53.2	61.9	68.4	75.7	80.2	77.2	70.8	64.4	56.9	34.2	**58.9**
1986	37.2	44.7	50.8	60.8	68.6	76.5	82.4	76.7	74.9	61.0	49.9	39.9	**60.3**
1987	36.1	43.1	51.8	57.7	73.4	77.5	80.2	81.1	72.2	54.6	52.4	44.1	**60.4**
1988	34.4	38.7	49.3	57.1	67.3	77.3	81.4	81.9	72.8	54.2	51.1	42.4	**59.0**
1989	44.9	39.0	52.6	59.3	65.7	74.7	79.1	78.0	70.5	61.0	51.4	29.5	**58.8**
1990	45.8	49.9	53.6	58.4	66.4	78.2	80.4	79.6	74.7	60.1	54.3	43.7	**62.1**
1991	39.2	43.9	52.5	63.8	74.2	78.2	81.1	78.3	72.3	61.2	47.2	44.5	**61.4**
1992	40.0	45.9	50.1	59.6	65.8	72.4	79.9	74.9	70.9	59.4	49.5	41.2	**59.1**
1993	41.6	39.3	47.1	56.7	67.6	75.9	83.3	81.0	71.0	58.6	47.4	40.3	**59.2**
1994	33.4	44.0	50.7	62.5	64.1	78.1	78.5	77.1	69.1	61.0	54.5	45.3	**59.9**
1995	38.6	40.4	53.5	60.9	68.5	74.7	80.8	83.3	70.7	60.0	44.0	39.5	**59.7**
1996	36.3	40.6	44.6	55.8	71.5	75.6	77.6	77.5	69.5	60.8	45.7	44.4	**58.3**
1997	37.3	45.6	53.6	54.4	63.2	72.0	79.8	76.9	71.9	59.8	45.5	39.5	**58.3**
1998	44.7	46.0	49.4	57.9	71.5	77.6	79.6	79.2	77.1	63.5	52.3	43.1	**61.8**
1999	42.5	45.8	45.6	62.6	67.6	76.5	81.9	79.4	71.9	59.9	54.0	43.7	**61.0**
2000	39.2	46.7	53.1	56.7	69.9	76.4	80.3	79.8	71.3	63.8	48.0	30.8	**59.7**
2001	35.4	44.7	45.3	63.7	68.8	73.4	79.8	78.8	70.2	58.5	54.3	44.9	**59.8**
2002	42.2	40.6	49.6	62.0	65.7	76.9	80.1	80.0	75.0	61.4	46.4	40.5	**60.0**
2003	32.9	38.0	52.0	61.2	67.2	71.9	78.3	79.3	70.2	60.6	53.5	40.3	**58.8**
2004	38.6	40.7	53.3	59.3	71.7	75.6	77.6	74.3	72.1	64.5	53.6	40.0	**60.1**
2005	43.4	45.0	47.6	59.6	66.1	76.9	81.1	81.8	75.1	61.1	51.3	37.5	**60.6**
2006	46.1	40.7	51.1	65.2	66.6	75.7	80.6	82.2	71.4	59.5	51.5	46.4	**61.4**
2007	41.7	37.1	58.2	57.3	71.1	77.9	79.9	86.9	75.8	65.4	49.8	46.3	**62.3**
2008	37.0	42.9	50.2	58.1	66.8	78.0	79.5	78.9	73.9	60.2	46.4	40.7	**59.4**
2009	35.2	43.8	52.0	59.0	67.6	77.9	75.7	77.1	72.3	56.9	51.3	39.3	**59.0**
2010	33.0	34.4	48.7	62.8	70.2	80.9	82.4	81.9	73.4	61.4	50.9	34.4	**59.6**
2011	34.4	43.7	51.3	62.8	67.2	78.6	8.03	80.5	69.1	58.6	52.0	43.8	**60.5**
2012	43.3	45.7	61.1	62.0	72.8	77.0	83.5	77.8	70.9	58.4	47.6	47.2	**62.3**
2013	42.0	42.4	44.9	59.2	67.4	77.1	77.8	77.9	73.1	61.8	46.3	41.3	**59.3**
2014	29.3	38.4	44.5	58.4	66.5	74.3	73.1	75.2	70.4	59.6	42.0	43.2	**56.2**
2015	35.6	30.4	48.9	59.5	67.9	75.4	77.6	73.3	70.0	59.2	53.5	51.8	**58.6**
2016	33.8	42.0	53.2	59.1	64.9	75.6	78.8	78.8	73.5	64.3	53.4	42.1	**59.9**
2017	45.0	48.3	50.4	62.7	66.3	72.2	77.2	74.4	68.0	60.9	50.1	39.9	**59.6**
2018	33.3	50.0	47.8	52.5	71.5	76.0	77.2	76.4	74.8	60.8	44.4	42.9	**59.0**
2019	39.6	47.1	46.2	59.1	70.0	73.5	77.8	76.7	75.7	61.7	44.7	45.6	**59.8**
2020	43.0	43.9	54.2	54.4	64.6	73.4	78.9	76.7	70.0	61.4	51.4	39.4	**59.2**
2021	39.4	37.5	52.8	55.2	63.1	73.9	77.0	77.1	69.0	62.9	45.6	50.1	**58.6**
2022	34.9	41.7	52.1	56.8	69.2	75.3	79.7	75.9	68.8	55.2	49.2	41.7	**58.4**

4-06 Storms and Floods

Major storms in the Cumberland River Basin are generally formed when a strong high-pressure area extends over the basin. The blocking effect of the high-pressure ridge creates a semi-stationary zone of convergence between warm moist air from the Gulf of Mexico and cold air from the north. These factors usually produce several storm waves along the pressure trough and heavy rainfall can occur for several days. Most floods on the Cumberland River and its tributaries result from relatively intense winter or early spring rains from late November to mid-May. This flooding is mainly because precipitation amounts are greatest during that time of year and hydrologic conditions are more conducive to excessive runoff. Intense thunderstorms occur in the basin when moist unstable Gulf air dominates the area and rapid moving fronts pass the basin. Storm duration varies considerably according to storm type. Summer storms are typically short in duration, but very intense. These types of storms generally do not cause major flooding on the Cumberland River itself but have the potential to produce flooding on its smaller tributaries. Winter and early spring storms are longer in duration and can produce large floods on the major streams. Based on NOAA Atlas 14 precipitation frequency estimates at the damsite, the precipitation frequency for the Center Hill Basin is given in Table 4-4 below.

Table 4-4. Point Precipitation Frequency Estimates

Duration		*Percent Chance Exceedance*						
		50	20	10	4	2	1	0.2
60 min	**Point Rainfall Depth (inches)**	1.57	1.95	2.28	2.73	3.12	3.53	4.62
2 hr		1.84	2.29	2.66	3.2	3.65	4.13	5.41
3 hr		2.00	2.47	2.86	3.43	3.90	4.40	5.73
6 hr		2.44	2.98	3.44	4.09	4.63	5.20	6.69
12 hr		2.94	3.58	4.11	4.86	5.48	6.13	7.78
24 hr		3.69	4.49	5.13	5.99	6.68	7.38	9.07
2 day		4.46	5.43	6.20	7.25	8.08	8.93	11.0
4 day		5.03	5.76	6.89	7.95	8.77	9.59	11.5

Historical Floods. Several destructive floods have occurred in the Center Hill Basin. Several significant events are listed chronologically below.

January 1918. This period was filled with heavy snowfall in McMinnville, TN with 10" falling in one day, which is the most ever recorded in a day there. Over 5 days, 18-22 January, 16" of

snow was recorded. As snow melt was combined with rainfall in the following weeks, the stage at Carthage, TN crested at 58.2', 18.2' above flood stage on 4 February 1918.

December 1926. The "Great Flood of 1927" is the second wettest period ever recorded in middle Tennessee. With 10.4" of precipitation falling from 20-28 December. The stage at Carthage, TN cresting at 59.8', 19.8' above flood stage on 30 December.

March 1929. Often referred to as the "Good Friday Flood", over a 48-hour period, 8.1" and 5.8" of precipitation fell in McMinnville, TN and Cookeville, TN respectively. This flood produced record flooding along the Caney Fork River and its tributaries effectively wiping out dozens of mills, houses, and bridges. The stage at Carthage, TN crested at 55.9', 15.9' above flood stage on 25 March.

January 1937. From 15-25 January 1937, there was 9.1" of precipitation in Carthage, TN. With the stage at Carthage, TN cresting at 54.7', 14.7' above flood stage on 26 January.

January 1946. The storm producing this flood was widespread and intense, covering most of south-central and southeastern United States and having numerous centers. During a 5-day span, 5.02" fell over the Center Hill Basin. With the stage at Carthage, TN cresting at 50.8', 10.8' above flood stage on 10 January.

February 1948. The flood was the result of a combination of snow and rain within a 4-day period in the Center Hill Basin. From 9-10 February, McMinnville, TN and Sparta, TN recorded 3.3" and 4.0" of snow respectively. In the following days, 12-13 February, 7.24" and 6.05" of precipitation fell in McMinnville, TN and Sparta, TN. With the stage at Carthage, TN cresting at 54.0', 14.0' above flood stage on 15 February.

March 1975. The widespread and intense rainstorm of 11-14 March produced flooding on nearly all streams in the Cumberland Basin, varying from slight to record-breaking. The flooding caused damages of major proportions in numerous localities and many counties in Tennessee and Kentucky were declared disaster areas. At the time, this event recorded the greatest one-day rainfall in Nashville of 4.66". In 48 hours, McMinnville, TN and Sparta, TN observed 7.46 and 7.35" of precipitation. Reservoir levels at Center Hill rose from elevation 640.5 on 11 March to 676.91 on 16 March. The maximum discharge at Center Hill reached near channel capacity, 30,000 cfs, at 28,693 cfs.

May 1984. Heavy rainfall occurred over all the Upper Cumberland River Basin during May. Basin average rainfall for the month was in excess of nine inches, or over twice the normal. The heaviest rain occurred over a three-day period, 06-08 May. This storm resulted in the third highest stage at Carthage since the closure of Cordell Hull with a stage of 40.2' on 08 May. The peak discharge from Center Hill was 28,408 cfs on 12 May. This storm also resulted in the highest pool ever recorded at Center Hill Dam at elevation 681.3 on 10 May 1984, 36.3' above the top of the Conservation Pool.

May 2010. A historic heavy rainfall and severe weather event occurred from the Mississippi River Valley eastward into the Southeast United States from 01-05 May. This event brought historical rainfall never witnessed in Middle Tennessee. With widespread flash flooding and river flooding on 01-02 May. Nashville set a record for one-day rainfall with 7.25" and a two-day total of 13.57". Rainfall intensity records for 6 hours (5.57") and 12 hours (7.20") were also set. The Cumberland River at Nashville had not been flooded in 26 years, but it reached its highest crest since flood control began, reaching 51.86'. Reservoir levels at Center Hill never reached the Flood Control Pool for this event but rose 16' from elevation 630.4 on 30 April to 646.48 on 05 May. This reservoir elevation did not reach Flood Control Pool for this event because the event occurred during the IRRM years for dam safety, during which time the reservoir elevation was being held near elevation 630 to reduce risk.

February 2019. Heavy rainfall occurred over all the Cumberland River Basin during February, making it the wettest February on record for the state of Tennessee. Center Hill received a total of approximately 10.9 inches of rain during the month of February. Average rainfall for LRN project watersheds for this month ranged from 10.7" to 13.4". The average rainfall for the month of February is typically around 4.3". This February event would have resulted in the highest natural stage at Nashville in history, a stage of approximately 57.2', slightly higher than the December 1926 event. However, a significant amount of the runoff was captured in the tributary projects resulting in significant reductions in observed elevations. Water Management was able to keep the observed stage at Nashville at 40.9' (16.2' lower than the natural modeled stage), 33.8' at Carthage (26.0' lower) and 32.6' at Celina (25.0' lower). The peak discharge from Center Hill was 25,303 cfs on 27 February. This storm also created a peak pool elevation of 678.0, 33.0' above the top of Conservation Pool.

4-07 Runoff Characteristics

Center Hill Dam creates a pool approximately 64 miles in length with a maximum width of approximately 1.0 mile. At elevation 648.0, the top of the Conservation Pool, the reservoir occupies an area of 28.5 mi^2.

Plate IV-4 and Plate IV-5 shows the 6-hr unit hydrographs developed for inflow into the Center Hill and Great Falls Reservoirs located in the Definite Project Report. Table 4-5 and Table 4-6 contain the 6-hour values obtained from the unit hydrographs for Great Falls Reservoir and Center Hill Reservoir.

Table 4-5. 6-Hour Unit Hydrograph for Inflow into Great Falls Reservoir

Time	Flow (cfs)	Time	Flow (cfs)	Time	Flow (cfs)
06	6,100	30	25,900	54	7,500
12	19,000	36	16,200	60	5,200
18	31,000	42	12,100	66	4,300
24	32,500	48	9,800	72	3,500

Table 4-6. 6-Hour Unit Hydrograph for Inflow into Center Hill Reservoir

Time	Flow (cfs)	Time	Flow (cfs)	Time	Flow (cfs)
06	20,100	30	31,200	54	8,700
12	25,700	36	21,000	60	7,000
18	35,500	42	15,900	66	5,500
24	36,200	48	11,500	72	3,900

Approximately 73 percent of the total annual runoff occurs between the five-month period of December through April. Approximately 82 percent occurs in the six-month period of December through May. Total runoff is approximately 24" per year. Infiltration rates are lowest in winter when they may be as low as 0.02" per hour, whereas rates of 0.10" per hour are typical in the summer and early fall. Average computed monthly inflows (dsf) and runoff (") are displayed in Table 4-7 below. The effects of the outflow from Great Falls Dam into Center Hill Reservoir were not considered in the inflow calculations below.

Table 4-7. Average Monthly Inflows (cfs) & Runoff ("), 1951-2022

Month	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	Mean
Inflow	6,623	7,606	7,837	6,159	3,946	1,881	1,337	871	965	1,208	2,219	5,454	**3,825**
Runoff	3.5	3.6	4.2	3.2	2.1	1.0	0.7	0.5	0.5	0.6	1.1	2.9	**2.0**

The average annual inflow into the Center Hill Reservoir is approximately 3,825 cfs.

4-08 Water Quality

LRN utilizes a multi-disciplinary approach to assess various environmental issues associated with Center Hill. The Water Quality mission objectives include:

1. Monitor and assess water quality conditions in the tailwater, reservoir, and significant tributaries.

2. Support Water Management operations while striving to meet USACE Environmental Operating Principles.

3. Evaluate annual water quality data for comparison to historical trends.

These objectives are accomplished by using physical, chemical, and biological indicators to support the effective operation of the Center Hill Project for the authorized purposes while maintaining the environmental integrity of project resources.

Center Hill water quality is considered good overall. However, several factors contribute to the degradation of water quality conditions in the reservoir. In addition to large scale climatic

influences on weather patterns, population growth, increased residential and commercial development, and agriculture activities in the watershed continue to have a negative impact on water quality. Nutrient and organic material loading from watershed runoff and wastewater treatment plants have led to increased algal activity which contributes to dissolved oxygen (DO) depletion in the reservoir during the summer and fall. The runoff is primarily from agricultural areas that have a significant number of plant nurseries. Wastewater discharges from McMinnville, Sparta, Baxter, Smithville, and Cookeville ultimately enter Center Hill Reservoir. Because of these influences, eutrophication has continued to increase, and the reservoir has changed from an overall rating of mesotrophic in the mid-1990s and early 2000s to eutrophic.

Center Hill is a deep, temperature stratified reservoir typical of large southern impoundments. Center Hill Reservoir has a mean depth of 73' at typical summer pool elevation and a hydraulic retention time of approximately 140 days. Typically, DO depletion occurs below the metalimnion during the warm season and results in insufficient DO availability in much of the water column to support fish and desirable aquatic life. The onset and severity of DO depletion in the hypolimnion varies due to the interaction of several biotic and abiotic factors, but the result is loss of available habitat in the hypolimnion during late summer and into the fall every year. Throughout the late fall and winter, DO is restored throughout the reservoir by cooling of surface waters (epilimnion) and the gradual mixing downward. This thermal de-stratification process, known as fall turnover, can be paused by brief spells of warm weather which slow the cooling and sinking process. Warmer winters may negatively impact the water quality at Center Hill by limiting mixing and lowering initial DO concentrations in the spring, meaning that depletion below the metalimnion may be increased.

During the summer and fall, thermal stratification causes low DO concentrations within the turbine intake zone, which results in discharges falling below the Tennessee state standard for a trout stream of 6.0 mg/L.

4-09 Channel and Floodway Characteristics

The uncontrolled drainage area of the Center Hill tailwater is approximately 411 mi^2. Starting at the confluence of the Caney Fork River and Cumberland River there are five creeks that join the Caney Fork River downstream of Center Hill Dam: Snow Creek, Bluff Creek, Mullherrin Creek, Hickman Creek, and Smith Fork Creek. The largest of these is Smith Fork Creek which joins the Caney Fork River at river mile 15.7; approximately 10.9 miles downstream of the dam. Smith Fork Creek contributes the largest amount to the total drainage area with approximately 214 mi^2. The remaining creeks, Snow, Bluff, Mullherrin, and Hickman, join the Caney Fork at river miles 2.8, 7.8, 8.7, and 11.9 respectively.

Carthage is the designated downstream control point for Center Hill. Control flow for Carthage is 72,000 cfs or a stage of 29'. The total drainage area at Carthage is 10,690 mi^2, 10,270 mi^2 (96%) of which is controlled by Center Hill and Cordell Hull. Flood stage, as determined by the

NWS, is 40'. Travel time from Center Hill to Carthage is approximately 10 to 16 hours; however, travel time can vary considerably based on flow, slope, and other factors. A table outlining approximate travel times is included in Table 4-8 below.

Table 4-8. Approximate Travel Times

Approximate Travel Times	Incremental (hours)	Total (From Center Hill)
Center Hill Dam - Carthage	10-16	-
Cordell Hull - Carthage	1	-
Carthage - Old Hickory Dam	10-16	20-32
Old Hickory Dam - Nashville	2-4	22-36
Nashville – Cheatham Dam	4-6	26-42
Cheatham Dam - Clarksville	2-4	28-46
Clarksville - Barkley Dam	10-18	38-64

The Caney Fork River channel capacity below Center Hill Dam is 30,000 cfs. The rating curve for Carthage is included on Plate IV-6. Plate IV-7 contains the Carthage damage center information. Additionally, rating curves for Center Hill tailwater, Smith Fork, Collins River, Calfkiller River, Falling Water River, and Stonewall are included on Plates IV-8, IV-9, IV-10, IV-11, IV-12, and IV-13 respectively.

4-10 Upstream Structures

The TVA operates Great Falls Dam upstream of Center Hill Dam at Caney Fork River mile 91.1.

4-11 Downstream Structures

Old Hickory Dam is located downstream of Center Hill Dam at Cumberland River mile 216.2.

4-12 Economic Data

The Center Hill Dam and Reservoir is a significant economic contributor to the region. Plate IV-14 shows the Caney Fork recreational access areas and Plate IV-15 the recreational areas on Center Hill Lake. In 2003, the Tennessee Wildlife Resources Agency (TWRA) estimated that the trout fishery below Center Hill alone had a total economic impact of $1.8 million dollars. In 2002, visitors spent over $110 million within 30 miles of Center Hill Reservoir (Corps 2007).

In addition to the economic benefits of recreation, the project also generates hydropower. Power produced is sufficient to supply a city with a population of 375,000. Between 1971 and 2021, hydropower returned an average of $3.74 million in hydropower revenues. Center Hill Dam prevents significant flood related damages. Since 1963, it is estimated that $2.7 billion in damages (in FY22 dollars) have been prevented for communities and businesses along the Caney Fork and Cumberland Rivers.

a. Population. Center Hill Dam and Reservoir is located in portions of DeKalb, Putnam, and White Counties in TN. County populations and other demographics obtained from the US Census Bureau (2022) are provided in Table 4-9.

Table 4-9. DeKalb, Putnam, and White County, TN Demographics

County	Population (2022)	Median Household Income ($)	% Below Poverty
DeKalb	21,003	45,728	15.5
Putnam	82,382	49,228	13.7
White	28,064	44,777	16.4

b. Agriculture. The entire Caney Fork River Watershed drains approximately 2,585 mi^2. 2022 land use statistics for DeKalb, Putnam, and White Counties, TN were compiled using CropScape. Predominant land use in the watershed is deciduous forest (51.80%) followed by pasture (21.96%). Developed areas represent approximately 10.68% of the total drainage area of the watershed. This is an increase in development within the watershed from approximately 9.0% in 2008. A breakdown of land use classifications within the watershed is listed in Table 4-10 on the following page.

Table 4-10. Land Use Statistics

Land Use	Acreage	Square Miles	% of Watershed
Cultivated Crops	26,316.40	39.47	3.70%
Other Hay/Non Alfalfa	24,090.70	36.14	3.38%
Sod/Grass Seed	21.80	0.03	0.00%
Fallow/Idle Cropland	2.00	0.00	0.00%
Open Water	18,478.10	27.72	2.59%
Developed/Open Space	40,401.10	60.60	5.67%
Developed/Low Intensity	23,056.10	34.58	3.24%
Developed/Medium Intensity	9,575.40	14.36	1.34%
Developed/High Intensity	3,097.30	4.65	0.43%
Barren	680.80	1.02	0.10%
Deciduous Forest	368,895.60	553.34	51.80%
Evergreen Forest	19,143.10	28.71	2.69%
Mixed Forest	18,371.60	27.56	2.58%
Shrubland	2,892.70	4.34	0.41%
Grass/Pasture	156,403.90	234.61	21.96%
Woody Wetlands	649.80	0.97	0.09%
Herbaceous Wetlands	88.70	0.13	0.01%
Total	**712,165.10**	**1,068.25**	**100.00%**

c. Industry. The Center Hill watershed is located in a rural area and consists primarily of deciduous forest. Industry in the area is of little to no consequence to the water control plan.

d. Flood damages. The Flood Control Pool has been used to some extent in 78% of all years since impoundment. The water surface has been above elevation 655.0 (17% Flood Control Pool volume used) in 33 of those years and above elevation 665.0 (43% Flood Control Pool volume used) in 15 years. The highest volume of flood control storage used was in 1984 when approximately 90% of the Flood Control Pool was used as the reservoir crested at elevation 681.52. Table 4-11 on the following page shows flood damages prevented each of the last sixteen years as well as cumulative flood damages prevented by all the Cumberland River Basin projects combined. Additionally, flood damages prevented are discussed further in section 8-02.

Table 4-11. Flood Damages Prevented

Fiscal Year	Damages Prevented (FY22 Dollars)	Cumulative Damages Prevented (FY22 Dollars)
2007	$87,577	$1,247,441,000
2008	$8,964,000	$1,256,405,000
2009	$51,829,000	$1,308,234,000
2010	$88,034,000	$1,396,268,000
2011	$39,030,000	$1,435,298,000
2012	$43,346,000	$1,478,645,000
2013	$38,386,000	$1,517,031,000
2014	$17,070,000	$1,534,101,000
2015	$32,667,000	$1,566,768,000
2016	$65,078,000	$1,631,846,000
2017	$32,563,000	$1,664,409,000
2018	$103,581,000	$1,767,990,000
2019	$368,190,000	$2,136,179,000
2020	$315,442,000	$2,451,622,000
2021	$272,137,000	$2,723,759,000
2022	$41,585,000	$2,765,344,000

V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01 Hydrometeorological Stations

a. Facilities. Plate V-1 shows the location of hydrometeorologic data collection locations. Plate V-2 is table containing the details of the data collection locations. These locations include:

- USGS 03423000 Falling Water River near Cookeville, TN
- USGS 03419530 Calfkiller River at HWY 70 at Sparta, TN
- USGS 03421000 Collins River near McMinnville, TN
- USGS 03424730 Smith Fork at Temperance Hall, TN
- USGS 03424860 Caney Fork at Stonewall
- Center Hill Dam Headwater
- Center Hill Dam Tailwater
- Statesville
- Monterey
- Great Falls

b. Reporting. All hydrometeorological station monitors are transmitted via Data Collection Platform (DCP) and the Geostationary Operational Environmental Satellite (GOES) system to the LRN district office where it is decoded by DEvice COnversion and DElivery System (DECODES) and stored in the Corps Water Management System (CWMS) Oracle database.

c. Maintenance. Maintenance contracts for the upkeep of individual hydrometeorological stations are dynamic and can change annually based on the Cooperative Stream Gaging Program between LRN, the NWS, and the USGS. Currently, LRN hydrologic technicians are responsible for the upkeep and maintenance of the headwater and tailwater redundant gages, and the gages at Cookeville, Smith Fork, McMinnville, Monterey, Statesville, and Great Falls. The Nashville, TN office of the USGS is responsible for the upkeep and maintenance of the gage at Stonewall and Sparta.

5-02 Water Quality Stations

For water quality monitoring at Center Hill, sampling schedules are organized into full and partial trips. Full sampling trips include the collection of in situ parameters, as well as water chemistry, chlorophyll a, and phytoplankton samples across active stations. Partial trips consist of only in situ parameters, collecting profiles in the reservoirs and near surface depths at tailwater and stream stations.

a. Facilities. The Center Hill Project has 24 actively sampled water quality stations for collection of physical, chemical, biological, and sediment contaminant data. There are seven outflow stations, six mainstem reservoir stations, five tributary embayment reservoir stations, and six inflow stations. Collection of in situ water quality parameters by LRN

Water Management is performed at least monthly throughout the year at Center Hill. Physical, chemical, chlorophyll a, and phytoplankton data are typically collected during the spring, summer, and fall periods. Once every ten years, full trips are conducted five times a year. Benthic macroinvertebrates are monitored once every three years at four inflow locations and two tailwater sites. Beginning in 2019, two other tailwater sites directly downstream of the dam are being sampled yearly in the spring and fall. To examine potential contaminants from metals and organic constituents, sediment samples are collected in the reservoir once every five years at six different locations. In addition to field sampling by Water Management staff, there is also a continuous water quality monitoring gage in the tailwater just downstream of the dam that collects water temperature, DO, conductivity, and pH data every thirty minutes throughout the year. A water temperature gage is also located on the Caney Fork River near Stonewall, TN. Plate V-3 shows the location of Center Hill water quality station locations. Table 5-1 shows the Center Hill Water Quality Station Types and Sample Collection.

Table 5-1. Center Hill Project Water Quality Station Types and Sample Collection

Station	Stream Name	Type	Water Quality Data Collections				
			In Situ	Physical Chemical	Phytoplankton/ Chlorophyll a	Benthic Macroinvertebrates	Sediment Contaminants
CEN10001	Caney Fork River	Tailwater / Outflow	✓	✓	-	-	-
CEN10055	Caney Fork River	Tailwater / Outflow	✓	-	-	-	-
CEN10050	Caney Fork River	River / Outflow	✓	-	-	✓	-
CEN10051	Caney Fork River	River / Outflow	✓	-	-	-	-
CEN10052	Caney Fork River	River / Outflow	✓	-	-	✓	-
CEN10054	Caney Fork River	River / Outflow	✓	-	-	✓	-
CEN10037	Caney Fork River	River / Outflow	✓	-	-	✓	-
CEN20002	Caney Fork River	Reservoir / Main Stem	✓	✓	✓	-	✓
CEN20003	Caney Fork River	Reservoir / Main Stem	✓	-	-	-	-
CEN20004	Caney Fork River	Reservoir / Main Stem	✓	✓	✓	-	✓
CEN20005	Caney Fork River	Reservoir / Main Stem	✓	-	-	-	-
CEN20006	Caney Fork River	Reservoir / Main Stem	✓	✓	✓	-	-
CEN20007	Caney Fork River	Reservoir / Main Stem	✓	-	-	-	✓
CEN20008	Falling Water River	Reservoir / Embayment	✓	✓	✓	-	✓
CEN20010	Fall Creek	Reservoir / Embayment	✓	✓	✓	-	✓
CEN20011	Pine Creek	Reservoir / Embayment	✓	-	-	-	-
CEN20014	Holmes Creek	Reservoir / Embayment	✓	-	-	-	-
CEN20015	Mine Lick Creek	Reservoir / Embayment	✓	✓	✓	-	✓
CEN10023	Fall Creek	Stream / Inflow	✓	✓	-	✓	-
CEN10024	Pine Creek	Stream / Inflow	✓	✓	-	✓	-
CEN10025	Falling Water River	River / Inflow	✓	-	-	✓	-
CEN10026	Falling Water River	River / Inflow	✓	✓	-	-	-
CEN10029	Mine Lick Creek	Stream / Inflow	✓	✓	-	✓	-
CEN10030	Caney Fork River	River / Inflow	✓	✓	-	-	-

b. Reporting. Water quality data collected manually as instantaneous measurements in the field are stored in the USACE Data Management and Analysis System for Reservoirs, Estuaries, and Rivers (CE-DASLER). Field data reports are prepared and distributed to stakeholders after the completion of each sampling trip. Continuous water quality

monitoring data collected from various gages are stored in the CWMS database in the district office. The most current water quality data is available at https://www.lrn-wc.usace.army.mil/basin_project.shtml?p=cen.

Physical, chemical, and biological data records span from 1970 to present. Based on requirements in the Water Resources Development Act (WRDA), data is uploaded into the USEPA Water Quality Portal and the USACE Access to Water (A2W) system to allow public access of information. Historical water quality data is available at the following websites:
https://www.epa.gov/waterdata/water-quality-data
https://water.usace.army.mil/a2w/f?p=100:1

c. Maintenance. LRN Water Management staff are responsible for the installation and maintenance of the continuous water quality monitors and stream gages.

5-03 Sediment Stations

a. Facilities. An original network of 13 sedimentation ranges was established in 1942. This original network included 12 ranges on the Caney Fork River and one on a tributary, Falling Water River. The first resurvey in April-May 1965 adds 11 ranges to the original network. These 11 included two each on Caney Fork and Falling Water Rivers and Indian, Holmes, and Lick Creeks. One range was established on Eagle Creek. Sediment deposition volumes were not calculated after the first resurvey because of an insufficient number of original ranges for accurate definition of volumes. The August 1984 resurvey collected the ranges of the original 1942 survey and the first resurvey in 1965. A third resurvey was completed in August 2022 utilizing a multibeam echosounder (MBES) which allowed for mapping the bathymetry of Center Hill.

b. Reporting. All hydrometeorological station monitors are transmitted via DCP and the GOES system to the LRN district office where it is decoded by DECODES and stored in the CWMS Oracle database.

c. Maintenance. The Water Resources Section of the Hydrology & Hydraulics Branch is responsible for maintaining sediment range data.

5-04 Recording Hydrologic Data

DCP transmitted data are defined by data type and position in the data stream using DECODES. Data is then stored in the CWMS Oracle database. DCP data is stored and maintained indefinitely.

5-05 Communication Network

In accordance with the continuity of operations plan (COOP), water management maintains the ability to forecast remotely. All legacy models and data are backed up on water management

servers. With virtual private network (VPN) capability, it is possible to operate the reservoir system from anywhere with network access either through the servers in the LRN district office, or through the COOP server at the Pittsburgh District (LRP) office if necessary.

5-06 Communication with Project

a. Regulating Office with Project Office. Communication between LRN Water Management and staff at Center Hill is rare. Since all generation schedules are issued by TVA and the hydropower unit is remotely operated by the operator at Cordell Hull, there is rarely a need for communication between LRN Water Management and Center Hill. Any hydrologic data issues from the project are handled by communicating with the Cordell Hull operator. Occasionally, either low or high water causes recreation impacts and communication between LRN Water Management staff and Center Hill Resource Management staff is necessary. Additionally, if the need arises to open sluice and/or spillway gates either for water control or water quality reasons, coordination is conducted through the operator at Cordell Hull.

b. Between Project Office and Others. LRN acquired all land up to elevation 690.0, however there are a small number of private docks on the reservoir. There are 11 active shoreline licenses in the USACE Real Estate Management Information System (REMIS) currently. There are also nine commercial marinas on Center Hill, but they are well-suited to adapt to changing headwater elevations so there is rarely a need for communication between the project office and others. Occasionally, coordination is required between agencies regarding water quality in the reservoir or stocking schedules.

5-07 Project Reporting Instructions

Headwater, tailwater, and discharge data is manually entered and sent to the LRN district office by the operator at Cordell Hull. Center Hill also has one redundant headwater gage and one redundant tailwater gage which transmit via DCP.

5-08 Warnings

The fisherman warning system is in place at Center Hill as it is at all LRN reservoirs. An audible alarm is sounded prior to a hydropower turbine being brought online to alert anyone in the tailwater area of the impending release. Additionally, if a spillway gate(s) and/or sluice gate(s) is opened, the tailwater area is visually checked prior to opening the gates. When spillway or sluice gates are being opened, strobe lights continually flash to broadcast the warning. The Center Hill Resource Manager's Office is notified of any non-turbine releases. Lastly, TVA is also notified of non-turbine releases so it will be mentioned on their release schedules issued to the public.

VI - HYDROLOGIC FORECASTS

6-01 General

The NWS is the federal agency tasked with providing weather, water, and climate forecasts and warnings for the United States for the protection of life and property and the enhancement of the national economy. LRN Water Management often makes additional forecasts of stream flows and reservoir levels to best meet basin-wide water management objectives. All hydrologic forecasts are coordinated and shared to the greatest extent possible between LRN and the NWS.

Although there are no NWS stream forecasts in the Center Hill Basin, releases from Center Hill have a significant impact on the forecast at the Cumberland River at Carthage.

As part of the daily forecasting routine, daily average inflows and outflows, daily total generation, and midnight headwater elevation forecasts are issued everyday by LRN Water Management.

a. Role of Corps. LRN Water Management is the sole agency responsible for Center Hill hydrologic forecasts.

b. Role of Other Agencies. Twice a day, the NWS issues Quantitative Precipitation Forecasts (QPF) with projected rainfall totals. Additionally, the Ohio River Forecast Center (OHRFC) forecasts the stage at Carthage at least daily, more often during high flow events or as requested.

TVA issues a generation preschedule every afternoon that forecasts the generation schedule for the following day. This is available to the public via TVA's website, LRN Water Management's website, and a toll-free telephone number (1-800-238-2264, option 4, option 37).

6-02 Forecasts

The following requirements and methods for forecasting at Center Hill are mandatory regardless of hydrologic conditions (flood, drought, conservation, long-range, etc.).

a. Requirements. Midnight headwater elevations, daily average inflows, and daily average discharges are forecast for Center Hill as part of the daily forecast routine by LRN Water Management. Following a model run and coordination with TVA, the final forecast product, the flowsheet, is distributed to stakeholders via e-mail and Local Data Manager (LDM) and to the public via LRN Water Management's website. This process is typically completed by the early afternoon each day.

b. Methods. In the LRN CWMS model, the Hydrologic Modeling Systems (HMS) for Center Hill is broken down into six subbasins with their respective areas (mi^2) listed below:

- Collins River near McMinnville (642.2)
- Calfkiller River at Sparta (157.8)
- Cane Creek near Spencer (133.9)
- Caney Fork River at Great Falls Locals (740.4)
- Falling Water River near Cookeville (63.3)
- Caney Fork River at Center Hill Locals (432.9)

The above subbasins are routed to a Center Hill In junction to create an inflow hydrograph for the reservoir.

In the LRN CWMS model, the Reservoir Simulation (ResSim) model for Center Hill includes stage-storage curves, monthly evaporation rates, and rating curves for the spillway, sluice gates, and turbines. The Flood Control, Conservation, and Inactive Pools are defined as well as the top and bottom SEPA curves. Additionally, built in rules designed to efficiently operate the reservoir, as well as the emergency operation schedule and rate of release limitations, are also included. A typical forecast routine allows for ResSim to initially determine project releases, but the forecaster has the capability to manually override these releases to further optimize project purposes both at Center Hill and at projects downstream.

Due to the unpredictable nature of forecasted rainfall timing and magnitude, it was formerly USACE policy that all forecasts are made using "rain on the ground," i.e., observed rainfall only. Generally, all CWMS forecasts are modeled using observed rainfall through 0600 of that day. However, CWMS is capable of modeling using forecasted rain and this is a tool often used by forecasters to evaluate rainfall scenarios and operational scenarios based off forecasted rain. Most forecasts issued publicly are made based on rain on the ground; however, occasionally when rain is imminent, a conservative amount of forecast rainfall is included in the daily forecast.

In addition to the daily forecast routine described above, CWMS also has more advanced tools for more detailed modeling of river conditions. These tools include the capability to create more detailed stage and timing forecasts at downstream locations using the Hydrologic Engineering Center's River Analysis System (HEC-RAS), create inundation maps, compute damages using HEC's Flood Impact Analysis (HEC-FIA), and natural flow modeling. These tools, in addition to QPF modeling, allow the water management team to evaluate release scenarios and the effect on downstream communities.

VII - WATER CONTROL PLAN

7-01 General Objectives

The Water Control Plan at Center Hill has two major objectives. These are:

- To store water during flood events and thereby reduce flood damages downstream along the Caney Fork and Cumberland Rivers.
- To generate hydropower.

Subsequent legislation since impoundment has expanded the authorized project purposes to include recreation, fish and wildlife conservation, water quality, and water supply.

Additionally, Center Hill is part of the comprehensive development plan for the Cumberland River Basin. There are ten multipurpose reservoirs on the Cumberland River and its tributaries operated and constructed by LRN. These ten reservoirs are operated as a system of reservoirs to best optimize prescribed project benefits.

7-02 Constraints

Several constraints apply to water management operations at Center Hill. They are covered more in depth later in this chapter, but they are listed below for ease of reference:

- The headwater elevation should not drop below elevation 618.0.
- Changes in hydropower generation are limited to ramping up from zero to one unit in the first hour and then up to two additional units in the second hour. Changes in hydropower generation are limited to two units down per hour.
- Spillway/sluice gate release increases are limited to 2,000 cfs per hour; decreases are limited to 4,000 cfs per hour.
- The minimum flow requirement from Center Hill Dam varies seasonally. During the non-low flow season, the minimum flow is one unit hour of generation every eight hours. During the low flow season, the minimum flow is 250 cfs continuous, typically through the orifice gate, and one unit hour of generation at least every 48 hours. The low flow season is generally understood to be between 01 June through 30 November but can be modified based on hydrologic conditions. The non-low flow season is understood to be any period outside of the low flow season, generally defined as 01 December through 31 May.

7-03 Overall Plan for Water Control

The following specific regulating rules apply to normal and drought periods.

- Maintain headwater elevation within the limits of the Conservation Pool and release water through the turbines as governed by hydropower generation schedules.
- Changes in hydropower generation are limited to ramping up from zero to one unit in the first hour and then up to two additional units in the second hour. Changes in hydropower generation are limited two units down per hour.

- The minimum flow requirement from Center Hill Dam varies seasonally. During the non-low flow season, the minimum flow is one unit hour of generation every eight hours. During the low flow season, the minimum flow is 250 cfs continuous, typically through the orifice gate, and one unit hour of generation at least every 48 hours. The low flow season is generally understood to be between 01 June through 30 November but can be modified based on hydrologic conditions. The non-low flow season is understood to be any period outside of the low flow season, generally defined as 01 December through 31 May. Minimum flow requirements may be suspended during times of flooding or drought.

The following information outlines the overall Center Hill project plan for water control:

a. Guide Curve. The regulation curve, or guide curve, represents the primary guidance for operations at Center Hill Dam. It defines the operating limits of reservoir elevations as a function of time of year and is presented graphically on Plate VII-1. The Center Hill guide curve consists of three "hard" lines and two "soft" lines. The hard lines are described as such because they form the congressionally authorized operating boundaries which horizontally divide the reservoir into three distinct "pools", as described below. The soft lines further subdivide the Conservation Pool and are discussed further in subsection c below.

b. Inactive Pool. Inactive storage at Center Hill extends from the bottom of the reservoir up to elevation 618.0, the first hard line. No further releases will be made if the water level in the reservoir falls below this elevation. Inactive storage is provided primarily to offset reservoir sedimentation and provide head for hydropower. Other benefits of this permanent pool include depth for recreation, water intake installation, habitat for fish and other aquatic life, and insurance water for drought periods.

c. Conservation Pool. The Conservation Pool extends from elevation 618.0 up to the second hard line at elevation 648.0. This 30-foot depth is the "normal" operating zone of the reservoir. This is the zone in which water is stored for the purpose of generating electricity, providing a pool for recreation, and providing volume for water supply. The Conservation Pool is usually permitted to fill during the wet winter and spring months and remain near elevation 648.0 from mid-May through mid-June. During the summer and fall seasons, hydropower releases result in a steady drawdown of the reservoir.

The Conservation Pool is further subdivided by two curves which define a continually varying zone within the Conservation Pool. This is called the "SEPA Power Marketing Zone" or the "SEPA Band". The SEPA Band ranges in depth from 4.85 to 8.5 feet, but for most of the year it ranges between 6.0 and 6.5 feet in depth. The location of the band within the Conservation Pool varies. Its low point is on 31 December when its bottom is at elevation 623.5, 5.5 feet above the bottom of the Conservation Pool. Its high point is from 15 May until 15 June at elevation 648.0, which corresponds to the top of the

Conservation Pool. The lines which bound this zone are sometimes referred to as "soft lines" because there is not a specific requirement to keep the pool within this zone.

d. Flood Control Pool. The Flood Control Pool extends from elevation 648.0 to the third and upper most hard line at elevation 685.0. The normal condition is for this pool to remain empty so that the space is available to store water during flood events and thus reduce downstream damages due to flooding. Following a flood event water is released from this pool as quickly as possible based on downstream conditions to restore the capability to mitigate future flood events.

e. Normal Regulation Outflow. During periods of normal regulation, the water surface elevation behind Center Hill Dam is maintained within the Conservation Pool bounds. Outside of the seasonal minimum flow requirement, the preference is for all releases to be made through the turbines as governed by the demand for power. There is a significant amount of flexibility in operating the Center Hill project within the bounds of the Conservation Pool, which is 30’ deep. As further guidance, the SEPA Band is used to locate a more specific desirable location for the water surface, but there is still a moderate amount of flexibility within the band, and there is no absolute requirement for the pool to remain within the SEPA Band.

As a result of a daily analysis of current hydrologic conditions, the Water Management Section directs TVA to schedule a specific amount of energy production for the following day at Center Hill and, if needed, to modify the generating schedule for the current day. TVA accepts this daily total generation and then schedules the energy on an hourly basis to best meet power demands.

f. Hydropower Generation. The Center Hill hydropower units are operated remotely from the Cordell Hull Dam powerhouse. The operators at Cordell Hull control all turbine releases from the dam 24 hours a day, seven days a week; however, spillway and sluice gate operations must be performed on site by Center Hill personnel. The TVA load coordinator in Knoxville communicates the hourly generation schedule directly to the Cordell Hull operators. The primary water management functions of the powerhouse operators are to ensure that headwater levels are above minimum allowable, that changes in generation do not exceed the defined ramp rates, and that the machinery is operated within allowable limits. If instructions are issued from TVA which conflict with these criteria, plant personnel are to inform TVA that such a conflict exists, and the execution of such instructions is not permitted. The attending personnel are supervised by the Operations Division, but it is the responsibility of the Water Management Section of the Engineering and Construction Division to issue specific project release instructions and to ensure adherence to the water control plan. Between 2015 and 2020, the Nashville District installed three new auto-venting turbines at Center Hill Dam. These new auto-venting turbines help improve the dissolved oxygen content of the water being generated

during the poor water quality season. All three units have an aeration and non-aeration setting which will impact the efficiency of the units while helping stabilize dissolved oxygen.

Large surges in releases can cause bank erosion, make commercial navigation more difficult downstream on the Cumberland River, and can be hazardous to recreational boaters. To minimize river level fluctuations, changes in hydropower generation are limited to ramping up from zero to one unit in the first hour and then up to two additional units in the second hour. Changes in hydropower generation are limited to two units down per hour.

In general, hydropower releases are scheduled to meet peak energy demands. Normally this results in more water being discharged during the Monday through Friday period with lesser amounts on the weekend. Sunday is usually the lowest energy demand day. However, strict adherence to peak power demand scheduling would result in adverse effects to the aquatic life in the tailwater, particularly during the low flow, low dissolved oxygen, high temperature months of the late summer and early fall. The minimum flow requirement from Center Hill Dam varies seasonally. During the non-low flow season, the minimum flow is one unit hour of generation every eight hours. During the low flow season, the minimum flow is 250 cfs continuous, typically through the orifice gate, and one unit hour of generation at least every 48 hours. The low flow season is generally understood to be between 01 June through 30 November but can be modified based on hydrologic conditions. The non-low flow season is understood to be any period outside of the low flow season, generally defined as 01 December through 31 May.

The following plates are relevant to the overall plan for water control:

- Plate VII-2; Area and Volume Table
- Plate VII-3; Turbine Discharge Curves (Aerating & Non-Aerating)
- Plate VII-4; Turbine Discharge Table (Aerating & Non-Aerating)
- Plate VII-5; Spillway Rating Curves
- Plate VII-6; Spillway Rating Table
- Plate VII-7; Sluice Rating Curve
- Plate VII-8; Sluice Rating Table
- Plate VII-9; Emergency Operations Schedule (EOS)

7-04 Standing Instructions to Damtender

In the unlikely event that contact cannot be established between operators of the Center Hill project and the Nashville District Water Management Section the following guidelines should be used by operators:

- The Conservation Pool at Center Hill extends between elevations 618.0 and 648.0. The minimum flow requirement from Center Hill Dam varies seasonally. During the non-low

flow season, the minimum flow is one unit hour of generation every eight hours. During the low flow season, the minimum flow is 250 cfs continuous, typically through the orifice gate, and one unit hour of generation at least every 48 hours. The low flow season is generally understood to be between 01 June through 30 November but can be modified based on hydrologic conditions. The non-low flow season is understood to be any period outside of the low flow season, generally defined as 01 December through 31 May.

- If the headwater level approaches the lower limit of the Conservation Pool, elevation 618.0, reduce or curtail hydropower discharges as necessary to prevent the headwater from falling below elevation 618.0 and notify the power scheduling agency.
- Changes in hydropower discharges are limited to ramping up from zero to one unit in the first hour and then two additional units in the second hour. Hydropower ramp rates down are limited to two units per hour. Changes in hydropower are limited to two units down per hour.
- When flood conditions develop downstream on the Cumberland River (Carthage approaches control flow of 72,000 cfs or a stage of 29'), the primary purpose of Center Hill is flood control. This function is served by storing water behind the dam until the downstream flooding has subsided. The Flood Control Pool extends between elevations 648.0 and 685.0. After the flood threat has passed, reservoir flood control storage is evacuated as rapidly as downstream conditions permit. The following paragraphs give guidance on operations for flood control.
- Even if the headwater is within the Conservation Pool, hydropower releases should be reduced or curtailed entirely in the interest of flood control. The hydropower scheduling agency should be notified of these actions.
- To the extent possible, limit flows at Carthage to a maximum of 72,000 cfs or a stage of 29'.
- Limit total project releases to bank full capacity of the Caney Fork River, 30,000 cfs, unless larger releases are required by the EOS, depicted on Plate VII-9.
- Limit increases in sluice or spillway gate discharges to 2,000 cfs per hour and decreases to 4,000 cfs per hour. All spillway gates should be operated at approximately the same opening.
- If Center Hill and Cordell Hull should require concurrent changes in spillway gate releases, limit combined increases to 5,000 cfs per hour and combined decreases to 10,000 cfs per hour.
- When Center Hill headwater is rising within the Flood Control Pool, routinely check the EOS. If the rate of rise in headwater criteria is met, follow EOS instructions without deviation.
- When all flood control storage has been evacuated by lowering the headwater to elevation 648.0, resume normal operations.

7-05 Flood Control

The following are specific regulating rules for Flood Periods:

- When spillway gates are being operated, maintain uniform openings of all gates as closely as possible, with no more than one foot difference among the gate openings.
- When sluice gates are operated, they will be either fully closed or fully opened.

- Limit the rate of increase of combined spillway and sluice gate releases to 2,000 cfs per hour, unless operating under the EOS. Limit decreases in these releases to 4,000 cfs per hour and, if practical, limit this decrease to 2,000 cfs per hour.
- In conjunction with Cordell Hull, limit the flow at Carthage to 72,000 cfs or a stage of 29'.
- Limit total project releases to bank full capacity of the Caney Fork River, 30,000 cfs, unless larger increases are required by the EOS.
- If forecasts indicate the need to completely utilize the Flood Control Pool and total project releases above 30,000 cfs are necessary, increase releases up to 2,000 cfs per hour until the required release rate is achieved or until the EOS indicates higher release rates. Once the EOS is triggered, calculate the rate of rise in the pool and determine the required releases from the EOS every two hours.
- If operating under the EOS, limit the rate of increase in total outflow to 35,000 cfs per two-hour period until pool elevation reaches the Limiting Surcharge Curve (the upper most curve depicted on Plate VII-9) or until free flow conditions are reached.
- Once the Limiting Surcharge Curve is reached, it must be followed without deviation.
- Although no special operations are necessary, if the pool reaches elevation 691.5, a 770' long and 34.4' high erodible fuse plug on top of the right rim saddle dam will be triggered. The top of the fuse plug is at elevation 692.0; however, the fuse plug pilot channel begins at 691.5 so depending on the duration of flow, fuse plug operation is possible slightly below 692.0. The fuse plug was designed to completely erode down to a concrete sill elevation of 658.0 in approximately 30 minutes. Once eroded, the project discharge capacity would increase by approximately 400,000 cfs.
- After the reservoir peaks (either during normal flood control operations or when the Limiting Surcharge Curve is reached while operating under EOS), maintain spillway gates at existing opening until the pool falls to elevation 685.0. Then adjust gates uniformly such that outflow approximates inflow until the flow at Carthage recedes to the maximum desired amount and project releases recede to below bank full discharge. After this is achieved, resume normal flood control procedures.

There are two distinct modes of operation relative to flood regulation:

- Normal flood operation where outflows are reduced to provide flood mitigation to Carthage, TN and other points downstream including the primary damage center of Nashville, TN.
- Emergency flood operation where downstream flood reduction is an objective, but protection of the dam is the prime concern.

The primary damage center affected by the operation of Center Hill during flood events is the Cumberland River at Nashville, TN. The reference gage for Nashville is located at Cumberland River Mile 191.1. This is 118 miles downstream of the confluence of the Caney Fork River with the Cumberland River, or a total of 144.6 miles downstream of Center Hill Dam. Due to the distance and corresponding travel time between Center Hill and Nashville, it is not possible to exert influence on the flows at Nashville quickly enough to have the desired impact on flood stages. Consequently, the key station controlling the operation of Center Hill during flood events

is at Carthage, TN. Carthage is located 26.6 river miles below the dam at the confluence of the Caney Fork River and the Cumberland River. The gage at this station is located on the Cumberland River, downstream of the Caney Fork confluence and the flow there includes Center Hill releases, releases from Cordell Hull Dam located 5.3 miles upstream on the Cumberland River, and local inflow from the intervening 420 square mile drainage area.

The control flow for Carthage has been established at 72,000 cfs (stage of 29'). The official flood stage at Carthage is 40' (110,000 cfs). It is recognized that the control flow (maximum desired flow) for Carthage result in a river stage below damage levels. The control flow has been set to leave room in the Cumberland River for uncontrolled inflows between Carthage and the primary damage center at Nashville. In addition to the control flow at Carthage, flood control operations include limiting the total Center Hill release to the channel capacity of the Caney Fork River below the dam, which is approximately 30,000 cfs.

Hourly changes in combined spillway releases from Cordell Hull and Center Hill are limited to a total of 5,000 cfs for increases and 10,000 cfs for decreases. It is desirable to limit decreases to 5,000 cfs per hour as well, and whenever practical, this limit is directed by the Water Management Section. Hourly increases in spillway releases at Center Hill are limited to 2,000 cfs and decreases are limited to 4,000 cfs. The purpose of these restrictions is to reduce sudden surges downstream and to reduce excessive bank erosion. These restrictions are waived during emergency flood operations as described below.

The Carthage flow is allowed to reach the maximum desired amount without flood control procedures being initiated. If the Carthage flow is forecasted to exceed the maximum desired level, releases from Center Hill are curtailed, and flood control storage is utilized in a manner that will reduce the flood crest at Carthage as much as practical. After the flood crest has passed, utilized flood control storage is evacuated as fast as practical to prepare for future potential floods. When evacuating flood control storage, consideration is given to preventing a second flood crest at Carthage, allowing Carthage flows to recede to the maximum desired amount, and limiting Center Hill discharges to the Caney Fork River channel capacity.

If forecasts indicate that limiting the project discharges to 30,000 cfs or the Carthage flow to the maximum desired amount would result in the water surface in the reservoir surpassing the top of the Flood Control Pool (elevation 685.0), then emergency operations should be initiated. This operation is controlled by the EOS presented as Plate VII-9. The intent of this plan is to prevent the overtopping of the dam while minimizing project discharges as much as practical. This is accomplished by utilizing induced surcharge storage by raising all spillway gates simultaneously so that any inflow in excess of the discharge will be stored above the nominal top of the Flood Control Pool. When operating according to the EOS project discharges are increased until the reservoir elevation peaks. Spillway gates should then remain at their existing opening until the pool falls to elevation 685.0. At that time gates should be adjusted uniformly such that outflow approximates inflow until the flow at Carthage recedes to the maximum desired amount and

project releases recede to 30,000 cfs. At that time, normal flood control procedures are to be resumed.

7-06 Recreation

Recreation is a congressionally authorized project purpose and release decisions by LRN Water Management take this into consideration during the daily forecast routine. Due to the temperate climate and relatively long recreation season, visitors have many opportunities to fish, hunt, camp, picnic, boat, canoe, hike, and enjoy the outdoors within the Caney Fork Basin. Center Hill supports eight recreation areas, 15 minor access areas, four campgrounds, nine marinas, two group camps, three state parks, and three picnic areas with 214 picnic sites. There are no private docks or mooring on the reservoir, and the commercial marinas are well suited to adjust to changing reservoir elevations. As long as the reservoir is operated within the Conservation Pool (elevations 618.0-642.0), there are little to no impacts to recreation. However, some campsites may become unusable if the reservoir rises above elevation 648.0. The Caney Fork tailwater sustains a well-known trout fishery. Fishing and boating, particularly trout fishing and canoeing, are the major activities in the Caney Fork below Center Hill Dam. Recreational interests on the Caney Fork River are well suited to adapt to changing hydrologic conditions. There is no formal closure of any ramp or access area due to high or low water and there is no storage in the reservoir allocated to downstream recreational interests. The typical weekly pattern of higher flows during the week and lower flows on weekends helps to provide more favorable access downstream on weekends and holidays. However, tailwater recreation is considered an ancillary benefit and there is no requirement to provide special releases for downstream recreation.

7-07 Water Quality

Water quality is a primary concern for the operation of Center Hill during both normal and drought periods. These needs are a primary consideration during the typically dry portion of the year, June through October. Operational adjustments for water quality improvements remain in place until DO concentrations sufficiently increase within the turbine intake zone. This critical period for water quality can often extend into December.

The Caney Fork River below Center Hill Dam supports a viable put and take trout fishery. The seasonal minimum flow requirement will increase wetted perimeter for aquatic habitat in the Caney Fork River. The Tennessee water quality standard for DO in a trout stream is 6.0 mg/L; turbine discharges occasionally fall below this standard in the summer and fall. Table 7-1 contains the guidance to enable the Center Hill project to operate so that downstream DO is maintained at an appropriate concentration for aquatic habitat:

Table 7-1. Suggested Operational Steps During Low DO

Tailwater DO During Generation	Suggested WM Operations
Greater than 6.0 mg/L	Normal operation for power or other project purposes.
Less than 6.0 mg/L	• Open air supply valves for turbine venting. • Adjust energy outputs either higher or lower. • Limit Generation – reduce number of operating units. • Sluice gate releases to blend with turbine discharge.

As water quality conditions improve, measures will be removed generally in the reverse of the order they were applied.

New auto-venting turbine (AVT) runners were installed at Center Hill Dam with two units coming online in 2020 and the third in 2021. Each AVT has six air supply valves, which can be opened or closed in groups of two, when conditions in the reservoir necessitate their use. After a field testing, the most practical and efficient use of the AVTs is to utilize all six valves together either all open or all closed. Since installation of the AVTs, DO concentrations in the turbine discharge have significantly improved and no longer requires sluice gate releases for environmental purposes. The use of sluice gates to mitigate low DO concentrations in the turbine discharge have only been necessary to assist with pool level control during the most critical water quality periods. Plates VII-10 and VII-11 display the typical annual cycle of the turbine discharge water temperature and DO data collected in the tailwater.

Old Hickory Dam is considered the water quality control point for the Cumberland River Basin system operations. Generally, when desirable DO conditions in releases from Old Hickory are maintained, acceptable water quality conditions along the Cumberland River mainstem are assured. The Tennessee water quality standard for DO (warmwater fishery) is a minimum of 5.0 mg/L. Table 7-2 contains the theoretical bi-weekly minimum average flows needed to meet this standard below Old Hickory have been estimated in the following table:

Table 7-2. Theoretical Minimum Flows at Old Hickory for Water Quality

Month	Theoretical Minimum Flow (cfs)
April	2,000
May	4,900
June	7,600
July	9,100
August	9,400
September[(1)]	7,400
October	2,000

[1]Higher flows are needed until Old Hickory destratifies.

Typical operational releases from projects upstream of Old Hickory, including Center Hill, aid in maintaining these flow rates.

7-08 Fish and Wildlife

Usually in late April or early May, the largemouth bass and crappie spawn occurs. For a two to three week period during this event, it is critical to keep a relatively stable pool for good spawning conditions. If, however, the water should rise in the Flood Control Pool and evacuation of this storage is necessary, it should be evacuated as rapidly as practical to attempt to delay spawn. Stabilization efforts are initiated when the Nashville District determines that the spawn is occurring based on criteria established by the TWRA. TWRA's criterion to identify the beginning of the spawning period for all reservoirs in Tennessee is a water temperature at a five-foot depth at or above 60 degrees Fahrenheit. Reservoir level stabilization to enhance the fish spawn is a cooperative effort between LRN, TWRA, SEPA, and TVA.

The Caney Fork River below Center Hill Dam extends 26.6 miles from the dam to the confluence with the Cumberland River. The depth is dependent on the pool elevation of Old Hickory Reservoir and discharges from Center Hill Dam. Usually the lower one-third of the Caney Fork River below the dam is slack water of Old Hickory Reservoir. Discharges from Center Hill make the upper portion of the tailwater considerably colder and ideally suited for a "put-and-take" fishery for rainbow and brown trout.

7-09 Water Supply

There are currently three permanent water supply intakes within the Center Hill Reservoir. They are the City of Cookeville in Putnam County, TN; City of Smithville in DeKalb County, TN; DeKalb Utility District in DeKalb County, TN. Relevant information about the three permanent intakes is shown in Table 7-3 below. A map displaying the locations of these Water Supply Intakes can be found in Plate VII-12.

Table 7-3. Water Supply Intakes

Water Supply User	Intake Location
City of Cookeville, TN	Mine Lick Creek, RM 3.0, Left Bank (36.070973, -85.693828)
City of Smithville, TN	Caney Fork River, RM 60.6, Left Bank (Sligo Bridge) (35.965485, -85.716353)
DeKalb Utility District	Holmes Creek, RM 4.2, Left Overbank (36.00211, -85.826858)

LRN has reallocated storage for water supply from the Conservation Pool at Center Hill for all three permanent users. The details of these agreements are listed in Table 7-4.

Table 7-4. Water Supply Intake Details

Water Supply User	Water Storage Agreement Number	Water Supply Storage Reallocation (ac-ft)	Estimated Population Served (2023)	Estimated Yield (MGD)	2015 Average Withdrawal (MGD)
City of Cookeville, TN	DACW62-04-WP-15	6,680	75,000	20	12.27
City of Smithville, TN	DACW62-04-WP-13	401	7,000	1.2	1.1
DeKalb Utility District	DACW62-10-WP-23	1,336	25,000	4	0.79

As discussed later under Effects of the Water control Plan, Center Hill Reservoir serves as the water supply source for approximately 107,000 people. The minimum pool level that the two water supply intakes can which withdraw water from is elevation 616.0. This is two feet below the top of the Inactive Pool and drought conditions would have to far exceed those previously experienced to threaten the viability of these intakes. During times of critical drought periods, when water supply is the top priority, the minimum flow may be reduced or temporarily halted to ensure water supply needs can be adequately met from the reservoir.

7-10 Hydroelectric Power

In general, hydropower releases are scheduled to meet peak energy demands. Normally this results in more water being discharged during the Monday through Friday period with lesser amounts on the weekend. Sunday is usually the lowest energy demand day. Strict adherence to peak power demand scheduling would result in adverse effects to the aquatic life in the tailwater, particularly during the low flow, low dissolved oxygen, high temperature months of the late summer and early fall. The minimum flow requirement from Center Hill Dam varies seasonally. During the non-low flow season, the minimum flow is one unit hour of generation every eight hours. During the low flow season, the minimum flow is 250 cfs continuous, typically through the orifice gate, and one unit hour of generation at least every 48 hours. The low flow season is generally understood to be between 01 June through 30 November but can be modified based on hydrologic conditions. The non-low flow season is understood to be any period outside of the low flow season, generally defined as 01 December through 31 May.

Large surges in releases can cause bank erosion and can make commercial navigation much more difficult downstream on the Cumberland River. In order to minimize river level fluctuations, changes in hydropower discharges are limited to ramping up from zero to one unit

in the first hour and then up to two additional units in the second hour. Changes in hydropower generation are limited to two units down per hour.

Every Thursday, LRN sends a power declaration to SEPA that shows total daily generation forecasts for the next week (Sunday-Saturday). According to the agreement between SEPA and TVA (control number 89-00-1501-1129, dated 15 September 1997), LRN Water Management will make available the following minimum declarations of energy during respective months:

- January - 24,000 MWH
- February - 29,400 MWH
- March - 32,000 MWH
- April - 32,000 MWH
- May - 22,600 MWH
- June - 24,600 MWH
- July - 32,200 MWH
- August - 32,200 MWH
- September - 21,000 MWH
- October - 15,800 MWH
- November - 16,000 MWH
- December - 20,000 MWH

Any week which falls within two months shall, for the purpose of determining the minimum energy to be made available, be considered to be completely within the month in which Wednesday of such week falls.

7-11 Navigation

Navigation is not a project purpose at Center Hill and no operations for navigation are anticipated during drought conditions. However, the changes in hydropower releases of one unit in the first hour and then two units in the second hour will remain in effect. Project operations for purposes described above should keep the navigable reservoir levels above the inactive pools in the mainstem. This alone would provide adequate depths for navigation through these slackwater pools.

7-12 Dam Safety

The DSAC is intended to provide consistent and systematic guidelines for appropriate actions to address the dam safety issues and deficiencies of USACE dams. USACE dams are given a DSAC rating based on their individual dam safety risk, considered as a combination of probability of failure and potential life safety, economic, environmental, or other consequences. Center Hill was reclassified from a DSAC I to a DSAC III dam in 2020 as the result of placing a grout curtain and concrete barrier wall in the main embankment in 2012 and 2015 and a RCC berm downstream of the saddle dam embankment in 2020. USACE considers this level of life-risk to be in a tolerable range, but the dam does not meet all essential USACE guidelines.

LRN dam safety personnel perform annual inspections at Center Hill Dam as part of a continuing evaluation program. Periodic inspections are conducted on a five-year frequency and include the inspecting, testing, operating, and evaluating of all components whose failure or failure to operate properly could impair the operational capacity of the structure. Periodic assessments are conducted on a ten-year recurring interval and in conjunction with the periodic inspection. In addition to the periodic inspection, a periodic assessment includes a potential failure mode analysis and a risk assessment. In addition to periodic inspections and assessments, powerhouse personnel are required to take site-specific dam safety training once every five years and are trained to continually survey the site for warning signs of impacts to dam safety. LRN dam safety personnel perform annual inspections at Center Hill Dam as part of the continuing dam safety requirements for all USACE structures. Part of those annual inspections is an annual instrumentation update which reviews the performance of all the instruments installed in the dam. Powerhouse personnel help with this review by reading manual instruments throughout the year and reporting anything different or wrong with the instruments. At Center Hill, manual instruments are an important part of monitoring the barrier wall and grout curtain performance inside the main dam embankment. Manual instruments are also important to monitor the saddle dam/RCC berm, concrete dam, and the seepage through the left rim.

In 1989, a dam safety study was completed to correct the spillway deficiencies at Center Hill Dam. The results of this study led to the installation of the erodible fuse plug in the saddle dam. The fuse plug is designed such that if the elevation of reservoir exceeds the top of the fuse plug (elevation 692.0) then the overtopping water will completely erode the sand fill down to the concrete sill elevation of 658.0 in approximately 30 minutes. Once the fuse plug is eroded, only the trapezoidal concrete weir will remain. The remaining saddle dam weir is designed to supply enough additional spillway capacity to significantly reduce the likelihood of overtopping the main dam.

7-13 Drought Contingency Plans

As specified in the Cumberland River Basin Drought Contingency Plan, dated November 1994, the system wide priorities for drought regulation in the basin are:

- Water Supply*
- Water Quality*
- Navigation
- Hydropower
- Recreation

*For Public Health and Safety

Of these purposes, only hydropower was specifically mentioned in the authorizing legislation. Flood Control is the other specifically authorized purpose, but it is not a factor during a drought. Center Hill Dam is also operated for water quality and fish and wildlife under the general authorities of the Federal Water Pollution Control Act Amendments and the Fish and Wildlife

Coordination Act respectively. In the interest of public health and safety, high priority is given to maintaining the reservoir level above the minimum operating elevations of all water supply intakes.

Together with Dale Hollow and Wolf Creek, Center Hill serves as one of the prime reservoirs which maintain desired Cumberland River flows during times of drought. Most of the water flowing downstream at such times is being released from a combination of these three reservoirs.

As discussed later under Effects of the Water control Plan, Center Hill Reservoir serves as the water supply source for approximately 107,000 people. The minimum pool level at which the systems can withdraw water from is elevation 616.0. This is two feet below the top of the inactive pool and drought conditions would have to far exceed those previously experienced to threaten the viability of these intakes.

Thermal power production water supply is not an authorized project purpose at Center Hill, Dale Hollow, or any other project in the Nashville District; however, hydropower generation is. There are two thermal power plants in the Cumberland River Basin. The first is the Gallatin Steam Plant at Old Hickory and the second is the Cumberland Steam Plant at Barkley. Since the power generating capacity at the Cumberland Steam Plant is almost three times the capacity of all nine Nashville District hydropower plants combined, and since this power is produced using approximately 9% of the water required by the hydropower plants, it is generally agreed that in times of scarce water it would not be prudent to continue weekday/weekend power peaking operations at the expense of thermal power. To accommodate thermal power demands for cooling water, minimum flows of between 4,000 and 6,000 cfs are desirable past the Cumberland Steam Plant located at 815 Cumberland City Rd, Cumberland City, TN. The Cumberland Steam Plant is scheduled to be completely shutdown by 2028, with the first unit expected to be shutdown in 2016. Every effort is made to provide this flow as long as other water management objectives are not impacted, however, during droughts it may be necessary to provide flows which are less than the desired amount. In an effort to partially offset this, a more uniform flow may be provided by eliminating the weekday/weekend peaking operation at the storage projects.

Water quality is a primary consideration for the operation of Center Hill during both normal and drought periods. Operation of the project would continue as described in the above paragraphs. Depending on the severity of the drought, the weekly average outflows from Center Hill and Old Hickory may be less than the desired quantity; however, every effort will be made to maintain an acceptable level of dissolved oxygen in the project tailwaters.

Navigation is not a project purpose at Center Hill and no operations for navigation are anticipated during drought conditions. However, the changes in hydropower releases of one unit in the first hour and then two units in the second hour will remain in effect. Project operations for purposes described above should keep the navigable reservoir levels above the inactive pools

in the mainstem. This alone would provide adequate depths for navigation through these slackwater pools.

As discussed in the Drought Contingency Plan, an informal agreement was signed between the Corps of Engineers and SEPA on 15 December 1988. This agreement states that if the combined volume of water in the Conservation Pools of Wolf Creek, Dale Hollow, and Center Hill is equal to or greater than that defined by the cumulative bottoms of the SEPA bands at each project, then the three projects will be operated normally. If the combined volume of water in the three Conservation Pools is between 70% and 100% of the Conservation Pool cumulative volumes below the SEPA bands, then hydropower releases may be reduced to a combined minimum daily average of 3,600 cfs. If the combined volume of water in the three Conservation Pools is less than 70% of the Conservation Pool cumulative volumes below the SEPA bands, then hydropower releases may be reduced to a combined minimum daily average of 2,000 cfs. However, during the summer months, water quality requirements may require higher flows.

Recreation is the last purpose specifically prioritized in the Drought Contingency Plan. Water should be conserved in the Conservation Pool to meet recreation needs to the extent possible. However, all the above discussed priorities take precedence over recreation. The impacts that drought may have on recreational facilities is discussed further in Chapter VIII.

7-14 Flood Emergency Action Plans

The Emergency Action Plan is updated annually and is available in the resource manager's office. Additionally, a hard copy is kept at the district office, in the Center Hill Superintendent's office, in the Cordell Hull control room, and an electronic copy is posted on the dam safety SharePoint site. It outlines emergency procedures and contact lists in the event of an emergency.

7-15 Other

Simple requests for specific hourly flows for events such as: water quality sampling, fish and wildlife surveys, support for special recreational events in the tailwater, swift water rescue trainings, or any other short-term special operations are routed through LRN Water Management and evaluated on a case-by-case basis to ensure compliance with the overall Water Control Plan.

7-16 Deviation from Normal Regulation

ER 1110-2-240 dated 30 May 2016 addresses deviations from the approved Water Control Plan. According to this regulation, the Division Commander is responsible for reviewing and approving any proposed deviations from the Water Control Plan. This responsibility may be delegated to the responsible Senior Executive, or Chief of the Water Management Division. Approval of certain deviations may be delegated to the District Commander. Delegation of approval authority must be documented in the guidance memorandum for the Water Management Division. In all cases, the delegated approving official must be a registered professional engineer with a civil engineering background. Deviations must also be coordinated

with the Division Water Control Manager, the Division Dam Safety Officer, and the District Dam Safety Officer.

Significant, recurrent, or prolonged deviations from operations prescribed by an approved Water Control Plan may indicate a need for a formal change to operations prescribed by an approved Water Control Plan. The Division Commander should evaluate whether revision of the approved Water Control Plan is appropriate in such a case. Deviations that impact the fulfillment of authorized purposes, that occur in three or more consecutive years, or that occur more than three times with a five-year period must be fully coordinated with CECW-CE.

a. Planned Deviations. Each request for a planned deviation shall be evaluated on its own merits. Examples include deviations for interim risk reduction measures and scheduled construction, maintenance, or inspection activities. Planned deviations shall receive advanced approval from the Division Commander. The deviation request should be self-supporting and self-explanatory. The following information will be submitted in written form to the Division Commander for consideration:

- Description of the proposed deviation, including purpose, proposed change from the approved Water Control Plan, duration, and other details about the deviation.
- The outcomes of adhering to the Water Control Plan and of employing the proposed deviation.
- Alternative deviation plans to include the application of risk and uncertainty in the analysis and the consequences of each.
- Effects of the proposed deviation on project and system operation, and on other project purposes.
- Review of the Potential Failure Mode Analysis (PFMA) for the dam and an analysis of the effect of the deviation on the probability of failure and consequences associated with the deviation.
- The potential flood threat with and without the proposed deviation.
- Current and predicted maximum storage, elevation, river stage, and other pertinent information with and without the deviation.
- Review of the alternatives under provisions of pertinent laws and regulations, including but not limited to the National Environmental Policy Act (NEPA) and the Endangered Species Act (ESA), when applicable.
- A description of the coordination that has been done with affected entities, both USACE and non-USACE, the effect on other local, regional, state, tribal, and federal agencies.
- Written comments from agencies, organizations, businesses, and individuals who may be impacted by, or supportive of the proposed change in flows, including federal, state, and local agencies; tribes; industries, organizations, and other stakeholders; and the public.
- Discussion of any other relevant issues.
- District Commander, or designee, recommendation.

b. Unplanned Deviations. The need for unplanned deviations may arise due to unforeseen conditions that do not allow sufficient time for a full analysis prior to the deviation. Each request for an unplanned deviation should be analyzed on its own merits, with an evaluation of factors such as potential failure mode and consequences, upstream watershed conditions, potential flood threat, condition of the reservoir, possible alternative measures, and potential adverse effects on the overall regulation of the project for the authorized purposes. Requests for and approval of unplanned deviations may be transmitted by telephone or electronic media. A follow-up evaluation, including all of the requirements for planned deviations, shall be documented and furnished to the Division Commander as soon as practicable.

c. Emergency Deviations. Emergencies may require deviation from the approved water control plan to mitigate an imminent threat to public health and safety, property, or the environment. Examples include dam safety issues, drowning and other accidents, failure of operation facilities, oil or chemical spills and drainage, bacterial contamination, harmful algal blooms, water or sewage treatment plant failures, and fish kills. Such situations require a rapid response which does not allow sufficient time for a full analysis of the deviation. Evaluation of emergency deviations may be based on available information with consideration of the potential for transfer of risk. Necessary actions under emergency conditions may be initiated by the District Commander. Requests for and approval of emergency deviations may be transmitted by telephone or electronic media. A follow-up evaluation, including all of the requirements for planned deviations, will be documented and furnished to the Division Commander as soon as practicable.

7-17 Rate of Release Change

Hourly changes in combined spillway releases from Cordell Hull and Center Hill are limited to a total of 5,000 cfs for increases and 10,000 cfs for decreases. It is desirable to limit decreases to 5,000 cfs per hour as well, and whenever practical, this limit is directed by the Water Management Section. Hourly increases in spillway releases at Center Hill are limited to 2,000 cfs and decreases are limited to 4,000 cfs. The purpose of these restrictions is to reduce sudden surges downstream and to reduce excessive bank erosion. These restrictions are waived during emergency flood operations as described in Section 7-05.

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VIII - EFFECT OF WATER CONTROL PLAN

8-01 General

Plate VIII-1 shows the annual peak headwater elevation of the Center Hill pool for the years 1951-2022, arranged in descending order. The pool elevation frequency duration curve displayed as Plate VIII-2 shows the percent of time that the pool has been at or below various elevations since the hydropower unit came online. As can be seen on this plate, the water surface of Center Hill Reservoir has been maintained within the limits of the Conservation Pool approximately 92% of the time. Plate VIII-3 shows the percent of time that the tailwater elevation has been at or below various elevations from 1989-2022. Plate VIII-4 shows the maximum, median, and minimum observed pool elevations each year since the project was impounded. Plate VIII-5 shows the daily observed inflow duration curve. Inflows are calculated on a daily basis using the change in storage at midnight headwater elevations and the observed discharge. This method of calculation computes approximately 5% of daily inflow values to be negative. Plate VIII-6 shows the volume frequency analytical plot for inflows. This was calculated using period of record observed daily inflows and computes a 1-day, 100-year return interval event to be approximately 170,000 dsf and a 365-day, 100-year return event to be approximately 7,600 dsf.

The history of project discharges is depicted in Plates VIII-7 and VIII-8. The monthly average discharge from the project is shown on Plate VIII-7. Non-turbine releases average slightly less than 7% of the observed total discharge since 1951. The month of March has the highest average turbine and spillway release. The month of September has the lowest average discharge. Plate VIII-8 shows the annual average turbine and spill discharge for each calendar year from 1948 through 2022. The largest volume of water passed through the project in 1973, while the largest volume to pass through the turbines occurred in 1989. The lowest volume of water passed through the project occurred in 2007. There were no discharges from the spillway gates in approximately 37% of the years.

8-02 Flood Control

As shown in Plate VIII-1, the Flood Control Pool has been used to some extent in 78% of all years since impoundment. The water surface has been above elevation 655.0 (17% Flood Control Pool volume used) in 33 of those years and above elevation 665.0 (43% Flood Control Pool volume used) in 15 years. The highest volume of flood control storage used was in 1984 when approximately 90% of the Flood Control Pool was used as the reservoir crested at elevation 681.52. The monetary value of this flood control is displayed annually on Plate VIII-9. In this plate, note that the value presented for 1963 represents damages prevented up to and including 1963. The cumulative flood control benefits adjusted for inflation through the year 2022 have been over $1.5 billion.

a. Spillway Design Flood. The original spillway design was completed in 1941 and an additional model study was completed in August 1945 using a 1 to 100 scale

comprehensive model of the entire spillway structure. The peak inflow used for the spillway design in the 1941 detailed project report was 514,000 cfs. The Center Hill spillway was designed with a peak outflow rate of 457,000 cfs under a 43-foot head. In December 1992, a further model study determined that Center Hill Dam was not safe for floods exceeding 72% of the probable maximum flood (PMF). This led to the addition of a fuse plug being constructed in lieu of part of the saddle dam at Center Hill Dam to add additional emergency release structures for flood control.

In April 2016, an Inflow Design Flood (IDF) study for Center Hill Dam was completed to check the adequacy of Center Hill Dam in an updated probable maximum precipitation (PMP) scenario. The total eight-day runoff volume was 19.5" (2,258,000 acre-ft). The IDF resulted in a peak inflow of 771,000 cfs and a peak headwater elevation of 696.6, resulting in overtopping of Center Hill Dam by 0.6 feet. Elevation 696.6 is 11.6 feet over the top of the spillway gates at elevation 685.0. The maximum release from Center Hill Dam in the IDF study was 674,300 cfs. It was recognized that there was a 50% increase in peak inflow from the original 1941 spillway design flood.

b. Other Floods. The two most notable flood events in recent past near Center Hill Dam are the May 2010 event and the February 2019 event. Also, the May 1984 flood event set the pool of record at Center Hill Reservoir. These events are further discussed in the following paragraphs.

The flood of May 2010 has been established as the new regulated flood of record for much of the middle and lower Cumberland River. Operations at Center Hill were irregular due to the IRRM drawdown for dam safety. When the rainfall started on 01 May, the elevation was at 630.46, 17.5' below the top of the Conservation Pool and spillway crest. A total storage capacity equivalent to 9.2" of runoff was available at that time. The pool rose 16.3' to a crest elevation of 646.76 on 05 May. This was 1.24' below the top of the Conservation Pool. Considering the majority of the precipitation fell below the flood storage projects, the total increase in storage produced by the May 2010 storm was equivalent to a runoff depth of 2.43" and none of the flood storage available at the onset of the event was utilized. However, the biggest concern at Center Hill Dam during May 2010 was the stage at the primary damage center, Carthage, TN. To help control the flood crest on the Cumberland River at Carthage and downstream damage centers, the turbine generation at Center Hill was reduced to zero for 27 hours from 1800 on 02 May to 2000 on 03 May. During this time, Nashville crested at 51.9', approximately 7' over major flood stage. On 03 May, Carthage reached flood stage and crested at 46.06', 0.94' below major flood stage but still within moderate flood stage. Carthage remained above flood stage for approximately 61 hours. Power generation resumed at Center Hill at 0600 on 04 May and began full generation at the end of 05 May. Plate VIII-10 illustrates rainfall, Carthage stage, and operations at Center Hill during the May 2010 flood event.

Leading into the February 2019 event, Center Hill was operating under IRRM measures still. On 20 February, the headwater elevation was at 644.15, 3.85' below the top of the Conservation Pool which correlates to 7.2" runoff available to top of gates. On 20 February 2019, precipitation began to fall over the basin which later resulted in a peak project headwater elevation of 678.02 on 26 February. The total change in storage was equivalent to 5.8" of runoff and the peak headwater elevation utilized 79.4% of the Flood Control Pool. Heading into the event, Center Hill was generating with a single hydropower unit for a discharge of approximately 4,000 cfs. One orifice gate, as well as 5 sluice gates were open. A single unit generation continued until discharge was zeroed at the project before heavy rainfall. Zero discharge was observed for approximately four days as the reservoir elevation steadily increased. Single unit generation resumed at 1900 on 24 February and spillway gates opened at 2200. The headwater elevation remained in the Flood Control Pool for 34 days, finally falling below elevation 648.0 on 27 March. Flood damages sustained at Center Hill were estimated to be $330M. Recreation areas and access roads across the project were impacted by the high water, debris load, and erosion caused by the heavy rains. Plate VIII-11 illustrates rainfall, Carthage stage, and operations at Center Hill during the February 2019 event.

In May 1984, heavy rainfall occurred over all of the Upper Cumberland River Basin. Basin average rainfall for the month was in excess of nine inches, or over twice the normal. The heaviest rain occurred over a three-day period, 06-08 May. This storm resulted in the third highest stage at Carthage since the closure of Cordell Hull with a stage of 40.2' on 08 May. The peak discharge from Center Hill was 28,408 cfs on 12 May. This storm also resulted in the highest pool ever recorded at Center Hill Dam at elevation 681.3 on 10 May 1984, 36.3' above the top of the Conservation Pool. The peak daily inflow into Center Hill Reservoir was approximately 99,000 cfs.

8-03 Recreation

Recreational use of the Center Hill project has grown tremendously since 1951. From approximately 400,000 visits in 1951, usage has grown to over 2.5 million visits in 2021. However, it is important to note that recreation calculation methodology changed dramatically in 2013, thus the large change in visits before and after this year. Plate VIII-12 shows the trends in visitation by type of activity over the project's history. The most popular activity at Center Hill is sightseeing. Fishing, the second most popular activity is not far behind. Center Hill's popularity is in the middle of the pack when compared to the other Nashville District reservoirs. It ranks fifth out of the ten projects.

The visitation dollar benefit attributed to Center Hill Reservoir is shown on Plate VIII-13. Plate VIII-14 shows the impacts of low reservoir levels on water based recreational facilities and water supply intakes.

8-04 Water Quality

Center Hill is a deep, temperature stratified reservoir typical of large southern impoundments. Center Hill Reservoir has a mean depth of 73' at typical summer pool elevation and a hydraulic retention time of approximately 140 days. Typically, DO depletion occurs below the metalimnion during the warm season and results in insufficient DO availability in much of the water column to support fish and desirable aquatic life. The onset and severity of DO depletion in the hypolimnion varies due to the interaction of several biotic and abiotic factors, but the result is loss of available habitat in the hypolimnion during late summer and into the fall every year. Throughout the late fall and winter, DO is restored throughout the reservoir by cooling of surface waters (epilimnion) and the gradual mixing downward. This thermal de-stratification process, known as fall turnover, can be paused by brief spells of warm weather which slow the cooling and sinking process. Warmer winters may negatively impact the water quality at Center Hill by limiting mixing and lowering initial DO concentrations in the spring, meaning that depletion below the metalimnion may be increased.

During the summer and fall, thermal stratification causes low DO concentrations within the turbine intake zone, which results in discharges falling below the Tennessee state standard for a trout stream of 6.0 mg/L.

In the late 1990s, measures were implemented to improve outflow DO concentrations. Hub baffles on the turbine runners along with auxiliary air supply valves were installed on all three turbines which increased the intake of air during generation. The combination of hub baffles and air supplies provided a boost to DO outflow concentrations of approximately 1.00-1.50 mg/L. Implementation of this turbine venting technique was able to reduce the period that Center Hill produced discharges less than the 6.0 mg/L standard.

Sluice and orifice gate releases have also been implemented at Center Hill to improve water quality conditions in the Caney Fork River downstream of the dam. Sluicing involves releasing 1,500 cfs per gate to produce highly aerated water to mix with the oxygen deficient turbine discharge. An orifice gate was installed on one of the sluice gates in 2007 and releases approximately 250 cfs. Sluice and orifice gate releases have been used since 2004 when necessary to improve downstream water quality conditions.

New auto-venting turbine (AVT) runners were installed at Center Hill Dam with two units coming online in 2020 and the third in 2021. Since then, DO concentrations in the turbine discharge have significantly improved and no longer require sluice gate releases for primarily environmental purposes. The use of sluice gates to mitigate low DO concentrations in the turbine discharge have only been necessary to assist with pool level control during the most critical water quality periods.

Tailwater Biota. Excluding the cold-water fishery, the Caney Fork River below Center Hill Dam supports a benthic macroinvertebrate fauna capable of exploiting the continually cold-water

environment. Dominant organisms include chironomids, isopods, amphipods, and multiple other organisms. As is typical in an unbalanced aquatic community, densities are dominated by a few types of organisms. This type of aquatic community exists down to the confluence with the Smith Fork; however, aquatic diversity of the benthic macroinvertebrate community gradually increases with distance from the dam, so that EPT organisms (Ephemeroptera, Plecoptera, and Trichoptera) begin to appear in larger numbers. Throughout its 26.5-mile reach, however, the Caney Fork River remains profoundly influenced by the cold-water discharges from Center Hill Dam. The pre-impoundment native mussel fauna is virtually extirpated from the river and is unlikely to return without a major change in the temperature regime.

8-05 Fish and Wildlife

Center Hill Reservoir supports an excellent fishery and is generally regarded as the top walleye fishery in the Southeast, in terms of numbers harvested. Other predominant species include largemouth, smallmouth, black and spotted bass, bluegill, and crappie. Generally, the nutrient supply feeding the reservoir seems to be at a favorable level for a productive fishery. The fish species found within Center Hill Reservoir include largemouth bass (Micropterus salmoides), smallmouth bass (M. dolomieui), spotted bass (M. punctulatus), walleye (Sander vitreus), crappie (Pomoxis spp.), various sunfish, white bass (Morone chrysops), various suckers, bluegill (Lepomis macrochirus) and other species of sunfish (Lepomis spp.), carp (Cyprinus carpio), and other minnows. Rockfish and sauger concentrate immediately below the dam during periods of heavy hydropower generation in the winter and early spring. As mentioned in the previous paragraph, oxygen depletion problems in the metalimnion (middle layer) have precluded efforts to establish a cold-water fishery in the reservoir.

Usually in late April or early May, the bass and crappie spawn occurs. For a two to three week period during this event, it is critical to keep a relatively stable pool for good spawning conditions. If, however, the water should rise into the Flood Control Pool and evacuation of this storage is necessary, it should be evacuated as rapidly as practical to attempt to delay spawn. Stabilization efforts are initiated when the Nashville District determines that the spawn is occurring based on criteria established by TWRA. The agency's criteria to identify the beginning of the spawning period for all reservoirs in Tennessee is a surface water temperature of 60 degrees Fahrenheit as measured on three consecutive days. Reservoir level stabilization to enhance fish spawn is a cooperative effort between LRN and TWRA.

The Caney Fork River below Center Hill Dam supports a viable "put and take" trout fishery. The Tennessee water quality dissolved oxygen standard for a cold-water fishery is 6.0 mg/L. In the late summer and early fall months the dissolved oxygen level of the Center Hill discharge often falls below this standard. During such occurrences the turbines may be operated at reduced capacity. This type of operation increases the tailwater dissolved oxygen level, thus helping to protect the fishery resource. However, to avoid excessive wear, the turbines should not be

operated below their cavitation limits. Full consideration is given to the overall reservoir system goals when determining the implementation plan for partial unit loading.

8-06 Water Supply

Although water supply was not an originally authorized purpose at Center Hill, subsequent legislation and executed water supply agreements have resulted in water supply being included as a project purpose and during drought periods water supply is the top priority for public safety. Center Hill has five users for water supply currently, three active water supply agreements and two surplus water users. The City of Cookeville, City of Smithville, and DeKalb Utility District have water supply agreements and two surplus user agreements are Honky Tonk National Golf Club and William Shell. Based on the latest available data, average monthly withdrawals from Center Hill are nearly 16 MGD for water supply with the largest user being City of Cookeville. For return flows into Center Hill, the City of Cookeville's wastewater treatment plant is the largest returner of water with monthly average returns for all users accounting for nearly 9 MGD. All water supply agreements include an allocated storage volume from the Conservation Pool, between elevations 648.0 and 618.0. Therefore, ensuring that pool elevations are maintained above this minimum Conservation Pool elevation of 618.0 is critical to maintaining available water for the water supply users. Information on these three systems is presented on Plate VII-12.

8-07 Hydroelectric Power

Total revenue from hydropower generation at Center Hill has been over $190 million between 1971 and 2021. During this same time period, the project has generated over 18,000 gigawatt hours of power. Annual generation and revenue are shown graphically on Plate VIII-15 and numerically on Plate VIII-16. The peak generation year was 1973, while the peak revenue year was 2018. The impact of the drought of the mid to late 1980s and early 2000s is evident in the generation values shown on Plate VIII-16.

Fluctuations in revenue do not necessarily follow the same annual fluctuation pattern as generation. Hydropower revenue attributed to individual projects tends to be more a function of accounting, as total revenue is divided among the Cumberland Basin hydropower projects. In addition, approximately one third of a project's hydropower revenue comes from the actual generation of power, while the remainder comes from selling power capacity. As at other LRN projects, revenues do not fluctuate solely with generation quantity due to the fact that a majority of revenues are derived from capacity and not from generation.

8-08 Navigation

Navigation is not a project purpose at Center Hill and its impacts to and support of navigation at downstream projects is minor.

8-09 Drought Contingency Plans

In the interest of public health and safety, the highest priority is given to maintaining the reservoir elevation above the minimum operating elevations of all water supply intakes. The minimum observed reservoir elevation at Center Hill was 620.6 on 18 January 1981, 2.6' above the top of the Inactive Pool.

8-10 Flood Emergency Action Plans

The Emergency Action Plan is updated annually and is available in the resource manager's office. Additionally, a hard copy is kept at the district office, in the Center Hill Superintendent's office, in the Cordell Hull control room, and an electronic copy is posted on the dam safety SharePoint site. It outlines emergency procedures and contact lists in the event of an emergency.

8-11 Frequencies

a. Peak Inflow Probability. Plate VIII-5 shows the inflow duration curve for Center Hill. Inflows are calculated daily using the change in storage at midnight headwater elevations and the observed discharge. This method of calculation computes over 30% of daily inflow values to be negative. Plate VIII-6 shows the volume frequency analytical plot for inflows. This was calculated using period of record observed daily inflows and computes a 1-day, 100-year return interval event to be approximately 170,000 dsf and a 365-day, 100-year return event to be approximately 7,600 dsf.

b. Pool Elevation Duration and Frequency. Plate VIII-1 shows the annual peak headwater elevation of the Center Hill pool from 1951 to 2022 arranged in descending order. The pool elevation frequency curve displayed as Plate VIII-2, shows the percent of time that the pool has been at or below various elevations. During the history of the project, the pool has been within the range of the Conservation Pool over 92 percent of the time and within the Flood Control Pool approximately eight percent of the time. Nearly the full range of the Conservation Pool is used quite regularly. Plate VIII-4 shows the range of pool elevation used during each year between 1948 and 2022. The first full year of normal reservoir level regulation was 1951. This chart shows the consistent use of almost the full range of the Conservation Pool and frequent use of the Flood Control Pool.

c. Key Control Points. The downstream control point, Carthage, is heavily controlled by Center Hill and Cordell Hull. The control flow at Carthage, TN is 72,000 cfs or a stage of 29'. The drainage area at Carthage is 10,690 mi^2. The majority of time the stage at Carthage will fluctuate between 5' and 14' and is mostly dependent on the discharge at Cordell Hull. Since the completion of Center Hill, the stage at Carthage has only been above Major Flood Stage of 47' once, in March 1975 (47.95' on 14 March). Plate VIII-17 shows the duration analysis plot for the Carthage from 1989-2022.

8-12 Other Studies

a. Examples of Regulation. On 01 August 2016, LRN transitioned their primary hydrologic forecasting model to CWMS. The previous model was developed in 1978 by CDM/Resource Analysis Inc. of Waltham, Massachusetts and was known as the RAI model. The RAI model used the antecedent precipitation index coaxial method to forecast runoff in 16 subbasins of the Cumberland River. This was produced for two components: surface runoff and groundwater baseflow for a 12-hour time step. The model was then hydraulically routed using an iterative process between selecting upstream releases, rerunning the model, and evaluating results. The final product was the LRN flowsheet that is nearly identical to the LRN flowsheet still used today. As of 2017, the RAI model is no longer being maintained and CWMS is the primary and only modeling application.

Project regulation examples are shown on Plates VIII-18 through VIII-95 in the form of annual observed reservoir elevation and discharge. Plate VIII-18 shows the daily maximum, median, and minimum average discharges, and midnight pool elevations from 1951 through 2022. Plate VIII-19 shows the daily maximum, median, and minimum midnight pool elevations from 1951 through 2022 exclusively. Plate VIII-20 shows the daily maximum, median, and minimum average discharge from 1951 through 2022 exclusively. Plates VIII-21 through VIII-95 show the daily average discharge and midnight pool elevations for every year from 1948 to 2022.

b. Channel and Floodway Improvement. No notable channel or floodway improvements have been undertaken at Center Hill since the completion of construction.

IX - WATER CONTROL MANAGEMENT

9-01 Responsibilities and Organization

a. Corps of Engineers. The owner of Center Hill Dam is the United States Government, operated through the U.S. Army Corps of Engineers, Nashville District. Plate IX-1 contains a list of key contacts phone numbers used by LRN Water Management.

LRD. LRD, and specifically the division engineer, has the primary responsibility and authority for direct action with respect to all phases of reservoir regulation (ER 1110-2-240) including:

- Basic policies, criteria, and concepts that determine operation plans
- Technical evaluations
- Approval of water control plans and manuals and associated activities
- Approval of deviations from the approved water control plan

The division office coordinates water control management activities associated with inter-district, inter-division, and inter-agency water resource needs. In accordance with ER 1110-2-1400, the LRD Water Management Division is responsible for administration of the Division Engineer's policy for water control management.

LRN. The normal operation of Center Hill Dam is under the jurisdiction of LRN. In general, LRN has the responsibility for flood risk mitigation, regulation of the use of the nation's navigable waters, dam safety, and the planning, construction, and operation of multi-purpose water resource projects (ER 110-2-240).

The main divisions within LRN that are responsible for Center Hill are Engineering and Construction, Operations, and Resource Management.

Within the Engineering and Construction Division, the Hydrology and Hydraulics Branch, Water Management Section is the responsible section for all water control activities. Their primary responsibilities are:

- General management of all district reservoir regulation activities
- Technical evaluations and performance of operations
- Implementation of plans and manuals for all district reservoirs

The Operations Division is responsible for the funding and staffing requirements at Center Hill Dam and Resource Management is responsible for the funding and staffing requirements at the Center Hill Resource Management Office.

b. Other Federal Agencies. Great Falls Dam is a hydropower project owned and operated by the Tennessee Valley Authority (TVA). It was constructed in 1916 by

Tennessee Electric Power Company and purchased by TVA in 1939. Great Falls Dam is located on the Caney Fork River approximately 64.5 river miles upstream of Center Hill Dam. The releases from Great Falls flow directly into the Center Hill Reservoir. LRN Water Management works with TVA on a daily basis to coordinate the releases from Great Falls with the daily forecast generation schedule at Center Hill.

c. State and County Agencies. Local and state agencies such as fire, police, and medical emergency groups are responsible for responding to emergencies in their respective fields. The LRN Natural Resource Management Branch coordinates any necessary activities with the TWRA, such as fish and wildlife surveys, safe boater education and patrols, and the enforcement of creel limits.

d. Private Organizations. No private organizations are involved in the operation or maintenance of Center Hill Dam.

9-02 Interagency Coordination

a. Local Press and Corps Bulletins. General information regarding the Center Hill project is made available to the public through various websites, which can be accessed through the main website for LRN at http://www.lrn.usace.army.mil/Locations/Reservoirs/Center-Hill-Reservoir/. Press releases and Corps bulletins are issued as needed when deviations from the approved Water Control Plan are necessary.

b. National Weather Service. Coordination between the NWS and LRN provides for the collection and dissemination of current project data for the Cumberland River Basin. The NWS provides a range of river and stream stage information and forecasts. Although the NWS does not provide any forecasts for stages above Center Hill Dam or in the 26.6 miles of tailwater below the dam, they do provide at least a daily forecast for Carthage, at the confluence of the Caney Fork and Cumberland Rivers; therefore, it is important that they receive accurate discharge forecasts from LRN. LRN Water Management provides observed rainfall and project headwater and tailwater readings at dams within the Cumberland River Basin, as well as reservoir outflow forecasts within the Basin.

The OHRFC hydrologists provide daily river stage and flow forecasts for locations along the Ohio River and most of its tributaries, including the Cumberland River. The OHRFC is co-located with the NWS Weather Forecast Office (WFO) in Wilmington, OH. Climate forecasts for the Center Hill drainage basin are made by the Nashville Weather Service Office (OHX).

c. U.S. Geological Survey. The cooperative stream gaging program (ER 1110-2-1455) was established in 1940 through cooperative arrangements between LRN and the USGS to meet special LRN data needs in connection with water resources (planning studies,

monitoring river conditions during construction, and for water control management of completed projects). Under this program, the USGS is responsible for the four stream gages within the Center Hill watershed.

The LRN Water Management Section will call to request the USGS to repair a gage critical to regulation of a reservoir. Annual meetings are held with the USGS concerning the cooperative program. Additional meetings are held with the USGS as necessary.

d. Power Marketing Agency. Every Thursday, LRN sends a power declaration to SEPA that shows total daily generation forecasts for the next week (Sunday-Saturday).

e. Other Federal, State, or Local Agencies. TVA issues a generation preschedule every afternoon for the next day's hourly generation schedule. This is published on their website, as well as LRN's website, and is also available by calling a TVA managed 800 number (1-800-238-2264, option 4, option 37).

9-03 Interagency Agreements

Agreements between LRN and outside agencies include real estate acquisition agreements and hydrologic and weather forecasting coordination agreements with USGS and NWS. Additionally, a contract between SEPA and TVA specifies the allocation of dependable capacity and net energy to be provided by the Cumberland projects.

9-04 Commissions, River Authorities, Compacts, and Committees

As mentioned throughout this document, several groups share interest in river basin water control activities, including TWRA, SEPA, TVA, and the USGS. Additionally, Team Cumberland, a group made up of representatives from SEPA, LRD, LRN, TVA, and power system customers, meets annually and has a mission in advancing responsible hydropower. Lastly, the Cumberland River Compact is a nonprofit organization established to enhance the health and enjoyment of the Cumberland River and its tributaries through education, collaboration, and action.

9-05 Non-Federal Hydropower

Great Falls Dam is a federal hydropower project upstream of Center Hill Dam that is operated by the Tennessee Valley authority. The releases from Great Falls Dam directly contribute to the total inflow at Center Hill Dam. Great Falls Dam has two hydropower units with a nameplate capacity rating of 36 megawatts. However, the hydropower production from Great Falls Dam does not contribute to the hydropower system totals produced by the Cumberland River System projects operated by the Nashville District.

9-06 Reports

Beginning in FY 2017, LRN furnished LRD with a Water Management Annual Report. This report serves as an annual report on water management operations at all reservoirs within the

district. It includes information on reservoir operations, hydrologic conditions and precipitation, hydropower generation, navigation, recreation usage, flood storage utilized, and damages prevented, water quality, sediment surveys, modeling upgrades, data collection and storage information, status of water control manuals, and any other relevant water management operations or issues from the previous year.

Lastly, LRN sends an annual Flood Damage Report to Congress every fiscal year.

Exhibit A. Center Hill Dam & Reservoir Supplementary Pertinent Data

DAM LOCATION

• Dam Location

State:	Tennessee
County:	DeKalb
Nearest Communities:	City of Smithville located 6.1 miles southwest of the project and the city of Carthage, located 14 miles northwest of the project.
River:	Caney Fork
Mile:	26.6
Latitude:	North 36°05'48"
Longitude:	West 85°49'38"

• Adjacent Water Control Facilities

Upstream		
Great Falls Dam	Caney Fork River,	Mile 91.1
Downstream		
Old Hickory Dam	Cumberland River,	Mile 216.2

ORIGINAL AUTHORIZATION AND HISTORY

• Primary Project Purposes	• Authorizing Legislation
Flood Control	PL 75-761, Flood Control Act of 1938
Hydropower	PL 79-525, River and Harbor Act of 1946
• Subsequent Authorized Operating Purposes	
Recreation	PL 78-534, Flood Control Act of 1944
Fish and Wildlife	PL 85-624, Fish and Wildlife Coordination Act of 1958
Water Quality	PL 92-500, Federal Water Pollution Control Act Amendments of 1972
Water Supply	Storage space is allocated for water supply on a permanent basis in accordance with PL 85-500, Water Supply Act of 1958. Consequently, during drought, the first priority is maintenance of water supply.

• Construction Dates

Began	18 March	42
Suspended due to WWII	March	43
Work Resumed	January	46
Closure	27 November	48
Impoundment	11 January	49
Inservice		
Power		
Unit 1	16 December	50
Unit 2	17 January	51
Unit 3	11 April	51

PHYSICAL COMPONENTS OF DAM

• Type of Structure		
Combination of concrete gravity and rolled earthfill embankment		
• Dam Section Lengths		
Spillway Section, Concrete	470 feet	143.2 m
Power Section, Concrete	267 feet	81.4 m
Left Side Non-overflow section, Concrete	400 feet	121.9 m
Right Side Non-overflow section, Concrete	245 feet	74.7 m
Embankment Section, Rolled Earthfill	778 feet	237.1 m
Total Dam Length	2,160 feet	658.3 m
• Structure Elevations		
Top of Dam, Roadway and Embankment	696 feet	212.1 m
Top of Gates	685 feet	208.8 m
Spillway Crest	648 feet	197.5 m
Flood Plain, General Elevation	510 feet	155.4 m
Minimum Tailwater, Zero Flow	476 feet	145.1 m
Stream Bed, approximate	470 feet	143.2 m
Base of Dam, Concrete Section, approx.	446 feet	135.9 m
• Outlet Works		
Spillway		
Type-Concrete Gravity, Ogee with Bucket Stilling Basin		
Total Effective Width	400 feet	121.9 m
Tainter Gates		
Number	8	
Width	50 feet	15.2 m
Height	37 feet	11.3 m
Design Discharge (with surcharge of 43.4 feet)	458,000 cfs	12,970.6 cms
Sluices		
Type-Cast Iron, Slide, Hydraulically operated		
Number of Conduits	6	
Width (of conduits)	4 feet	1.22 m
Height (of conduits)	6 feet	1.83 m
Discharge Capacity (pool at spillway crest)	9,600 cfs	271.9 cms

PHYSICAL COMPONENTS OF DAM (continued)		
• Saddle Dam & Fuse Plug (approximately 0.5 mile east of main dam)		
Type-Rolled-fill Dike		
Top of Dam	692 feet	212.3 m
Maximum Height	125 feet	38.1 m
Top Length	770 feet	234.7 m
Top Width	35 feet	10.7 m
Maximum Base Width	600 feet	182.9 m
• Power Plant		
Type-3 Francis blade propeller turbines		
Operating Heads		
Maximum with full Flood Control Pool	207 feet	63.1 m
Nominal (normal for design)	160 feet	48.8 m
Minimum with full drawdown	131 feet	39.9 m
Penstock		
Number	3	
Diameter	20 feet	6.1 m
Penstock Elevation	549.9 feet	
Discharge at full rating	3,750 cfs each	106.2 cms
50,000 kva, 160-foot head	(11,250 cfs total)	318.6 cms
Nameplate Power Rating	57 MW each (171 MW total)	
Estimated average annual generation	351,000 MWH	

HYDRAULICS AND HYDROLOGY		
•Drainage Areas		
Project		
Total	2,174 sq.mi.	5,630 sq.km
Local Uncontrolled (between Center Hill and Great Falls)	499 sq. mi.	1,292 sq. km
Control Point-Carthage, TN		
Total	10,690 sq.mi.	27,684 sq. km
Local Uncontrolled (between Carthage and Cordell Hull/Center Hill)	420 sq. mi.	3,636 sq. km.

HYDRAULICS AND HYDROLOGY (continued)		
Downstream Project-Old Hickory		
Total	11,674 sq. mi.	30,233 sq. km.
Local Uncontrolled (between Old Hickory and Cordell Hull/Center Hill)	1,404 sq. mi.	3,636 sq. km.
• Top of Pool Elevations		
Flood Control	685.00 feet	208.8 m
Conservation	648.00 feet	197.5 m
Inactive	618.00 feet	188.4 m
• Surface Area at top of pools		
Flood Control	23,060 acres	9,335 hectares
Conservation	18,220 acres	7,376 hectares
Inactive	14,590 acres	5,947 hectares
• Length of Reservoir at top of pools		
Flood Control	64.0 miles	103.0 km
Conservation	63.6 miles	102.3 km
Inactive	62.4 miles	100.4 km
• Shoreline length at top of pool		
Flood Control	415 miles	667.8 km
• Storage Volumes	Acre Feet	Cubic Hectometers
Flood Control	762,000	940
Conservation	492,000	607
Inactive	422,000	1,034
Total	2,092,000	2,581
Day Second Feet (day cfs)		
Flood Control	384,000	
Conservation	248,000	
Inactive	422,000	
Total	1,054,000	
Runoff (to fill pool)	Inches	Centimeters
Flood Control	6.51	16.5
Conservation	4.21	10.7
Inactive	7.16	18.2
Total	17.88	45.4

• Average Outflows (cfs) 1951 to 2021				
Month	Generation	Spill*	Total	Total (cms)
Jan	5,612	310	5,922	168
Feb	5,470	554	6,024	171
Mar	5,784	706	6,490	184
Apr	5,506	496	6,002	170
May	3,645	286	3,931	111
Jun	2,419	43	2,462	70
Jul	1,953	20	1,973	56
Aug	1,571	52	1,623	46
Sep	1,424	81	1,505	43
Oct	1,718	132	1,850	52
Nov	2,086	99	2,185	62
Dec	4,547	120	4,667	132
Annual	3,478	241	3,719	105

* These values include releases from the spillway gates, sluice gates, and the orifice gate.

REAL ESTATE			
• Acquisition			Hectares
Fee Holdings	38,551	acres	15,606.7
Easement Holdings	102	acres above the dam	41.3
	427	acres below the dam	172.9
• Elevation of Acquisition Line	Elevation 690 plus additional lands deemed necessary to avoid paying excessive severance or incidental damages due to isolation.		

ACCESS LOCATIONS

	Reservoir Sailing Line (Mile)*	Bank (looking downstream)	
• Bridge Crossings			
TN Highway 96	26.6 (at dam)		
TN Highway 56	42.6		
TN Highway 70	60.1		
• Recreation Areas			
Corps of Engineers			
Long Branch	26.4	L	
Buffalo Valley	26.5	R	
Center Hill Rec. Area	27.0	L	
Cane Hollow	53.0	R	
Holmes Creek	32.2	L	(Holmes Creek)
Floating Mills	38.6	R	
Hurricane Bridge	42.2	R	
Johnson Chapel	53.0	R	(Falling Water River)
Ragland Bottom	58.3	R	
By Others			
Edgar Evins State Park	27.1	L and R	
Burgess Falls State	53.0	R	(Not on Corps Prop.)
Window Cliff Nat. Area	53.0	R	(Falling Water River)
Rock Island State Park	87.6	L and R	
Commercial Boat Docks			
Center Hill Marina	28.6	L	
Hurricane Marina	40.8	R	
Edgar Evins Marina	27.6	R	
Horseshoe Bend Marina	86.1	R	
Cookeville Boat Dock	53.0	R	
Hidden Harbor Marina	32.2	L	
Sligo Marina	59.6	L	
Four Seasons Marina	62.6	L	
Pates Ford Marina	73.6	L	

* The reservoir mile represents a much more direct path than the river mile of the old channel. Since recreation areas generally exceed one mile in length, the reservoir mile given is approximately the midpoint of the area.

GREAT FALLS DAM		
• River:	Caney Fork	
• Mile:	91.1	
• Project Purpose:	Hydropower	
• Project History:	Built in 1916 by private interests. Enlarged and raised in 1925. Acquired by TVA in 1939.	
• Type of Structure:	Concrete Gravity	
• Drainage	1,675 sq. mil	4,338 sq. km.
• Storage Volumes		
Top of Gates (flat pool @ elev. 805.16)	54,500 acre-feet	67.2 cu. hectometer
Normal Minimum (to top of gates)	49,400 acre-feet	60.9 cu. hectometer
• Pool Elevations		
Maximum Pool (for design) (approx. 150, 000 cfs)	812 feet	247.5 m
Minimum Pool	761.12 feet	232.3 m
Normal Tailwater (full load)	657.7 feet	200.5 m
Minimum Tailwater (no load)	649.0 feet	210.3 m
• Structure Elevations		
Top of Gates	805.16 feet	245.4 m
Spillway Crest	791.16 feet	241.1 m
• Outlets Works		
Type-Tainter Gates		
Number	18	
Width	25 feet	7.6 m
Height	14 feet	4.3 m
Maximum Design Discharge	150,000 cfs	4,248 cms
• Power Plant		
Number of Units	2	
Normal Head	151 feet	46.0 m
Minimum head	114 feet	34.8 m
Discharge at Full Rating (151-foot head)	3,200 cfs	90.6 cms
Total Rated Capacity	32 MW	

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Exhibit B. Standing Instructions to Damtenders

Standing Instructions Center Hill

In the unlikely event that contact cannot be established between operators of the Center Hill project and the Nashville District Water Management Section the following guidelines should be used by operators.

1. The Conservation Pool at Center Hill extends between elevations 618.0 and 648.0. The minimum flow requirement from Center Hill Dam varies seasonally. During the non-low flow season, the minimum flow is one unit hour of generation every eight hours. During the low flow season, the minimum flow is 250 cfs continuous, typically through the orifice gate, and one unit hour of generation at least every 48 hours. The low flow season is generally understood to be between 1 June through 30 November but can be modified based on hydrologic conditions. The non-low flow season is understood to be any period outside of the low flow season, generally defined as 1 December through 31 May.
2. If the headwater level approaches the lower limit of the Conservation Pool, elevation 618.0, reduce or curtail hydropower discharges as necessary to prevent the headwater from falling below elevation 618.0 and notify the power scheduling agency.
3. Changes in hydropower generation are limited to ramping up from zero to one unit in the first hour and then up to two additional units in the second hour. Changes in hydropower generation are limited two units down per hour.
4. When flood conditions develop downstream on the Cumberland River, the primary purpose of Center Hill is flood control. This function is served by storing water upstream of the dam until the downstream flooding has subsided. The Flood Control Pool extends between elevations 648.0 and 685.0. After the flood threat has passed, reservoir flood control storage is evacuated as rapidly as downstream conditions permit. The following paragraphs give guidance on operations for flood control.
5. Even if the headwater is within the Conservation Pool, hydropower releases should be reduced or curtailed entirely in the interest of flood control. The hydropower scheduling agency should be notified of these actions.
6. To the extent possible, limit flows at Carthage to a maximum of 72,000 cfs or a stage of 29'.
7. Limit total project releases to bank full capacity of Caney Fork River, 30,000 cfs, unless larger releases are required by the Emergency Operations Schedule (EOS).
8. Limit increases in sluice or spillway gate discharges to 2,000 cfs per hour and decreases to 4,000 cfs per hour. All spillway gates should be operated at approximately the same opening.
9. If Center Hill and Cordell Hull should require concurrent changes in spillway gate releases, limit combined increases to 5,000 cfs per hour and combined decreases to 10,000 cfs per hour.
10. When Center Hill headwater is rising within the Flood Control Pool, routinely check the EOS. If the rate of rise in headwater criteria is met, follow EOS instructions without deviation.
11. Although no special operations are necessary, if the pool reaches elevation 691.5, a 770-foot long and 34.4-foot high erodible fuse plug on top of the right rim saddle dam will be triggered. The top of the fuse plug is at elevation 692.0; however, the fuse plug pilot channel begins at 691.5 so depending on the duration of flow, fuse plug operation is possible slightly below 692.0. The fuse plug was designed to completely erode down to a concrete sill elevation of 658.0 in approximately 30 minutes. Once eroded, the project discharge capacity would increase by approximately 400,000 cfs.
12. When all flood control storage has been evacuated by lowering the headwater to elevation 648' resume normal operations.

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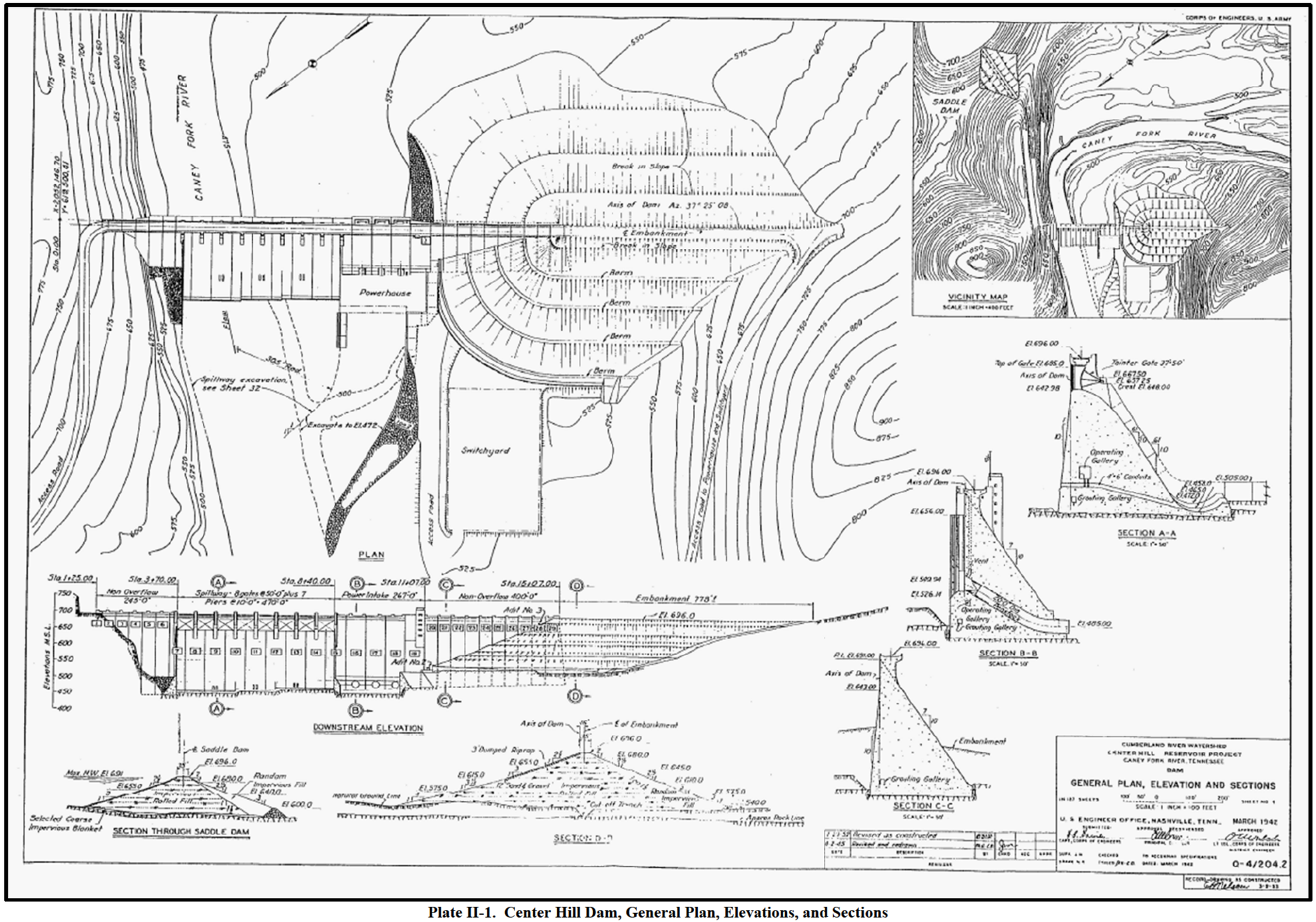


Plate II-1. Center Hill Dam, General Plan, Elevations, and Sections

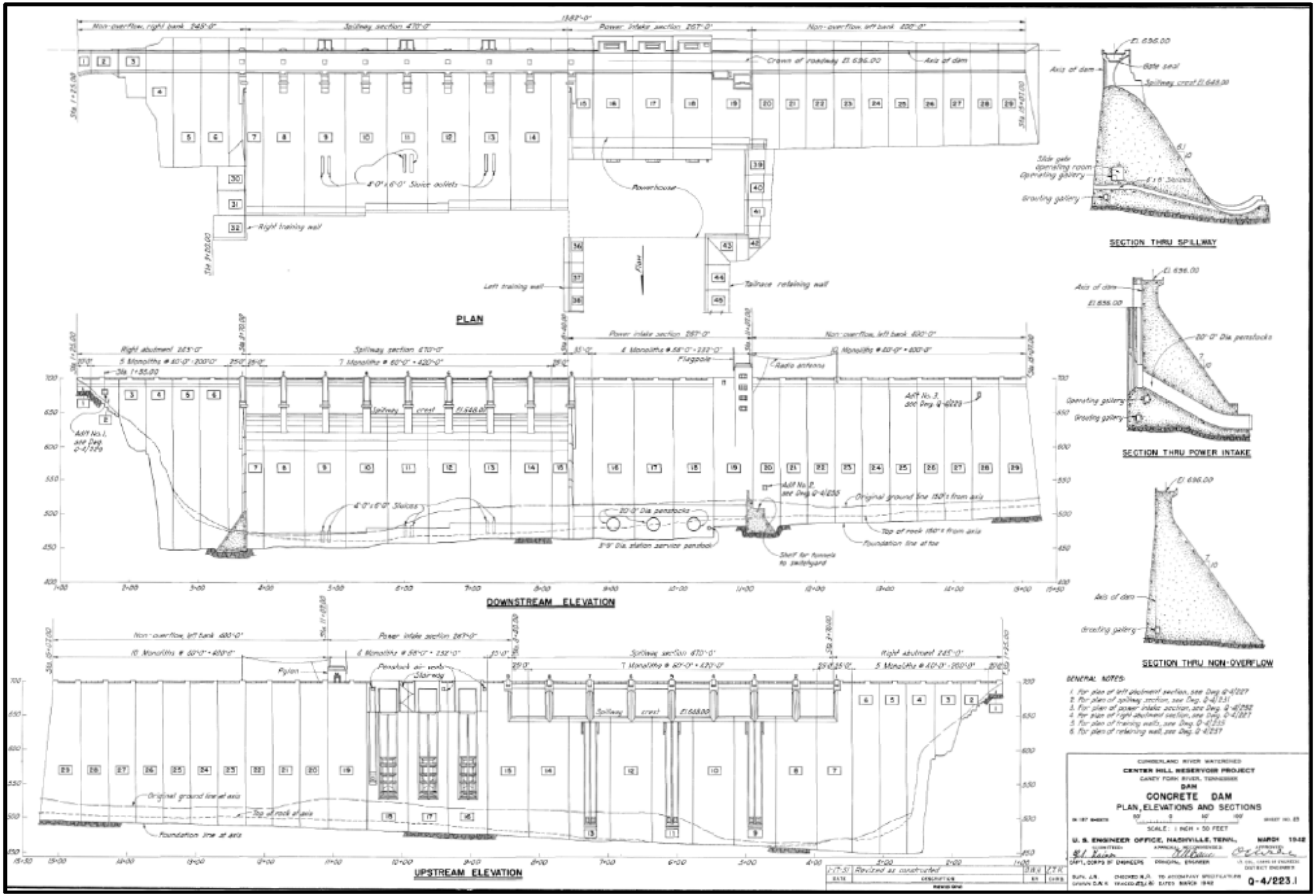


Plate II-2. Center Hill Dam, Concrete Dam Plan, Elevations, and Sections

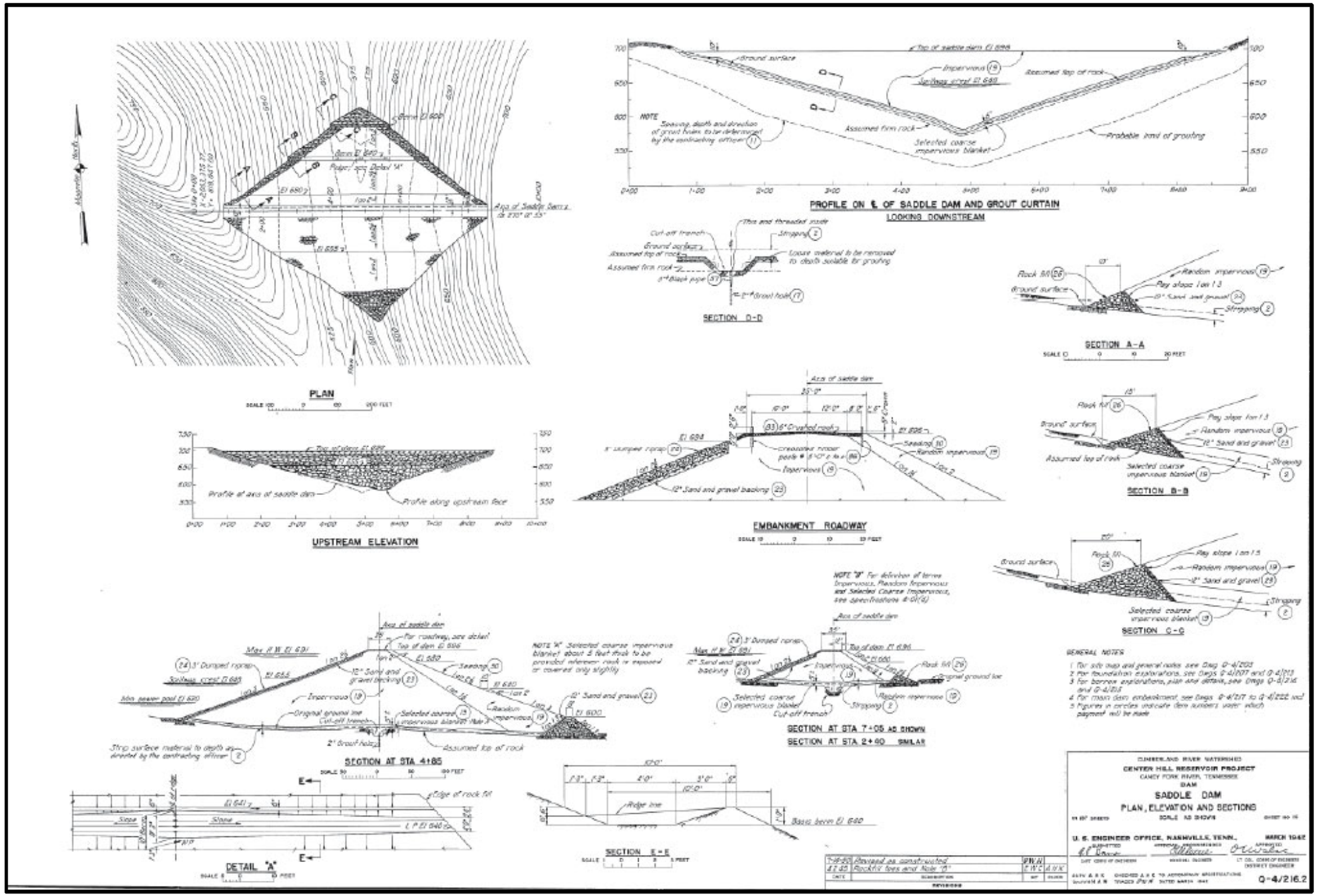


Plate II-3. Center Hill Dam, Saddle Dam Plan, Elevation, and Sections.

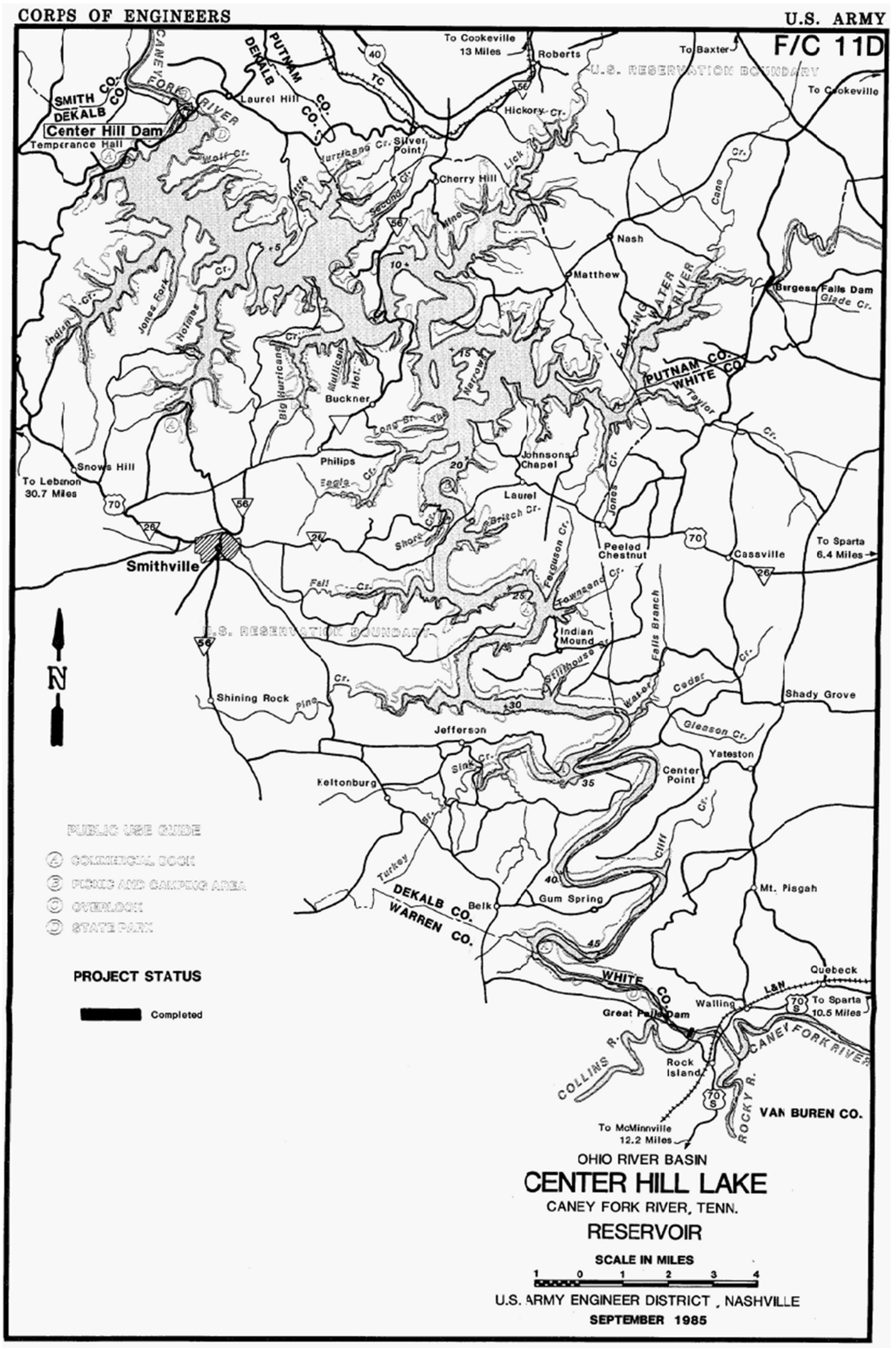


Plate II-4. Center Hill Reservoir

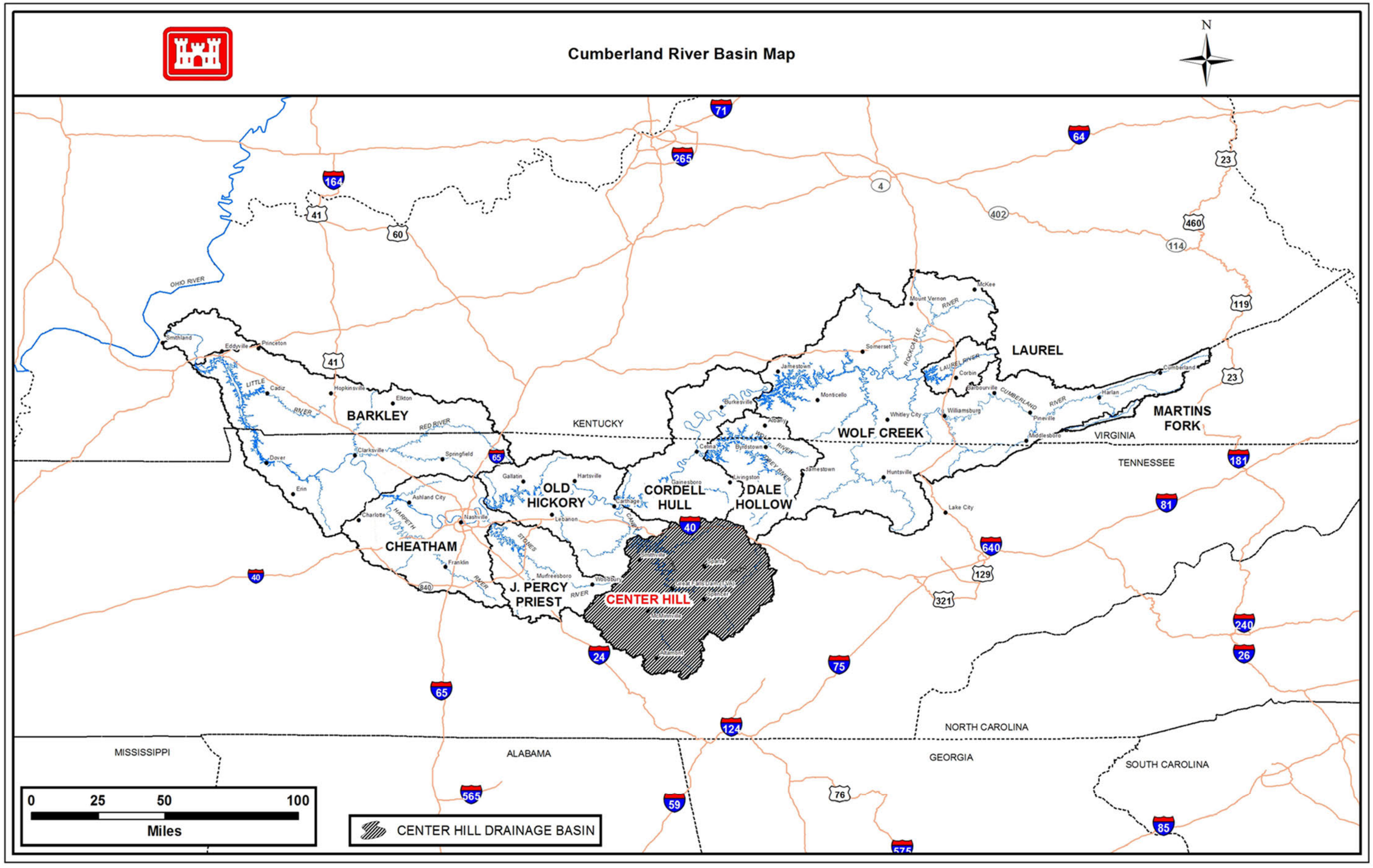


Plate II-5. Cumberland River Basin Map

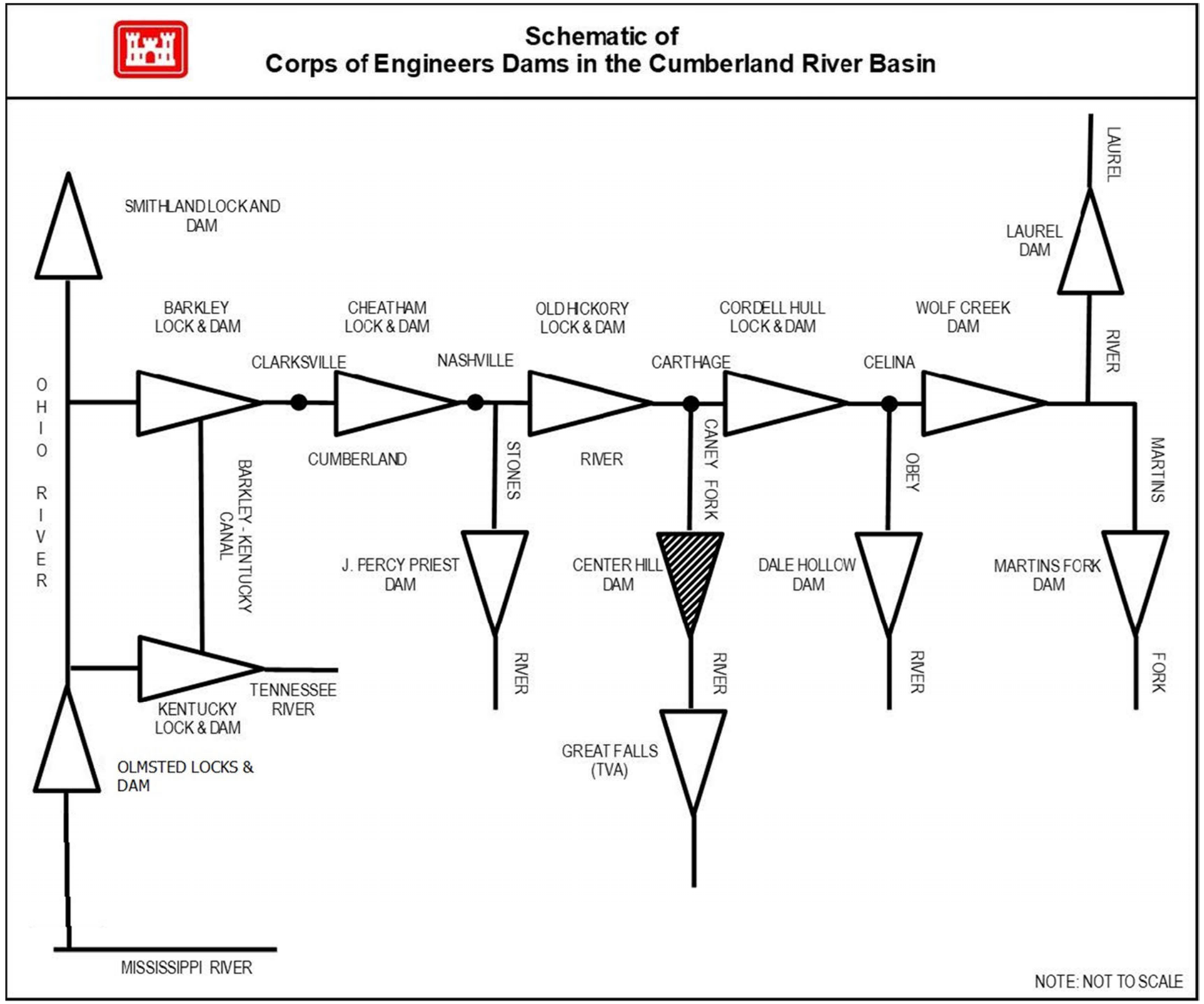


Plate II-6. Schematic of Corps Dams in the Cumberland River Basin

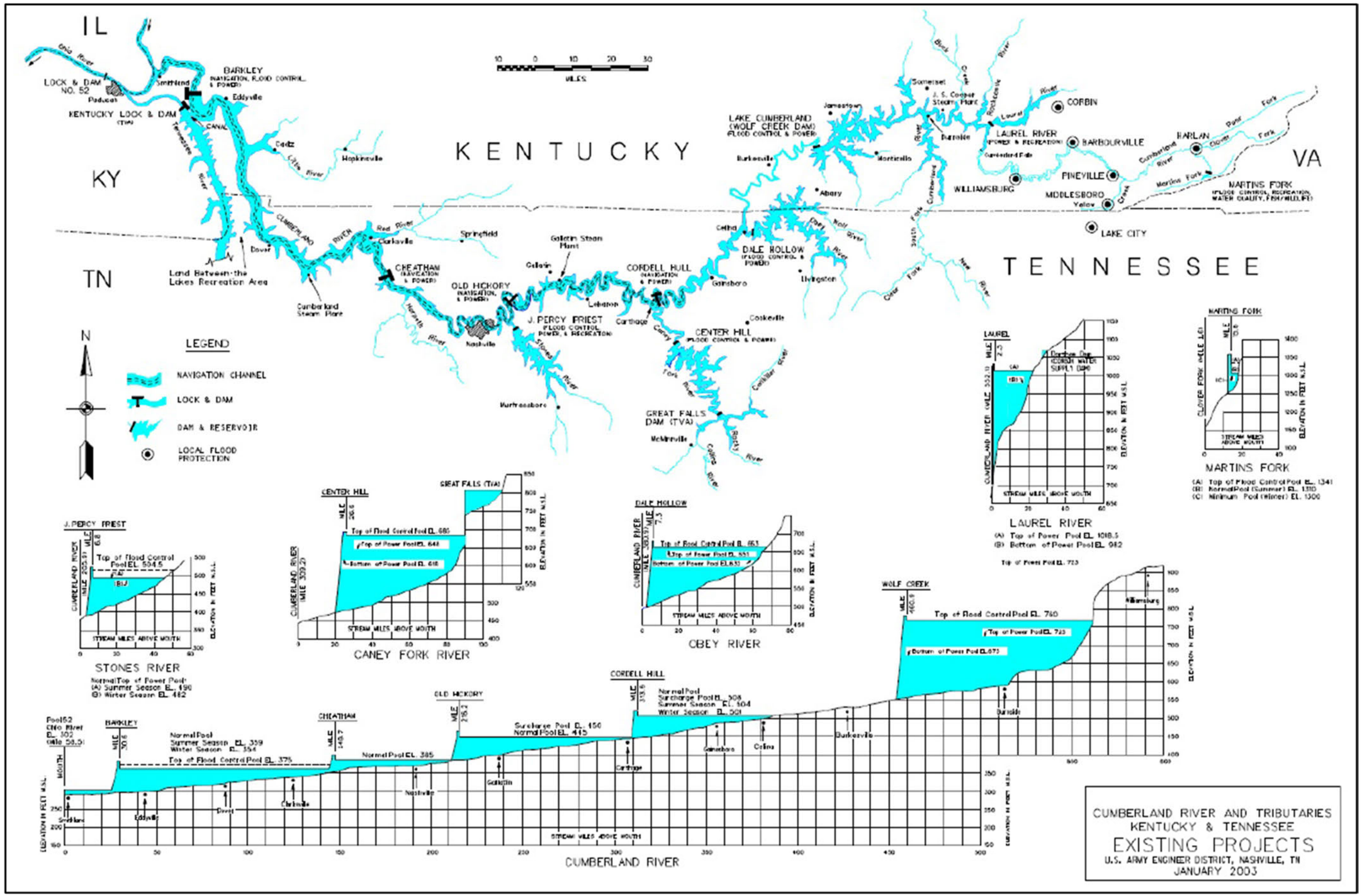


Plate II-7. Profile of Cumberland River

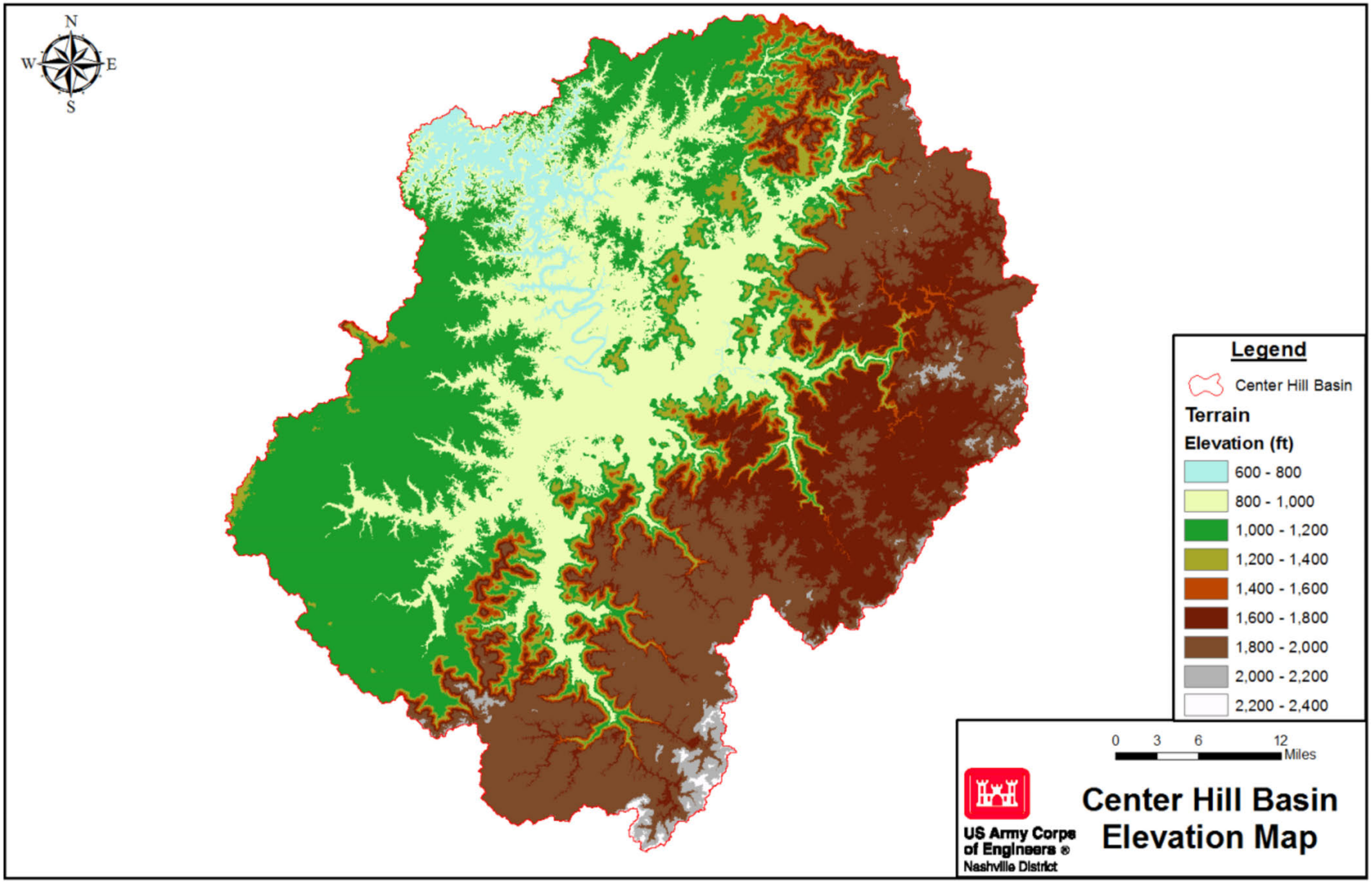


Plate IV-1. Elevation Map for the Center Hill Basin

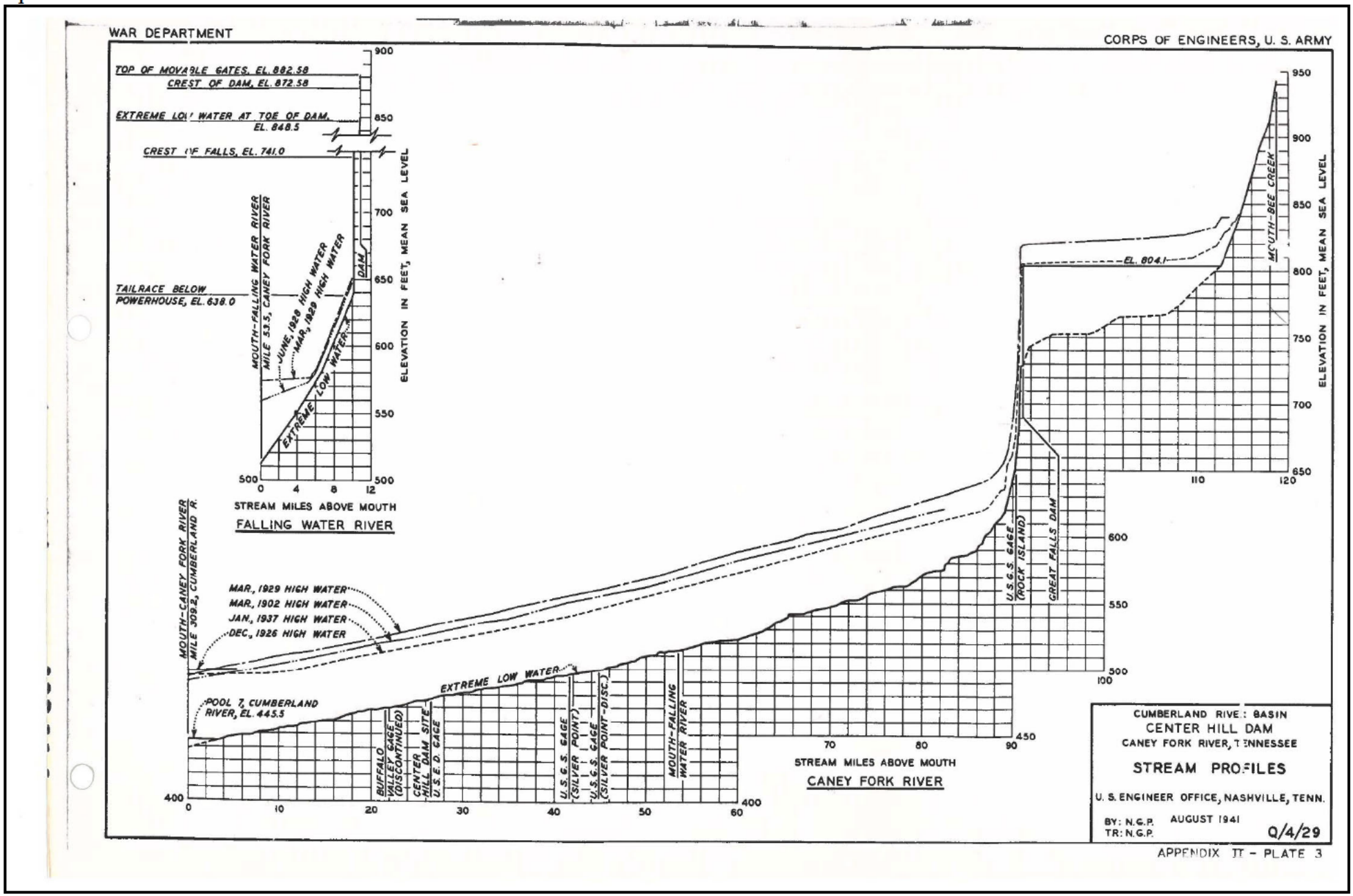
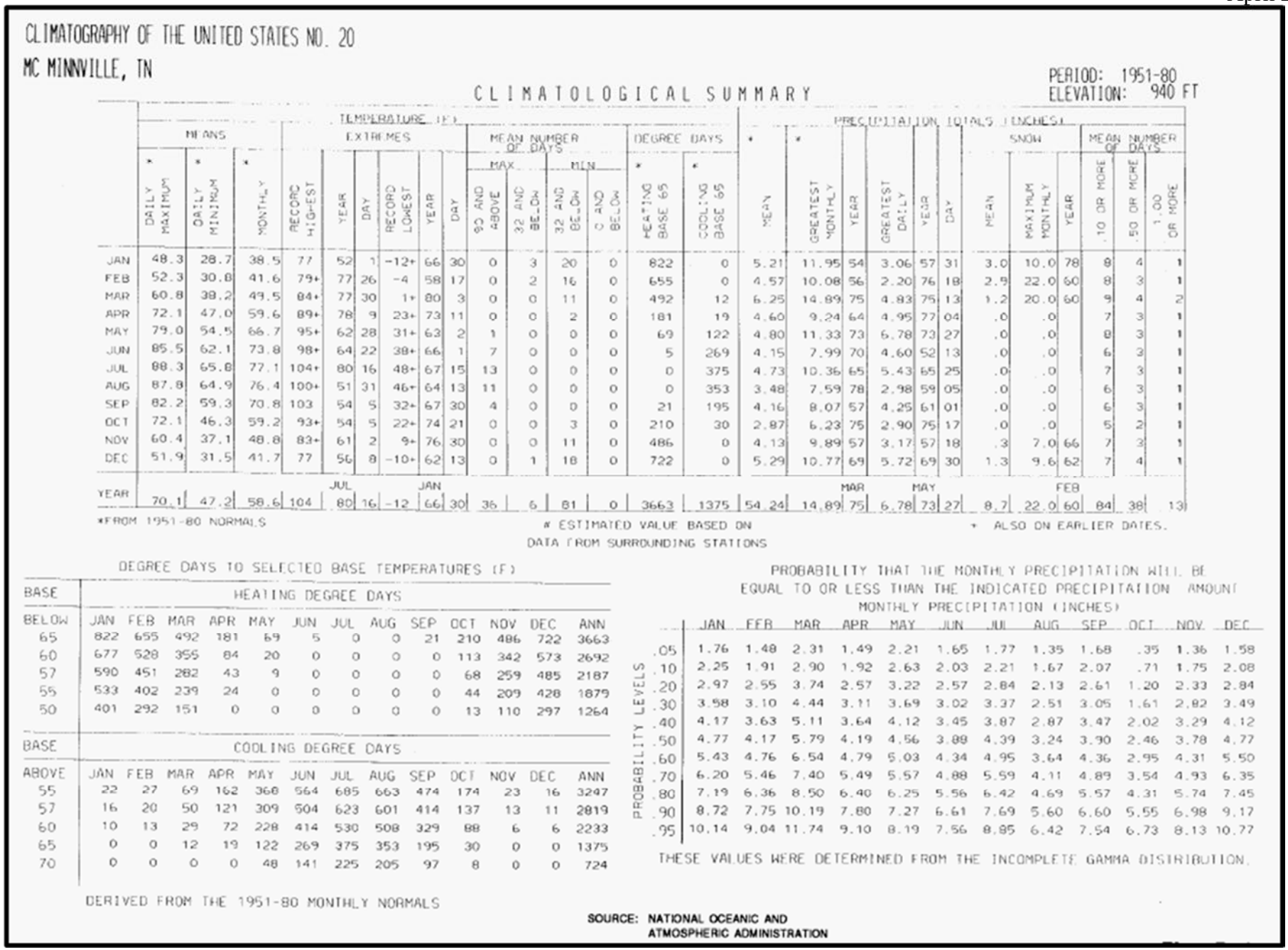


Plate IV-2. Stream Profiles



CLIMATOGRAPHY OF THE UNITED STATES NO. 20

MC MINNVILLE, TN

PERIOD: 1951-80
ELEVATION: 940 FT

CLIMATOLOGICAL SUMMARY

TEMPERATURE (F)

	MEANS			EXTREMES					MEAN NUMBER OF DAYS				DEGREE DAYS	
									MAX		MIN			
	DAILY MAXIMUM	DAILY MINIMUM	MONTHLY	RECORD HIGHEST	YEAR	DAY	RECORD LOWEST	YEAR	DAY	90 AND ABOVE	32 AND BELOW	32 AND BELOW	0 AND BELOW	HEATING BASE 65	COOLING BASE 65
JAN	48.3	28.7	38.5	77	52	1	-12+	66	30	0	3	20	0	822	0
FEB	52.3	30.8	41.6	79+	77	26	-4	58	17	0	2	16	0	655	0
MAR	60.8	38.2	49.5	84+	77	30	1+	80	3	0	0	11	0	492	12
APR	72.1	47.0	59.6	89+	78	9	23+	73	11	0	0	2	0	181	19
MAY	79.0	54.5	66.7	95+	62	28	31+	63	2	1	0	0	0	69	122
JUN	85.5	62.1	73.8	98+	64	22	38+	66	1	7	0	0	0	5	269
JUL	88.3	65.8	77.1	104+	80	16	48+	67	15	13	0	0	0	0	375
AUG	87.8	64.9	76.4	100+	51	31	46+	64	13	11	0	0	0	0	353
SEP	82.2	59.3	70.8	103	54	5	32+	67	30	4	0	0	0	21	195
OCT	72.1	46.3	59.2	93+	54	5	22+	74	21	0	0	3	0	210	30
NOV	60.4	37.1	48.8	83+	61	2	9+	76	30	0	0	11	0	486	0
DEC	51.9	31.5	41.7	77	56	8	-10+	62	13	0	1	18	0	722	0
YEAR	70.1	47.2	58.6	104	JUL 80	16	-12	JAN 66	30	36	6	81	0	3663	1375

PRECIPITATION TOTALS (INCHES)

	MEAN	GREATEST MONTHLY	YEAR	GREATEST DAILY	YEAR	DAY	SNOW MEAN	SNOW MAXIMUM MONTHLY	SNOW YEAR	MEAN NUMBER OF DAYS .10 OR MORE	.50 OR MORE	1.00 OR MORE
JAN	5.21	11.95	54	3.06	57	31	3.0	10.0	78	8	4	1
FEB	4.57	10.08	56	2.20	76	18	2.9	22.0	60	8	3	1
MAR	6.25	14.89	75	4.83	75	13	1.2	20.0	60	9	4	2
APR	4.60	9.24	64	4.95	77	04	.0	.0		7	3	1
MAY	4.80	11.33	73	6.78	73	27	.0	.0		8	3	1
JUN	4.15	7.99	70	4.60	52	13	.0	.0		6	3	1
JUL	4.73	10.36	65	5.43	65	25	.0	.0		7	3	1
AUG	3.48	7.59	78	2.98	59	05	.0	.0		6	3	1
SEP	4.16	8.07	57	4.25	61	01	.0	.0		6	3	1
OCT	2.87	6.23	75	2.90	75	17	.0	.0		5	2	1
NOV	4.13	9.89	57	3.17	57	18	.3	7.0	66	7	3	1
DEC	5.29	10.77	69	5.72	69	30	1.3	9.6	62	7	4	1
YEAR	54.24	14.89	MAR 75	6.78	MAY 73	27	8.7	22.0	FEB 60	84	38	13

*FROM 1951-80 NORMALS

ESTIMATED VALUE BASED ON DATA FROM SURROUNDING STATIONS

+ ALSO ON EARLIER DATES.

DEGREE DAYS TO SELECTED BASE TEMPERATURES (F)

BASE BELOW	HEATING DEGREE DAYS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
65	822	655	492	181	69	5	0	0	21	210	486	722	3663
60	677	528	355	84	20	0	0	0	0	113	342	573	2692
57	590	451	282	43	9	0	0	0	0	68	259	485	2187
55	533	402	239	24	0	0	0	0	0	44	209	428	1879
50	401	292	151	0	0	0	0	0	0	13	110	297	1264

BASE ABOVE	COOLING DEGREE DAYS JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
55	22	27	69	162	368	564	685	663	474	174	23	16	3247
57	16	20	50	121	309	504	623	601	414	137	13	11	2819
60	10	13	29	72	228	414	530	508	329	88	6	6	2233
65	0	0	12	19	122	269	375	353	195	30	0	0	1375
70	0	0	0	0	48	141	225	205	97	8	0	0	724

DERIVED FROM THE 1951-80 MONTHLY NORMALS

PROBABILITY THAT THE MONTHLY PRECIPITATION WILL BE EQUAL TO OR LESS THAN THE INDICATED PRECIPITATION AMOUNT

MONTHLY PRECIPITATION (INCHES)

PROBABILITY LEVELS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
.05	1.76	1.48	2.31	1.49	2.21	1.65	1.77	1.35	1.68	.35	1.36	1.58
.10	2.25	1.91	2.90	1.92	2.63	2.03	2.21	1.67	2.07	.71	1.75	2.08
.20	2.97	2.55	3.74	2.57	3.22	2.57	2.84	2.13	2.61	1.20	2.33	2.84
.30	3.58	3.10	4.44	3.11	3.69	3.02	3.37	2.51	3.05	1.61	2.82	3.49
.40	4.17	3.63	5.11	3.64	4.12	3.45	3.87	2.87	3.47	2.02	3.29	4.12
.50	4.77	4.17	5.79	4.19	4.56	3.89	4.39	3.24	3.90	2.46	3.78	4.77
.60	5.43	4.76	6.54	4.79	5.03	4.34	4.95	3.64	4.36	2.95	4.31	5.50
.70	6.20	5.46	7.40	5.49	5.57	4.88	5.59	4.11	4.89	3.54	4.93	6.35
.80	7.19	6.36	8.50	6.40	6.25	5.56	6.42	4.69	5.57	4.31	5.74	7.45
.90	8.72	7.75	10.19	7.80	7.27	6.61	7.69	5.60	6.60	5.55	6.98	9.17
.95	10.14	9.04	11.74	9.10	8.19	7.56	8.85	6.42	7.54	6.73	8.13	10.77

THESE VALUES WERE DETERMINED FROM THE INCOMPLETE GAMMA DISTRIBUTION.

SOURCE: NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Plate IV-3. Climatological Summary – McMinnville, TN

405882 MC MINNVILLE, TN LAT: 35 41N (DEG MIN) LONG: 85 48W (DEG MIN) PERIOD: 1951-80

FREEZE DATA

PROBABILITY OF LATER DATE IN SPRING (THRU JULY 31) THAN INDICATED(*)

SPRING FREEZE DATES (MO/DAY)

TEMP (F)	.90	.80	.70	.60	.50	.40	.30	.20	.10
36	4/10	4/16	4/20	4/24	4/27	5/01	5/04	5/09	5/15
32	3/27	4/01	4/05	4/08	4/11	4/14	4/17	4/21	4/26
28	3/14	3/19	3/23	3/26	3/28	3/31	4/03	4/07	4/11
24	2/19	2/26	3/04	3/09	3/13	3/17	3/22	3/28	4/04
20	1/26	2/05	2/12	2/18	2/23	3/01	3/07	3/14	3/24
16	1/22	1/31	2/07	2/12	2/17	2/21	2/26	3/04	3/12

PROBABILITY OF EARLIER DATE IN FALL (BEGINNING AUG 1) THAN INDICATED(*)

FALL FREEZE DATES (MO/DAY)

TEMP (F)	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	10/02	10/06	10/09	10/12	10/14	10/16	10/19	10/22	10/26
32	10/08	10/13	10/17	10/20	10/23	10/26	10/29	11/02	11/07
28	10/21	10/26	10/29	11/01	11/04	11/07	11/10	11/13	11/18
24	10/28	11/02	11/05	11/08	11/11	11/14	11/17	11/20	11/25
20	11/05	11/11	11/16	11/19	11/23	11/26	11/30	12/04	12/11
16	11/21	11/28	12/04	12/09	12/14	12/18	12/23	12/30	1/08

PROBABILITY OF LONGER THAN INDICATED FREEZE FREE PERIOD (DAYS)

FREEZE FREE PERIOD

TEMP (F)	.10	.20	.30	.40	.50	.60	.70	.80	.90
36	192	184	178	173	169	164	160	154	146
32	213	206	202	198	194	191	187	182	176
28	241	234	228	224	220	216	212	207	199
24	264	256	251	247	242	238	233	228	221
20	306	294	286	279	272	265	258	249	237
16	>365	325	313	305	297	290	283	275	263

(*)PROBABILITY OF OBSERVING A TEMPERATURE AS COLD, OR COLDER, LATER IN THE SPRING OR EARLIER IN THE FALL THAN THE INDICATED DATE. 0/00 INDICATES THAT THE PROBABILITY OF OCCURRENCE OF THRESHOLD TEMPERATURE IS LESS THAN INDICATED PROBABILITY.

GROWING DEGREE UNITS TO SELECTED BASE TEMPERATURES (F)

GROWING DEGREE UNITS

BASE		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
40	M	124	152	331	594	836	1021	1157	1134	930	603	298	156	7336
	S	124	276	607	1201	2037	3058	4215	5349	6279	6882	7180	7336	
45	M	66	85	213	447	681	871	1002	979	780	451	188	85	5848
	S	66	151	364	811	1492	2363	3365	4344	5124	5575	5763	5848	
50	M	31	41	122	310	527	721	847	824	630	308	102	40	4503
	S	31	72	194	504	1031	1752	2599	3423	4053	4361	4463	4503	
55	M	12	16	60	192	377	571	692	669	481	188	46	16	3320
	S	12	28	88	280	657	1228	1920	2589	3070	3258	3304	3320	
60	M	3	4	23	103	239	421	537	514	335	95	16	4	2294
	S	3	7	30	133	372	793	1330	1844	2179	2274	2290	2294	

M = MONTHLY DATA S = SUM OF MONTHLY DATA

GROWING DEGREE UNITS FOR CORN

CORN		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
	M	74	95	206	382	547	696	797	780	620	391	190	94	4872
	S	74	169	375	757	1304	2000	2797	3577	4197	4588	4778	4872	

NOTE: FOR CORN THE BASE IS 50, AND THE DEGREE UNITS ARE ADJUSTED FOR TEMPERATURES BELOW 50 AND ABOVE 86

OTHER CLIMATOLOGICAL DATA ARE AVAILABLE IN A VARIETY OF SUMMARIES AND FORMATS, SUCH AS THE CLIMATOGRAPHY OF THE UNITED STATES: NO. 60 - CLIMATE OF STATES; NO. 81 - MONTHLY NORMALS (AND SUPPLEMENTS: ANNUAL DEGREE DAYS TO SELECTED BASES DERIVED FROM THE 1951-80 NORMALS; AND MONTHLY PRECIPITATION PROBABILITIES, SELECTED PROBABILITY LEVELS DERIVED FROM THE 1951-80 NORMALS); NO. 84 - DAILY NORMALS; NO. 85 - DIVISIONAL NORMALS. A VARIETY OF DATA IS AVAILABLE EITHER ON MAGNETIC TAPE, MICROFICHE, OR PAPER COPY.

TO OBTAIN INFORMATION ABOUT CLIMATOLOGICAL DATA AND RELATED PUBLICATIONS, CONTACT:

DIRECTOR
NATIONAL CLIMATIC DATA CENTER
FEDERAL BUILDING
ASHEVILLE, NC 28801-2696
(OR TELEPHONE: (704) 259-0682)

DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICE
NATIONAL CLIMATIC DATA CENTER
ASHEVILLE, NC

USCOMM-NOAA-ASHEVILLE, NC 7/84/200

Plate IV-3. Climatological Summary – McMinnville, TN, Cont.

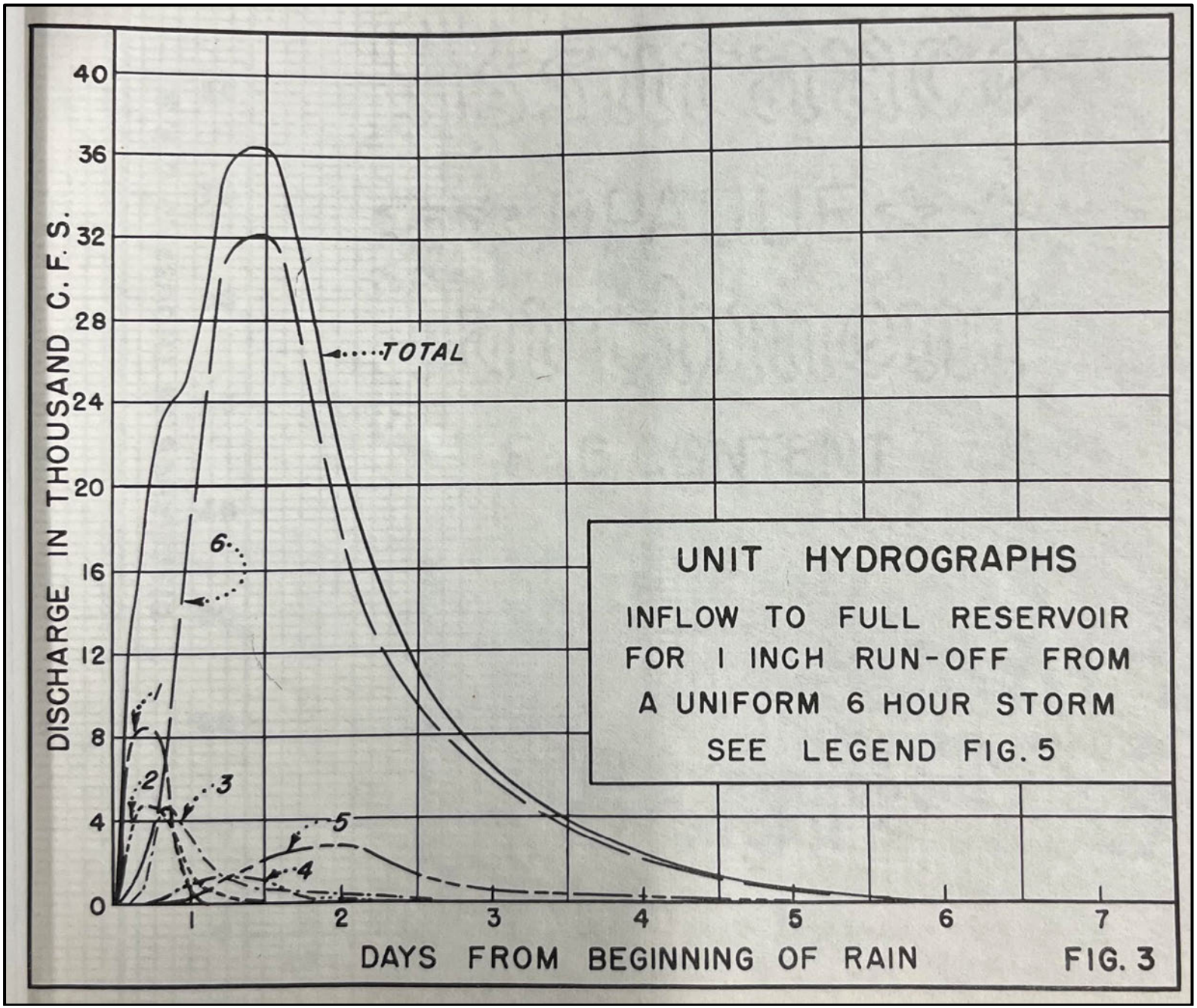


Plate IV-4. 6 Hour Inflow Unit Hydrograph for Center Hill Reservoir

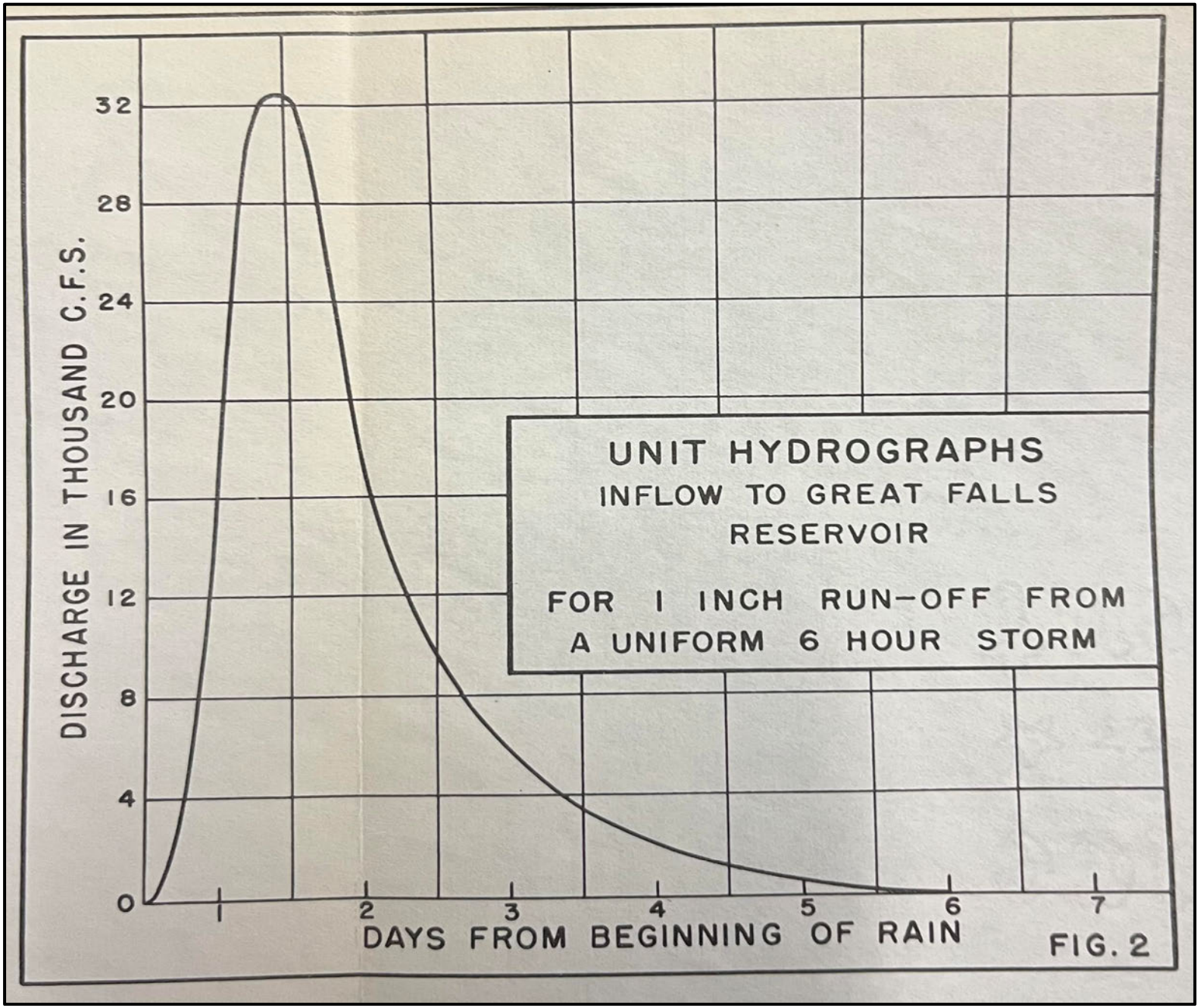


Plate IV-5. 6 Hour Inflow Unit Hydrograph for Great Falls Reservoir

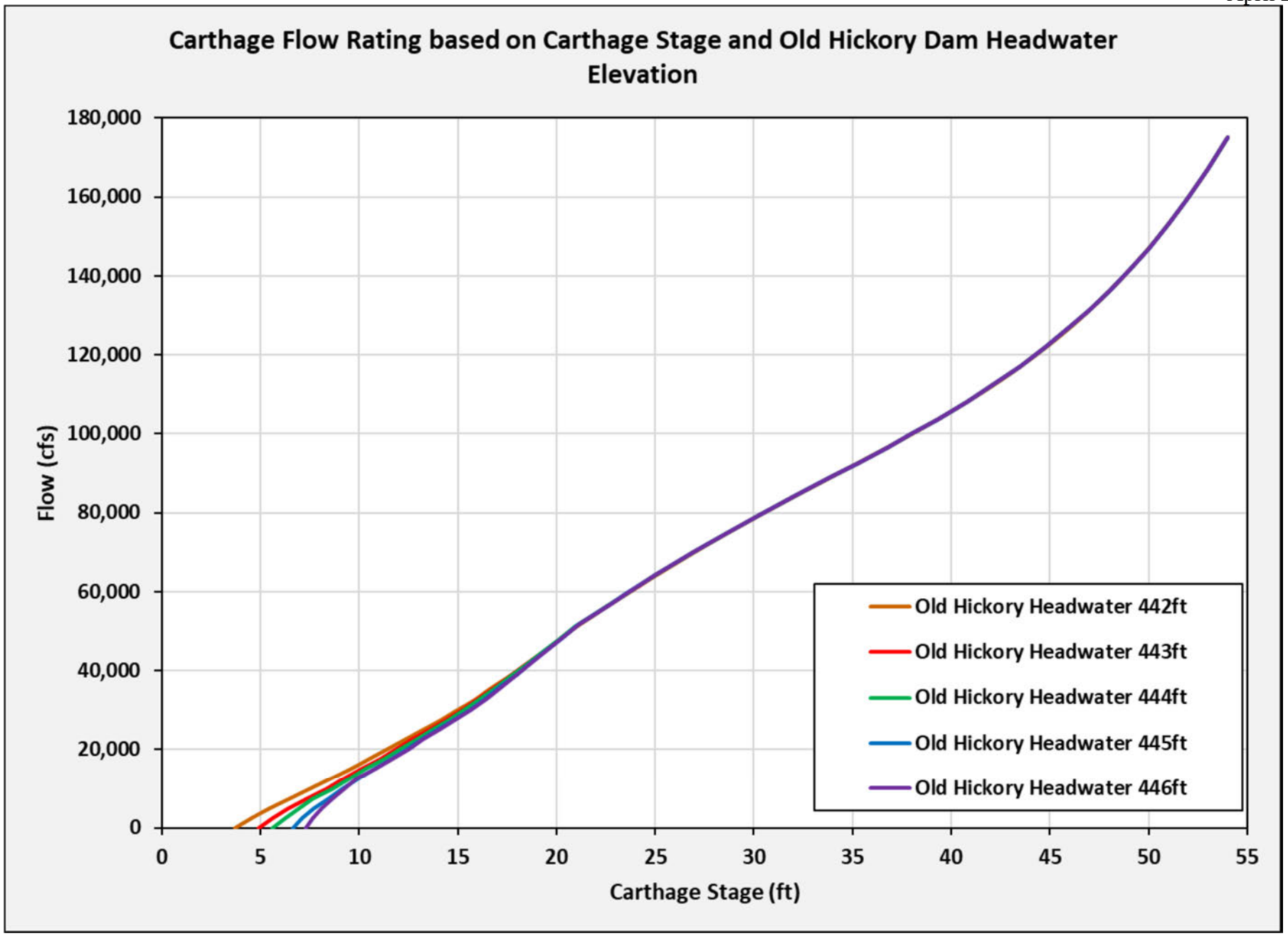


Plate IV-6. Rating Curve, Cumberland River at Carthage

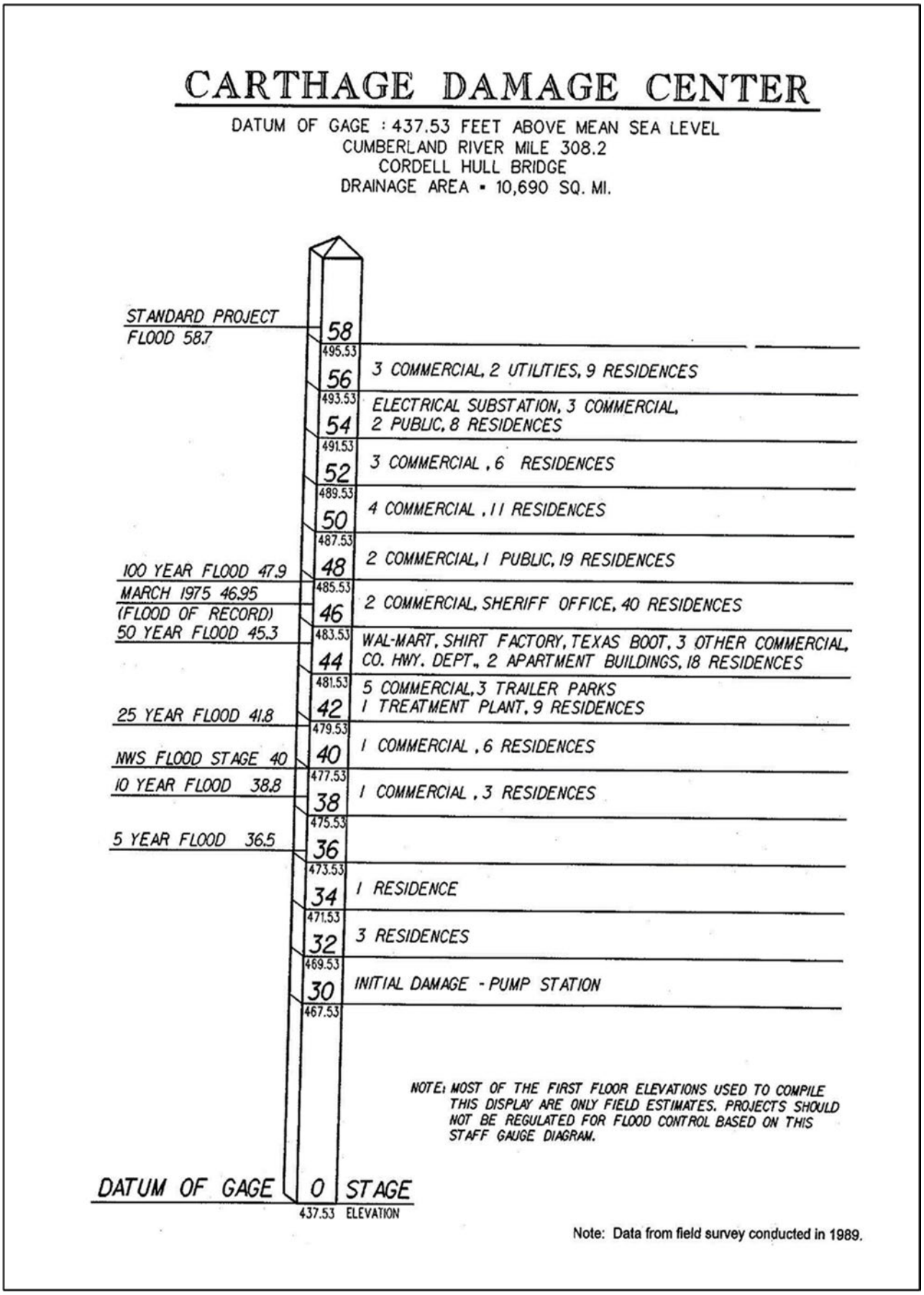


Plate IV-7. Carthage Damage Center Information

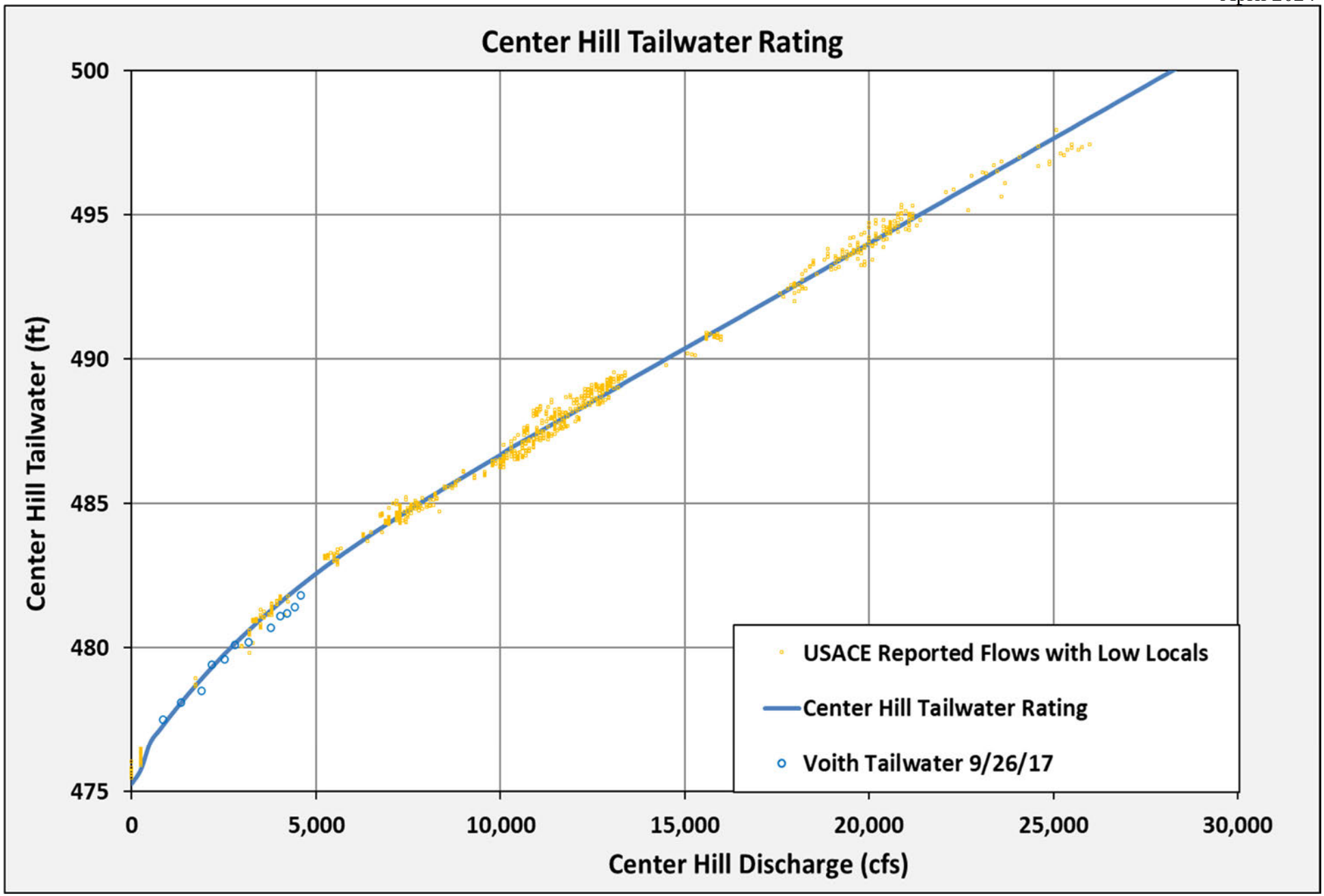


Plate IV-8. Rating Curve, Center Hill Tailwater

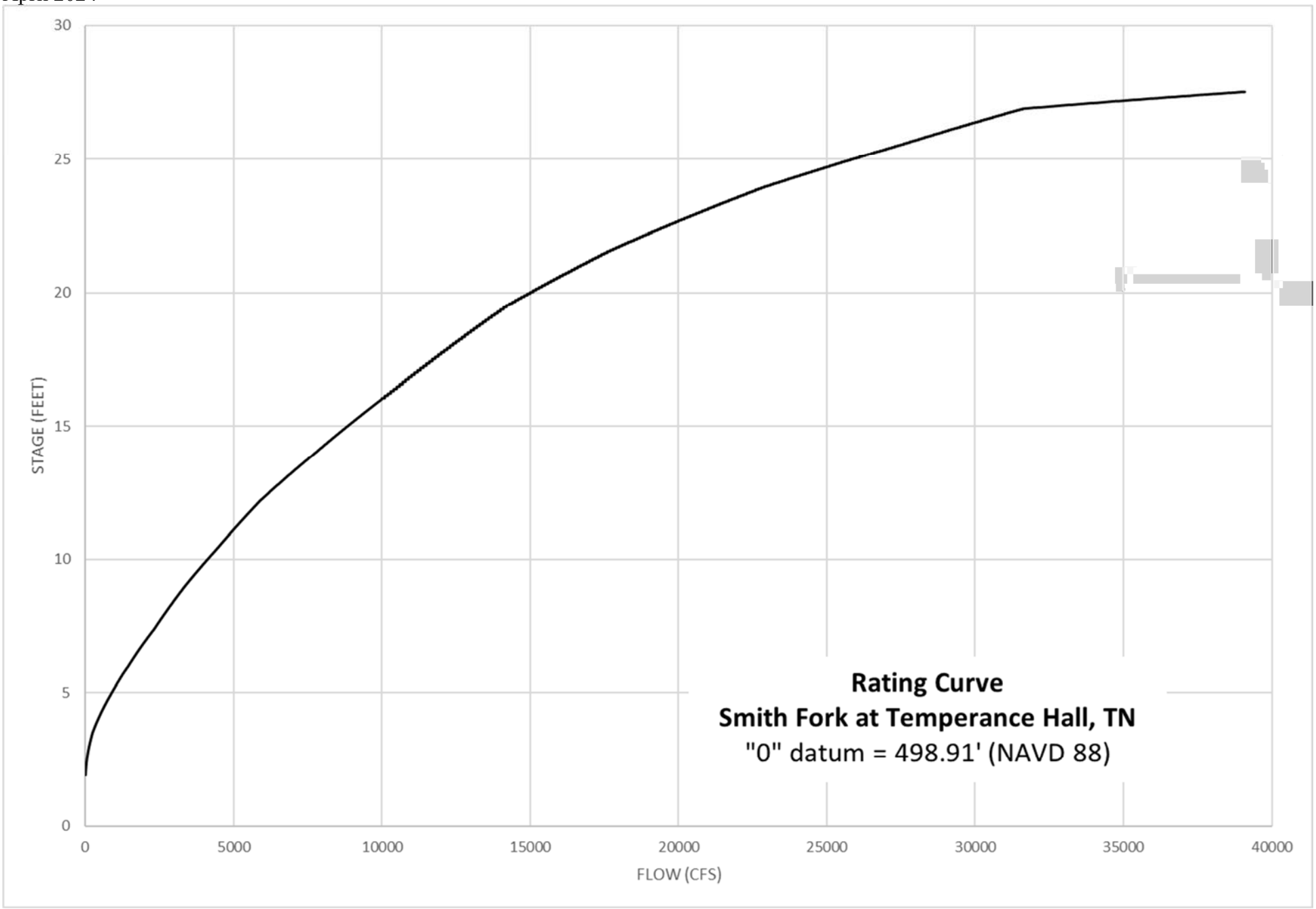


Plate IV-9. Rating Curve, Smith Fork at Temperance Hall, TN

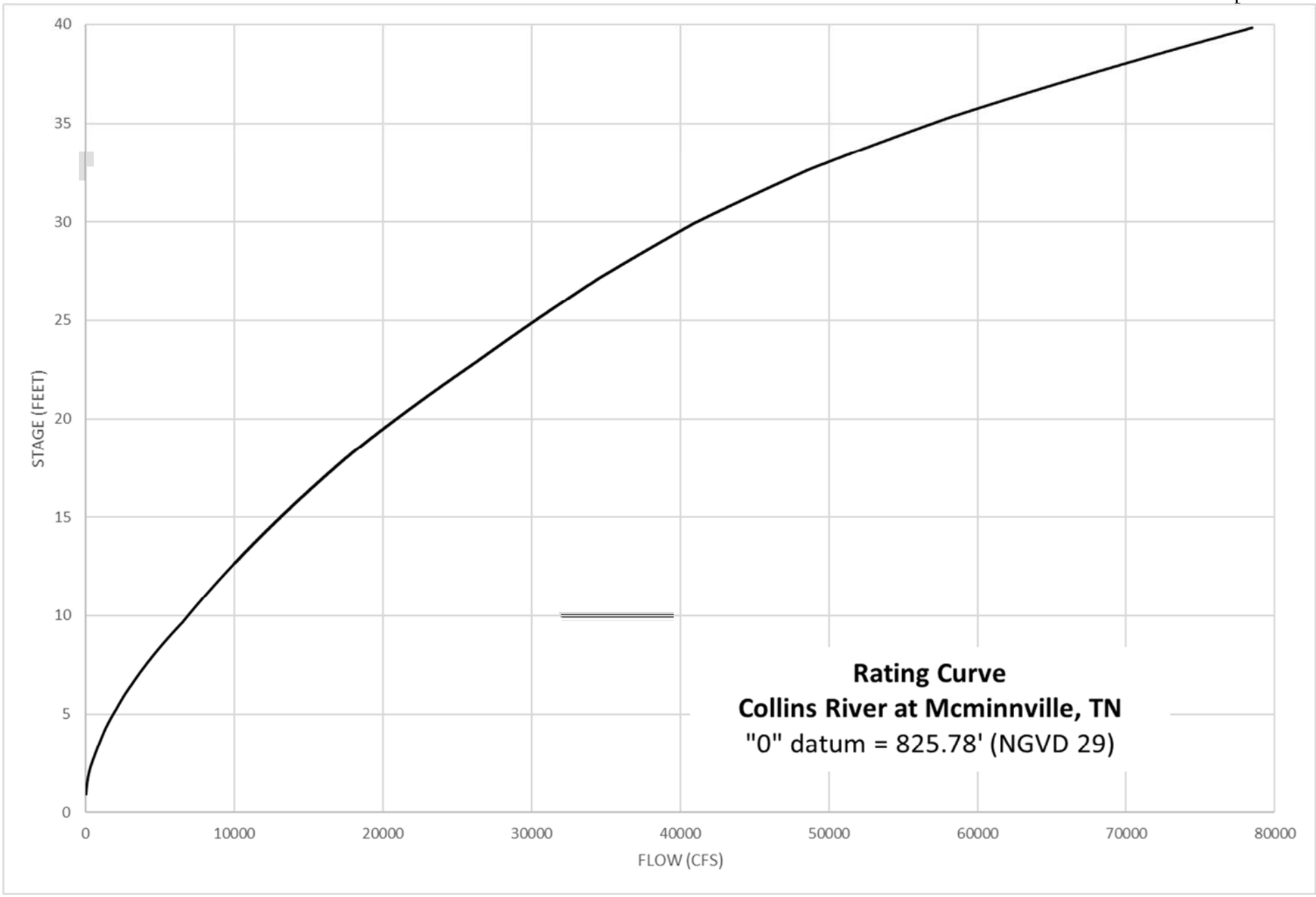


Plate IV-10. Rating Curve, Collins River at McMinnville, TN

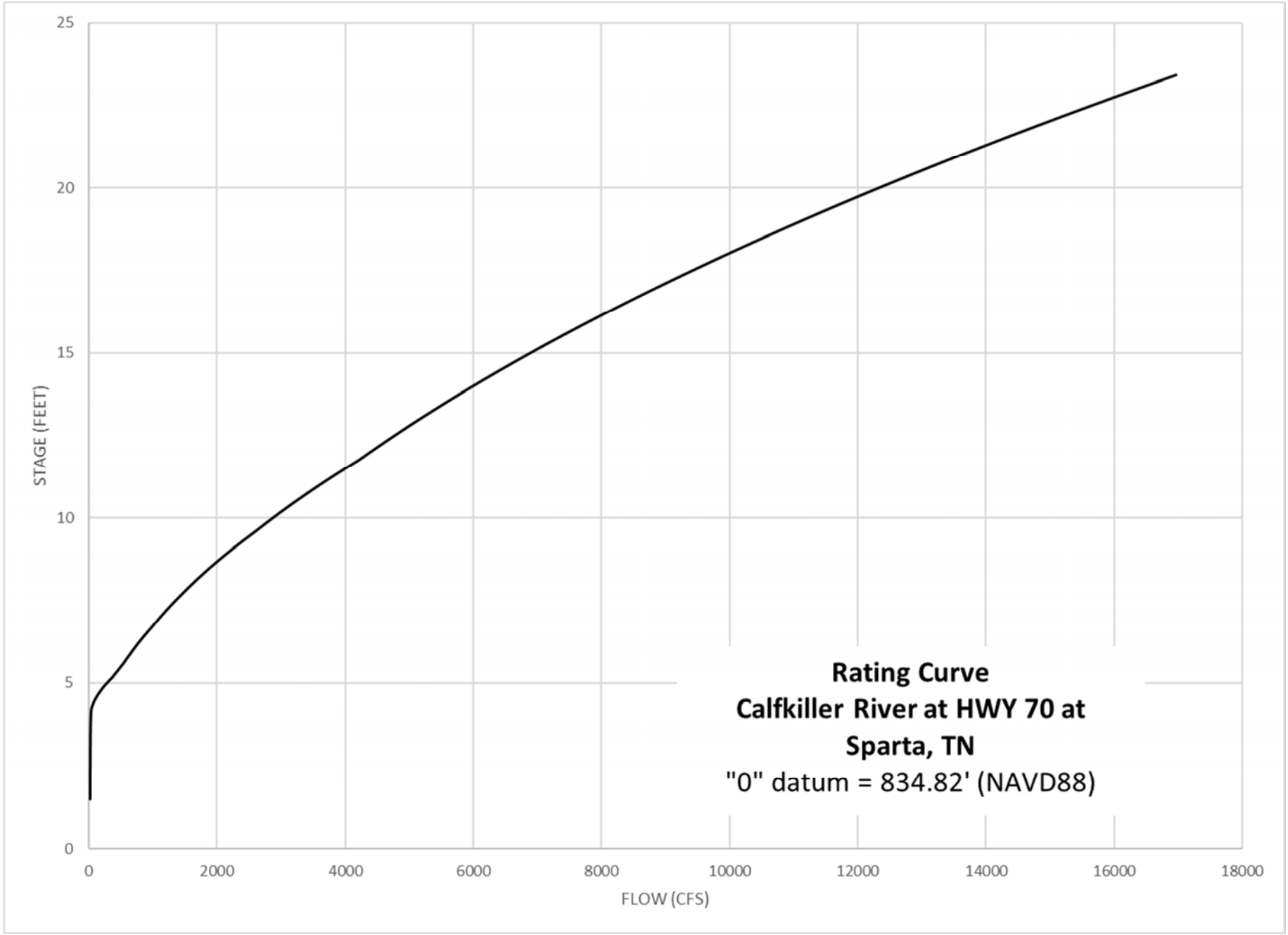


Plate IV-11. Rating Curve, Calfkiller River at HWY 70 at Sparta, TN

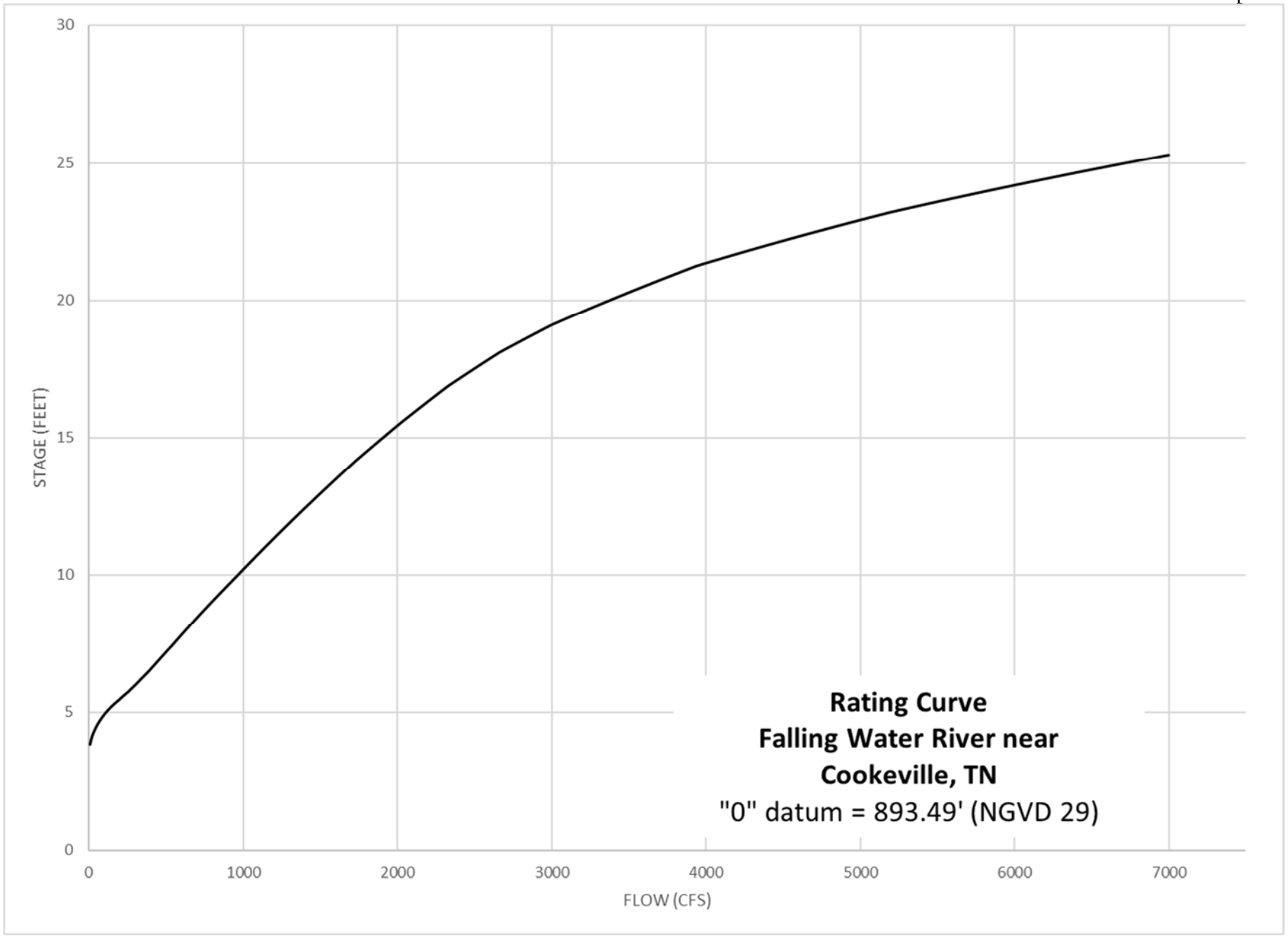


Plate IV-12. Rating Curve, Falling Water River Near Cookeville, TN

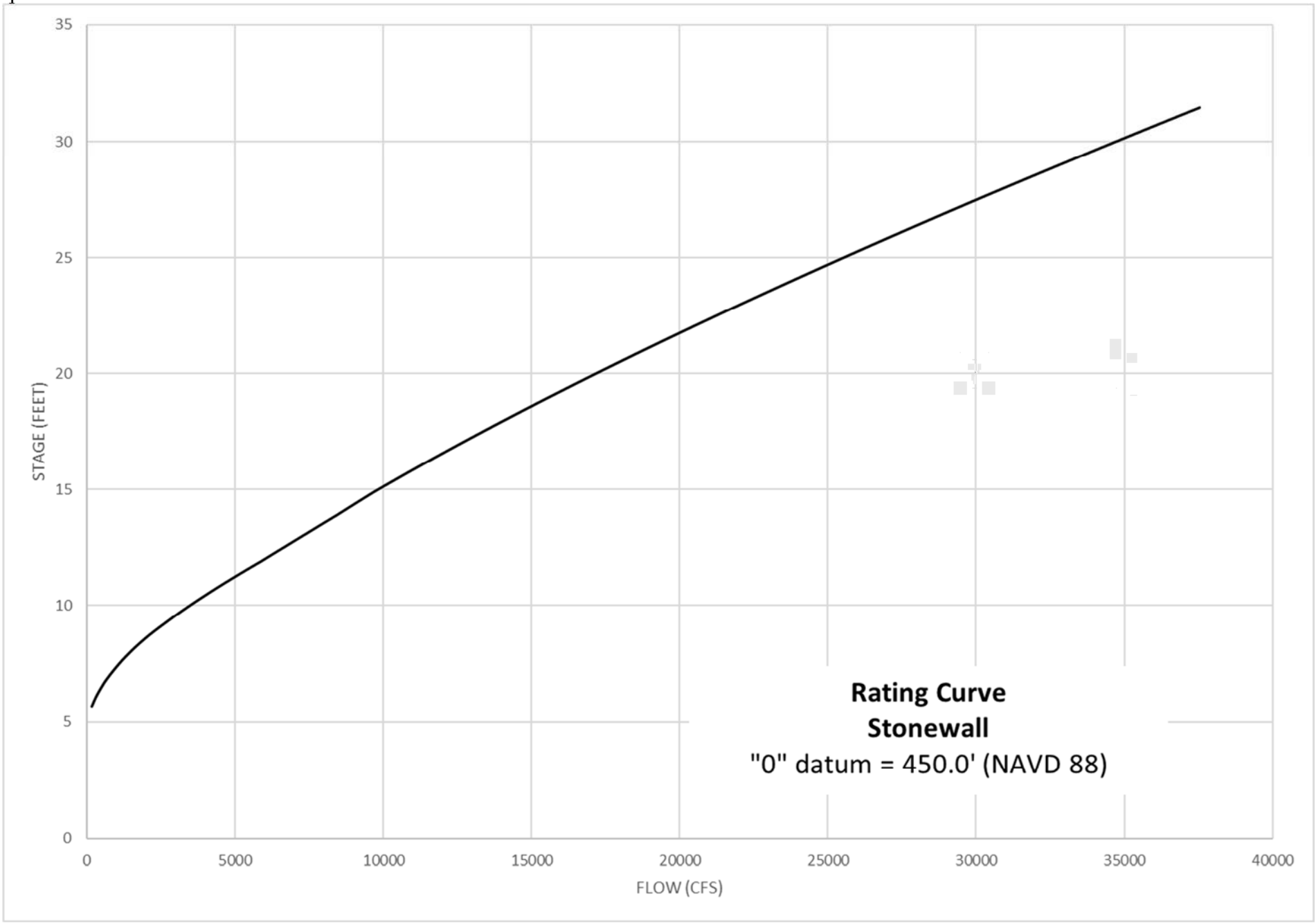


Plate IV-13. Rating Curve, Stonewall

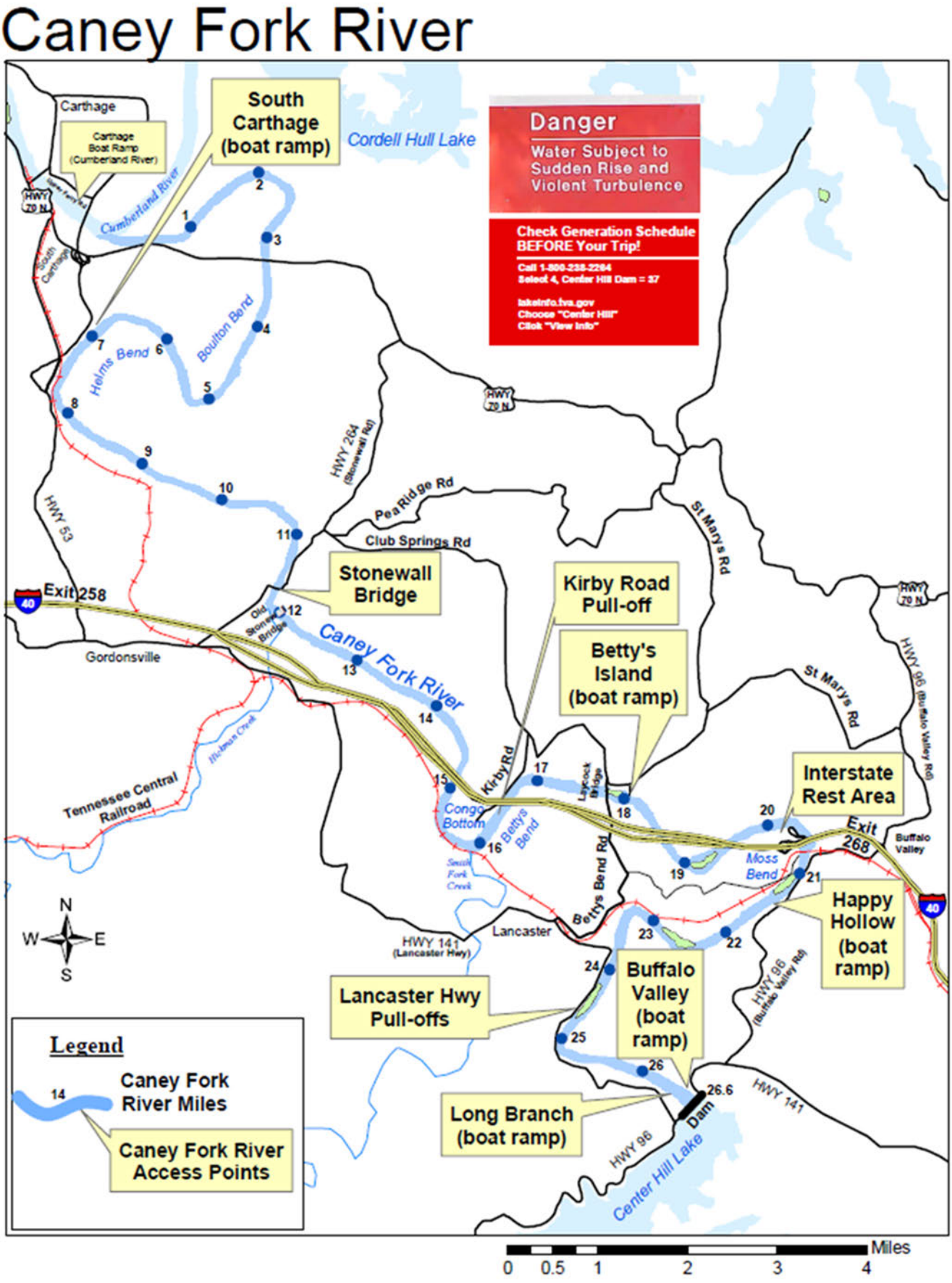


Plate IV-14. Caney Fork Access Areas

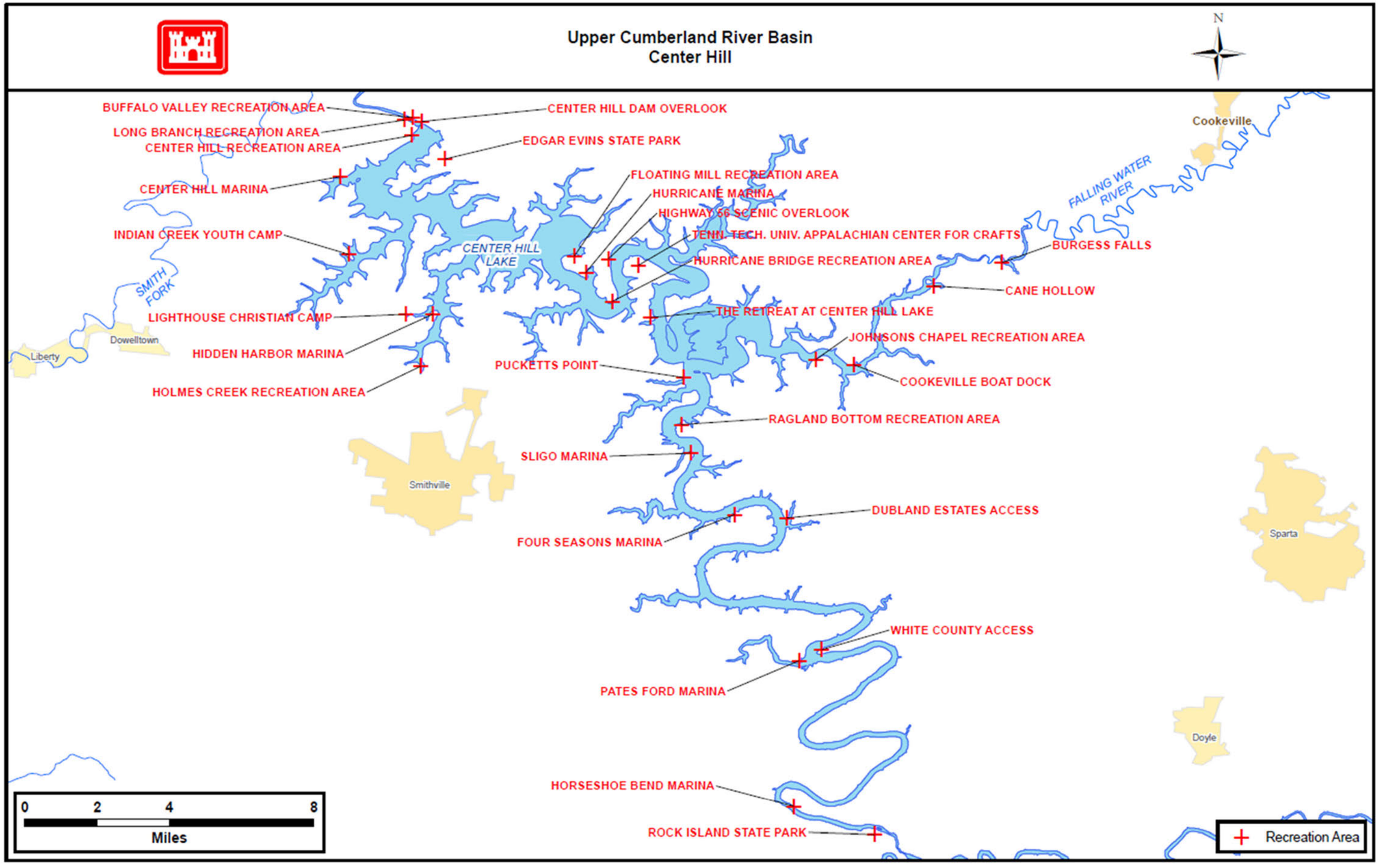
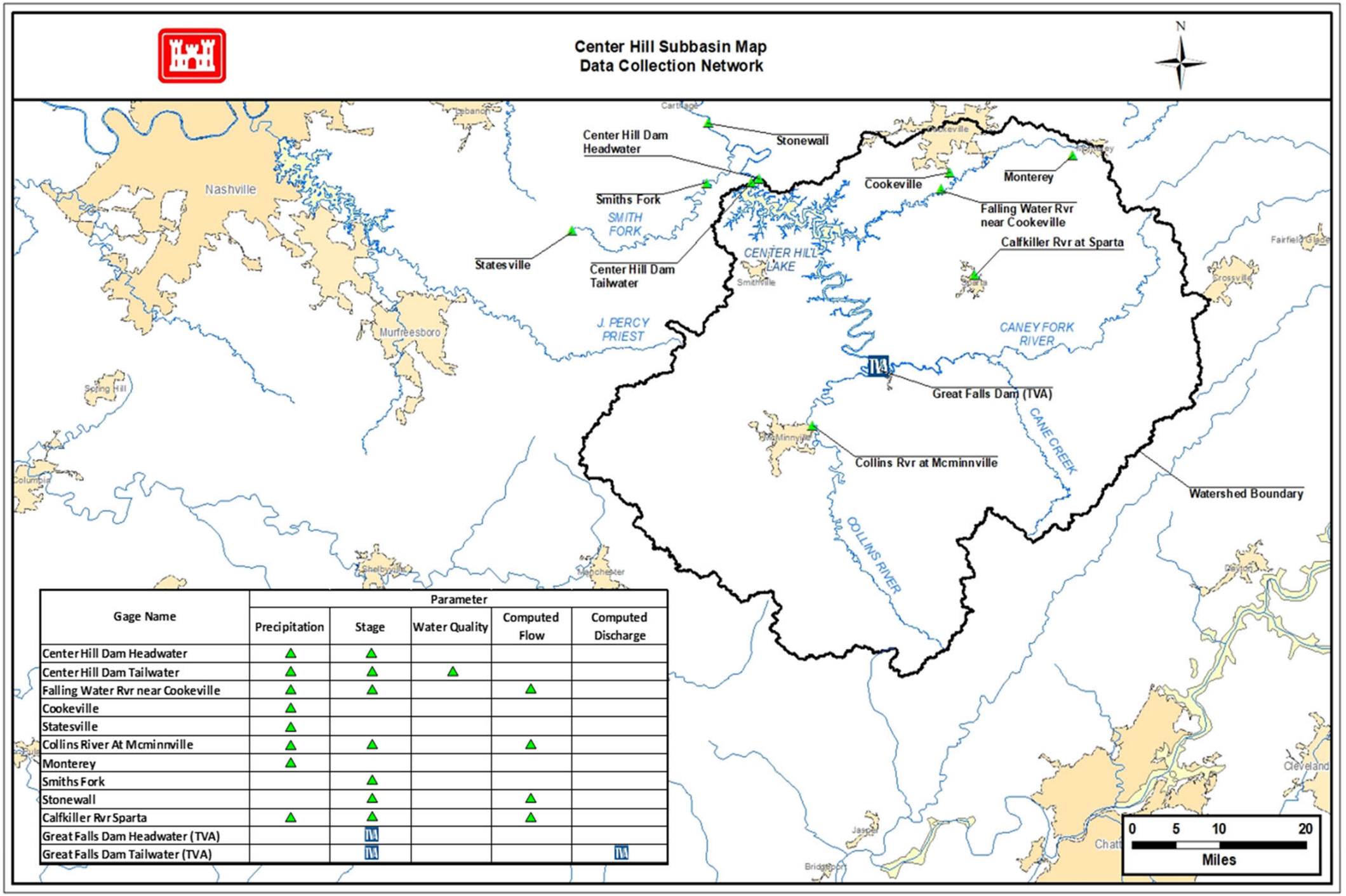


Plate IV-15. Recreation Areas



Gage Name	Parameter				
	Precipitation	Stage	Water Quality	Computed Flow	Computed Discharge
Center Hill Dam Headwater	▲	▲			
Center Hill Dam Tailwater	▲	▲	▲		
Falling Water Rvr near Cookeville	▲	▲		▲	
Cookeville	▲				
Statesville	▲				
Collins River At Mcminnville	▲	▲		▲	
Monterey	▲				
Smiths Fork		▲			
Stonewall		▲		▲	
Calfkiller Rvr Sparta	▲	▲		▲	
Great Falls Dam Headwater (TVA)		M			
Great Falls Dam Tailwater (TVA)		M			M

Plate V-1. Data Collection Network Map

CENTER HILL DATA COLLECTION NETWORK								
LOCATION	STATE	STAGE	PRECIP	WATER QUALITY	STREAM	MILE	DRAINAGE (sq mi)	DATUM
Center Hill Dam Headwater	TN	S	P		Caney Fork River	26.6	2,174	-
Center Hill Dam Tailwater	TN	S	P	WQ	Caney Fork River	26.6	411	-
Falling Water Rvr near Cookeville	TN	S	P		Falling Water River	11.0*	67	893.49
Cookeville	TN		P		-	-	-	-
Statesville	TN		P		Smith Fork Creek	-	-	-
Collins River At McMinnville	TN	S	P		Collins River	19.5	642	825.78
Monterey	TN		P		-	-	-	-
Smith Fork	TN	S			Smith Fork Creek	8.8	214	498.91
Stonewall	TN	S			Caney Fork River	11.2	-	450.00
Calfkiller Rvr at HWY 70 at Sparta	TN	S	P		Calfkiller River	14.1*	157	-
Great Falls Dam Headwater (TVA)	TN	S			Caney Fork River	91.1	1,675	-
Great Falls Dam Tailwater (TVA)	TN	S			Caney Fork River	91.1	-	-

*Approximate River Mile

LOCATION	DCP ADDRESS	HANDBOOK 5CODE	USGS ID	LATITUDE (NORTH)	LONGITUDE (WEST)
Center Hill Dam Headwater	CE56088C	CEHT1	-	36.096389	85.820556
Center Hill Dam Tailwater	CE05D37A	CETT1	-	36.0985	85.829306
Falling Water Rvr near Cookeville	-	-	3423000	36.077222	85.521389
Cookeville	CE5633C5	COOT1	-	36.15	85.504444
Statesville	CE66786C	STLT1	-	36.018333	86.121389
Collins River At McMinnville	CE56065E	MCGT1	3421000	35.708333	85.731944
Monterey	CE66863A	MNYT1	-	36.13333	85.241667
Smith Fork	CE1DB5A4	GVST1	3424730	36.0875	85.907778
Stonewall	CE56C340	STWT1	3424860	36.186111	85.903889
Calfkiller Rvr Sparta	-	-	3419530	35.9265	85.467431
Great Falls Dam Headwater (TVA)	CE24339C	GRTT1	-	35.80805556	85.63361111
Great Falls Dam Tailwater (TVA)	-	-	-	35.801662	85.622634

Plate V-2. Data Collection Network Tables

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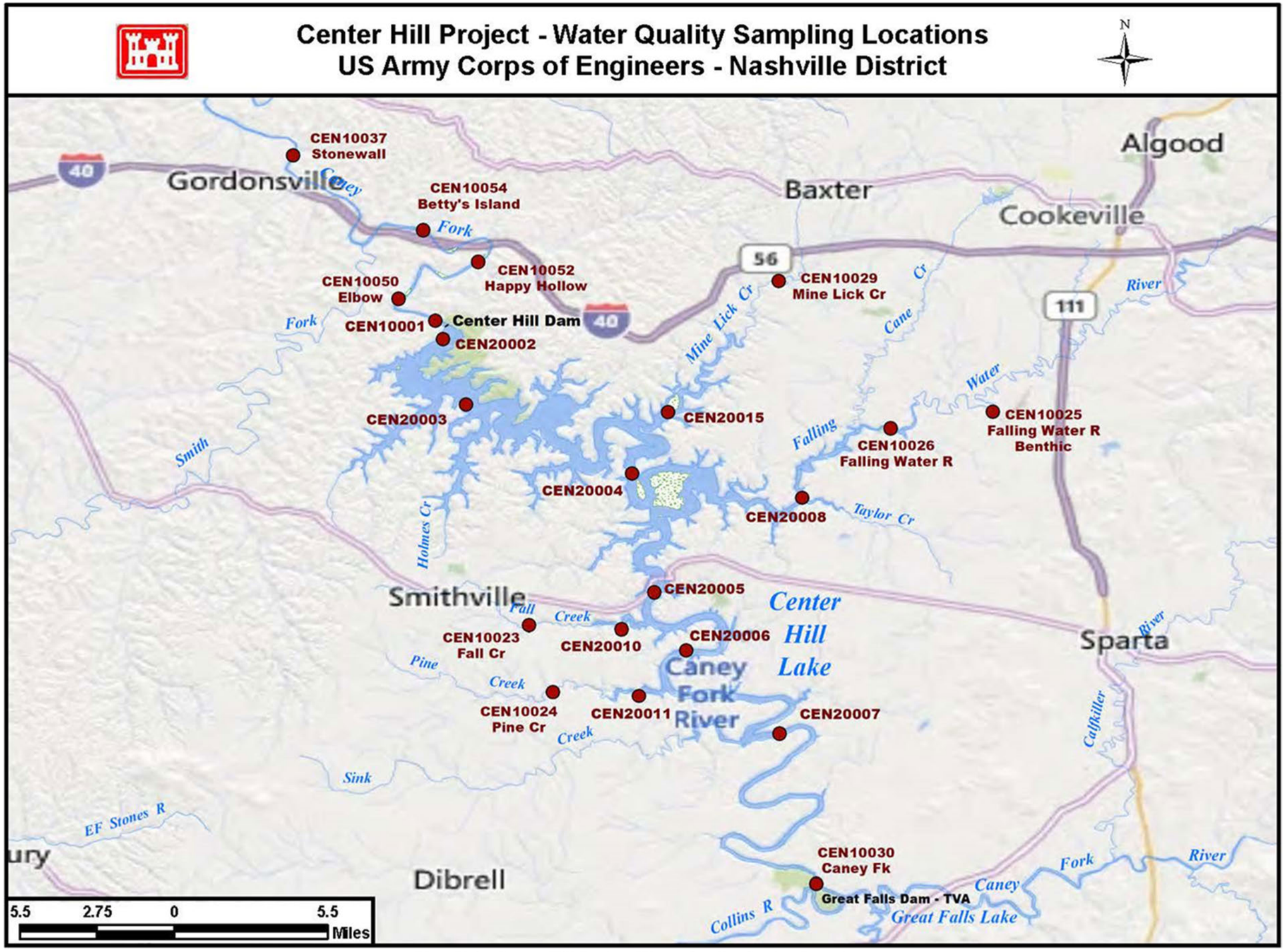

Plate V-3. Center Hill Project Water Quality Station Locations

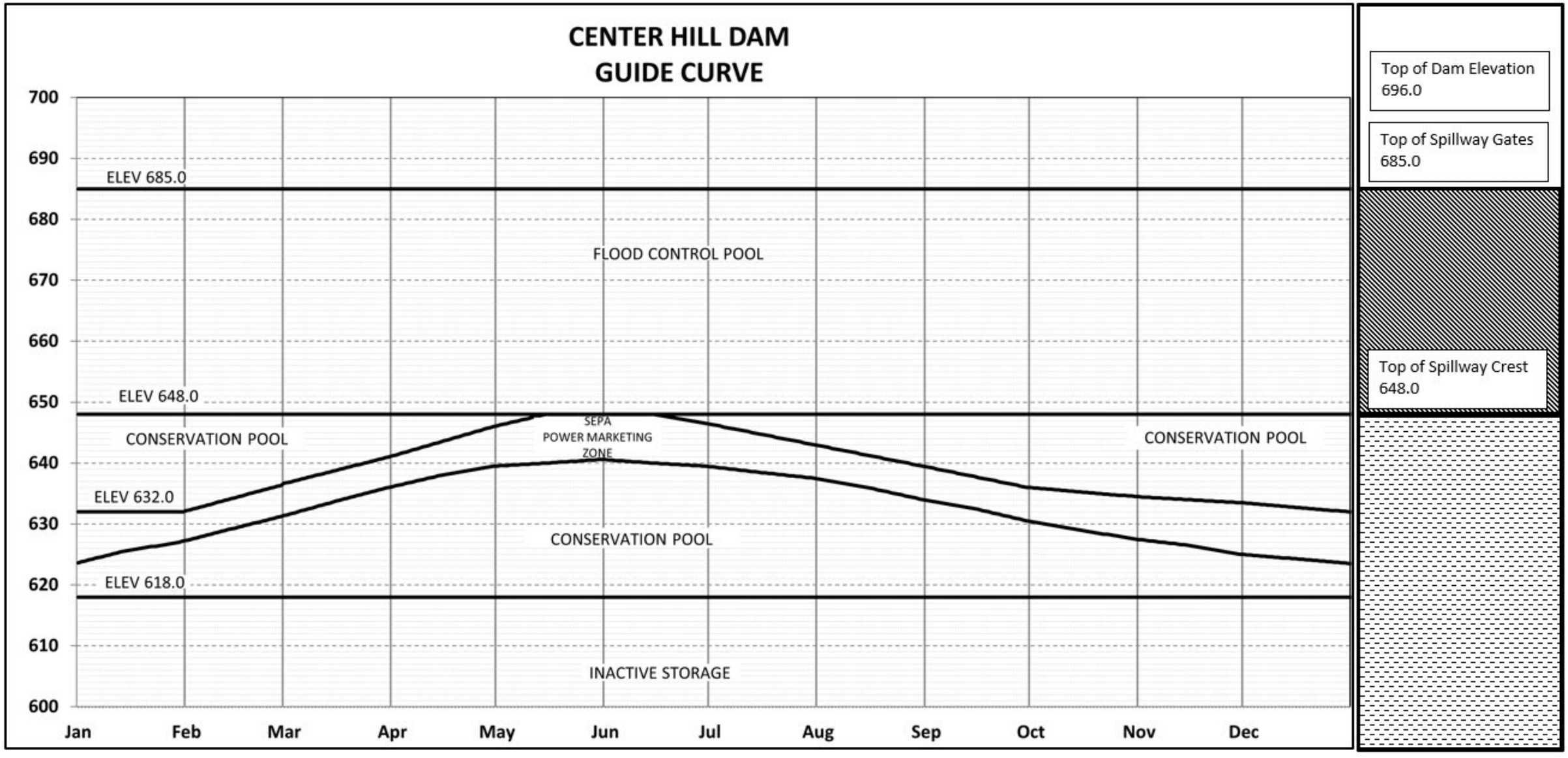

Plate VII-1. Center Hill Guide Curve

Center Hill Reservoir – Area & Volume Table
(Dam Site at River Mile 26.6)

Elevation M.S.L.	Area (acres)	Volume (acre-feet)	Volume (DSF)	Elevation M.S.L.	Area (acres)	Volume (acre-feet)	Volume (DSF)	Elevation M.S.L.	Area (acres)	Volume (acre-feet)	Volume (DSF)
465	0	0	0	510	1424	19001	9582	555	5909	175289	88396
466	1	1	1	511	1493	20460	10318	556	6042	181264	91409
467	1	2	1	512	1564	21988	11088	557	6172	187372	94489
468	2	3	2	513	1632	23586	11894	558	6299	193608	97634
469	2	5	3	514	1701	25252	12734	559	6425	199970	100842
470	3	8	4	515	1777	26991	13611	560	6552	206458	104114
471	4	12	6	516	1857	28807	14527	561	6688	213077	107452
472	5	16	8	517	1944	30707	15485	562	6826	219835	110860
473	9	23	12	518	2025	32692	16486	563	6964	226730	114337
474	13	34	17	519	2110	34759	17528	564	7103	233763	117884
475	20	50	25	520	2199	36913	18615	565	7248	240939	121502
476	29	75	38	521	2292	39158	19747	566	7390	248258	125193
477	41	109	55	522	2389	41499	20927	567	7534	255719	128956
478	54	157	79	523	2491	43939	22158	568	7679	263327	132792
479	67	216	109	524	2591	46480	23439	569	7817	271075	136699
480	84	292	147	525	2686	49119	24770	570	7951	278959	140675
481	105	386	195	526	2781	51852	26148	571	8085	286978	144719
482	126	502	253	527	2875	54681	27575	572	8220	295131	148831
483	148	638	322	528	2969	57602	29048	573	8359	303420	153011
484	173	798	402	529	3064	60619	30569	574	8502	311851	157262
485	203	986	497	530	3160	63731	32139	575	8648	320553	161650
486	232	1204	607	531	3261	66941	33757	576	8798	328487	165651
487	262	1451	732	532	3362	70253	35428	577	8949	338404	170652
488	291	1727	871	533	3464	73666	37149	578	9109	346338	174653
489	325	2035	1026	534	3560	77179	38920	579	9269	356256	179655
490	361	2378	1199	535	3657	80786	40739	580	9429	366173	184656
491	396	2757	1390	536	3753	84491	42608	581	9589	376090	189657
492	432	3170	1599	537	3850	88292	44524	582	9749	386008	194658
493	471	3622	1827	538	3951	92193	46492	583	9907	395925	199659
494	510	4112	2074	539	4051	96194	48509	584	10049	405842	204660
495	550	4642	2341	540	4154	100295	50577	585	10207	415760	209662
496	593	5213	2629	541	4259	104502	52699	586	10348	425677	214663
497	635	5827	2938	542	4367	108815	54874	587	10498	437578	220664
498	684	6485	3270	543	4478	113238	57104	588	10647	447495	225666
499	737	7196	3629	544	4588	117771	59390	589	10786	457413	230667
500	791	7959	4014	545	4700	122415	61732	590	10917	469314	236669
501	856	8782	4429	546	4812	127171	64131	591	11056	481214	242670
502	920	9670	4876	547	4930	132041	66586	592	11187	491132	247671
503	983	10622	5357	548	5049	137030	69102	593	11325	503033	253673
504	1043	11635	5867	549	5164	142137	71678	594	11447	514933	259674
505	1103	12708	6408	550	5281	147359	74311	595	11585	526834	265675
506	1163	13841	6980	551	5400	152700	77005	596	11706	538735	271677
507	1226	15035	7582	552	5519	158159	79757	597	11835	550636	277678
508	1288	16292	8216	553	5643	163739	82571	598	11956	562537	283680
509	1354	17612	8881	554	5775	169447	85450	599	12086	574437	289681

Plate VII-2. Area and Volume Table

Center Hill Reservoir – Area & Volume Table
(Dam Site at River Mile 26.6)

Elevation M.S.L.	Area (acres)	Volume (acre-feet)	Volume (DSF)	Elevation M.S.L.	Area (acres)	Volume (acre-feet)	Volume (DSF)	Elevation M.S.L.	Area (acres)	Volume (acre-feet)	Volume (DSF)
600	12215	586338	295682	645	17717	1264059	637448	690	22915	2172827	1095727
601	12335	600223	302684	646	17828	1281831	646410	691	23047	2195809	1107317
602	12456	612123	308685	647	17932	1299711	655427	692	23177	2218921	1118972
603	12585	624024	314687	648	18026	1317690	664493	693	23308	2242164	1130693
604	12705	637909	321689	649	18117	1335760	673606	694	23439	2265537	1142480
605	12825	649809	327690	650	18209	1353922	682765	695	23570	2289041	1154332
606	12946	663694	334692	651	18303	1372177	691970	*696	23701	2312677	1166252
607	13075	675595	340693	652	18402	1390529	701225	697	23833	2336444	1178237
608	13196	689479	347695	653	18503	1408981	710530	698	23964	2360342	1190289
609	13325	701380	353696	654	18606	1427536	719887	699	24095	2384371	1202406
610	13446	717247	361698	655	18711	1446194	729296	700	24226	2408532	1214590
611	13576	731132	368700	656	18819	1464959	738759	701	24357	2432824	1226840
612	13705	743033	374701	657	18927	1483832	748277	702	24488	2457246	1239156
613	13826	756917	381703	658	19040	1502816	757850	703	24619	2481799	1251538
614	13956	770801	388704	659	19153	1521913	767480	704	24751	2506484	1263986
615	14085	784685	395706	660	19269	1541124	777168	705	24884	2531301	1276501
616	14206	800553	403708	661	19383	1560450	786914	706	25017	2556251	1289083
617	14335	814437	410709	662	19499	1579891	796718	707	25150	2581335	1301732
618	14456	828976	418041	663	19614	1599447	806580	708	25284	2606552	1314449
619	14585	843495	425363	664	19730	1619119	816500	709	25418	2631903	1327233
620	14705	858391	432875	665	19847	1638907	826479	710	25553	2657389	1340085
621	14825	873267	440377	666	19963	1658812	836517				
622	14945	888302	447958	667	20081	1678834	846613				
623	15065	903436	455590	668	20201	1698975	856770				
624	15184	918709	463292	669	20320	1719235	866987				
625	15294	934080	471044	670	20440	1739615	877264				
626	15405	949571	478856	671	20561	1760116	887603				
627	15525	965161	486717	672	20681	1780737	898002				
628	15644	980890	494649	673	20801	1801478	908461				
629	15755	996718	502631	674	20921	1822339	918981				
630	15875	1012685	510683	675	21042	1843321	929562				
631	15996	1028752	518786	676	21163	1864424	940204				
632	16125	1044957	526957	677	21285	1885648	950907				
633	16245	1061280	535189	678	21406	1906994	961671				
634	16365	1077723	543481	679	21528	1928461	972497				
635	16519	1092885	551127	680	21651	1950050	983384				
636	16640	1109464	559488	681	21774	1971762	994333				
637	16758	1126162	567908	682	21899	1993598	1005345				
638	16875	1142979	576389	683	22025	2015560	1016420				
639	16995	1159914	584929	684	22150	2037647	1027558				
640	17122	1176970	593530	685	22276	2059860	1038760				
641	17240	1194151	602194	686	22402	2082199	1050025				
642	17356	1211449	610917	687	22529	2104664	1061354				
643	17476	1228865	619700	688	22656	2127256	1072746				
644	17598	1246402	628544	689	22785	2149977	1084204				

*Values above elevation 696' represent areas and volumes above the top of the dam.

Note: Areas and volumes were updated based on 2022 sediment surveys

Plate VII-2. Area and Volume Table, Cont.

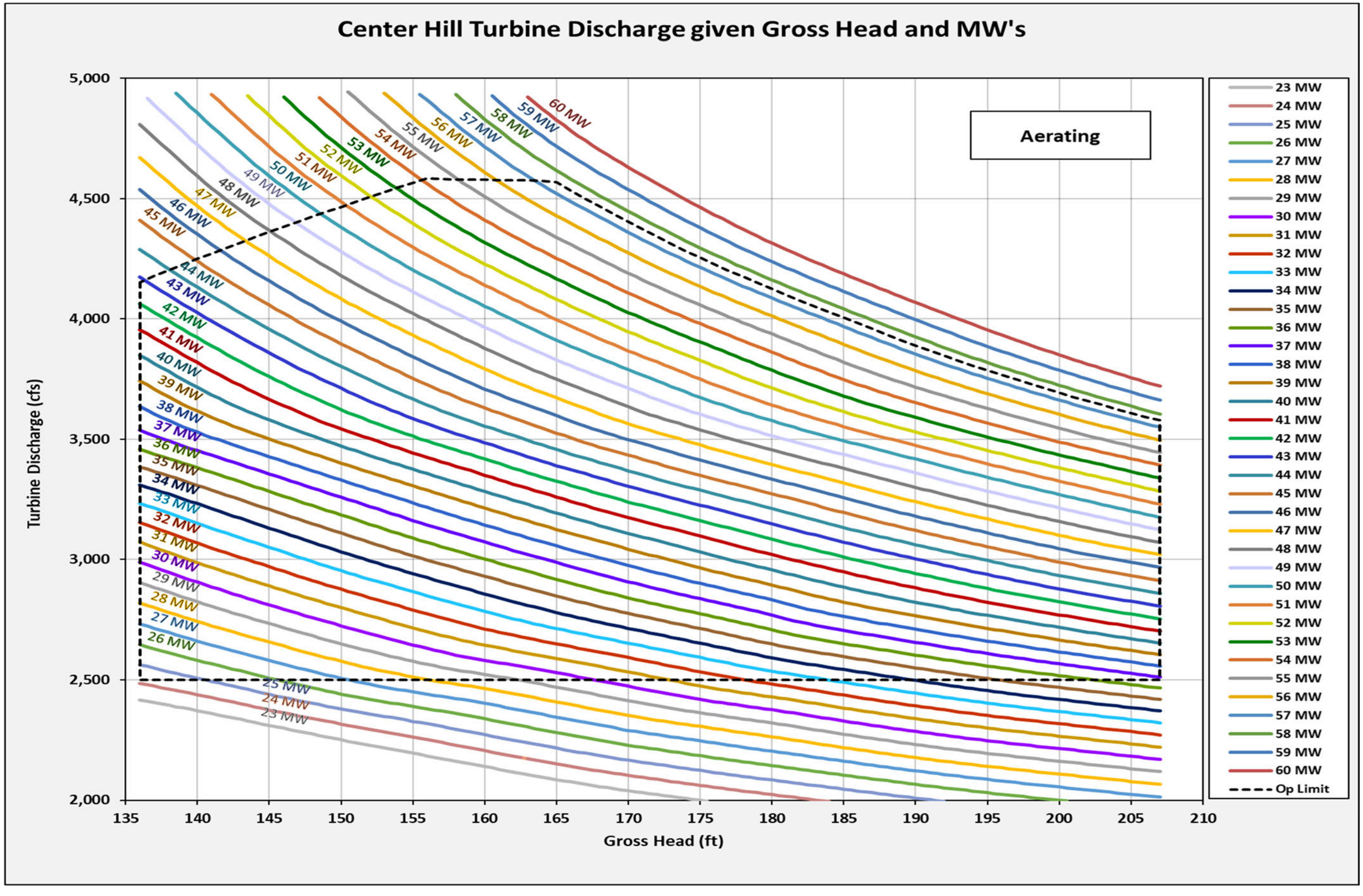

Plate VII-3. Turbine Rating Curves

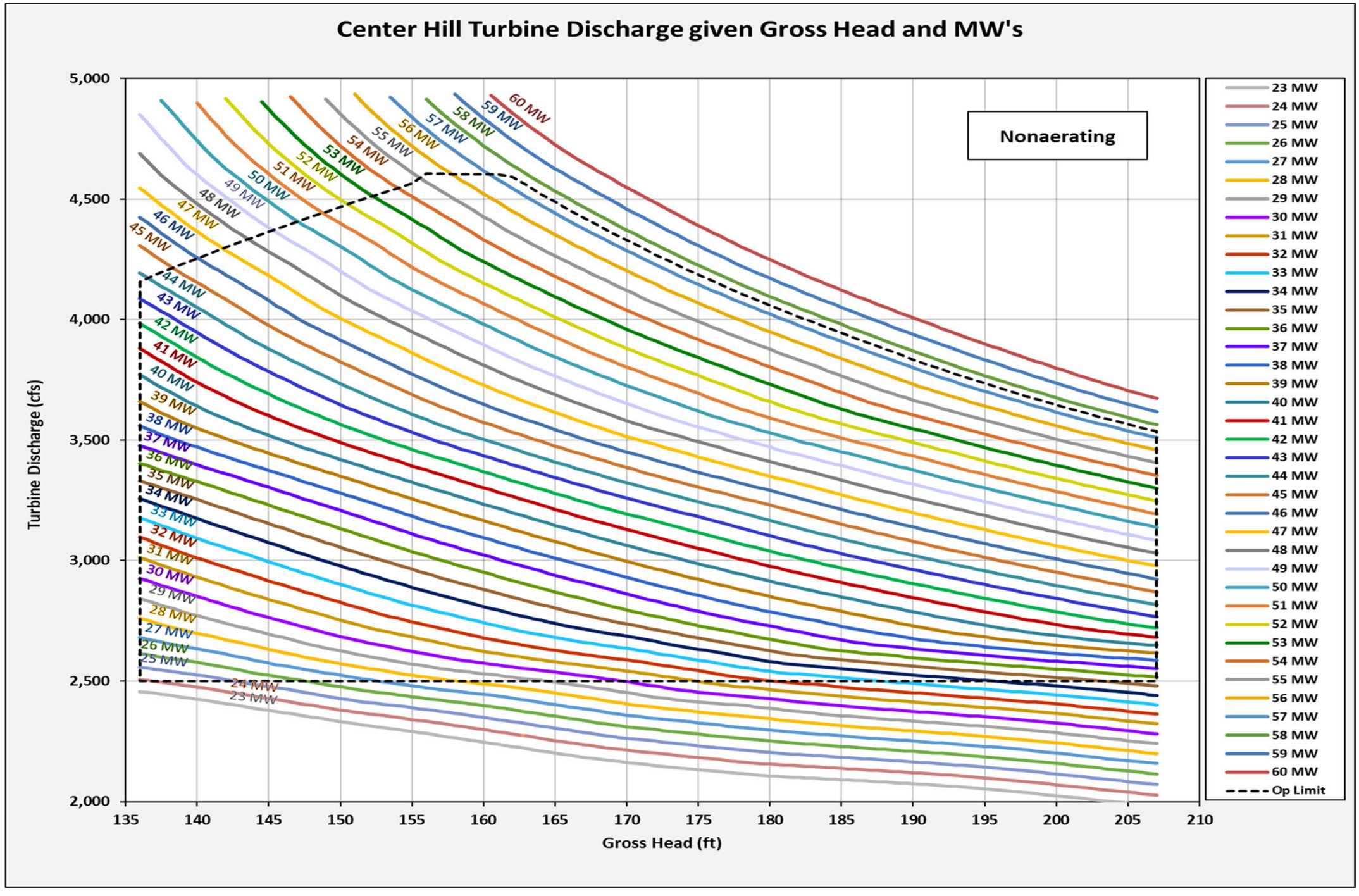

Plate VII-3. Turbine Rating Curves cont.

Center Hill Units with New Turbine (Aaerating) *Red Cells are Outside of Operating Limits

Aerating Gross Head, ft	MegaWatts																																							
	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
136.0	2417	2486	2563	2646	2733	2820	2905	2990	3073	3155	3233	3309	3384	3457	3537	3636	3742	3848	3956	4064	4174	4289	4410	4537	4671	4808												
136.5	2411	2480	2556	2638	2723	2810	2894	2979	3062	3144	3223	3300	3375	3448	3525	3620	3725	3831	3938	4045	4155	4268	4387	4512	4644	4780	4917										
137.0	2405	2474	2548	2629	2714	2800	2884	2968	3051	3133	3213	3291	3367	3438	3514	3605	3709	3814	3920	4027	4135	4248	4364	4488	4618	4753	4888										
137.5	2400	2468	2541	2621	2705	2790	2874	2957	3040	3122	3203	3281	3357	3429	3503	3590	3692	3797	3903	4009	4117	4227	4342	4464	4592	4726	4860										
138.0	2394	2462	2534	2613	2696	2781	2864	2946	3029	3111	3193	3272	3348	3420	3493	3577	3676	3781	3886	3991	4098	4207	4321	4440	4567	4700	4832										
138.5	2388	2456	2527	2605	2687	2771	2854	2936	3018	3101	3183	3262	3338	3410	3482	3564	3660	3764	3869	3974	4080	4188	4300	4417	4541	4674	4805	4939									
139.0	2383	2450	2521	2597	2679	2762	2844	2926	3007	3090	3172	3252	3328	3401	3472	3552	3645	3747	3852	3956	4061	4168	4279	4394	4516	4647	4778	4911									
139.5	2378	2444	2514	2589	2670	2753	2834	2916	2997	3079	3162	3242	3318	3391	3462	3540	3630	3731	3835	3939	4044	4150	4259	4373	4492	4621	4751	4883									
140.0	2372	2438	2507	2582	2661	2743	2825	2906	2986	3069	3151	3232	3309	3382	3453	3529	3616	3715	3818	3922	4026	4131	4240	4351	4469	4594	4724	4855									
140.5	2366	2432	2500	2574	2653	2734	2815	2896	2976	3058	3141	3222	3299	3372	3443	3518	3603	3699	3802	3905	4008	4113	4220	4330	4446	4568	4698	4828									
141.0	2360	2426	2494	2566	2644	2725	2806	2886	2967	3048	3131	3212	3289	3363	3434	3507	3591	3684	3785	3888	3991	4095	4201	4310	4423	4543	4671	4801	4933								
141.5	2354	2420	2487	2559	2636	2716	2797	2877	2957	3038	3120	3202	3279	3353	3424	3497	3578	3670	3769	3871	3974	4077	4182	4289	4401	4519	4645	4774	4905								
142.0	2348	2414	2481	2552	2628	2707	2787	2867	2947	3028	3110	3191	3269	3343	3414	3487	3567	3655	3753	3855	3957	4059	4163	4269	4380	4495	4619	4746	4878								
142.5	2342	2407	2474	2545	2620	2699	2778	2858	2938	3019	3100	3181	3259	3333	3405	3477	3555	3642	3737	3838	3940	4042	4145	4250	4359	4473	4593	4720	4850								
143.0	2336	2401	2467	2537	2612	2690	2769	2848	2928	3009	3090	3171	3249	3323	3395	3467	3544	3629	3722	3822	3923	4025	4127	4231	4339	4451	4569	4693	4823								
143.5	2329	2395	2460	2530	2604	2682	2760	2839	2919	2999	3080	3161	3239	3313	3385	3457	3533	3616	3708	3806	3907	4007	4109	4212	4319	4430	4545	4667	4795	4928							
144.0	2323	2388	2453	2523	2596	2673	2751	2830	2909	2990	3071	3151	3228	3303	3376	3447	3522	3604	3693	3790	3890	3990	4091	4194	4299	4408	4522	4642	4768	4900							
144.5	2317	2381	2446	2515	2589	2665	2743	2821	2900	2980	3061	3141	3218	3293	3366	3437	3511	3592	3680	3775	3874	3974	4074	4176	4280	4388	4499	4617	4741	4872							
145.0	2310	2375	2440	2508	2581	2657	2734	2812	2890	2971	3051	3131	3208	3283	3356	3428	3501	3580	3666	3760	3858	3957	4057	4158	4261	4368	4478	4593	4715	4844							
145.5	2305	2369	2434	2501	2573	2649	2726	2803	2881	2961	3041	3121	3198	3273	3346	3418	3491	3569	3653	3745	3842	3941	4040	4140	4242	4348	4456	4571	4689	4817							
146.0	2299	2363	2427	2494	2565	2641	2717	2794	2871	2951	3032	3111	3189	3264	3336	3408	3481	3557	3640	3731	3826	3925	4023	4122	4223	4328	4436	4548	4665	4790	4923						
146.5	2293	2357	2421	2487	2558	2632	2708	2785	2862	2941	3022	3101	3178	3254	3327	3398	3471	3546	3627	3717	3811	3909	4006	4105	4205	4309	4415	4525	4641	4764	4895						
147.0	2287	2351	2415	2480	2550	2624	2700	2776	2853	2931	3012	3091	3169	3244	3317	3389	3461	3535	3614	3703	3796	3893	3990	4088	4187	4290	4395	4504	4618	4737	4868						
147.5	2281	2346	2409	2474	2543	2616	2691	2768	2844	2922	3002	3082	3159	3234	3307	3379	3451	3524	3601	3689	3782	3877	3974	4071	4169	4271	4375	4482	4595	4711	4841						
148.0	2275	2340	2403	2467	2535	2608	2683	2759	2835	2913	2992	3072	3149	3224	3298	3369	3441	3513	3589	3676	3768	3862	3958	4054	4151	4252	4355	4461	4572	4687	4814						
148.5	2269	2334	2397	2460	2528	2600	2675	2750	2826	2904	2982	3062	3140	3215	3288	3360	3431	3503	3576	3663	3753	3847	3942	4038	4134	4234	4336	4441	4550	4663	4787	4920					
149.0	2263	2328	2391	2453	2521	2593	2667	2742	2818	2895	2973	3052	3130	3205	3278	3350	3421	3493	3565	3649	3740	3832	3927	4022	4117	4216	4317	4421	4529	4640	4762	4893					
149.5	2257	2322	2385	2447	2514	2585	2659	2733	2809	2885	2963	3042	3120	3196	3269	3340	3411	3482	3555	3635	3726	3818	3911	4006	4100	4198	4298	4401	4508	4617	4736	4866					
150.0	2251	2316	2379	2441	2507	2577	2651	2725	2800	2877	2954	3032	3110	3186	3259	3331	3401	3472	3544	3623	3712	3803	3896	3990	4084	4180	4280	4382	4487	4596	4712	4840					
150.5	2245	2311	2373	2435	2500	2570	2643	2717	2792	2868	2945	3023	3101	3176	3249	3321	3392	3462	3533	3611	3698	3789	3882	3975	4067	4163	4262	4363	4467	4575	4689	4813	4944				
151.0	2240	2305	2368	2429	2494	2563	2635	2708	2783	2859	2936	3013	3091	3167	3240	3311	3382	3452	3523	3599	3684	3775	3867	3960	4052	4146	4244	4344	4447	4554	4666	4788	4917				
151.5	2234	2300	2363	2424	2487	2556	2627	2700	2775	2850	2927	3004	3081	3157	3230	3302	3372	3442	3513	3587	3671	3761	3853	3945	4036	4130	4226	4325	4428	4533	4643	4763	4890				
152.0	2229	2295	2358	2419	2481	2549	2619	2692	2766	2842	2918	2995	3071	3147	3221	3292	3363	3432	3502	3576	3658	3747	3838	3930	4021	4114	4209	4307	4408	4512	4621	4738	4864				
152.5	2223	2289	2353	2414	2476	2542	2612	2684	2758	2833	2910	2986	3061	3137	3211	3283	3353	3422	3492	3565	3645	3733	3824	3915	4006	4098	4192	4289	4389	4492	4599	4714	4839				
153.0	2218	2284	2348	2409	2470	2536	2604	2676	2749	2825	2901	2977	3052	3127	3201	3274	3344	3413	3482	3555	3633	3719	3810	3901	3991	4083	4176	4272	4370	4472	4578	4692	4813	4940			
153.5	2212	2279	2344	2404	2465	2530	2597	2668	2741	2816	2892	2968	3043	3117	3191	3264	3335	3404	3473	3544	3621	3706	3796	3886	3976	4067	4160	4254	4352	4453	4557	4669	4788	4914			
154.0	2206	2273	2338	2399	2460	2524	2590	2660	2733	2808	2884	2959	3034	3108	3182	3255	3326	3394	3463	3534	3609	3692	3781	3872	3962	4052	4144	4237	4334	4434	4537	4646	4764	4888			
154.5	2201	2268	2333	2395	2455	2518	2584	2653	2725	2799	2875	2951	3025	3098	3172	3245	3316	3385	3453	3523	3598	3679	3767	3857	3947	4037	4128	4221	4316	4415	4517	4625	4740	4862			
155.0	2195	2262	2327	2390	2451	2512	2578	2645	2717	2791	2867	2942	3016	3089	3163	3236	3307	3376	3444	3513	3587	3667	3753	3843	3933	4022	4113	4205	4299	4396	4497	4603	4716	4837			
155.5	2190	2257	2322	2385	2446	2507	2571	2638	2708	2782	2858	2933	3007	3080	3153	3226	3297	3367	3435	3502	3576	3655	3740	3829	3918	4008	4098	4188	4282	4378	4478	4582	4693	4812	4934	
156.0	2184	2251	2317	2380	2441	2502	2565	2631	2701	2774	2849	2925	2998	3071	3144	3217	3288	3357	3425	3493	3564	3642	3726	3815	3904	3993	4083	4173	4265	4360	4459	4562	4671	4787	4908	
156.5	2179	2246	2312	2375	2436	2497	2559	2624	2693	2766	2841	2916	2990	3062	3135	3207	3278	3348	3416	3483	3553	3631	3713	3801	3890	3979	4068	4157	4249	4343	4440	4541	4649	4763	4884	
157.0	2173	2240	2306	2370	2431	2492	2553	2617	2685	2758	2832	2908	2981	3054	3126	3198	3269	3339	3407	3474	3542	3619	3700	3787	3876	3964	4053	4142	4233	4325	4422	4522	4627	4740	4859	
157.5	2167	2234	2301	2365	2427	2487	2547	2610	2678	2750	2824	2899	2973	3045	3117	3189	3260	3329	3397	3464	3533	3607	3688	3773	3861	3950	4038	4127	4217	4308	4403	4502	4606	4716	4834	

Plate VII-4. Turbine Rating Tables (Aerating)

Aerating	MegaWatts																																										
Gross Head, ft	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
158.0	2161	2229	2295	2360	2423	2483	2542	2603	2670	2742	2816	2891	2964	3036	3108	3180	3251	3320	3388	3455	3523	3597	3676	3760	3847	3936	4024	4112	4201	4292	4386	4483	4585	4694	4810	4933		
158.5	2156	2223	2290	2355	2418	2478	2537	2597	2663	2734	2808	2882	2956	3028	3099	3171	3241	3311	3379	3446	3514	3586	3664	3747	3833	3921	4009	4097	4186	4276	4368	4465	4565	4672	4785	4907		
159.0	2150	2217	2284	2350	2413	2474	2532	2591	2656	2726	2800	2874	2947	3019	3091	3162	3232	3301	3370	3437	3504	3575	3652	3734	3819	3907	3995	4082	4171	4260	4351	4446	4546	4651	4762	4881		
159.5	2145	2211	2278	2344	2408	2469	2527	2586	2650	2719	2792	2866	2939	3011	3082	3153	3223	3292	3360	3428	3495	3565	3641	3721	3806	3893	3980	4068	4156	4244	4335	4429	4526	4630	4739	4856		
160.0	2139	2206	2272	2338	2402	2464	2523	2581	2644	2712	2784	2858	2930	3002	3074	3144	3214	3283	3351	3419	3486	3555	3630	3709	3792	3879	3966	4053	4141	4229	4319	4411	4508	4609	4716	4831		
160.5	2134	2200	2266	2332	2397	2459	2518	2576	2638	2705	2776	2849	2922	2993	3065	3135	3205	3273	3341	3409	3476	3545	3619	3697	3779	3865	3952	4039	4126	4213	4303	4394	4489	4589	4695	4807	4927	
161.0	2128	2195	2261	2326	2391	2454	2513	2571	2633	2698	2769	2841	2914	2985	3055	3126	3196	3265	3332	3399	3467	3536	3609	3685	3767	3851	3938	4024	4111	4198	4287	4377	4471	4570	4673	4783	4902	
161.5	2123	2189	2255	2320	2385	2448	2508	2567	2627	2692	2761	2833	2905	2976	3047	3117	3187	3256	3323	3390	3457	3526	3598	3674	3754	3837	3923	4010	4097	4183	4271	4361	4454	4551	4652	4760	4877	
162.0	2117	2183	2249	2315	2380	2443	2503	2562	2622	2686	2754	2826	2897	2968	3038	3108	3178	3247	3314	3380	3447	3516	3588	3663	3742	3824	3909	3996	4082	4169	4256	4345	4437	4532	4632	4738	4852	
162.5	2112	2178	2244	2309	2374	2437	2498	2556	2616	2679	2747	2818	2889	2959	3029	3100	3170	3238	3305	3370	3437	3507	3578	3652	3730	3811	3896	3982	4068	4154	4241	4328	4420	4514	4612	4716	4828	
163.0	2107	2172	2238	2304	2368	2432	2493	2551	2610	2673	2740	2810	2881	2951	3021	3091	3161	3229	3296	3361	3428	3497	3568	3641	3718	3798	3882	3968	4054	4139	4226	4313	4403	4496	4593	4695	4805	4923
163.5	2101	2167	2232	2298	2363	2426	2487	2546	2605	2667	2733	2802	2873	2943	3013	3082	3152	3220	3287	3352	3418	3486	3558	3630	3706	3786	3869	3953	4039	4125	4211	4298	4387	4479	4574	4674	4782	4897
164.0	2096	2161	2227	2292	2357	2420	2481	2540	2599	2661	2727	2795	2865	2935	3004	3074	3143	3212	3278	3343	3409	3477	3547	3619	3695	3774	3855	3940	4025	4110	4196	4282	4371	4462	4556	4654	4760	4873
164.5	2091	2156	2221	2287	2351	2415	2476	2535	2594	2655	2720	2787	2857	2926	2996	3065	3134	3202	3269	3334	3400	3467	3537	3609	3683	3761	3843	3926	4011	4096	4181	4267	4355	4445	4538	4635	4738	4850
165.0	2086	2151	2216	2281	2346	2409	2470	2529	2588	2649	2713	2780	2849	2918	2988	3057	3125	3193	3260	3326	3391	3457	3526	3598	3672	3750	3830	3913	3997	4082	4167	4252	4339	4429	4521	4616	4717	4827
165.5	2081	2146	2211	2276	2340	2403	2464	2524	2583	2644	2707	2773	2841	2910	2980	3049	3117	3184	3251	3317	3382	3448	3516	3587	3661	3738	3817	3900	3983	4067	4152	4237	4324	4413	4504	4598	4697	4804
166.0	2076	2141	2205	2270	2334	2397	2459	2519	2578	2638	2701	2766	2833	2902	2972	3041	3108	3175	3242	3308	3373	3439	3506	3576	3650	3726	3805	3887	3970	4053	4138	4223	4309	4397	4487	4581	4678	4783
166.5	2071	2136	2200	2265	2329	2392	2453	2513	2572	2632	2694	2759	2826	2894	2963	3032	3100	3167	3233	3299	3365	3430	3496	3565	3639	3715	3793	3874	3956	4039	4123	4208	4294	4381	4471	4563	4659	4762
167.0	2066	2131	2195	2259	2323	2386	2447	2508	2567	2627	2688	2752	2818	2886	2955	3024	3092	3158	3224	3291	3356	3421	3486	3555	3628	3703	3781	3861	3943	4026	4109	4193	4279	4365	4454	4546	4641	4742
167.5	2061	2126	2190	2254	2317	2380	2442	2502	2561	2621	2682	2746	2811	2878	2947	3016	3084	3150	3216	3282	3348	3412	3476	3545	3617	3692	3769	3849	3930	4012	4095	4179	4264	4350	4438	4529	4623	4722
168.0	2057	2121	2185	2249	2312	2375	2436	2496	2556	2615	2676	2739	2804	2871	2939	3008	3076	3141	3207	3273	3339	3404	3467	3535	3606	3680	3758	3837	3917	3999	4081	4164	4249	4335	4423	4513	4605	4703
168.5	2052	2117	2180	2243	2307	2369	2430	2491	2550	2610	2670	2733	2797	2863	2931	3000	3068	3133	3199	3265	3331	3395	3459	3525	3595	3669	3746	3825	3905	3985	4067	4150	4234	4319	4407	4496	4588	4684
169.0	2048	2112	2175	2238	2301	2363	2425	2485	2545	2604	2665	2726	2790	2855	2924	2992	3060	3125	3191	3256	3322	3387	3451	3516	3584	3658	3735	3813	3892	3973	4054	4136	4219	4304	4391	4480	4571	4666
169.5	2044	2108	2171	2233	2296	2358	2419	2480	2539	2599	2659	2720	2783	2848	2916	2984	3052	3117	3182	3248	3313	3378	3442	3507	3574	3646	3723	3801	3880	3960	4040	4122	4205	4289	4376	4464	4554	4648
170.0	2039	2103	2166	2229	2290	2352	2414	2474	2533	2593	2653	2714	2776	2841	2908	2976	3043	3110	3175	3240	3305	3370	3434	3498	3564	3635	3712	3790	3868	3947	4027	4108	4191	4274	4360	4448	4538	4631
170.5	2035	2099	2162	2224	2285	2347	2408	2468	2527	2587	2647	2708	2770	2834	2901	2968	3035	3102	3167	3232	3296	3361	3425	3490	3555	3624	3700	3778	3856	3935	4014	4095	4176	4259	4345	4432	4521	4613
171.0	2031	2095	2157	2220	2281	2342	2402	2462	2522	2581	2641	2702	2764	2827	2893	2960	3028	3094	3159	3224	3288	3352	3417	3482	3546	3613	3689	3766	3844	3922	4001	4081	4162	4244	4329	4416	4505	4596
171.5	2027	2090	2153	2215	2277	2337	2397	2456	2516	2575	2635	2696	2757	2820	2886	2953	3020	3086	3152	3216	3280	3343	3408	3473	3537	3603	3677	3755	3832	3910	3989	4068	4148	4230	4314	4401	4489	4579
172.0	2023	2086	2149	2211	2272	2333	2392	2451	2510	2569	2629	2689	2751	2814	2879	2945	3012	3078	3144	3209	3272	3335	3399	3465	3529	3594	3666	3743	3821	3898	3976	4055	4135	4216	4299	4385	4473	4562
172.5	2019	2082	2145	2207	2268	2328	2387	2445	2504	2563	2623	2683	2745	2807	2872	2937	3004	3070	3136	3201	3264	3327	3390	3456	3520	3584	3655	3732	3809	3886	3964	4042	4121	4202	4285	4369	4457	4546
173.0	2015	2078	2141	2202	2264	2324	2382	2440	2498	2557	2617	2677	2738	2801	2865	2930	2996	3063	3128	3193	3256	3319	3382	3447	3511	3575	3644	3720	3797	3875	3952	4030	4108	4188	4270	4354	4441	4529
173.5	2011	2074	2136	2198	2260	2320	2377	2434	2492	2551	2611	2671	2732	2794	2858	2923	2989	3055	3121	3185	3249	3311	3373	3438	3503	3566	3634	3708	3786	3863	3940	4017	4095	4174	4256	4339	4425	4512
174.0	2007	2070	2132	2194	2255	2315	2372	2429	2486	2545	2605	2665	2726	2788	2851	2915	2981	3047	3113	3178	3241	3303	3365	3429	3494	3557	3623	3697	3774	3851	3928	4005	4082	4161	4242	4324	4409	4496
174.5	2003	2066	2128	2189	2251	2311	2368	2424	2481	2539	2599	2659	2720	2781	2844	2908	2973	3039	3105	3170	3234	3295	3357	3421	3485	3548	3614	3685	3762	3839	3916	3993	4070	4148	4228	4310	4394	4480
175.0	2000	2062	2123	2185	2246	2306	2363	2419	2475	2533	2593	2653	2713	2775	2837	2901	2966	3031	3097	3162	3226	3288	3349	3412	3476	3539	3604	3674	3750	3827	3904	3981	4057	4135	4214	4295	4378	4464
175.5	1996	2058	2119	2180	2242	2302	2359	2414	2470	2528	2587	2647	2707	2769	2831	2894	2958	3023	3089	3155	3219	3280	3342	3404	3468	3530	3594	3664	3738	3815	3892	3969	4045	4122	4201	4281	4363	4448
176.0		2054	2115	2176	2238	2298	2355	2409	2465	2522	2581	2640	2701	2762	2824	2887	2951	3015	3081	3147	3211	3273	3334	3396	3459	3522	3585	3653	3727	3804	3880	3957	4033	4110	4187	4267	4349	4433
176.5		2050	2111	2172	2233	2293	2350	2405	2460	2517	2575	2634	2694	2756	2818	2880	2943	3008	3073	3139	3203	3265	3327	3388	3451	3513	3576	3643	3716	3792	3868	3945	4021	4097	4174	4253	4334	4417
177.0		2046	2107	2168	2229	2289	2346	2401	2455	2511	2569	2628	2688	2749	2811	2874	2936	3000	3066	3131	3195	3258	3319	3380	3442	3504	3567	3633	3704	3780	3857	3933	4009	4085	4161	4240	4320	4402
177.5		2042	2103	2164	2225	2284	2342	2397	2451	2506	2563	2622	2681	2742	2804	2867	2929	2993	3058	3123	3187	3250	3312	3373	3434	3495	3558	3623	3694	3768	3845	3921	3997	4072	4149	4226	4306	4387
178.0		2038	2099	2160	2220	2280	2337	2393	2446	2501	2558	2616	2675	2736	2797	2860	2922	2986	3050	3115	3180	3242	3304	3365	3426	3487	3549	3614	3683	3757	3833	3909	3985	4060	4136	4213	4292	4372
178.5		2034	2095	2155	2216	2276	2334	2388	2442	2496	2552	2609	2668	2729	2791	2853	2915	2979	3043	3108	3172	3235	3297	3357	3418	3479	3540	3604	3673	3745	3821	3897	3973	4048	4124	4200	4278	4358
179.0		2031	2091	2151	2212	2272	2330	2384	2438	2492	2547	2604	2662	2722	2784	2846	2908	2971	3035	3100	3164	3227	3289	3350	3410	3471	3532	3595	3662	3734	3809	3886	3961	4036	4111	4187	4264	4344
179.5		2027	2088	2148	2208	2267	2326	2380	2434	2487	2541	2597	2655	2715	2777	2839	2901	2964	3028	3092	3156	3220	3281	3342	3402	3463	3523	3586	3652	3723	3798	3874	3949	4024	4099	4174	4251	4329
180.0		2023	2084	2144	2204	2263	2321	2376	2429	2482	2536	2591	2649	2708	2769	2832	2894	2957	3020	3084	3149	3212	3274	3334	3395	3455	3515	3577	3642	3713	3786	3862	3937	4012	4087	4162	4238	4315

Plate VII-4. Turbine Rating Tables (Aerating) cont.

Aerating	MegaWatts																																							
Gross Head, ft	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
180.5		2020	2080	2140	2200	2259	2317	2372	2425	2478	2531	2586	2643	2701	2762	2824	2887	2950	3013	3077	3141	3204	3266	3327	3387	3447	3507	3568	3633	3702	3775	3850	3925	4000	4075	4150	4225	4302
181.0		2016	2076	2136	2196	2254	2312	2367	2421	2473	2527	2581	2637	2694	2754	2816	2879	2942	3006	3069	3133	3197	3258	3319	3379	3439	3498	3559	3623	3691	3763	3838	3914	3988	4063	4137	4212	4289
181.5		2012	2073	2132	2191	2250	2307	2362	2416	2469	2522	2576	2631	2688	2746	2808	2872	2935	2998	3062	3125	3189	3251	3312	3372	3431	3490	3550	3614	3681	3752	3826	3902	3977	4051	4125	4200	4275
182.0		2008	2069	2128	2187	2245	2302	2358	2411	2464	2517	2571	2626	2682	2740	2800	2864	2928	2991	3054	3117	3180	3243	3304	3364	3423	3482	3542	3604	3671	3741	3815	3890	3965	4039	4113	4187	4262
182.5		2004	2065	2124	2183	2241	2297	2353	2407	2460	2513	2566	2621	2677	2734	2793	2857	2921	2984	3047	3110	3172	3235	3296	3357	3416	3474	3533	3595	3661	3731	3803	3878	3953	4027	4101	4175	4250
183.0		2001	2061	2120	2179	2236	2293	2348	2402	2455	2508	2562	2616	2671	2728	2787	2849	2913	2977	3040	3102	3164	3227	3289	3349	3408	3466	3525	3586	3651	3720	3792	3866	3941	4015	4089	4163	4237
183.5		1997	2057	2116	2175	2232	2288	2343	2397	2451	2504	2557	2611	2666	2722	2781	2842	2906	2970	3032	3094	3156	3219	3281	3342	3401	3459	3517	3578	3642	3710	3781	3855	3929	4004	4077	4150	4224
184.0		1993	2053	2112	2170	2228	2283	2338	2393	2446	2499	2552	2606	2661	2717	2775	2836	2899	2962	3025	3087	3149	3210	3273	3334	3394	3451	3509	3569	3632	3699	3770	3843	3918	3992	4065	4138	4212
184.5			2050	2108	2166	2223	2279	2334	2388	2441	2494	2548	2601	2656	2711	2769	2829	2892	2955	3018	3080	3141	3203	3265	3326	3386	3444	3501	3561	3623	3689	3759	3832	3906	3980	4053	4126	4199
185.0			2046	2104	2162	2219	2274	2329	2383	2437	2490	2543	2596	2650	2706	2763	2823	2885	2948	3011	3072	3133	3195	3257	3318	3379	3436	3494	3552	3614	3679	3748	3820	3894	3968	4042	4114	4187
185.5			2042	2100	2158	2214	2270	2324	2379	2432	2485	2538	2592	2646	2701	2758	2817	2878	2941	3004	3065	3126	3187	3249	3310	3371	3429	3486	3544	3605	3670	3738	3809	3883	3957	4030	4102	4175
186.0			2038	2097	2154	2210	2265	2320	2374	2427	2481	2534	2587	2641	2696	2752	2810	2872	2934	2996	3058	3118	3179	3241	3302	3363	3422	3478	3536	3596	3660	3728	3798	3871	3945	4018	4091	4163
186.5			2035	2093	2150	2206	2261	2315	2369	2423	2476	2529	2582	2636	2691	2747	2805	2865	2927	2990	3051	3111	3171	3233	3295	3355	3414	3471	3528	3588	3651	3717	3787	3860	3933	4006	4079	4151
187.0			2031	2089	2146	2201	2257	2311	2365	2418	2471	2525	2578	2631	2686	2741	2799	2859	2921	2983	3044	3104	3164	3225	3287	3347	3407	3464	3520	3579	3641	3707	3777	3848	3921	3995	4067	4139
187.5			2027	2085	2141	2197	2252	2307	2360	2414	2467	2520	2573	2627	2681	2736	2793	2853	2914	2976	3037	3096	3156	3217	3279	3339	3399	3456	3513	3571	3632	3698	3766	3837	3910	3983	4055	4127
188.0			2023	2081	2137	2193	2248	2302	2356	2409	2462	2515	2569	2622	2676	2731	2787	2847	2908	2969	3030	3089	3149	3210	3271	3332	3391	3448	3505	3563	3623	3688	3756	3826	3898	3971	4044	4116
188.5			2020	2077	2134	2189	2244	2298	2352	2405	2458	2511	2564	2617	2671	2726	2782	2840	2901	2962	3023	3082	3142	3202	3263	3324	3383	3441	3497	3555	3615	3679	3746	3815	3887	3960	4032	4104
189.0			2016	2073	2130	2185	2240	2294	2347	2400	2453	2506	2559	2613	2666	2720	2776	2834	2895	2956	3016	3076	3135	3195	3255	3316	3375	3433	3489	3547	3606	3670	3736	3805	3876	3948	4020	4092
189.5			2013	2070	2126	2181	2236	2290	2343	2396	2449	2502	2555	2608	2661	2715	2771	2828	2888	2949	3010	3069	3128	3187	3248	3308	3368	3425	3482	3539	3598	3661	3726	3794	3865	3937	4009	4080
190.0			2009	2066	2122	2177	2232	2285	2339	2392	2445	2497	2550	2603	2656	2710	2765	2823	2882	2943	3003	3062	3121	3180	3240	3300	3360	3418	3474	3531	3590	3652	3717	3784	3854	3925	3997	4069
190.5			2005	2062	2118	2173	2228	2281	2335	2388	2440	2493	2546	2598	2651	2705	2760	2817	2876	2936	2996	3055	3114	3173	3233	3293	3352	3410	3466	3523	3582	3643	3707	3774	3843	3914	3986	4057
191.0			2002	2059	2114	2169	2224	2277	2331	2383	2436	2488	2541	2594	2647	2700	2755	2811	2870	2930	2990	3049	3107	3166	3225	3285	3344	3402	3459	3515	3574	3635	3698	3764	3833	3903	3974	4046
191.5			1999	2055	2111	2166	2220	2274	2327	2379	2432	2484	2536	2589	2642	2695	2749	2805	2863	2923	2983	3042	3100	3159	3218	3278	3337	3395	3451	3507	3566	3626	3689	3754	3822	3892	3963	4034
192.0			1995	2052	2107	2162	2216	2270	2323	2375	2428	2480	2532	2584	2637	2690	2744	2800	2857	2917	2977	3035	3094	3152	3211	3270	3329	3387	3443	3500	3558	3618	3680	3745	3812	3881	3951	4022
192.5				2048	2104	2158	2212	2266	2319	2371	2423	2476	2528	2580	2632	2685	2739	2794	2851	2910	2970	3029	3087	3145	3204	3263	3321	3379	3436	3492	3550	3609	3671	3735	3802	3870	3940	4011
193.0				2045	2100	2155	2209	2262	2315	2367	2419	2471	2523	2575	2627	2680	2734	2789	2846	2904	2964	3022	3080	3138	3196	3255	3314	3372	3428	3485	3542	3601	3662	3726	3792	3860	3929	4000
193.5				2041	2097	2151	2205	2258	2311	2363	2415	2467	2519	2571	2623	2676	2729	2784	2840	2898	2957	3016	3074	3131	3189	3248	3307	3364	3421	3477	3534	3593	3654	3717	3782	3849	3918	3988
194.0				2038	2093	2148	2202	2255	2307	2360	2411	2463	2515	2566	2619	2671	2724	2778	2834	2892	2951	3009	3067	3125	3182	3241	3299	3357	3413	3469	3526	3584	3645	3707	3772	3839	3907	3977
194.5				2034	2090	2144	2198	2251	2304	2356	2408	2459	2510	2562	2614	2666	2719	2773	2829	2886	2944	3003	3060	3118	3175	3233	3292	3349	3406	3462	3518	3576	3636	3698	3763	3829	3897	3966
195.0				2031	2086	2141	2195	2248	2300	2352	2404	2455	2506	2558	2609	2661	2714	2768	2823	2880	2938	2996	3054	3111	3169	3226	3284	3342	3398	3454	3510	3568	3628	3689	3753	3819	3886	3955
195.5				2028	2083	2137	2191	2244	2296	2348	2400	2451	2502	2554	2605	2657	2709	2763	2817	2874	2932	2990	3047	3104	3162	3219	3277	3335	3391	3446	3502	3560	3619	3680	3744	3809	3876	3944
196.0				2025	2080	2134	2188	2241	2293	2345	2396	2447	2498	2549	2601	2652	2704	2757	2812	2868	2925	2983	3041	3098	3155	3212	3270	3327	3384	3439	3494	3552	3610	3672	3734	3799	3865	3933
196.5				2021	2077	2131	2184	2237	2290	2341	2393	2443	2494	2545	2596	2648	2700	2752	2806	2862	2919	2977	3034	3091	3148	3205	3263	3320	3376	3431	3486	3543	3602	3663	3725	3789	3855	3922
197.0				2018	2073	2128	2181	2234	2286	2338	2389	2440	2490	2541	2592	2643	2695	2747	2801	2856	2913	2971	3028	3084	3141	3198	3256	3313	3369	3424	3479	3535	3594	3654	3716	3780	3845	3912
197.5				2015	2070	2124	2178	2231	2283	2334	2385	2436	2487	2537	2588	2639	2690	2742	2796	2851	2907	2964	3021	3078	3135	3191	3249	3306	3362	3417	3471	3527	3586	3645	3707	3770	3835	3901
198.0				2012	2067	2121	2175	2227	2279	2331	2382	2432	2483	2533	2583	2634	2685	2737	2791	2845	2901	2958	3015	3071	3128	3185	3242	3298	3354	3409	3464	3519	3577	3637	3698	3761	3825	3891
198.5				2009	2064	2118	2171	2224	2276	2328	2378	2429	2479	2529	2579	2630	2681	2732	2786	2840	2895	2952	3008	3065	3121	3178	3235	3291	3347	3402	3456	3512	3569	3628	3689	3751	3815	3881
199.0				2006	2061	2115	2168	2221	2273	2324	2375	2425	2475	2525	2575	2625	2676	2728	2780	2835	2890	2946	3002	3058	3115	3171	3228	3284	3340	3395	3449	3504	3561	3620	3680	3742	3806	3871
199.5				2003	2058	2112	2165	2218	2270	2321	2372	2422	2472	2521	2571	2620	2671	2723	2775	2829	2884	2940	2996	3052	3108	3165	3221	3277	3333	3388	3442	3496	3553	3611	3671	3733	3796	3861
200.0				2000	2055	2109	2162	2215	2266	2318	2368	2419	2468	2518	2567	2616	2666	2718	2770	2824	2878	2934	2989	3045	3102	3158	3214	3271	3326	3381	3435	3489	3545	3603	3663	3724	3787	3851
200.5				1997	2051	2106	2159	2211	2263	2314	2365	2415	2465	2514	2563	2612	2662	2713	2765	2818	2873	2928	2983	3039	3095	3151	3208	3264	3319	3374	3428	3481	3537	3595	3654	3715	3777	3841
201.0					2048	2102	2156	2208	2260	2311	2362	2412	2461	2510	2559	2608	2657	2708	2760	2813	2868	2922	2977	3033	3089	3145	3201	3257	3312	3367	3421	3474	3529	3586	3645	3706	3768	3831
201.5					2045	2099	2153	2205	2257	2308	2358	2408	2458	2507	2555	2603	2653	2703	2755	2808	2863	2917	2972	3027	3082	3138	3194	3250	3305	3360	3414	3467	3522	3579	3637	3697	3759	3821
202.0					2042	2096	2150	2202	2254	2305	2355	2405	2454	2503	2551	2599	2648	2699	2750	2803	2858	2912	2966	3021	3076	3131	3187	3243	3299	3353	3407	3460	3514	3571	3629	3688	3749	3812
202.5					2039	2093	2146	2199	2250	2301	2352	2401	2451	2499	2547	2595	2644	2694	2745	2798	2852	2906	2961	3015	3070	3125	3180	3236	3292	3347	3400	3453	3507	3563	3620	3680	3740	3802

Plate VII-4. Turbine Rating Tables (Aerating) cont.

Aerating	MegaWatts																																											
Gross Head, ft	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
203.0					2036	2090	2143	2196	2247	2298	2348	2398	2447	2496	2543	2591	2639	2689	2740	2793	2847	2901	2955	3010	3064	3119	3174	3229	3285	3340	3394	3446	3500	3555	3612	3671	3731	3793
203.5					2033	2087	2140	2192	2244	2295	2345	2395	2444	2492	2539	2587	2635	2684	2736	2788	2841	2896	2950	3004	3058	3113	3167	3222	3278	3333	3387	3440	3493	3547	3604	3663	3722	3783
204.0					2030	2084	2137	2189	2241	2292	2342	2391	2440	2488	2535	2583	2631	2680	2731	2783	2836	2890	2945	2999	3053	3107	3161	3216	3271	3326	3380	3433	3486	3540	3596	3654	3713	3774
204.5					2027	2081	2134	2186	2238	2288	2339	2388	2436	2484	2531	2578	2626	2675	2726	2778	2831	2885	2939	2993	3047	3101	3154	3209	3264	3319	3373	3426	3478	3532	3588	3646	3705	3765
205.0					2024	2078	2131	2183	2234	2285	2335	2385	2433	2480	2527	2574	2622	2671	2721	2773	2826	2880	2934	2988	3041	3095	3148	3202	3257	3312	3366	3419	3471	3525	3581	3638	3696	3756
205.5					2022	2075	2128	2180	2231	2282	2332	2381	2429	2477	2523	2570	2618	2666	2716	2768	2821	2875	2929	2983	3036	3089	3142	3196	3250	3305	3359	3412	3465	3518	3573	3629	3687	3747
206.0					2019	2072	2124	2176	2227	2278	2329	2378	2426	2473	2519	2566	2613	2662	2712	2763	2816	2870	2924	2977	3031	3083	3136	3189	3243	3298	3352	3405	3458	3511	3565	3621	3679	3738
206.5					2016	2069	2121	2173	2224	2275	2325	2375	2423	2469	2515	2562	2609	2657	2707	2759	2811	2865	2919	2972	3025	3078	3130	3183	3236	3291	3345	3399	3451	3504	3558	3613	3671	3729
207.0					2013	2066	2118	2170	2220	2271	2322	2371	2420	2466	2512	2558	2605	2653	2703	2754	2806	2860	2913	2967	3020	3072	3124	3176	3229	3284	3338	3393	3445	3497	3550	3606	3662	3721

Plate VII-4. Turbine Rating Tables (Aerating) cont.

Center Hill Units with New Turbine (Nonaerating) *Red Cells are Outside of Operating Limits

Nonaerating Gross Head, ft	MegaWatts																																						
	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
136.0	2457	2507	2557	2613	2682	2761	2842	2926	3012	3097	3178	3256	3331	3404	3478	3559	3659	3772	3879	3983	4086	4193	4307	4424	4545	4689	4851												
136.5	2454	2504	2554	2609	2675	2752	2833	2917	3002	3086	3168	3246	3321	3394	3467	3547	3643	3754	3861	3965	4069	4174	4286	4402	4522	4657	4817												
137.0	2450	2500	2550	2605	2668	2743	2824	2907	2991	3075	3157	3236	3312	3384	3457	3535	3628	3736	3843	3948	4051	4156	4265	4380	4498	4628	4784												
137.5	2446	2495	2546	2599	2662	2735	2815	2898	2981	3064	3146	3226	3302	3374	3447	3523	3613	3718	3826	3931	4034	4138	4245	4359	4475	4600	4751	4910										
138.0	2442	2491	2542	2594	2656	2727	2806	2888	2970	3053	3136	3216	3292	3365	3437	3512	3599	3701	3808	3913	4017	4121	4226	4337	4453	4573	4719	4876										
138.5	2438	2487	2538	2591	2650	2720	2797	2879	2961	3042	3125	3206	3283	3356	3427	3501	3586	3685	3790	3896	4000	4103	4207	4316	4431	4548	4685	4842										
139.0	2433	2483	2534	2587	2645	2712	2788	2870	2951	3032	3114	3195	3273	3346	3417	3491	3574	3670	3773	3878	3982	4086	4189	4296	4409	4526	4655	4809										
139.5	2429	2480	2530	2583	2640	2706	2780	2861	2941	3021	3104	3185	3264	3337	3407	3481	3561	3655	3756	3860	3964	4069	4171	4276	4388	4503	4626	4776										
140.0	2425	2476	2526	2578	2635	2699	2771	2852	2932	3011	3093	3175	3254	3328	3398	3471	3550	3641	3740	3843	3947	4051	4154	4257	4366	4481	4601	4743	4897									
140.5	2420	2471	2521	2573	2629	2692	2763	2843	2922	3001	3083	3165	3244	3319	3388	3460	3538	3627	3725	3826	3929	4033	4136	4239	4346	4459	4576	4711	4863									
141.0	2416	2466	2516	2568	2624	2686	2755	2833	2913	2992	3072	3154	3234	3309	3379	3450	3527	3613	3709	3809	3911	4015	4119	4221	4325	4437	4553	4680	4830									
141.5	2412	2462	2511	2562	2618	2679	2747	2824	2904	2983	3063	3144	3224	3299	3370	3440	3516	3600	3695	3793	3894	3997	4102	4203	4306	4416	4531	4652	4797									
142.0	2407	2457	2506	2557	2612	2672	2740	2815	2894	2973	3053	3134	3214	3289	3361	3431	3505	3588	3680	3777	3877	3979	4084	4186	4287	4395	4508	4626	4764	4918								
142.5	2402	2452	2500	2551	2606	2666	2732	2806	2884	2964	3044	3124	3204	3279	3351	3421	3495	3575	3666	3762	3860	3961	4066	4168	4269	4374	4486	4603	4734	4884								
143.0	2397	2447	2495	2545	2600	2659	2725	2797	2875	2954	3035	3114	3193	3270	3342	3412	3484	3564	3653	3748	3844	3944	4047	4151	4251	4354	4464	4579	4704	4851								
143.5	2392	2442	2490	2540	2593	2652	2718	2789	2865	2945	3025	3104	3183	3260	3332	3402	3474	3552	3639	3733	3828	3926	4029	4133	4234	4335	4443	4556	4678	4818								
144.0	2387	2437	2486	2534	2587	2646	2710	2781	2856	2935	3015	3095	3173	3250	3323	3393	3464	3541	3626	3719	3813	3910	4010	4115	4217	4317	4421	4534	4652	4787								
144.5	2382	2433	2481	2529	2581	2639	2703	2773	2847	2926	3006	3085	3163	3240	3313	3383	3455	3530	3614	3705	3799	3894	3992	4097	4199	4299	4401	4511	4628	4758	4905							
145.0	2378	2428	2477	2524	2575	2632	2696	2765	2839	2916	2996	3075	3153	3230	3304	3374	3445	3519	3601	3691	3784	3878	3975	4078	4182	4281	4381	4489	4604	4729	4873							
145.5	2374	2424	2473	2519	2569	2626	2688	2757	2830	2907	2986	3065	3144	3220	3294	3364	3435	3509	3589	3677	3770	3863	3959	4059	4163	4264	4362	4468	4580	4703	4841							
146.0	2369	2419	2468	2514	2564	2619	2681	2749	2822	2898	2976	3055	3134	3210	3285	3355	3425	3498	3577	3664	3756	3848	3942	4041	4145	4247	4344	4447	4558	4677	4811							
146.5	2365	2415	2463	2510	2559	2612	2673	2741	2813	2889	2966	3045	3124	3201	3275	3346	3416	3488	3565	3651	3741	3834	3927	4023	4126	4229	4327	4427	4535	4651	4781	4926						
147.0	2360	2409	2458	2506	2553	2606	2665	2732	2805	2880	2957	3035	3114	3191	3265	3337	3406	3478	3554	3638	3728	3819	3911	4006	4107	4211	4310	4408	4514	4628	4753	4895						
147.5	2356	2404	2453	2501	2549	2600	2658	2724	2796	2871	2947	3026	3104	3181	3256	3327	3397	3468	3543	3625	3714	3805	3897	3990	4089	4193	4293	4390	4493	4604	4725	4864						
148.0	2351	2399	2447	2495	2544	2594	2651	2716	2788	2862	2938	3016	3094	3172	3246	3318	3388	3458	3532	3613	3700	3791	3882	3974	4070	4174	4275	4372	4473	4581	4700	4833						
148.5	2346	2394	2442	2490	2538	2589	2644	2707	2779	2853	2928	3006	3085	3162	3236	3308	3378	3448	3521	3601	3687	3777	3868	3959	4053	4155	4258	4355	4453	4559	4674	4803						
149.0	2342	2390	2438	2486	2534	2583	2638	2700	2771	2845	2919	2996	3075	3152	3227	3299	3369	3439	3511	3589	3673	3763	3853	3944	4037	4136	4240	4338	4435	4537	4650	4775	4914					
149.5	2337	2385	2433	2481	2529	2578	2631	2692	2762	2836	2910	2987	3065	3143	3217	3289	3360	3429	3501	3577	3660	3749	3839	3929	4021	4118	4221	4321	4417	4517	4627	4748	4884					
150.0	2332	2380	2428	2476	2525	2573	2626	2685	2753	2827	2901	2977	3055	3133	3208	3280	3350	3420	3490	3566	3648	3735	3825	3915	4006	4100	4202	4303	4400	4498	4604	4722	4854					
150.5	2328	2376	2424	2472	2520	2568	2620	2678	2745	2818	2892	2968	3046	3123	3199	3270	3341	3410	3480	3555	3635	3721	3811	3901	3990	4083	4183	4286	4382	4479	4582	4696	4825					
151.0	2323	2371	2419	2467	2515	2563	2614	2671	2737	2809	2883	2959	3036	3114	3189	3261	3331	3401	3470	3543	3623	3708	3797	3887	3976	4067	4164	4267	4365	4461	4561	4671	4797	4934				
151.5	2319	2368	2415	2463	2510	2558	2608	2665	2729	2800	2875	2950	3027	3104	3180	3252	3322	3391	3460	3533	3611	3694	3783	3873	3961	4051	4145	4248	4348	4443	4541	4648	4770	4904				
152.0	2315	2364	2411	2458	2505	2553	2603	2659	2722	2792	2866	2942	3018	3094	3170	3242	3313	3382	3451	3522	3599	3681	3769	3859	3947	4036	4128	4229	4330	4425	4522	4626	4744	4875				
152.5	2311	2360	2408	2454	2501	2548	2597	2652	2715	2783	2857	2933	3009	3085	3160	3233	3303	3372	3441	3512	3587	3669	3755	3844	3933	4021	4112	4209	4312	4408	4503	4605	4719	4846				
153.0	2307	2357	2404	2451	2496	2543	2591	2647	2708	2775	2848	2924	3000	3075	3150	3223	3294	3363	3431	3501	3576	3656	3741	3830	3919	4007	4096	4191	4293	4391	4485	4585	4695	4819				
153.5	2303	2353	2401	2447	2492	2538	2586	2641	2701	2767	2840	2915	2991	3066	3140	3213	3285	3354	3422	3491	3565	3644	3728	3816	3905	3992	4081	4173	4274	4373	4468	4565	4672	4792	4922			
154.0	2299	2349	2397	2444	2488	2533	2580	2635	2695	2760	2831	2907	2982	3056	3130	3204	3275	3344	3412	3481	3554	3631	3714	3802	3890	3978	4066	4157	4254	4356	4451	4546	4651	4767	4894			
154.5	2295	2345	2394	2440	2484	2528	2575	2629	2689	2753	2823	2898	2973	3047	3121	3194	3266	3335	3403	3471	3543	3619	3701	3788	3876	3964	4051	4141	4236	4337	4434	4528	4630	4743	4866			
155.0	2291	2341	2390	2436	2480	2524	2570	2624	2683	2746	2815	2889	2964	3038	3111	3185	3256	3326	3393	3461	3532	3608	3689	3774	3862	3950	4037	4125	4217	4318	4416	4510	4610	4720	4840			
155.5	2287	2337	2385	2432	2476	2520	2566	2618	2677	2740	2808	2881	2955	3029	3102	3175	3247	3316	3384	3452	3522	3596	3676	3760	3848	3936	4023	4110	4200	4299	4398	4493	4590	4697	4814			
156.0	2283	2333	2381	2428	2472	2516	2562	2613	2671	2733	2800	2872	2947	3020	3093	3165	3238	3307	3375	3442	3511	3585	3664	3747	3834	3922	4008	4095	4184	4279	4380	4475	4571	4676	4789	4914	
156.5	2278	2329	2378	2424	2468	2512	2557	2608	2664	2727	2793	2864	2938	3011	3084	3156	3228	3298	3366	3433	3501	3574	3652	3734	3820	3907	3994	4081	4168	4261	4362	4458	4553	4655	4766	4887	
157.0	2274	2325	2374	2421	2465	2508	2553	2602	2658	2720	2786	2856	2929	3002	3075	3147	3219	3289	3357	3424	3491	3563	3640	3721	3806	3893	3980	4066	4153	4244	4343	4440	4535	4634	4743	4861	
157.5	2269	2321	2371	2417	2461	2504	2548	2597	2651	2713	2779	2848	2921	2994	3066	3138	3210	3280	3348	3415	3481	3552	3628	3708	3792	3879	3966	4052	4138	4227	4324	4422	4517	4614	4721	4836	

Plate VII-4. Turbine Rating Tables (Nonaerating) cont.

Nonaerating Gross Head, ft	MegaWatts																																							
	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
158.0	2265	2317	2367	2414	2458	2501	2544	2591	2646	2706	2771	2840	2912	2985	3057	3129	3201	3271	3339	3406	3472	3541	3617	3696	3779	3865	3952	4038	4124	4211	4305	4404	4499	4595	4699	4812	4934	
158.5	2260	2312	2362	2410	2455	2498	2541	2587	2640	2699	2764	2833	2904	2976	3049	3121	3192	3262	3329	3396	3462	3531	3606	3684	3766	3851	3937	4024	4109	4196	4287	4386	4482	4576	4677	4789	4908	
159.0	2255	2307	2358	2406	2452	2495	2537	2583	2634	2692	2757	2825	2896	2968	3040	3112	3183	3252	3320	3387	3453	3521	3595	3672	3753	3837	3923	4009	4095	4181	4270	4367	4464	4558	4657	4766	4883	
159.5	2251	2303	2354	2403	2449	2492	2534	2579	2629	2686	2749	2817	2888	2959	3032	3104	3174	3243	3311	3378	3444	3512	3584	3660	3740	3823	3909	3995	4081	4167	4255	4349	4446	4540	4637	4744	4859	
160.0	2247	2298	2349	2399	2446	2489	2531	2575	2624	2679	2742	2809	2880	2951	3023	3095	3166	3234	3302	3369	3435	3503	3574	3649	3728	3810	3895	3981	4066	4152	4240	4332	4428	4522	4618	4722	4835	
160.5	2243	2294	2345	2395	2442	2486	2528	2571	2619	2673	2735	2802	2872	2943	3014	3086	3157	3226	3293	3360	3426	3494	3564	3637	3715	3797	3881	3967	4052	4138	4224	4315	4410	4504	4599	4701	4812	4930
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161.5	2234	2286	2336	2386	2435	2479	2521	2563	2610	2662	2722	2787	2856	2926	2997	3069	3140	3209	3275	3341	3408	3475	3544	3616	3692	3771	3854	3938	4024	4109	4195	4283	4374	4469	4563	4660	4767	4882
162.0	2229	2281	2332	2382	2430	2475	2517	2559	2605	2657	2715	2780	2848	2918	2989	3060	3131	3200	3266	3332	3399	3465	3534	3605	3680	3759	3840	3925	4010	4095	4180	4268	4358	4451	4545	4641	4745	4858
162.5	2224	2277	2328	2377	2426	2471	2513	2555	2601	2651	2709	2773	2840	2910	2981	3052	3122	3191	3258	3323	3390	3456	3524	3595	3669	3747	3827	3911	3996	4081	4166	4252	4341	4434	4527	4622	4724	4834
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163.5	2215	2267	2319	2367	2416	2463	2506	2548	2592	2642	2698	2759	2825	2894	2964	3035	3104	3173	3240	3305	3371	3437	3504	3574	3647	3723	3802	3884	3968	4053	4137	4223	4309	4400	4492	4586	4683	4789
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164.5	2206	2258	2309	2359	2407	2455	2499	2541	2584	2632	2687	2746	2810	2878	2948	3018	3087	3155	3222	3288	3353	3419	3485	3554	3625	3699	3777	3857	3940	4025	4109	4194	4279	4367	4458	4551	4645	4746
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165.5	2197	2248	2301	2350	2398	2446	2491	2534	2576	2623	2676	2733	2796	2863	2932	3001	3070	3138	3204	3270	3336	3400	3466	3534	3604	3677	3753	3832	3913	3997	4081	4165	4250	4336	4425	4517	4609	4706
166.0	2192	2244	2296	2346	2394	2442	2487	2530	2572	2619	2670	2727	2789	2855	2924	2993	3062	3129	3195	3261	3327	3391	3457	3524	3594	3666	3741	3820	3900	3983	4067	4151	4235	4320	4409	4500	4592	4686
166.5	2188	2240	2292	2342	2389	2437	2483	2526	2569	2615	2666	2721	2782	2847	2916	2985	3054	3121	3186	3252	3318	3383	3448	3515	3583	3655	3730	3807	3888	3970	4053	4136	4220	4305	4393	4483	4575	4668
167.0	2184	2236	2288	2337	2385	2433	2479	2522	2565	2611	2661	2716	2775	2840	2908	2977	3046	3113	3178	3244	3310	3374	3439	3505	3573	3644	3718	3796	3875	3956	4039	4122	4206	4290	4377	4467	4558	4650
167.5	2180	2232	2283	2333	2381	2428	2475	2518	2562	2607	2657	2710	2768	2832	2901	2969	3038	3104	3169	3235	3301	3365	3430	3495	3563	3633	3707	3784	3863	3943	4025	4108	4191	4275	4361	4450	4541	4632
168.0	2177	2228	2278	2327	2376	2424	2470	2514	2557	2603	2652	2706	2762	2825	2893	2961	3030	3096	3161	3226	3292	3357	3421	3486	3553	3623	3696	3772	3850	3930	4012	4094	4177	4261	4346	4434	4525	4616
168.5	2173	2223	2273	2322	2372	2419	2466	2510	2553	2599	2648	2701	2756	2817	2885	2954	3022	3088	3153	3218	3284	3348	3412	3477	3543	3612	3685	3760	3838	3918	3998	4080	4163	4246	4331	4418	4509	4599
169.0	2170	2220	2269	2318	2367	2415	2461	2506	2549	2594	2644	2696	2749	2810	2877	2946	3014	3080	3145	3210	3275	3340	3404	3468	3533	3601	3674	3749	3826	3905	3985	4066	4149	4231	4316	4402	4492	4582
169.5	2166	2217	2266	2314	2362	2410	2457	2502	2546	2591	2640	2691	2743	2803	2870	2938	3006	3072	3137	3202	3267	3331	3395	3459	3524	3591	3663	3738	3815	3893	3972	4053	4134	4217	4301	4387	4476	4566
170.0	2162	2214	2263	2311	2358	2405	2452	2497	2542	2588	2636	2686	2737	2796	2862	2930	2998	3064	3129	3194	3259	3323	3387	3451	3515	3580	3652	3727	3803	3881	3960	4040	4121	4203	4286	4372	4460	4549
170.5	2159	2210	2260	2308	2355	2401	2448	2493	2538	2585	2632	2681	2731	2788	2854	2922	2990	3056	3122	3187	3251	3315	3378	3442	3506	3571	3641	3716	3792	3869	3947	4027	4107	4189	4271	4357	4444	4532
171.0	2156	2207	2257	2305	2351	2397	2443	2489	2534	2580	2627	2676	2726	2782	2847	2914	2982	3049	3114	3179	3243	3306	3370	3434	3498	3561	3631	3705	3781	3857	3935	4014	4093	4174	4257	4342	4428	4516
171.5	2153	2204	2254	2302	2349	2394	2438	2484	2530	2575	2622	2670	2720	2775	2839	2907	2974	3041	3106	3171	3235	3298	3361	3425	3490	3552	3620	3695	3770	3846	3923	4001	4080	4161	4243	4327	4412	4500
172.0	2150	2201	2251	2298	2346	2391	2433	2479	2525	2570	2616	2664	2714	2769	2832	2899	2967	3033	3099	3164	3228	3290	3353	3417	3481	3543	3609	3684	3759	3834	3911	3988	4067	4147	4228	4312	4397	4484
172.5	2147	2198	2247	2295	2343	2388	2430	2474	2520	2566	2611	2659	2708	2763	2825	2892	2959	3025	3091	3156	3220	3283	3345	3408	3473	3535	3599	3673	3748	3823	3899	3976	4054	4133	4214	4297	4381	4468
173.0	2144	2195	2244	2292	2340	2385	2426	2470	2516	2561	2606	2653	2702	2756	2818	2885	2951	3017	3083	3148	3212	3275	3337	3400	3465	3527	3590	3663	3737	3812	3887	3964	4041	4120	4200	4282	4366	4452
173.5	2141	2192	2241	2289	2337	2382	2422	2465	2512	2557	2601	2648	2696	2749	2811	2877	2944	3010	3075	3140	3205	3267	3329	3392	3456	3519	3581	3652	3726	3801	3876	3952	4029	4107	4186	4268	4351	4436
174.0	2139	2189	2238	2286	2334	2379	2419	2461	2508	2552	2596	2642	2690	2743	2804	2870	2936	3002	3067	3133	3197	3259	3321	3383	3447	3510	3572	3640	3715	3790	3864	3940	4016	4094	4173	4253	4336	4421
174.5	2136	2186	2235	2283	2330	2376	2416	2458	2503	2548	2591	2637	2685	2737	2797	2863	2929	2994	3059	3125	3190	3252	3313	3375	3439	3502	3563	3630	3704	3779	3853	3928	4004	4081	4159	4239	4322	4406
175.0	2133	2183	2232	2280	2327	2372	2414	2455	2499	2543	2587	2632	2680	2730	2790	2855	2922	2987	3051	3117	3182	3244	3305	3367	3430	3493	3555	3619	3693	3768	3842	3917	3992	4068	4146	4225	4307	4390
175.5	2130	2180	2229	2277	2324	2369	2411	2452	2495	2539	2583	2627	2674	2725	2783	2848	2915	2979	3044	3109	3174	3237	3297	3359	3422	3485	3546	3609	3682	3757	3831	3905	3980	4056	4133	4212	4292	4375
176.0	2127	2177	2226	2274	2321	2366	2408	2448	2490	2533	2578	2623	2669	2719	2776	2841	2907	2972	3036	3101	3166	3229	3290	3351	3414	3476	3538	3600	3671	3746	3820	3894	3968	4044	4120	4198	4278	4360
176.5	2124	2174	2223	2271	2318	2364	2406	2445	2485	2528	2573	2618	2664	2713	2770	2834	2900	2965	3029	3093	3158	3221	3282	3343	3405	3468	3529	3591	3660	3735	3808	3882	3956	4031	4107	4185	4264	4346
177.0	2121	2171	2220	2268	2314	2361	2404	2442	2481	2523	2568	2613	2658	2708	2764	2827	2893	2957	3021	3085	3150	3214	3275	3336	3397	3460	3521	3581	3650	3724	3797	3871	3945	4019	4095	4172	4250	4331
177.5	2118	2168	2217	2265	2311	2358	2402	2440	2478	2519	2563	2608	2653	2702	2758	2820	2886	2950	3014	3077	3142	3206	3267	3328	3389	3451	3512	3573	3639	3713	3786	3860	3933	4007	4082	4159	4237	4317
178.0	2116	2165	2214	2262	2309	2355	2399	2438	2476	2515	2558	2602	2648	2696	2751	2813	2879	2943	3006	3069	3134	3198	3260	3320	3381	3443	3504	3564	3629	3702	3775	3849	3922	3996	4070	4146	4223	4303
178.5	2113	2162	2211	2259	2306	2352	2396	2436	2474	2512	2553	2597	2642	2691	2746	2807	2872	2936	2999	3062	3126	3191	3253	3313	3373	3435	3496	3556	3620	3691	3764	3837	3911	3984	4058	4133	4210	4289
179.0	2111	2160	2208	2256	2304	2350	2393	2434	2471	2508	2549	2591	2636	2685	2740	2800	2865	2929	2991	3054	3118	3183	3245	3306	3366	3426	3488	3547	3610	3680	3753	3826	3899	3972	4046	4121	4197	4275
179.5	2109	2158	2206	2254	2301	2347	2390	2431	2468	2505	2544	2586	2631	2680	2734	2794	2858	2922	2984	3047	3111	3175	3238	3298	3358	3419	3479	3539	3601	3669	3742	3815	3888	3961	4034	4108	4184	4261
180.0	2107	2156	2204	2251	2298	2344	2387	2427	2465	2502	2540	2581	2626	2674	2728	2788	2851	2915	2977	3039	3103	3167	3230	3291	3351	3411	3471	3530	3592	3659	3731	3804	3877	3949	4022	4096	4171	4248

Plate VII-4. Turbine Rating Tables (Nonaerating) cont.

Nonaerating Gross Head, ft	MegaWatts																																					
	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
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181.0	2103	2152	2199	2247	2293	2337	2380	2421	2459	2497	2534	2573	2615	2663	2717	2776	2838	2901	2963	3025	3087	3151	3215	3275	3335	3395	3454	3514	3574	3639	3710	3782	3854	3927	3999	4072	4146	4221
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182.0	2100	2148	2196	2242	2287	2331	2374	2414	2453	2492	2529	2567	2607	2651	2705	2764	2826	2888	2949	3010	3072	3136	3199	3260	3320	3380	3439	3497	3557	3620	3688	3760	3832	3904	3976	4048	4121	4195
182.5	2099	2146	2194	2240	2285	2328	2370	2411	2451	2489	2527	2565	2604	2647	2699	2758	2819	2881	2942	3003	3065	3128	3191	3252	3312	3372	3431	3489	3548	3610	3678	3749	3821	3893	3965	4037	4109	4183
183.0	2097	2145	2192	2237	2282	2325	2367	2408	2448	2487	2525	2562	2600	2642	2693	2752	2813	2875	2936	2996	3057	3120	3183	3244	3304	3365	3424	3481	3540	3601	3668	3739	3810	3882	3954	4025	4097	4170
183.5	2095	2143	2190	2235	2280	2323	2365	2405	2445	2484	2523	2559	2597	2637	2687	2747	2807	2868	2929	2989	3050	3112	3175	3236	3296	3357	3416	3474	3532	3592	3658	3728	3799	3871	3942	4014	4086	4158
184.0	2094	2141	2188	2233	2277	2320	2362	2402	2442	2481	2520	2557	2593	2632	2681	2741	2801	2862	2922	2982	3043	3105	3167	3229	3289	3349	3409	3466	3524	3583	3648	3717	3789	3860	3931	4002	4074	4146
184.5	2092	2140	2186	2231	2275	2318	2359	2400	2440	2479	2517	2554	2590	2629	2676	2735	2795	2855	2916	2976	3036	3097	3159	3221	3281	3341	3401	3459	3516	3575	3638	3706	3778	3849	3920	3991	4062	4134
185.0	2091	2138	2184	2229	2273	2315	2357	2397	2437	2476	2513	2551	2588	2626	2670	2728	2789	2849	2909	2969	3029	3090	3151	3213	3273	3334	3394	3452	3508	3567	3629	3696	3767	3838	3909	3980	4051	4122
185.5	2089	2136	2182	2227	2270	2313	2354	2395	2434	2473	2511	2548	2585	2622	2666	2721	2783	2843	2903	2962	3022	3083	3144	3205	3265	3326	3386	3444	3501	3559	3620	3686	3756	3827	3898	3968	4039	4110
186.0	2088	2135	2180	2225	2268	2310	2352	2392	2432	2470	2508	2546	2583	2619	2661	2716	2777	2837	2896	2956	3015	3076	3136	3197	3258	3318	3378	3437	3494	3551	3610	3675	3745	3816	3887	3957	4028	4099
186.5	2086	2133	2178	2223	2266	2308	2349	2390	2429	2468	2506	2543	2580	2616	2657	2710	2771	2830	2890	2949	3009	3068	3129	3190	3250	3310	3371	3430	3486	3543	3602	3665	3735	3806	3876	3946	4016	4087
187.0	2085	2131	2177	2221	2264	2306	2347	2387	2427	2465	2503	2541	2577	2614	2653	2705	2765	2824	2883	2943	3002	3062	3122	3182	3243	3302	3363	3422	3479	3535	3593	3656	3724	3795	3865	3935	4005	4075
187.5	2083	2129	2175	2219	2262	2304	2345	2385	2425	2463	2501	2538	2575	2611	2651	2700	2759	2818	2877	2936	2995	3055	3115	3175	3235	3295	3355	3414	3472	3528	3585	3646	3714	3784	3854	3924	3994	4064
188.0	2082	2128	2173	2217	2260	2302	2343	2383	2422	2461	2499	2536	2572	2609	2648	2695	2753	2812	2871	2930	2989	3048	3108	3168	3228	3287	3347	3407	3464	3521	3578	3638	3703	3773	3843	3913	3983	4053
188.5	2080	2126	2171	2215	2258	2300	2341	2381	2420	2459	2496	2533	2570	2606	2645	2691	2747	2806	2865	2923	2982	3041	3101	3161	3220	3280	3340	3399	3457	3513	3570	3629	3693	3762	3832	3902	3972	4041
189.0	2078	2124	2169	2213	2256	2298	2339	2379	2418	2457	2494	2531	2567	2603	2642	2687	2741	2800	2859	2917	2976	3034	3094	3153	3213	3273	3332	3391	3449	3506	3563	3621	3684	3752	3822	3891	3961	4030
189.5	2076	2122	2167	2211	2253	2295	2336	2377	2416	2454	2492	2529	2564	2600	2638	2682	2735	2794	2853	2911	2969	3028	3087	3146	3206	3265	3324	3383	3441	3498	3555	3613	3675	3741	3811	3880	3949	4019
190.0	2075	2120	2165	2209	2251	2293	2334	2374	2414	2452	2490	2526	2562	2597	2634	2676	2730	2788	2846	2905	2963	3021	3080	3139	3199	3258	3317	3375	3433	3491	3547	3605	3666	3731	3800	3869	3938	4008
190.5	2073	2118	2163	2207	2249	2291	2332	2372	2411	2450	2487	2524	2559	2594	2631	2671	2724	2782	2840	2899	2957	3015	3073	3132	3192	3251	3309	3368	3426	3483	3540	3597	3657	3721	3789	3858	3928	3996
191.0	2071	2116	2161	2205	2247	2289	2330	2370	2409	2448	2485	2521	2556	2591	2628	2668	2718	2776	2835	2892	2950	3008	3066	3125	3185	3243	3302	3360	3418	3475	3532	3589	3649	3712	3779	3848	3917	3985
191.5	2069	2114	2159	2203	2245	2287	2328	2368	2407	2445	2482	2519	2554	2589	2625	2664	2713	2770	2829	2886	2944	3002	3059	3118	3178	3236	3294	3353	3410	3468	3524	3581	3640	3703	3769	3837	3906	3974
192.0	2067	2112	2157	2200	2243	2285	2326	2366	2405	2443	2480	2516	2552	2586	2622	2661	2708	2765	2823	2880	2938	2995	3053	3111	3170	3229	3287	3345	3403	3460	3516	3573	3632	3694	3759	3827	3895	3963
192.5	2065	2110	2155	2198	2241	2283	2323	2363	2402	2440	2478	2514	2549	2584	2620	2657	2703	2759	2817	2874	2932	2989	3046	3104	3163	3222	3280	3337	3395	3452	3509	3565	3624	3685	3749	3816	3885	3953
193.0	2062	2108	2152	2196	2239	2280	2321	2361	2400	2438	2475	2511	2547	2582	2617	2654	2699	2754	2810	2868	2925	2982	3039	3097	3156	3215	3273	3330	3388	3444	3501	3558	3616	3676	3740	3806	3874	3942
193.5	2060	2106	2150	2194	2236	2278	2319	2359	2398	2436	2473	2509	2545	2580	2615	2652	2695	2748	2804	2862	2919	2976	3033	3091	3149	3208	3266	3323	3380	3437	3493	3550	3607	3667	3730	3796	3864	3931
194.0	2058	2103	2148	2191	2234	2276	2317	2357	2395	2433	2471	2507	2543	2578	2612	2649	2691	2742	2798	2856	2913	2970	3027	3084	3142	3201	3258	3315	3372	3429	3485	3542	3599	3659	3721	3786	3853	3920
194.5	2055	2101	2145	2189	2232	2274	2314	2354	2393	2431	2468	2505	2541	2575	2610	2646	2687	2736	2792	2850	2907	2963	3020	3077	3135	3194	3251	3308	3365	3421	3477	3534	3591	3650	3712	3777	3843	3910
195.0	2053	2098	2143	2187	2229	2271	2312	2352	2391	2429	2466	2503	2538	2573	2607	2643	2683	2731	2787	2844	2900	2957	3014	3071	3128	3187	3244	3301	3357	3414	3470	3526	3583	3642	3703	3767	3833	3899
195.5	2050	2096	2140	2184	2227	2269	2310	2350	2389	2427	2464	2500	2536	2570	2604	2639	2679	2727	2781	2838	2894	2951	3007	3064	3122	3180	3237	3294	3350	3406	3462	3518	3575	3633	3694	3758	3823	3889
196.0	2048	2093	2138	2182	2224	2266	2307	2347	2386	2424	2462	2498	2533	2568	2601	2636	2674	2722	2776	2832	2888	2945	3001	3057	3115	3173	3230	3287	3343	3399	3454	3510	3566	3625	3685	3748	3813	3879
196.5	2045	2090	2135	2179	2222	2264	2305	2345	2384	2422	2459	2496	2531	2565	2599	2633	2671	2717	2771	2827	2883	2939	2995	3051	3108	3166	3223	3280	3335	3391	3447	3502	3558	3616	3676	3739	3804	3869
197.0	2042	2088	2132	2176	2219	2261	2302	2342	2381	2420	2457	2494	2529	2563	2596	2631	2668	2712	2765	2821	2877	2933	2989	3045	3101	3159	3216	3273	3328	3384	3439	3494	3550	3608	3668	3730	3794	3859
197.5	2039	2085	2130	2173	2216	2258	2300	2340	2379	2417	2455	2491	2527	2561	2594	2628	2665	2708	2760	2815	2871	2927	2982	3038	3095	3152	3209	3266	3321	3377	3432	3486	3542	3600	3659	3721	3784	3849
198.0	2036	2082	2127	2171	2214	2256	2297	2337	2377	2415	2452	2489	2524	2559	2592	2625	2662	2704	2754	2810	2865	2921	2976	3032	3088	3145	3202	3259	3314	3370	3424	3479	3534	3591	3650	3711	3774	3838
198.5	2033	2079	2124	2168	2211	2253	2294	2334	2374	2413	2450	2487	2522	2556	2589	2623	2658	2699	2749	2804	2860	2915	2970	3025	3082	3138	3196	3252	3307	3362	3417	3471	3526	3583	3642	3702	3765	3828
199.0	2030	2076	2121	2165	2208	2250	2291	2332	2371	2410	2448	2484	2520	2554	2587	2620	2655	2695	2744	2799	2854	2909	2964	3019	3075	3132	3189	3245	3300	3355	3410	3464	3519	3575	3633	3693	3755	3818
199.5	2027	2073	2118	2162	2205	2247	2288	2329	2369	2407	2445	2482	2518	2552	2585	2617	2652	2692	2739	2793	2848	2903	2958	3013	3068	3125	3182	3238	3294	3348	3403	3457	3511	3567	3625	3684	3746	3808
200.0	2024	2070	2115	2159	2202	2244	2285	2326	2366	2405	2443	2480	2515	2550	2583	2615	2649	2688	2734	2788	2842	2897	2952	3007	3062	3118	3175	3231	3287	3341	3396	3449	3504	3559	3616	3676	3736	3799
200.5	2021	2067	2112	2155	2198	2241	2282	2323	2363	2402	2440	2477	2513	2548	2581	2613	2647	2685	2730	2782	2837	2891	2946	3001	3056	3111	3168	3224	3280	3334	3388	3442	3496	3551	3608	3667	3727	3789
201.0	2018	2064	2108	2152	2195	2238	2279	2320	2360	2399	2437	2475	2511	2546	2579	2611	2644	2681	2725	2777	2831	2885	2940	2994	3049	3105	3161	3218	3273	3327	3381	3435	3489	3543	3600	3658	3718	3779
201.5	2015	2061	2105	2149	2192	2234	2276	2317	2357	2396	2435	2472	2508	2544	2577	2609	2642	2678	2721	2771	2825	2880	2934	2988	3043	3098	3154	3211	3266	3320	3375	3428	3482	3536	3592	3649	3709	3770
202.0	2012	2058	2102	2146	2189	2231	2273	2314	2354	2393	2432	2469	2506	2541	2575	2607	2639	2674	2716	2766	2820	2874	2928	2983	3037	3092	3148	3204	3259	3314	3368	3421	3475	3528	3584	3641	3700	3760
202.5	2009	2055	2099	2143	2185	2228	2269	2310	2351	2390	2429	2467	2503	2539	2573	2605	2636	2672	2712	2761	2814	2868	2922	2977	3031	3086	3141	3197	3253	3307	3361	3415	3468	3521	3576	3633	3691	3751

Plate VII-4. Turbine Rating Tables (Nonaerating) cont.

Nonaerating	MegaWatts																																							
Gross Head, ft	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
203.0	2006	2051	2096	2139	2182	2224	2266	2307	2348	2387	2426	2464	2501	2537	2570	2602	2634	2669	2709	2756	2808	2862	2917	2971	3025	3079	3134	3190	3246	3300	3354	3408	3461	3514	3568	3624	3682	3742
203.5	2003	2048	2093	2136	2179	2221	2263	2304	2344	2384	2423	2461	2498	2534	2567	2599	2631	2666	2705	2751	2803	2856	2911	2965	3019	3073	3128	3184	3239	3293	3347	3401	3454	3507	3561	3616	3674	3733
204.0	2000	2045	2090	2133	2176	2218	2259	2300	2341	2381	2420	2458	2495	2531	2565	2597	2629	2663	2702	2747	2797	2850	2905	2959	3013	3067	3121	3177	3232	3286	3340	3394	3447	3500	3553	3608	3665	3724
204.5	1997	2042	2087	2130	2173	2215	2256	2297	2338	2378	2417	2456	2493	2528	2563	2595	2627	2661	2698	2742	2792	2845	2899	2953	3007	3061	3115	3170	3226	3280	3333	3387	3440	3493	3546	3601	3657	3715
205.0	1994	2039	2083	2127	2170	2211	2253	2294	2335	2375	2414	2453	2490	2526	2561	2594	2625	2658	2694	2737	2787	2839	2893	2947	3001	3055	3109	3164	3219	3273	3327	3380	3433	3486	3539	3593	3649	3706
205.5		2036	2080	2124	2167	2208	2250	2291	2331	2372	2411	2450	2487	2524	2559	2593	2623	2655	2691	2733	2781	2833	2887	2941	2995	3049	3103	3157	3212	3266	3320	3373	3426	3479	3531	3585	3641	3698
206.0		2033	2077	2121	2164	2205	2247	2288	2328	2368	2408	2447	2485	2522	2557	2590	2621	2653	2688	2729	2776	2828	2881	2935	2989	3043	3096	3151	3205	3260	3313	3367	3420	3472	3524	3578	3633	3690
206.5		2030	2074	2118	2161	2203	2244	2285	2325	2365	2405	2444	2482	2519	2555	2588	2619	2650	2685	2725	2771	2822	2875	2929	2983	3037	3090	3144	3199	3253	3307	3360	3413	3465	3518	3571	3625	3681
207.0		2027	2071	2115	2158	2200	2241	2282	2322	2362	2402	2441	2480	2517	2552	2585	2617	2648	2683	2721	2767	2817	2869	2923	2977	3031	3084	3138	3192	3246	3300	3353	3406	3458	3511	3564	3618	3673

Plate VII-4. Turbine Rating Tables (Nonaerating) cont.

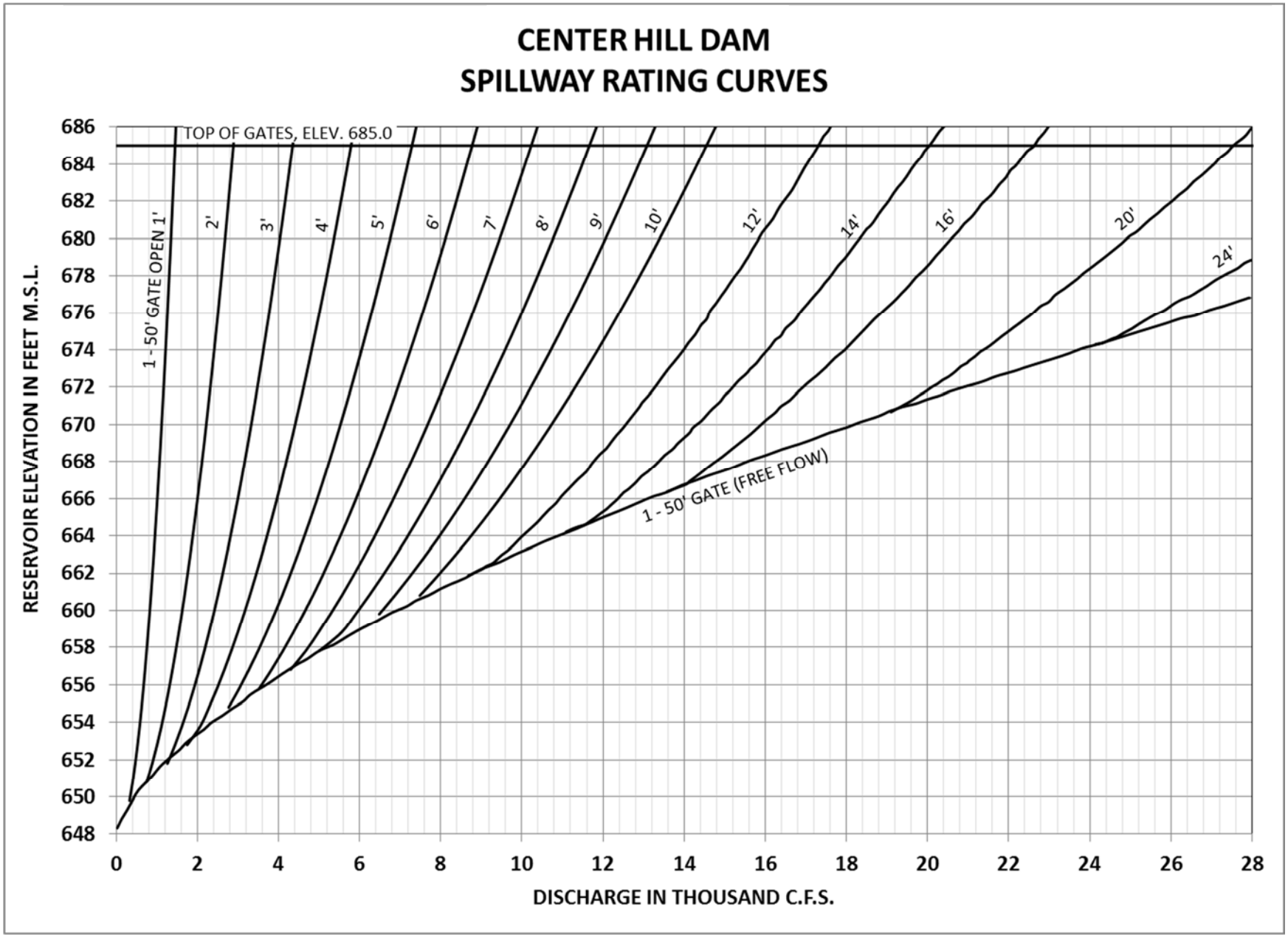

Plate VII-5. Spillway Rating Curves

SPILLWAY RATING TABLE
CENTER HILL DAM
(Discharge per Gate)

1-ft Gate Opening

Discharge in cfs.

Elevation	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
648	0	7	16	27	40	55	71	89	109	131
649	156	181	207	233	260	288	317	348	380	413
650	330	480	515	551	588	626	664	703	743	784
651	408	868	911	955	1000	1045	1091	1137	1184	1232
652	472	1330	1380	1431	1482	1534	1586	1639	1693	1747
653	529	1858	1914	1971	2029	2087	2146	2205	2265	2325
654	581	2447	2509	2572	2635	2699	2763	2828	2893	2959
655	628	3093	3161	3229	3298	3368	3438	3508	3579	3650
656	671	3794	3867	3940	4014	4088	4163	4238	4314	4390
657	713	4545	4623	4701	4780	4859	4939	5019	5100	5181
658	751	5345	5428	5511	5595	5679	5764	5849	5935	6021
659	788	6195	6283	6371	6460	6549	6638	6728	6818	6909
660	824	7091	7183	7275	7367	7460	7554	7649	7744	7840
661	858	8032	8129	8226	8324	8423	8522	8621	8720	8819
662	890	9018	9119	9220	9322	9424	9527	9630	9734	9838
663	922	10047	10152	10258	10364	10470	10577	10685	10793	10901
664	952	11119	11228	11338	11448	11559	11670	11782	11893	12005
665	981	12230	12345	12459	12574	12688	12804	12919	13035	13150
666	1010	13384	13502	13621	13739	13857	13977	14096	14216	14335
667	1038	14577	14698	14820	14941	15063	15187	15312	15436	15561
668	1065	15812	15939	16065	16192	16319	16447	16576	16704	16833
669	1091	17090	17219	17348	17477	17606	17738	17870	18002	18134
670	1117	18400	18533	18667	18800	18934	19069	19203	19338	19472
671	1142	18745	19883	20021	20159	20297	20438	20579	20720	20861
672	1167	21144	21285	21427	21568	21710	21852	21994	22137	22279
673	1191	22566	22711	22856	23001	23146	23293	23440	23587	22734
674	1215	24028	24176	24323	24471	24618	24768	24918	25069	25219
675	1238	25521	25673	25826	25978	26130	26285	26440	26595	26750
676	1261	27064	27222	27380	27539	27698	27856	28013	28171	28328
677	1283	28644	28803	28961	29120	29278	29440	29603	29765	29928
678	1305	30253	30416	30580	30743	30906	31074	31241	31409	31576
679	1327	31910	32077	32243	32410	32576	32745	32913	33082	33250
680	1348	33590	33761	33933	34104	34275	34447	34619	34792	34964
681	1369	35310	35484	35657	35831	36005	36180	36355	36530	36705
682	1390	37059	37239	37418	37598	37777	37959	38140	38322	38503
683	1410	38866	39046	39227	39407	39588	39771	39955	40138	40322
684	1430	40690	40875	41060	41245	41430	41618	41806	41994	42182
685	1450									

Sheet 1 of 11

Notes:
(1) To ascertain the discharge for more than one gate, sum the tabular discharge for each gate in operation

(2) Center Hill has eight (8) spillway gates

Plate VII-6. Spillway Rating Table

SPILLWAY RATING TABLE
CENTER HILL DAM
(Discharge per Gate)

2-ft Gate Opening

Discharge in cfs.

Elevation	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
648	0	7	16	27	40	55	71	89	109	131
649	156	181	207	233	260	288	317	348	380	413
650	446	480	515	551	588	626	664	703	722	737
651	752	766	780	794	808	822	836	850	864	877
652	890	903	916	929	941	953	965	977	988	999
653	1010	1021	1032	1043	1054	1065	1076	1087	1098	1108
654	1118	1128	1138	1148	1158	1168	1178	1188	1197	1206
655	1215	1224	1233	1242	1251	1260	1269	1278	1287	1296
656	1305	1314	1323	1332	1341	1350	1358	1366	1374	1382
657	1390	1398	1406	1414	1422	1430	1438	1446	1454	1462
658	1469	1477	1485	1492	1500	1508	1515	1522	1530	1537
659	1545	1552	1559	1567	1574	1582	1589	1596	1603	1610
660	1617	1624	1631	1638	1645	1652	1659	1665	1672	1679
661	1686	1693	1699	1706	1712	1719	1726	1732	1739	1745
662	1752	1759	1765	1771	1778	1784	1790	1797	1803	1810
663	1816	1822	1829	1835	1841	1847	1854	1860	1866	1872
664	1878	1884	1890	1896	1902	1908	1914	1920	1925	1931
665	1937	1943	1949	1954	1960	1966	1972	1978	1983	1989
666	1995	2001	2006	2012	2017	2023	2029	2034	2040	2045
667	2051	2057	2062	2068	2073	2079	2084	2090	2095	2101
668	2106	2111	2117	2122	2128	2133	2139	2144	2149	2155
669	2160	2165	2170	2176	2181	2186	2191	2196	2201	2206
670	2211	2216	2221	2226	2231	2236	2242	2247	2252	2257
671	2262	2267	2272	2277	2282	2287	2292	2297	2302	2307
672	2312	2317	2322	2327	2332	2337	2341	2346	2351	2356
673	2361	2366	2371	2375	2380	2385	2390	2395	2400	2404
674	2409	2414	2419	2423	2428	2433	2437	2442	2447	2451
675	2456	2461	2465	2470	2474	2479	2484	2488	2493	2497
676	2502	2507	2511	2516	2520	2525	2529	2534	2538	2543
677	2547	2551	2556	2560	2565	2569	2574	2578	2582	2587
678	2591	2595	2600	2604	2609	2613	2617	2622	2626	2631
679	2635	2639	2644	2648	2652	2657	2661	2665	2670	2674
680	2678	2682	2687	2691	2695	2699	2703	2708	2712	2716
681	2720	2724	2728	2732	2737	2741	2745	2749	2753	2757
682	2761	2765	2769	2773	2777	2781	2786	2790	2794	2798
683	2802	2806	2810	2814	2818	2822	2826	2830	2834	2838
684	2842	2846	2850	2854	2858	2862	2866	2870	2874	2878
685	2882									

Sheet 2 of 11

Notes:
(1) To ascertain the discharge for more than one gate, sum the tabular discharge for each gate in operation

(2) Center Hill has eight (8) spillway gates

Plate VII-6. Spillway Rating Table, Cont.

SPILLWAY RATING TABLE
CENTER HILL DAM
(Discharge per Gate)

3-ft Gate Opening

Discharge in cfs.

Elevation	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
648	0	7	16	27	40	55	71	89	109	131
649	156	181	207	233	260	288	317	348	380	413
650	446	480	515	551	588	626	664	703	743	784
651	826	868	911	955	1000	1045	1091	1137	1184	1232
652	1264	1284	1304	1323	1342	1361	1380	1398	1416	1434
653	1452	1470	1487	1504	1521	1538	1555	1572	1589	1606
654	1622	1638	1654	1670	1686	1701	1716	1731	1746	1761
655	1776	1791	1805	1819	1833	1847	1861	1875	1889	1903
656	1917	1931	1945	1959	1972	1985	1998	2011	2024	2037
657	2050	2063	2076	2089	2101	2113	2125	2137	2149	2161
658	2173	2185	2197	2209	2221	2233	2245	2256	2267	2278
659	2289	2301	2312	2323	2335	2346	2357	2368	2379	2390
660	2401	2412	2423	2434	2445	2455	2465	2476	2486	2497
661	2507	2517	2528	2538	2548	2558	2569	2579	2589	2599
662	2609	2619	2629	2639	2649	2659	2668	2678	2688	2698
663	2708	2717	2727	2736	2746	2755	2764	2774	2783	2793
664	2802	2811	2820	2829	2838	2847	2857	2866	2875	2884
665	2893	2902	2911	2920	2929	2938	2947	2956	2965	2974
666	2983	2992	3000	3009	3017	3026	3035	3043	3052	3060
667	3069	3078	3086	3094	3103	3111	3120	3128	3136	3145
668	3153	3161	3170	3178	3186	3194	3202	3211	3219	3227
669	3235	3243	3251	3259	3267	3275	3283	3291	3299	3307
670	3315	3323	3331	3339	3347	3354	3362	3370	3378	3385
671	3393	3401	3408	3416	3423	3431	3438	3446	3453	3461
672	3468	3476	3483	3491	3498	3506	3513	3521	3528	3536
673	3543	3550	3558	3565	3572	3580	3587	3594	3602	3609
674	3616	3623	3630	3638	3645	3652	3659	3666	3673	3680
675	3687	3694	3701	3708	3715	3722	3730	3737	3744	3751
676	3758	3765	3772	3778	3785	3792	3799	3806	3812	3819
677	3826	3833	3840	3846	3853	3860	3867	3873	3880	3886
678	3893	3900	3906	3913	3920	3927	3933	3940	3947	3953
679	3960	3967	3973	3980	3986	3993	3999	4006	4012	4019
680	4025	4032	4038	4045	4051	4058	4064	4071	4077	4084
681	4090	4096	4103	4109	4116	4122	4128	4135	4141	4148
682	4154	4160	4166	4173	4179	4185	4191	4197	4204	4210
683	4216	4222	4228	4234	4240	4246	4253	4259	4265	4271
684	4277	4283	4289	4295	4301	4307	4314	4320	4326	4332
685	4338									

Sheet 3 of 11

Notes: (1) To ascertain the discharge for more than one gate, sum the tabular discharge for each gate in operation

(2) Center Hill has eight (8) spillway gates

Plate VII-6. Spillway Rating Table, Cont.

SPILLWAY RATING TABLE
CENTER HILL DAM
(Discharge per Gate)

4-ft Gate Opening

	Discharge in cfs.									
Elevation	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
648	0	7	16	27	40	55	71	89	109	131
649	156	181	207	233	260	288	317	348	380	413
650	446	480	515	551	588	626	664	703	743	784
651	826	868	911	955	1000	1045	1091	1137	1184	1232
652	1281	1330	1380	1431	1482	1534	1586	1639	1693	1747
653	1802	1858	1883	1908	1932	1956	1980	2004	2028	2052
654	2075	2098	2121	2144	2167	2190	2212	2234	2256	2278
655	2290	2311	2332	2352	2372	2392	2412	2431	2450	2469
656	2488	2507	2525	2543	2561	2579	2597	2615	2633	2650
657	2667	2684	2701	2718	2735	2752	2769	2786	2803	2820
658	2837	2853	2869	2885	2901	2917	2933	2949	2965	2981
659	2997	3013	3029	3044	3059	3074	3089	3104	3119	3134
660	3149	3164	3179	3194	3209	3224	3238	3252	3266	3280
661	3294	3308	3322	3336	3350	3364	3378	3392	3406	3420
662	3433	3447	3460	3474	3487	3501	3514	3527	3541	3554
663	3567	3580	3593	3606	3619	3632	3644	3657	3670	3683
664	3696	3709	3721	3734	3746	3758	3771	3784	3796	3809
665	3821	3833	3846	3858	3870	3882	3895	3907	3919	3931
666	3943	3955	3966	3978	3989	4001	4013	4024	4036	4047
667	4059	4070	4082	4093	4104	4116	4127	4138	4149	4161
668	4172	4183	4194	4205	4216	4228	4239	4250	4261	4272
669	4283	4294	4305	4315	4326	4337	4348	4359	4369	4380
670	4391	4402	4413	4423	4433	4444	4454	4465	4475	4486
671	4496	4507	4517	4528	4538	4549	4559	4570	4580	4591
672	4601	4611	4621	4632	4642	4652	4662	4672	4682	4692
673	4702	4712	4722	4731	4742	4751	4761	4770	4780	4789
674	4799	4809	4818	4828	4838	4847	4857	4866	4876	4886
675	4895	4905	4914	4923	4933	4943	4953	4962	4972	4981
676	4991	5000	5010	5019	5028	5038	5047	5056	5066	5075
677	5084	5093	5102	5112	5121	5130	5139	5148	5157	5166
678	5175	5184	5193	5202	5211	5220	5229	5238	5247	5256
679	5265	5274	5283	5291	5300	5309	5318	5327	5335	5344
680	5353	5362	5370	5379	5388	5397	5405	5413	5422	5431
681	5440	5449	5457	5466	5474	5483	5491	5500	5508	5517
682	5525	5533	5542	5550	5559	5567	5575	5584	5592	5601
683	5609	5617	5626	5634	5642	5651	5659	5667	5675	5684
684	5692	5700	5708	5717	5725	5733	5741	5749	5758	5766
685	5774									

Sheet 4 of 11

Notes:
(1) To ascertain the discharge for more than one gate, sum the tabular discharge for each gate in operation

(2) Center Hill has eight (8) spillway gates

Plate VII-6. Spillway Rating Table, Cont.

SPILLWAY RATING TABLE
CENTER HILL DAM
(Discharge per Gate)

5-ft Gate Opening

Discharge in cfs.

Elevation	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
648	0	7	16	27	40	55	71	89	109	131
649	156	181	207	233	260	288	317	348	380	413
650	446	480	515	551	588	626	664	703	743	784
651	826	868	911	955	1000	1045	1091	1137	1184	1232
652	1281	1330	1380	1431	1482	1534	1586	1639	1693	1747
653	1802	1858	1914	1971	2029	2087	2146	2205	2265	2325
654	2386	2447	2509	2572	2616	2643	2670	2696	2722	2748
655	2774	2800	2826	2852	2878	2904	2930	2956	2982	3008
656	3033	3057	3081	3105	3129	3153	3177	3201	3225	3249
657	3272	3295	3318	3341	3364	3386	3408	3430	3452	3474
658	3496	3517	3538	3559	3580	3601	3622	3643	3664	3684
659	3704	3724	3744	3764	3784	3804	3824	3844	3864	3883
660	3902	3921	3940	3959	3978	3997	4016	4035	4054	4073
661	4092	4110	4128	4146	4164	4182	4200	4218	4236	4253
662	4270	4287	4304	4322	4339	4356	4373	4390	4408	4425
663	4442	4459	4476	4492	4509	4526	4543	4560	4576	4593
664	4610	4626	4643	4659	4675	4692	4708	4724	4740	4756
665	4772	4788	4804	4819	4835	4851	4867	4883	4898	4913
666	4928	4943	4958	4973	4988	5003	5018	5033	5048	5063
667	5078	5093	5108	5122	5137	5152	5166	5181	5195	5210
668	5224	5238	5253	5267	5281	5295	5309	5323	5337	5351
669	5365	5379	5393	5407	5420	5434	5448	5462	5475	5489
670	5502	5516	5529	5543	5556	5570	5583	5597	5610	5624
671	5637	5650	5664	5677	5690	5704	5717	5730	5744	5757
672	5770	5783	5796	5809	5822	5835	5848	5861	5873	5886
673	5899	5912	5924	5937	5950	5962	5975	5988	6000	6013
674	6025	6038	6050	6062	6075	6087	6100	6112	6124	6137
675	6149	6161	6173	6186	6198	6210	6222	6234	6246	6258
676	6270	6282	6294	6306	6318	6330	6342	6354	6365	6377
677	6389	6401	6413	6424	6436	6448	6459	6471	6483	6494
678	6506	6518	6529	6541	6552	6564	6575	6586	6598	6609
679	6620	6631	6643	6654	6666	6677	6688	6699	6711	6722
680	6733	6744	6755	676	6777	6788	6800	6811	6822	6833
681	6844	6855	6866	6877	6888	6899	6910	6921	6931	6942
682	6953	6964	6975	6985	6996	7007	7018	7029	7039	7050
683	7061	7071	7081	7092	7102	7113	7124	7134	7145	7155
684	7166	7176	7187	7197	7208	7218	7228	7239	7249	7260
685	7270									

Notes: (1) To ascertain the discharge for more than one gate, sum the tabular discharge for each gate in operation

(2) Center Hill has eight (8) spillway gates

Plate VII-6. Spillway Rating Table, Cont.

SPILLWAY RATING TABLE
CENTER HILL DAM
(Discharge per Gate)

6-ft Gate Opening

Discharge in cfs.

Elevation	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
648	0	7	16	27	40	55	71	89	109	131
649	156	181	207	233	260	288	317	348	380	413
650	446	480	515	551	588	626	664	703	743	784
651	826	868	911	955	1000	1045	1091	1137	1184	1232
652	1281	1330	1380	1431	1482	1534	1586	1639	1693	1747
653	1802	1858	1914	1971	2029	2087	2146	2205	2265	2325
654	2386	2447	2509	2572	2635	2699	2763	2828	2893	2959
655	3026	3093	3161	3229	3298	3368	3403	3435	3467	3498
656	3529	3560	3591	3621	3651	3681	3711	3741	3771	3800
657	3829	3858	3887	3915	3943	3971	3999	4027	4054	4081
658	4108	4135	4162	4188	4214	4240	4266	4292	4317	4342
659	4367	4392	4417	4442	4467	4492	4517	4542	4566	4590
660	4614	4638	4662	4686	4710	4734	4757	4780	4803	4826
661	4849	4872	4895	4918	4940	4962	4984	5006	5028	5050
662	5072	5093	5114	5135	5156	5177	5198	5219	5240	5261
663	5282	5303	5324	5345	5366	5387	5407	5427	5448	5468
664	5488	5508	5528	5548	5568	5588	5608	5629	5649	5669
665	5689	5708	5727	5746	5765	5784	5803	5822	5841	5860
666	5879	5897	5916	5934	5953	5971	5989	6008	6026	6045
667	6063	6081	6099	6117	6135	6153	6170	6188	6206	6224
668	6242	6260	6277	6295	6312	6330	6347	6364	6382	6399
669	6416	6433	6450	6467	6484	6501	6518	6535	6552	6569
670	6586	6603	6619	6636	6652	6669	6686	6702	6719	6735
671	6752	6768	6784	6801	6817	6833	6849	6865	6881	6897
672	6913	6929	6945	6960	6976	6992	7008	7024	7039	7055
673	7071	7087	7102	7118	7133	7149	7164	7180	7195	7211
674	7226	7241	7256	7272	7287	7302	7317	7332	7347	7362
675	7377	7392	7407	7421	7436	7451	7466	7481	7495	7510
676	7525	7540	7554	7569	7583	7598	7612	7627	7641	7656
677	7670	7684	7699	7713	7727	7742	7756	7770	7785	7799
678	7813	7827	7841	7855	7869	7883	7897	7911	7925	7939
679	7953	7967	7981	7994	8008	8022	8036	8050	8063	8077
680	8091	8105	8118	8132	8145	8159	8172	8186	8199	8213
681	8226	8239	8253	8266	8279	8293	8306	8319	8333	8346
682	8359	8372	8385	8399	8412	8425	8438	8451	8464	8477
683	8490	8503	8516	8529	8542	8555	8568	8581	8593	8606
684	8619	8632	8645	8657	8670	8683	8696	8709	8721	8734
685	8747									

Sheet 6 of 11

Notes: (1) To ascertain the discharge for more than one gate, sum the tabular discharge for each gate in operation

(2) Center Hill has eight (8) spillway gates

Plate VII-6. Spillway Rating Table, Cont.

SPILLWAY RATING TABLE
CENTER HILL DAM
(Discharge per Gate)

7-ft Gate Opening

Discharge in cfs.

Elevation	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
648	0	7	16	27	40	55	71	89	109	131
649	156	181	207	233	260	288	317	348	380	413
650	446	480	515	551	588	626	664	703	743	784
651	826	868	911	955	1000	1045	1091	1137	1184	1232
652	1281	1330	1380	1431	1482	1534	1586	1639	1693	1747
653	1802	1858	1914	1971	2029	2087	2146	2205	2265	2325
654	2386	2447	2509	2572	2635	2699	2763	2828	2893	2959
655	3026	3093	3161	3229	3298	3368	3438	3508	3579	3650
656	3722	3794	3867	3940	4014	4088	4163	4238	4262	4297
657	4332	4367	4402	4436	4470	4504	4538	4571	4604	4637
658	4670	4702	4733	4765	4796	4828	4859	4891	4922	4954
659	4985	5015	5045	5074	5104	5134	5163	5193	5223	5252
660	5282	5310	5338	5367	5395	5423	5451	5479	5507	5535
661	5563	5590	5617	5643	5670	5697	5723	5750	5777	5803
662	5830	5856	5882	5907	5933	5959	5984	6010	6035	6061
663	6086	6111	6136	6160	6185	6210	6234	6259	6283	6308
664	6332	6356	6380	6403	6427	6450	6474	6497	6521	6544
665	6567	6590	6613	6636	6659	6682	6704	6727	6750	6772
666	6795	6817	6840	6862	6884	6906	6928	6950	6972	6993
667	7015	7036	7058	7079	7101	7122	7143	7165	7186	7207
668	7229	7250	7271	7292	7313	7334	7355	7376	7396	7417
669	7438	7458	7478	7499	7519	7539	7559	7579	7599	7619
670	7639	7659	7679	7698	7718	7738	7757	7777	7797	7816
671	7836	7855	7874	7894	7913	7932	7951	7970	7990	8009
672	8028	8047	8066	8084	8103	8122	8140	8159	8178	8196
673	8215	8233	8252	8270	8289	8307	8325	8344	8362	8381
674	8399	8417	8435	8453	8471	8489	8507	8525	8542	8560
675	8578	8596	8613	8631	8648	8666	8684	8701	8719	8736
676	8754	8771	8788	8806	8823	8840	8857	8874	8892	8909
677	8926	8943	8960	8977	8994	9011	9028	9045	9061	9078
678	9095	9112	9128	9145	9161	9178	9195	9211	9228	9244
679	9261	9277	9294	9310	9326	9343	9359	9375	9391	9408
680	9424	9440	9456	9472	9488	9504	9520	9536	9552	9568
681	9584	9600	9616	9631	9647	9663	9679	9695	9710	9726
682	9742	9758	9773	9789	9804	9820	9835	9851	9866	9882
683	9897	9912	9927	9943	9958	9973	9988	10003	10019	10034
684	10049	10064	10079	10095	10110	10125	10140	10155	10170	10185
685	10200									

Notes: (1) To ascertain the discharge for more than one gate, sum the tabular discharge for each gate in operation

(2) Center Hill has eight (8) spillway gates

Plate VII-6. Spillway Rating Table, Cont.

SPILLWAY RATING TABLE
CENTER HILL DAM
(Discharge per Gate)

8-ft Gate Opening

Discharge in cfs.

Elevation	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
648	0	7	16	27	40	55	71	89	109	131
649	156	181	207	233	260	288	317	348	380	413
650	446	480	515	551	588	626	664	703	743	784
651	826	868	911	955	1000	1045	1091	1137	1184	1232
652	1281	1330	1380	1431	1482	1534	1586	1639	1693	1747
653	1802	1858	1914	1971	2029	2087	2146	2205	2265	2325
654	2386	2447	2509	2572	2635	2699	2763	2828	2893	2959
655	3026	3093	3161	3229	3298	3368	3438	3508	3579	3650
656	3722	3794	3867	3940	4014	4088	4163	4238	4314	4390
657	4467	4545	4623	4701	4780	4859	4939	5019	5100	5141
658	5180	5219	5257	5295	5333	5371	5408	5445	5482	5518
659	5554	5590	5626	5661	5696	5731	5766	5801	5836	5870
660	5904	5938	5972	6005	6038	6071	6104	6137	6170	6203
661	6235	6266	6298	6329	6361	6392	6423	6455	6486	6518
662	6649	6579	6609	6640	6670	6700	6730	6760	6790	6820
663	6850	6879	6908	6936	6965	6994	7022	7051	7080	7108
664	7137	7165	7192	7220	7247	7275	7303	7330	7358	7385
665	7413	7440	7466	7493	7519	7546	7573	7599	7626	7652
666	7679	7705	7731	7756	7782	7808	7833	7859	7885	7910
667	7936	7961	7986	8011	8036	8061	8086	8111	8135	8160
668	8185	8209	8233	8258	8282	8306	8330	8354	8379	8403
669	8427	8451	8474	8498	8521	8545	8568	8592	8615	8639
670	8662	8685	8708	8731	8754	8777	8800	8823	8846	8869
671	8891	8913	8936	8958	8980	9003	9025	9047	9070	9092
672	9114	9136	9158	9180	9202	9224	9246	9268	9289	9310
673	9331	9352	9374	9395	9417	9438	9459	9481	9502	9524
674	9545	9566	9587	9607	9628	9649	9670	9691	9711	9732
675	9753	9773	9794	9814	9835	9855	9875	9896	9916	9937
676	9957	9977	9997	10017	10037	10057	10077	10097	10117	10137
677	10156	10176	10195	10215	10234	10254	10274	10293	10313	10332
678	10352	10371	10390	10410	10429	10448	10467	10486	10506	10525
679	10544	10563	10582	10601	10620	10639	10658	10677	10696	10715
680	10733	10752	10770	10789	10807	10826	10845	10863	10882	10900
681	10919	10937	10955	10974	10992	11010	11028	11046	11065	11083
682	11101	11119	11137	11155	11173	11191	11209	11227	11245	11263
683	11281	11299	11316	11334	11351	11369	11387	11404	11422	11439
684	11457	11474	11491	11509	11526	11543	11560	11577	11595	11612
685	11629									

Sheet 8 of 11

Notes: (1) To ascertain the discharge for more than one gate, sum the tabular discharge for each gate in operation

(2) Center Hill has eight (8) spillway gates

Plate VII-6. Spillway Rating Table, Cont.

SPILLWAY RATING TABLE
CENTER HILL DAM
(Discharge per Gate)

9-ft Gate Opening

Discharge in cfs.

Elevation	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
648	0	7	16	27	40	55	71	89	109	131
649	156	181	207	233	260	288	317	348	380	413
650	446	480	515	551	588	626	664	703	743	784
651	826	868	911	955	1000	1045	1091	1137	1184	1232
652	1281	1330	1380	1431	1482	1534	1586	1639	1693	1747
653	1802	1858	1914	1971	2029	2087	2146	2205	2265	2325
654	2386	2447	2509	2572	2635	2699	2763	2828	2893	2959
655	3026	3093	3161	3229	3298	3368	3438	3508	3579	3650
656	3722	3794	3867	3940	4014	4088	4163	4238	4314	4390
657	4467	4545	4623	4701	4780	4859	4939	5019	5100	5181
658	5263	5345	5428	5511	5595	5679	5764	5849	5935	6021
659	6077	6118	6159	6200	6241	6282	6323	6364	6405	6445
660	6485	6524	6563	6602	6640	6678	6716	6754	6792	6830
661	6868	6905	6942	6979	7015	7051	7087	7123	7159	7195
662	7231	7266	7301	7336	7371	7406	7440	7474	7508	7542
663	7576	7610	7644	7677	7710	7743	7776	7809	7842	7875
664	7908	7940	7972	8004	8036	8086	8100	8132	8164	8195
665	8226	8257	8288	8319	8350	8381	8412	8442	8472	8502
666	8532	8562	8592	8622	8652	8682	8711	8740	8769	8798
667	8827	8856	8885	8914	8943	8972	9000	9028	9056	9084
668	9112	9140	9168	9196	9224	9252	9280	9307	9334	9361
669	9388	9415	9442	9469	9496	9523	9550	9577	9604	9631
670	9657	9683	9710	9736	9762	9789	9815	9842	9868	9894
671	9920	9946	9972	9998	10023	10048	10073	10098	10123	10148
672	10173	10198	10223	10248	10273	10298	10323	10348	10373	10398
673	10422	10447	10472	10497	10522	10547	10571	10595	10619	10643
674	10667	10691	10715	10739	10763	10787	10811	10835	10858	10881
675	10904	10927	10950	10974	10997	11020	11043	11066	11090	11113
676	11136	11159	11182	11204	11227	11250	11273	11296	11318	11341
677	11364	11386	11409	11431	11453	11476	11498	11520	11543	11565
678	11587	11609	11631	11653	11675	11697	11719	11741	11763	11784
679	11806	11828	11849	11871	11892	11914	11935	11957	11978	12000
680	12021	12042	12063	12085	12106	12127	12148	12169	12190	12211
681	12232	12253	12274	12294	12315	12336	12357	12377	12398	12419
682	12440	12460	12481	12501	12522	12542	12562	12583	12603	12624
683	12644	12664	12684	12704	12724	12744	12765	12785	12805	12825
684	12845	12865	12885	12904	12924	12944	12964	12984	13003	13023
685	13043									

Notes: (1) To ascertain the discharge for more than one gate, sum the tabular discharge for each gate in operation

(2) Center Hill has eight (8) spillway gates

Plate VII-6. Spillway Rating Table, Cont.

SPILLWAY RATING TABLE
CENTER HILL DAM
(Discharge per Gate)

10-ft Gate Opening

	Discharge in cfs.									
Elevation	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
648	0	7	16	27	40	55	71	89	109	131
649	156	181	207	233	260	288	317	348	380	413
650	446	480	515	551	588	626	664	703	743	784
651	826	868	911	955	1000	1045	1091	1137	1184	1232
652	1281	1330	1380	1431	1482	1534	1586	1639	1693	1747
653	1802	1858	1914	1971	2029	2087	2146	2205	2265	2325
654	2386	2447	2509	2572	2635	2699	2763	2828	2893	2959
655	3026	3093	3161	3229	3298	3368	3438	3508	3579	3650
656	3722	3794	3867	3940	4014	4088	4163	4238	4314	4390
657	4467	4545	4623	4701	4780	4859	4939	5019	5100	5181
658	5263	5345	5428	5511	5595	5679	5764	5849	5935	6021
659	6108	6195	6283	6371	6460	6549	6638	6728	6818	6909
660	7000	7091	7135	7179	7223	7267	7311	7355	7398	7441
661	7484	7527	7569	7611	7653	7695	7737	7779	7820	7861
662	7902	7943	7984	8024	8064	8104	8144	8183	8222	8261
663	8300	8339	8378	8416	8454	8492	8530	8567	8604	8641
664	8678	8715	8752	8789	8825	8861	8897	8933	8969	9005
665	9041	9076	9111	9146	9181	9216	9251	9286	9321	9356
666	9391	9425	9459	9493	9527	9561	9594	9627	9660	9693
667	9726	9759	9792	9825	9858	9891	9923	9955	9987	10019
668	10051	10083	10115	10147	10179	10211	10242	10273	10304	10335
669	10366	10397	10428	10459	10490	10521	10552	10582	10612	10642
670	10672	10702	10732	10762	10792	10822	10852	10881	10910	10939
671	10968	10997	11026	11055	11084	11113	11142	11171	11200	11229
672	11258	11287	11316	11345	11373	11401	11429	11457	11485	11513
673	11541	11569	11597	11625	11653	11681	11708	11735	11762	11789
674	11816	11843	11870	11897	11924	11951	11978	12005	12032	12059
675	12085	12111	12138	12164	12190	12217	12243	12269	12296	12322
676	12348	12374	12400	12425	12451	12477	12503	12529	12554	12580
677	12606	12631	12656	12682	12707	12732	12757	12782	12808	12833
678	12858	12883	12908	12932	12957	12982	13007	13032	13056	13081
679	13106	13130	13155	13179	13203	13228	13252	13276	13301	13325
680	13349	13373	13397	13421	13445	13469	13493	13517	13540	13564
681	13588	13612	13635	13659	13682	13706	13729	13753	13776	13800
682	13823	13846	13869	13893	13916	13939	13962	13985	14008	14031
683	14054	14077	14099	14122	14144	14167	14190	14212	14235	14257
684	14280	14302	14325	14347	14369	14392	14414	14436	14459	14481
685	14503									

Sheet 10 of 11

Notes:
(1) To ascertain the discharge for more than one gate, sum the tabular discharge for each gate in operation

(2) Center Hill has eight (8) spillway gates

Plate VII-6. Spillway Rating Table, Cont.

SPILLWAY RATING TABLE
CENTER HILL DAM
(Discharge per Gate)

Free Flow

Discharge in cfs.

Elevation	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
648	0	7	16	27	40	55	71	89	109	131
649	156	181	207	233	260	288	317	348	380	413
650	446	480	515	551	588	626	664	703	743	784
651	826	868	911	955	1000	1045	1091	1137	1184	1232
652	1281	1330	1380	1431	1482	1534	1586	1639	1693	1747
653	1802	1858	1914	1971	2029	2087	2146	2205	2265	2325
654	2386	2447	2509	2572	2635	2699	2763	2828	2893	2959
655	3026	3093	3161	3229	3298	3368	3438	3508	3579	3650
656	3722	3794	3867	3940	4014	4088	4163	4238	4314	4390
657	4467	4545	4623	4701	4780	4859	4939	5019	5100	5181
658	5263	5345	5428	5511	5595	5679	5764	5849	5935	6021
659	6108	6195	6283	6371	6460	6549	6638	6728	6818	6909
660	7000	7091	7183	7275	7367	7460	7554	7649	7744	7840
661	7936	8032	8129	8226	8324	8423	8522	8621	8720	8819
662	8918	9018	9119	9220	9322	9424	9527	9630	9734	9838
663	9942	10047	10152	10258	10364	10470	10577	10685	10793	10901
664	11010	11119	11228	11338	11448	11559	11670	11782	11893	12005
665	12116	12230	12345	12459	12574	12688	12804	12919	13035	13150
666	13266	13384	13502	13621	13739	13857	13977	14096	14216	14335
667	14455	14577	14698	14820	14941	15063	15187	15312	15436	15561
668	15685	15812	15939	16065	16192	16319	16447	16576	16704	16833
669	16961	17090	17219	17348	17477	17606	17738	17870	18002	18134
670	18266	18400	18533	18667	18800	18934	19069	19203	19338	19472
671	19607	19745	19883	20021	20159	20297	20438	20579	20720	20861
672	21002	21144	21285	21427	21568	21710	21852	21994	22137	22279
673	22421	22566	22711	22856	23001	23146	23293	23440	23587	23734
674	23881	24028	24176	24323	24471	24618	24768	24918	25069	25219
675	25369	25521	25673	25826	25978	26130	26285	26440	26595	26750
676	26905	27064	27222	27380	27539	27698	27856	28013	28171	28328
677	28486	28644	28803	28961	29120	29278	29440	29603	29765	29928
678	30090	30253	30416	30580	30743	30906	31074	31241	31409	31576
679	31744	31910	32077	32243	32410	32576	32745	32913	33082	33250
680	33419	33590	33761	33933	34104	34275	34447	34619	34792	34964
681	35136	35310	35484	35657	35831	36005	36180	36355	36530	36705
682	36880	37059	37239	37418	37598	37777	37959	38140	38322	38503
683	38685	38866	39046	39227	39407	39588	39771	39955	40138	40322
684	40505	40690	40875	41060	41245	41430	41618	41806	41994	42182
685	42370									

Sheet 11 of 11

Notes:
(1) To ascertain the discharge for more than one gate, sum the tabular discharge for each gate in operation

(2) Center Hill has eight (8) spillway gates

Plate VII-6. Spillway Rating Table, Cont.

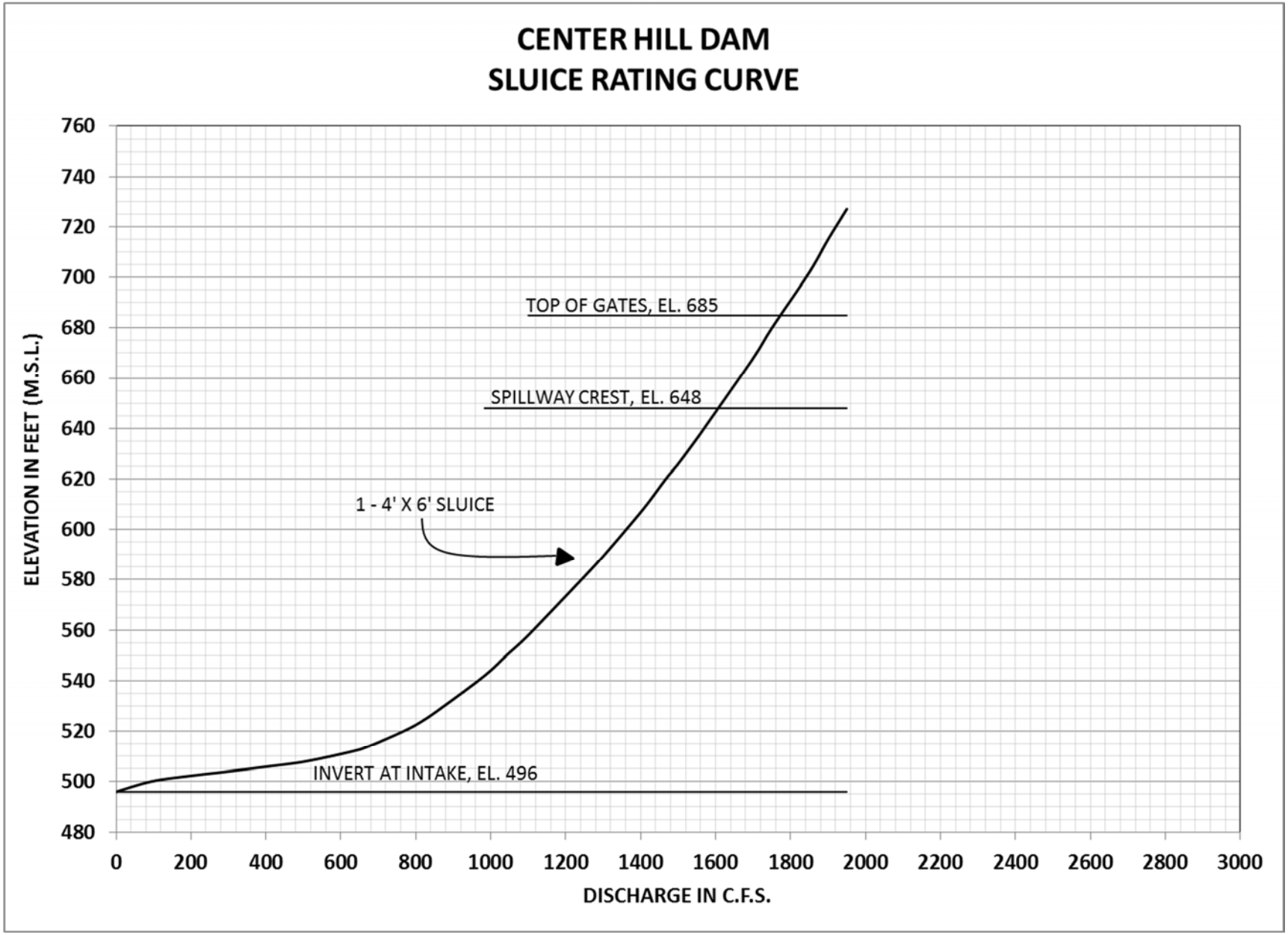

Plate VII-7. Sluice Rating Curve

SLUICE RATING TABLE - CENTER HILL DAM
(Discharge per Sluice)

Head	Discharge in cfs.									
in feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
125	1401	1401	1402	1403	1403	1404	1404	1405	1405	1406
126	1406	1407	1408	1408	1409	1409	1410	1410	1411	1412
127	1412	1413	1413	1414	1414	1415	1415	1416	1416	1417
128	1418	1418	1419	1419	1420	1520	1421	1421	1422	1423
129	1423	1424	1424	1425	1425	1526	1426	1427	1428	1428
130	1429	1429	1430	1430	1431	1431	1432	1432	1433	1434
131	1434	1435	1435	1436	1436	1437	1437	1438	1438	1439
132	1440	1440	1441	1441	1442	1442	1443	1443	1444	1444
133	1445	1446	1446	1447	1447	1448	1448	1449	1449	1450
134	1450	1451	1452	1452	1453	1453	1454	1454	1455	1455
135	1456	1456	1457	1457	1458	1459	1459	1460	1460	1461
136	1461	1462	1462	1463	1463	1464	1464	1465	1466	1466
137	1467	1467	1468	1468	1468	1469	1470	1470	1471	1471
138	1472	1472	1473	1474	1474	1475	1475	1476	1476	1477
139	1477	1478	1478	1479	1479	1480	1480	1481	1482	1482
140	1483	1483	1484	1484	1485	1485	1486	1486	1487	1487
141	1488	1488	1489	1489	1490	1490	1491	1492	1492	1493
142	1493	1494	1494	1495	1495	1496	1496	1497	1497	1498
143	1498	1499	1499	1500	1500	1501	1502	1502	1503	1503
144	1504	1504	1505	1505	1506	1506	1507	1507	1508	1508
145	1509	1509	1510	1510	1511	1511	1512	1512	1513	1513
146	1514	1515	1515	1516	1516	1517	1517	1518	1518	1519
147	1519	1520	1520	1521	1521	1522	1522	1523	1523	1524
148	1524	1525	1525	1526	1526	1527	1527	1528	1528	1529
149	1529	1530	1531	1531	1532	1532	1533	1533	1534	1534
150	1535	1535	1536	1536	1537	1537	1538	1538	1539	1539
151	1540	1540	1541	1541	1542	1542	1543	1543	1544	1544
152	1545	1545	1546	1546	1547	1547	1548	1548	1549	1549
153	1550	1550	1551	1551	1552	1552	1553	1553	1554	1554
154	1555	1555	1556	1556	1557	1557	1558	1558	1559	1559
155	1560	1560	1561	1561	1562	1562	1563	1563	1564	1564
156	1565	1565	1566	1567	1567	1568	1568	1569	1569	1570
157	1570	1570	1571	1572	1572	1573	1573	1574	1574	1575
158	1575	1575	1576	1576	1577	1577	1578	1578	1579	1579
159	1580	1580	1581	1581	1582	1582	1583	1583	1584	1584
160	1585	1585	1586	1586	1587	1587	1588	1588	1589	1589
161	1590	1590	1591	1591	1592	1592	1593	1593	1594	1594
162	1595	1595	1596	1596	1597	1597	1598	1598	1599	1599
163	1600	1600	1601	1601	1602	1602	1603	1603	1604	1604
164	1605	1605	1606	1606	1607	1607	1608	1608	1609	1609
165	1610	1610	1610	1611	1611	1612	1612	1613	1613	1614

Sheet 1 of 2

Notes: (1) Head is differential in feet between reservoir and tailwater elevations.
(2) To ascertain the discharge for more than one sluice, sum the tabular discharge for each sluice in operation.
(3) Center Hill has six (6) sluice gates.

Plate VII-8. Sluice Rating Table

SLUICE RATING TABLE - CENTER HILL DAM
(Discharge per Sluice)

Head	Discharge in cfs.									
in feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
165	1610	1610	1610	1611	1611	1612	1612	1613	1613	1614
166	1614	1615	1615	1616	1616	1617	1617	1618	1618	1619
167	1619	1620	1620	1621	1621	1622	1622	1623	1623	1624
168	1624	1625	1625	1626	1626	1626	1627	1627	1629	1628
169	1629	1629	1630	1630	1631	1631	1632	1632	1633	1633
170	1634	1634	1635	1635	1636	1636	1637	1637	1638	1638
171	1639	1639	1639	1640	1640	1641	1641	1642	1642	1643
172	1643	1644	1644	1645	1645	1646	1646	1647	1647	1648
173	1648	1649	1649	1649	1650	1650	1651	1651	1652	1652
174	1653	1653	1654	1654	1655	1655	1656	1656	1657	1657
175	1658	1658	1659	1659	1659	1660	1660	1661	1661	1662
176	1662	1663	1663	1664	1664	1665	1665	1666	1666	1667
177	1667	1667	1668	1668	1669	1669	1670	1670	1671	1671
178	1672	1672	1673	1673	1674	1674	1675	1675	1675	1676
179	1676	1677	1677	1678	1678	1679	1679	1680	1680	1681
180	1681	1682	1682	1682	1683	1683	1684	1684	1685	1685
181	1686	1686	1687	1687	1688	1688	1689	1689	1689	1690
182	1690	1691	1691	1692	1692	1693	1693	1694	1694	1695
183	1695	1695	1696	1696	1697	1697	1698	1698	1699	1699
184	1700	1700	1701	1701	1702	1702	1702	1703	1703	1704
185	1704	1705	1705	1706	1706	1707	1707	1707	1708	1708
186	1709	1709	1710	1710	1711	1711	1712	1712	1713	1713
187	1713	1714	1714	1715	1715	1716	1716	1717	1717	1718
188	1718	1718	1719	1719	1720	1720	1721	1721	1722	1722
189	1723	1723	1724	1724	1724	1725	1725	1726	1726	1727
190	1727	1728	1728	1729	1729	1729	1730	1730	1731	1731
191	1732	1732	1733	1733	1733	1734	1734	1735	1735	1736
192	1736	1737	1737	1738	1738	1738	1739	1739	1740	1740
193	1741	1741	1742	1742	1743	1743	1743	1744	1744	1745
194	1745	1746	1746	1747	1747	1747	1748	1748	1749	1749
195	1750	1750	1751	1751	1752	1752	1752	1753	1753	1754
196	1754	1755	1755	1756	1756	1756	1757	1757	1758	1758
197	1759	1759	1760	1760	1760	1761	1761	1762	1762	1763
198	1763	1764	1764	1764	1765	1765	1766	1766	1767	1767
199	1768	1768	1768	1769	1769	1770	1770	1771	1771	1772
200	1772									

Sheet 2 of 2

Notes: (1) Head is differential in feet between reservoir and tailwater elevations.
(2) To ascertain the discharge for more than one sluice, sum the tabular discharge for each sluice in operation.
(3) Center Hill has six (6) sluice gates.

Plate VII-8. Sluice Rating Table, Cont.

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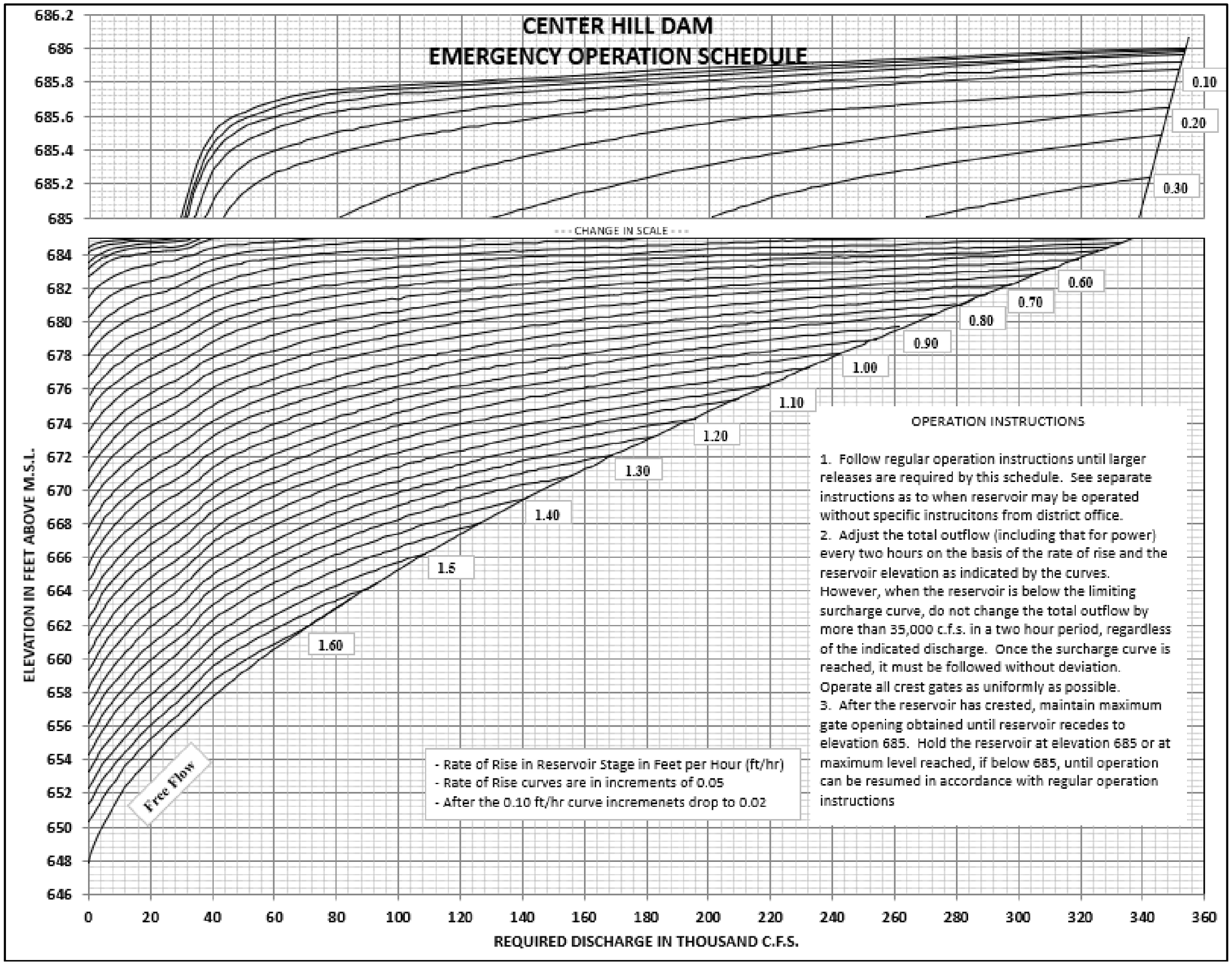

Plate VII-9. Emergency Operation Schedule

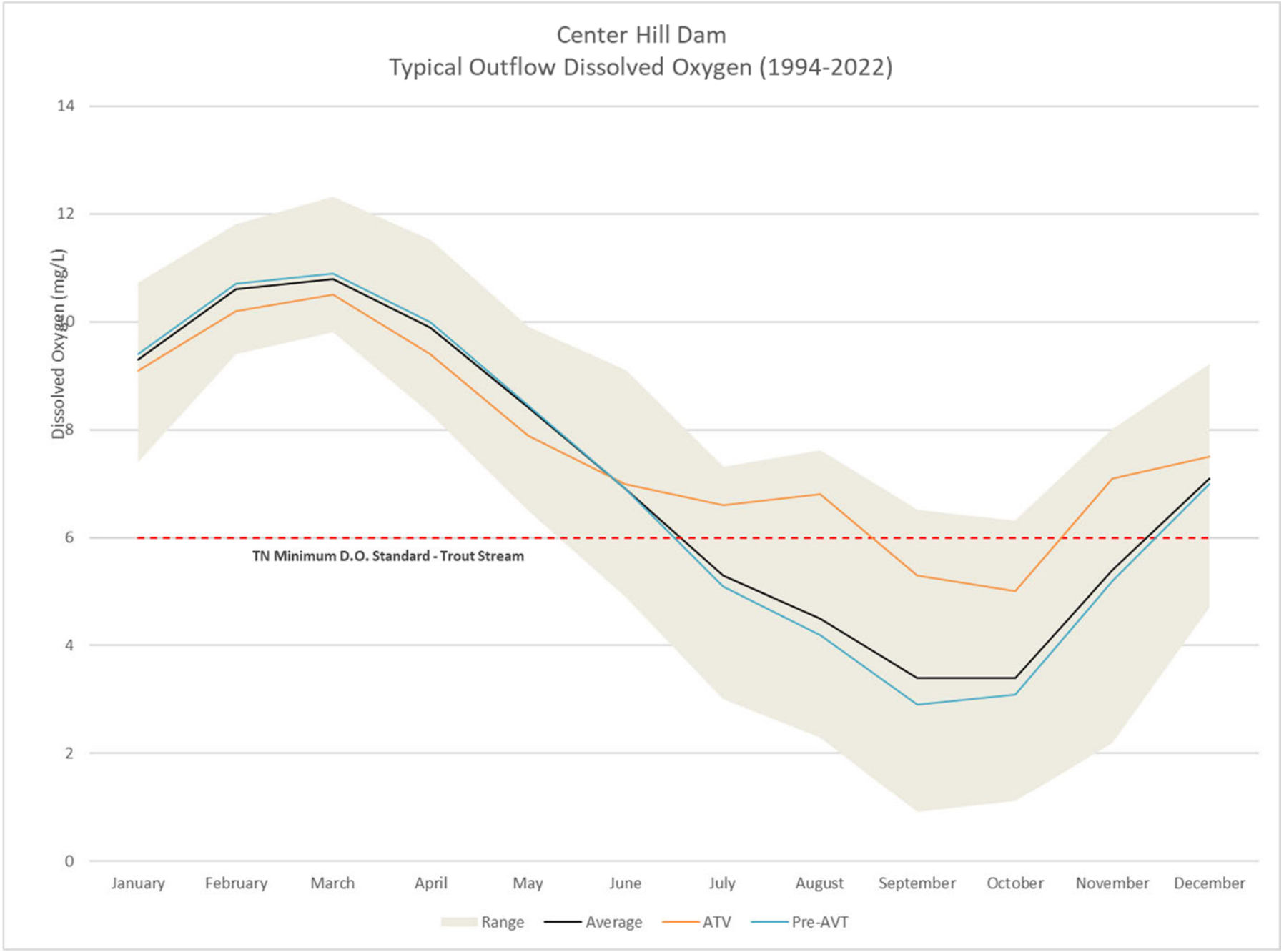

Plate VII-10. Water Quality, Typical Outflow Dissolved Oxygen, Turbine Discharge

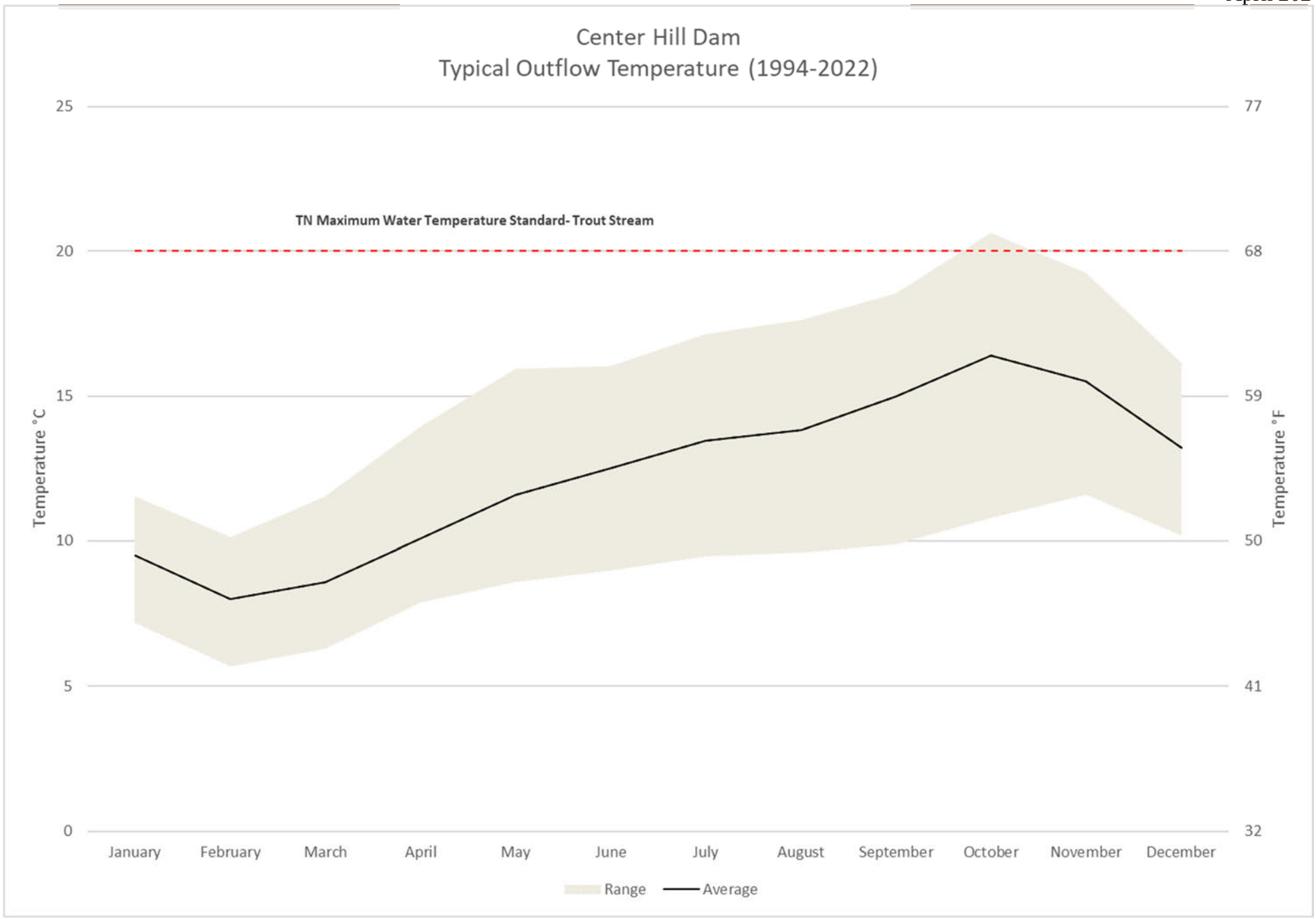

Plate VII-11. Water Quality, Typical Outflow Temperature, Turbine Discharge

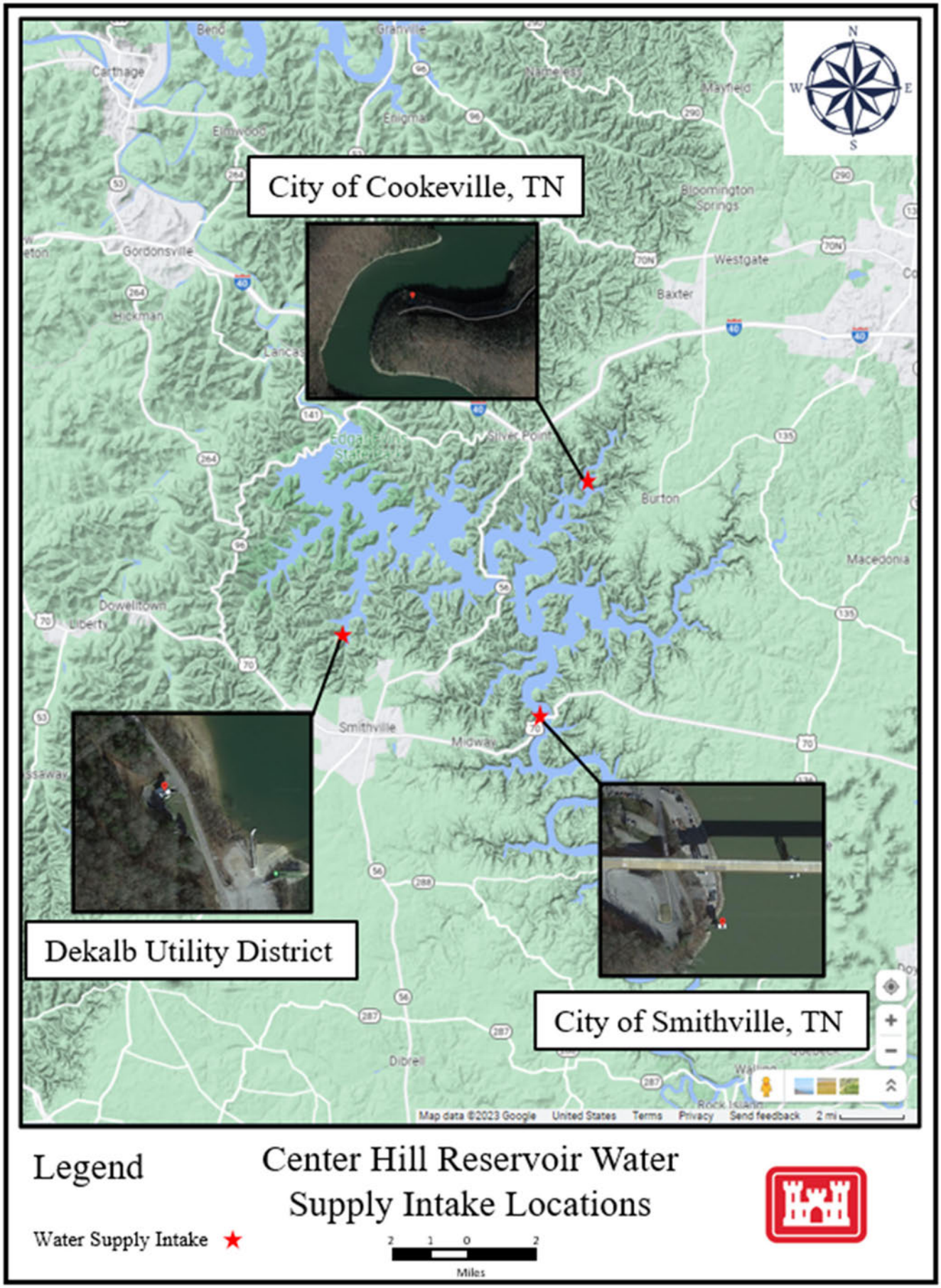

Plate VII-12. Water Supply Intakes

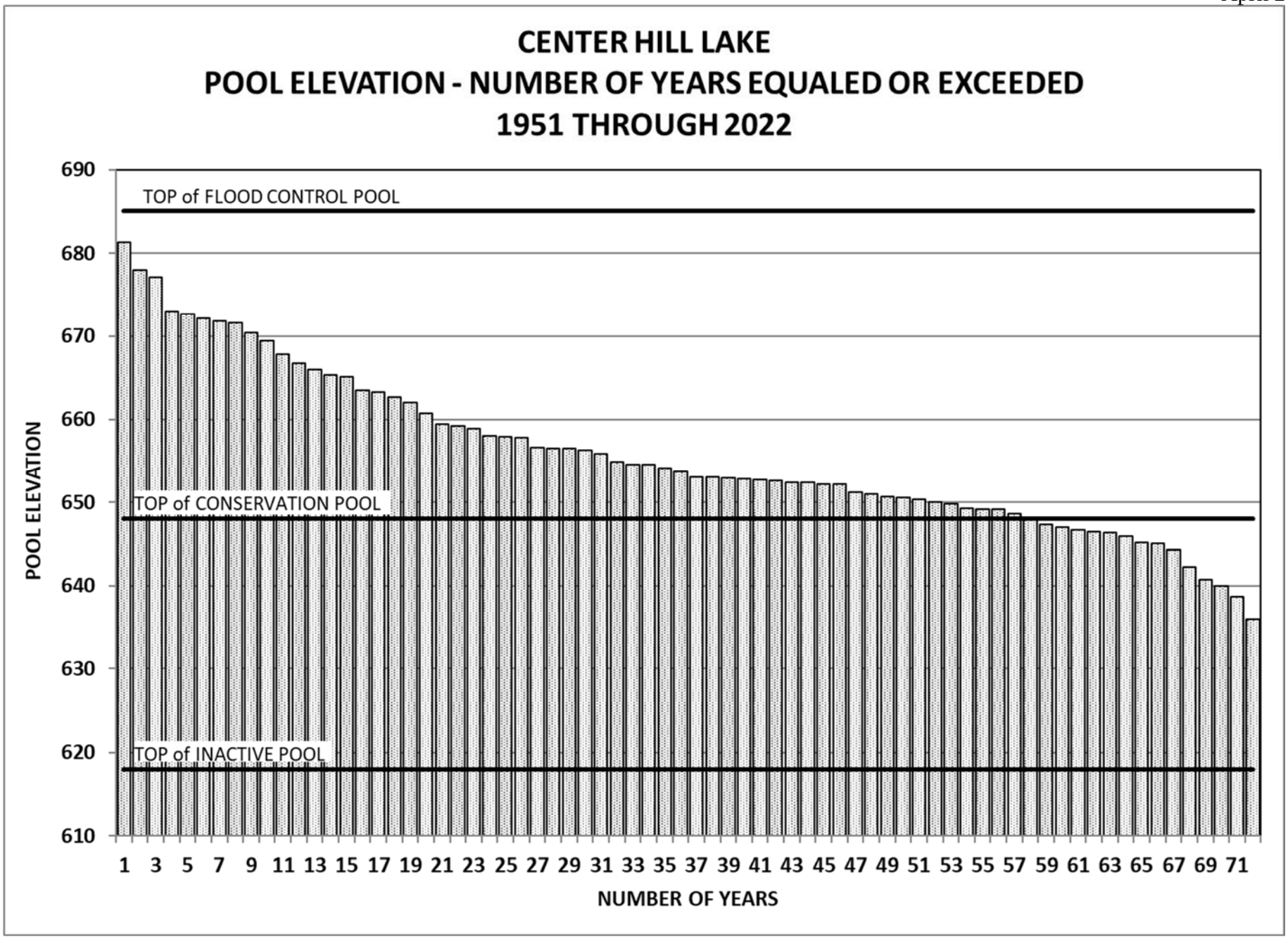

Plate VIII-1. Pool Elevation Chart, Number of Years Equaled or Exceeded

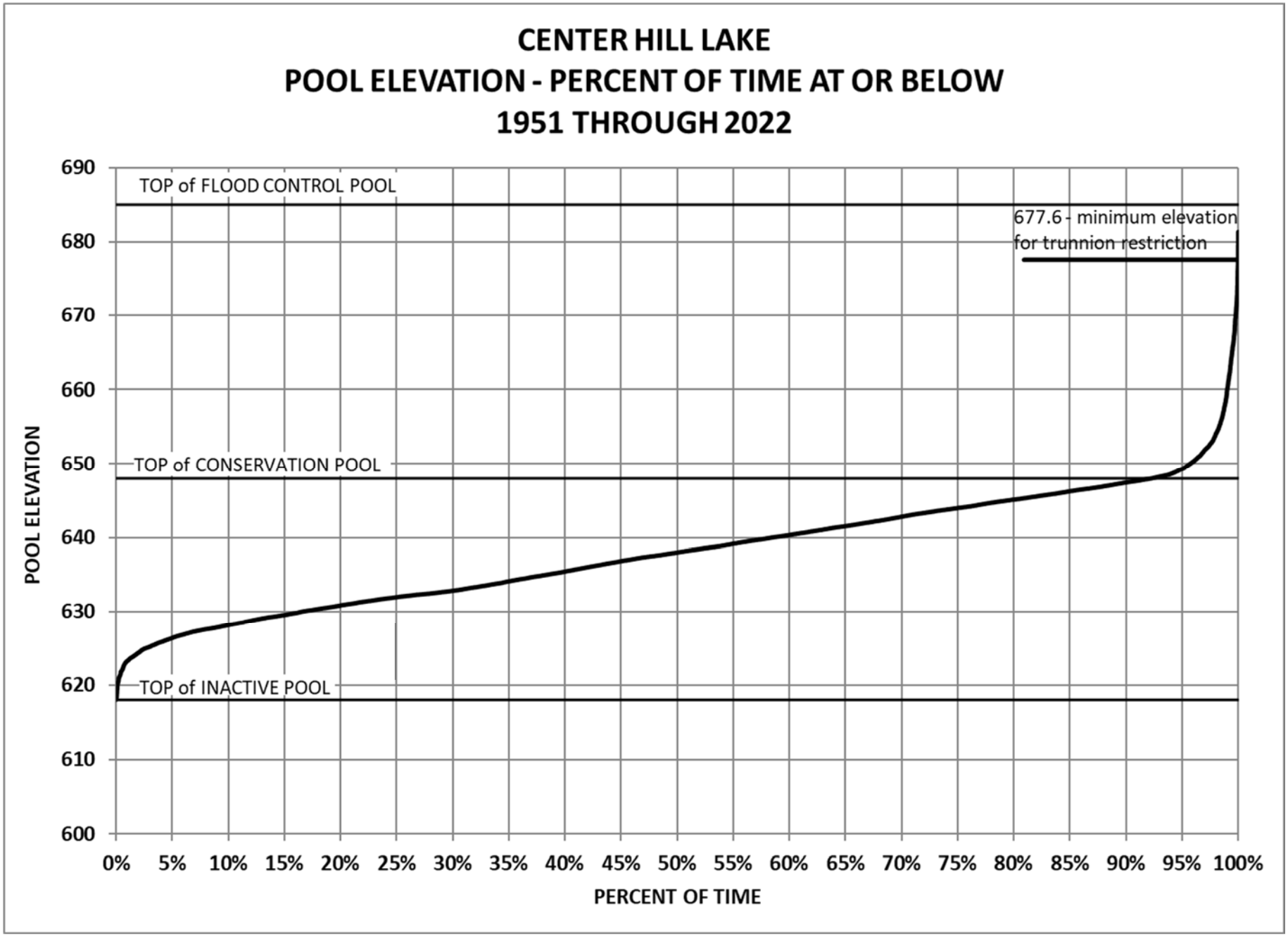

Plate VIII-2. Pool Elevation Chart, Percent of Time at or Below

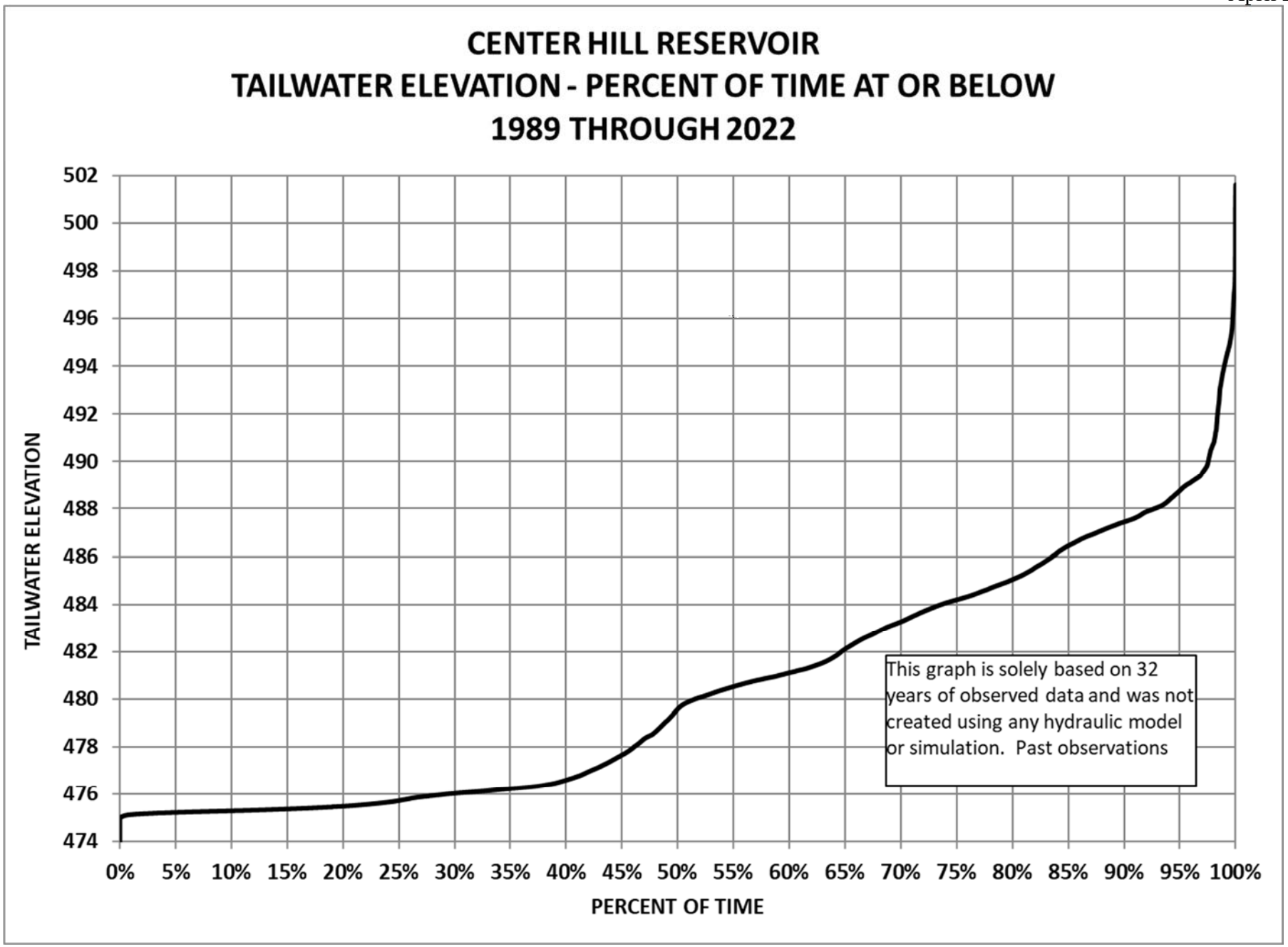

Plate VIII-3. Tailwater Elevation Chart, Percent of Time at or Below

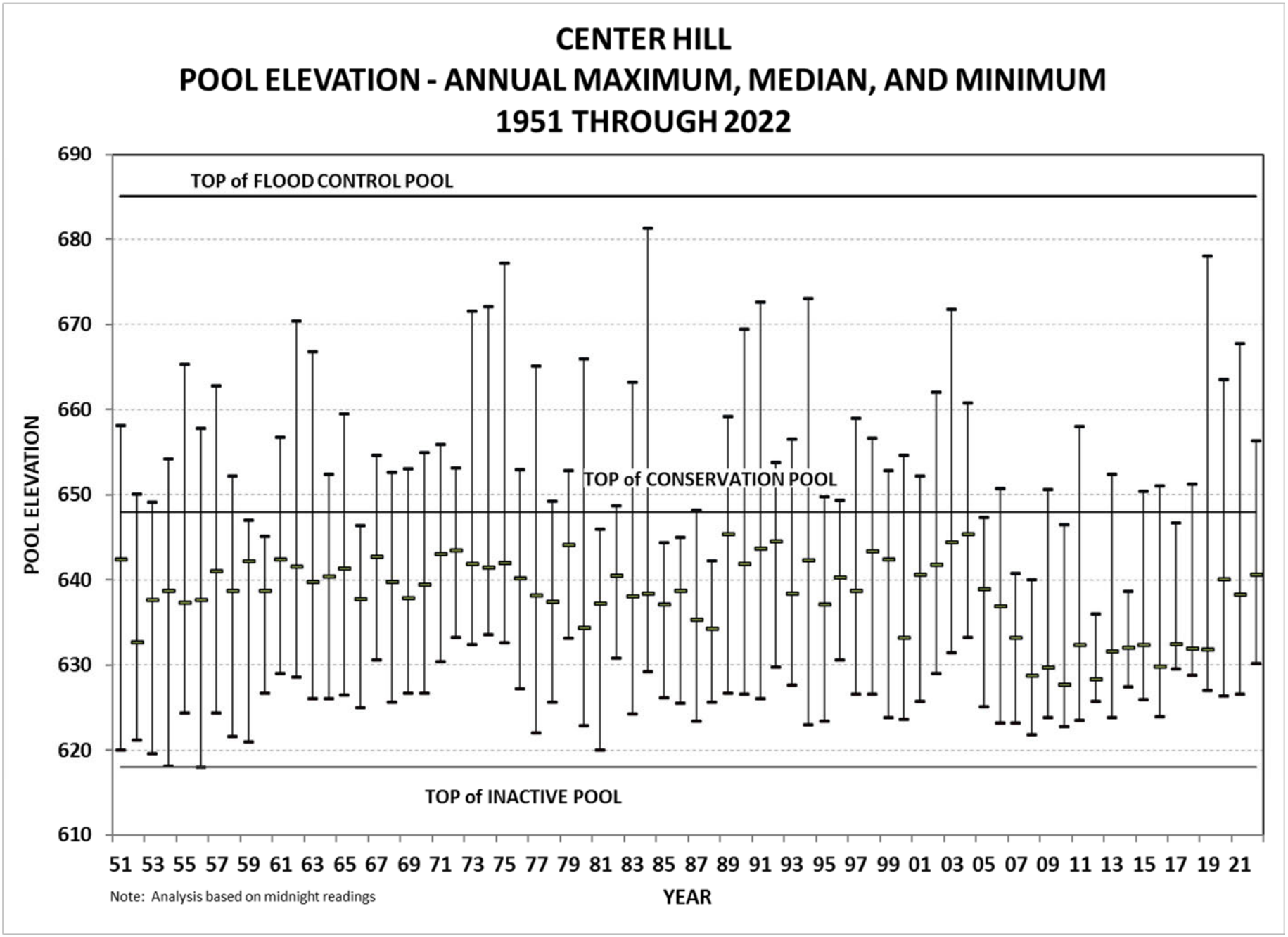

Plate VIII-4. Pool Elevation Chart, Annual Maximum, Median and Minimum

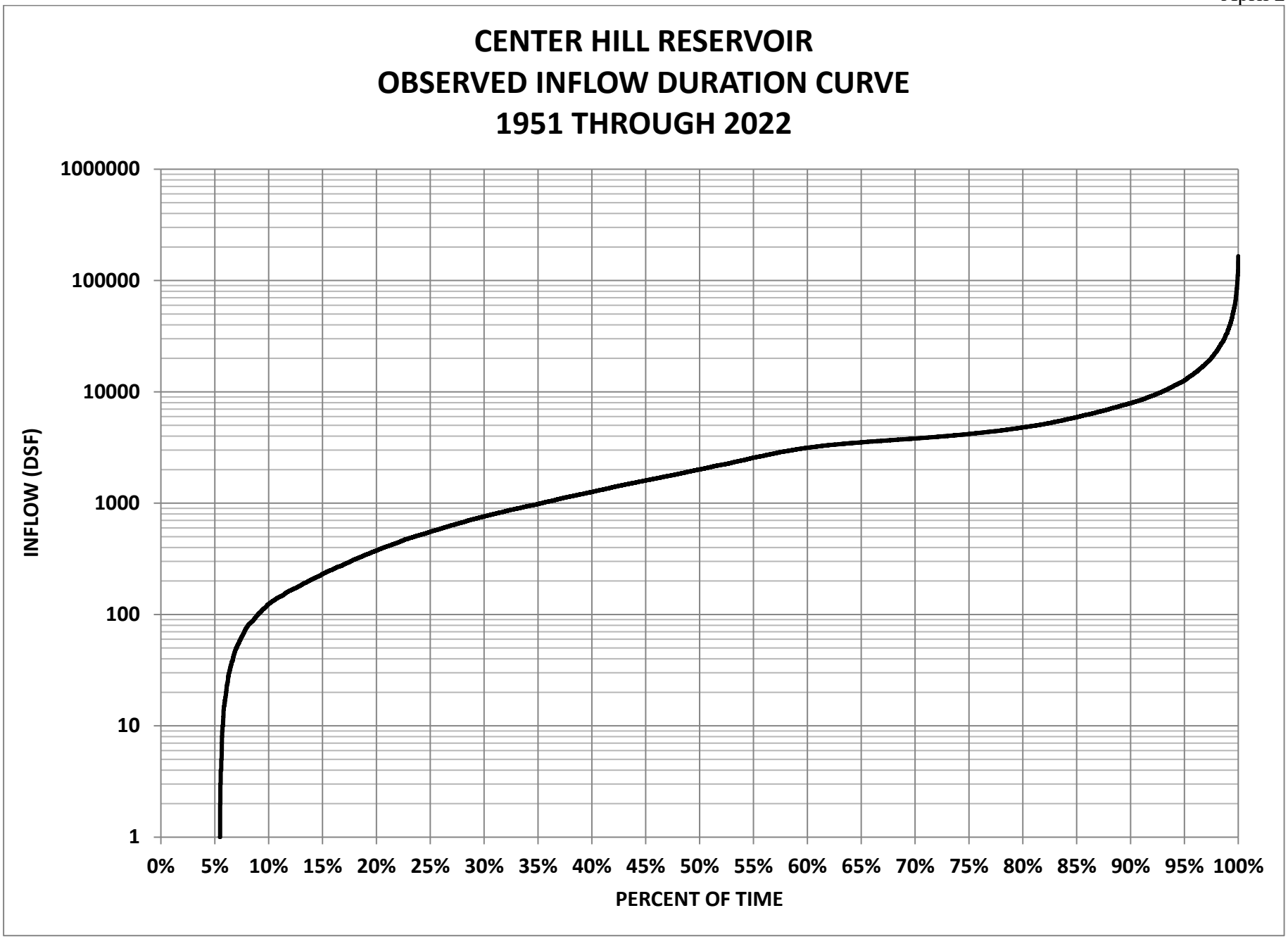

Plate VIII-5. Observed Inflow Duration Curve

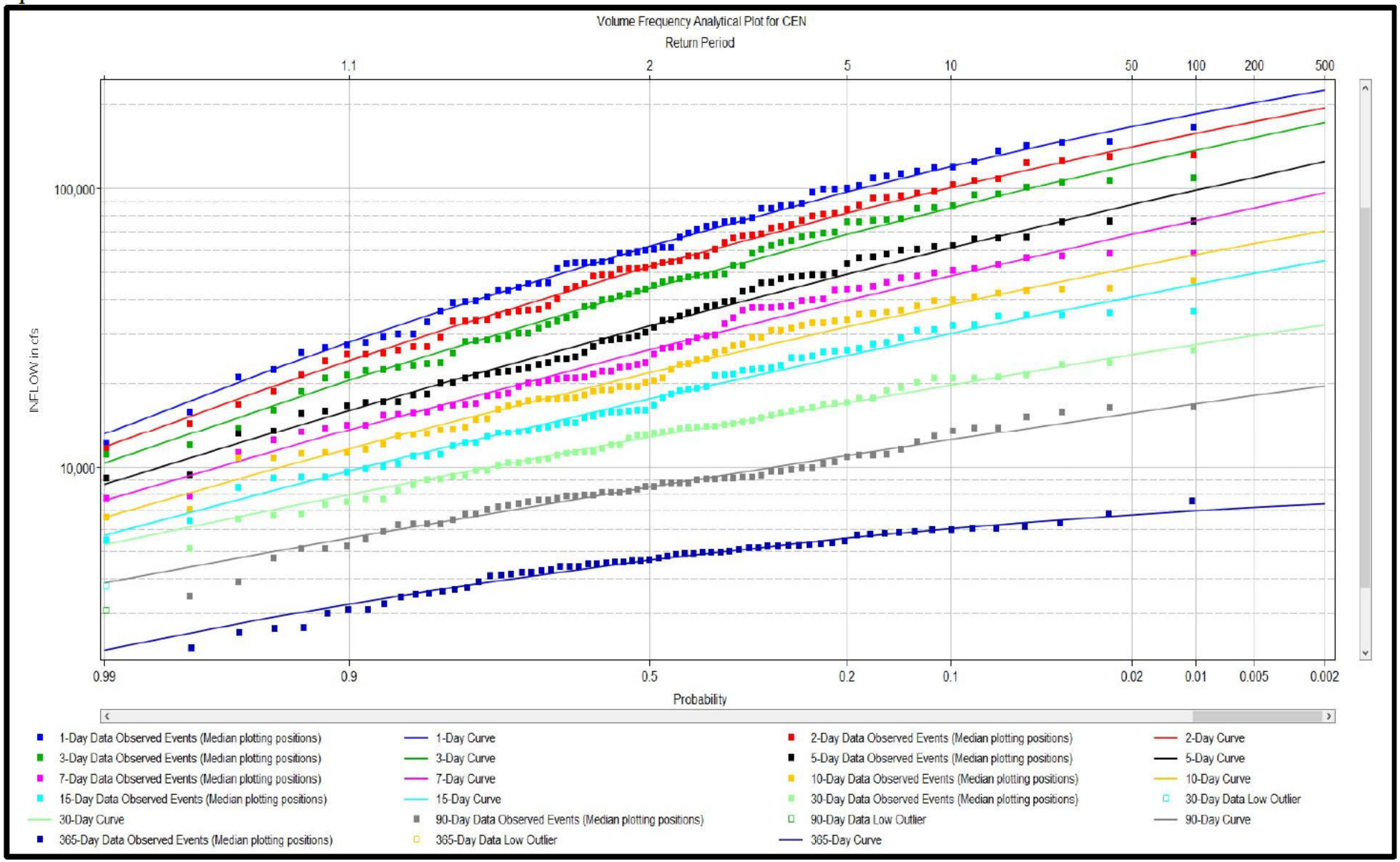

Plate VIII-6. Volume Frequency Analytical Plot (1948-2022)

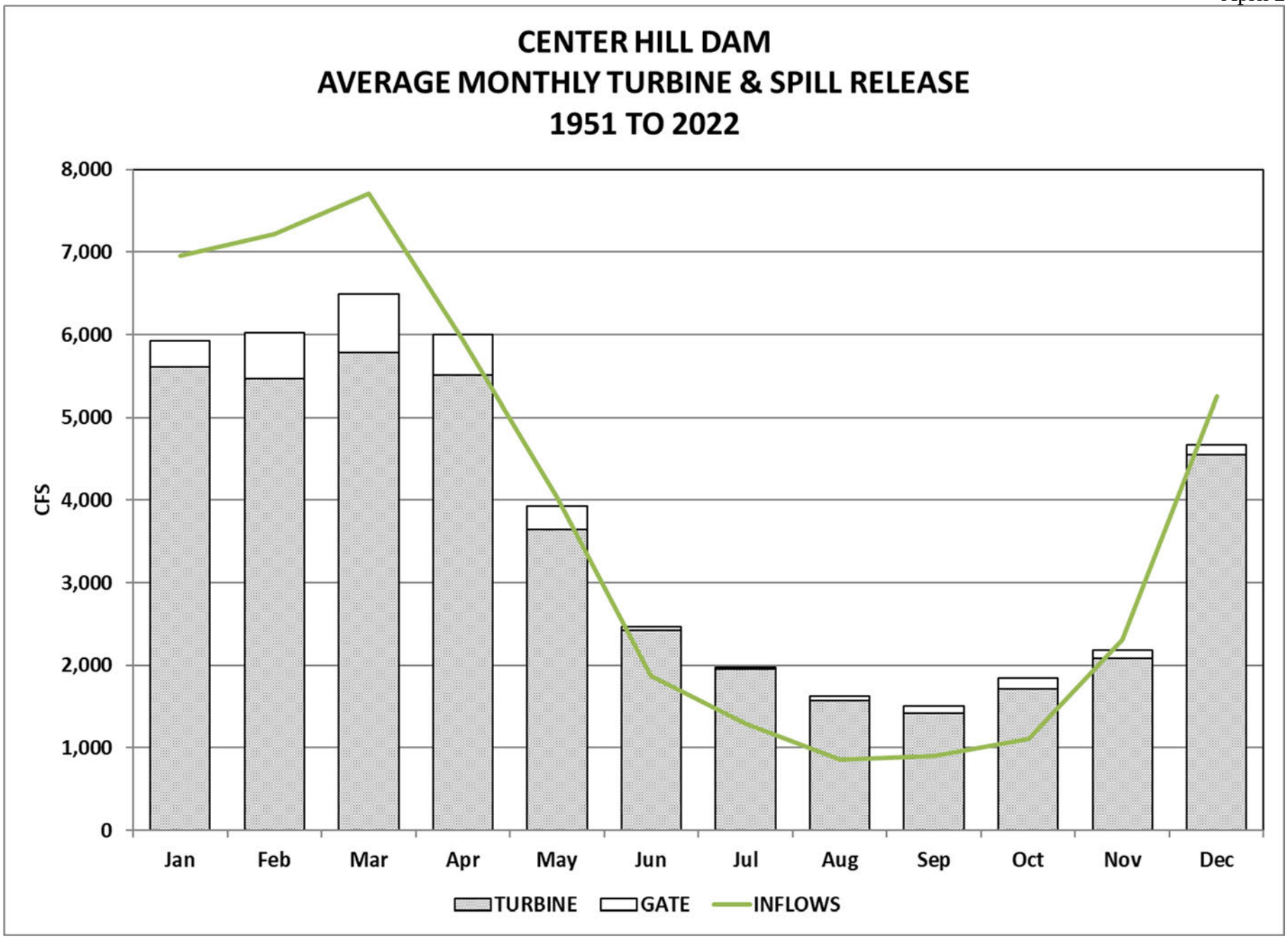

Plate VIII-7. Discharge Chart, Monthly Average Turbine and Spill

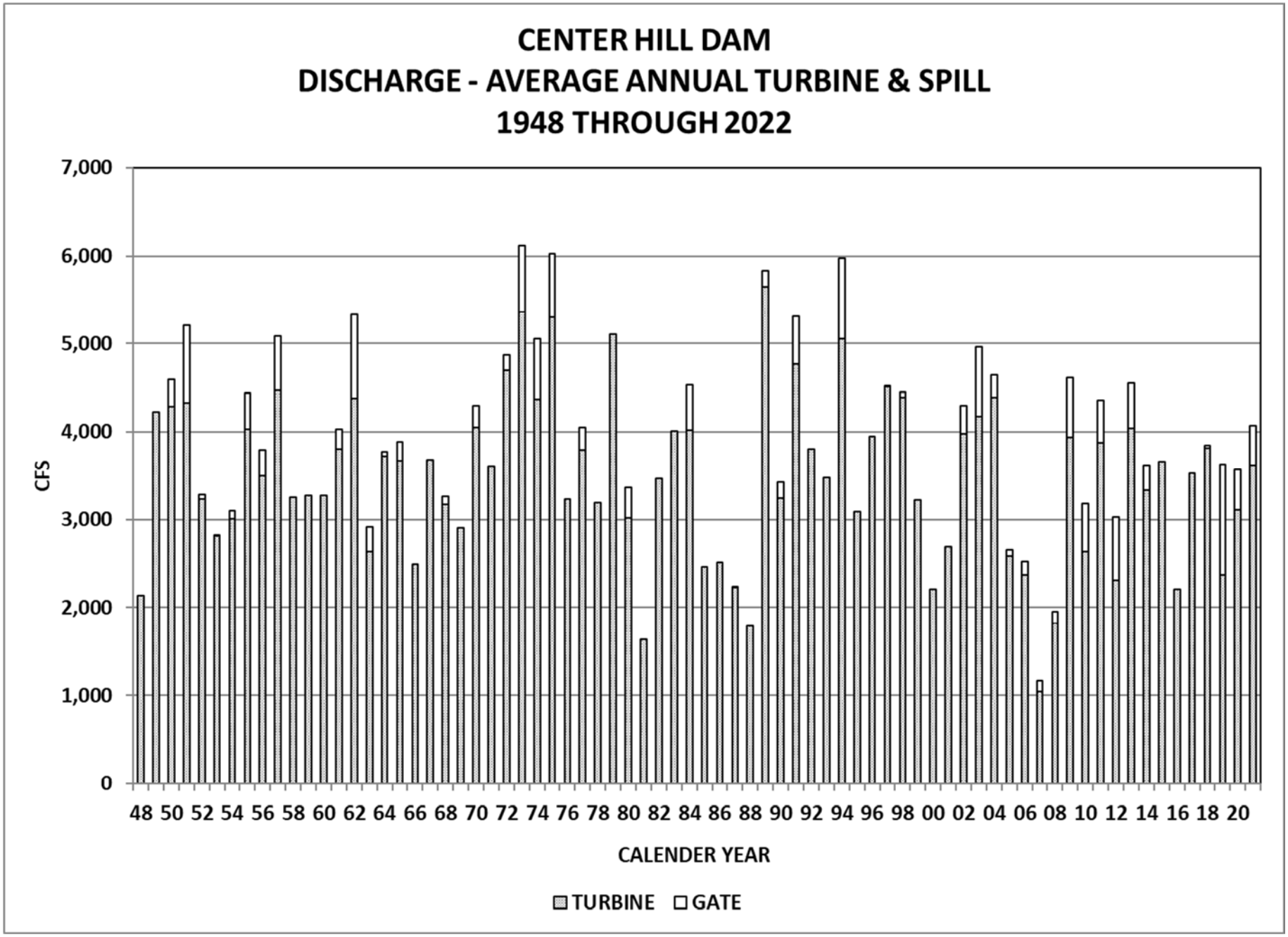

Plate VIII-8. Discharge Chart, Annual Average Turbine and Spill

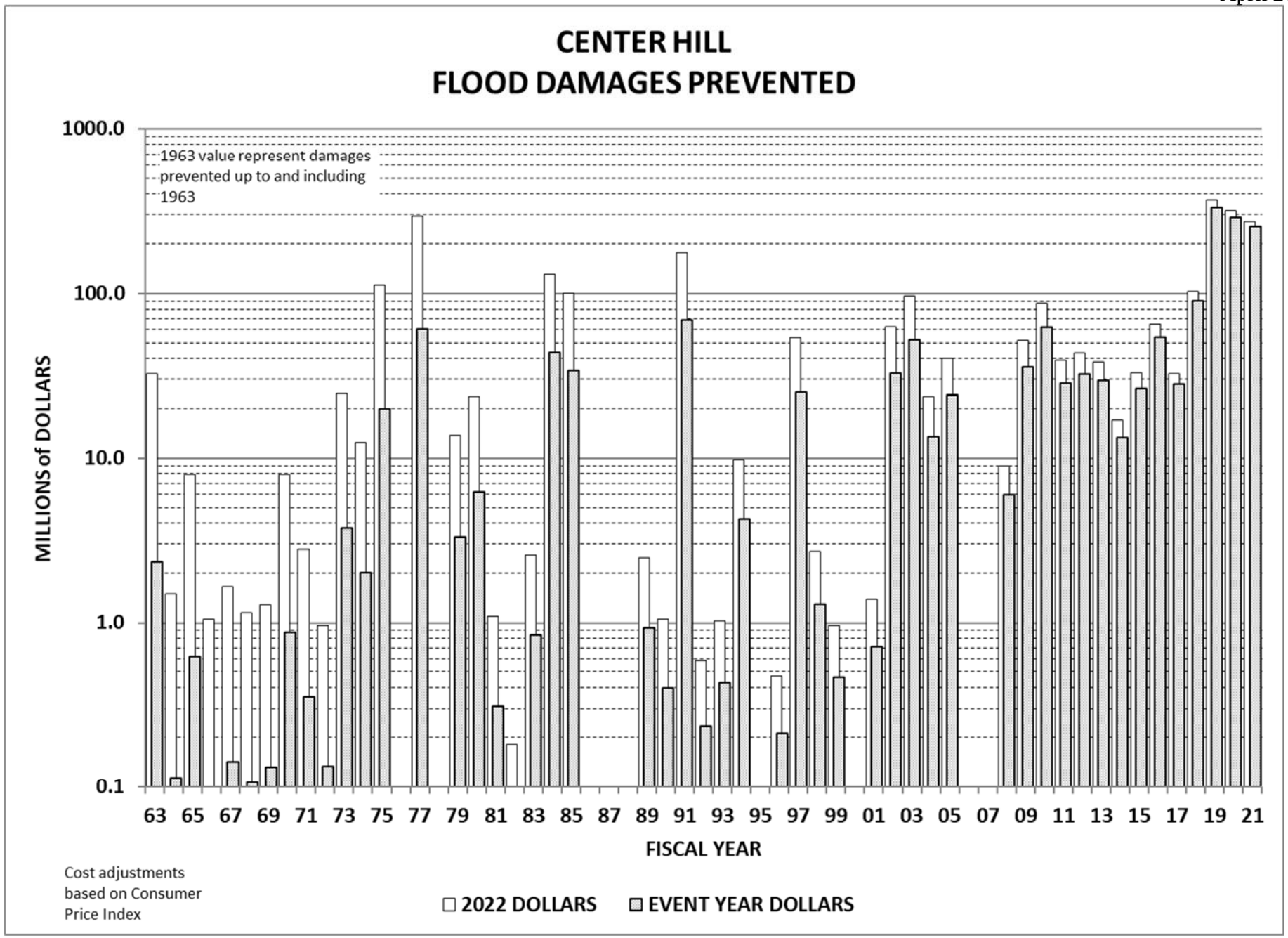

Plate VIII-9. Flood Damages Prevented

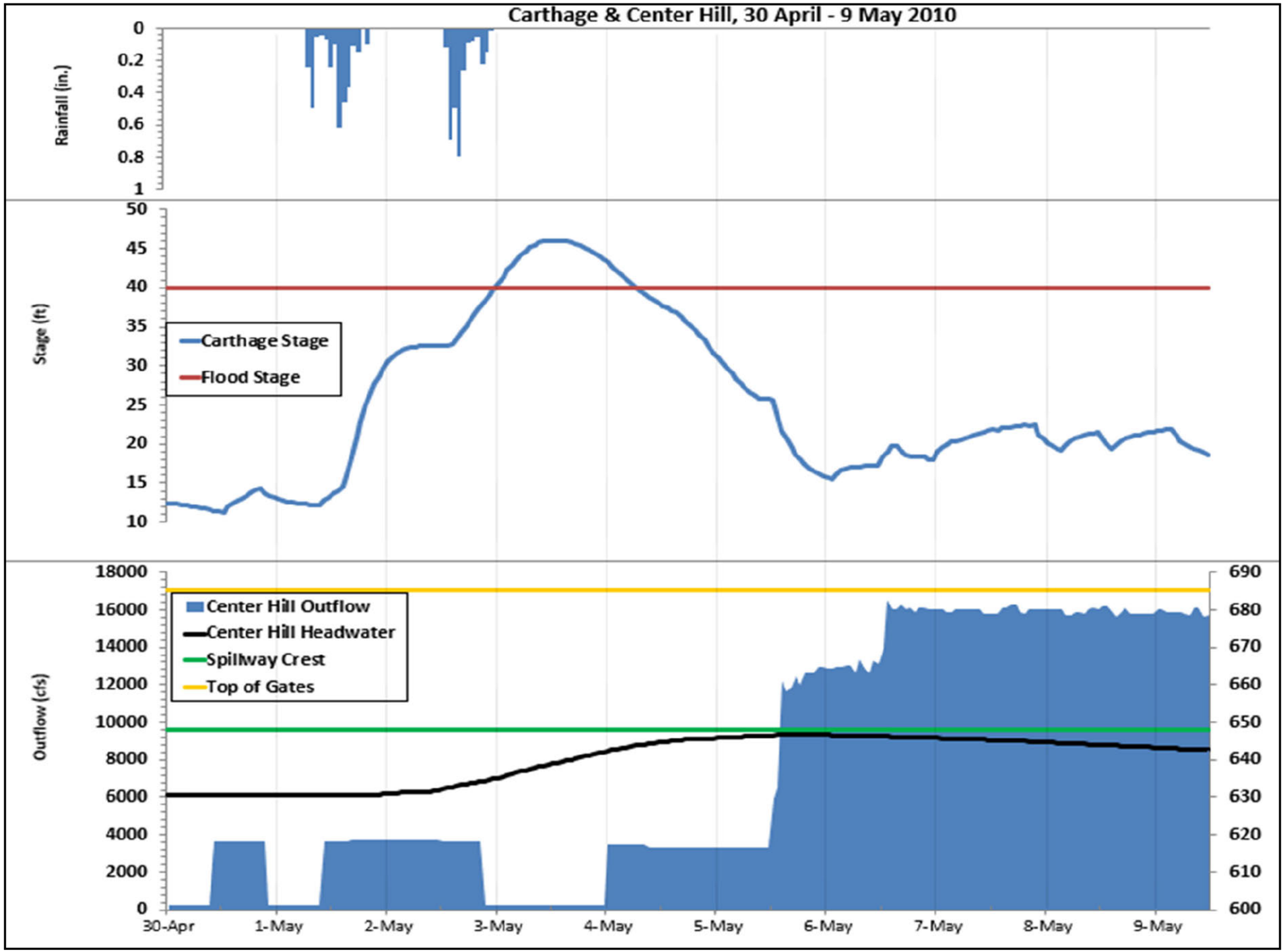

Plate VIII-10. Project Operations, May 2010 Flood Event

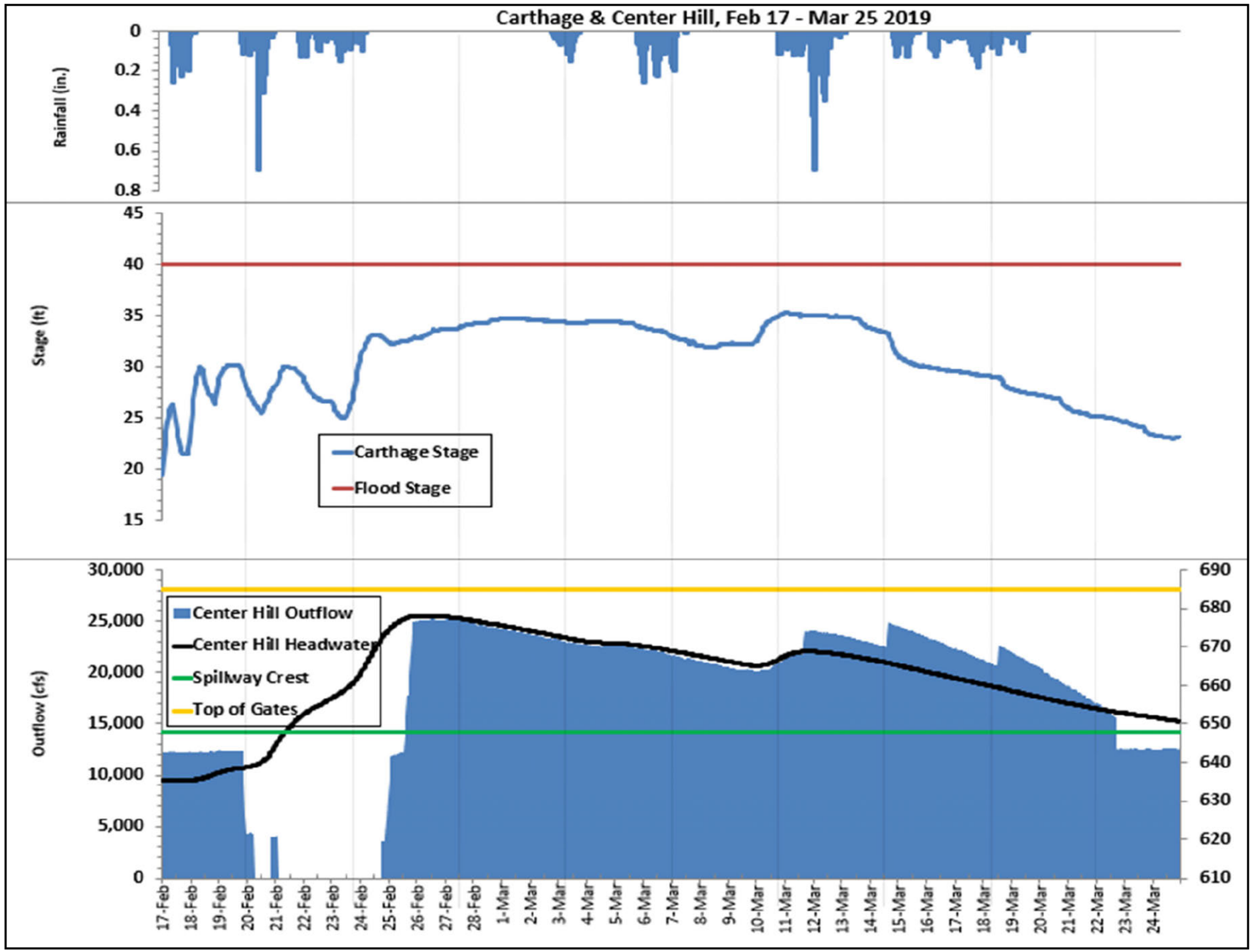

Plate VIII-11. Project Operations, February 2019 Flood Event

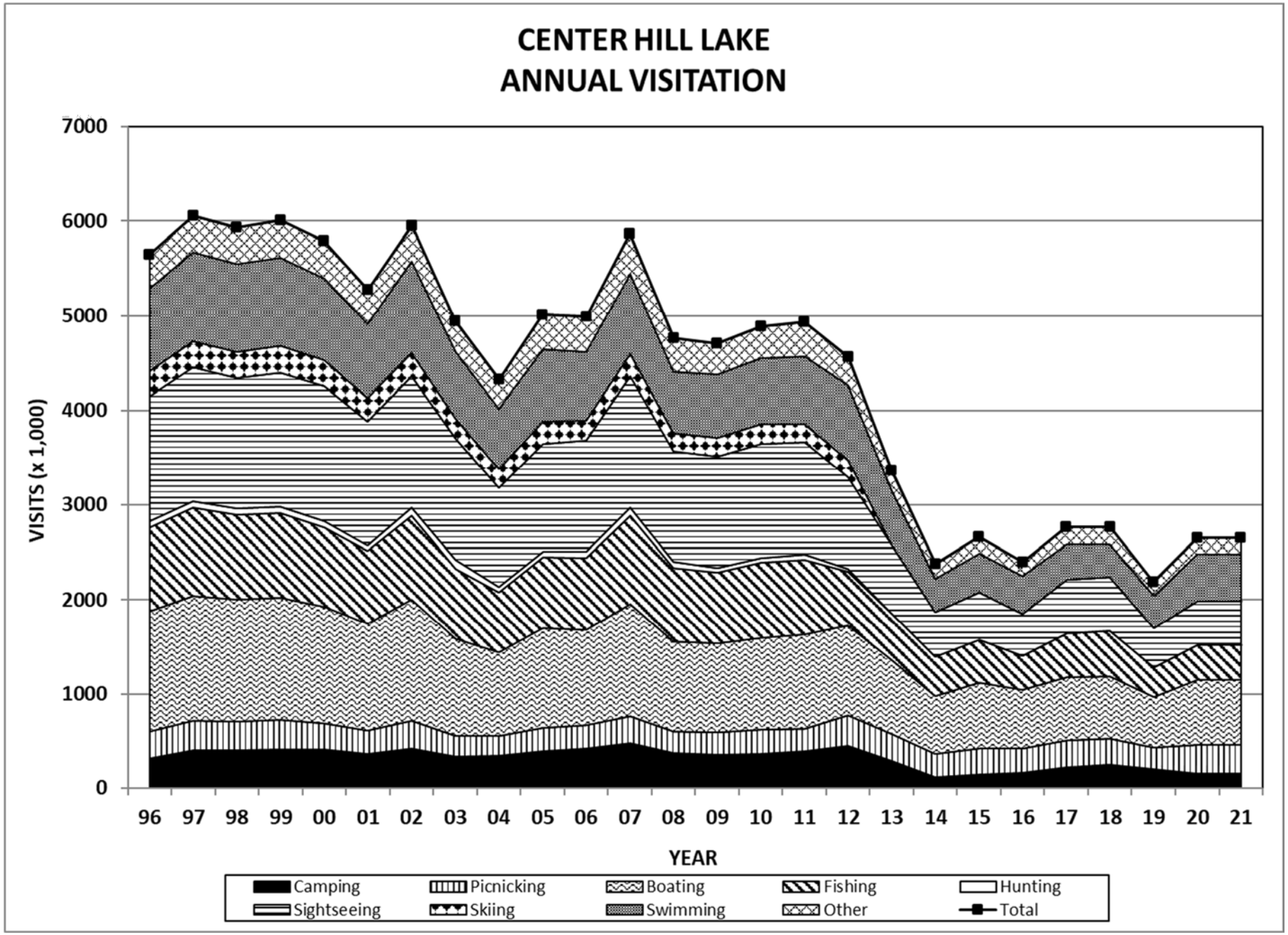

Plate VIII-12. Visitation Charts, Annual by Types

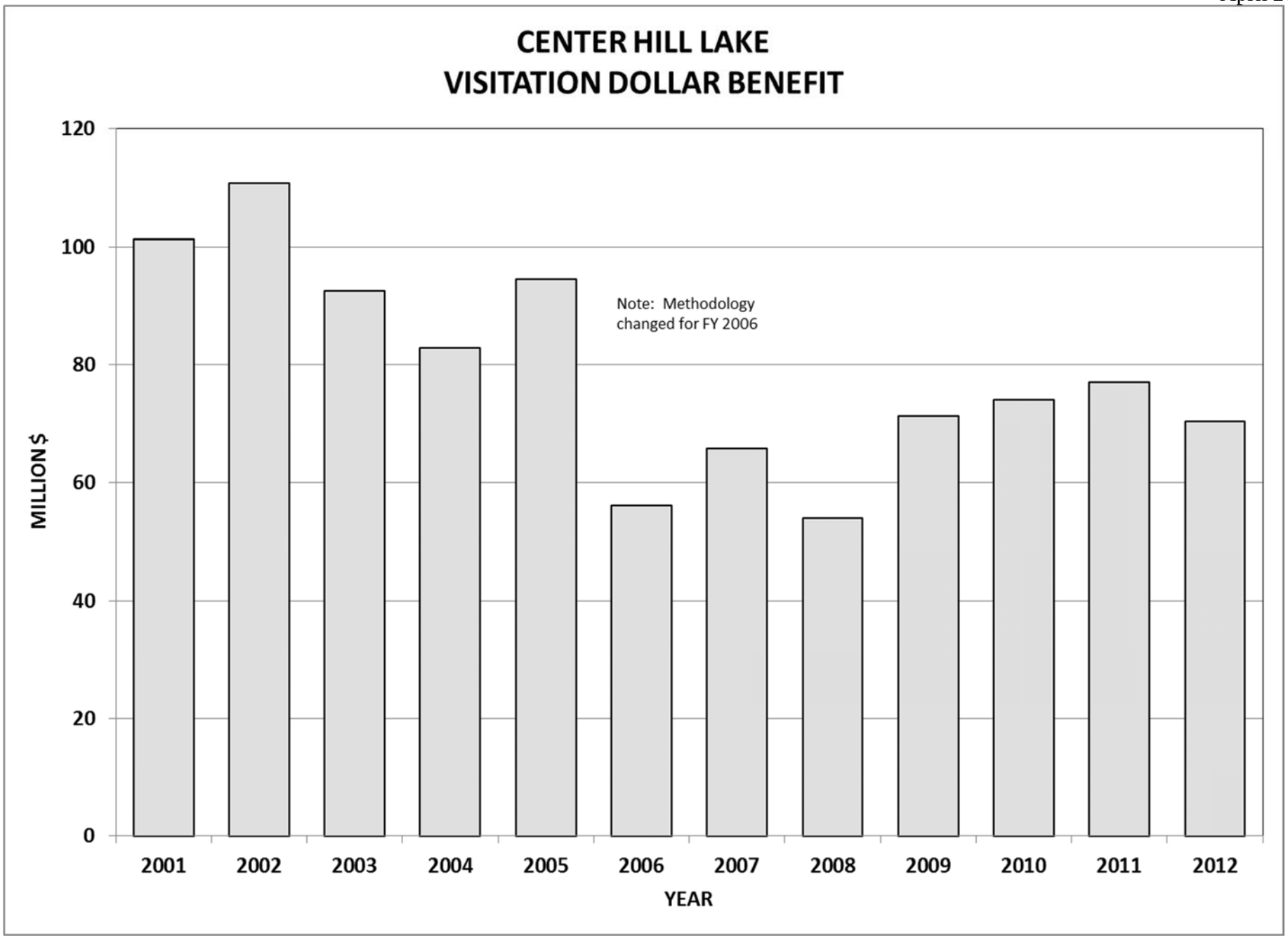

Plate VIII-13. Visitation Chart, Dollar Benefit

CENTER HILL RESERVOIR IMPACTS OF LAKE LEVELS ON RECREATION AND NATURAL RESOURCES
SUMMER PEAK, TOP OF SEPA BAND - ELEVATION 648.0
SUMMER PEAK, BOTTOM OF SEPA BAND - ELEVATION 640.6

WATER BASED FACILITIES		INITIAL IMPACT (A) ELEVATION 630.0 (10.6 feet below bottom of SEPA Band)			MAJOR IMPACT (B) ELEVATION 625.0 (15.6 feet below bottom of SEPA Band)			SEVERE IMPACT (C) ELEVATION 618.0 (22.6 feet below bottom of SEPA Band)		
Type	Number	Usable	Marginal or Unusable	Percent Reduction	Usable	Marginal or Unusable	Percent Reduction	Usable	Marginal or Unusable	Percent Reduction
Beaches	7	2	5	71%	0	7	100%	0	7	100%
Boat Ramps	35	28	7	20%	20	15	43%	0	35	100%
Marinas	7	7	0	0%	6	1 (D)	14%	6	1 (D)	14%
Wet Moorage at Marinas	1,223	1,223	0	0%	1,143	80	7%	1,063	160	13%
Private Docks	36	36	0	0%	36	0	0%	36	0	0%
Public Water Intakes	2	2	0	0%	2	0	0%	2	0	0%
Industrial Water Intakes	0	-	-	N/A	-	-	N/A	-	-	N/A
Water Surface Acreage	18,220	16,060	2,160	12%	15,460	2,760	15%	14,620	3,620	20%

Plate VIII-14. Recreation, Impacts of Reservoir Levels

CENTER HILL LAKE
IMPACTS OF LAKE LEVELS ON RECREATION AND NATURAL RESOURCES

FOOTNOTES:

A. Initial Impacts - The level where recreation and natural resources management impacts are first observed: some ramps are unusable, most beaches are unusable or minimally usable, and/or navigation hazards begin to surface.

B. Major Impacts - The level where significant impact would occur: water or boating access would be significantly limited, a significant number of boat ramps would be unusable, major navigation hazards occur, channels to marinas would become impassable and/or slips would have to be relocated, exposed mud or rock bottom surfaces would make water access from recreation areas inaccessible, a majority of privately permitted boat docks would be unusable or relocated, and all swimming beaches are unusable.

C. Severe Impacts - The level where a majority of recreation facilities are virtually out of business: all or almost all boat ramps are closed, all swimming beaches are closed, major navigation hazards severely limit lake use, channels to marinas are impassable, and slips are unusable, and a majority of the privately permitted boat docks are unusable.

D. Holmes Creek Marina

Plate VIII-14. Recreation, Impacts of Reservoir Levels, cont.

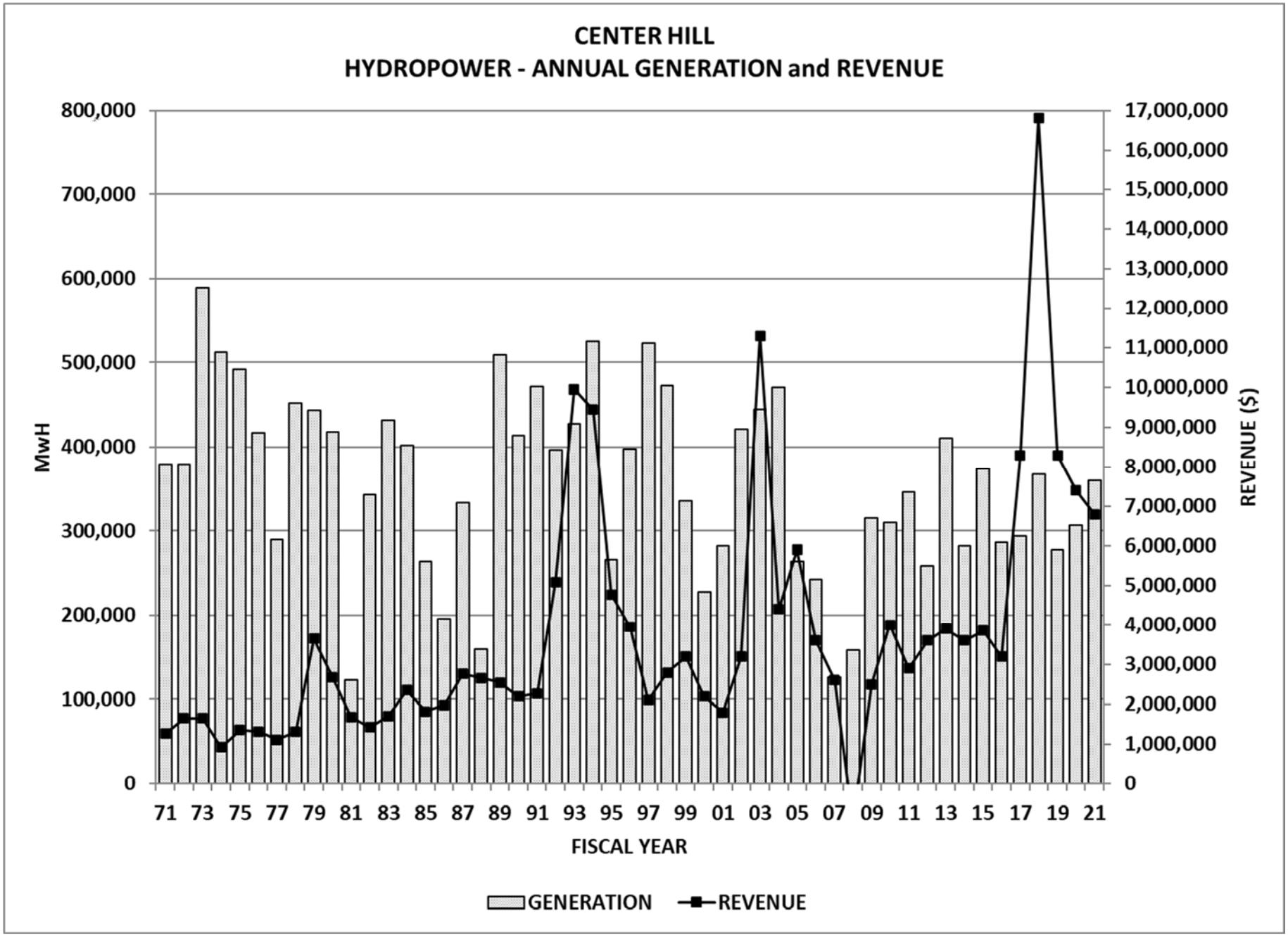

Plate VIII-15. Hydropower Chart, Annual Generation and Revenue

SUMMARY OF CENTER HILL DAM HYDROPOWER OUTPUT

FISCAL YEAR	ESTIMATED ANNUAL GENERATION (million khw)	GROSS GENERATION (million kwh)	% ABOVE/BELOW ESTIMATED ANNUAL GENERATION	STATION USE (million kwh)	NET GENERATION (million kwh)	REVENUE ($ million)	REVENUE (¢ / kwh sold)
1971	351	382.2	9	2.4	379.8	1.26	0.33
1972	351	382.0	9	2.3	379.6	1.65	0.44
1973	351	591.8	69	2.4	589.4	1.65	0.28
1974	351	514.0	46	2.0	512.0	0.92	0.18
1975	351	493.0	40	1.5	491.5	1.36	0.28
1976	351	418.2	19	1.8	416.4	1.32	0.32
1977	351	292.2	-17	2.1	290.1	1.12	0.39
1978	351	454.1	29	1.9	452.3	1.31	0.29
1979	351	445.6	27	2.0	443.6	3.65	0.82
1980	351	419.8	20	1.8	418.0	2.67	0.64
1981	351	124.5	-65	1.9	122.6	1.69	1.39
1982	351	345.1	-2	1.9	343.3	1.42	0.42
1983	351	434.1	24	1.8	432.3	1.71	0.40
1984	351	404.1	15	2.0	402.0	2.35	0.58
1985	351	266.4	-24	2.2	264.1	1.82	0.69
1986	351	198.2	-44	2.2	196.0	1.98	1.02
1987	351	336.3	-4	2.3	334.0	2.76	0.83
1988	351	161.7	-54	2.5	159.2	2.66	1.68
1989	351	511.3	46	2.3	509.0	2.55	0.50
1990	351	416.0	19	2.5	413.5	2.2	0.53
1991	351	473.5	35	2.4	471.1	2.27	0.48
1992	351	398.7	14	3.0	396.2	5.08	1.28
1993	351	430.0	22	3.1	427.4	9.96	2.33
1994	351	527.3	50	3.1	524.6	9.44	1.80
1995	351	268.6	-23	3.1	265.9	4.77	1.80
1996	351	400.4	14	3.2	397.7	3.95	0.99
1997	351	524.9	50	3.0	522.4	2.1	0.41
1998	351	474.7	35	3.1	472.0	2.8	0.58
1999	351	337.7	-4	2.8	335.3	3.2	0.96
2000	351	213.3	-39	3.3	227.7	2.2	0.97
2001	351	285.1	-19	3.2	281.9	1.8	0.64
2002	351	424.4	21	3.3	421.1	3.2	0.76
2003	351	447.5	27	3.2	444.3	11.3	2.54
2004	351	473.7	35	3.1	470.6	4.4	0.93
2005	351	266.9	-24	3.2	263.7	5.9	2.24
2006	351	246.4	-30	3.4	243.0	3.6	1.48
2007	351	129.7	-64	3.3	126.364	2.1	1.70
2008	351	160.9	-54	3.3	157.594	2.6	1.67
2009	351	318.2	-9	3.2	315.004	4.8	1.51
2010	351	311.9	-11	2.1	309.827	4.8	1.54
2011	351	349.7	1	3.6	346.091	5.1	1.47
2012	351	265.9	-25	2.9	262.943	5.2	1.96
2013	351	410.3	17	3.5	406.816	8.0	1.95
2014	351	282.1	-20	3.1	279.046	5.6	1.99
2015	351	374.1	7	3.2	370.913	6.5	1.75
2016	351	286.4	-18	2.8	283.608	6.0	2.12
2017	351	293.5	-16	2.8	290.756	5.9	2.03
2018	351	367.2	5	2.9	364.367	7.3	2.00
2019	351	278.4	-21	2.6	275.82	5.3	1.91
2020	351	306.4	-13	2.8	303.576	5.4	1.78
2021	351	360.1	3	3.1	357.023	6.6	1.86

Plate VIII-16. Hydropower Table, Annual Generation and Revenue

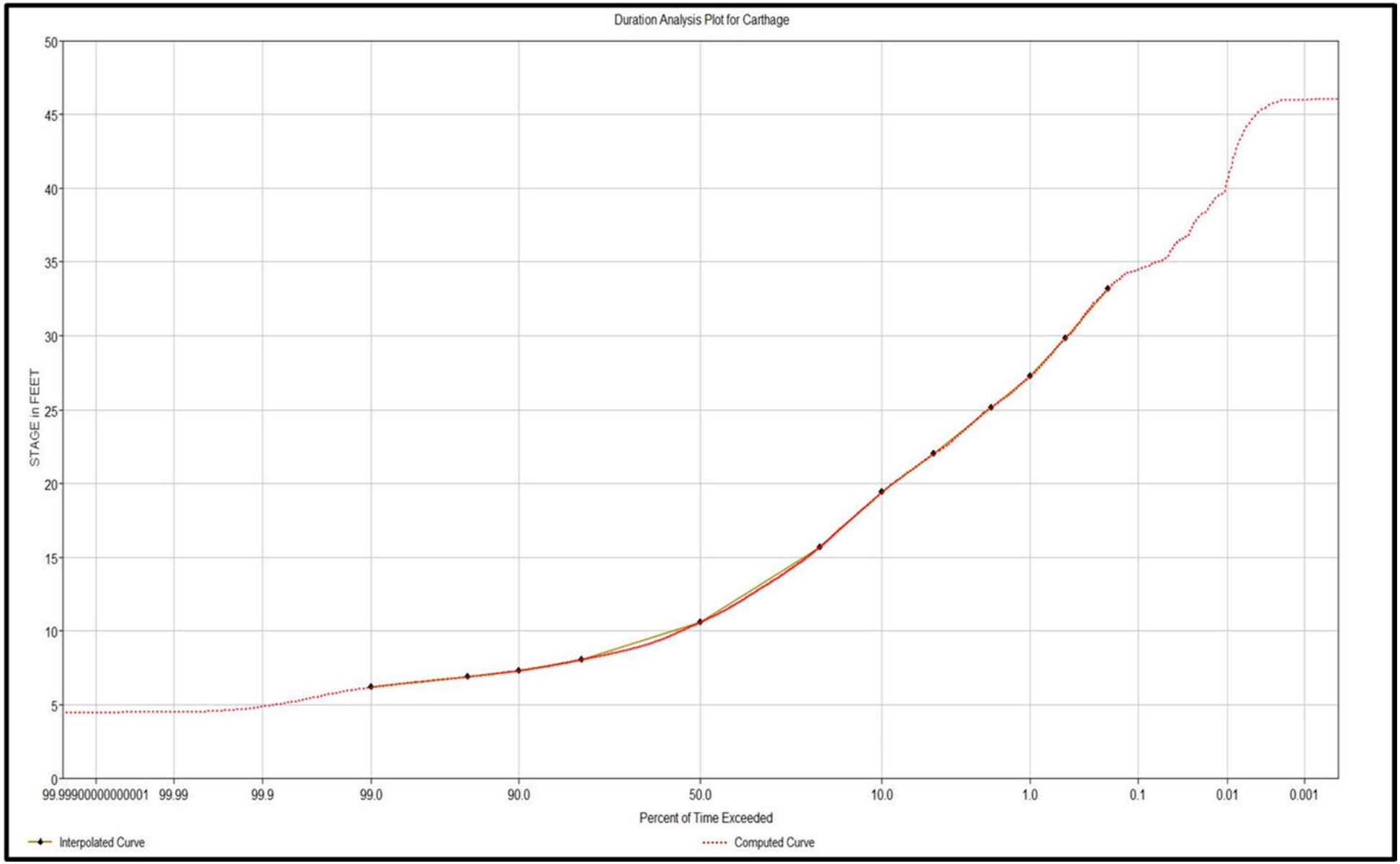

Plate VIII-17. Duration Analysis Plot for Carthage (1989-2022)

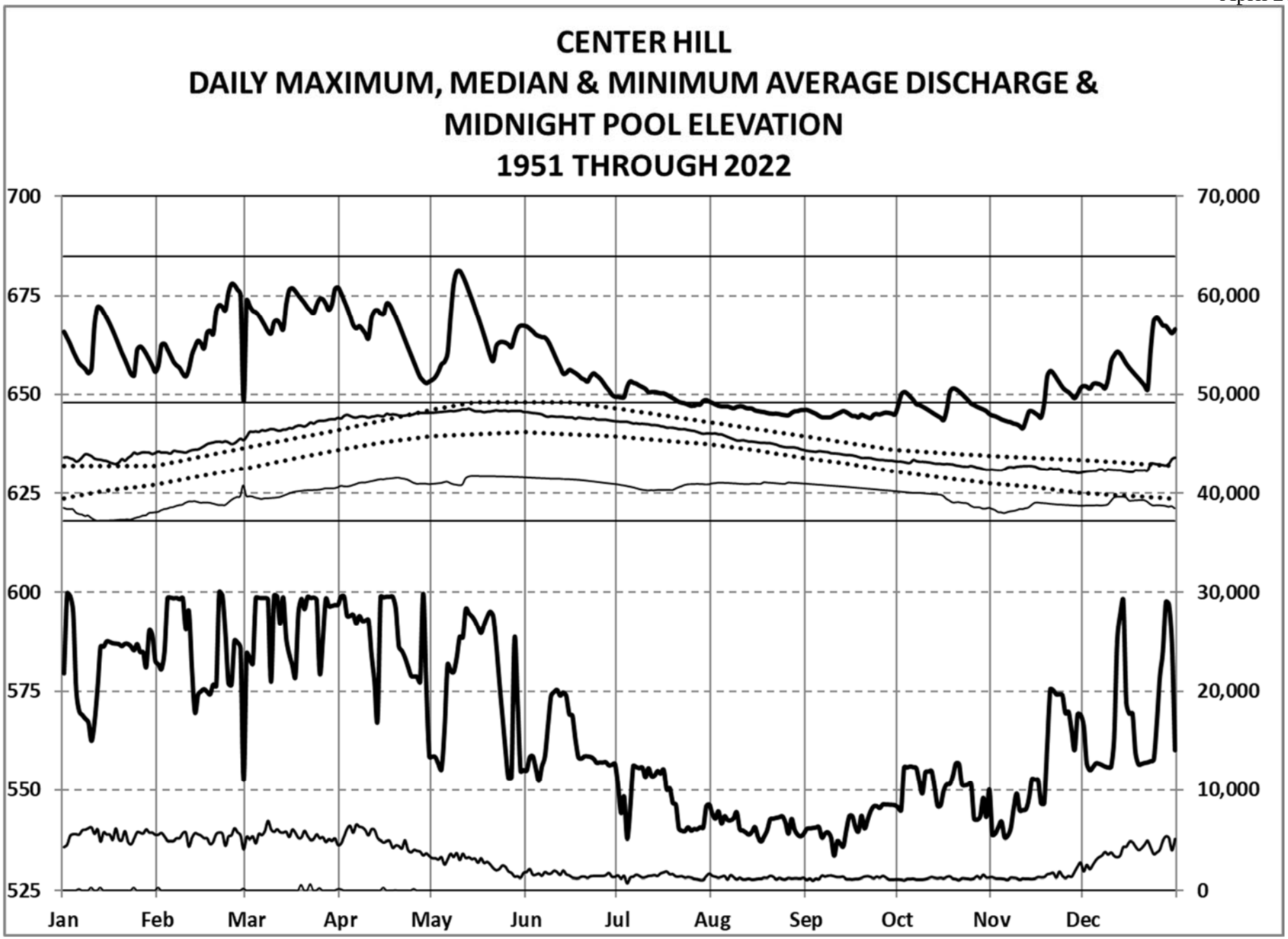

Plate VIII-18. Center Hill Maximum, Median & Minimum Daily Average Discharges & Pool Elevations

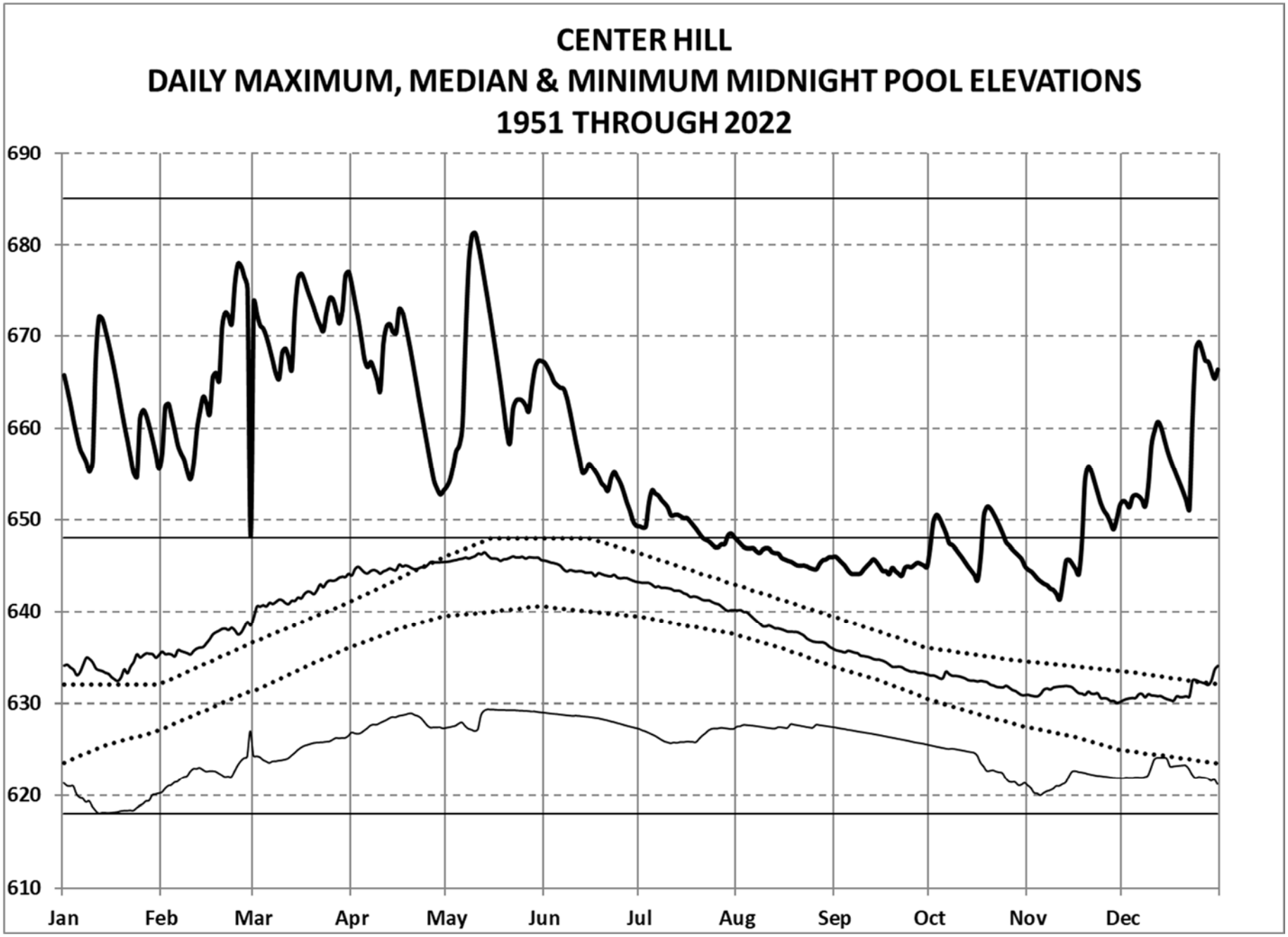

Plate VIII-19. Center Hill Maximum, Median & Minimum Pool Elevations

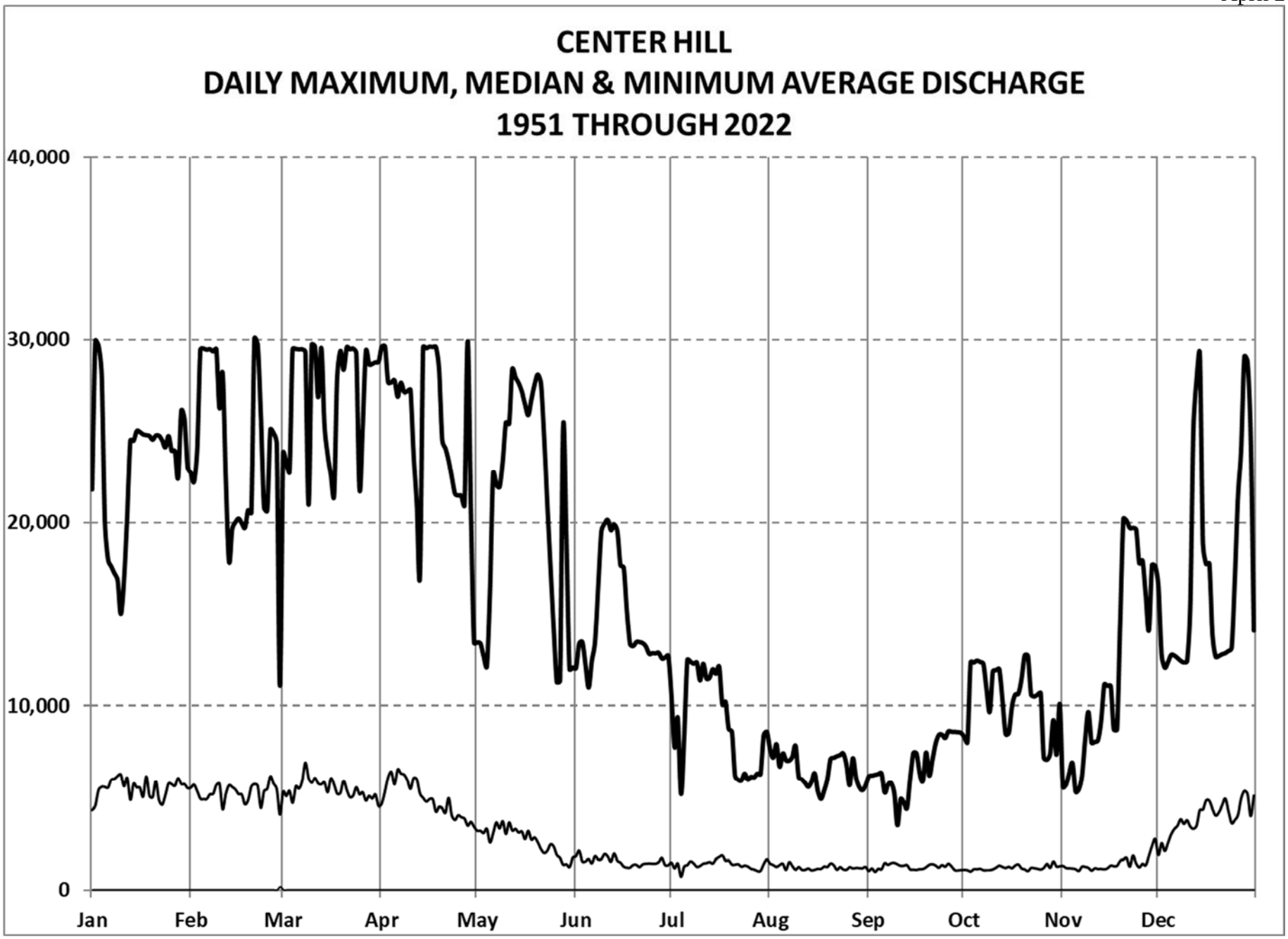

Plate VIII-20. Center Hill Maximum, Median & Minimum Daily Average Discharges

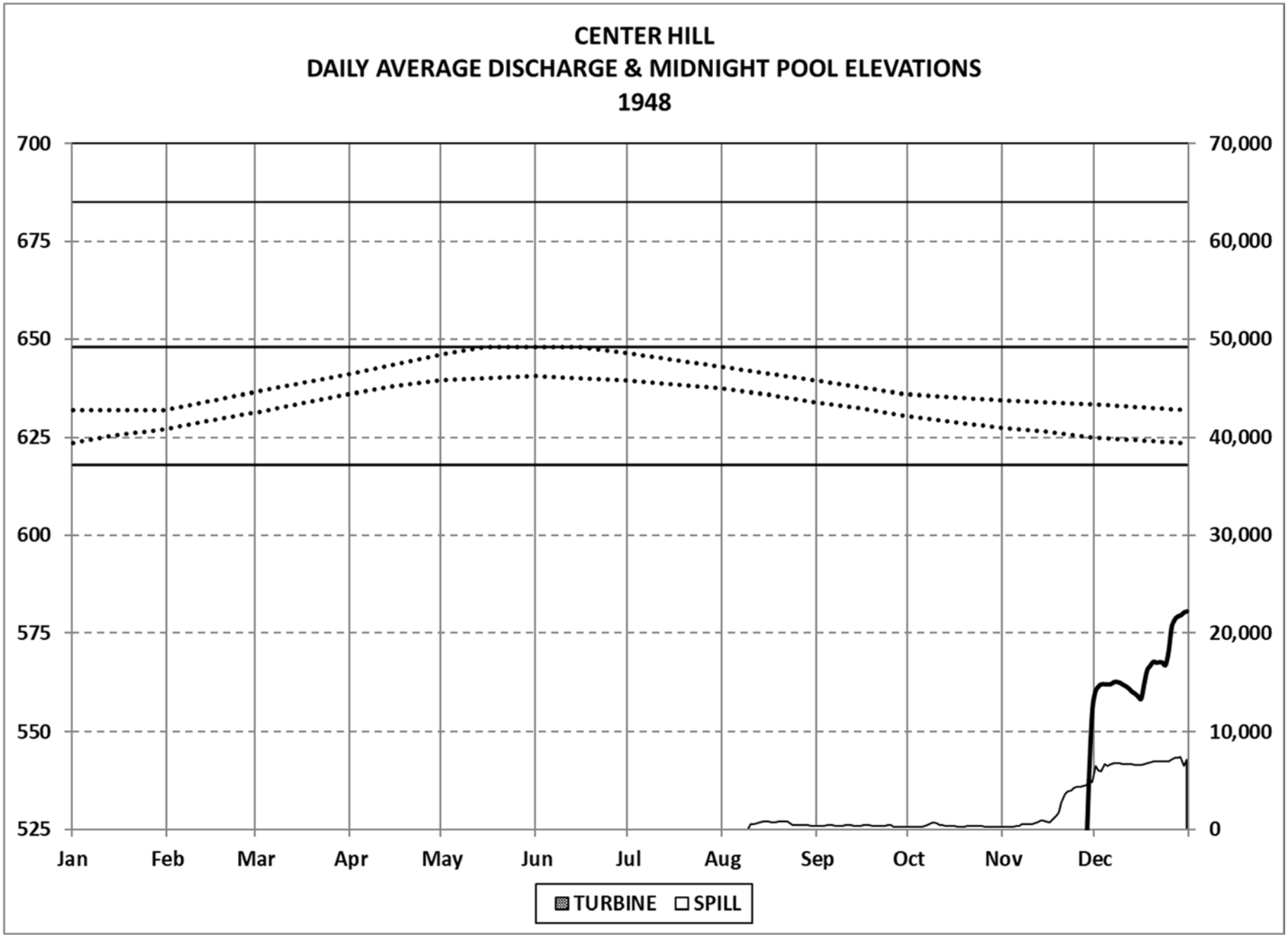

Plate VIII-21. Historical Pool Elevations and Discharges, 1948

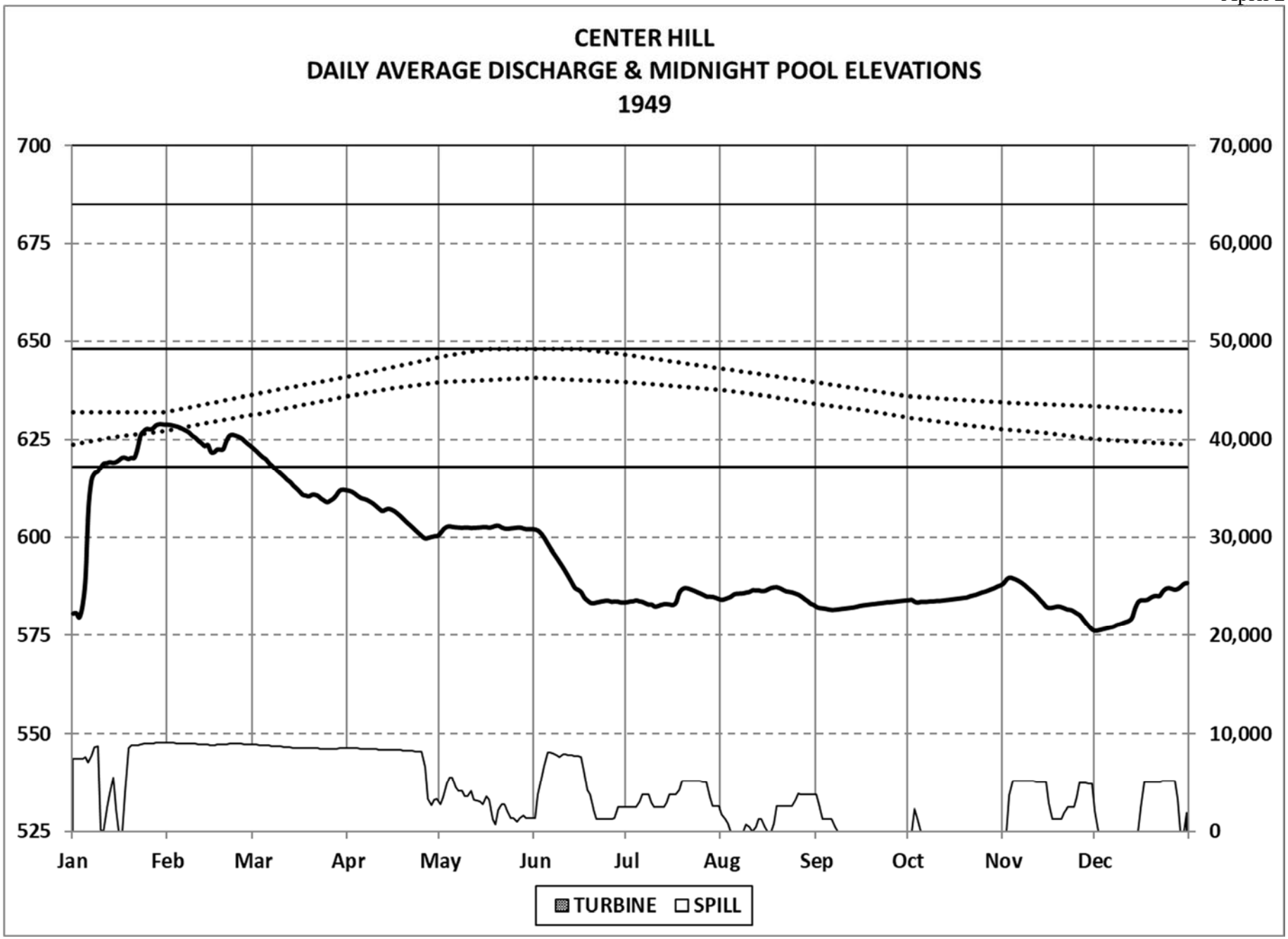

Plate VIII-22. Historical Pool Elevations and Discharges, 1949

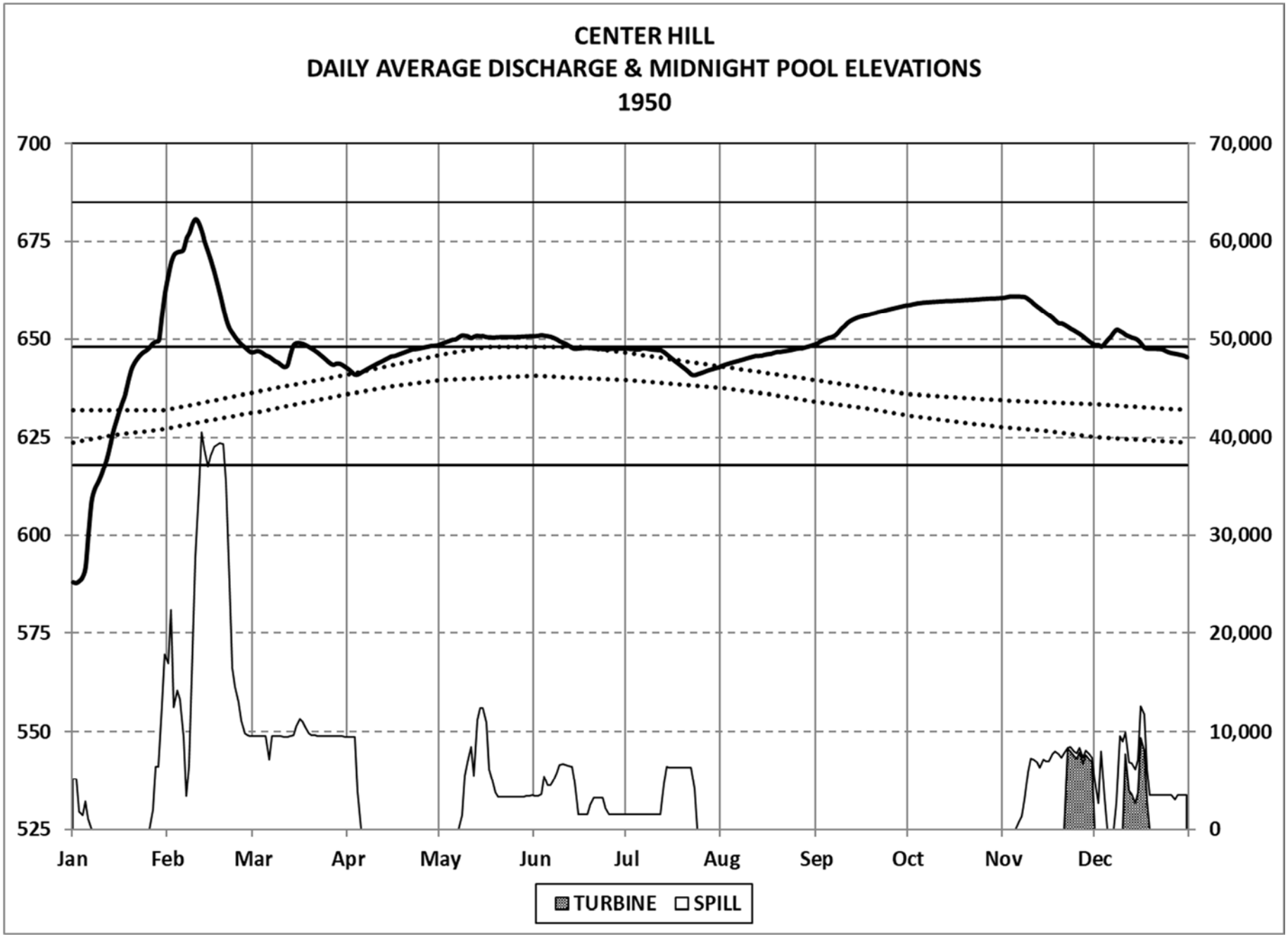

Plate VIII-23. Historical Pool Elevations and Discharges, 1950

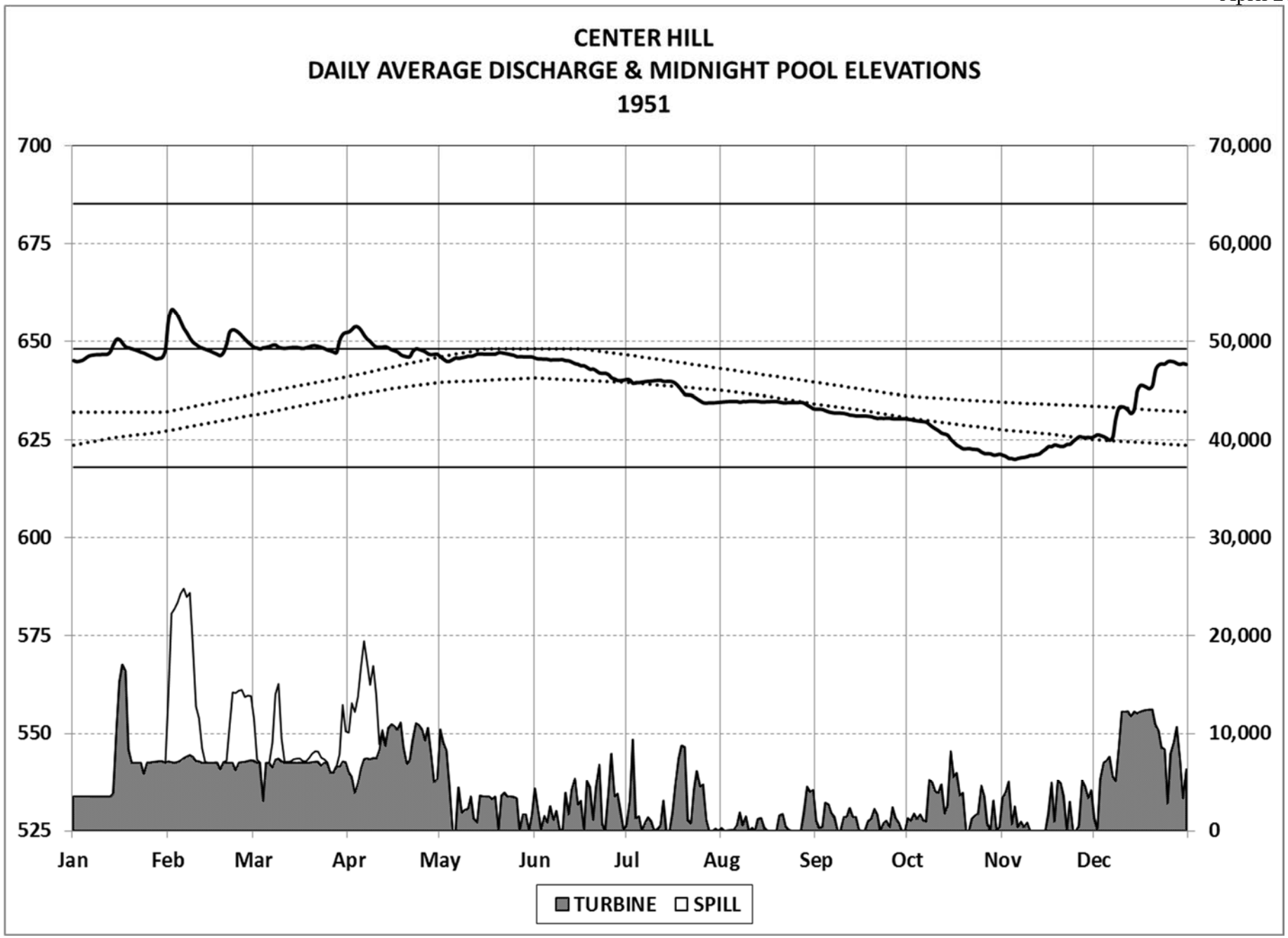

Plate VIII-24. Historical Pool Elevations and Discharges, 1951

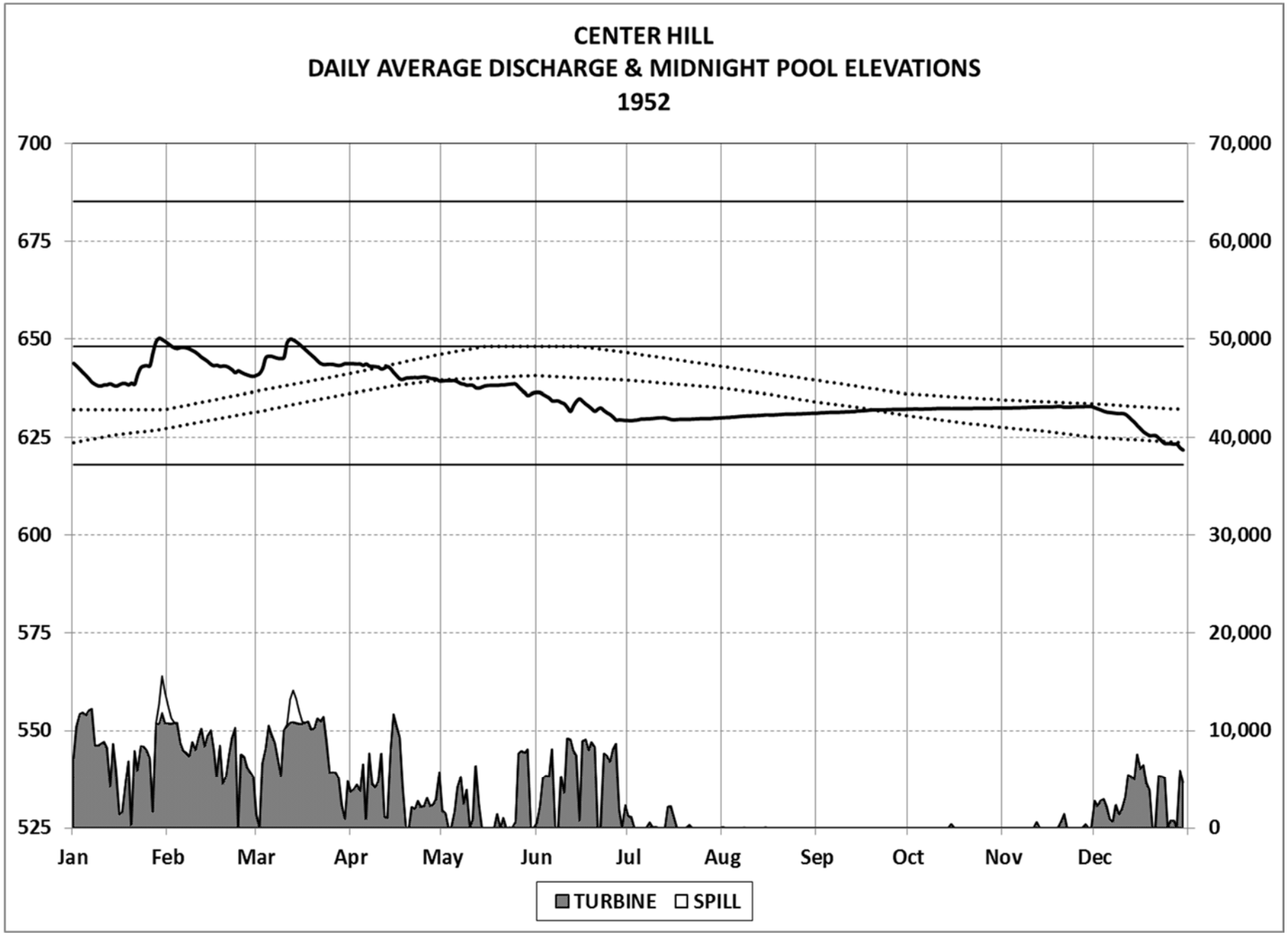

Plate VIII-25. Historical Pool Elevations and Discharges, 1952

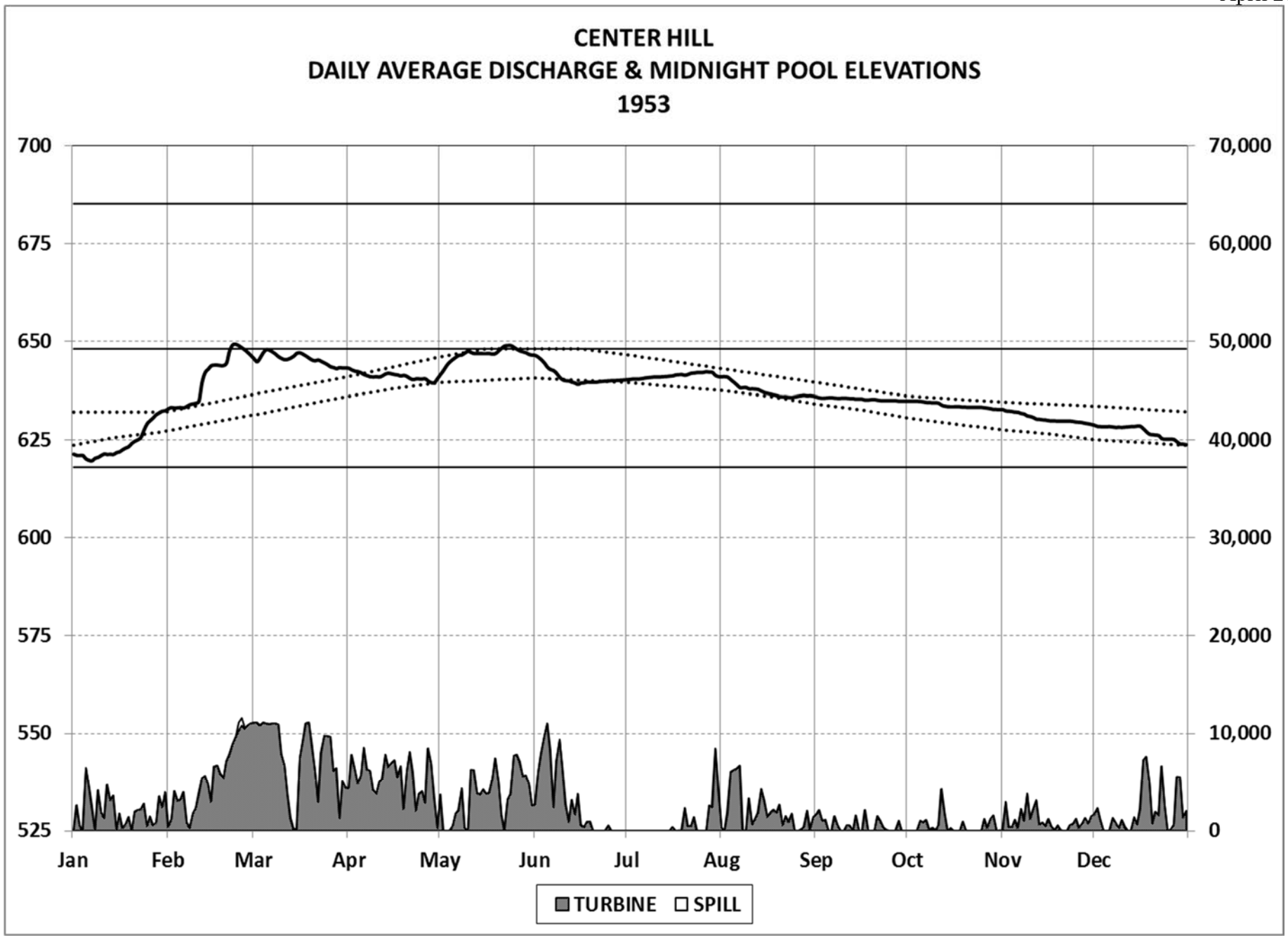

Plate VIII-26. Historical Pool Elevations and Discharges, 1953

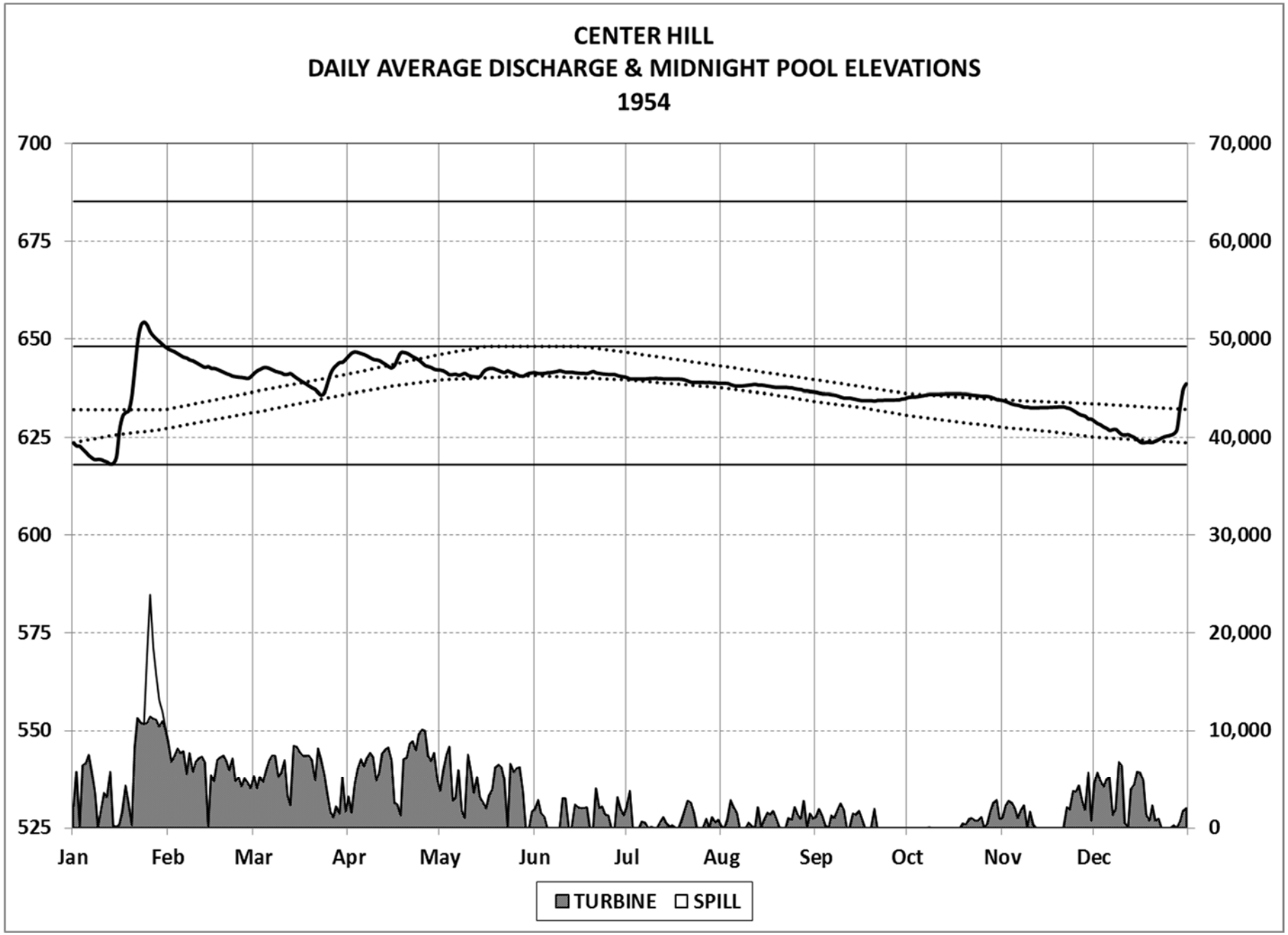

Plate VIII-27. Historical Pool Elevations and Discharges, 1954

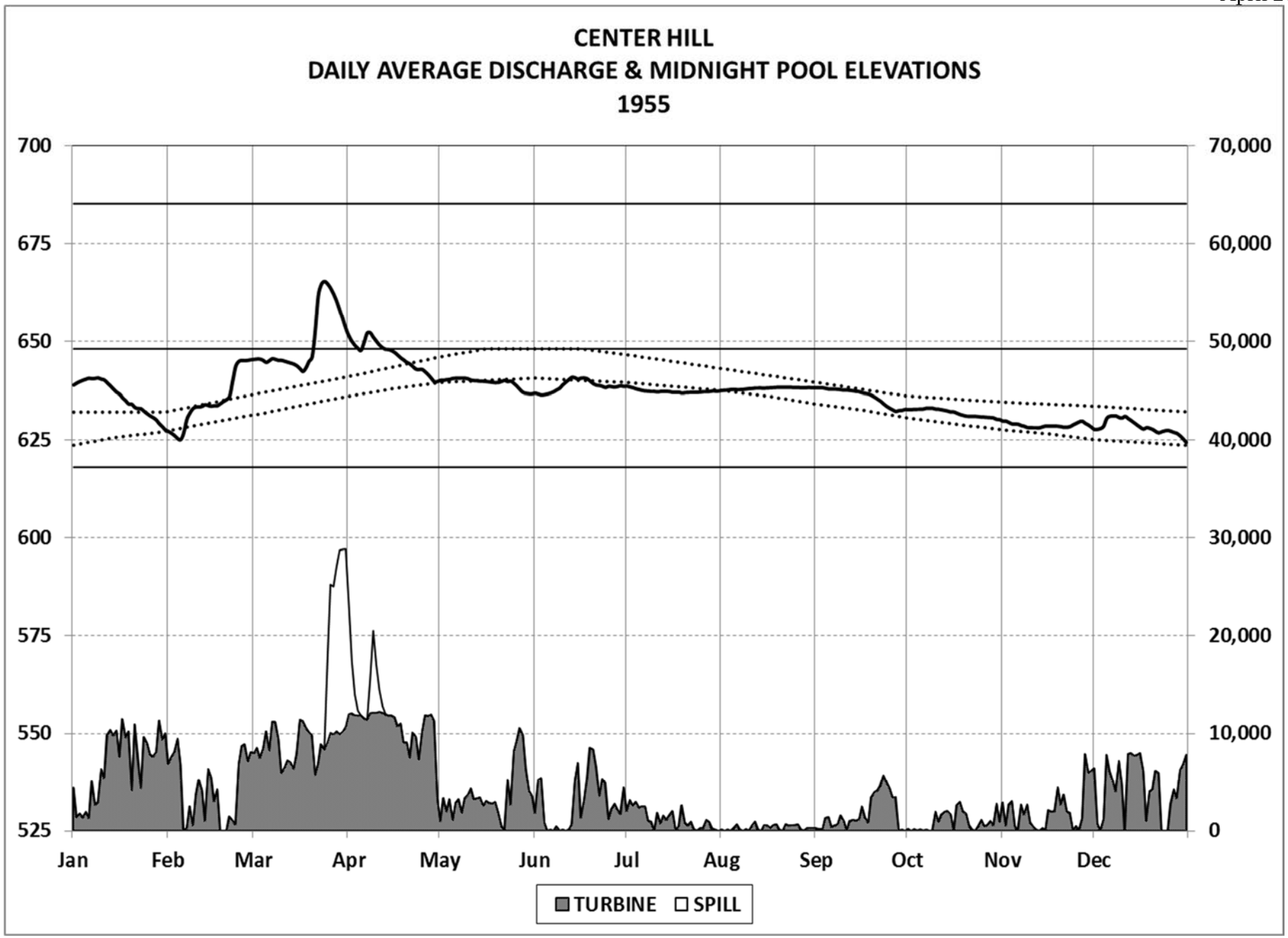

Plate VIII-28. Historical Pool Elevations and Discharges, 1955

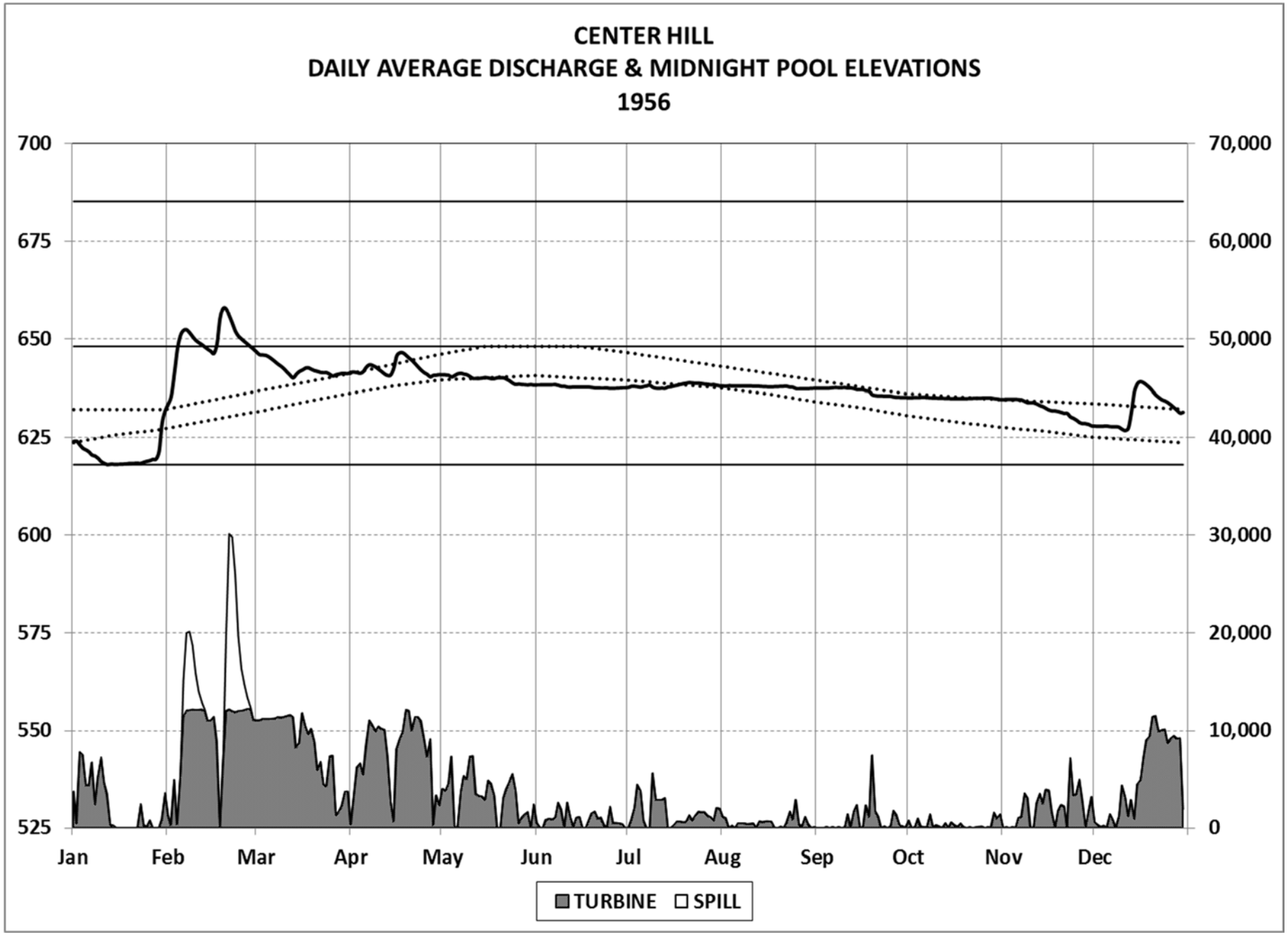

Plate VIII-29. Historical Pool Elevations and Discharges, 1956

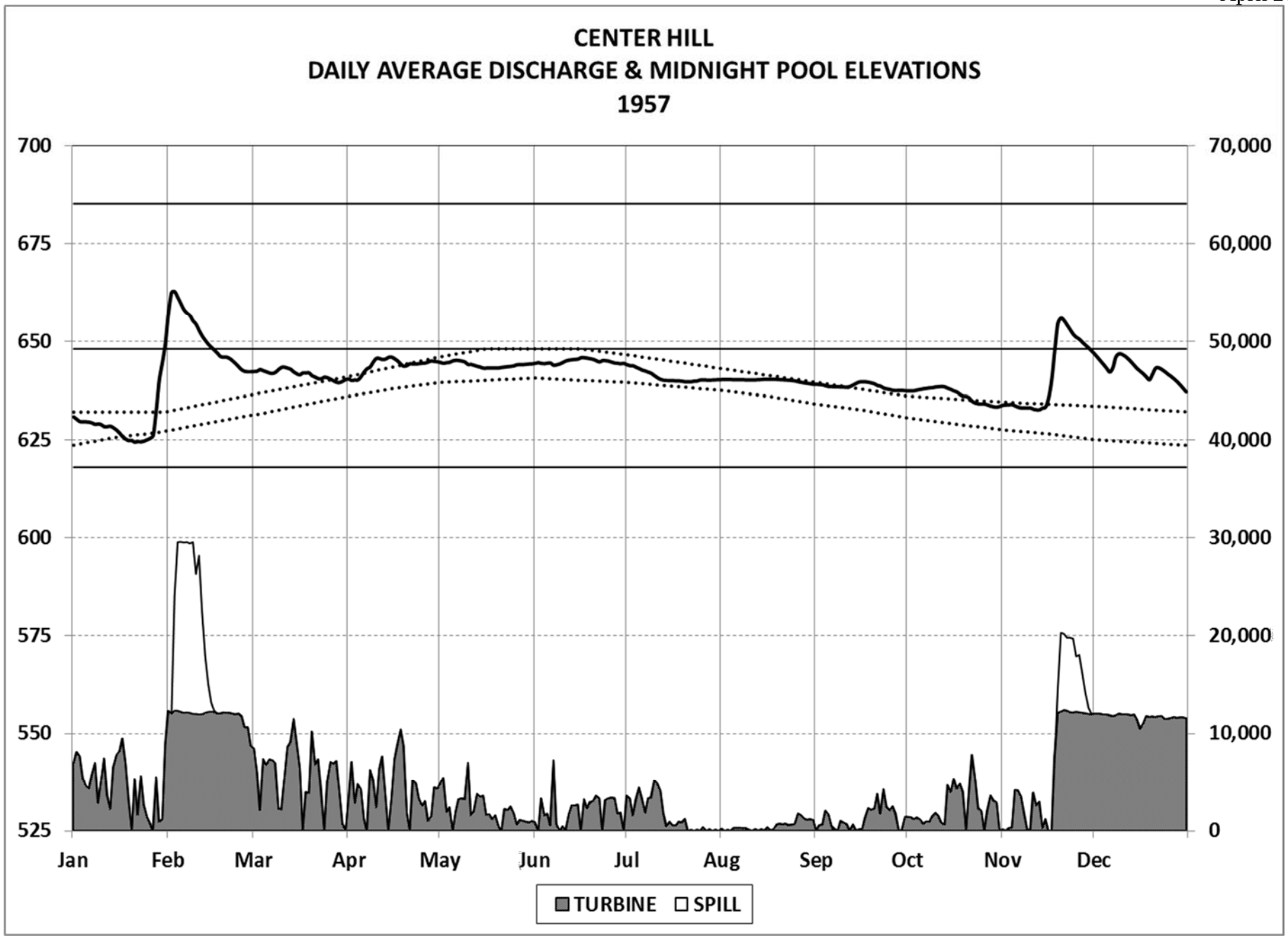

Plate VIII-30. Historical Pool Elevations and Discharges, 1957

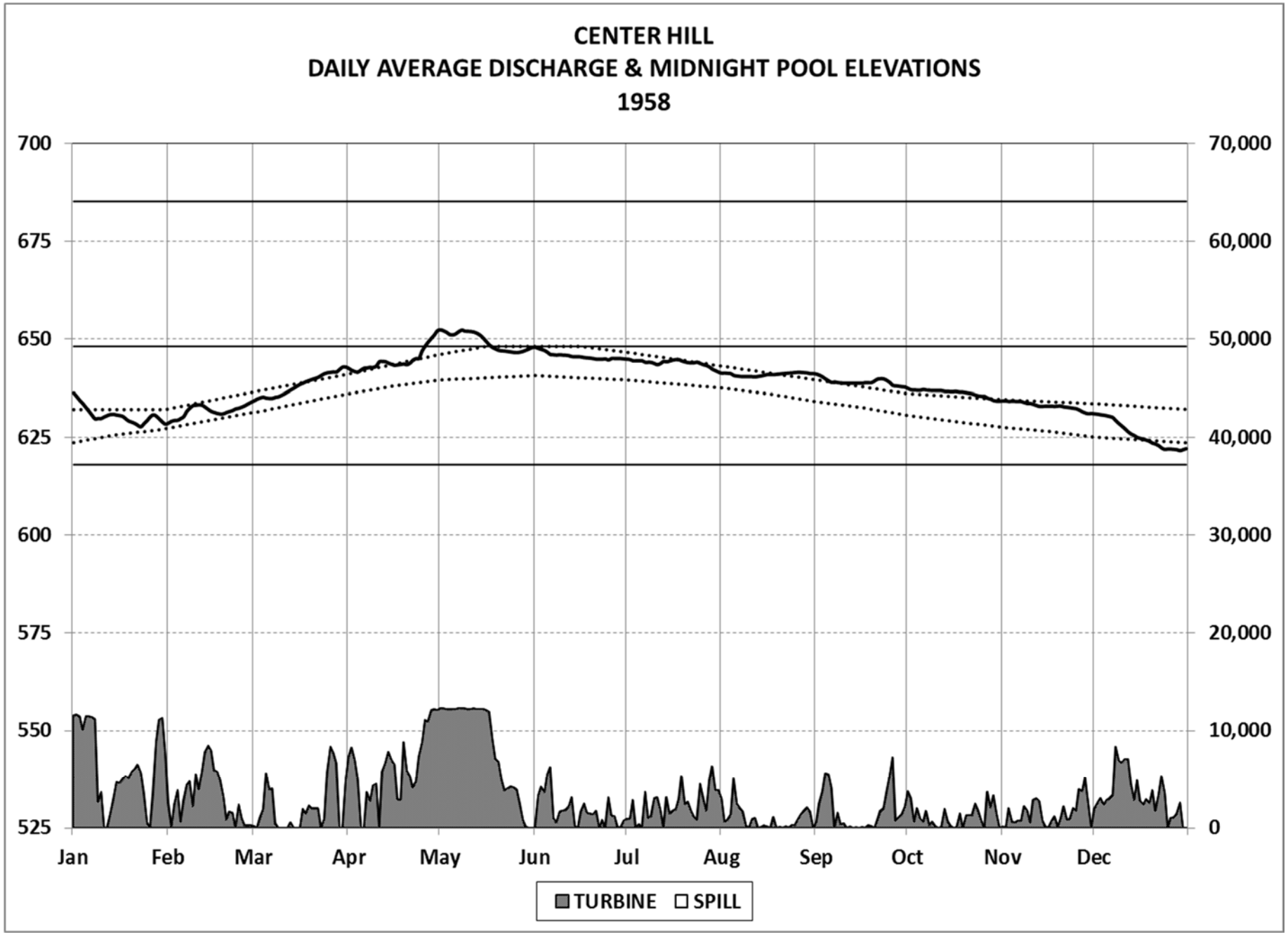

Plate VIII-31. Historical Pool Elevations and Discharges, 1958

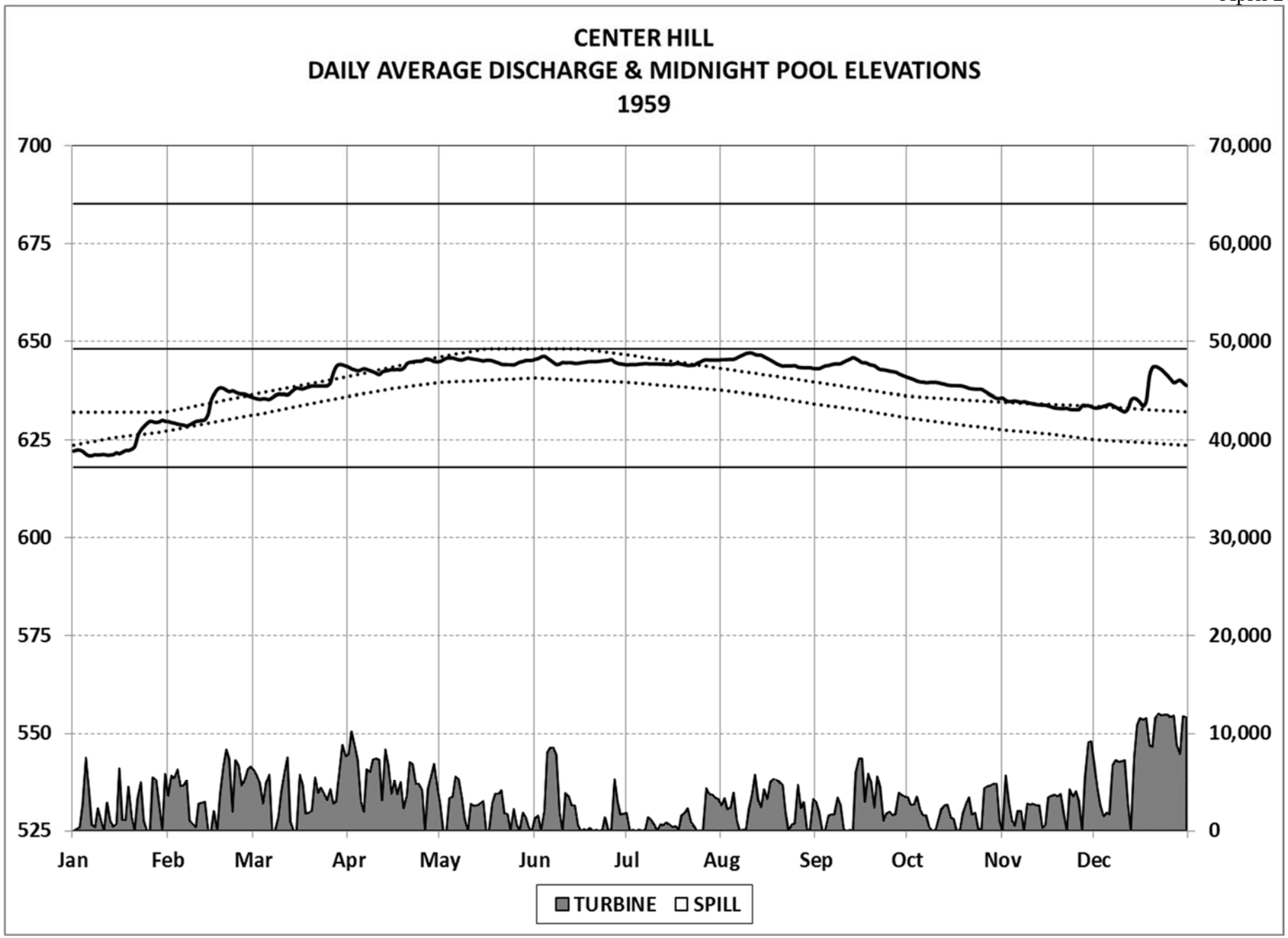

Plate VIII-32. Historical Pool Elevations and Discharges, 1959

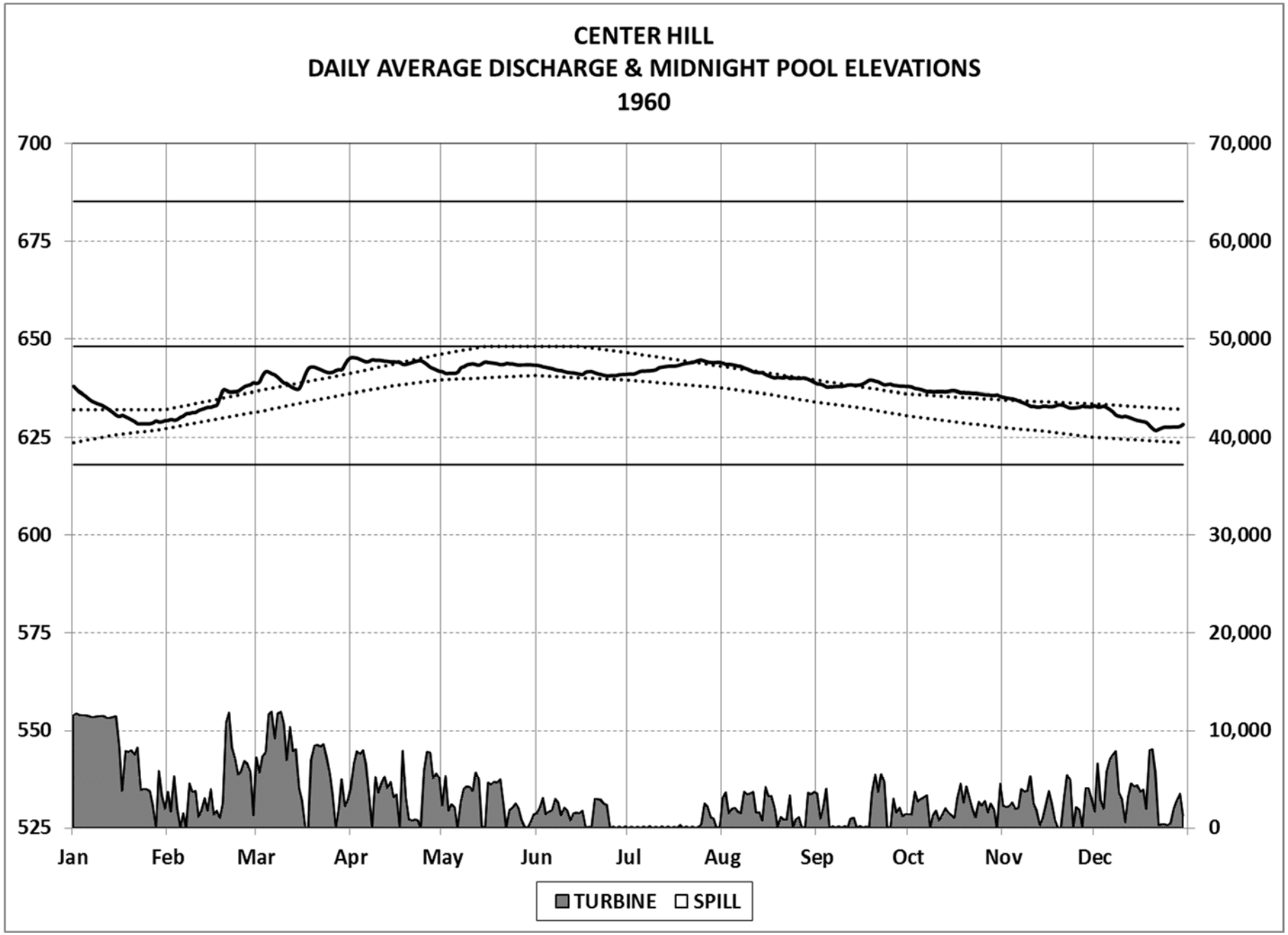

Plate VIII-33. Historical Pool Elevations and Discharges, 1960

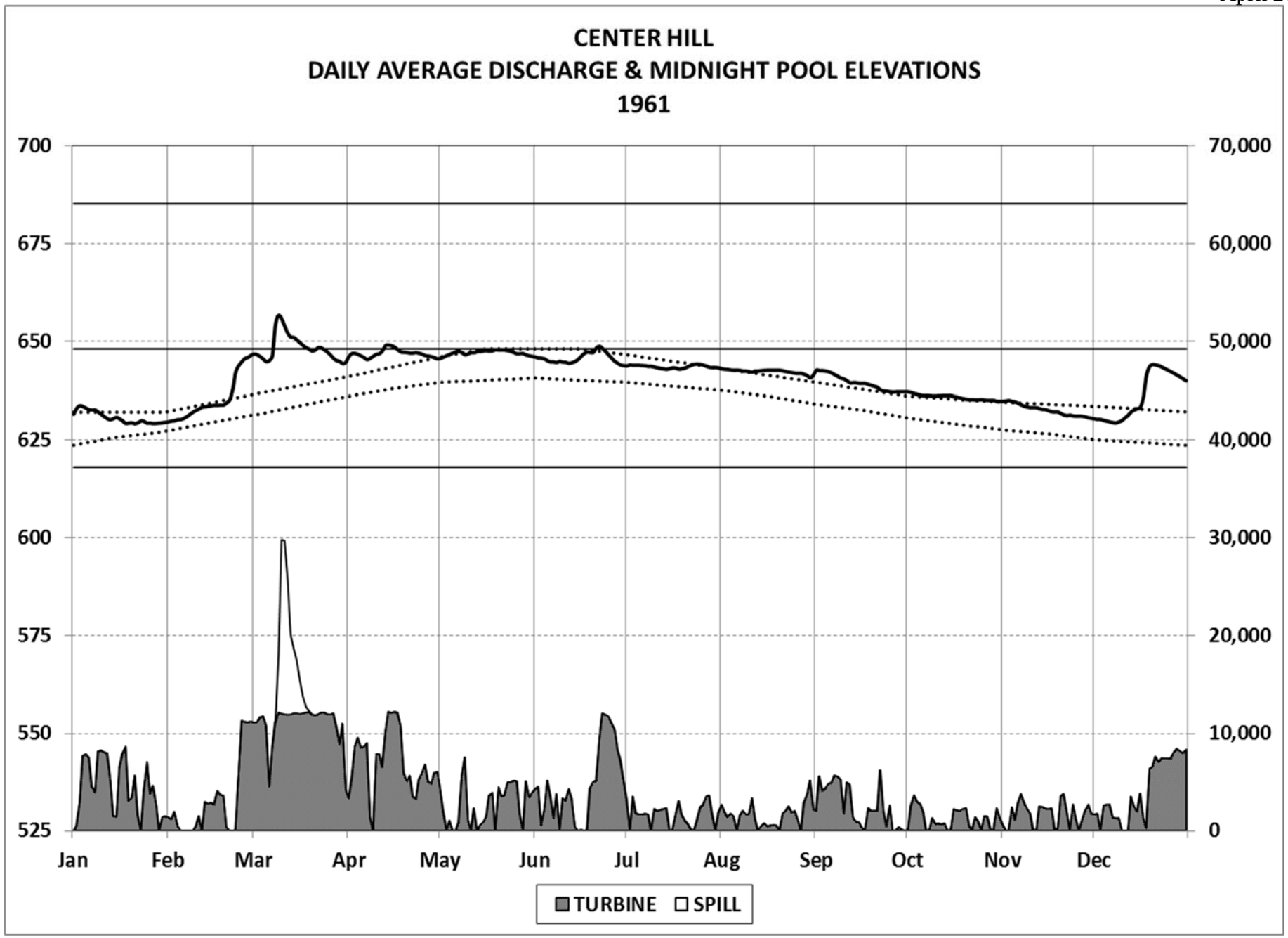

Plate VIII-34. Historical Pool Elevations and Discharges, 1961

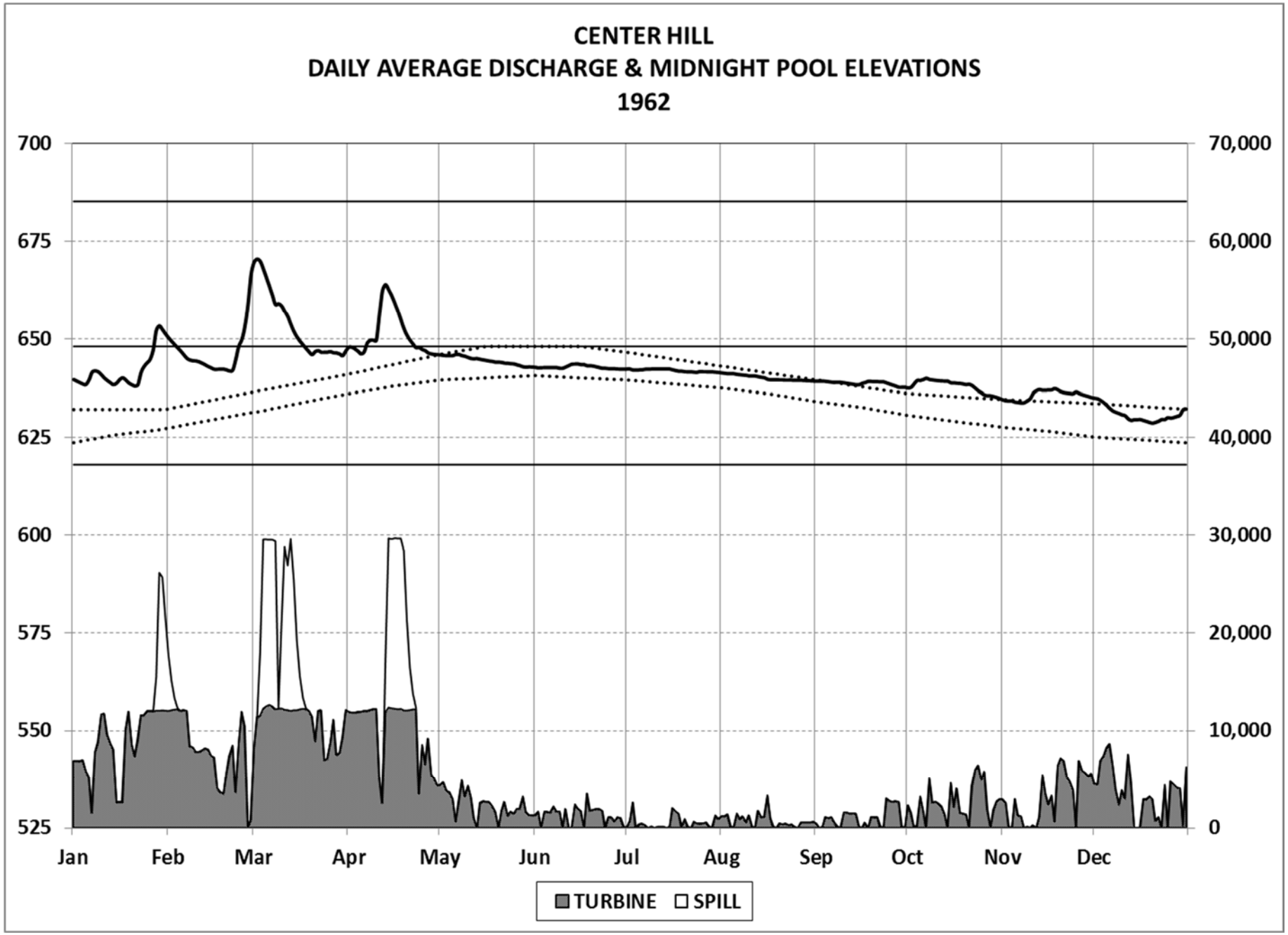

Plate VIII-35. Historical Pool Elevations and Discharges, 1962

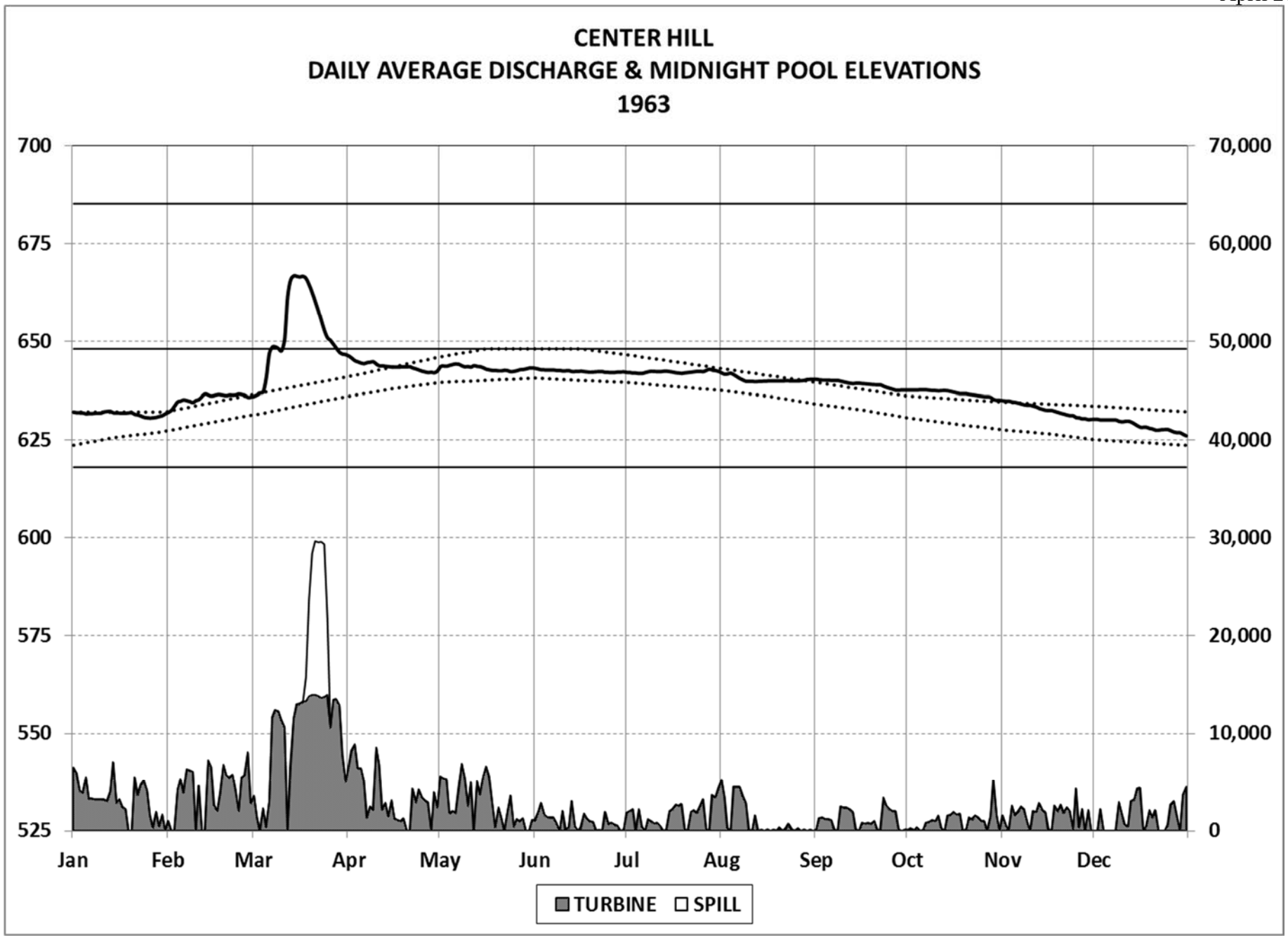

Plate VIII-36. Historical Pool Elevations and Discharges, 1963

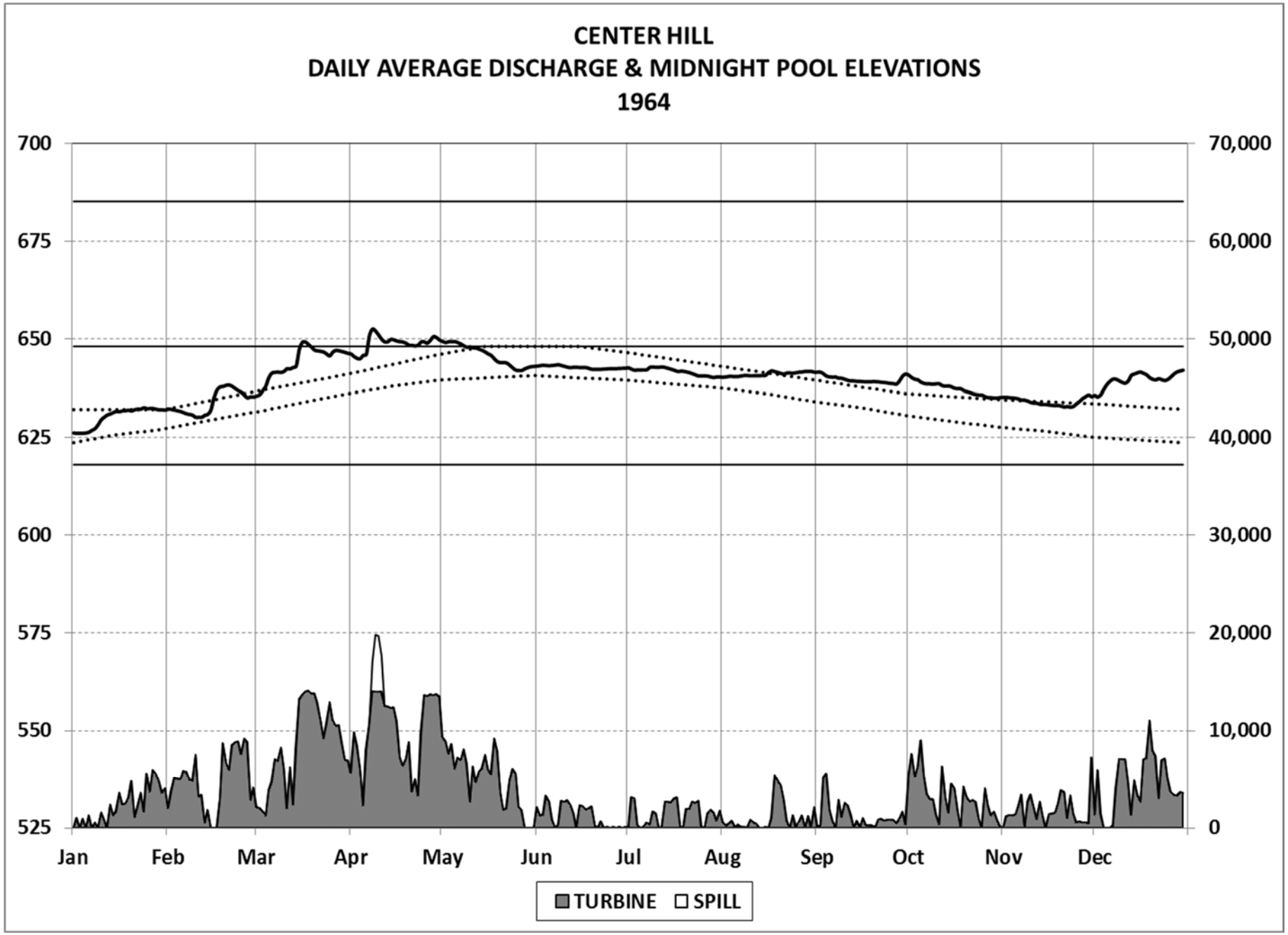

Plate VIII-37. Historical Pool Elevations and Discharges, 1964

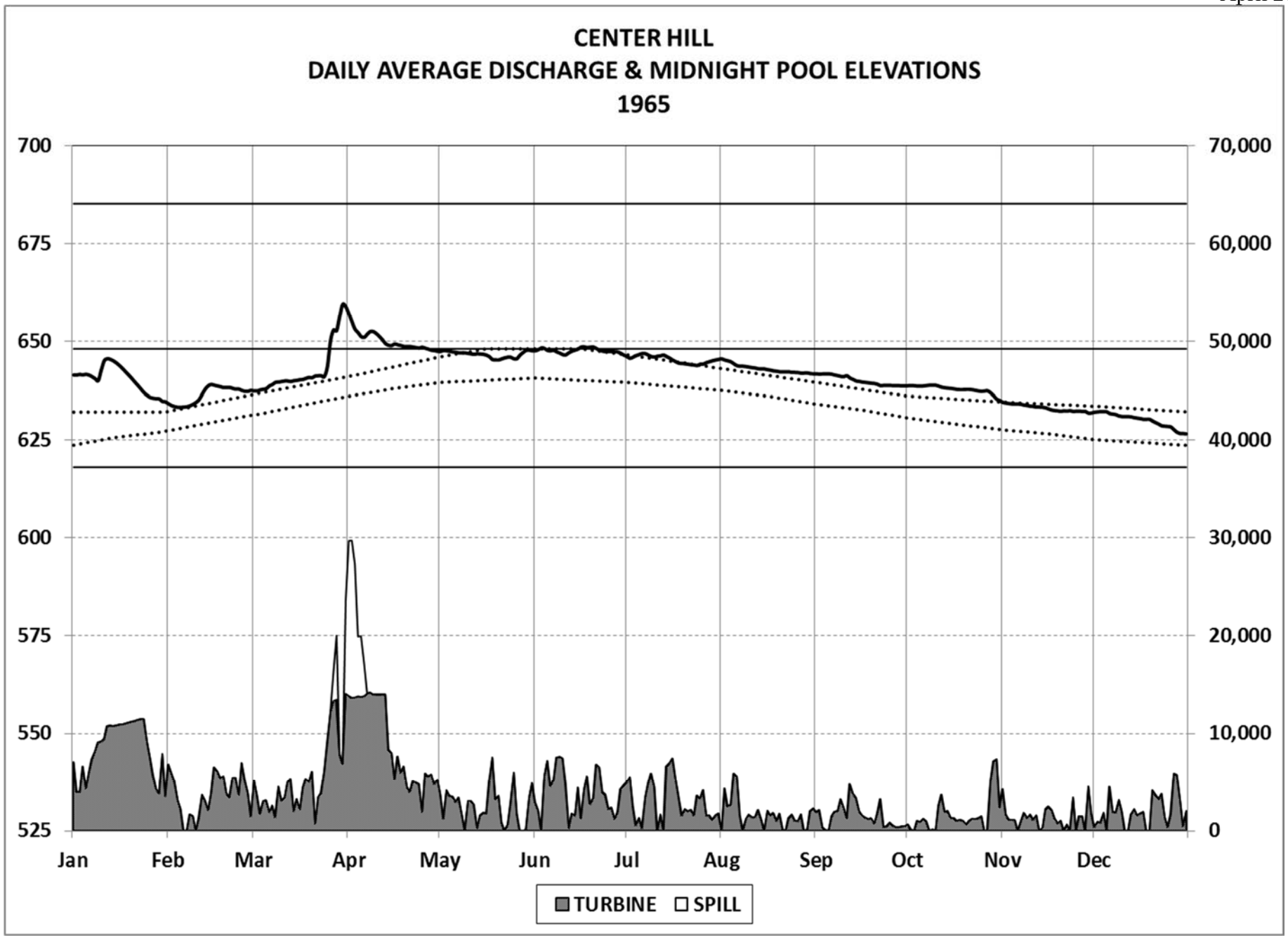

Plate VIII-38. Historical Pool Elevations and Discharges, 1965

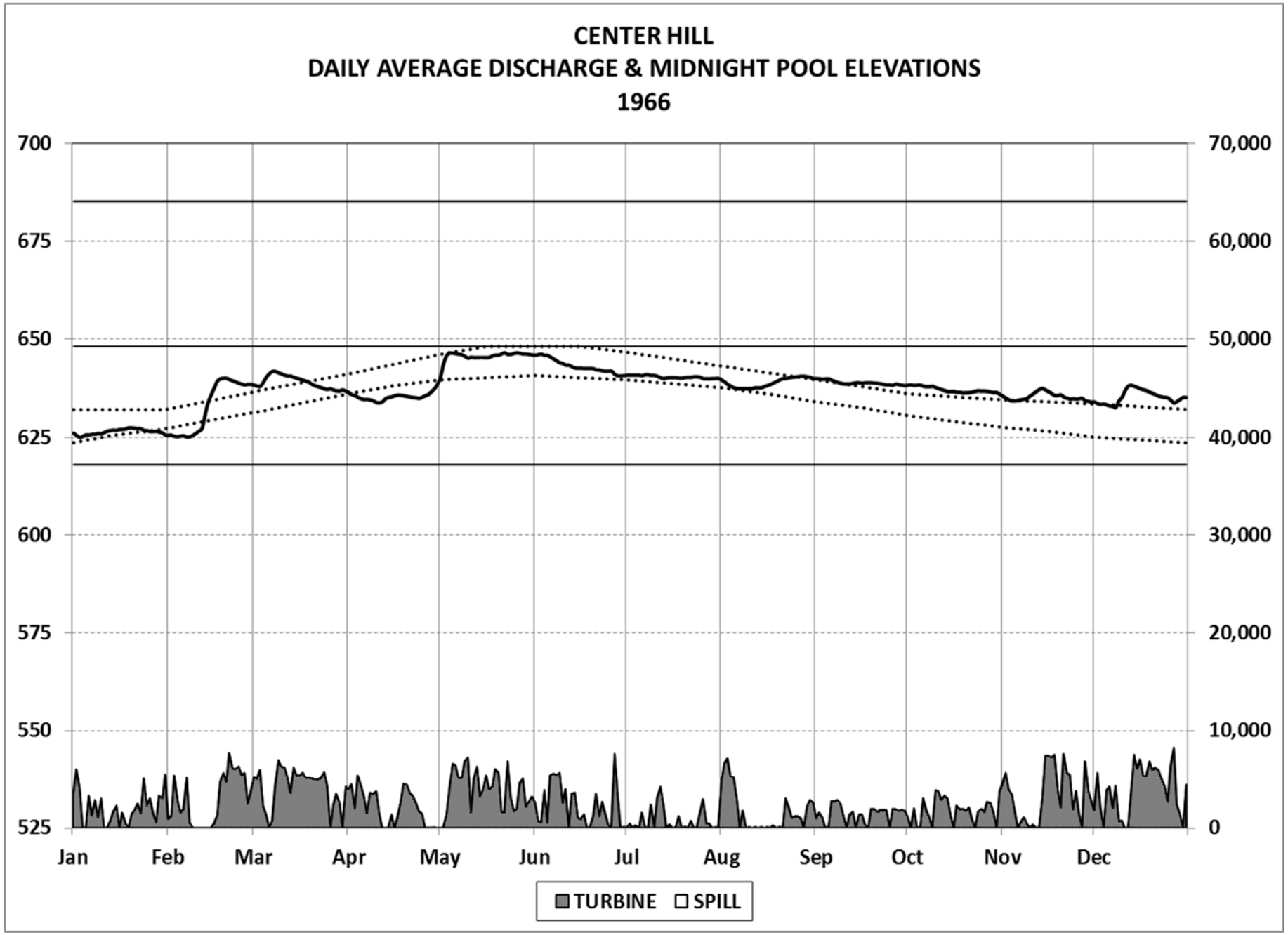

Plate VIII-39. Historical Pool Elevations and Discharges, 1966

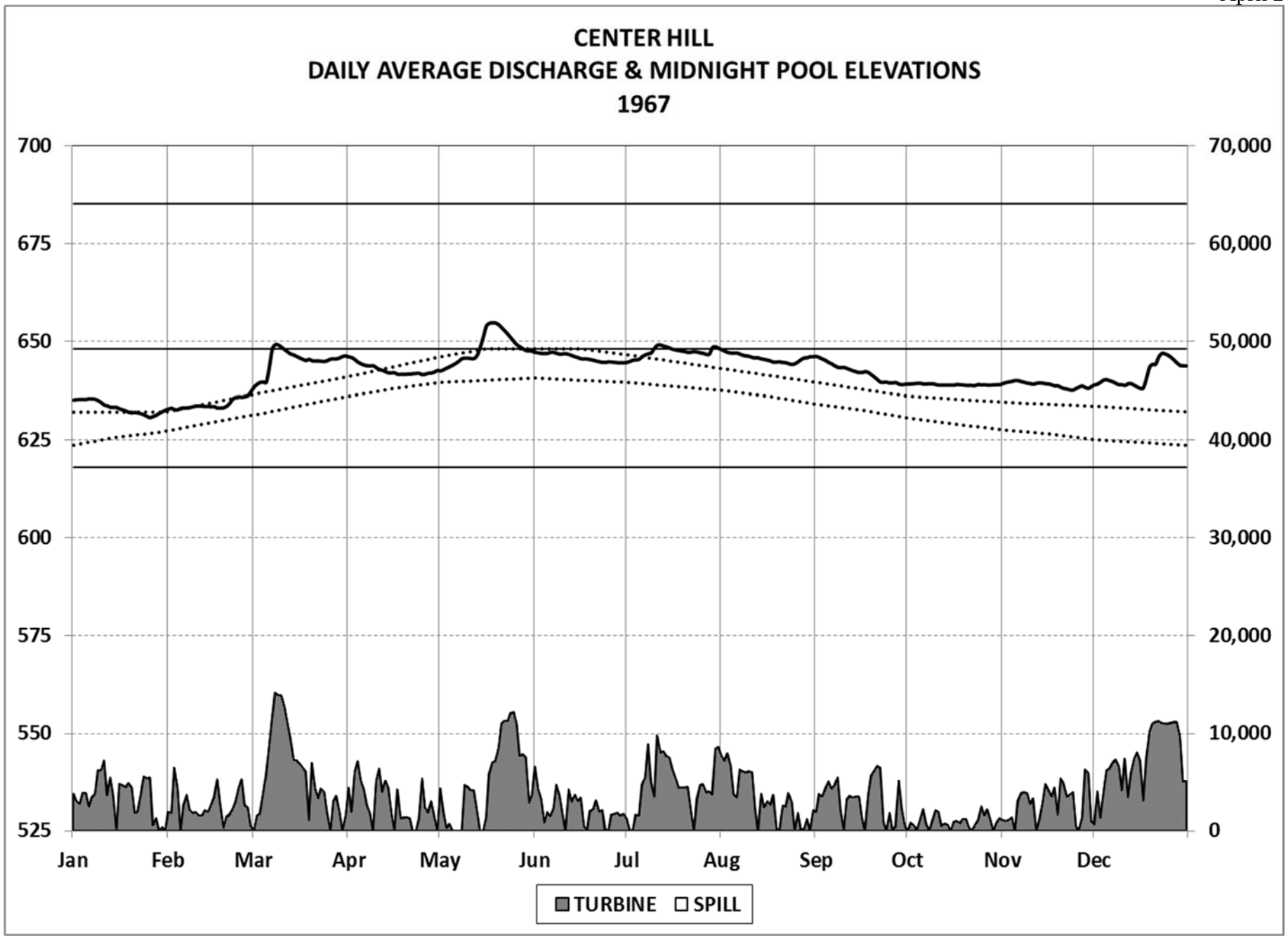

Plate VIII-40. Historical Pool Elevations and Discharges, 1967

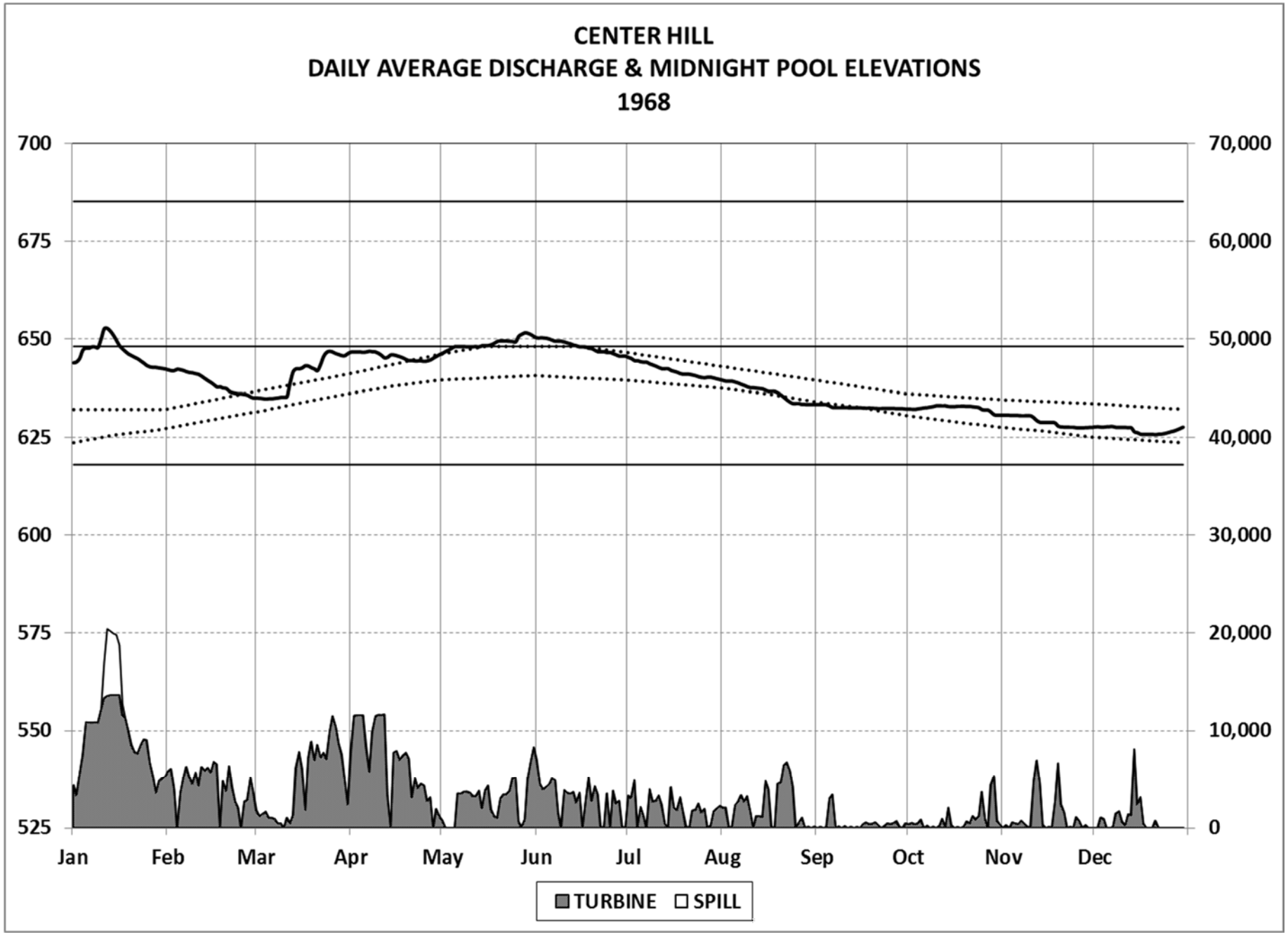

Plate VIII-41. Historical Pool Elevations and Discharges, 1968

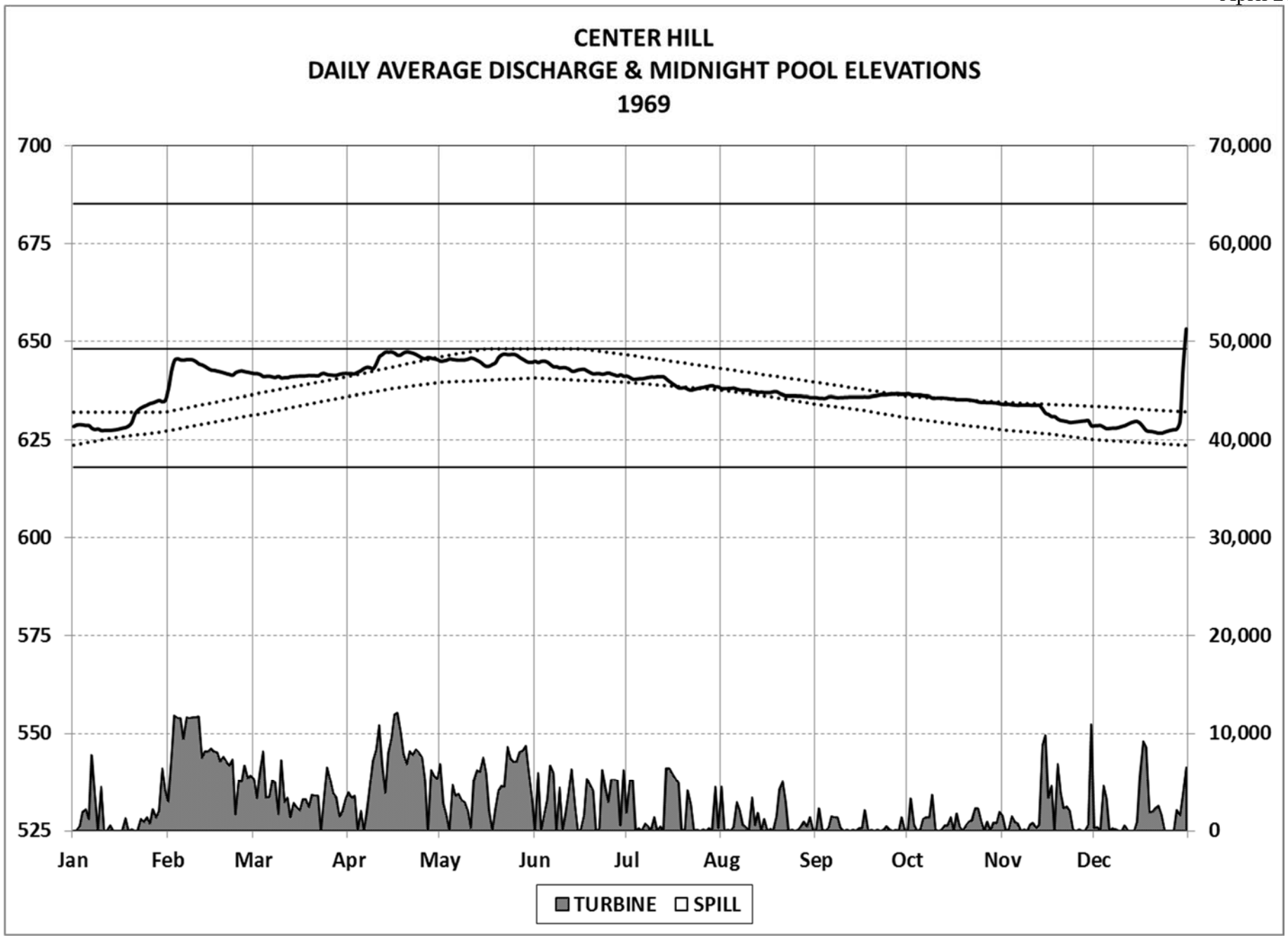

Plate VIII-42. Historical Pool Elevations and Discharges, 1969

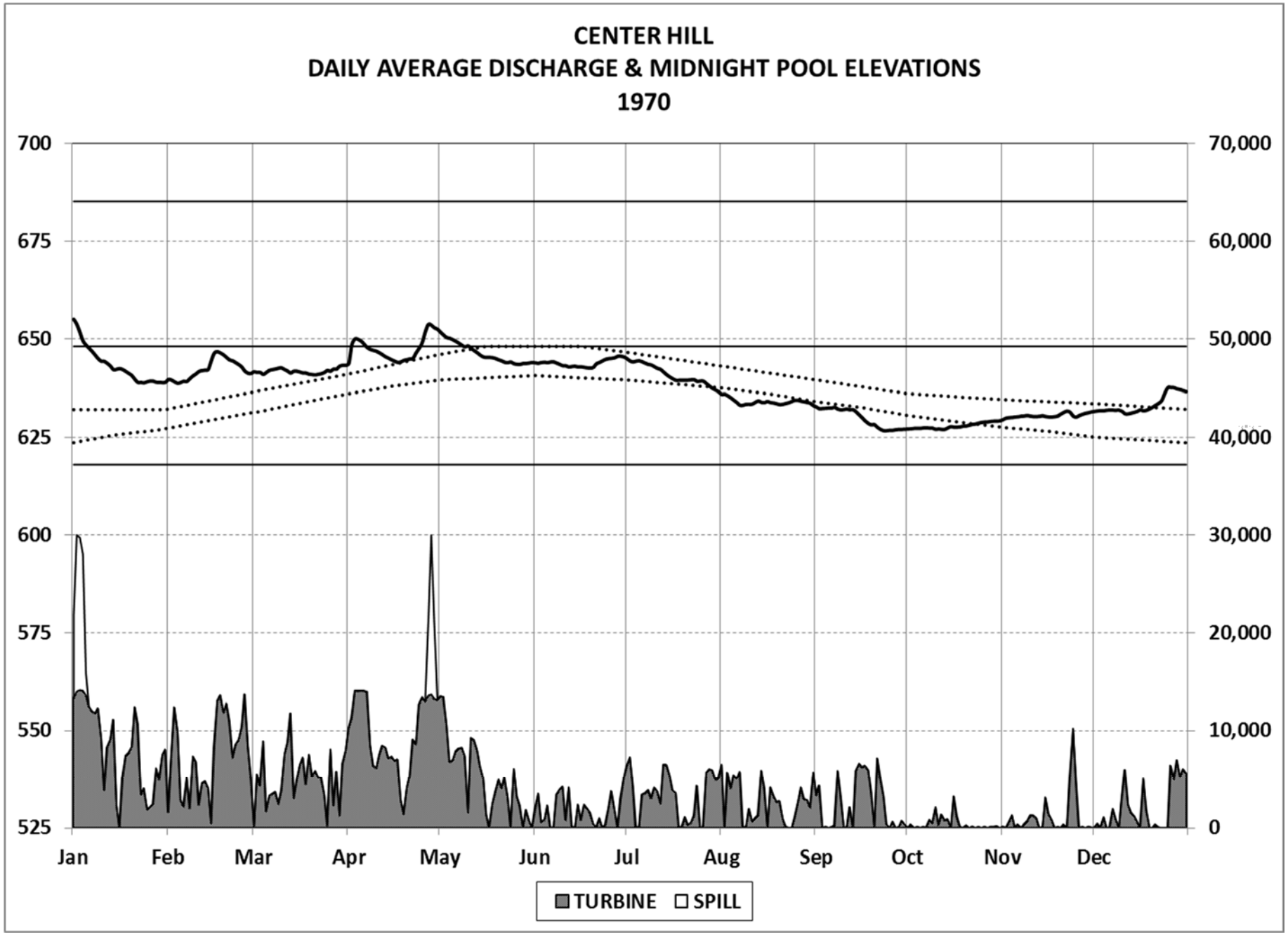

Plate VIII-43. Historical Pool Elevations and Discharges, 1970

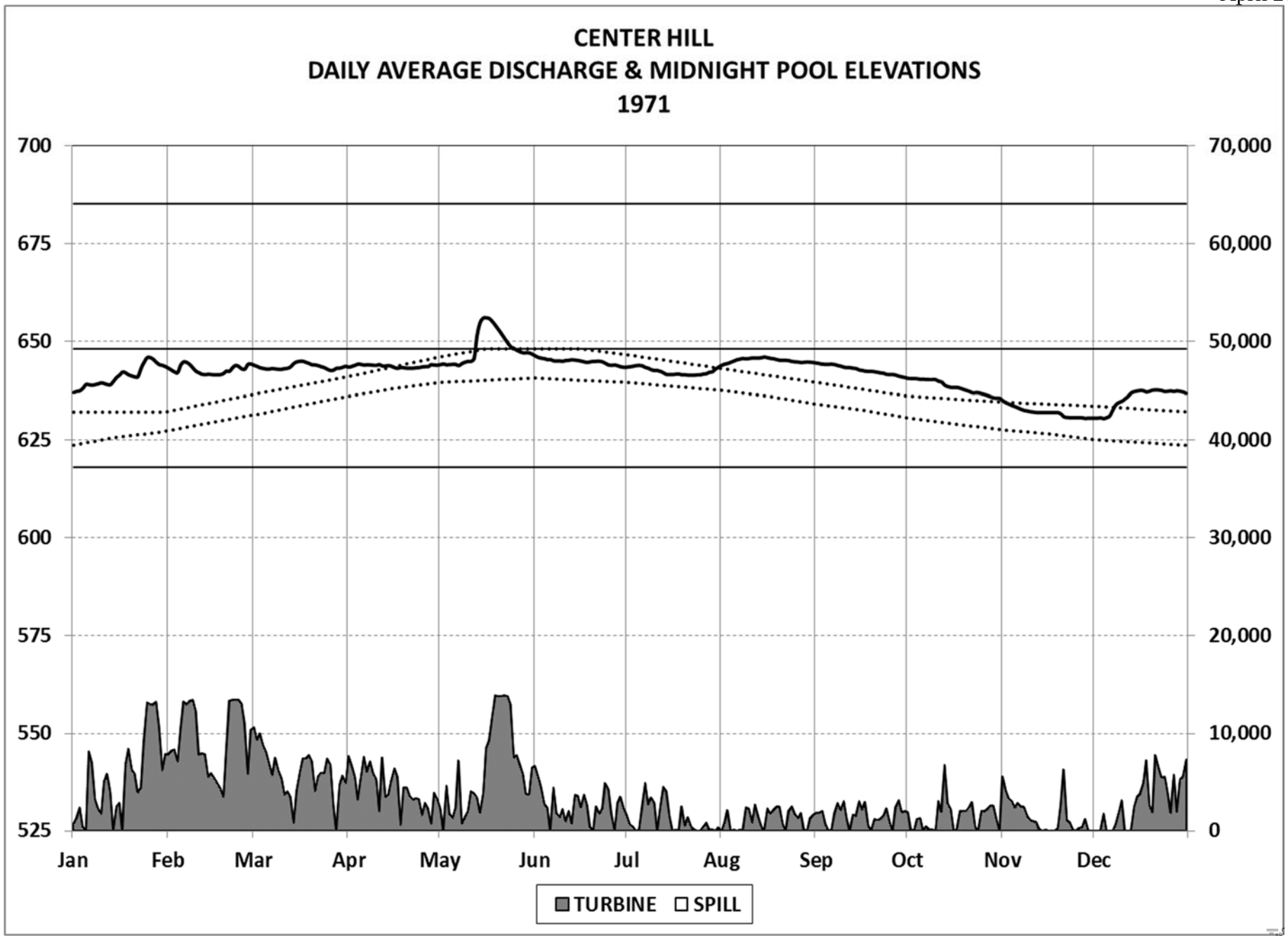

Plate VIII-44. Historical Pool Elevations and Discharges, 1971

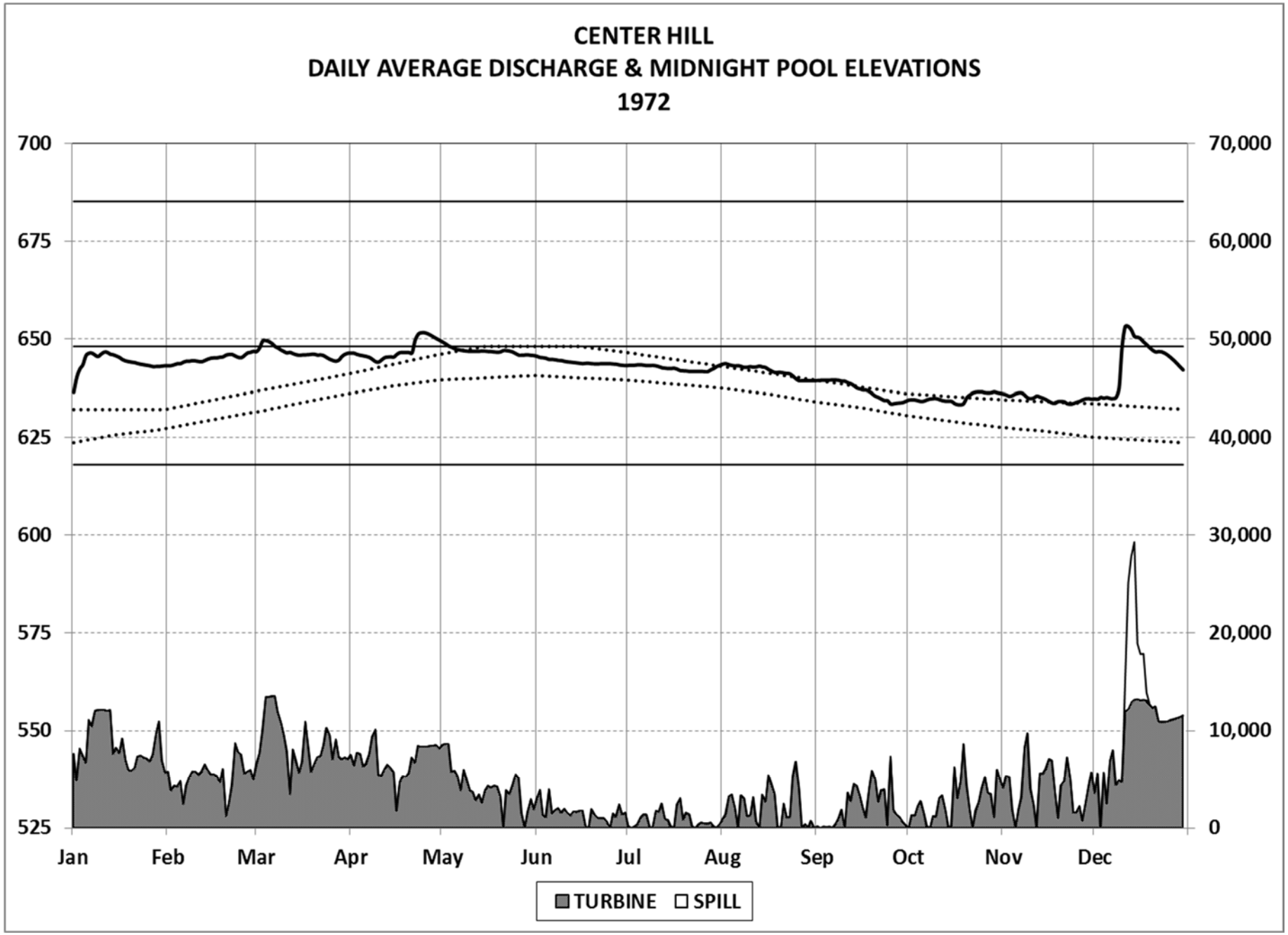

Plate VIII-45. Historical Pool Elevations and Discharges, 1972

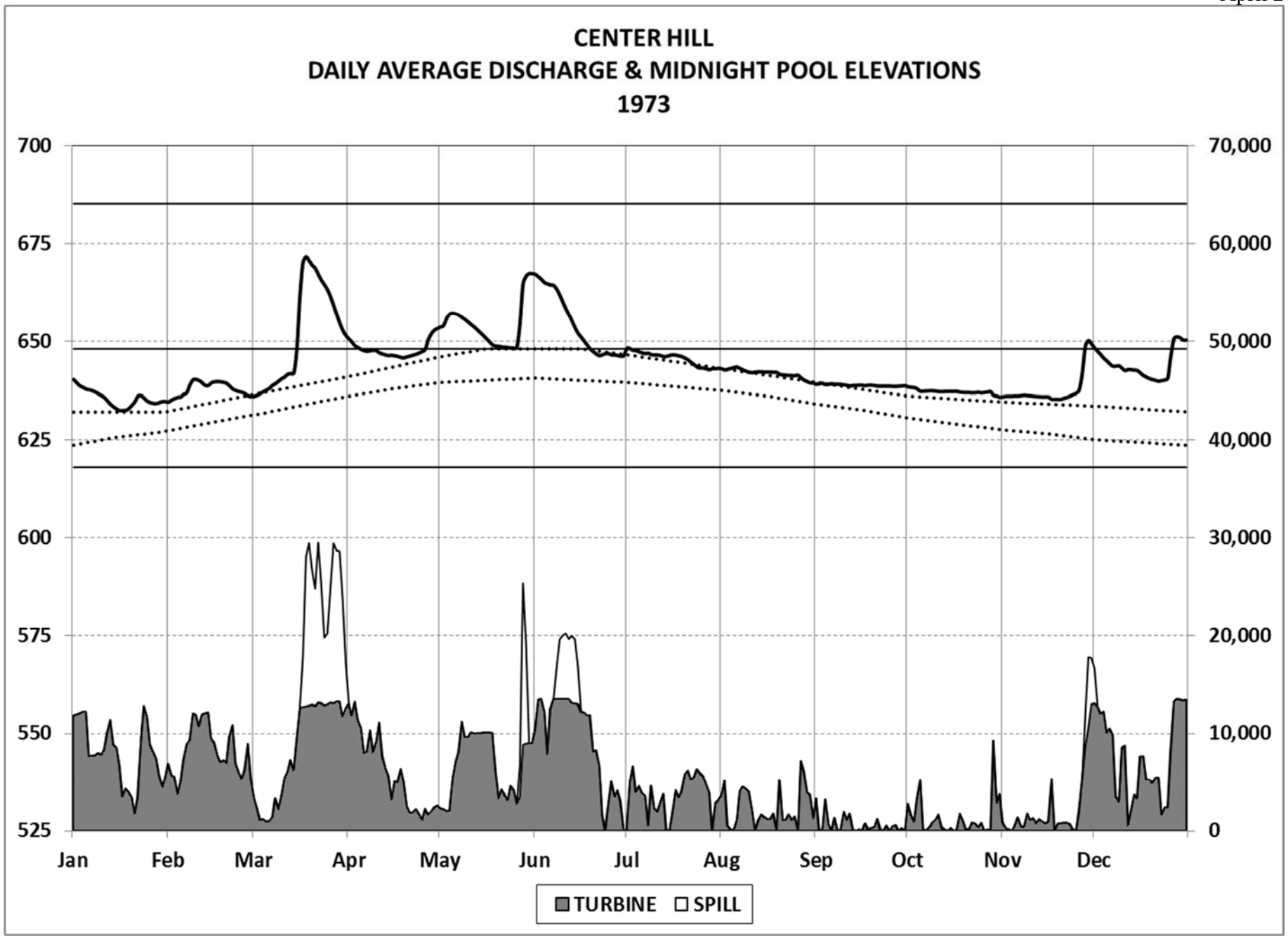

Plate VIII-46. Historical Pool Elevations and Discharges, 1973

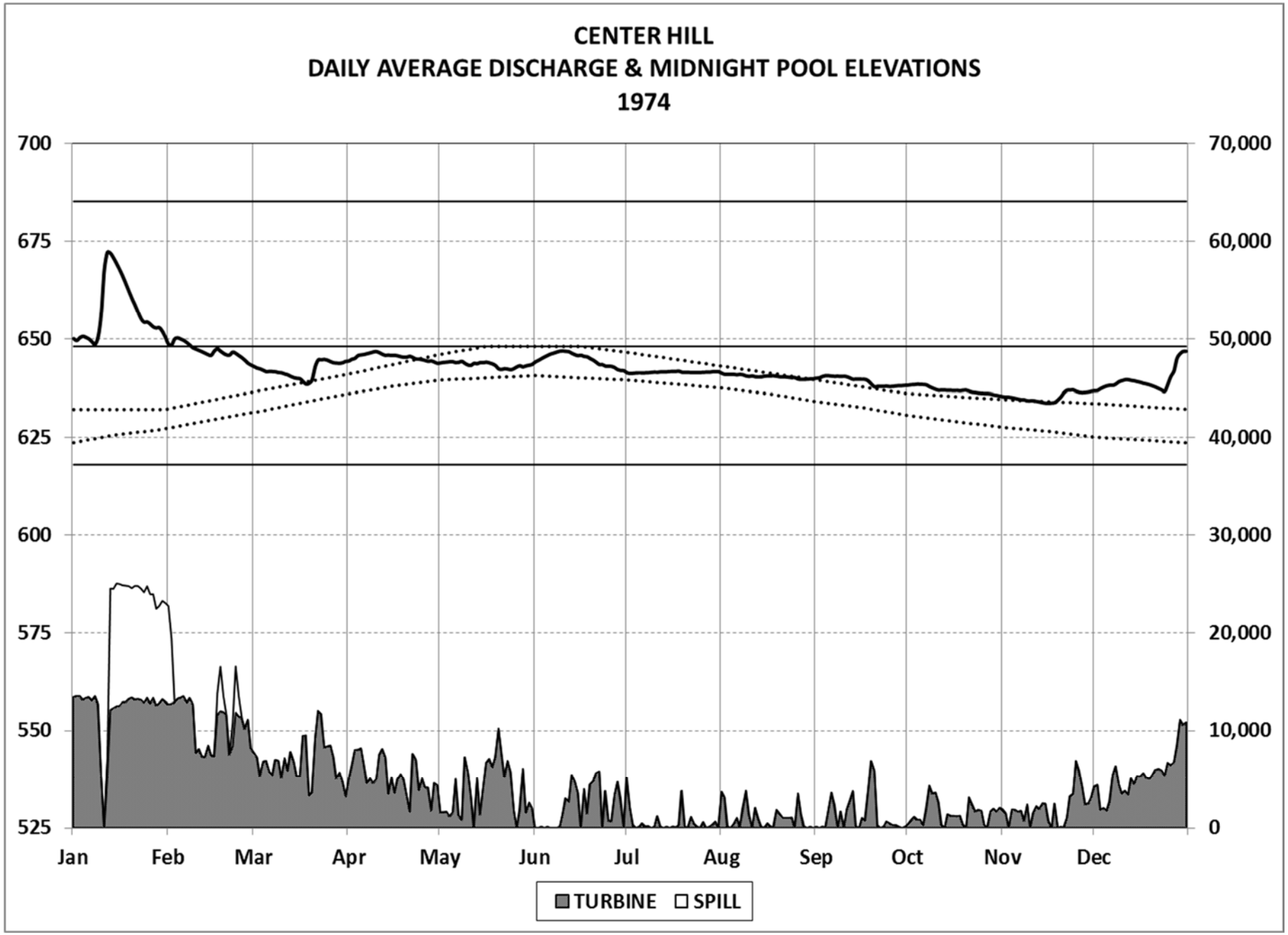

Plate VIII-47. Historical Pool Elevations and Discharges, 1974

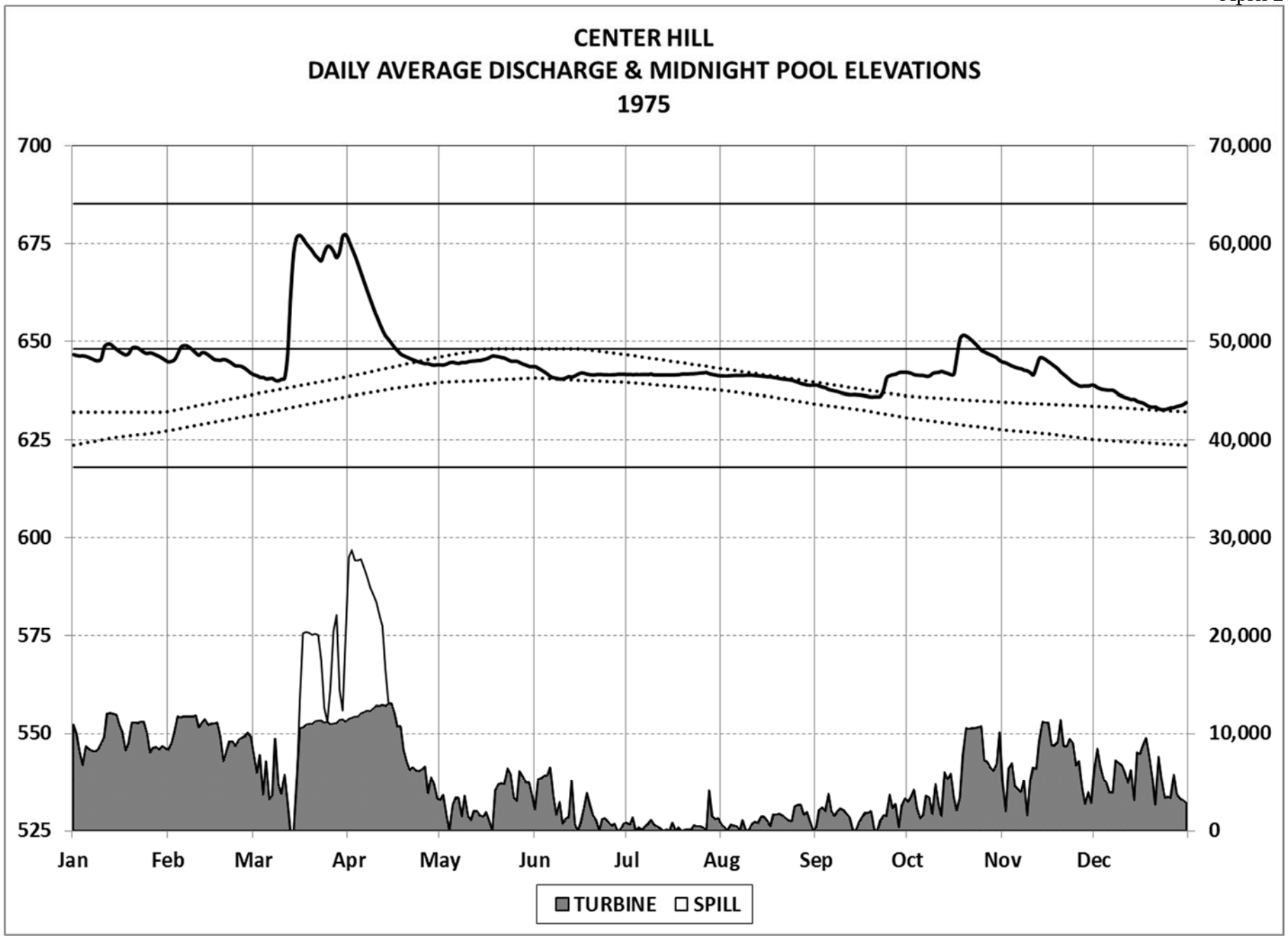

Plate VIII-48. Historical Pool Elevations and Discharges, 1975

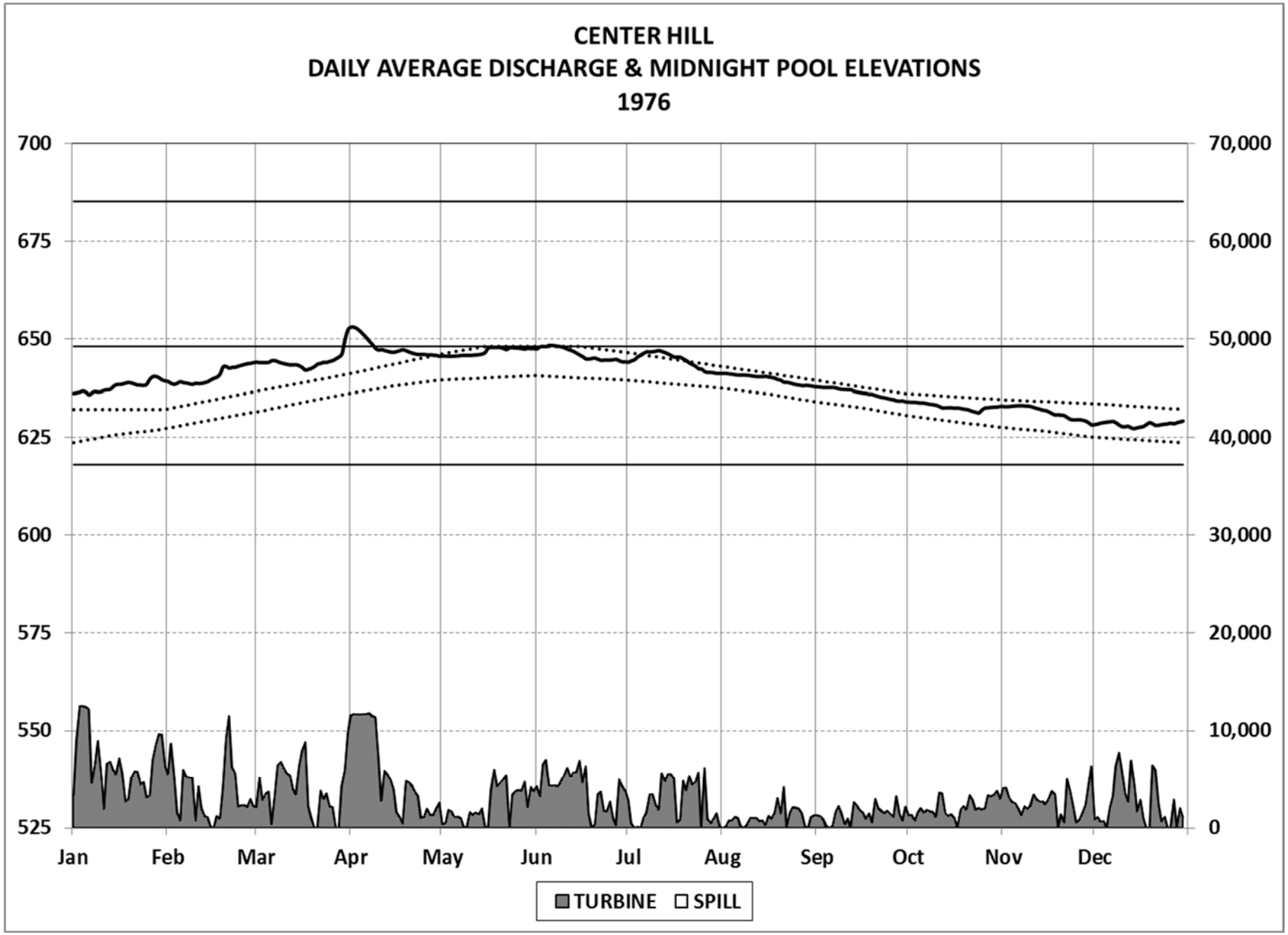

Plate VIII-49. Historical Pool Elevations and Discharges, 1976

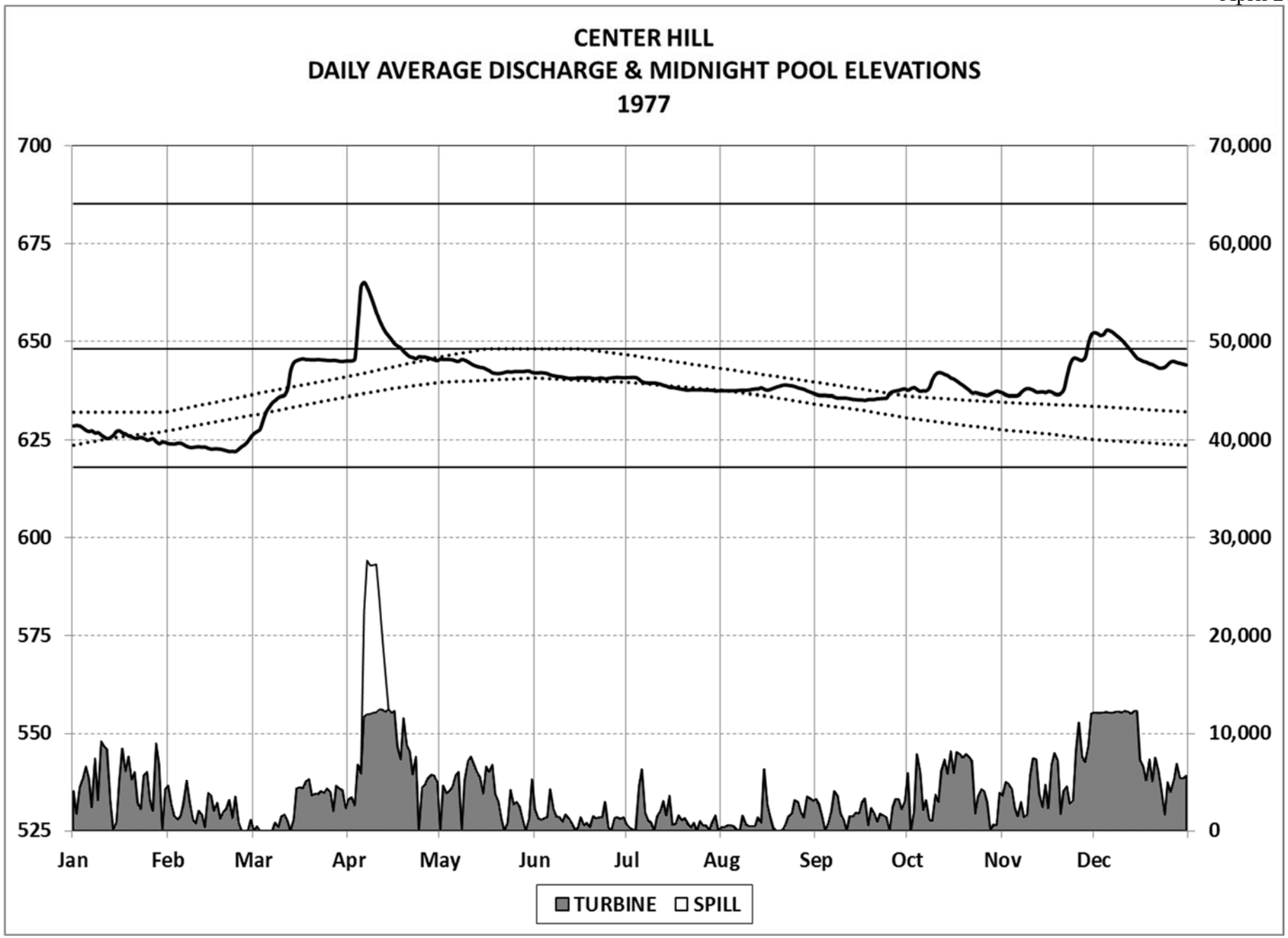

Plate VIII-50. Historical Pool Elevations and Discharges, 1977

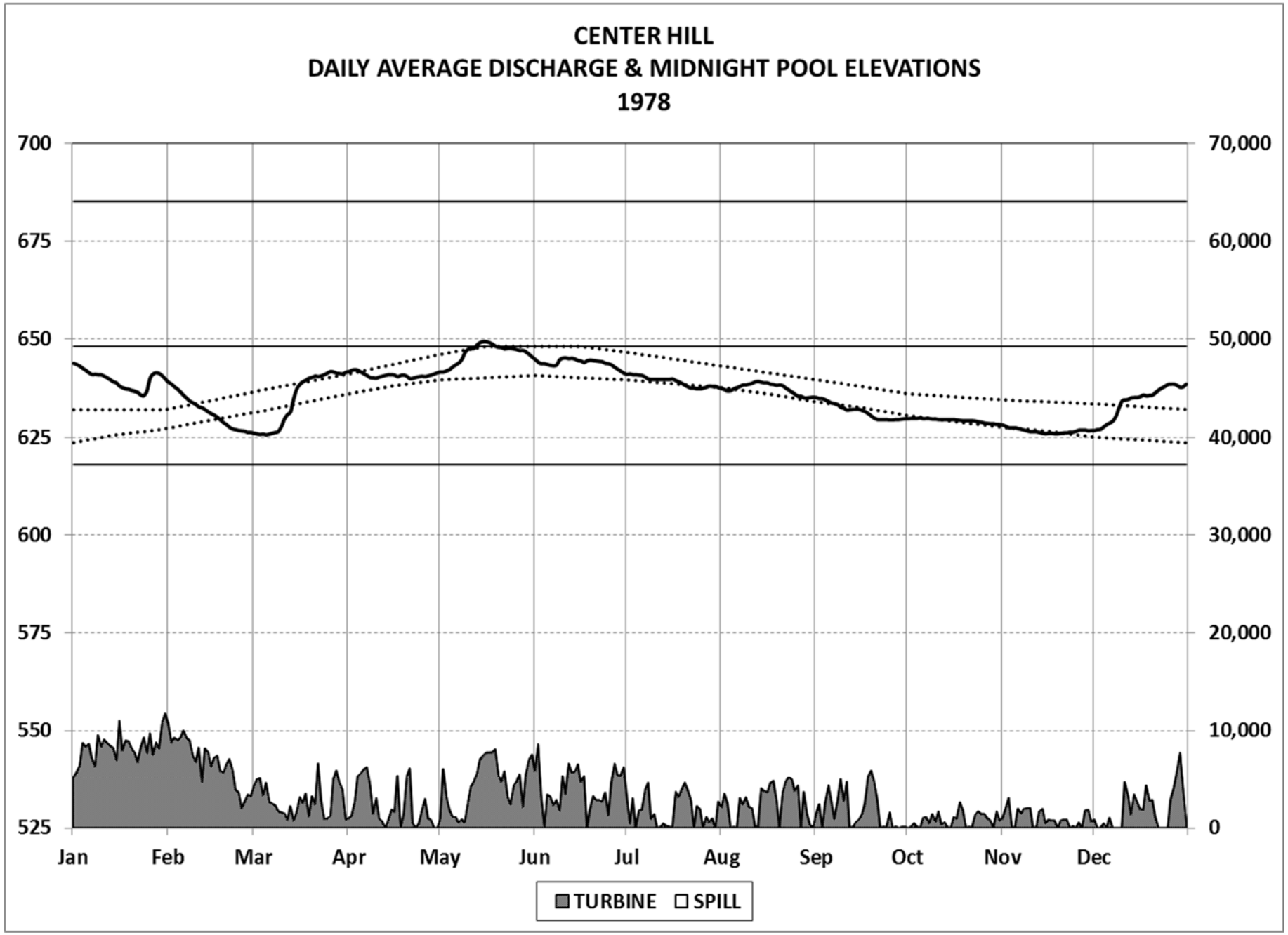

Plate VIII-51. Historical Pool Elevations and Discharges, 1978

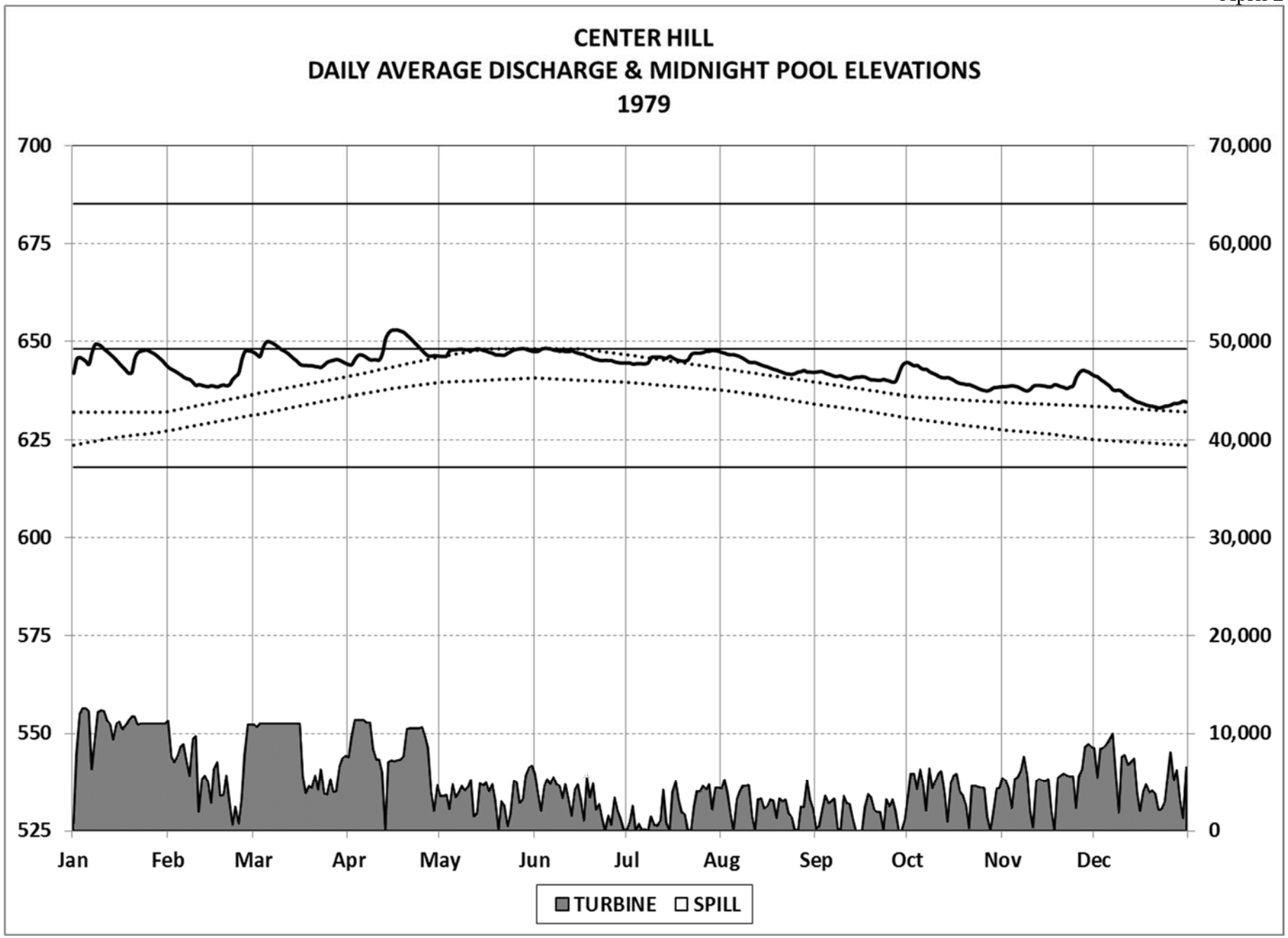

Plate VIII-52. Historical Pool Elevations and Discharges, 1979

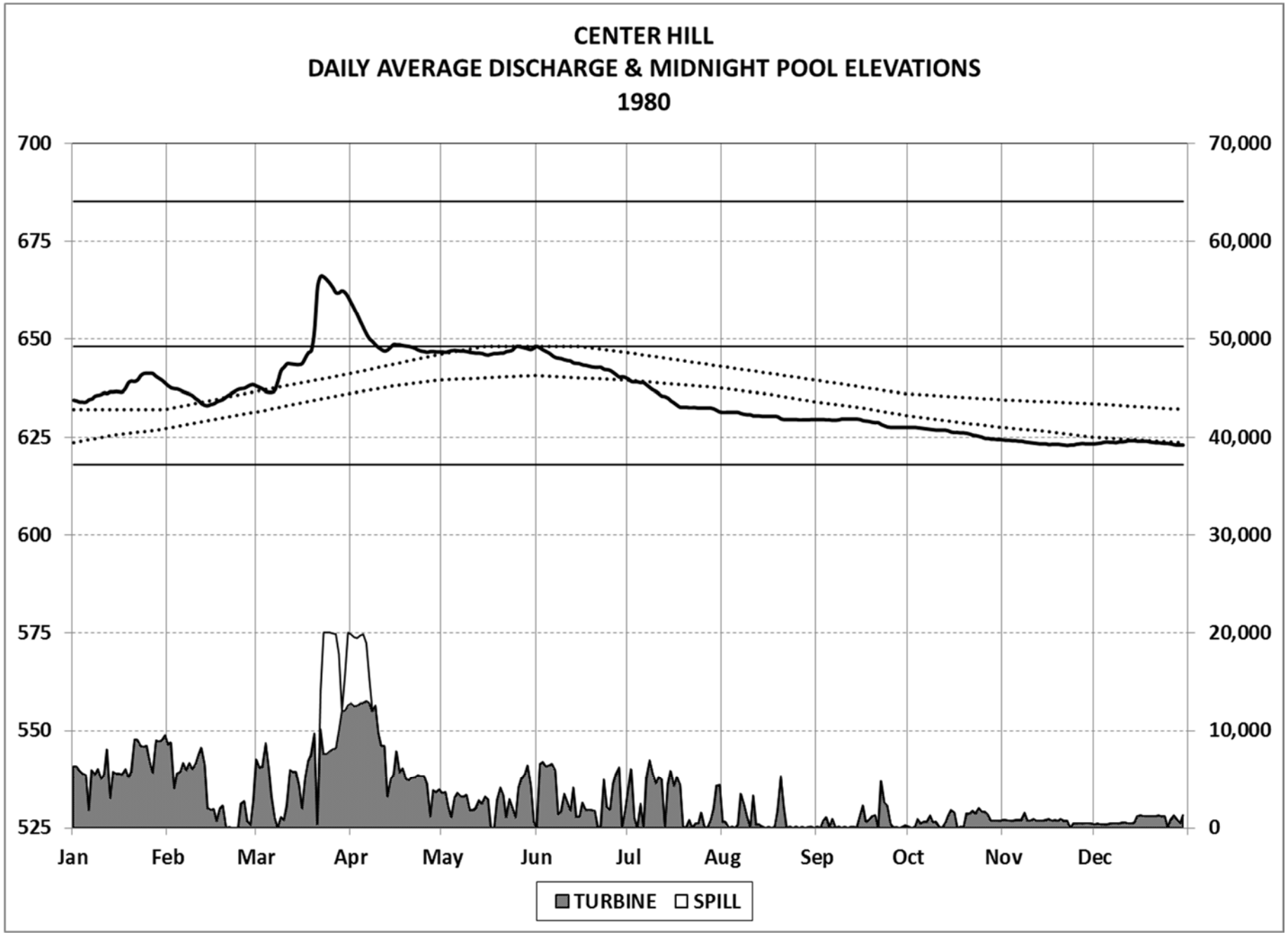

Plate VIII-53. Historical Pool Elevations and Discharges, 1980

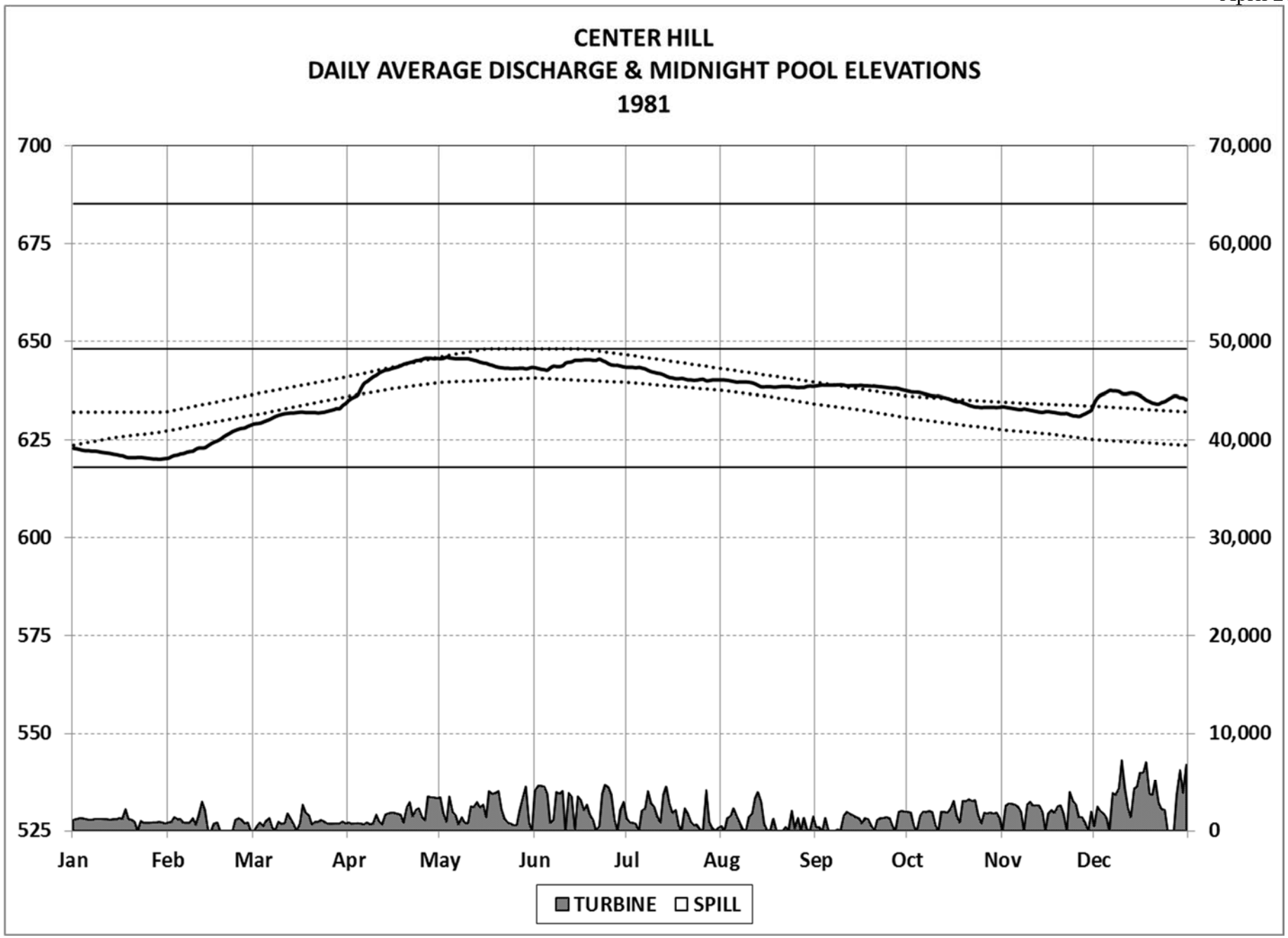

Plate VIII-54. Historical Pool Elevations and Discharges, 1981

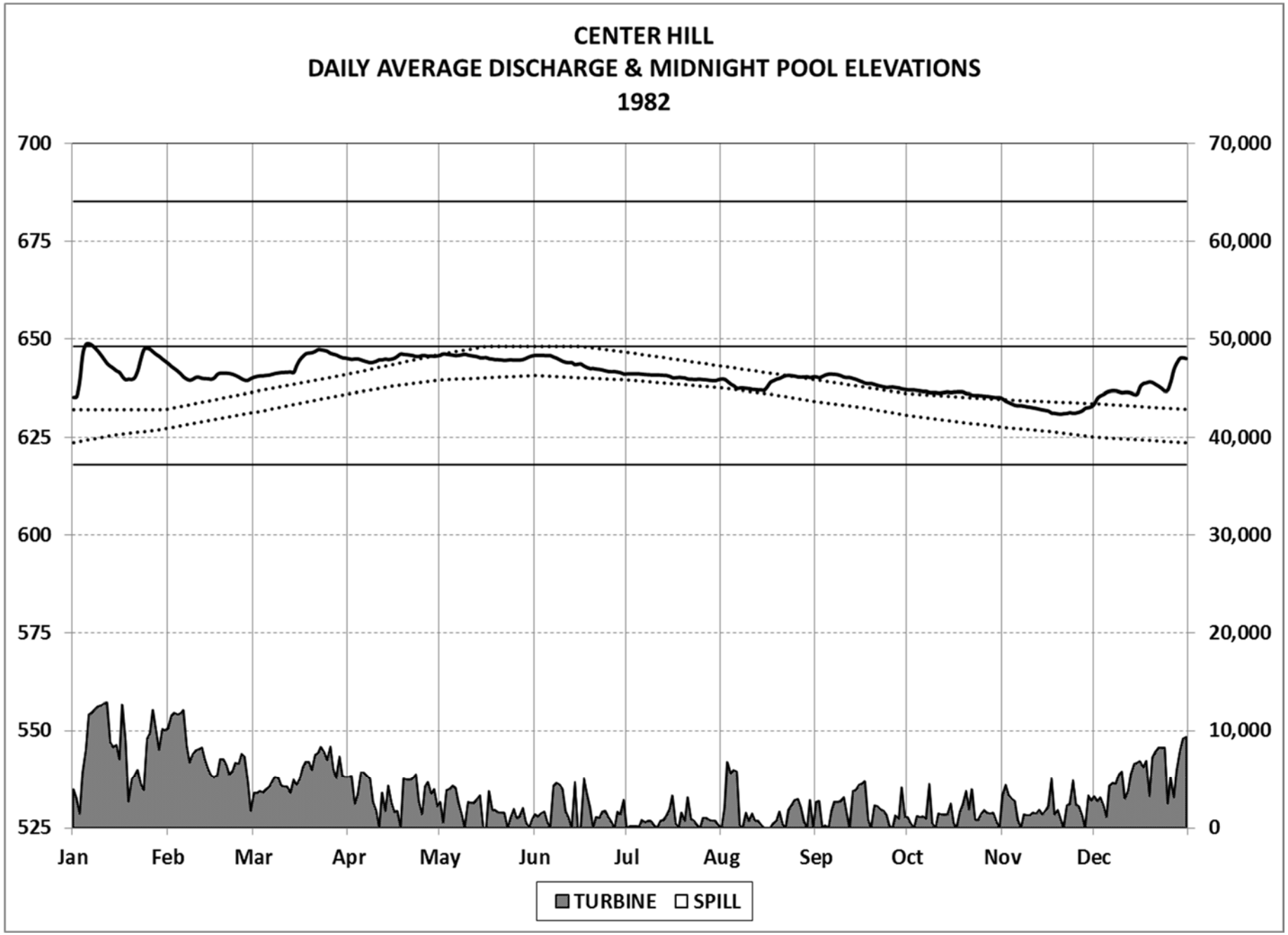

Plate VIII-55. Historical Pool Elevations and Discharges, 1982

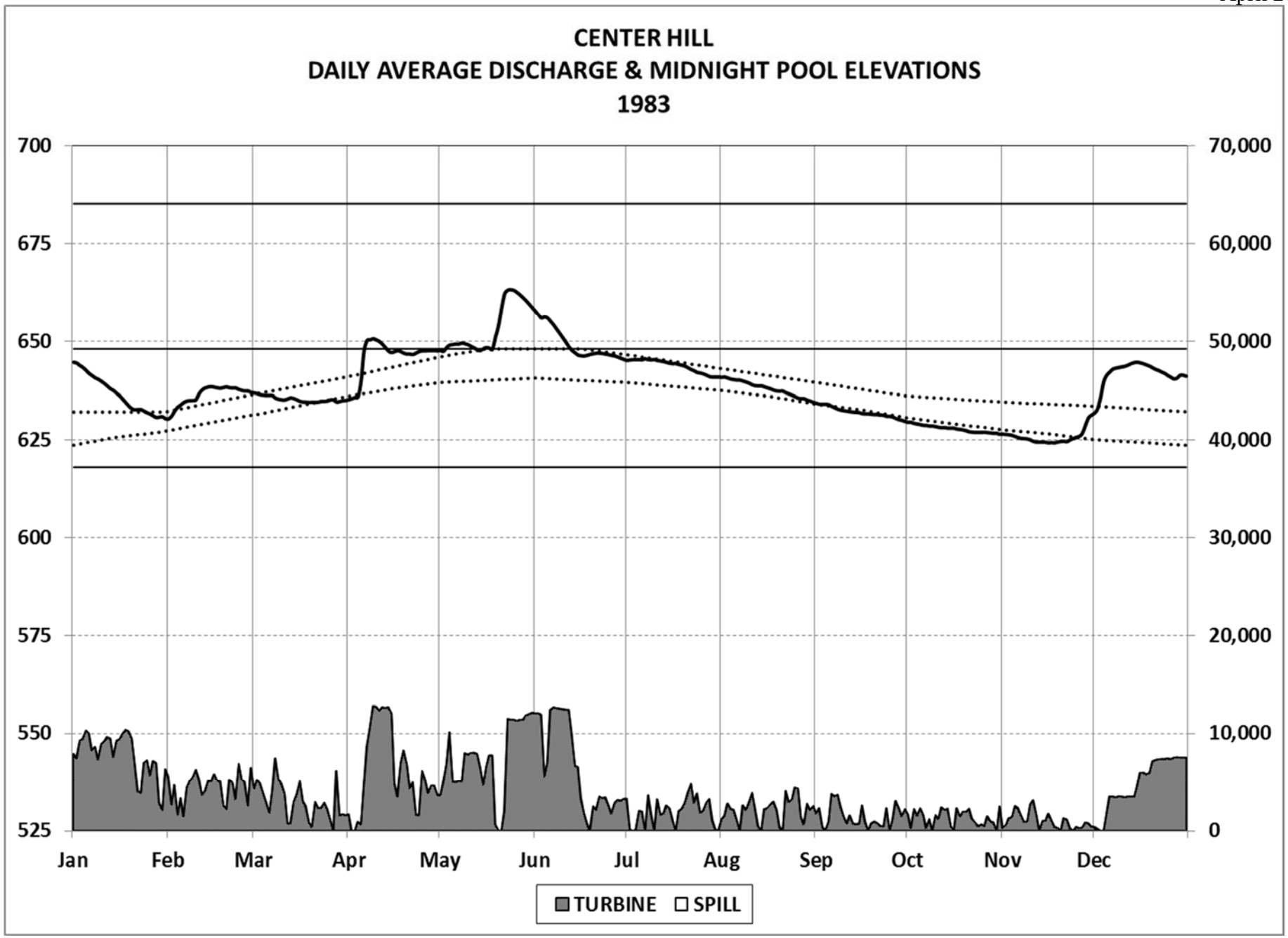

Plate VIII-56. Historical Pool Elevations and Discharges, 1983

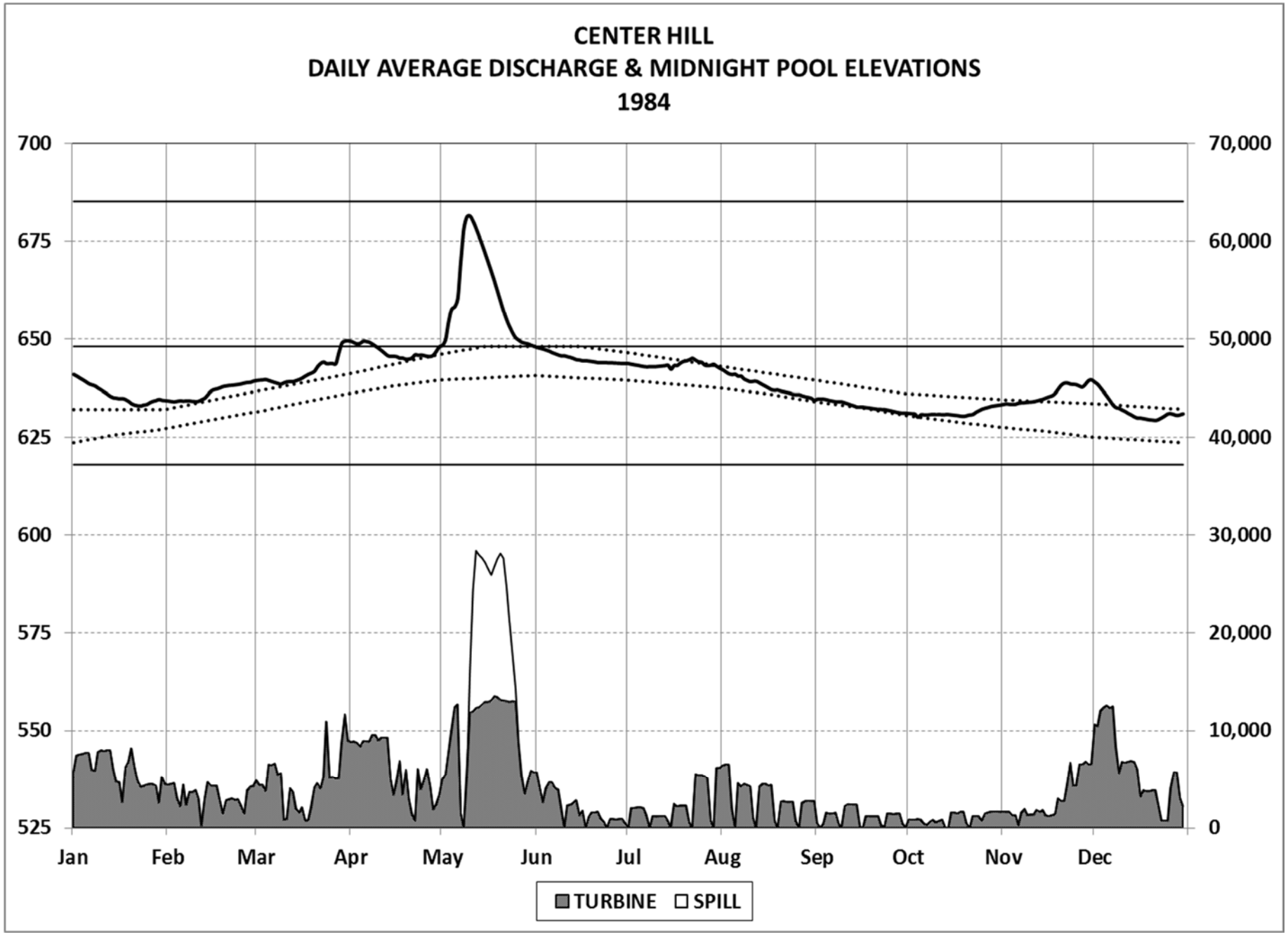

Plate VIII-57. Historical Pool Elevations and Discharges, 1984

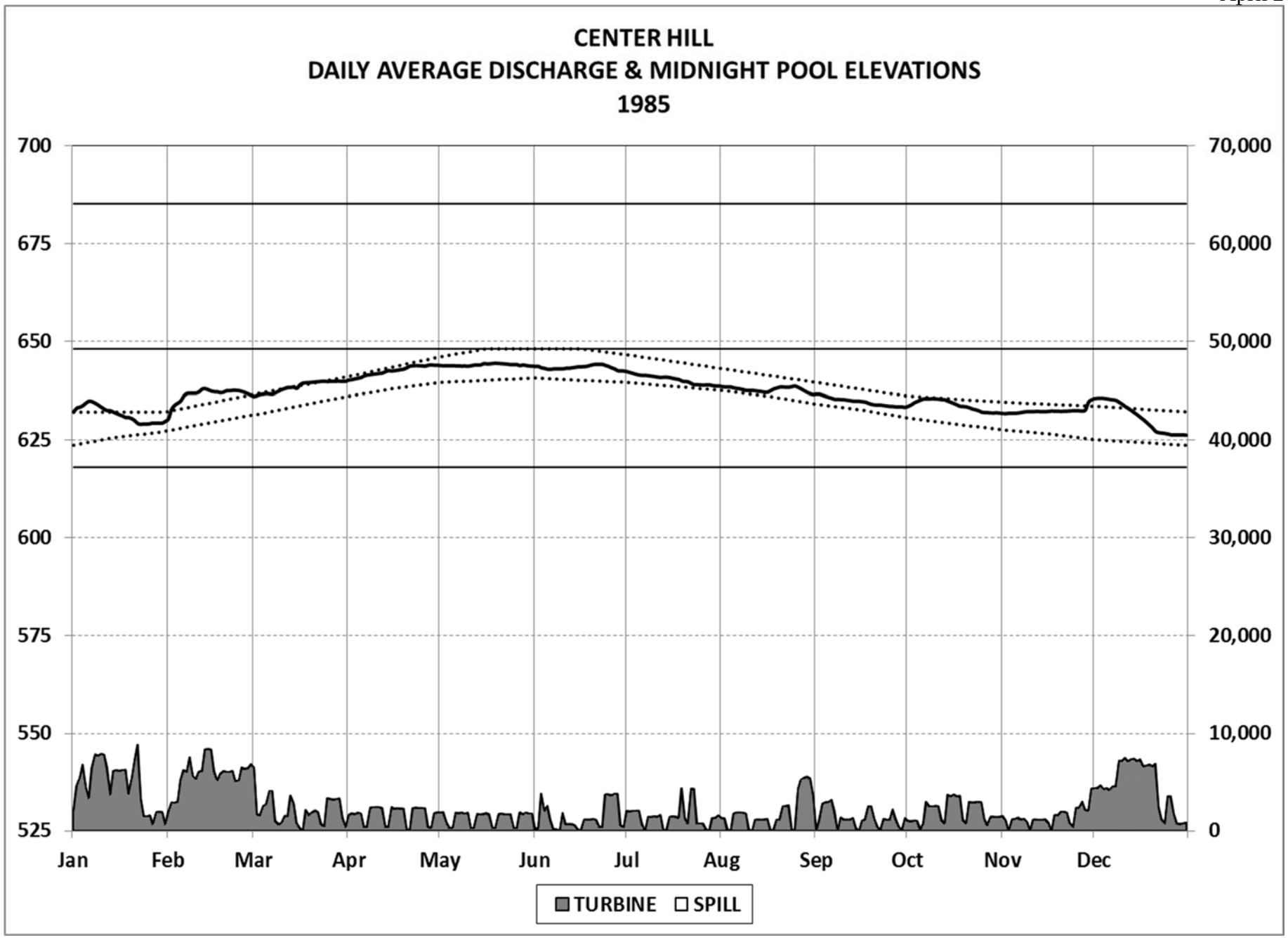

Plate VIII-58. Historical Pool Elevations and Discharges, 1985

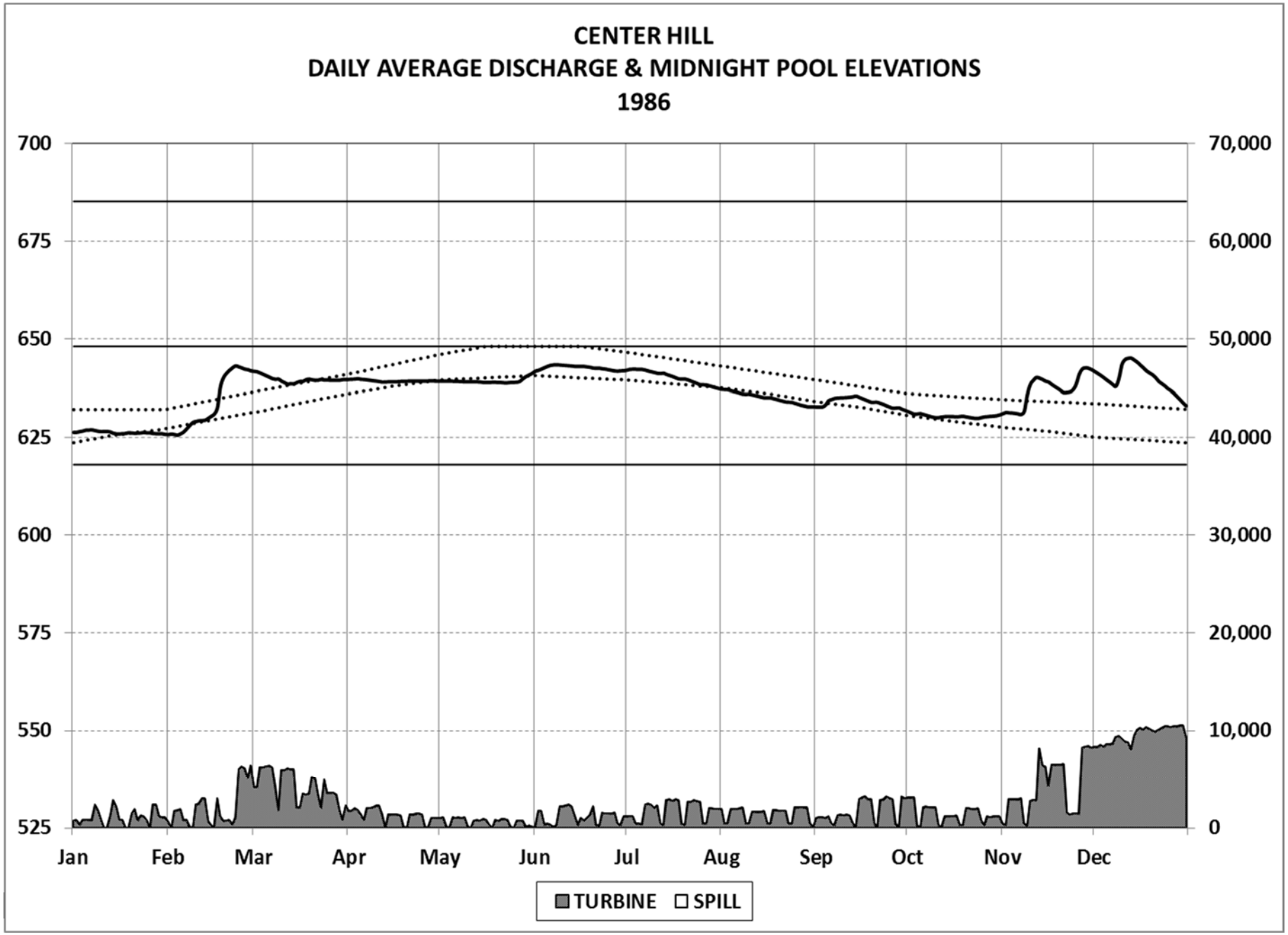

Plate VIII-59. Historical Pool Elevations and Discharges, 1986

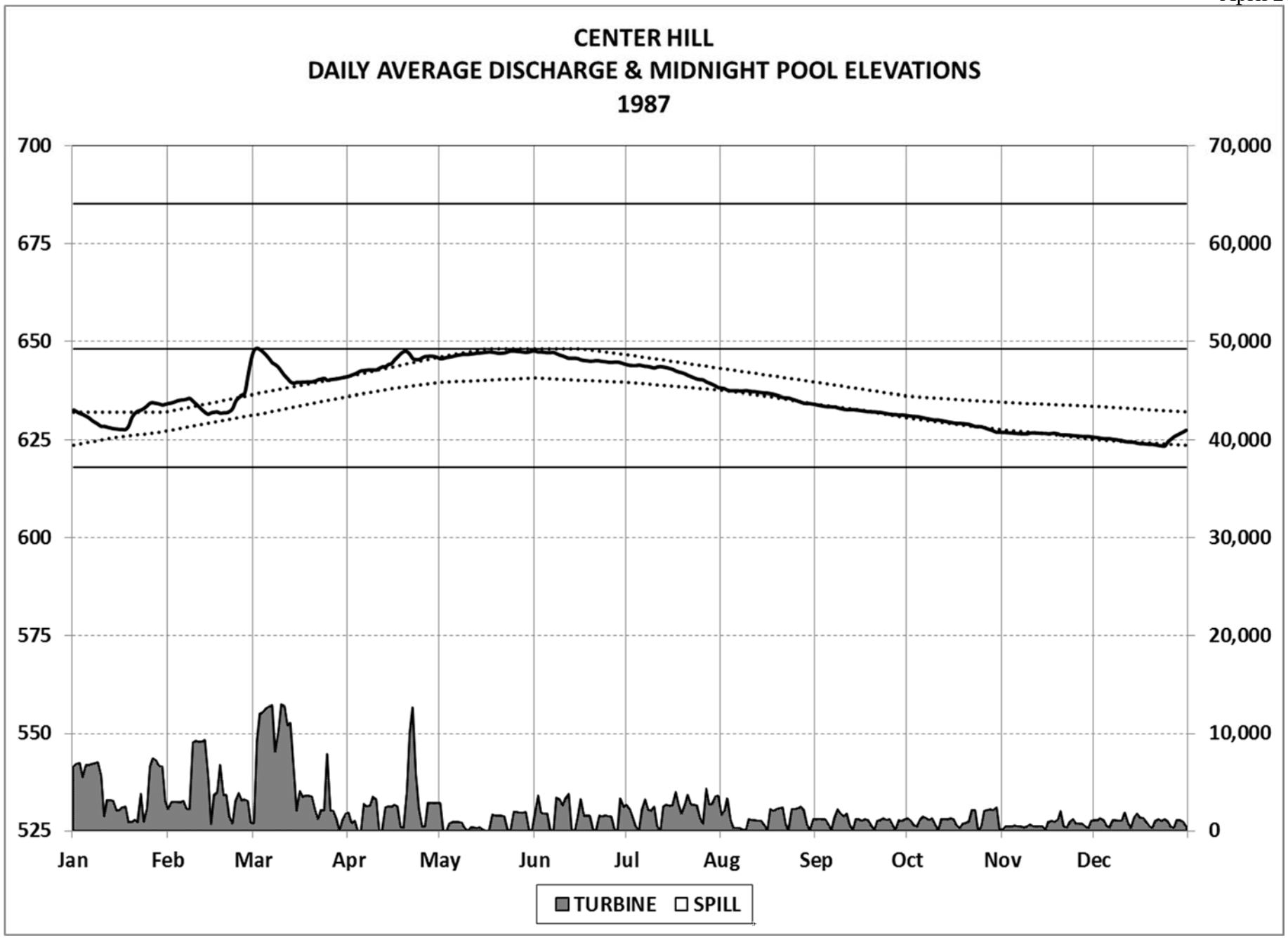

Plate VIII-60. Historical Pool Elevations and Discharges, 1987

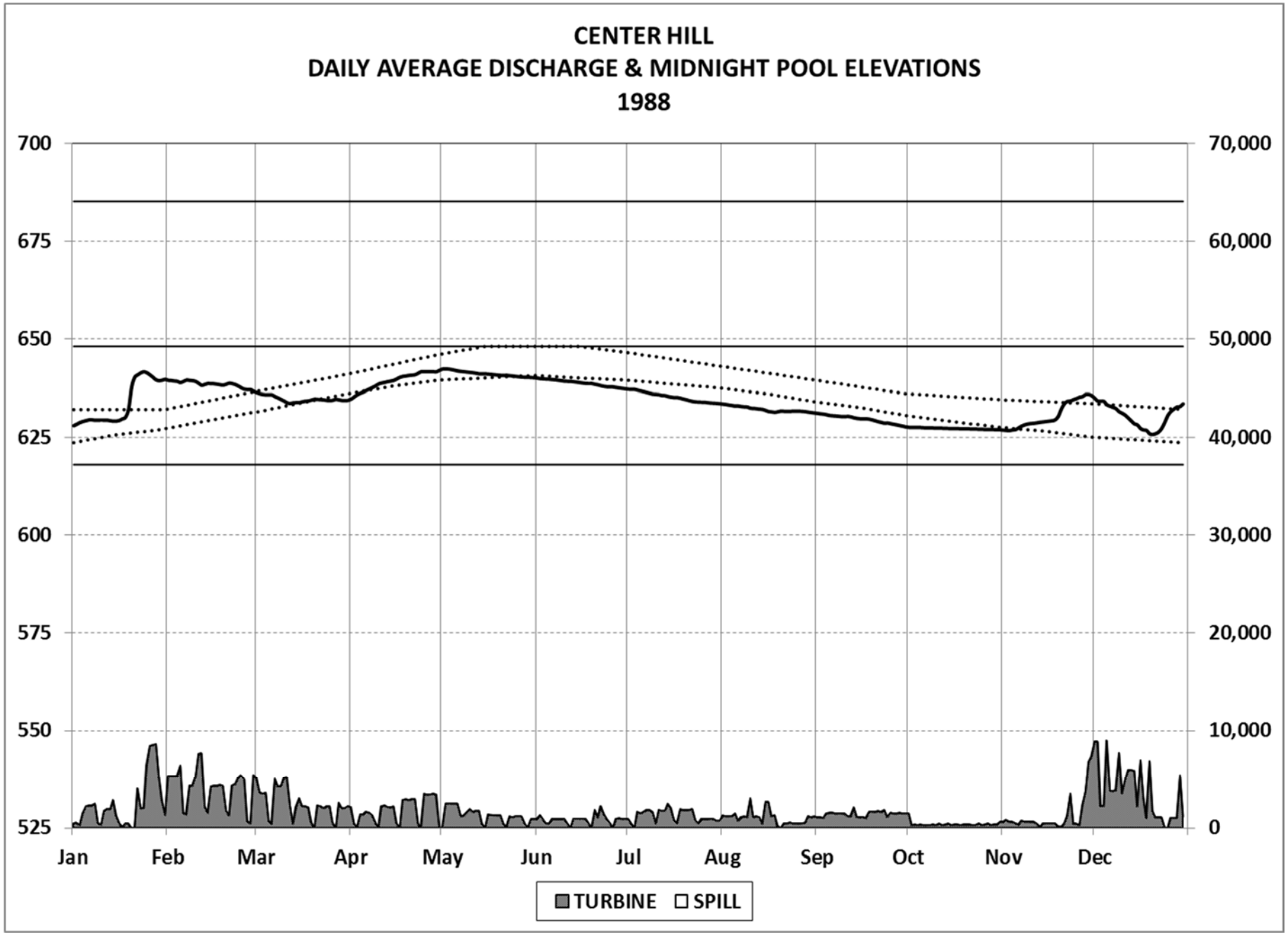

Plate VIII-61. Historical Pool Elevations and Discharges, 1988

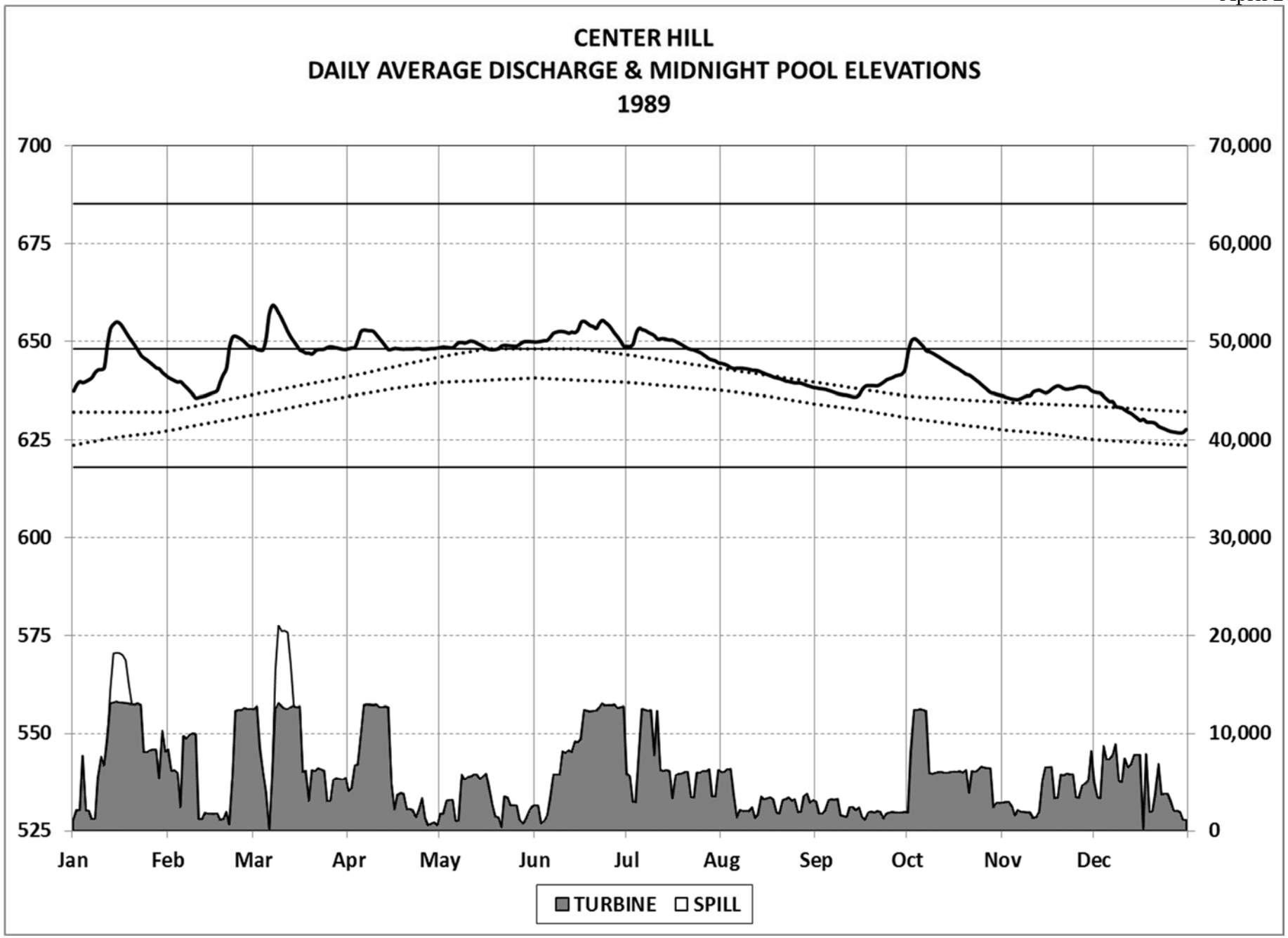

Plate VIII-62. Historical Pool Elevations and Discharges, 1989

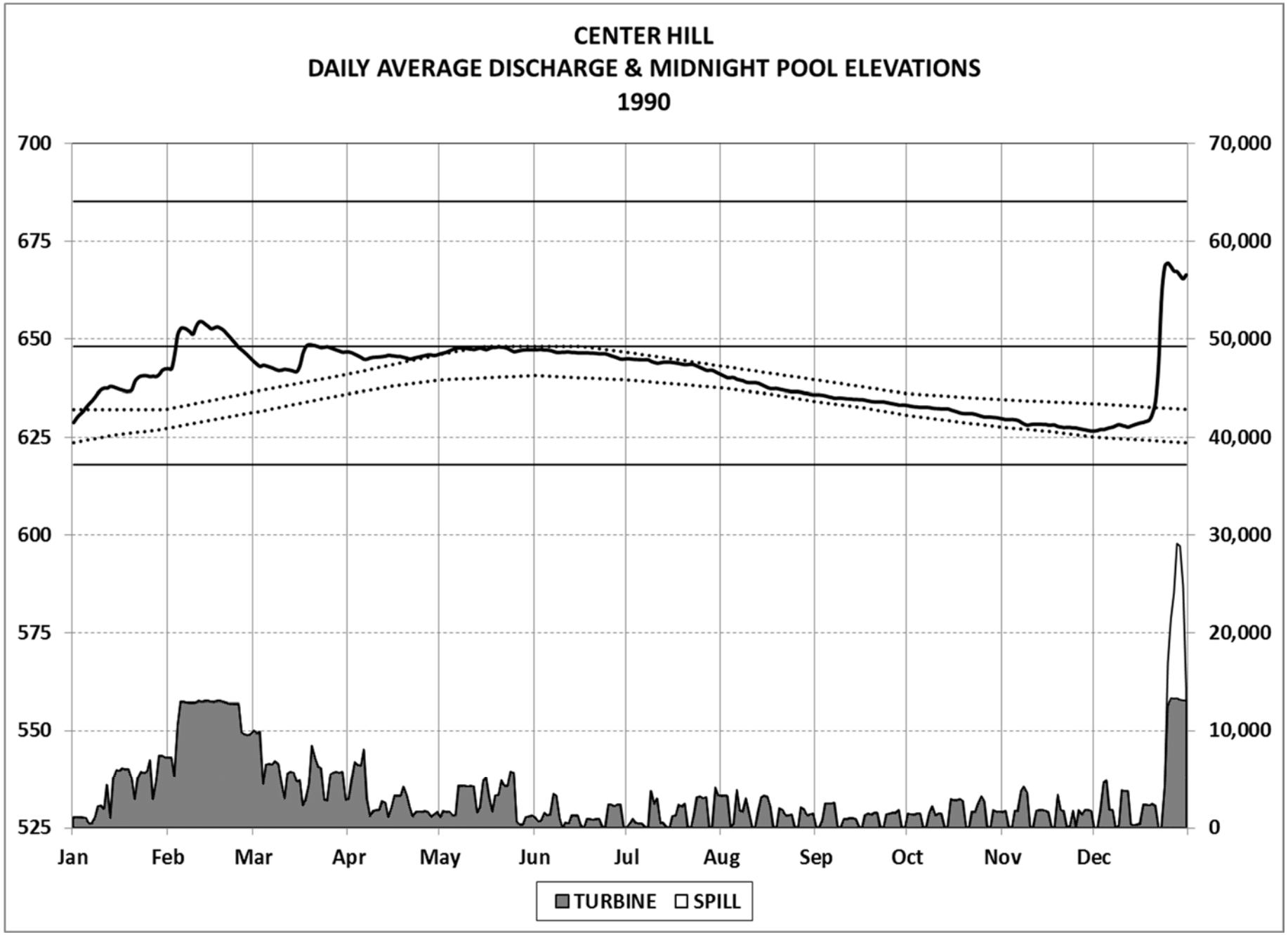

Plate VIII-63. Historical Pool Elevations and Discharges, 1990

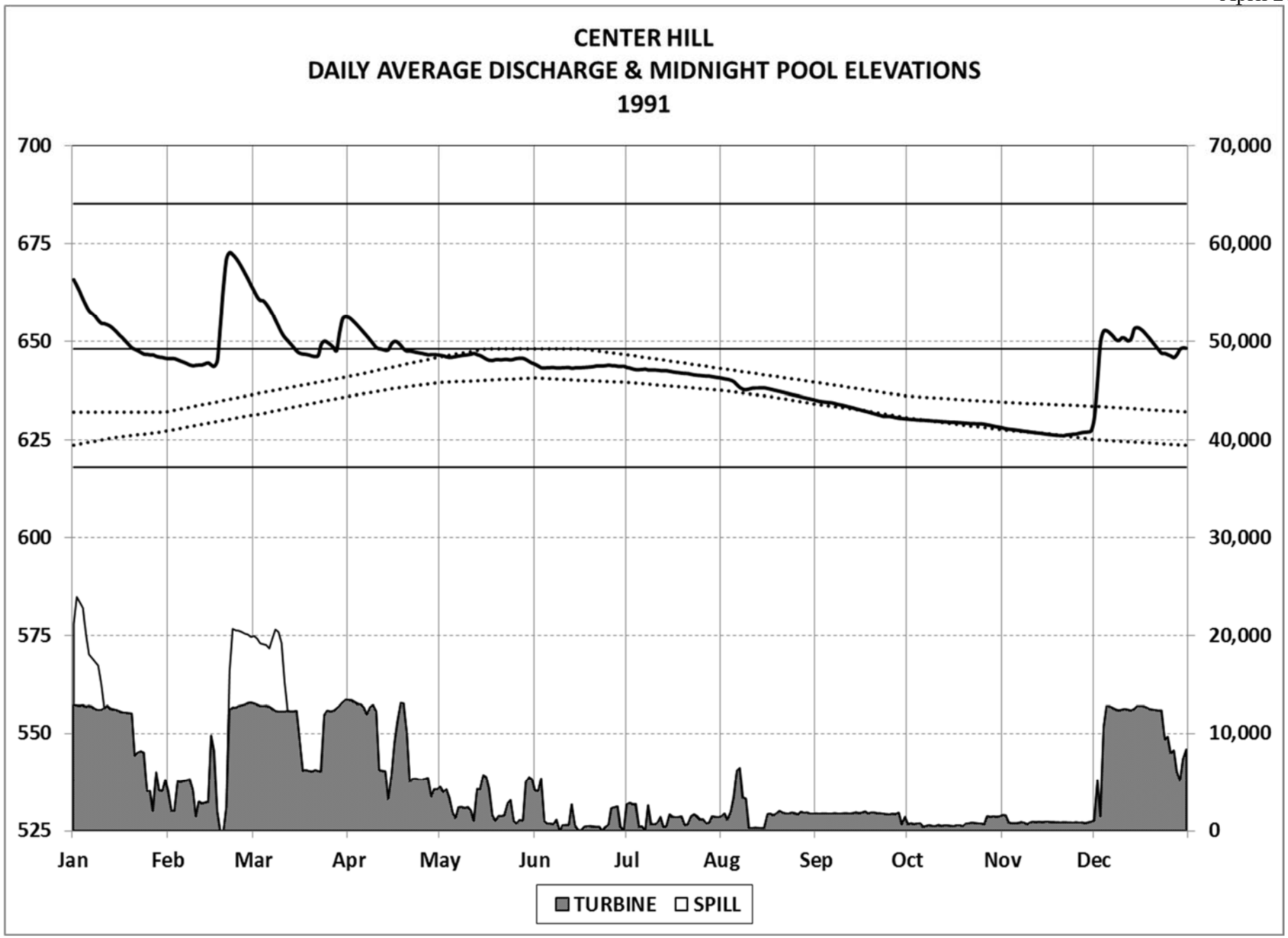

Plate VIII-64. Historical Pool Elevations and Discharges, 1991

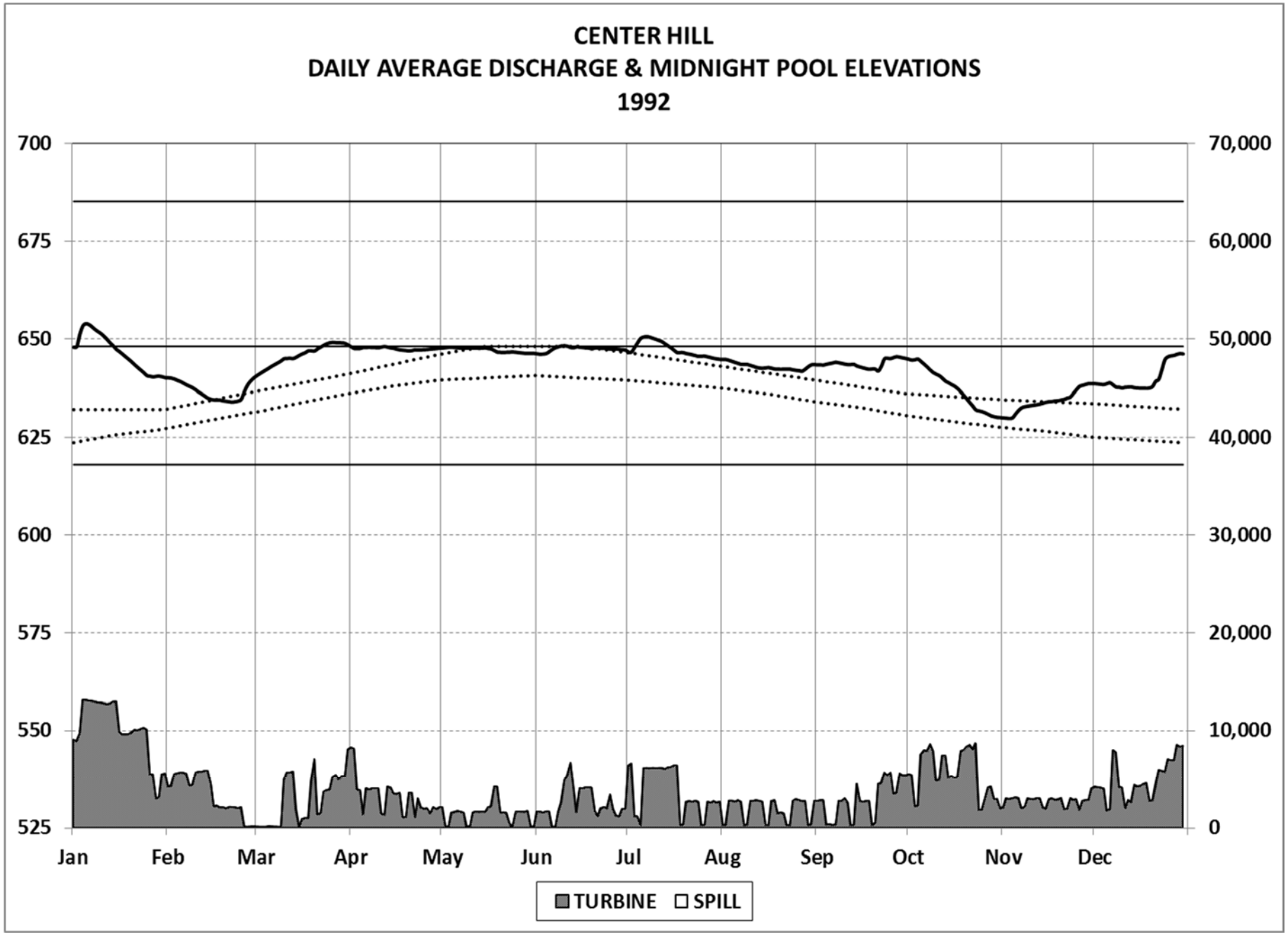

Plate VIII-65. Historical Pool Elevations and Discharges, 1992

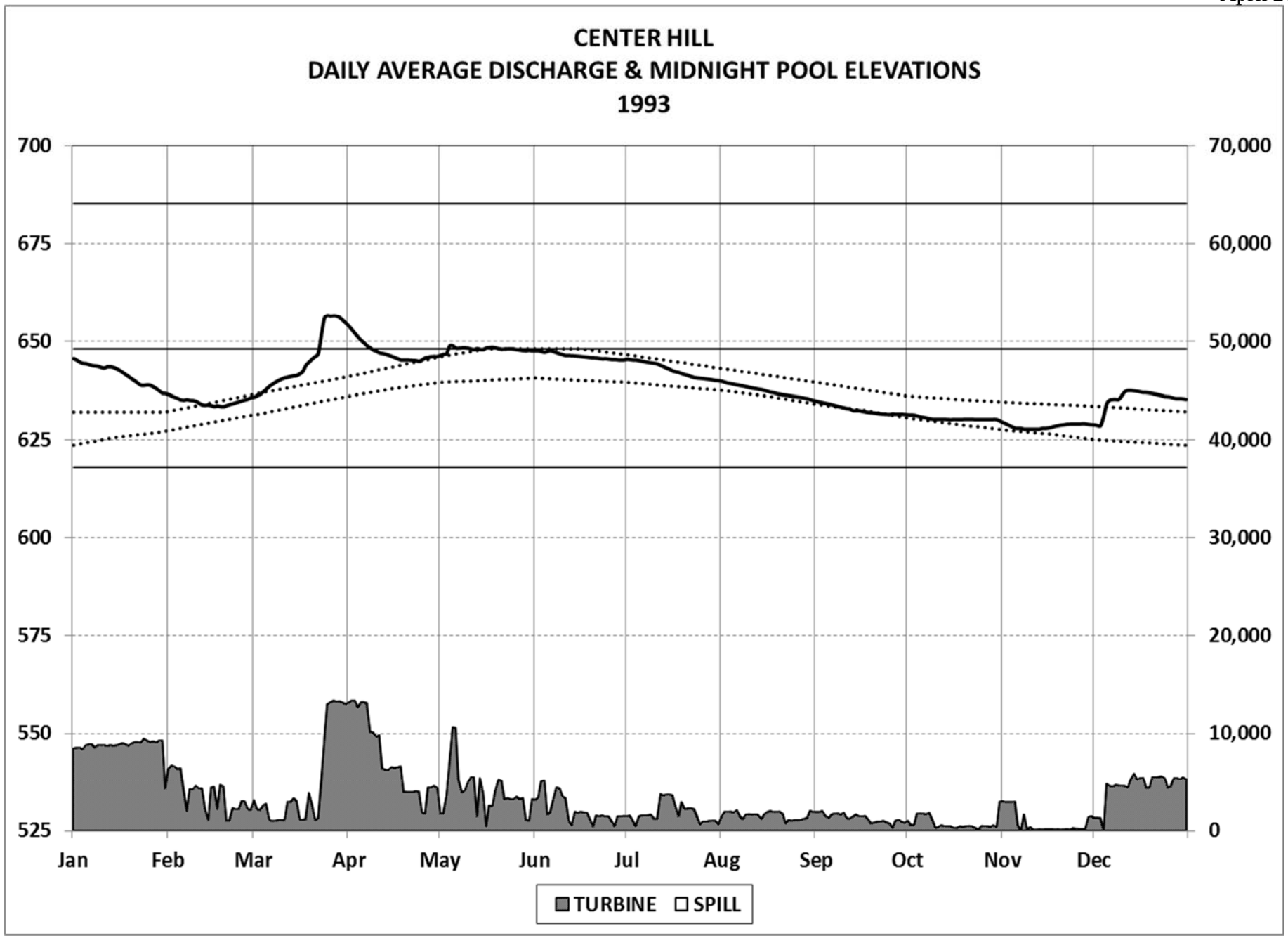

Plate VIII-66. Historical Pool Elevations and Discharges, 1993

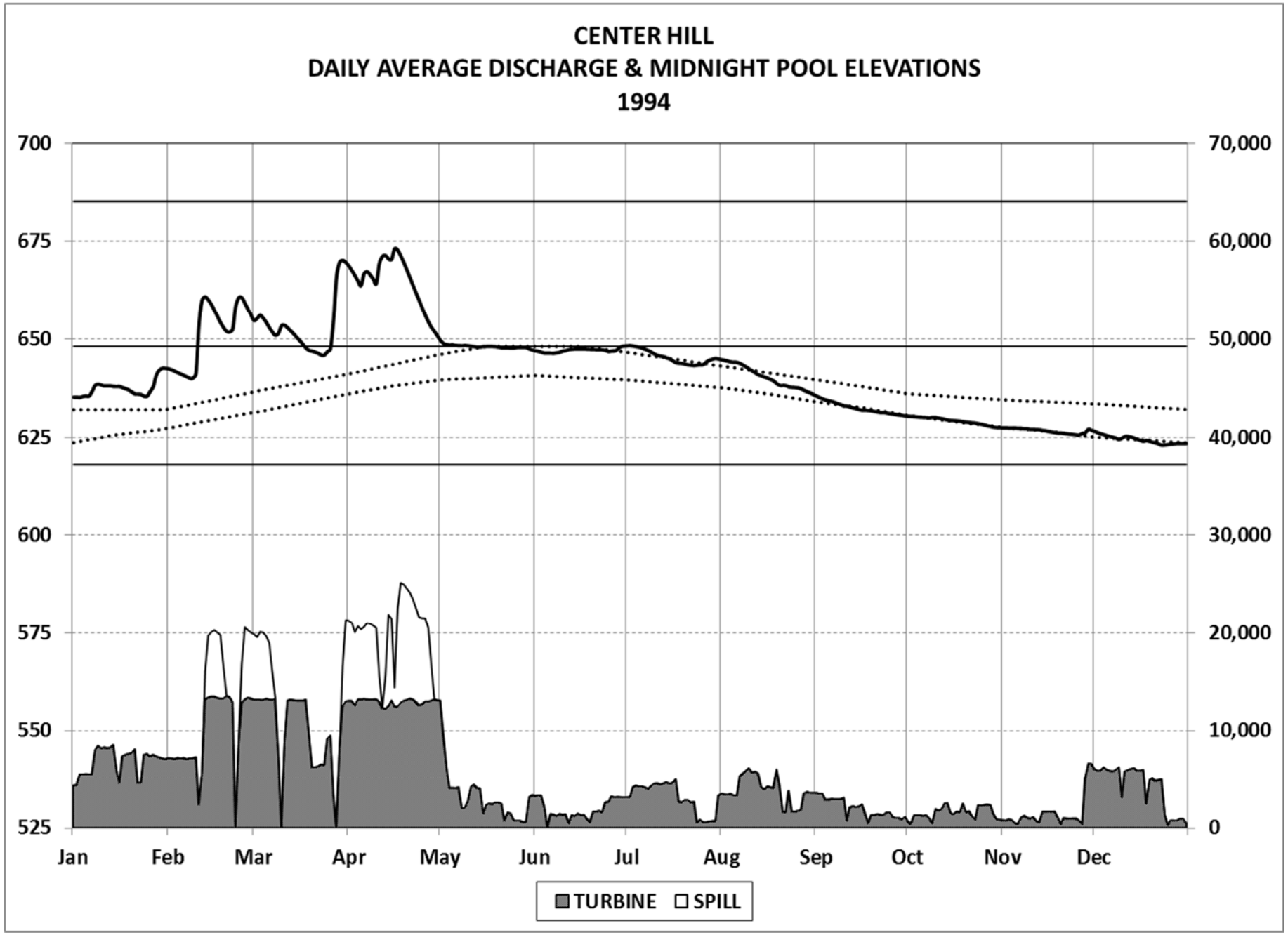

Plate VIII-67. Historical Pool Elevations and Discharges, 1994

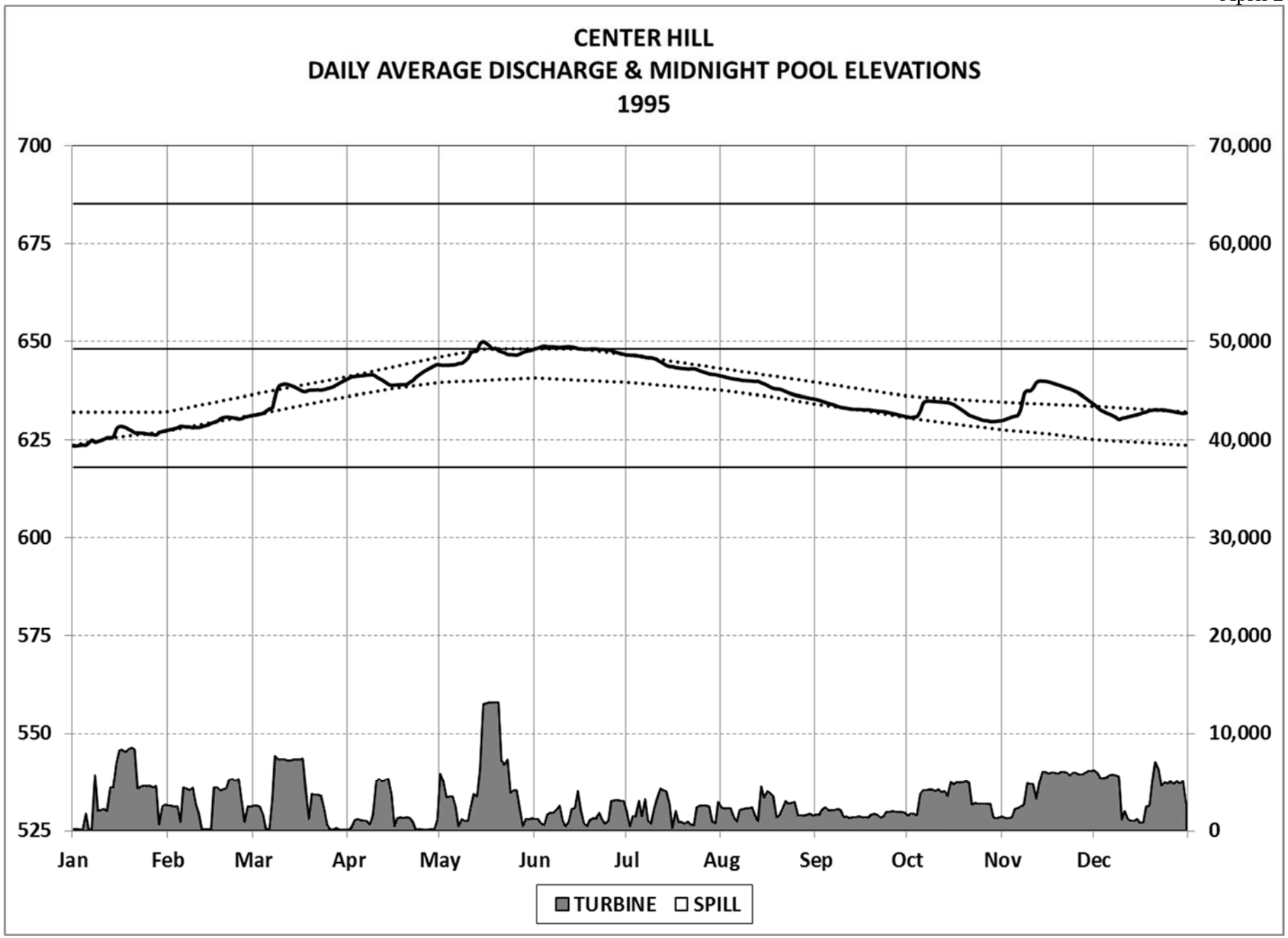

Plate VIII-68. Historical Pool Elevations and Discharges, 1995

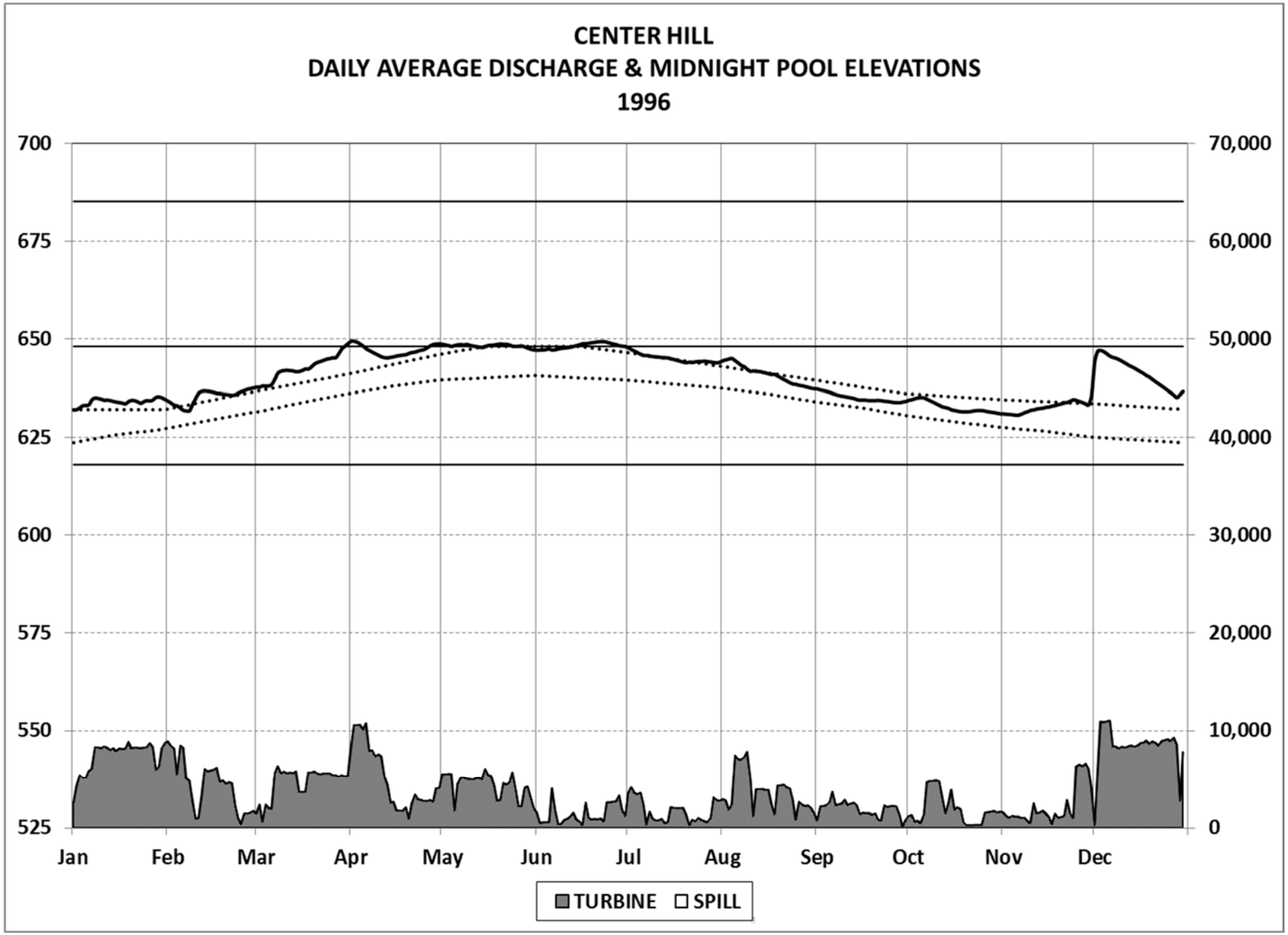

Plate VIII-69. Historical Pool Elevations and Discharges, 1996

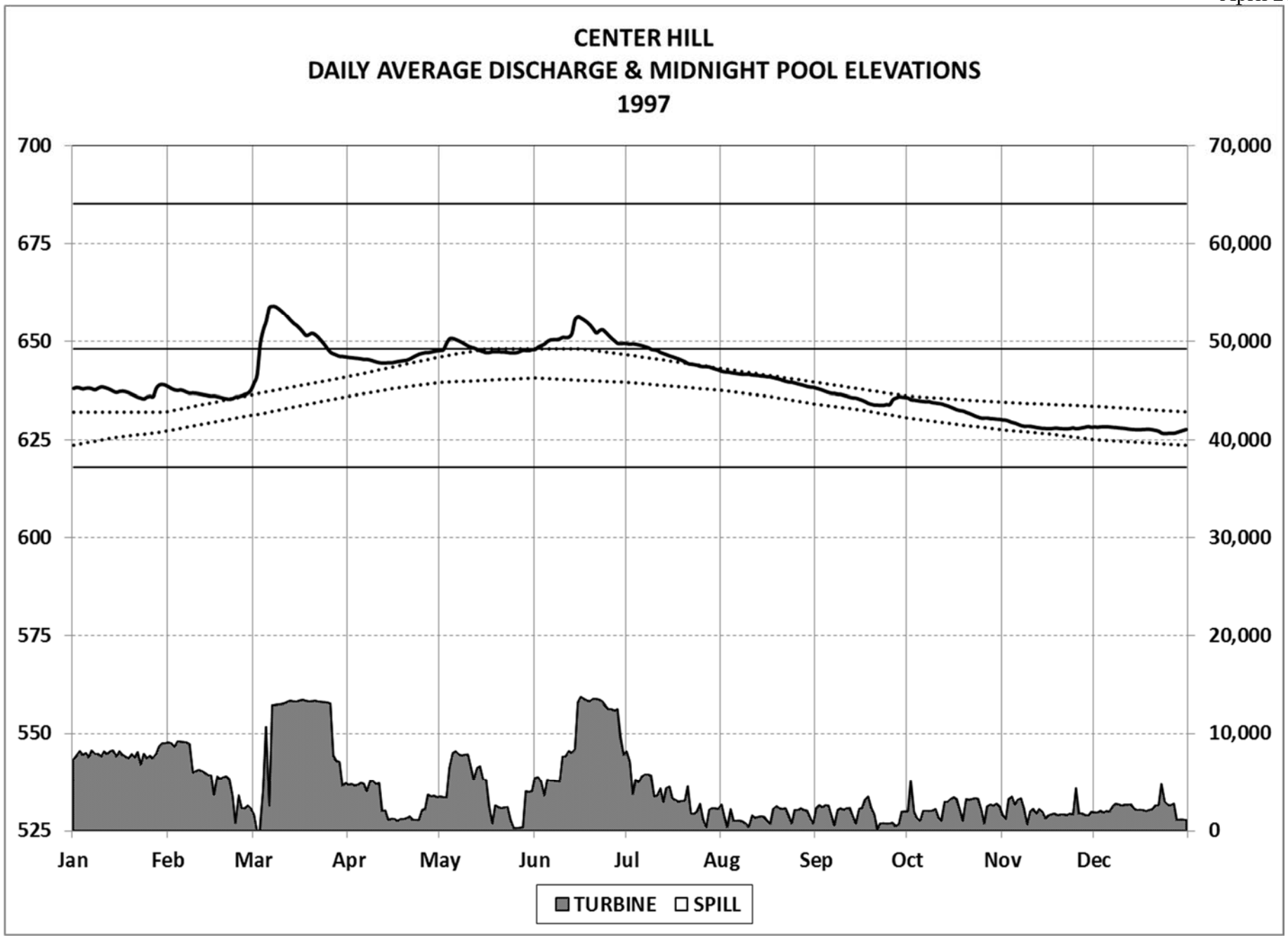

Plate VIII-70. Historical Pool Elevations and Discharges, 1997

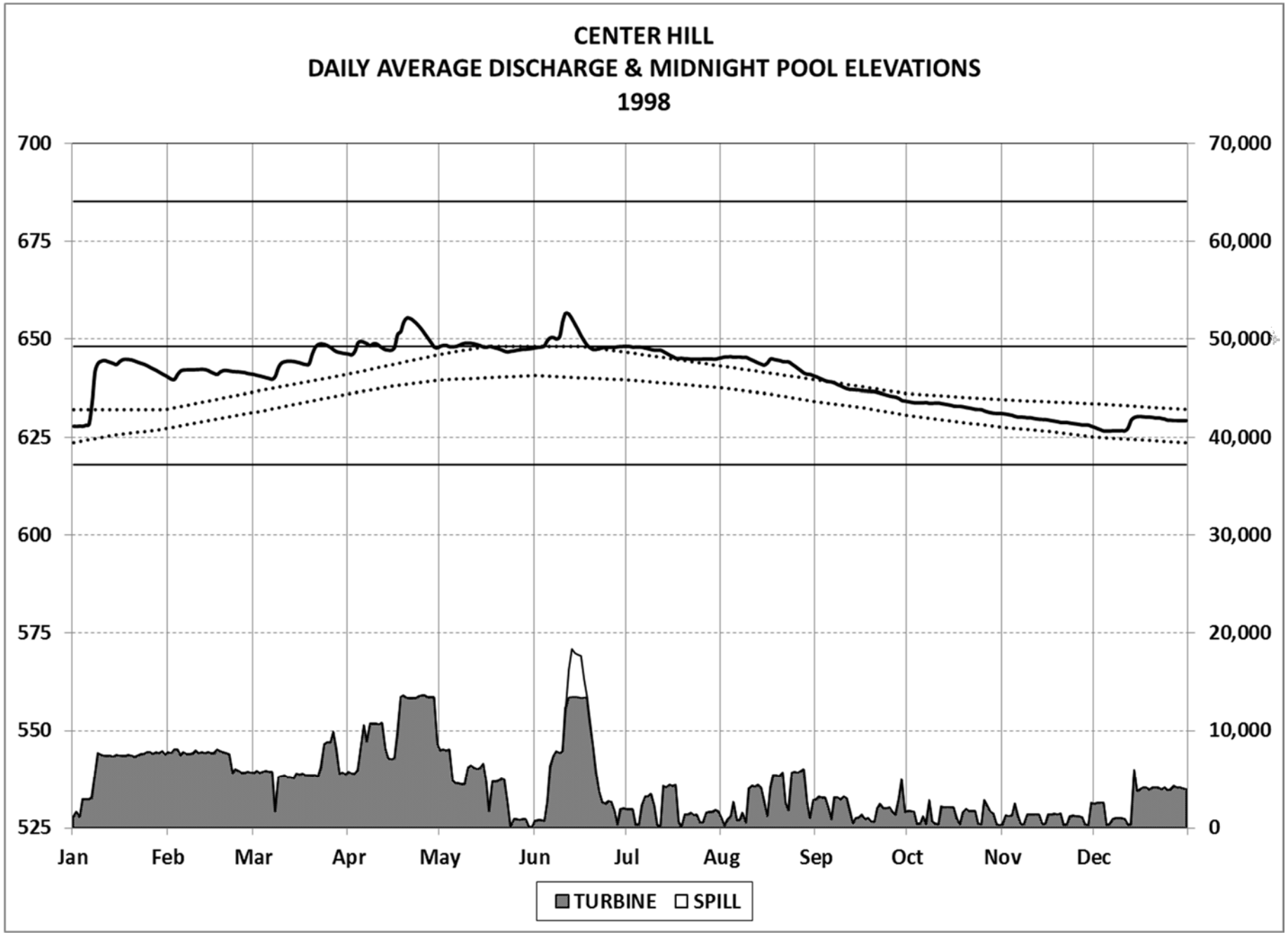

Plate VIII-71. Historical Pool Elevations and Discharges, 1998

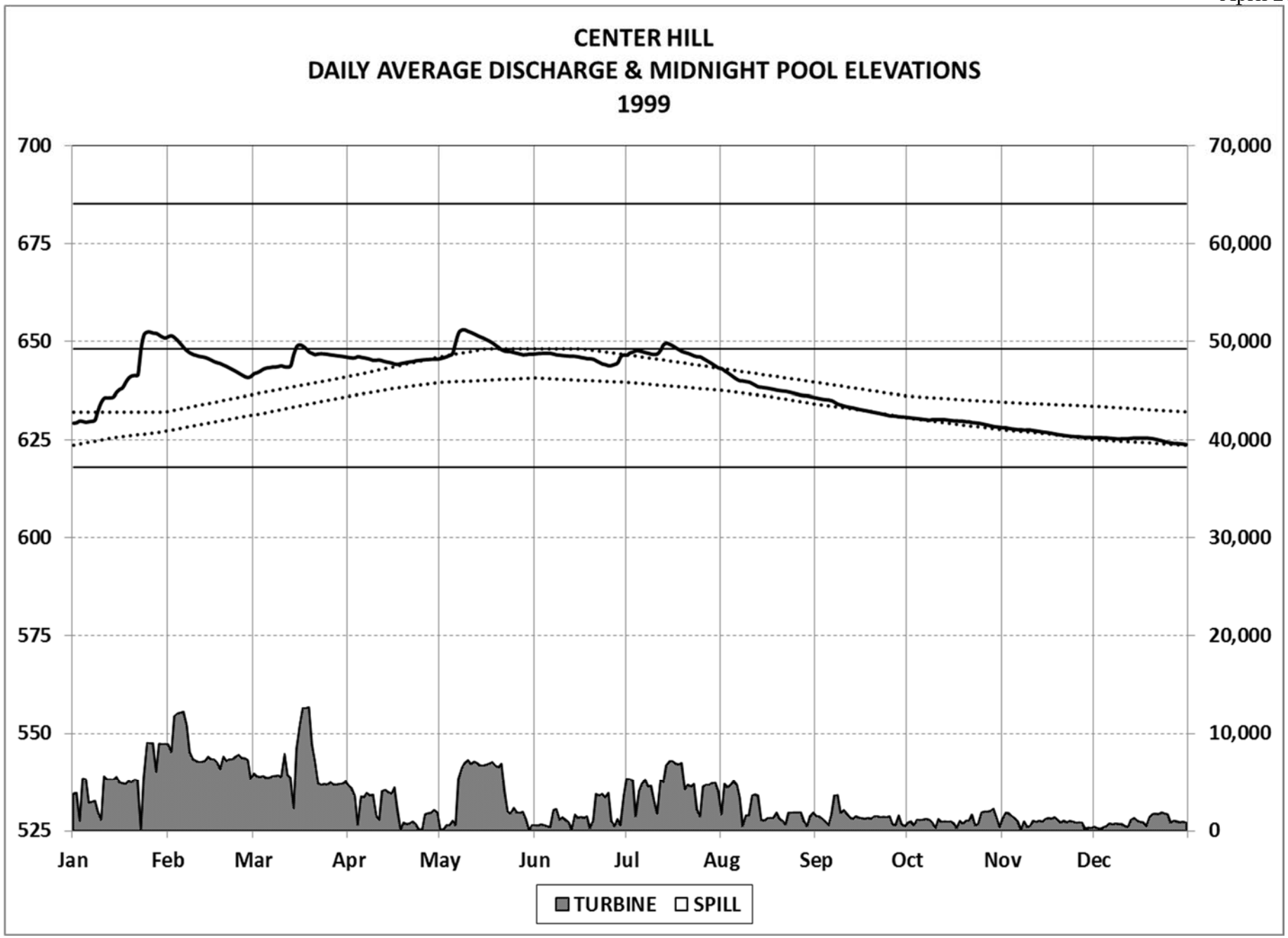

Plate VIII-72. Historical Pool Elevations and Discharges, 1999

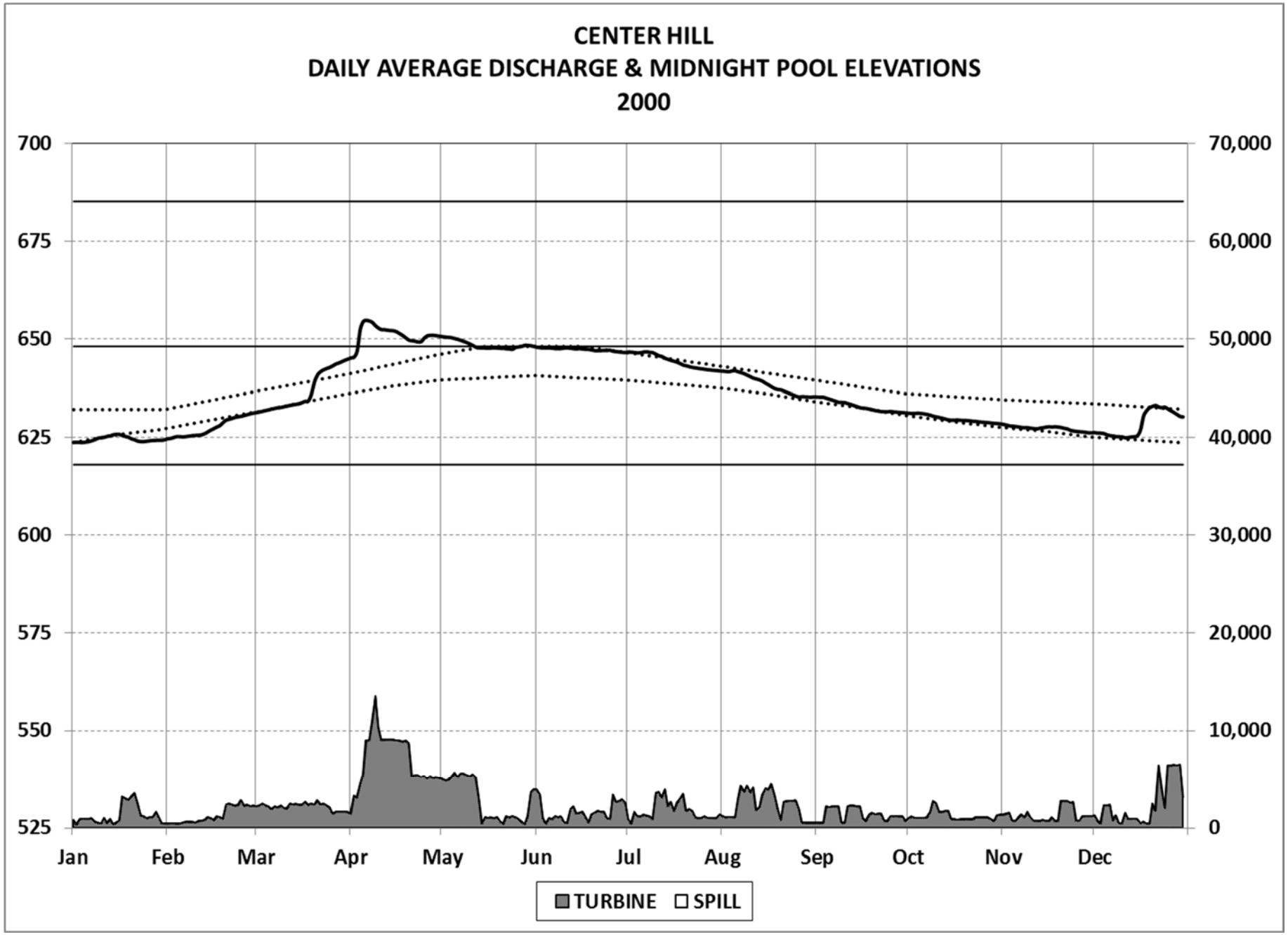

Plate VIII-73. Historical Pool Elevations and Discharges, 2000

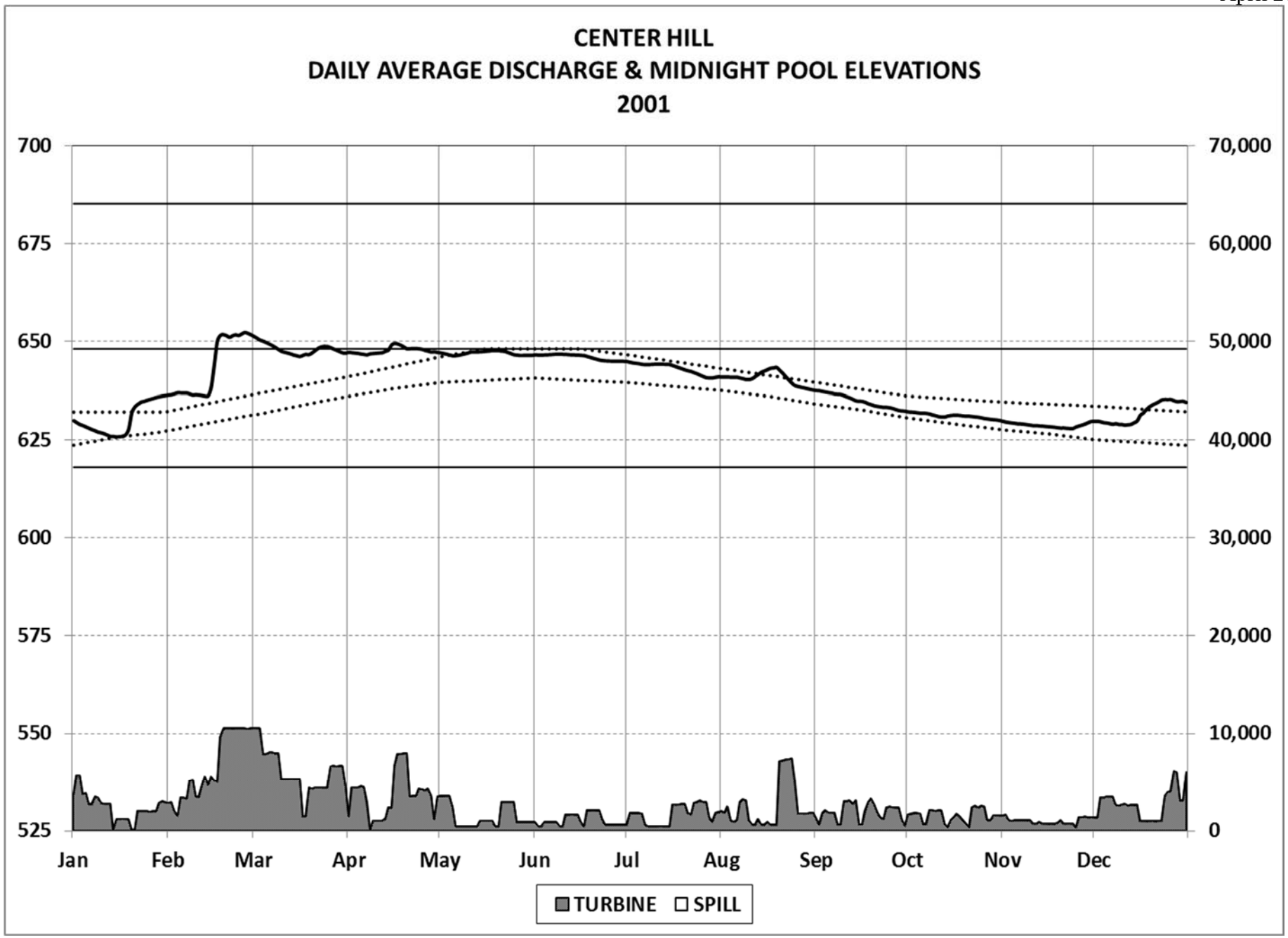

Plate VIII-74. Historical Pool Elevations and Discharges, 2001

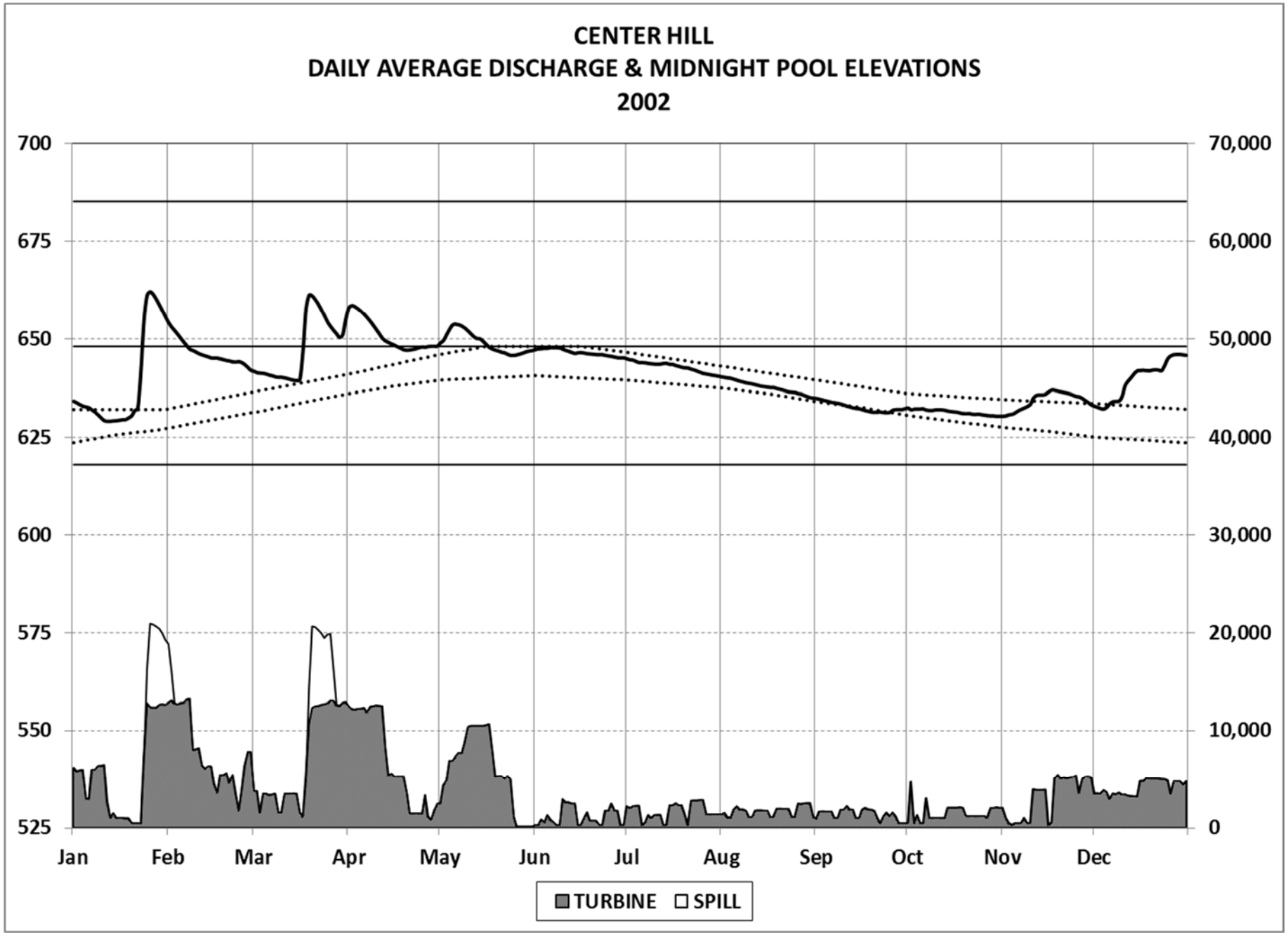

Plate VIII-75. Historical Pool Elevations and Discharges, 2002

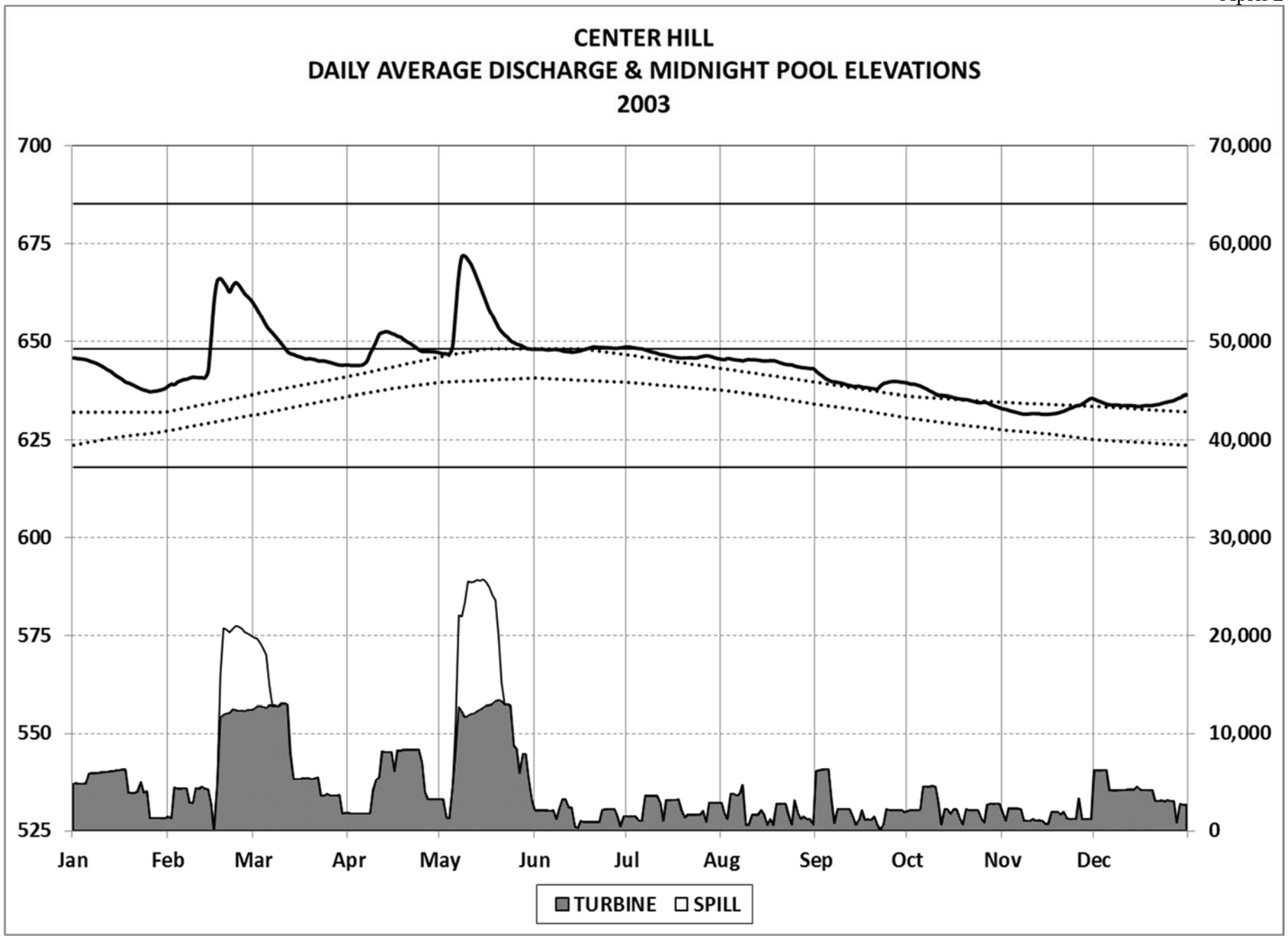

Plate VIII-76. Historical Pool Elevations and Discharges, 2003

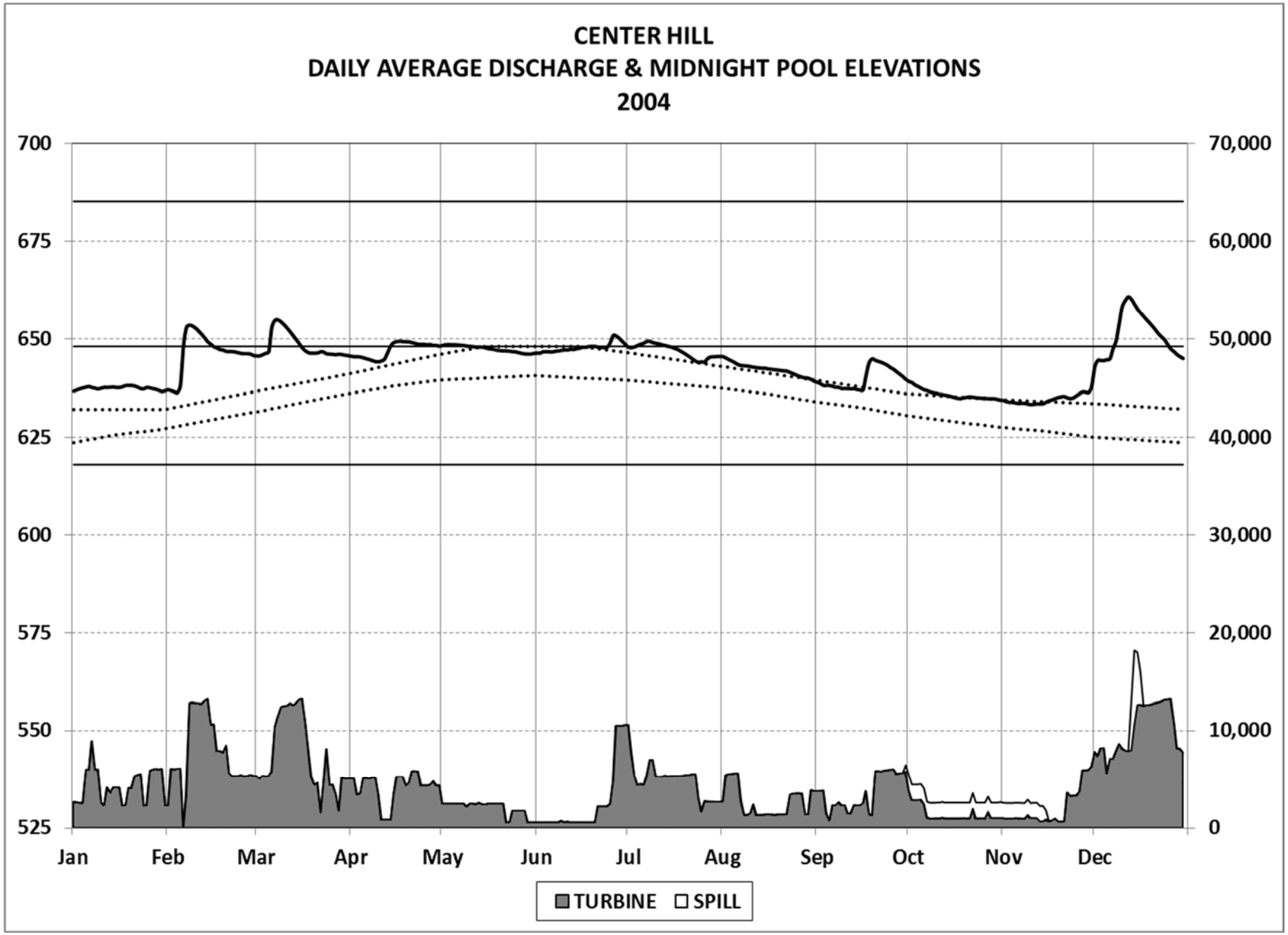

Plate VIII-77. Historical Pool Elevations and Discharges, 2004

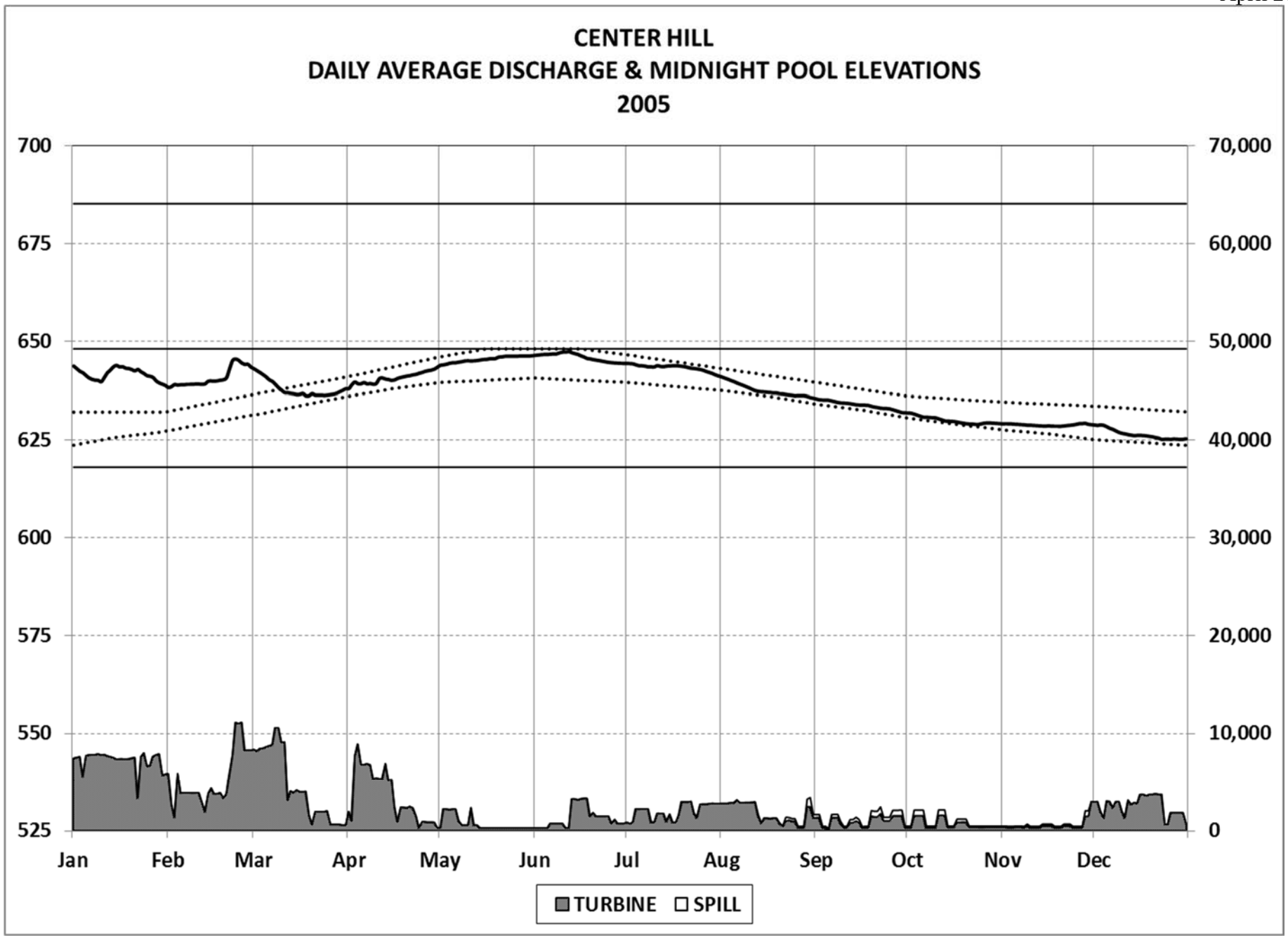

Plate VIII-78. Historical Pool Elevations and Discharges, 2005

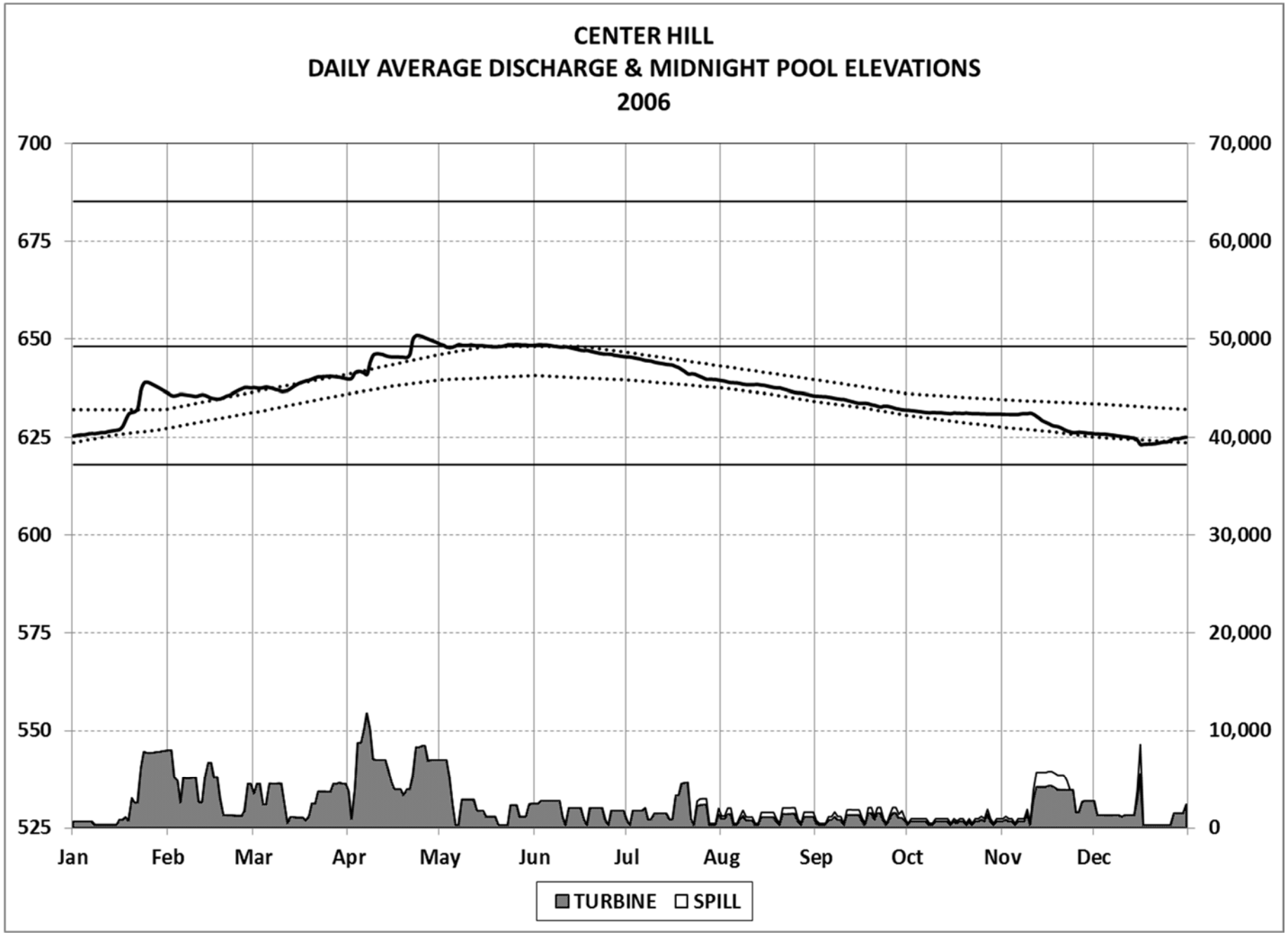

Plate VIII-79. Historical Pool Elevations and Discharges, 2006

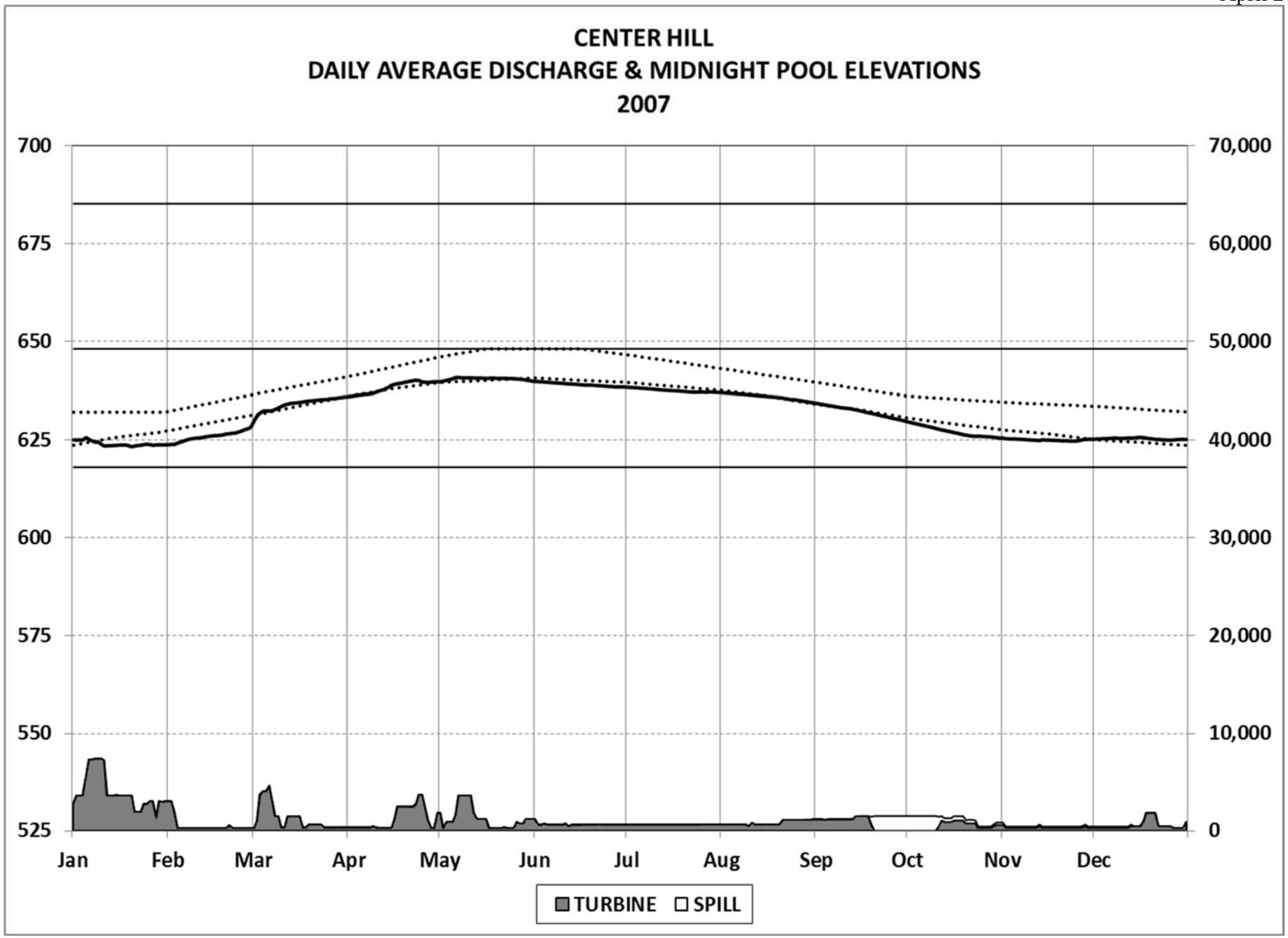

Plate VIII-80. Historical Pool Elevations and Discharges, 2007

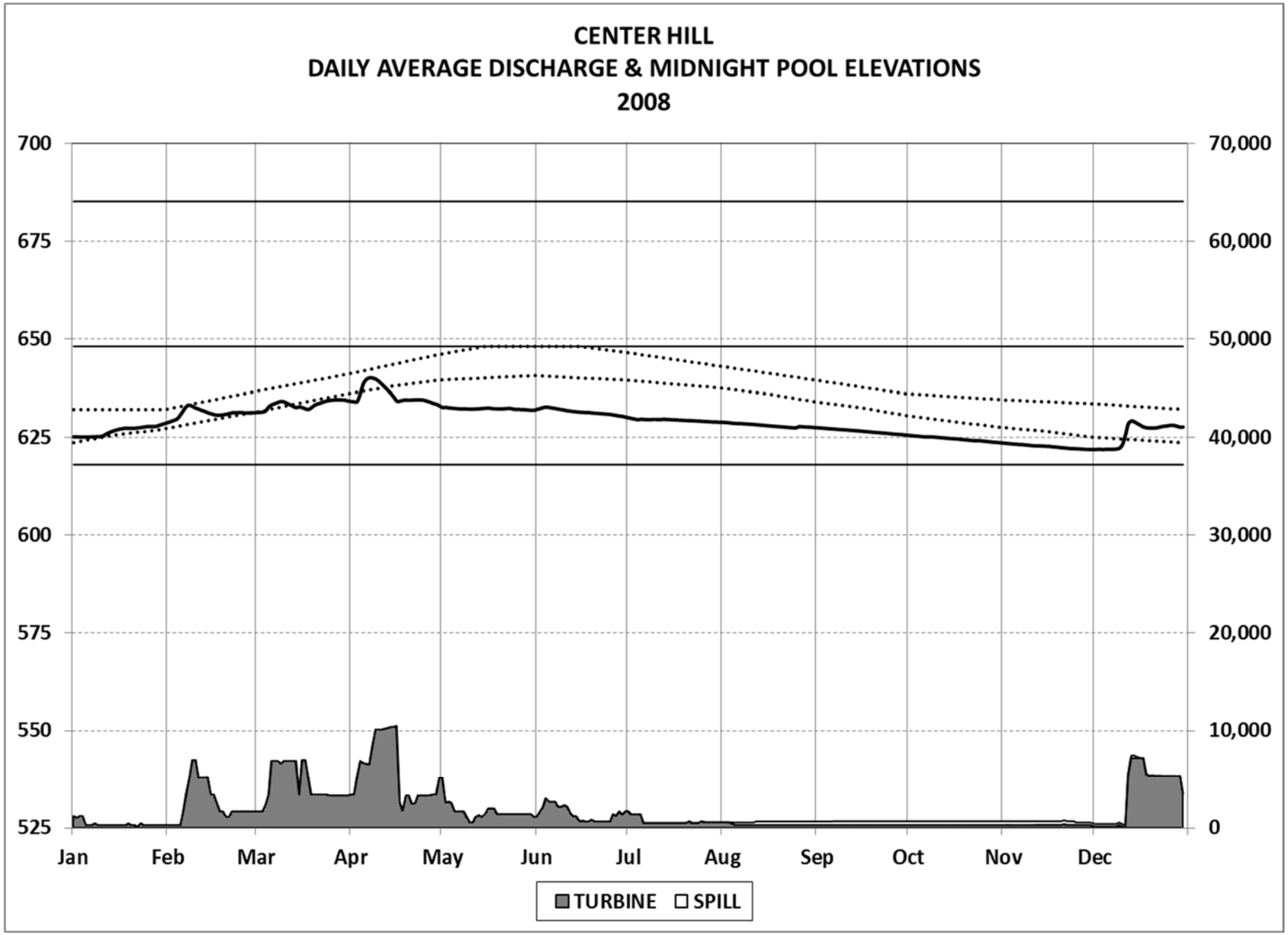

Plate VIII-81. Historical Pool Elevations and Discharges, 2008

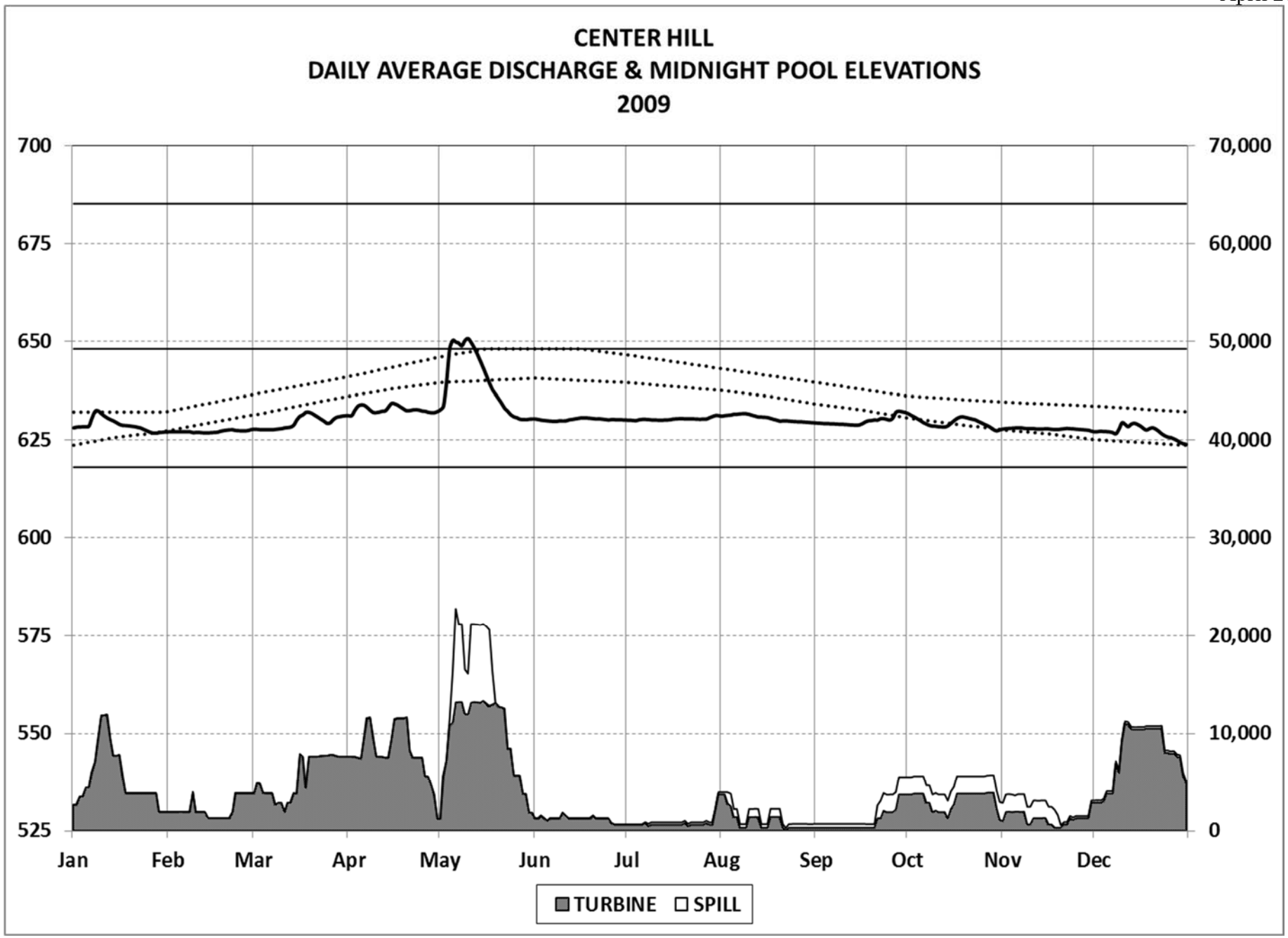

Plate VIII-82. Historical Pool Elevations and Discharges, 2009

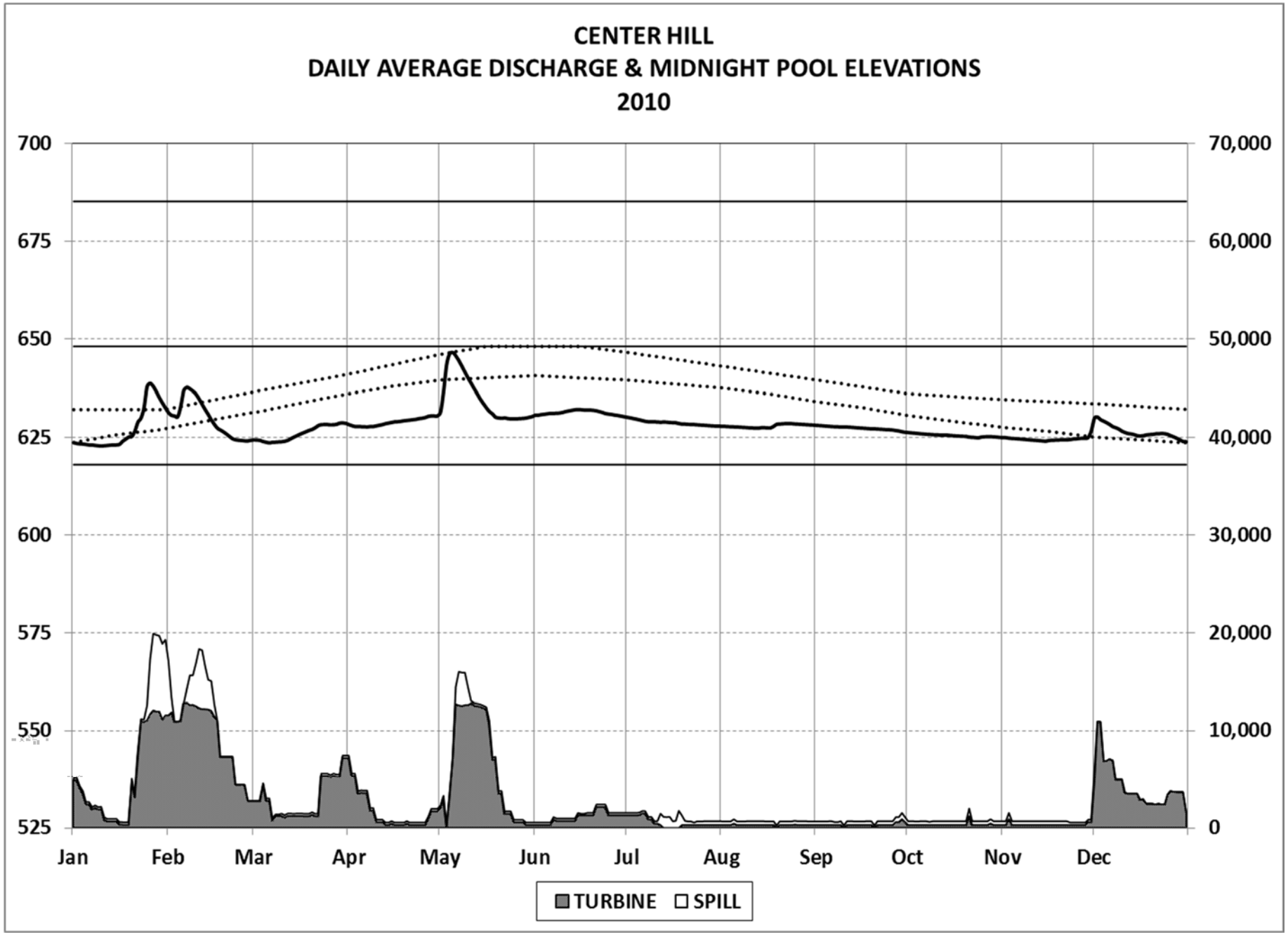

Plate VIII-83. Historical Pool Elevations and Discharges, 2010

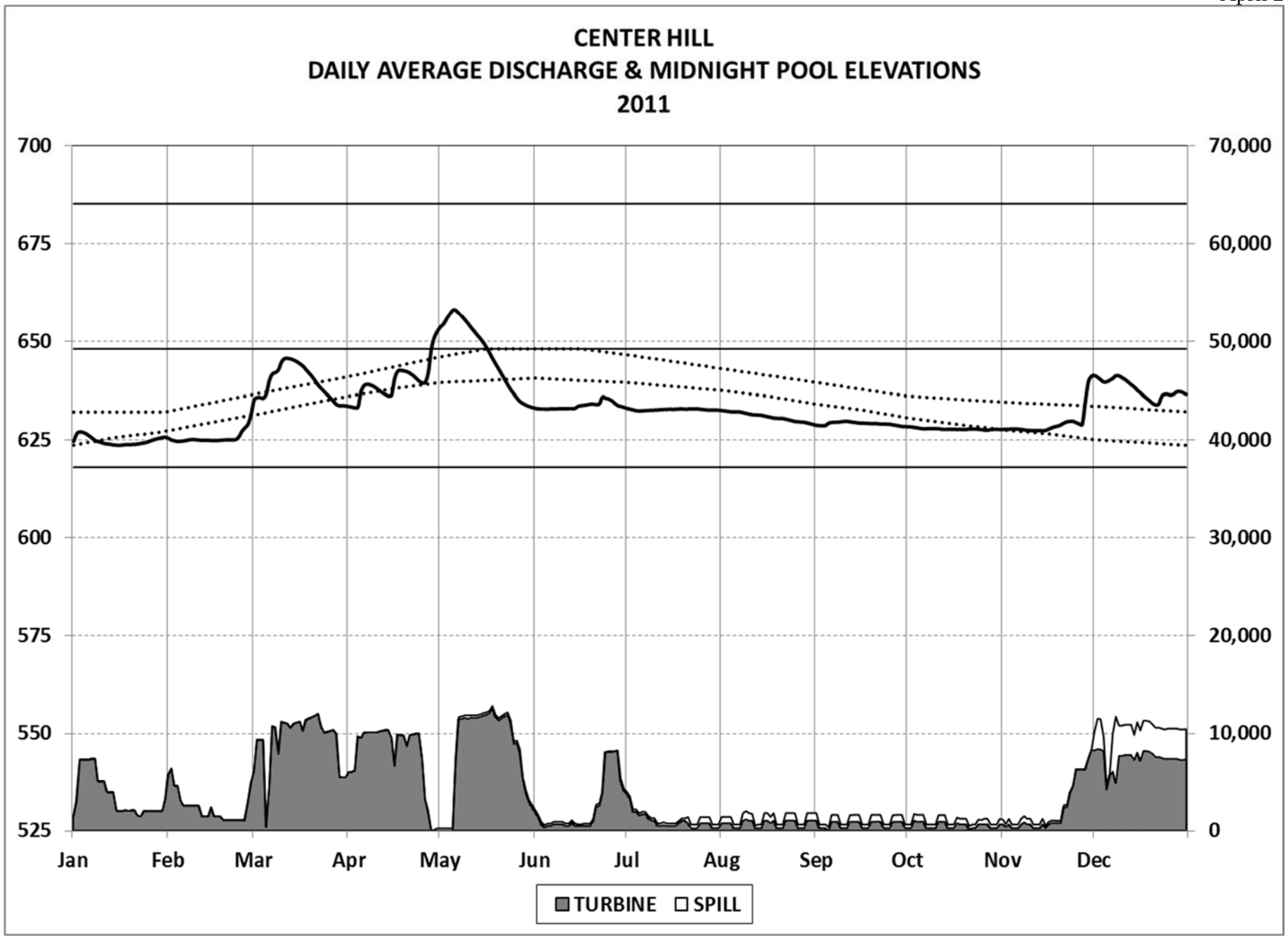

Plate VIII-84. Historical Pool Elevations and Discharges, 2011

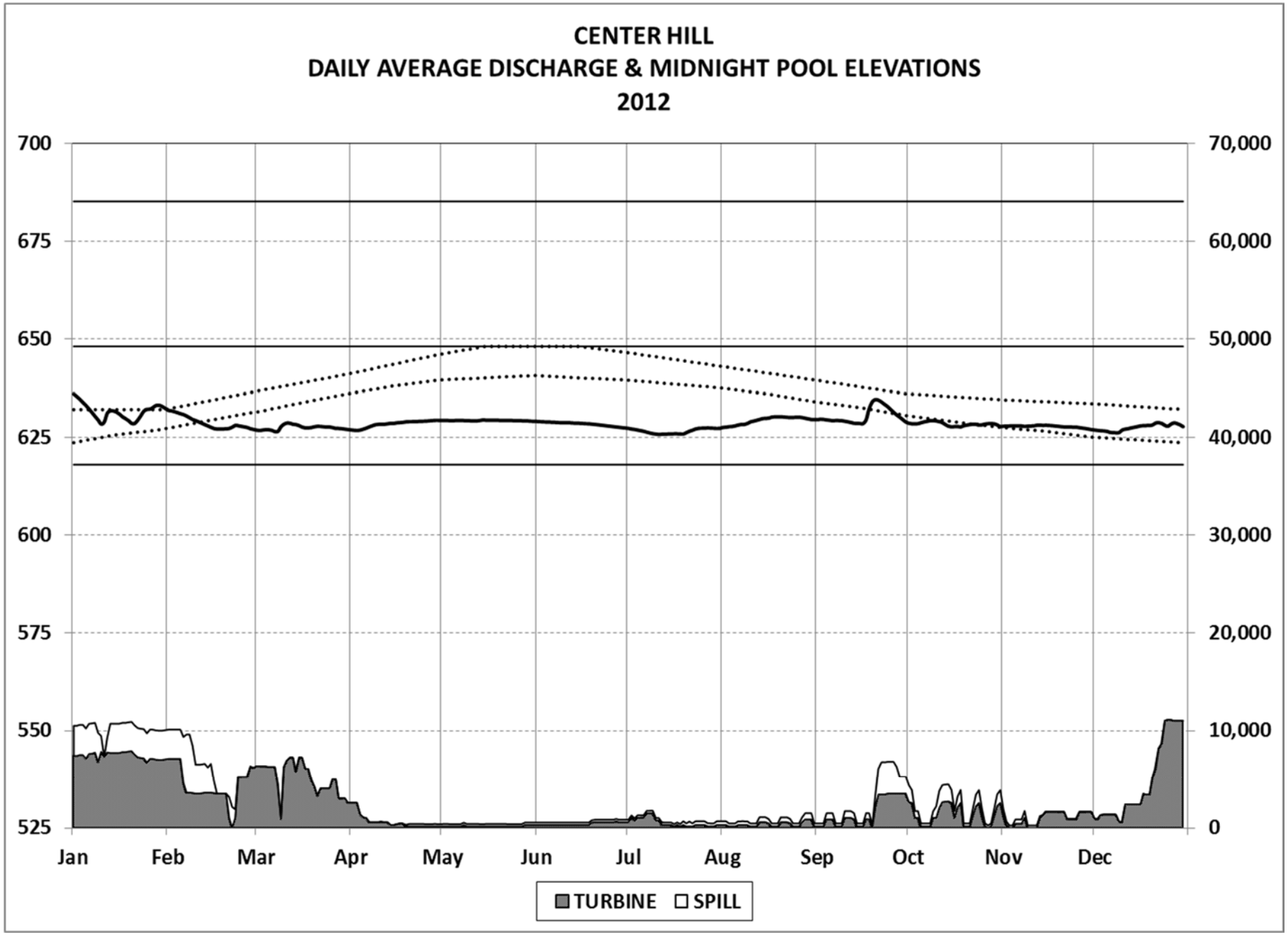

Plate VIII-85. Historical Pool Elevations and Discharges, 2012

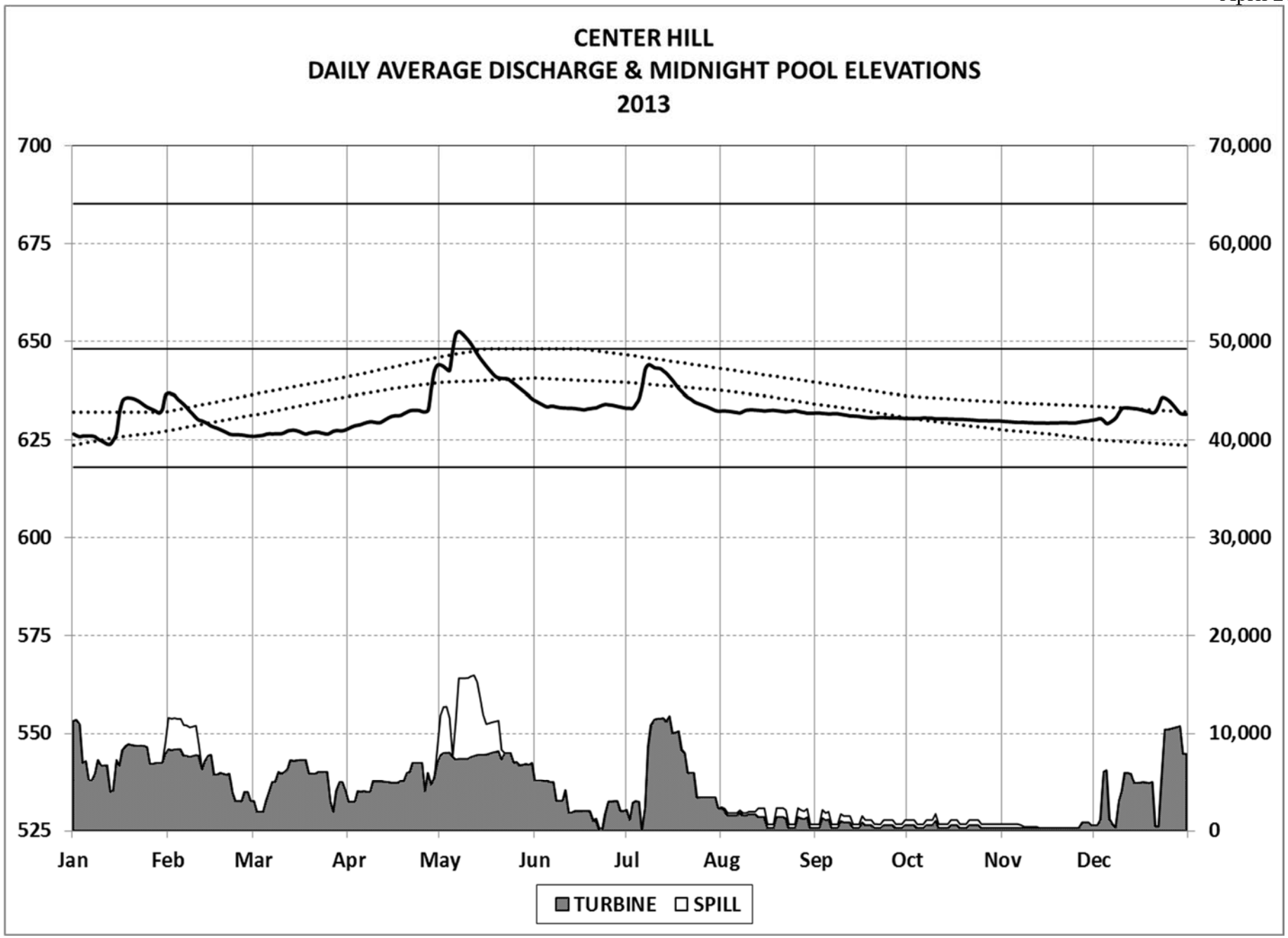

Plate VIII-86. Historical Pool Elevations and Discharges, 2013

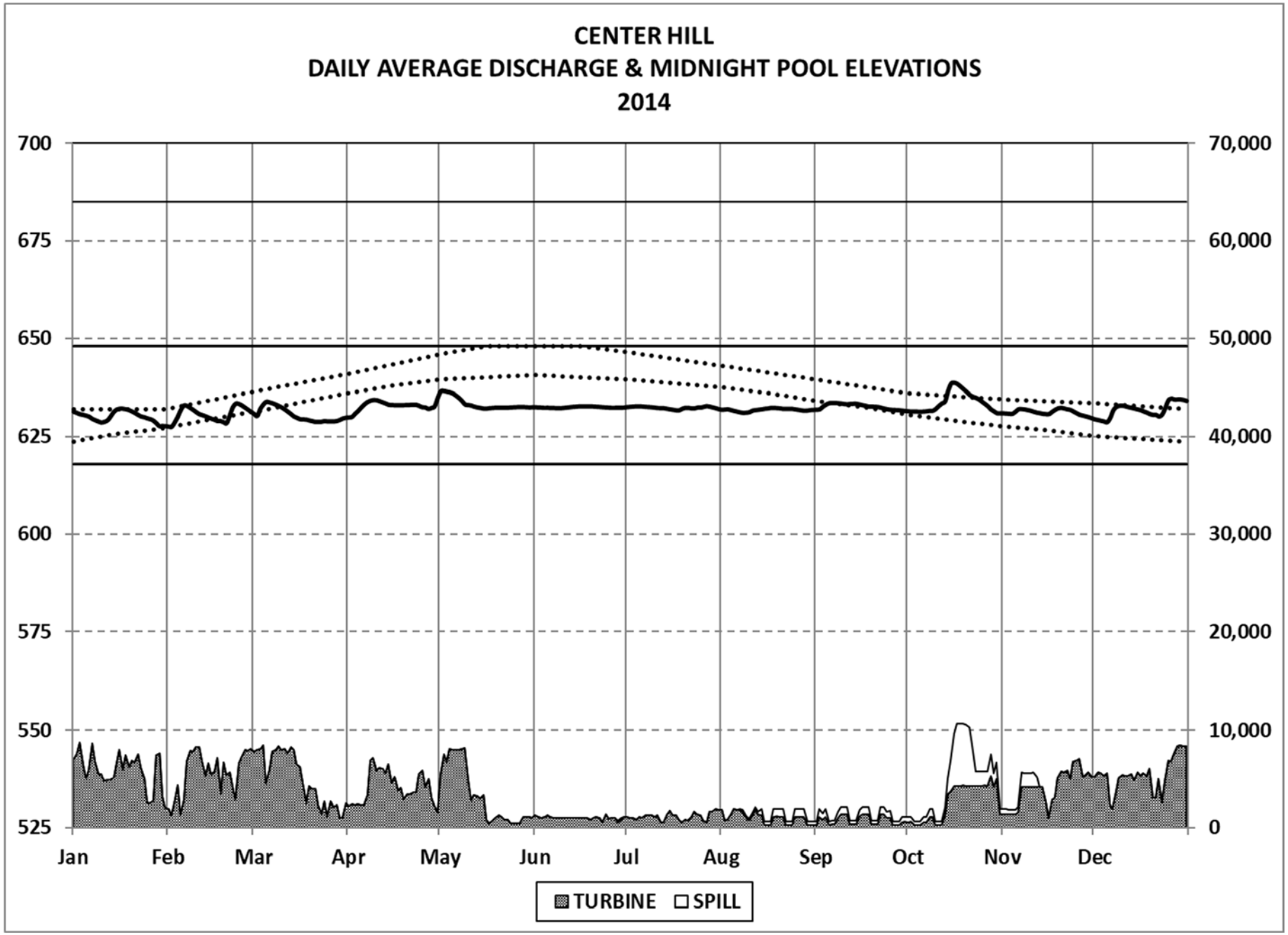

Plate VIII-87. Historical Pool Elevations and Discharges, 2014

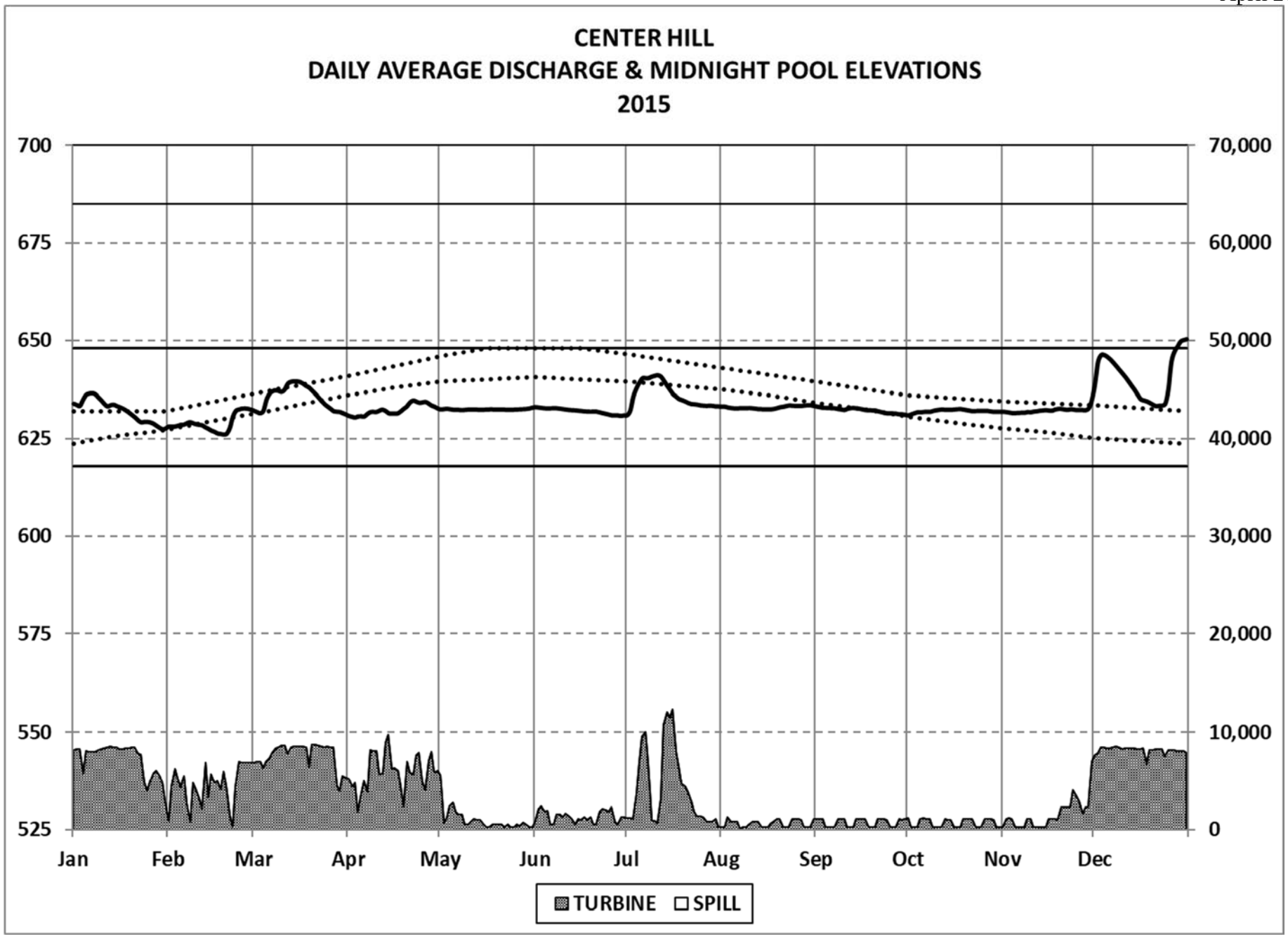

Plate VIII-88. Historical Pool Elevations and Discharges, 2015

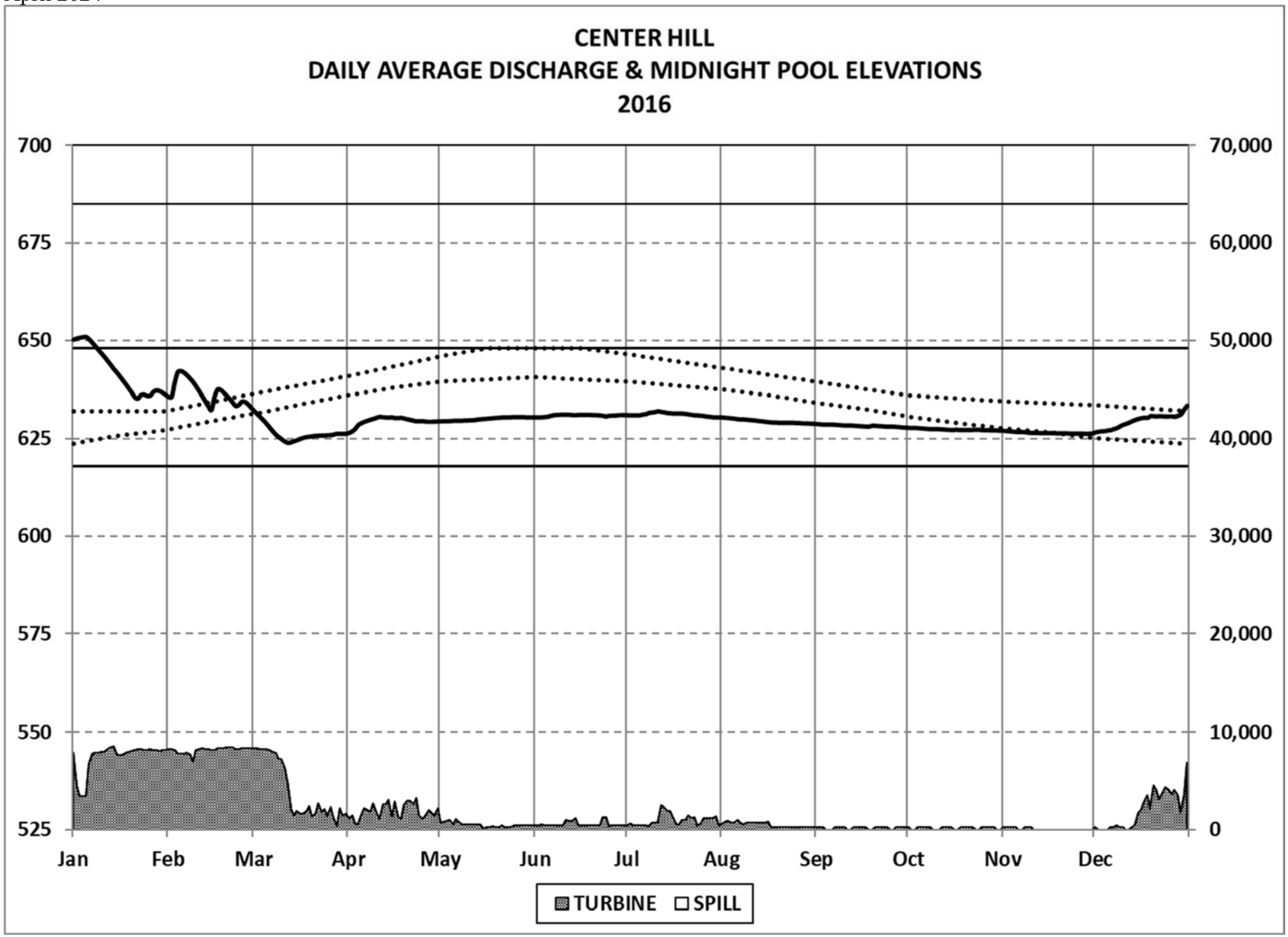

Plate VIII-89. Historical Pool Elevations and Discharges, 2016

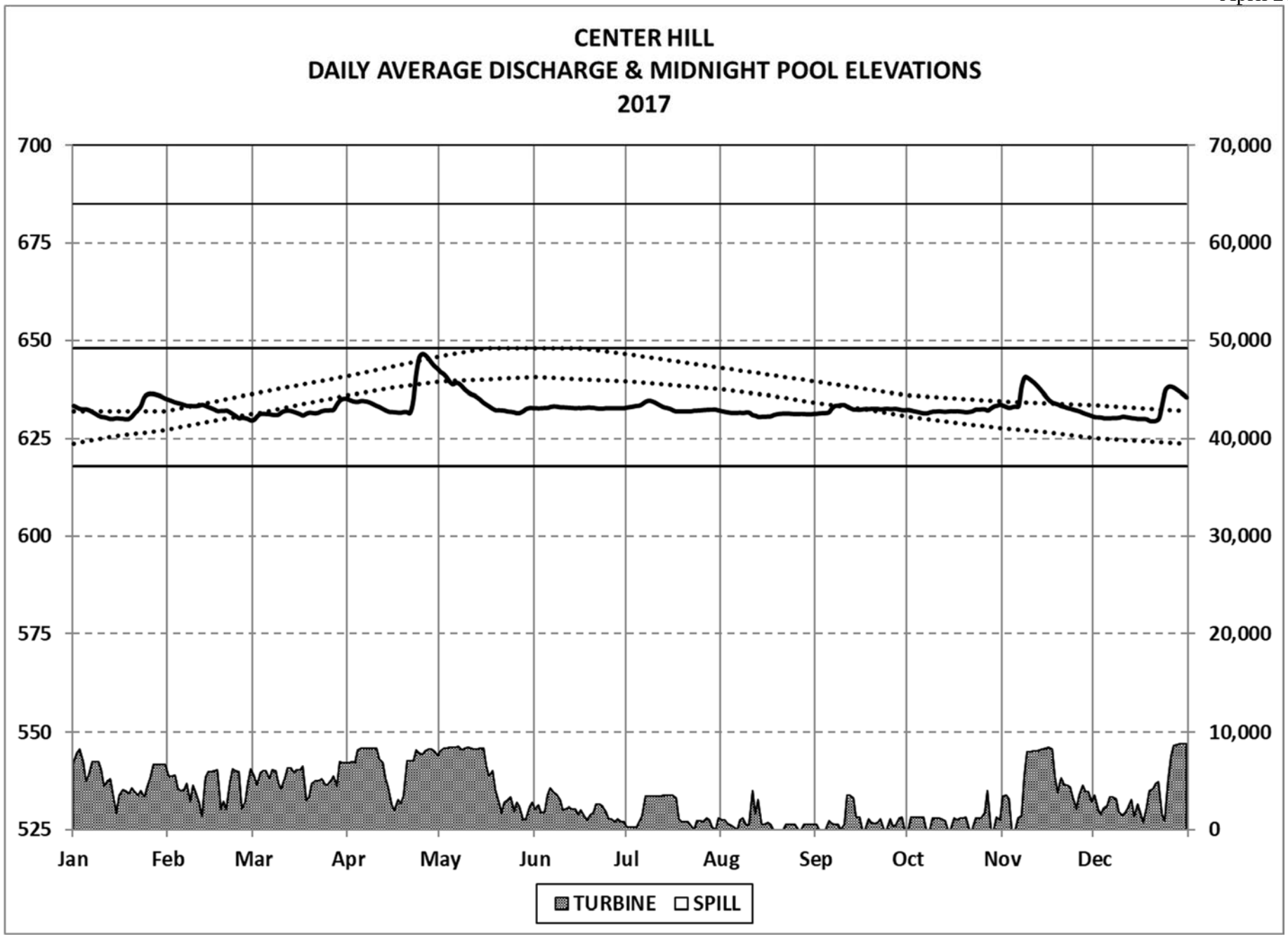

Plate VIII-90. Historical Pool Elevations and Discharges, 2017

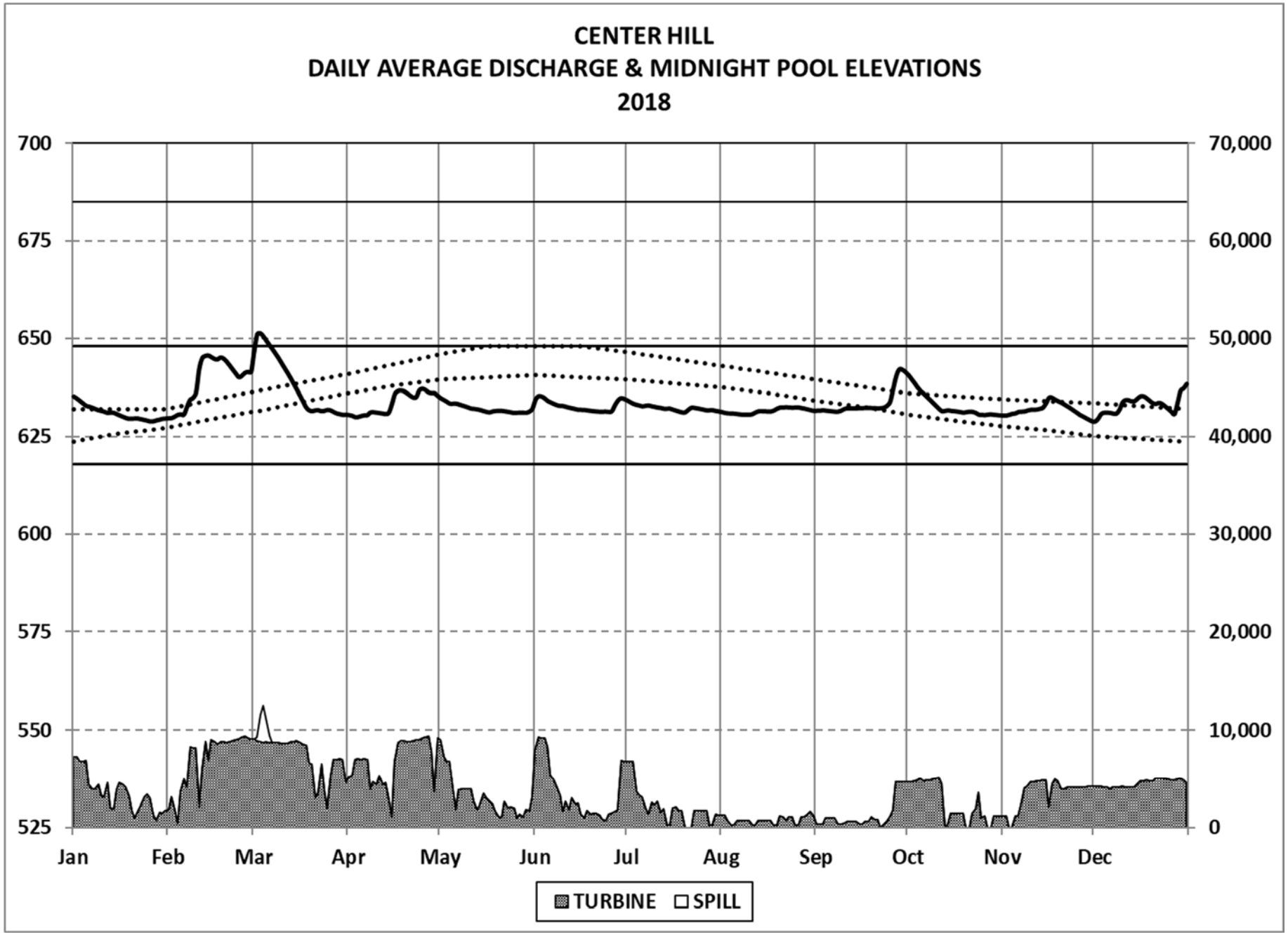

Plate VIII-91. Historical Pool Elevations and Discharges, 2018

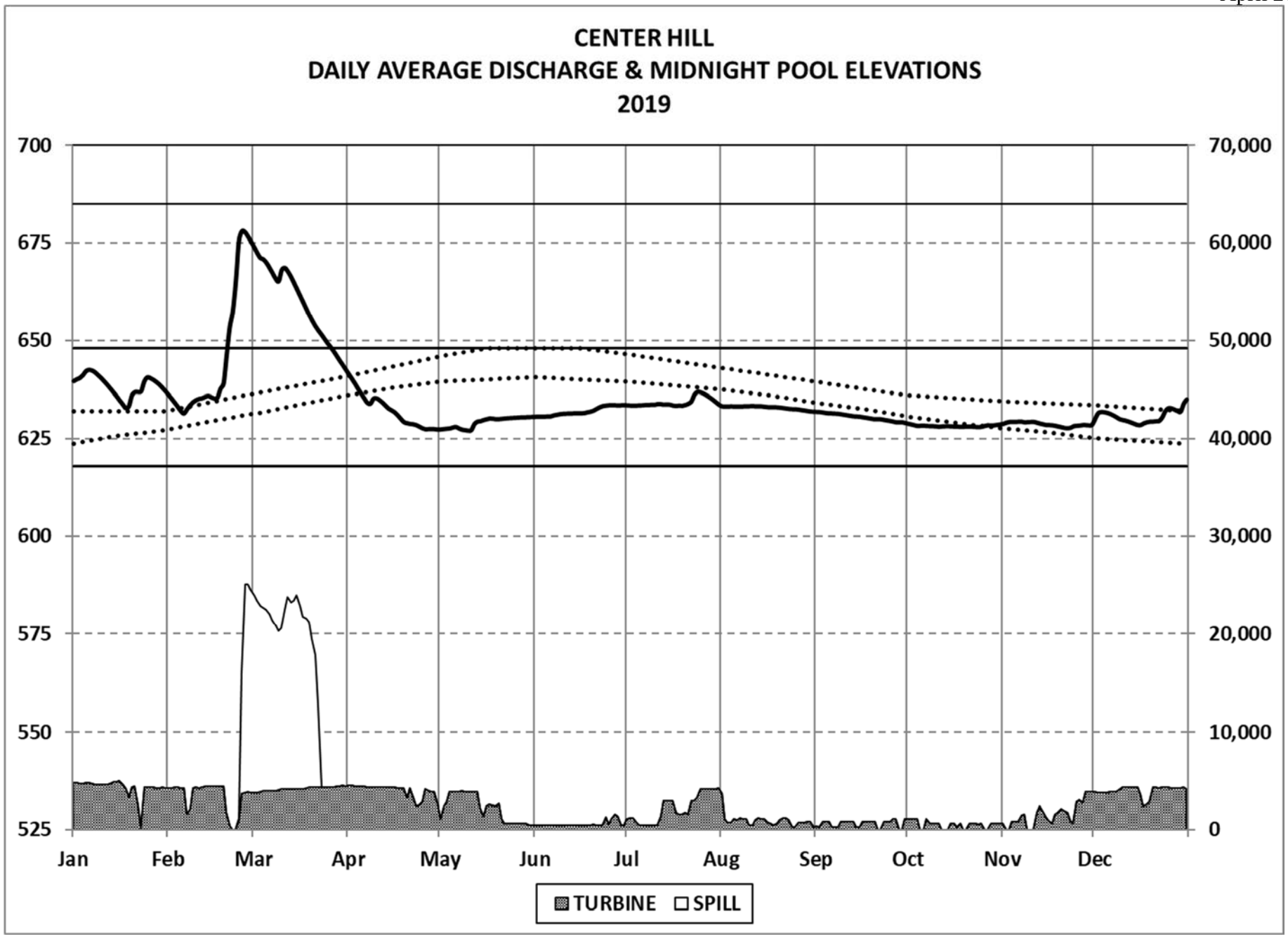

Plate VIII-92. Historical Pool Elevations and Discharges, 2019

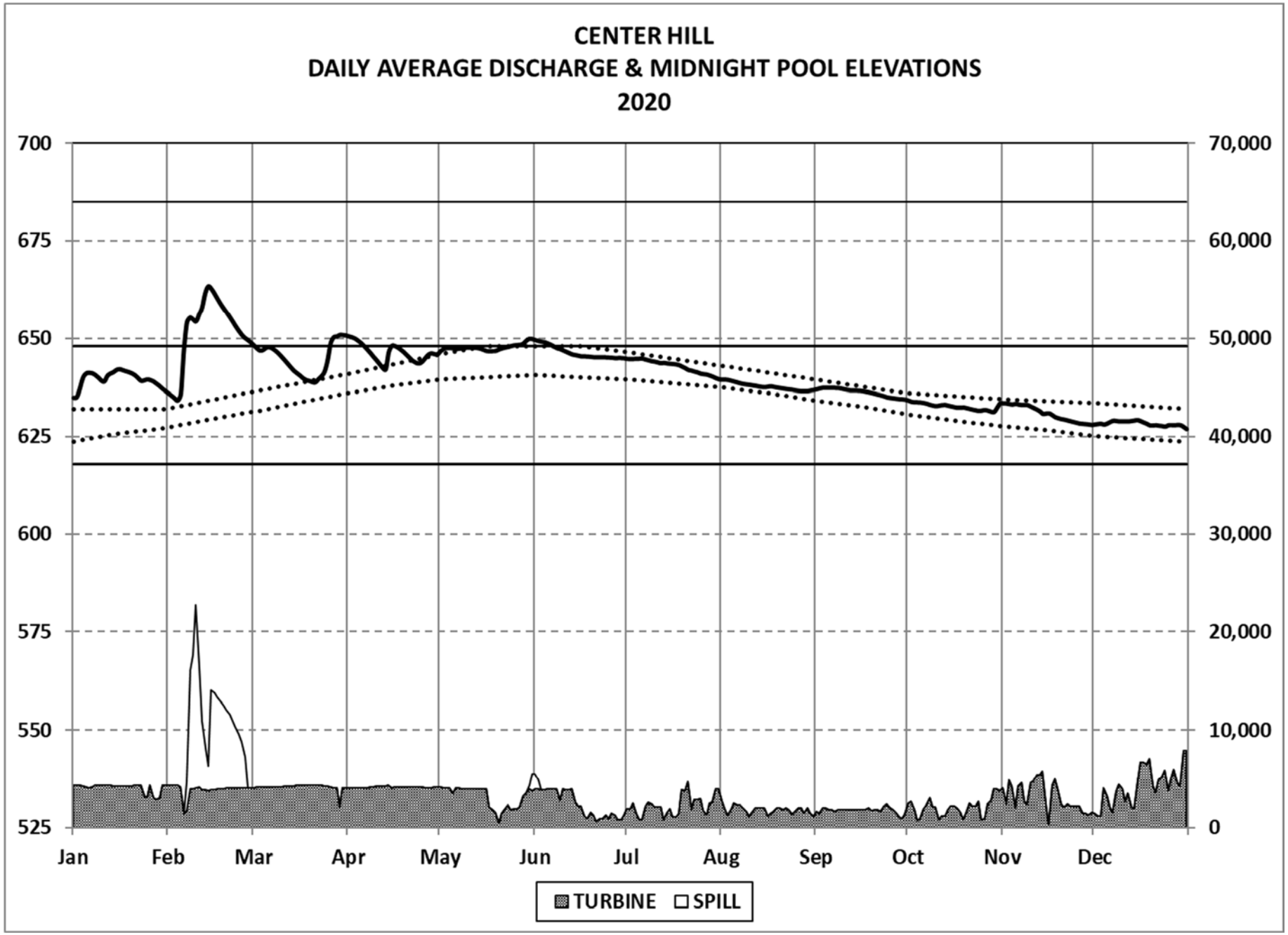

Plate VIII-93. Historical Pool Elevations and Discharges, 2020

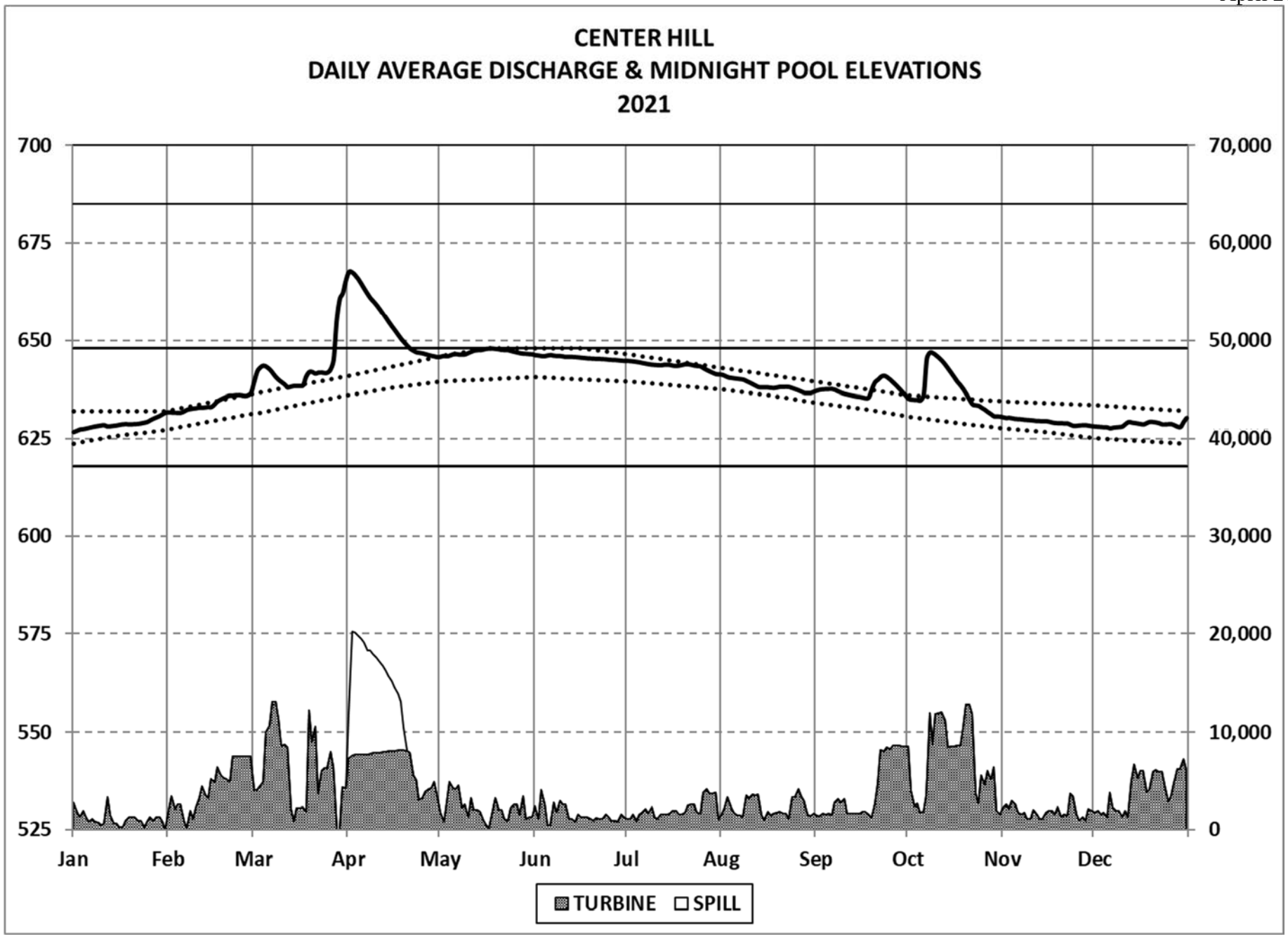

Plate VIII-94. Historical Pool Elevations and Discharges, 2021

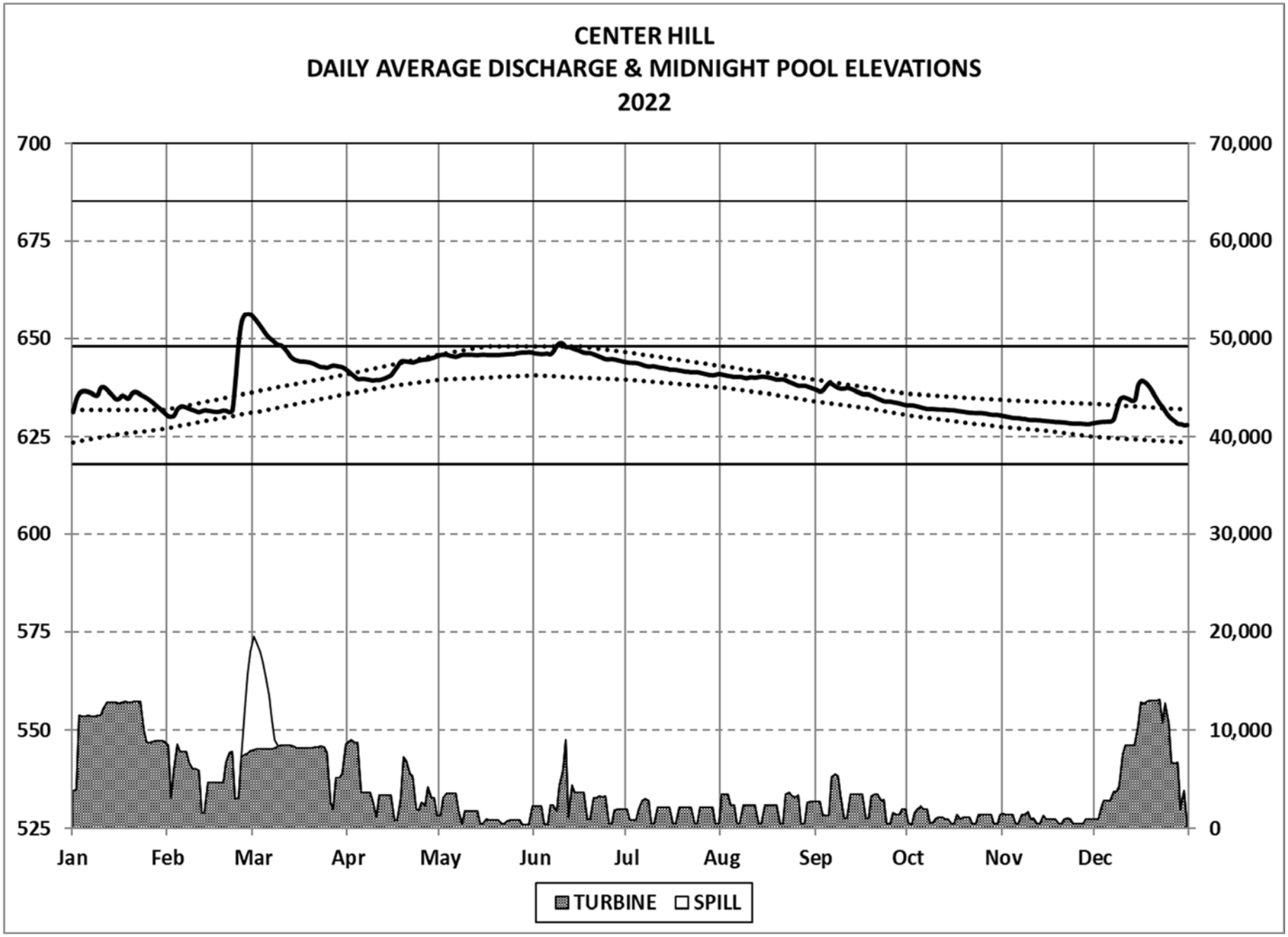

Plate VIII-95. Historical Pool Elevations and Discharges, 2022