WATER CONTROL MANUAL

CORDELL HULL DAM AND RESERVOIR

Cumberland River Basin
Tennessee

U.S. ARMY CORPS OF ENGINEERS
NASHVILLE DISTRICT

MAY 2021

PHOTOGRAPH

NOTICE TO USERS OF THIS MANUAL

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

REGULATION ASSISTANCE PROCEDURES

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

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Cordell Hull Dam and Reservoir
U.S. Army Corps of Engineers
Nashville District
May 2021

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Cordell Hull Dam and Reservoir
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UNIT CONVERSIONS

All elevations in this report are referenced to NGVD29 feet, at the dam site, the NGVD29 to NAVD88 offset is -0.30 foot i.e., 464.50 NGVD29 = 464.20 NAVD88.

PERTINENT DATA

a. Location. Cordell Hull Dam is located at N 36°17'25", W 85°56'37" on Cumberland River Mile 313.5 in Smith County, Tennessee four miles north of the City of Carthage.

b. Drainage Area. The Cordell Hull Dam local drainage basin encompasses 1,372 mi^2, the total drainage area above the dam is 8,095 mi^2. One inch of runoff in the basin equates to a volume of 36,892 day-second-feet (dsf) or 73,175 acre-feet (ac-ft).

c. Physical Components. Cordell Hull Dam is a combination concrete gravity and earthfill embankment dam with a total length of 1,306 feet. The powerhouse section is 310 feet long and has three Kaplan adjustable blade turbines with a generating capacity of 33.3 MW each for a 100 MW total and a maximum turbine discharge of approximately 30,000 cfs. The spillway section is 291 feet long consisting of five Tainter gates, 41.2 feet high by 45 feet wide. The spillway crest elevation is 464.5. The spillway capacity is approximately 193,800 cfs with a headwater of 508 feet. The lock section is 168 feet long containing 84 feet by 400 feet lock. The embankment section is 468 feet long and the right-side non-overflow section is 69 feet long. The turbine penstock centerline is at elevation 454.0 with a diameter of 40 feet.

d. Real Estate. Fee holdings at the project include 26,109 acres and easement holdings total 474 acres. The guideline used for acquisition at the dam was elevation 504 feet plus 300 feet or elevation 510, whichever was greater. The guideline used for acquisition at the upper end of the project was elevation 504 feet plus 300 feet or elevation 518, whichever was greater. The guideline used for acquisition in intermediate areas varied between elevation 504 and 518.

e. Pertinent Elevations. Pertinent elevations are displayed in Table P-1 on the following page.

Table P-1. Pertinent Elevations

	Reservoir Capacity					
	Elevation (Feet, NGVD)	Area (acres)	Cumulative Volume (acre-feet)	Cumulative Volume (dsf)	Incremental Volume (acre-feet to Surcharge Pool)	Incremental Runoff (inches)
Top of Surcharge Pool	508.0	13,920	310,870	156,730	-	-
Top of Spillway Gates	505.7	12,780	280,190	141,260	30,680	0.4
Top of Summer Pool (1 May – 30 Sep)	504.5	12,200	265,190	133,700	45,680	0.6
Recreational Pool (1 May – 30 Sep)	503.0	11,500	247,380	124,720	63,490	0.9
Top of Winter Pool (1 Dec – 15 Apr)	501.0	10,630	225,270	113,570	85,600	1.2
Inactive Pool	499.0	9,820	204,820	103,260	106,050	1.4
Spillway Crest	464.5	2,045	36,800	18,550	274,070	-
Turbine Penstock Centerline	454.0	-	-	-	-	-

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 format, content, and procedures.

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 Cordell Hull project, and to provide background information on the project. This manual presents the plan of regulation for the Cordell Hull project and furnishes information pertinent to its operation.

1-03 Related Manuals and Reports

This manual supersedes the previous "Cordell Hull 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	Revised March 1954
B:	Regulation Manual for Dale Hollow	Revised March 1954
C:	Regulation Manual for Center Hill	Revised 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	December 1998
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	December 1998
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. Some related manuals are the Cumberland River Basin Drought Contingency Plan - November 1994; the Emergency Action Plan - April, 2020; and a series of design memorandums printed prior to construction.

1-04 Project Owner

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

1-05 Operating Agency

The operating agency is the USACE, Nashville District (LRN). The dam is attended by the project staff at Cordell Hull power plant. The staff includes 16 full time employees. The machine shop has one senior mechanic, two journeyman, and two maintenance workers. The electric shop has one senior electrician and two journeymen. Each shop works 10-hour shifts Monday to Thursday. Typical staffing consists of six senior operators and is staffed 24 hours a day seven days a week. Operators usually work 12-hour shifts. The operators also remotely control Center Hill and Dale Hollow generating units. One office assistant and the power plant superintendent work Monday to Friday 0730 to 1630.

The Cordell Hull Natural Resource Management Office currently has 15 full time employees. The staff consists of; one Operations Manager, one Resource Manager, one Budget Technician, one Civil Technician, one Office Assistant, one Conservation Biologist, one Environmental Protection Specialist, three Rangers, one Co-op Ranger, one Facility Manager, one Contract Specialist, one Contract clerk/inspector and one Maintenance Mechanic.

1-06 Regulating Agencies

LRN is the regulating agency for Cordell Hull Dam. The Water Management Section of the Hydrology and Hydraulics Branch is responsible for directing the regulation of the dam. The operators at Cordell Hull 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 stream gages, as well as rain gages, in the Cordell Hull basin. Dual rain and stream gages are on the Cumberland River near Burkesville, Cumberland River at Celina, Cumberland River at Penitentiary Branch, Crocus Creek near Amandaville, and Jennings Creek near Whitleyville. Additionally, rain gages are located at Cordell Hull Dam and Livingston. LRN also maintains redundant headwater and tailwater gages at the dam site. The USGS began operating the stream gage Roaring River near Hilham, TN in September 2018.

Weather and river information are provided to LRN from the National Weather Service (NWS). River forecasts for the Cumberland River at Burkesville, Cumberland River at Celina, and Cumberland River at Carthage are also provided by the NWS.

II - DESCRIPTION OF PROJECT

2-01 Location

Cordell Hull Dam is located at N 36°17'25", W 85°56'37" on Cumberland River Mile 313.5 in Smith County, Tennessee, four miles north of the City of Carthage.

2-02 Purpose

Initial primary authorizing purposes include navigation (PL 79-525, River and Harbors Act of 1946), hydropower (PL 79-525, River and Harbor Act of 1946), and recreation (PL 78-534, Flood Control Act of 1944). Additional authorized operating purposes include fish and wildlife (PL 85-624, Fish and Wildlife Coordination Act of 1958, and 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 shows a general plan view and the physical components of Cordell Hull Dam. Plate II-2 and Plate II-3 shows further details of the physical components of Cordell Hull Dam.

a. Dam. Concrete gravity and earthfill embankment with a total length of 1,306 feet. This includes concrete spillway section 291 feet long; powerhouse section 310 feet long; lock section 168 feet long; embankment section 468 feet long; right side non-overflow section 69 feet long. Top of embankment elevation is 513 feet.

b. Spillway. Total effective width of 225 feet. Controlled by five 45 feet wide by 41.2 feet high Tainter gates. The spillway crest elevation is 464.5 feet.

c. Navigation Lock. The single lock is 400 feet long by 84 feet wide with a normal lift of 59 feet and a maximum lift of 63 feet.

d. Power Plant. Three Kaplan adjustable blade propeller turbines with 33.3 MW nameplate power rating. The nominal discharge is 30,000 cfs. The centerline of the intakes is elevation 454.0.

2-04 Related Control Facilities

Wolf Creek and Dale Hollow Dams are located upstream of Cordell Hull Dam. Cordell Hull Dam is located upstream of Old Hickory and where discharge from Center Hill Dam enters the Cumberland River. Plate II-4 shows the location of Cordell Hull Dam in relation to the

Cumberland River Basin. Plate II-5 shows a schematic of dams on the Cumberland River. Plate II-6 shows a profile of the Cumberland River and its Tributaries.

2-05 Real Estate Acquisition

Fee holdings at the project include 26,109 acres and easement holdings total 474 acres. The guideline used for acquisition at the dam was elevation 504 feet plus 300 feet or elevation 510, whichever was greater. The guideline used for acquisition at the upper end of the project was elevation 504 feet plus 300 feet or elevation 518, whichever was greater. The guideline used for acquisition in intermediate areas varied between elevation 504 and 518.

2-06 Public Facilities

There are multiple public recreation areas maintained by LRN as well as two commercial marinas. Activities range from land-based recreation like bird watching, hunting, and hiking to water-based recreation including fishing, boating, and swimming. Camping is another popular pursuit, either at the two developed campgrounds or on primitive sites. All these facilities are listed in Exhibit A and the Corps facilities are shown on Plate II-7.

The Cordell Hull Wildlife Refuge encompasses about 600 acres along both sides of Cordell Hull reservoir between the State Route 85A Bridge and the State Route 56 Bridge in Jackson County (CRM 349.5 to CRM 357.6). The refuge was created to establish a resident goose population, primarily for Canada Geese, but also for all types of waterfowl.

The Cordell Hull Wildlife Management Area covers 24,893 acres encompassing almost all the land owned by the USACE along Cordell Hull reservoir. The management area was leased by the Tennessee Wildlife Resource Agency (TWRA) from the Corps on 15 April 2013 for 25 years. This is the second 25-year lease of the area by TWRA. It contains between 2,000 and 2,500 farmable acres of land. Lease payments are in the form of allowing a portion of the crops to remain unharvested for use by the wildlife. Due to the current poor economic benefits of farming, leases exist for only about 900 to 1,000 acres.

Both the Wildlife Refuge and the Wildlife Management Area are managed by TWRA. Except for additional hunting restrictions in the area designated as the Wildlife Refuge, the two areas are essentially managed as one entity.

III - HISTORY OF PROJECT

3-01 Authorization

The initial purposes for which Cordell Hull Dam and Reservoir was authorized include navigation (PL 79-525, River and Harbors Act of 1946), hydropower (PL 79-525, River and Harbor Act of 1946), and recreation (PL 78-534, Flood Control Act of 1944).

Additional authorized purposes for which the project is operated include fish and wildlife (PL 85-624, Fish and Wildlife Coordination Act of 1958, and 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

Cordell Hull Reservoir is a major unit in the comprehensive plan for the development of the Cumberland River Basin.

Subsequent Congressional authorizations expanded project purposes to include fish and wildlife conservation, water supply, and water quality. 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." 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. Storage space in the reservoir may be allocated for water supply on a permanent basis in accordance with the Water Supply Act of 1958 (PL 85-500).

The overall project design and plan of development was formulated by the Corps of Engineers in cooperation with other federal, state, and local agencies. The Cordell Hull project was authorized under the name of Carthage by the River and Harbor Act approved 24 July 1946 (Public Law 525, 79th Congress, Second Session), in accordance with the recommendations contained in House Document No. 761, 79th Congress, Second Session. Subsequently, Public Law 85-843, approved 28 August 1958, changed the name of the project to Cordell Hull in honor of the late Secretary of State and Senator from Tennessee.

3-03 Construction

Construction of Cordell Hull Dam began 25 May 1963. Closure was achieved 4 October 1970 and impoundment began 13 March 1973. The dam was placed in service in February 1973 and

the lock in March 1973. The three generating units were placed in service in August 1973, October 1973, and February 1974, respectively.

3-04 Related Projects

Wolf Creek and Dale Hollow Dams are located upstream of Cordell Hull Dam. Wolf Creek is at Cumberland River Mile 460.9, 147.4 miles upstream of Cordell Hull Dam. Dale Hollow is at Obey River Mile 7.3, 73.8 miles upstream of Cordell Hull Dam. Cordell Hull Dam is located 97.3 miles upstream of Old Hickory Dam.

Cordell Hull Dam is part of the comprehensive development plan for the Cumberland River Basin. Including Cordell Hull, there are ten multi-purpose 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 Modifications to Regulations

This manual replaces the original Cordell Hull 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-foot stage, typically 15 April to 15 December. This modification is first mentioned in Section 4-09.
- Hydropower ramp rates, while still limited to two units per hour, are now strongly preferred to be limited to one unit per hour unless a power emergency necessitates a two unit per hour ramp rate. This modification is first mentioned in Section 7-02.
- Although spill operations are typically limited to a 5,000 cfs increase and a 10,000 cfs decrease, spill releases greater than these can be implemented by the project to pass debris downstream once due diligence has been done to ensure safe passage of the debris. However, these spill releases are less than one hour in duration. This modification is first mentioned in Section 7-02.

3-06 Principal Regulation Problems

Since project completion, this project has had no documented regulation problems including erosion, boils, severe leakage, embankment overtopping, encroachment, etc. have been documented.

3-07 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. Cordell Hull is classified as a DSAC III (moderate) dam. USACE considers this level of life-risk to be in the range of tolerability, but the dam does not meet all essential USACE guidelines. This ranking was based off a Periodic Assessment conducted in April 2016. A Periodic Assessment is conducted on a ten-year cycle and includes a Periodic Inspection, Semi-Quantitative Risk Assessment, and Potential Failure Mode Analysis. LRN dam safety personnel inspect Cordell Hull annually as part of a continuing evaluation inspection with major periodic inspections occurring every five years. Additionally, 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.

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IV - WATERSHED CHARACTERISTICS

4-01 General Characteristics

The Cumberland River is one of the major tributaries of the Ohio River. The source of the Cumberland River is located at the junction of the Poor and Clover Forks near the City of Harlan, Kentucky. From Harlan, the Cumberland River meanders southwesterly to the City of Nashville, Tennessee. From Nashville, the river flows in a northwesterly direction to Smithland, Kentucky, where it joins the Ohio River.

Cordell Hull Lock and Dam lies near the middle of the Cumberland River Basin, located in Smith County, Tennessee at Cumberland River Mile 313.5 about 5.3 miles upstream from the town of Carthage at the upper end of Old Hickory Reservoir with the dam being the head of that impoundment. The Cordell Hull Project impoundment lies in Smith, Jackson, Putnam and Clay Counties in Tennessee, and Monroe County in Kentucky. The reservoir extends upstream 67.3 miles. It has 381 miles of shoreline with a local, drainage area of 1,372 square miles. The uplands are generally rolling, except where deep incision of the streams produce a rugged terrain. Some cultivation exists in the narrow river valleys and on the rolling uplands, but, in general, the land is covered with brush and trees, with some merchantable timber. Plate IV-1 is a map of the Cordell Hull Watershed.

The majority of the Cordell Hull drainage area is controlled by Wolf Creek and Dale Hollow dams. Discharges from Wolf Creek typically take 24 to 30 hours to reach the Cordell Hull reservoir while discharges from Dale Hollow take approximately 12 hours. Due to Cordell Hull being a “run-of–river” project (the project has no flood storage capacity), inflows are basically equal to outflows. In addition, since the majority of the Cordell Hull drainage area is controlled by Wolf Creek and Dale Hollow projects, the releases from those two projects typically have a greater influence on project operations than runoff from the local drainage area.

Cordell Hull Reservoir is operated primarily for hydroelectric power production, navigation, and recreation and experiences annual pool fluctuations of five feet with potential fluctuations, during flood periods of nine feet. The reservoir has 11,960 acres of water surface at summer recreation pool elevation 504.0.

4-02 Topography

The Upper Cumberland-Cordell Hull Watershed is located in middle Tennessee. The Upper Cumberland-Cordell Hull Watershed falls within two Level IV sub-ecoregions as described below.

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 hardwoods 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 than the Inner Basin. Deciduous forest 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) geologic strata include Mississippian-age limestone, chert, shale and dolomite predominate, and karst terrain sinkholes and depressions.

Outer Nashville Basin (71h) encompasses almost 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

Cordell Hull reservoir has an uncontrolled drainage area of 1,372 mi^2. The Cordell Hull Dam was closed in February 1973, and the first sedimentation range survey for the reservoir was conducted in September 1973. Resurveys were conducted in June 1980, June 1988, and February 1993, which was the last survey conducted for Cordell Hull. The period of calculation for the February 1993 resurvey is September 1973 to February 1993. Thirteen of the 54 sediment ranges established on the reservoir could not be used for volumetric calculations.

The sediment deposition rate below elevation 508 is approximately 0.12 acre-feet/mi^2/year. The average annual sediment deposition is approximately 161 acre-feet per year and the total

sediment deposition from September 1973 to February 1993 was measured at 3,150 acre-feet. When compared to sediment deposition rates and totals calculated in past resurveys, these values suggest that most of the sediment deposition occurred in the first 15 years of reservoir operation and that deposition has steadily decreased. Approximately 73% of the total deposition in Cordell Hull reservoir occurred in the downstream 30% of the reservoir. Sediment is deposited below elevation 486. At elevation 508, a combined deposition volume of 239 acre-feet was calculated for the tributaries included in the reservoir. Scour was calculated in several tributaries.

None of the reports adjusted the stage-storage curves; however, the stage-storage curves used today have been adjusted by decreasing storage 3,150 acre-feet at elevation 485 and above. All previous storage values below elevation 485 were lowered 3 percent. In addition, LiDAR data was used to extend the stage-storage curves from elevation 515 to 525 in 2020.

4-05 Climate

The project is in a geographical region with a moderate continental climate. The mean annual temperature is approximately 60 degrees Fahrenheit, and the mean annual precipitation is around 48 inches. January is the coldest month with an average temperature of 38 degrees Fahrenheit and July is the warmest month with 80 degrees Fahrenheit being the average temperature. Weather changes are due to the eastward movement of air masses combining with masses from south of the region. Most of the runoff from rainfall occurs from the months of December thru April. During this time storms can be widespread over long periods and intermittent rainfall and evapotranspiration losses are at a minimum.

Celina averages approximately 53 inches of rain annually with the spring months of March-May being the wettest typically receiving 4.3 to 5.5 inches on average and September-October being the driest with average observed precipitation totals of approximately 3.6 inches. Average monthly rainfall totals are included on Table 4-1 below. Average yearly snowfall totals are around five inches, but snowmelt is rarely an issue as temperatures rarely stay sub-freezing for an extended period. There are three nearby NWS pan evaporation stations: Jamestown, KY, Crossville, TN, and Carthage, TN. Table 4-2 below displays pan evaporation data averaged between these three nearby sites. See Table 4-3 for monthly average mean temperatures for 1980-2018 at Celina. See Table 4-4 for point precipitation frequency estimates.

The Cumberland River watershed, where Cordell Hull Dam and Reservoir is located, is a region where the risk due to climate change is relatively low compared to other areas (such as coastal regions or arid regions). The 2015 USACE report titled “Recent US Climate Change and Hydrology Literature Applicable to US Army Corps of Engineers Missions – Ohio Region 05” (USACE,2015) forms the primary basis of this statement. Also taken into consideration for the study area are the findings from the National Oceanic and Atmospheric (NOAA), National

Centers for Environmental Information, State Climate Summary for Tennessee. While NOAA predicts an increase in the number of intense precipitation events in the future, the findings published by USACE are less conclusive. The above-referenced USACE report for the Ohio Region 5, which includes Tennessee, concludes that clear consensus is lacking in hydrologic projections.

According to the USACE screening and analysis tools there may be an increase in the intensity and magnitude of flooding events in the future. However, there is not enough agreement in the literature and data to determine whether this will increase the risk to this project.

Tennessee, like much of the southeastern United States, has exhibited little overall warming over the 20th century. However, under a higher emissions pathway, historically unprecedented warming is projected by the end of the 21st century. Total precipitation and the number of heavy rainfall events have been generally above average over the previous two decades. Future increases in extreme precipitation are projected to occur over the State. The intensity of naturally occurring droughts are also projected to increase in the future due to temperature-caused higher evaporation rates.

In addition, since the Cordell Hull reservoir is immediately downstream from Wolf Creek and Dale Hollow dams, any potential impacts due to extreme weather events such as flooding or drought from climate change would be minimized.

Table 4-1. Average Monthly Rainfall (inches)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4.17	4.61	4.65	4.33	5.51	4.49	4.84	4.06	3.74	3.50	4.17	5.43

Table 4-2. Mean Pan Evaporation (inches)

Apr	May	Jun	Jul	Aug	Sep	Oct
0.15	0.16	0.19	0.19	0.17	0.14	0.09

Table 4-3. Monthly Average Mean Temperatures (°F) at Celina, 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	57.8	48.5	41	**59.2**
1981	35.5	42.6	47.5	64	64.2	77.5	79.8	76.6	68.1	60.4	49.9	38.3	**58.7**
1982	34	39.5	52.5	54.6	71	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	**59.2**
1984	32.2	43.4	46.1	58.2	64.2	77.4	76.1	76.5	68.6	66.7	46	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	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	52.6	59.3	65.7	74.7	79.1	78	70.5	61	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	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	71	58.6	47.4	40.3	**59.2**
1994	33.4	44	50.7	62.5	64.1	78.1	78.5	77.1	69.1	61	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	44	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	79.8	76.9	71.9	59.8	45.5	39.5	**58.3**
1998	44.7	46	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	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	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	65.7	76.9	80.1	80	75	61.4	46.4	40.5	**60.0**
2003	32.9	38	52	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	**60.1**
2005	43.4	45	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	42.9	50.2	58.1	66.8	78	79.5	78.9	73.9	60.2	46.4	40.7	**59.4**
2009	35.2	43.8	52	59	67.6	77.9	75.7	77.1	72.3	56.9	51.3	39.3	**59.0**
2010	33	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	83	80.5	69.1	58.6	52	43.8	**60.5**
2012	43.3	45.7	61.1	62	72.8	77	83.5	77.8	70.9	58.4	47.6	47.2	**62.3**
2013	42	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	40.1	43.1	53.1	59.6	67.5	74.5	79.5	80.1	68.5	59.1	52.2	44.2	**60.1**
2015	38.2	45.1	48.9	61.5	69.7	76.5	81.2	81.2	72	58.5	48.5	42.1	**60.3**
2016	37.1	40.9	50.2	57.8	70.1	79.5	82.1	79.3	71.2	61.1	50.6	42.5	**60.2**
2017	37.4	41.1	51.2	58.5	69.8	79.2	84.1	80.2	72.2	62.2	51.1	43.2	**60.8**
2018	39.4	39.7	51.2	58	71.1	80.0	82.3	79.7	71.5	62	51.2	43	**60.6**
Mean	**38.4**	**42.2**	**50.6**	**59.6**	**68.3**	**76.3**	**80.2**	**79.3**	**71.9**	**50.5**	**50.2**	**41.3**	**59.9**

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 type 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 for Celina, TN, the precipitation frequency for the Cordell Hull Basin is given in Table 4-4 below.

Table 4-4. Rainfall Frequency-Depth-Duration for the Celina, TN Region

Duration		*Percent Chance Exceedance*						
		50	20	10	4	2	1	0.2
60 min	**Point Rainfall Depth (inches)**	1.49	1.86	2.15	2.58	2.93	3.30	4.28
2 hr		1.76	2.18	2.53	3.05	3.48	3.96	5.24
3 hr		1.91	2.35	2.73	3.28	3.75	4.25	5.60
6 hr		2.33	2.84	3.29	3.94	4.49	5.08	6.66
12 hr		2.79	3.40	3.92	4.68	5.31	5.99	7.79
24 hr		3.42	4.17	4.78	5.64	6.34	7.07	8.89
2 day		4.09	5.01	5.77	6.84	7.72	8.65	11.00
4 day		4.67	5.68	6.50	7.64	8.55	9.50	11.90

Cordell Hull was not designed for flood storage. Reservoir storage above elevation 504.5 exists to replace lost natural valley storage that occurred with project construction. Dam discharges and headwater levels are determined considering operation at projects upstream and downstream of Cordell Hull and controlling outflow to minimize any flooding impacts downstream. Several destructive floods have occurred in the Upper Cumberland River Basin. Most of the historic

crests at the Carthage gage occurred prior to the closure of Cordell Hull. The only recorded stage at Carthage above major flood stage of 47 feet since Cordell Hull was completed was a stage of 47.95 feet on 14 March 1975. The stage associated with the May 2010 flood was 46.1 feet. Several significant events are listed chronologically below.

December 1926. On 25 December 1926 the Cumberland River at Nashville, TN reached a stage of 56.2 feet, a level that remains a record to this day. Five days later on 30 December the Carthage gage reached the historic crest of 59.8 feet. Rainfall during December 1926 contributed significantly to the great Mississippi River flood of 1927.

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 36-hour period, an average of 4.7-inches fell over the Upper Cumberland Basin. The Carthage stage crested at 50.8 feet on 10 January.

January - February 1957. During a period of about three weeks, starting on 20 January and ending on 10 February, there was rainfall every day in part or all of the Cumberland and Tennessee River Basins. Individual stations recorded some rainfall on an average of 17 out of 21 days and a few stations recorded a trace or more each day for 21 consecutive days. Accumulated rainfall amounts recorded for the 21-day period at official stations in the Upper Cumberland River Basin ranged from about 8 to 12 inches. The most significant part of the storm for this area was a series of thunderstorms with high-intensity rainfall on 28 and 29 January. A maximum recorded rainfall depth in the area for this critical period was 5.8 inches in 24 hours.

March 1975. Flooding occurred on major streams in the Upper Cumberland as a result of the 12-14 March storm with the second highest recorded stage at Williamsburg on the Cumberland River after the April 1977 event and the second highest flooding on the Cumberland River in Nashville after the May 2010 event since the construction of the flood control projects. The peak stage on the Carthage gage was 47.95 feet, the highest stage recorded since the closure of Cordell Hull Dam. The peak discharge from Cordell Hull was 116,000 cfs.

May 1984. Heavy rainfall occurred over all of 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 feet on 08 May. The peak discharge from Cordell Hull was 85,000 cfs.

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. The heavy rainfall in this event was particularly devastating for Tennessee, where over a foot of rain fell over the span of two days. The back-to-back nature of this event on the first two days in May resulted in

historic rainfall totals across portions of Tennessee and Kentucky. The heaviest rainfall fell in a swath stretching from Memphis to Nashville in West and Middle Tennessee. Officially, Nashville received 13.57 inches of rainfall over the two-day period, more than doubling the previous two-day rainfall record of 6.68 inches set in September 1979, and even exceeding the previous monthly May record of 11.04 inches. Elsewhere across the affected region rainfall amounts of five to ten inches were common. The record pool elevation of 508.33 at Cordell Hull occurred during the historic Cumberland River flood of 2010. The project had a record maximum discharge of approximately 121,800 cfs during this event. Both records occurred on 03 May 2010. The Carthage gage reached a stage of 46.1 feet on 03 May as well.

February 2019. Heavy rainfall occurred over all of the Cumberland River Basin during February, making it the wettest February on record for the state of Tennessee. Average rainfall for project watersheds for the month ranged from 10.7 to 13.4 inches, average rainfall for the month is around 4.3 inches. The February event would have resulted in the highest natural stage at Nashville in history, a stage of approximately 57.16 feet, 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. Wolf Creek set a new pool of record on 26 February at elevation 756.52 and a new discharge of record of 59,910 cfs on 27 February. The Dale Hollow pool crested on 25 February at elevation 660.09, less than 0.9 feet below its pool of record. By storing water in the upstream projects, Water Management was able to keep the observed stage at Nashville at 40.93 feet (16.2 feet lower), 33.80 feet at Carthage (26 feet lower) and 32.61 feet at Celina (25 feet lower). The peak daily average discharge from Cordell Hull was 69,300 cfs on 24 February, however the maximum daily average for 2019 was 71,172 cfs on 11 March mostly due to the high releases from Wolf Creek.

4-07 Runoff Characteristics

The Cumberland River is a major waterway of the Southern United States. The 688-mile-long river drains almost 18,000 square miles of southern Kentucky and north-central Tennessee. The river flows generally west from a source in the Appalachian Mountains to its confluence with the Ohio River near Paducah, Kentucky, and the mouth of the Tennessee River. Major tributaries include the Obey, Caney Fork, Stones, Harpeth, and Red Rivers. Near Celina, the river crosses south into Tennessee, where it is joined by the Obey River and Caney Fork. Northeast of Nashville, the river is dammed twice more, forming Cordell Hull and Old Hickory reservoirs. The majority of the Cordell Hull drainage area is controlled by Wolf Creek and Dale Hollow Dams. Discharges from Wolf Creek typically take 24 to 30 hours to reach Cordell Hull while discharges from Dale Hollow take approximately 12 hours. Many of the tributaries and streams entering the Cordell Hull local area have unit hydrographs which reach peak inflow in 5 to 8 hours. The Cordell Hull local runoff area and the Roaring River at Gainesboro, TN unit hydrographs usually take 10 to 14 hours from initial runoff to peak. Due to Cordell Hull being a

"run-of–river" project inflows are basically equal to outflows. In addition, since the majority of the Cordell Hull drainage area is controlled by Wolf Creek and Dale Hollow projects, the releases from those projects typically have a greater influence on operations than the runoff from the local drainage area. Average monthly discharges from Cordell Hull are shown below in Table 4-5.

Table 4-5. Average Monthly Discharges (cfs)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
18,552	18,757	20,029	17,334	13,668	11,285	9,697	9,391	7,770	6,966	8,337	14,806

4-08 Water Quality

The Cordell Hull Reservoir water quality is primarily affected by the releases from two upstream storage projects: Wolf Creek and Dale Hollow. Cold water released from these projects moves rapidly through the main channel of Cordell Hull resulting in a theoretical hydrologic retention time of only about seven days. Because of this short retention time in the mainstem of the reservoir, thermal stratification, and dissolved oxygen (DO) depletion are typically moderate and occur for short periods during the summer months. Reservoir tributary embayments exhibit a higher degree of thermal stratification and DO depletion during the warm season because of greater retention times and influence of higher nutrient inputs from local watersheds. The most critical months for DO levels are typically observed from June through September. Destratification in the reservoir is normally completed by mid-October but may occur later in some years depending on air temperatures and flows.

Improvements in the quality of releases from Wolf Creek and Dale Hollow enhance water quality both in the Cordell Hull pool and for a considerable distance downstream of the dam. The Cordell Hull Dam tailwater is classified as a "warm water aquatic habitat" which has a state water quality standard of a minimum DO level of 5 mg/l, which is consistently met or exceeded in releases from Cordell Hull Dam. However, since Wolf Creek and Dale Hollow tailraces are considered "cold water areas" the state standard for DO below those projects is 6.0 mg/l which helps ensure the state standard of 5.0 mg/l is met at Cordell Hull. However, periods of low flow during the drawdown of Wolf Creek Reservoir from 2007-13 to repair Wolf Creek Dam resulted in DO for turbine discharges falling below the 5.0 mg/l target. During those occurrences, aerated releases from the spillway gates at Cordell Hull were used to supplement the low DO in turbine discharges in order to strive to meet the state standard, as good environmental stewards. Concentrations of metals and nutrients in the reservoir are typically consistent from year to year and are generally not a concern in discharges from the dam.

Across the reservoir, Cordell Hull historically ranks as 'Eutrophic' in terms of biological productivity. Some of the elevated productivity can be attributed to several years where low flows from Wolf Creek Dam adversely impacted temperatures and water chemistry. Forebay

phytoplankton communities tend to be dominated by golden algae, green algae, and dinoflagellates. The combination of cold-water temperatures and low residence time likely help reduce the influence from problematic groups such as cyanobacteria and issues from Harmful Algal Blooms (HABs). Historically, there have been no HABs observed in Cordell Hull reservoir. The mainstem portions of the reservoir bottom are generally dominated by environmentally tolerant benthic macroinvertebrate organisms such as worms (Oligochaetes), true flies (Diptera), and midges (chironomids). Organisms that are indicators for good water quality are present in the reservoir but comprise a small percentage of the overall benthic community in Cordell Hull. This likely relates to the sort of habitat present, which is typically shifting and originally enriched mud/sand/silt substrate. Benthic communities are more variable in the tributary embayments, which show some influences from upstream watershed areas. As with the mainstem of Cordell Hull, tributary embayments are generally dominated by tolerant organisms.

4-09 Channel and Floodway Characteristics

Celina is the upstream damage center for Cordell Hull. Control flow for Celina is 40,000 cfs (25-foot stage). The total drainage area at Celina is 7,307 mi^2, 6,724 mi^2 (92%) of which is controlled by Wolf Creek and Dale Hollow projects. Flood stage, as determined by the NWS, at Celina is 40 feet or a flow of approximately 75,000 cfs. Travel time from Dale Hollow to Celina is approximately one to two hours. Carthage is the designated downstream control point for Cordell Hull and Center Hill, see Plate VII-8. Control flow for Carthage is 72,000 cfs (29-foot stage). The official flood stage for Carthage is 40 feet or a flow of approximately 110,000 cfs. Discharges from Cordell Hull can reach Carthage in as little as 1 hour. A table outlining approximate travel times to Cheatham Dam is included in Table 4-6 below.

Table 4-6. Approximate Travel Times (hours)

Approximate Travel Time (hours) Between:	Incremental	Total (from Cordell Hull)
Wolf Creek Dam to Celina	**14-24**	**N/A**
Dale Hollow Dam to Celina	**1-2**	**N/A**
Celina to Cordell Hull	**10-16**	**N/A**
Cordell Hull to Carthage	**1**	**1**
Carthage to Old Hickory	**10-16**	**11-17**
Old Hickory to Nashville	**2-4**	**13-21**
Nashville to Cheatham	**4-6**	**17-27**

4-10 Upstream Structures

Wolf Creek Dam (Cumberland River Mile 460.9) and Dale Hollow Dam (Obey River Mile 7.3) are located upstream of Cordell Hull Dam.

4-11 Downstream Structures

Old Hickory Dam (Cumberland River Mile 216.2) and Center Hill Dam (Caney Fork River Mile 26.6) are located downstream of Cordell Hull Dam.

4-12 Economic Data

The Cordell Hull Watershed includes parts of Clay, Jackson, Macon, Overton, Putnam, and Smith Counties located in Tennessee, and drains approximately 790 square miles. Predominant land use in the watershed is forest (61.8%) followed by pasture (14.4%). Developed areas represent approximately 1.2% of the total drainage area of the watershed.

a. Population. Cordell Hull Reservoir encompasses portions of Clay, Jackson, Smith, and Putnam Counties in Tennessee and Monroe County in Kentucky. Nearby population centers include Albany and Burkesville in Kentucky and Celina, Livingston, Gainesboro, Cookeville, and Carthage in Tennessee. County populations and other demographics obtained from the US Census Bureau (2013) are provided in Table 4-7.

Table 4-7. County Population Data within Cordell Hull Project Area.

County	Population (2013)
Clay	7,774
Jackson	11,517
Macon	22,701
Monroe	10,681
Overton	22,075
Putnam	73,525
Smith	19,074

b. Agriculture. According to CropScape as of 2018 agricultural practices, pasture/hay and cultivated crops total approximately 27.33% of the counties listed above.

c. Industry. Business communities in the Cordell Hull watershed are very diverse, ranging from locally owned to multinational corporations. Sixty eight percent of the US population is within a 600-mile radius of this region. The northern middle Tennessee area serves as a distribution point for 75% of all major US markets. The watershed area has a geographical advantage for manufacturing, distribution, and corporate headquarters. Jackson County, located approximately in the middle of the watershed, has a small airport, a Port Authority on the Cumberland River, and is only minutes from I-40.

d. Flood damages. Flood control is not an authorized purpose for Cordell Hull Reservoir. Only a small amount of surcharge storage is available to mitigate the effects of the reservoir by replacing natural valley storage lost due to impoundment. Therefore, no flood damage reductions are computed for Cordell Hull.

V - DATA COLLECTION AND COMMUNICATION NETWORKS

5-01 Hydrometeorological Stations

a. Facilities. Plate V-1 shows the location of hydrometeorologic data collection locations. These locations include:

- Cordell Hull Dam Redundant Headwater
- Cordell Hull Dam Redundant Tailwater
- USGS 03414100 Cumberland River at Burkesville
- USGS 03417500 Cumberland River at Celina
- USGS 03417600 Cumberland River at Penitentiary Branch
- USGS 03418224 Jennings Creek near Whitleyville
- USGS 03414078 Crocus Creek near Amandaville
- USGS 03418000 Roaring River near Hilham

These gages are summarized in a table on Plate V-2.

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 redundant gage and the Penitentiary Branch gage. The Nashville, TN office of the USGS is responsible for the upkeep and maintenance of the gages at the tailwater, Celina, Jennings Creek, and Roaring River. The Williamsburg, KY USGS office is responsible for maintenance of the Burkesville and Crocus Creek gages.

5-02 Water Quality Stations

a. Facilities. The Cordell Hull Project has sixteen actively sampled water quality stations for collection of physical, chemical, biological, and sediment contaminant data. There are eight main stem reservoir stations, three tributary embayment reservoir stations, four inflow stations, and the tailwater station. Water quality sampling by LRN Water Management is performed typically three times per year. Once every ten years Cordell Hull is sampled intensively five times in a year. Physical, chemical,

chlorophyll-a, and phytoplankton (algae) data are collected seasonally usually during late spring, summer, and early fall. Benthic macroinvertebrates are monitored once every three years at three inflow locations and five reservoir stations. Sediment contaminant samples are collected in the reservoir once every five years at five different locations. A map of the LRN water quality sampling locations is included on Plate V-3.

In addition to field sampling by Water Management staff, there are two continuous water quality monitors in the Cordell Hull Project that collect and transmit data every thirty minutes. The monitors are located in the Cordell Hull tailwater at Cumberland River Mile (CRM) 313.4 and on the upper end of the reservoir near Celina, TN at CRM 380.8. Water Temperature is collected year-round at these sites with dissolved oxygen, specific conductance, and pH typically collected from March through October.

b. Reporting. Water quality data that is collected manually in the field is stored in the CE-DASLER database. Typically, field data reports are prepared and sent to stakeholders after the completion of every sampling trip. Data from the water quality monitors are transmitted via DCP and the GOES network to the CWMS database in the district office. Water Quality Physical, Chemical, and Biological data records span from 1973 to present and can be accessed at the following website:

https://water.usace.army.mil/

c. Maintenance. The LRN Water Management hydrologic technicians are responsible for the installation and maintenance of the water quality monitors.

5-03 Sediment Stations

a. Facilities. The first sediment range survey for Cordell Hull was conducted in September 1973. The original sediment range network consisted of 54 ranges. Ten of the ranges are located in the main stem of the Cumberland River. Forty-nine of the original ranges were established in September 1973, however five ranges were not surveyed during that time due to construction activity. Fifty-four ranges were surveyed during the last sediment survey in February 1993. A number of ranges have been destroyed or relocated since the original survey. The majority of sediment deposition occurs in the Cumberland River. Only 8% (239 acre-feet) of the total calculated deposition settled in tributaries. However, deposition was not calculated in all tributaries. A scour volume of 205 acre-feet (at elevation 508) was calculated for Defeated Creek. Scour volumes were also calculated for Martin Creek, Doe Creek, Mill Creek and Proctor Creek. Deposition was calculated for all remaining tributaries.

b. Reporting. No sediment stations regularly report to the district office at this time. The last full survey was completed in February 1993 and showed an insignificant change,

0.12 acre-feet/mi^2/year. Resurveys were conducted in June 1980, June 1988, and February 1993.

c. Maintenance. The Water Resources Section of the Hydrology and 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 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 servers at the Lakes and Rivers Division (LRD) office if necessary.

5-06 Communication with Project

a. Regulating Office with Project Office. Communication between LRN Water Management and staff at Cordell Hull may take place several times a day or go for several days without any contact. Since all generation schedules are issued by TVA and the hydropower units are operated by the operator at Cordell Hull, there is rarely a need for communication between LRN Water Management and Cordell Hull regarding generation schedules. However, any hydrologic data issues from the project are handled by communicating with the Cordell Hull operator. Additionally, the operation of spillway gates requires communication, as well as upcoming unit outages, maintenance requests involving special generation needs, and other flow or elevation requests. Occasionally, low or high water causes impacts and communication between LRN Water Management staff and Cordell Hull Resource Management staff might be necessary

b. Between Project Office and Others. The majority of communication with regards to Cordell Hull takes place between the Regulating office and the plant operator. However, during spillway operations the plant operator will contact the local Nashville NWS office and the lock operator on duty for Cordell Hull Lock.

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. Cordell Hull also has one redundant headwater gage and one

redundant tailwater gage which transmit via DCP. All hydrologic data (elevations and discharges) are automated via DCP. The standard procedure for making gate changes is for water management to phone the Cordell Hull plant operator and provide instructions on time of change, rate of discharge change, and total flow desired. Once changes are made, the project enters the observed data and sends it with the other observed project data.

5-08 Warnings

The fisherman warning system is in place at Cordell Hull as it is at all LRN reservoirs with generating units. An audible alarm is sounded prior to the hydropower turbine being brought online to alert anyone in the tailwater area of the impending release. Additionally, if spillway gate operations are necessary, the tailwater area is visually checked prior to opening the gates. When spillway gates are being opened, strobe lights continually flash to broadcast the warning. The Nashville NWS and Cordell Hull lock operator are also notified of any spillway gate changes.

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 Celina, TN and the Cumberland River at Burkesville, KY are the only NWS forecast locations in the Cordell Hull Basin, releases from Cordell Hull have a significant impact on the forecast at the Cumberland River at Carthage, TN.

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 Cordell Hull hydrologic forecasts.

b. Role of Other Agencies. Twice a day, the NWS issues Quantitative Precipitation Forecasts (QPF) with projected rainfall totals. Additionally, the OHRFC forecasts the stage at Celina and 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 47).

6-02 Flood Condition Forecasts

The following requirements and methods for forecasting at Cordell Hull are mandatory regardless of hydrologic conditions (flood, drought, conservation, etc.).

a. Requirements. Midnight headwater elevations, daily average inflows, and daily average discharges are forecast for Cordell Hull 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 the Local Data Manager (LDM) and to the public through 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 Cordell Hull is broken down into nine sub-basins with their respective areas (mi^2) listed below:

- Crocus Creek near Amandaville (104.7)
- Cumberland River at Burkesville local (126.4)
- Marrowbone Creek near Waterview (68.5)
- Cumberland River at Celina local (284.3)
- Cumberland River at Penitentiary Branch local (130.2)
- Roaring River near Hilham (77.7)
- Roaring River at Gainesboro local (197.6)
- Jennings Creek near Whitleyville (67.3)
- Cordell Hull local (315.3)

The above sub-basins are routed to a Cordell Hull Inflow junction to create an inflow hydrograph for the reservoir.

In the LRN CWMS model, the Reservoir Simulation (ResSim) model for Cordell Hull includes stage-storage curves, monthly evaporation rates, and rating curves for the spillway and turbines. The Flood Control, Conservation Pool (sometimes referred to as the Power Pool), and Inactive Pools are defined as well as the Recreation Pool. Additionally, rules designed to efficiently operate the reservoir as well as the rate of release limitations, are 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 Cordell Hull and at other projects in the Cumberland Basin.

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 Cordell Hull has four primary objectives. These are:

- To provide a nine-foot channel depth to permit commercial navigation from the dam to Celina, Tennessee.
- To generate hydropower.
- To provide a relatively stable pool for the recreational enjoyment of the public.
- To provide a small amount of surcharge storage to mitigate the effects of the reservoir by replacing natural valley storage lost due to impoundment.

Subsequent legislation since impoundment has expanded the general objectives to include fish and wildlife conservation, water quality, and water supply. Additionally, Cordell Hull is part of the comprehensive development plan for the Cumberland River Basin. Including Cordell Hull, 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 Cordell Hull. They are covered more in-depth later in this chapter, but they are listed below for ease of reference:

- Maintain the headwater elevation within the limits of the seasonal conservation pool (elevations 499.0 to 501.0 in the winter and 503.0 to 504.5 in the summer) and release all water through the turbines as governed by the hydropower generation schedules.
- Changes in hydropower generation are limited to two units per hour, up or down. Additionally, it is strongly desired to limit changes to one unit per hour, up or down.
- Combined spillway/sluice release increases at Cordell Hull and Center Hill are limited to 5,000 cfs per hour except during periods of extreme flooding; decreases are limited to 10,000 cfs per hour. During times that debris is passed through the spillway gates higher rates are allowed but for only short durations of less than one hour.
- There is no minimum release discharge from Cordell Hull; however, during the summer months, the daily average discharge should be no less than 1,800 dsf to benefit Gallatin Steam Plant and prevent recirculation for the cooling water intakes.
- Maintain headwater elevation at or below elevation 508.0 under all circumstances until free flow discharges are attained.

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 all water through the turbines as governed by hydropower generation schedules.
- Limit change in hydropower generation to two units per hour, up or down, with a preference for limiting changes to one unit per hour, up or down.
- There is no designated minimum release rate or volume for Cordell Hull Dam except for the preferred daily average for Gallatin Steam Plant in the summer months.

The following information outlines the overall Cordell Hull project plan for water control:

a. Guide Curve. The regulation curve, or guide curve, represents the primary guidance for operations at Cordell Hull 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 guide curve divides the storage volume of the reservoir into distinct horizontal zones. The zones change with the time of year as described below.

b. Inactive Pool. Inactive storage at Cordell Hull extends from the bottom of the reservoir up to elevation 499. Water is not released if it would bring the surface of the pool below the top of this zone. Inactive storage is provided primarily to offset sedimentation and provide head for hydropower. Other benefits of this permanent pool include depth for slack water navigation, recreation, providing depth for water intakes, habitat for fish and other aquatic life, and insurance water for drought periods.

c. Conservation Pool. The Conservation Pool extends from elevation 499 to elevation 501 in the winter, and from elevation 503 to 504.5 in the summer. Each year the periods between 15 April and 01 May, and between 01 October and 01 December, are transition times during which the pool gradually moves between the summer and winter levels. The water level in the reservoir is within the ranges of this pool over 95 percent of the time. This is the normal condition of the reservoir. Fluctuations within this pool are very frequent, but usually one foot or less. Changes can occur hourly, and the full range of the pool is used at times.

d. Recreation Pool. The Recreation Pool extends from elevation 499 to elevation 503 during the late spring and summer months. Each year between 15 April and 01 May, the pool is transitioning to its normal summer level. The full summer recreation pool is normally provided for five months, from May through September. Drawdown of the pool begins on 01 October and ends on 01 December. There is no storage pool allocated for recreation from 01 December through 15 April.

The original authorized purposes of Cordell Hull were navigation, hydropower, and recreation. Because of these original authorizations, this was once known as the Power and Recreation Pools. Due to subsequent legislation authorizing additional purposes for the project (fish and wildlife conservation, water supply and water quality); the pools are now more commonly referred to as the Conservation Pool and Recreation Pool.

d. Surcharge Pool. The Surcharge Pool is the uppermost zone of the reservoir. It extends from elevation 501 to elevation 508 in the winter, and from elevation 504.5 to elevation 508 in the summer. The storage volume within the Surcharge Pool is used to mitigate the effects of the existence of the reservoir on the propagation of flood crests down river. The mere presence of Cordell Hull Reservoir tends to accelerate and increase the magnitude of a flood crest as it moves down the Cumberland River. Water is permitted in the Surcharge Pool only during flood events. It is utilized to store a quantity of water that would, under natural conditions, have been stored in the former river valley. The specific methods for use of this space are discussed more fully in Section 7-05.

e. Normal Regulation Outflow. During periods of normal regulation, the water surface elevation behind Cordell Hull Dam is maintained within the Conservation Pool limits and all releases are made through the turbines as governed by the demand for power. This regulation procedure is in effect as long as inflows to the project remain less than the discharge capacity of the turbines. When reservoir inflows exceed turbine capacity, and the pool tends to rise, spillway releases may be initiated to augment power discharges, and spill is increased as required to keep the reservoir from exceeding top of Conservation Pool until control flows are reached. Power plant operators have the authority to initiate spillway releases during this time, however unless given prior instructions from water management, the operators will attempt to contact water management personnel before initiating spill operations.

f. Hydropower Generation. 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 at Cordell Hull 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. LRN discourages TVA from deviating from the prescribed daily generation at the project. The Cordell Hull powerhouse is manned twenty-four hours a day, seven days a week. TVA river scheduling in Knoxville communicates the hourly generation schedule directly to the Cordell Hull operators who, in turn, control all turbine releases from the dam. The Cordell Hull operators also remotely control all hydropower operations for the Center Hill and Dale Hollow projects. The primary water management functions of the powerhouse operators are to ensure that headwater and tailwater levels are above the minimum allowable, that changes in

generation do not exceed two units per hour, and that the machinery is operated within allowable limits. It is the responsibility of the Water Management Section to issue specific project release instructions and to ensure adherence to the water control plan.

Large surges in releases can cause bank erosion and make commercial navigation much more difficult downstream on the Cumberland River. In order to minimize river level fluctuations, changes in hydropower generation normally are limited to two units per hour, up or down. However, it is strongly preferred to limit ramp rates to one unit per hour unless a power emergency or similar situation necessitates a two unit per hour ramp rate.

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

- Plate VII-2; Area and Volume Table
- Plate VII-3; Spillway Rating Table
- Plate VII-4; Spillway Rating Curves
- Plate VII-5; Turbine Discharge Curves
- Plate VII-6; Turbine Discharge Table
- Plate VII-7; Estimated Unit Efficiency
- Plate VII-8; Carthage Rating Curve
- Plate VII-9; Celina Rating Curve
- Plate VII-10; Tailwater Rating Curve

7-04 Standing Instructions to Damtender

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

- Maintain the headwater elevation within the limits of the seasonal Conservation Pool (elevations 499 to 501 in winter and 503 to 504.5 in summer) and release all water through the turbines as governed by the hydropower generation schedules.
- If the reservoir level approaches the lower limit of the pool, elevations 499 in winter and 503 in summer, reduce or curtail hydropower releases as necessary to prevent the headwater from falling below the seasonal bottom of the conservation pool and notify the power scheduling agency.
- Limit changes in hydropower generation to two units per hour, up or down, preferably one unit change per hour.
- When increased inflows tend to cause the headwater to rise above the seasonal top of Conservation Pool, elevations 501 in winter and 504.5 in summer, increase generation at no more than one unit per hour to maximum turbine capacity as required to return the

pool to normal seasonal levels and notify the power scheduling agency, unless the future generation schedule is expected to return the pool to lower levels.

- If the headwater continues to rise, supplement turbine capacity with spillway releases at a rate of 5,000 cfs per hour in an effort to stop the rise and return the pool to normal seasonal levels. All gates should be operated at approximately the same opening. If Center Hill should require concurrent increases in spillway discharges, limit combined increases of both projects to a total of 5,000 cfs per hour.
- To the extent possible, limit flows at Carthage to a maximum of 72,000 cfs or a stage of 29 feet.
- Maintain headwater at or below elevation 508.0 under all circumstances until free flow discharges are attained.
- When the pool level crests, the gate setting existing at the time of the crest should be maintained until the reservoir recedes to the top of conservation pool. Then reduce discharges; however, combined decreased in spillway releases from Cordell Hull and Center Hill are limited to 10,000 cfs per hour.
- When the reservoir is stabilized within the conservation pool, resume normal operations.

7-05 Flood Control

The following are specific regulating rules for Flood Periods:

- Subject to the 5,000 cfs per hour increase limitation stated below, spillway releases can be used for pre-flood drawdown to lower reservoir to minimum conservation pool before flood inflows arrive, but only under direction of the Water Management Section.
- Continue to pass as much flow as practical through the hydropower turbines; however, changes in hydropower generation are still limited to two units per hour, preferably one per hour.
- If river flows increase to the point that reservoir inflows are more than that which can pass through the turbines, open spillway gates to maintain the water surface elevation within the Conservation Pool limits subject to the following criteria unless Water Management Section directs otherwise.
    - In conjunction with Center Hill, limit the flow at Carthage to 72,000 cfs or a stage of 29 feet.
    - If the control flow at Carthage cannot be maintained while holding water surface within the conservation pool, set the surcharge pool fill rate at or below 0.15 foot per hour, subject to the 5,000 cfs per hour increase limitation stated below.
    - If control flows at Carthage cannot be maintained with a surcharge pool fill rate of 0.15 foot per hour, then limit the maximum combined increase in spillway discharges from Cordell Hull and Center Hill to 5,000 cfs per hour.

    - Limit maximum combined decrease in spillway discharges from Cordell Hull and Center Hill to 10,000 cfs per hour; however, if possible, decreases of no more than 5,000 cfs per hour are preferred.
- When Surcharge Pool is full, increase spillway releases as required to prevent the headwater from exceeding elevation 508.0.
- When the river begins falling, release water stored in the Surcharge Pool at a rate which allows downstream stages to continue falling. As the pool approaches the top of hydropower storage, the rate of fall in the pool should be reduced.

The Cordell Hull project does not have any "flood control" storage capabilities. It does have a small amount of space dedicated to "flood surcharge" storage. These two terms are often confused with each other, but they are distinct. The most significant difference between flood control storage and flood surcharge storage is its intended purpose. Projects with flood control storage are intended to hold back vast amounts of water during flood events. These projects can substantially reduce downstream flood stages by providing a space to hold flood waters until a flood crest has passed and the excess water can then be released at a rate which minimizes potential damages. There is no such intended goal at projects which have flood surcharge storage. Surcharge storage replaces natural valley storage lost due to impoundment of a reservoir.

A flood crest moving downstream tends to be accelerated by the presence of a reservoir in the system. The loss of valley storage can send flood waters into a reach of river quicker than would be the case under natural conditions and subsequently stages at downstream points can be higher than would be the case had the project not been built. To prevent Cordell Hull Reservoir from causing such an increase in downstream flood depths, the flood surcharge storage space is used to store this excess water and thus return downstream flood stages to those that would have existed had Cordell Hull Dam never been built. Thus no overall improvement in downstream flood stage conditions is expected from the flood surcharge storage at Cordell Hull.

During the flood season, Cordell Hull has a volume of about 86,000 acre-feet designated as flood surcharge storage. This equates to about 1.17 inches of runoff from the local project drainage area and only 0.2 inches of the total drainage area above Cordell Hull. As a comparison, the four major flood control projects in the Cumberland Basin (Wolf Creek, Dale Hollow, Center Hill, and J. Percy Priest) are capable of storing from 5 to 7 inches of runoff from their respective drainage basins in their Flood Control Pools. This demonstrates the vast difference in capacity to hold back flood waters between projects with "flood control" and "flood surcharge" storage.

The typical travel time of a wave through the Cordell Hull sub-basin is about 12 hours from Dale Hollow Dam and about 30 hours from Wolf Creek Dam. This translates to be an average wave

velocity through Cordell Hull reservoir of about 6 mph and an average wave velocity in the Cumberland River upstream of the impoundment of about 4 mph.

Flood surcharge storage is best used just prior to the peak of the flood to maximize reduction of the peak outflow from the project. At any other time, use of surcharge storage will result in taking flow out of the river at non-peak times and may not reduce the peak stages downstream. If the flood surcharge storage is used too soon, there could be no storage space remaining when the peak arrives.

The size of the surcharge storage pool was derived considering flows expected while the storage reservoirs were being emptied. It was not intended to also compensate for heavy local runoff simultaneous with peak releases from Wolf Creek, Dale Hollow, and Center Hill. Therefore, it is prudent to utilize the surcharge storage only during major floods. If additional rain were to occur while using surcharge storage to reduce the peak of a moderate flood, full compensation for lost valley storage would not be possible. Thus, the surcharge storage and any additional storage that can be gained by pre-flood drawdown should be preserved until it is clearly evident that the storm has passed. Additionally, priority should be given to evacuating surcharge storage over flood control storage.

There is one exception to the policy of conserving all surcharge storage where it is advisable to allow the reservoir to rise above the top of the Conservation Pool prior to spill. If the rise is expected to be short term, and the reservoir level is projected to return to normal operating levels without spill, then spillway releases are not required, and the used surcharge storage will be evacuated via hydropower generation.

The Surcharge Storage Pool is between elevations 501 and 508 in the winter, and between elevations 504.5 and 508 in the summer. The top of the spillway gates in the closed position are at elevation 505.7. In order to use the full Surcharge Storage Pool, the gates must be open as the headwater rises above elevation 505.7. This is referred to as an induced surcharge operation.

Adequate freeboard to prevent water from overtopping the gates must be maintained as the gates are being raised. For this reason, and also to insure proper stilling action in the spillway bucket, all gates should be raised to uniform openings. The following tabulation shows the minimum possible spillway releases for various headwater levels, assuming no freeboard below the top of gates.

Table 7-1. Minimum Possible Spillway Releases

Headwater Elevation (feet)	Minimum Gate Opening (feet)	Minimum Spillway Discharge (cfs)
504	0	0
505	0	0
506	0.3	1,710
507	1.3	7,540
508	2.3	13,505

The primary control point for releases from Cordell Hull Dam is Carthage, Tennessee which is located 5.3 miles downstream of the dam. Flow past Carthage is directly affected by releases from both Cordell Hull Dam and Center Hill Dam. Center Hill is a flood control structure, so it has a greater capacity to reduce the peak Carthage flow rate more than Cordell Hull which has only a small surcharge storage capacity. The total flow at Carthage is the combination of Cordell Hull and Center Hill discharges, plus runoff from the 420 square mile uncontrolled drainage area. Discharges from all three of these sources must be considered when developing an operating plan to achieve a desired flow or a rate of change in flow at Carthage.

The control flow for Carthage is 72,000 cfs or a stage of 29 feet. The official flood stage at Carthage is 40 feet, approximately 110,000 cfs. It is recognized that the control flow (maximum desired flow) for Carthage results in a river stage significantly below damage levels. The control flow has been set to leave room in the channel to accommodate additional runoff from subsequent rainfall events during periods when flood control storage is being evacuated from upstream projects. This criterion was set primarily to minimize damages in the Nashville area.

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. The purposes of these restrictions are to reduce sudden surges downstream, reduce stream bank erosion, and minimize impacts on navigation.

As a flood progresses, Cordell Hull discharges are increased, and Carthage flows are allowed to reach control flow before any surcharge storage is used. Once the control flow is reached, Center Hill discharges are then reduced to maintain the control flow at Carthage. If the control flow at Carthage cannot be maintained while holding the water surface within the conservation pool, then flood surcharge storage is utilized. If the headwater is rising faster than 0.15 foot per hour, Cordell Hull releases are increased and the Carthage control flow is exceeded, but the

increase in maximum combined spillway releases from Cordell Hull and Center Hill is still limited to 5,000 cfs per hour. This operating constraint remains in effect until all surcharge storage is used, at which time the discharge is increased as necessary to maintain the water surface at the top of the flood surcharge pool, elevation 508. After the reservoir peaks, the maximum discharge reached is maintained until the headwater level recedes back to the top of the Conservation Pool. The maximum combined decrease in spillway discharges from Cordell Hull and Center Hill is limited to 10,000 cfs per hour, however, if possible, decreases of no more than 5,000 cfs per hour are preferred.

During flood periods, the hydropower turbines are generally run at full generating capacity, 24 hours per day. Adjustments to flow are then made by manipulating the spillway gates. Instructions for these manipulations come from the Water Management Section directly to the powerhouse and may change periodically depending on hydrologic circumstances. These can be in one of two different forms. The Water Management Section can issue a release schedule or issue a headwater elevation schedule. If desired, Water Management could issue a schedule which combines the two.

If the Water Management Section issues a required release rate schedule, project personnel determine gate openings required to meet such rates, while maintaining the actual flow within plus or minus 2,000 cfs of target flows. Release rates will be rates of flow past the dam and will include hydropower releases.

If the Water Management Section issues a required headwater elevation schedule, project personnel determine gate openings required to achieve these elevations while maintaining the headwater within plus or minus 0.2 foot of the target elevations. In addition, they must maintain the plus 5,000 and minus 10,000 cfs per hour net change restriction in spillway discharges from Cordell Hull and Center Hill combined. If the above becomes impossible, the operator may increase the headwater variation to plus or minus 0.5 foot of target elevations. If it becomes necessary to reduce turbine releases to keep the reservoir within 0.5 foot of the designated elevation, plant personnel should advise the Water Management Section.

Under no circumstances should the headwater be allowed to rise above the top of the Surcharge Pool, elevation 508. During a flood, this requirement takes precedent over all other operating criteria. When the headwater rises to elevation 508, the 5,000 cfs per hour limitation will no longer apply and releases may be increased as necessary to prevent any further rises in the headwater.

After the pool level has peaked, the gate setting normally will remain unchanged until the pool returns to top of the Conservation Pool. Discharges are then to be reduced until the pool levels stabilize. Under some circumstances, following this procedure may cause a rapid drop in stages downstream which can adversely impact navigation. If forecasts show that following normal

procedures would result in undesirable navigation conditions, project discharges may start to be reduced prior to all surcharge storage being evacuated. This results in discharge reductions being spread out over a longer period of time and reduces the rate of fall of river levels downstream.

7-06 Recreation

The recreational opportunities at Cordell Hull are considered to be of great importance to the middle Tennessee area. The project offers many recreational activities such as swimming, boating, water skiing, fishing, hunting, picnicking, camping, enjoying nature, wildlife, and biking.

Cordell Hull Reservoir is located within 500 miles, or a day's travel, of the main population base of the United States. Actual public use, however; is mostly comprised of use from the local area and weekenders from the adjacent communities in the region. Occasional visitors reported being from out of state, but nowhere near the numbers reported from Nashville District's "destination areas" like Dale Hollow, Center Hill, and Wolf Creek. The appeal of Cordell Hull is that it is a treasure enjoyed by locals, filled with peaceful waters and many favorite fishing holes.

The water resource needs for the recreational use of Cordell Hull Reservoir are similar to those for the navigational use of the pool. Initial impacts to recreation do not occur until the pool elevation is two feet below the bottom of the summer pool. This has never happened during the five-month period between 01 May and 30 September in the history of the project. For the winter months minor impacts to recreation occur when the pool falls below the top of the winter pool at elevation 501. Plate VII-11 shows the impacts of low pool levels on water based recreational facilities and water supply intakes.

7-07 Water Quality

Under non-drought conditions, operations are not usually conducted at Cordell Hull for water quality purposes. The water quality monitor in the Cordell Hull tailwater is used primarily to determine if supplemental releases from Dale Hollow and Wolf Creek are needed for water quality control. Even though water quality is the second-highest regulation priority during a drought, it is doubtful that specific water quality operations would be required at Cordell Hull during such an event. Releases for water quality would probably originate at upstream storage projects. If inflow ever got so low that it took a considerable period of time to fill the pool, releases for water quality might become necessary. Such releases would probably take the form of brief mandatory periods of generation. The details of such operations will probably not be worked out unless there are occurrences of droughts worse than those of record to this date.

In addition to targeting the state minimum DO limit of 5 mg/l in the tailwater at Cordell Hull, operations can also play a role in meeting targeted DO minimums on the Cumberland mainstem.

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 dissolved oxygen (warmwater fishery) is a minimum of 5.0 mg/1. The theoretical bi-weekly minimum average flows needed to meet this standard below Old Hickory are listed in Table 7-2 below.

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	7,400[1]
October	2,000

[1]Higher flows are needed until Old Hickory destratifies

Actual flow requirements during a specific year may vary significantly from these numbers. Since there is no significant storage capacity at Cordell Hull or Old Hickory to supply such flows, releases from the upstream storage projects would be used to meet this need. However, since those upstream reservoirs do not have specific authorization for water quality, releases would typically be for hydropower generation and water quality would be an ancillary benefit.

7-08 Fish and Wildlife

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

As part of the overall recreational plan for Cordell Hull, a substantial coldwater fishery was expected to develop in the reservoir after impoundment. Unfortunately, this fishery has not yet developed to the extent envisioned. This lack of development can be attributed at least partially to the unstable thermal stratification in the reservoir. This condition is not conducive to the development of either warmwater or coldwater fisheries and is suspected to influence visitors

engaged in water contact activities as well. Nevertheless, fishing remains by far the number one recreational aspect of the reservoir.

Major species caught include largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolomieui*), spotted bass (*M. punctulatus*), walleye, 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.

To improve conditions for the warm water fishery and water contact recreation in the embayment of Cordell Hull, the installation of submerged weirs at the mouths of two of the local sub-basin tributaries was modeled in 1988. The tests, conducted by the Waterways Experiment Station (WES) concluded that little of the desired warming of the embayments could be expected. The weirs would prevent lower-level exchange which would cause the hypolimnetic water behind the weirs to become stagnant and the dissolved oxygen levels to reach unacceptably low levels.

The Cordell Hull Wildlife Refuge encompasses about 600 acres along both sides of Cordell Hull reservoir between the State Route 85A Bridge and the State Route 56 Bridge in Jackson County (CRM 349.5 to CRM 357.6). The refuge was created to establish a resident goose population, primarily for Canada Geese, but also for all types of waterfowl.

The Cordell Hull Wildlife Management Area covers 24,893 acres encompassing almost all the land owned by the Corps of Engineers along Cordell Hull Reservoir. It contains between 2,000 and 2,500 farmable acres of land. The intent was to lease this land to local farmers who would grow crops for sale. Lease payments were to be in the form of allowing a portion of the crop to remain unharvested for use by the wildlife. Due to the current poor economic benefits of farming, leases exist for only about 900 to 1,000 acres.

Both the Wildlife Refuge and the Wildlife Management Area are managed by TWRA. Except for additional hunting restrictions in the area designated as the Wildlife Refuge, the two areas are essentially managed as one entity.

7-09 Water Supply

Cordell Hull Reservoir is directly used by four public water supply systems that have intakes located in Tennessee. These intakes serve the City of Celina, the Northwest Clay Utility District, the Town of Gainesboro, and the City of Livingston. The four systems supply a total population of approximately 26,000 people. The higher minimum operating elevation of the four intakes which draw from the reservoir is 497.0 feet (City of Livingston). This is two feet below the normal minimum pool elevation of 499.0 feet. In the event of a drought, water supply to these systems should be easily maintainable unless the drought reached truly catastrophic proportions.

In addition, there are two other water supply intakes that are located in Kentucky on the headwaters of Cordell Hull watershed. These two intakes, the City of Burkesville, and Monroe County Water District, serve a total population of approximately 12,000 people. The water for the intakes is supplied from Wolf Creek releases and local runoff and are not located within the backwater of the Cordell Hull Reservoir.

Basic data on all the systems which have water intakes in Cordell Hull reservoir is listed on Table 7-3. Maps showing the locations of the intakes for the reservoir in Tennessee and the two located in Kentucky on the headwaters are on Plates VII-12 and 13, respectively. No water supply storage reallocation is required for the intakes on LRN Lock and Dam projects at this time. Hence there are no Water Supply agreement numbers for these intakes.

Table 7-3. Water Supply Intakes

Water Supply User	Intake Location	Intake Lat-Long	2016 Water Withdrawal (MGD)
Celina, TN	Obey River Mile [redacted] Cumberland River Mile [redacted]	[redacted]	0.53
Northwest Clay Utility District, TN	Cumberland River Mile [redacted]	[redacted]	0.40
Gainesboro, TN	Cumberland River Mile [redacted]	[redacted]	0.49
Livingston, TN	At [redacted] on the Cumberland River Mile [redacted]	[redacted]	2.38
City of Burkesville, KY	Cumberland River Mile [redacted]	[redacted]	0.67
Monroe County Water District, KY	Cumberland River Mile [redacted]	[redacted]	NA

7-10 Hydroelectric Power

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 Corps projects, including Cordell Hull 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. The LRN District discourages TVA from deviating from the prescribed daily generation at the project. 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 weekends. Sunday is usually the lowest energy demand day. During the warmer summer months, it is highly encouraged to schedule at least a couple of hours of one unit generation in the morning to maintain flow in the river.

Large surges in releases can cause bank erosion and make commercial navigation much more difficult downstream on the Cumberland River. To minimize river level fluctuations, changes in hydropower generation normally are limited to two units per hour, up or down; while it is strongly preferred to limit changes to one unit 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

The operating plan for Cordell Hull provides a reliable nine-foot-deep commercial navigation channel year-round from the dam structure upstream to the head of navigation at Celina, TN, river mile 381. Navigation within the Cordell Hull pool is very minor in magnitude as compared with other portions of the inland river system. However, since the navigation behind Cordell Hull Dam up to Celina is on a slackwater pool it can be maintained without any inflow.

7-12 Drought Contingency Plans

As specified in the Cumberland River Basin Drought Contingency Plan, 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 operating purposes, navigation, hydropower, and recreation were specifically authorized by Congress. Cordell Hull 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. While there is no general authority at Cordell Hull for storage allocated for water supply on either a permanent (PL 85-500) or temporary (PL 78-534) basis, water is being withdrawn for municipal and industrial purposes. Consequently, in the interest of public health and safety, high priority is given to maintaining the pool level above the minimum operating elevations of all water supply intakes.

The first priority during drought conditions is the maintenance of water supply. Cordell Hull Reservoir is directly used by four public water supply systems that have intakes located in Tennessee. These intakes serve the City of Celina, the Northwest Clay Utility District, the Town of Gainesboro, and the City of Livingston. The four systems supply a total population of approximately 26,000 people. The higher minimum operating elevation of the four intakes which draw from the reservoir is 497.0 feet. This is two feet below the normal minimum pool elevation of 499.0 feet. In the event of a drought, water supply to these systems should be easily maintainable unless the drought reached truly catastrophic proportions. Basic data on the two systems which have water intakes in Cordell Hull Reservoir is presented in Table 7-3.

Under non-drought conditions, operations are not usually conducted at Cordell Hull for water quality purposes. The water quality monitor in the Cordell Hull tailwater is used primarily to determine if supplemental releases from Dale Hollow and Wolf Creek are needed for water quality control. Even though water quality is the second highest regulation priority during a drought, it is doubtful that specific water quality operations would be required at Cordell Hull during such an event. Releases for water quality would probably originate at upstream storage projects. However, on rare occasions, Cordell Hull has spilled water to improve DO conditions downstream. If inflow ever got so low that it took a considerable period of time to fill the conservation pool, releases for water quality might become necessary. Such releases would probably take the form of brief mandatory periods of generation. The details of such operations will probably not be worked out unless there are occurrences of droughts worse than those of record to this date.

Navigation is the third regulation priority during drought events in the Nashville District. Navigation within the Cordell Hull pool is very minor in magnitude as compared with other

portions of the inland river system. However, since the navigation behind Cordell Hull Dam up to Celina, Tennessee is on a slackwater pool it can be maintained without any inflow.

Hydropower is near the bottom of the priority list during drought conditions only because it uses such great quantities of water. As drought conditions worsen, hydropower would continue to be generated, but the quantities of power generated by this means would decrease proportionally to the decrease in availability of water.

The water resource needs for the recreational use of Cordell Hull Reservoir are similar to those for the navigational use of the pool. Initial impacts to recreation do not occur until the pool elevation is 2 feet below the bottom of the summer pool. This has never happened during the five-month period between May 1 and September 30 in the history of the project. For the winter months minor impacts to recreation are felt when the pool falls below the top of the winter pool at elevation 501.

Unless a drought reaches catastrophic proportions, only very minor operational changes are anticipated at Cordell Hull. One example may involve evenly spreading generation to improve flow conditions past Gallatin Steam Plant, thus reducing generation on peak hours. The primary adverse effect of drought at Cordell Hull is expected to be a decrease in the generation of hydropower in direct proportion to the decrease in Cumberland River flows.

Thermal power production water supply is not an authorized project purpose at Cordell Hull or any other project in the Nashville District. However, hydropower generation is. TVA's Cumberland Fossil Plant is located at Cumberland City, TN at Cumberland River Mile 103.5, 276.5 miles below Celina. The power generating capacity at the Cumberland Fossil Plant is almost three times the capacity of all nine Nashville District hydropower plants combined, and this power is produced using approximately 9% of the water required by the hydropower plants. 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 Fossil Plant. 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.

7-13 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 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.

7-14 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.

7-15 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 within 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, will 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 that 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.

7-16 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. The purposes of these restrictions are to reduce sudden surges downstream, reduce stream bank erosion, and minimize impacts on navigation. 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 Cordell Hull pool for the years 1974-2019, 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. As can be seen on this plate, the water surface of Cordell Hull Reservoir has been maintained within the limits of the Conservation Pool over 95% of the time.

Plate VIII-3 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. Plate VIII-4 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 143,000 dsf and a 365-day, 100-year return event to be almost 24,000 dsf.

Plate VIII-5 shows the maximum, median, and minimum observed pool elevations. Plate VIII-6 shows the monthly average discharge for turbine and spill. Plate VIII-7 shows the average annual discharge for turbine and spillway.

8-02 Flood Control

The full Surcharge Pool has been used three times in the history of the project. This occurred in March 1975, May 1984, and May 2010. A staff gage diagram indicating types of structures affected during various stages of flooding in Carthage is shown on Plate VIII-8.

a. Spillway Design Flood. After review of the design documents and the Cordell Hull Lock and Dam Water Control Manual, very little detailed information concerning the original Spillway Design Flood (SDF) was obtained. No data could be recovered that details the event of the SDF. The original design memorandum states the routing of the SDF will result in a peak release of 151,000 cfs and occurs with the pool at the maximum surcharge level of elevation 508 feet (NGVD29). At this elevation the spillway has a capacity of 175,000 cfs. A dam break study was conducted in 1984 and this had the inflow hydrograph for the SDF peaking at 168,900 cfs.

The Inflow Design Flood (IDF) resulted in 14.6 feet of overtopping. The maximum non-breach release for the IDF is 458,000 cfs, and the estimated downstream non-damaging discharge is approximately 100,000 cfs. The primary non-breach consequence center is Carthage, Tennessee located approximately 5.5 miles downstream of the dam. The estimated non-breach inundation for the IDF impacts the town of Carthage, and the estimated loss of life would likely be 0 to 1. Two levees downstream of Cordell Hull

Dam would be impacted by releases from the dam. Metro Center Levee and Gaylord Opryland Levee, located in Nashville, would both be impacted by an IDF event. Additionally, the Old Hickory Dam and Cheatham Dam are downstream of Cordell Hull and would be impacted. The IDF has an estimated annual chance exceedance of less than 1/20,000.

b. Other Floods. Since impoundment, the three most notable flood events at Cordell Hull are the March 1975, May 1984, and the May 2010 floods. These events are further discussed in the following paragraphs.

The March 1975 event occurred in only the third year after the dam was completed and resulted in the pool elevation reaching the top of the Flood Surcharge Pool elevation of 508.0 at midnight on 13 March. The maximum daily average discharge was 115,995 cfs on 13 March with a maximum hourly discharge of 123,850 cfs from 2100 to 0500 13-14 March. Both Celina and Carthage gages reached maximum stages of record for the regulated reservoir flood storage period during the March 1975 flood with recorded stages of 38.15 feet and 47.95 feet, respectively. Note the stage at Celina was still almost 2 feet below flood stage of 40 feet. Based on the Flood Damage Survey prepared for the Nashville District, damages in the Carthage area for the 1975 flood event totaled $1,449,200 (in 1975 event year dollars or approximately $6.7 million in 2018 dollars) with almost two thirds of that amount being to industrial facilities. Five industrial plants in Carthage lost supplies, finished products, and manufacturing equipment and were shut down for two to six weeks following the flooding. This was the second most heavily damaged area in the Cumberland Basin after the Nashville area. Damages within the Cordell Hull area totaled $723,600 with almost three quarters of that amount being to the transportation infrastructure. Damages in the portion of the basin upstream of Cordell Hull reservoir and downstream of Wolf Creek Dam amounted to $70,100. Total flood damages in the entire Cumberland Basin for this event were about $18,000,000. The flood crest at the Carthage damage center was estimated to have been reduced by 21.5 feet due to the combined flood control effect of all upstream Corps of Engineers dams. It was estimated that this stage reduction prevented an additional $20,000,000 in damages in the Carthage area alone.

The May 1984 flood resulted in a maximum pool elevation of 508.0 as well at 0400 on 08 May. The daily average discharge for the 1984 event was 85,213 cfs on 08 May, significantly less than the March 1975 daily average discharge. The maximum hourly discharge was 88,500 cfs at 2000 on 08 May. The stage at Celina crested at 35.40 feet on 07 May. The stage at Carthage crested at 40.20 feet on 08 May, just 0.2 foot above flood stage.

In May 2010, Cordell Hull recorded the pool of record, elevation 508.33, at 0500 on 03 May. The daily average discharge was 104,100 cfs on 03 May, with a record maximum hourly discharge of record of 121,800 cfs at 0700 on 03 May. The stage at Celina during the May 2010 event was not significant due to how the rainfall fell, but the stage at Carthage reached 46.10 feet on 3 May, less than one foot below the Major Flood Stage of 47 feet.

8-03 Recreation

Pool level elevations tend to temporarily affect recreational benefits both within the reservoir, as well as other related recreational activities such as camping, sightseeing, picnicking and hunting. Plate VII-11 shows the impacts of pool levels on water based recreational facilities.

Visitors to Cordell Hull Reservoir are a diverse group ranging from campers who enjoy the two Corps-operated campgrounds, hunters who use the wildlife management areas associated with Cordell Hull Reservoir, day users who picnic and use playgrounds, marina customers accessing the water, and many other user groups. Visitation to Cordell Hull Reservoir is at its highest during the months of April to August, with a sharp decline during the colder months of December to March.

Visitation to Cordell Hull Reservoir is consistently in the top 25% most-visited Corps of Engineers reservoirs in the nation. Cordell Hull Reservoir ranked the 105th most visited Corps Reservoir in fiscal year 2016. Recent trends in visitation indicate about 680,000 visits to Cordell Hull Reservoir annually. See Plate VIII-9 Recreation Report for Cordell Hull for FY 2016.

In addition to overall visitation numbers, utilization data gives a picture of how frequently Corps-operated campground facilities are being occupied. Plate VIII-10 shows campground utilization data for Cordell Hull Reservoir's campgrounds: Defeated Creek and Salt Lick. This data is from the National Recreation Reservation System, (NRRS). In FY17, Defeated Creek had a utilization rate of 68.45%. At nearly 70% Defeated Creek's utilization rate puts it in the top 5% of the most utilized Corps of Engineers campgrounds in the nation. Salt Lick's 40.70% utilization rate puts it in the top 40% of the most utilized Corps campgrounds. These rankings are compared with over 500 campgrounds across the nation reporting use rates. The high utilization of these areas speaks to the value and importance these public places offer and the enjoyment they provide to visitors.

8-04 Water Quality

The Cordell Hull Reservoir water quality is primarily affected by the releases from two upstream storage projects, Wolf Creek and Dale Hollow. Cold water released from these projects moves rapidly through the main channel of Cordell Hull resulting in a theoretical hydrologic retention time of about 7 days. Because of this short retention time in the mainstem of the reservoir,

thermal stratification and dissolved oxygen (DO) depletion are typically moderate and occur for short periods during the summer months. Reservoir tributary embayments exhibit a higher degree of thermal stratification and DO depletion during the warm season because of greater retention times and influence of higher nutrient inputs from local watersheds. The most critical months for DO levels are typically observed from June through September. Destratification in the reservoir is normally completed by mid-October but may occur later in some years depending on air temperatures and flows. Typical water quality releases for Cordell Hull are shown in Plate VIII-11.

Improvements in the quality of releases from Wolf Creek and Dale Hollow enhance water quality both in the Cordell Hull pool and for a considerable distance downstream of the dam. The Tennessee state standard for water quality in a warmwater fishery is a minimum DO level of 5 mg/l. The Corps strives to maintain DO levels above the State of Tennessee's target of 5.0 mg/L, which is consistently met or exceeded in releases from Cordell Hull Dam. However, periods of low flow during the drawdown of Wolf Creek from 2007-13 to repair Wolf Creek Dam resulted in DO for turbine discharges falling below 5.0 mg/l. During those occurrences, aerated releases from spillway gates were used to supplement the low DO in turbine discharges in order to strive to meet the state standard, as good environmental stewards. Concentrations of metals and nutrients in the reservoir are typically consistent from year to year and are generally not a concern in discharges from the dam. Water quality permits are not required for discharges from reservoirs, but the Corps attempts to meet downstream water quality standards to the maximum extent practicable, so long as those operations do not impact the project's Congressionally authorized purposes.

Across the reservoir, Cordell Hull historically ranks as 'Eutrophic' in terms of biological productivity. Some of the elevated productivity can be attributed to several years where low flows from Wolf Creek Dam adversely impacted temperatures and water chemistry. Forebay phytoplankton communities tend to be dominated by golden algae, green algae, and dinoflagellates. The combination of cold-water temperatures and low residence time likely help reduce the influence from problematic groups such as cyanobacteria and issues from Harmful Algal Blooms (HABs). Historically, there have been no HABs observed at Cordell Hull. The mainstem portions of the reservoir bottom are generally dominated by environmentally tolerant benthic macroinvertebrate organisms such as worms (Oligochaetes), true flies (Diptera), and midges (chironomids). Organisms that are indicators for good water quality are present in the reservoir but comprise a small percentage of the overall benthic community in Cordell Hull. This likely relates to the sort of habitat present, which is typically shifting and originally enriched mud/sand/silt substrate. Benthic communities are more variable in the tributary embayments, which show some influences from upstream watershed areas. As with the mainstem of Cordell Hull, tributary embayments are generally dominated by tolerant organisms.

8-05 Fish and Wildlife

There are a total of 63 fish species that have been documented to be found in Cordell Hull Reservoir. These species are divided into three categories: game fish, rough fish, and forage fish. Game fish are generally considered those species that are highly desirable for recreational fishing since they are sporting to catch and/or desirable to eat. Non-game fish (rough and forage) would include those that anglers generally do not pursue, are threatened or endangered, or are too small or undesirable to eat. Rough fish are those often considered undesirable or less desirable to sport anglers although they often are pursued and preferred by some fishermen. Forage fish are those which are often used as bait and that provide vital natural food resources for game fish as well as birds and other wildlife.

Cordell Hull Reservoir boasts the state record striped bass (striper or rockfish), *Morone saxatilis*, caught on 1 May 2000, weighing 65 lbs. 6oz. Striped bass were formerly strictly anadromous along the Atlantic and Gulf coasts but are now stocked in many inland waters of the United States (Etneir, 1993) including reservoirs such as Cordell Hull where the TWRA maintains the striper population from their annual hatchery stockings. White bass (stripe), *M. chrysops*, are also found in Cordell Hull Reservoir as well as the *M. saxatilis* x *M. chrysops* hybrid. The hybrids are also known as Cherokee bass. Other game fish found in Cordell Hull Reservoir include black bass (largemouth, smallmouth, and spotted bass), crappie (white and black), bluegill, walleye, and sauger. Rough fish include several species of catfish, buffalo, redhorse, suckers, as well as carp, drum, gar, and paddlefish. The dominant forage fishes are gizzard shad, threadfin shad, and skipjack herring.

The Cordell Hull Wildlife Management Area (WMA) covers 24,893 acres encompassing almost all the land owned by the Corps along Cordell Hull reservoir. The management area was leased by the TWRA from the Corps on 15 April 2013 for 25 years. This is the second 25-year lease of the area by TWRA. These lands provide excellent habitat for a variety of wildlife species and excellent hunting and wildlife observation opportunities for people. In addition, the WMA contains between 2,000 and 2,500 farmable acres of land. Lease payments are in the form of allowing a portion of the crops to remain unharvested for use by the wildlife. Due to the current poor economic benefits of farming, leases exist for only about 900 to 1,000 acres. Both the Wildlife Refuge and the WMA are managed by TWRA. Except for additional hunting restrictions in the area designated as the Wildlife Refuge, the two areas are essentially managed as one entity.

Major mammals found on project fee lands include: whitetail deer (*Odocoileus virginianus*), eastern cottontail rabbit (*Sylvilagus floridanus*), squirrel (*Sciurus niger and S. carolinensis*), raccoon (*Procyon lotor*), skunk (*Mephitis mephitis*), opossum (*Didelphis virginiana*), nine-banded armadillo (*Dasypus novemcinctus*), coyote (*Canis latrans*), and numerous species of gamebirds- turkey (*Meleagris gallopavo*), bobwhite quail (*Colinus virginianus*), mourning dove

(*Zenaida macroura*), Canada goose (*Branta canadensis*), wood duck (*Aix sponsa*), and mallard (*Anas platyrhynchos*). Numerous non-game songbirds, raptors, reptiles, amphibians, and small mammals are known to inhabit project lands as well.

8-06 Water Supply

The operating plan for Cordell Hull Dam has had no effect on the quantitative supply of water for the four public water supply systems that directly use the reservoir. These systems, serve about 26,000 people. The maintenance of normal minimum pool elevation 499.0 assures an adequate depth for the water intake systems, elevation 497.0 is the highest intake of the four. Pertinent information on the systems is presented in Table 7-3.

8-07 Hydroelectric Power

The nine hydropower plants in the Cumberland Basin have a combined nameplate generating capacity of 928 megawatts. Cordell Hull can supply up to 100 MWs or 11 percent of the system capacity. Since Cordell Hull is a run-of-river project, which means that in general, water must be released from the project at almost the same rate it arrives, there is not very much flexibility as to when to generate power. However, when the conservation pool is empty, it can store about 17 hours' worth of the average annual flow. This gives the project some flexibility to operate as a peaking plant, but very little. The range of flexibility is generally limited to less than one day's operation. However, as flows and resulting power generating potential decrease, the flexibility increases as to when this limited capacity can be used.

A summary of the Cordell Hull Dam hydropower output is presented graphically on Plate VIII-12 and in tabular form on Plate VIII-13. The estimated annual generation is 350 GWH. Actual generation has ranged from 198 GWH to 538 GWH. 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, only approximately one third of a project's hydropower revenue comes from the actual generation of power, while the remainder comes from selling power capacity.

Water regulation problems have been very minor since the closure of the Cordell Hull project. The most significant is that the project is somewhat limited in the timing of hydropower production; however, this was considered and is inherent in the basic design of the project. It cannot, however, normally store water all weekend to be used for weekday peaking power. The limited power storage capacity can sometimes require the project to generate more than desired during the weekend.

8-08 Navigation

Implementation of the water control plan has provided a reliable nine foot deep commercial navigation channel year-round from the dam structure upstream to the head of navigation at Celina, Tennessee, river mile 381. Plate VIII-14 shows the number of lockages through Cordell Hull each year from 1982 through 2019. Total lockages at Cordell Hull have only averaged around 40 for years 2014 to 2016 with no significant commercial lockages since 1989.

8-09 Drought Contingency Plans

The initial purposes of which Cordell Hull Dam and Reservoir was authorized include hydropower, navigation, and recreation. The additional purposes for which Cordell Hull Dam is operated include water quality (PL 92-500, Federal Water Pollution Control Act Amendments of 1972), fish and wildlife conservation (PL 85-624, Fish and Wildlife Coordination Act and PL 93-205, Endangered Species Act), and water supply. While there is no general authority at Cordell Hull for storage allocated for water supply on either a permanent (PL 85-500) or temporary (PL 78-534) basis, water is being withdrawn for municipal and industrial purposes. Consequently, in the interest of public health and safety, high priority is given to maintaining the pool level above the minimum operating elevations of all water supply intakes. However, due to Cordell Hull being a run of river project with limited storage, seasonal reservoir levels would still be maintained at Cordell Hull even in the most severe droughts.

8-10 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 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-1 shows the annual peak headwater elevation of the Cordell Hull pool for the years 1974-2019, 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. As can be seen on this plate, the water surface of Cordell Hull Reservoir has been maintained within the limits of the Conservation Pool over 95% of the time.

Plate VIII-3 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. Plate VIII-4 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 143,000 dsf and a 365-day, 100-year return event to be almost 24,000 dsf.

b. Pool Elevation Duration and Frequency. Plate VIII-1 shows the annual peak headwater elevation at Cordell Hull Reservoir since closure 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. As can be seen on Plate VIII-2, the water surface of Cordell Hull Reservoir has historically been within the Conservation Pool a great majority of the time. During winter pool period, the Flood Surcharge Pool has been in use around 15 percent of the time and most of that has been at relatively low usage levels. During summer pool period, the water surface has been within the Conservation Pool limits over 95 percent of the time. Plate VIII-5 shows the range of the pool used during each year from 1974 through 2019. The Conservation Pool, which is never more than two feet deep for this run-of-river project, is seldom used in its entirety. The full Flood Surcharge Pool has only been used only three times in the history of the project. Average monthly discharges and average annual discharges are shown on Plates VIII-6 and VIII-7, respectively. Efficient use of the small Conservation Pool has resulted in a relatively low amount of spillway gate releases from the project. Releases from the spillway gates account for less than four percent of the total historical flow and usually occur between December and May. Except for a few isolated events, there has been very little spillway gate releases from the project between June and November.

c. Key Control Points. The upstream control point, Celina, is heavily controlled by the tributary projects Dale Hollow and Wolf Creek. The total drainage area at Celina is 7,307 mi^2; however, 6,724 mi^2 is controlled by Dale Hollow and Wolf Creek, leaving only a 583 mi^2 uncontrolled drainage area (8% of the total drainage area). Because such a large percentage of the drainage area is controlled by flood control projects, the stage at Celina will typically only fluctuate approximately 14 feet. Approximately 98% of the time, the observed stage is between 11 and 25 feet well below the established Flood Stage of 40 feet.

Celina discharge is rated based on the observed stage at Celina and the stage at Penitentiary Branch (Cumberland River Mile 365.0, USGS ID 03417600). The rating curve information is included on Plate VII-9.

The downstream control point, Carthage, is affected by discharges from both Cordell Hull and Center Hill in addition to the local runoff. The majority of time the stage at Carthage will fluctuate between 5 and 14 feet and is mostly dependent on the discharge at Cordell Hull. Since the completion of Cordell Hull, the stage at Carthage has only been above Major Flood Stage of 47 feet once, in March 1975 (stage was 47.95 feet on 14

March). The Carthage rating curve is shown in Plate VII-8 and Plate VIII-8 shows varying stages and resulting damages.

8-12 Other Studies

a. Examples of Regulation. On 1 August 2016, LRN transitioned their primary hydrologic and hydraulic 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 sub-basins 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. CWMS 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, 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. For a complete description of the CWMS modeling platform visit the USACE HEC website for CWMS; https://www.hec.usace.army.mil/cwms/

Project regulation examples are shown on Plates VIII-15 through VIII-64 in the form of annual observed reservoir elevation and discharge

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

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IX - WATER CONTROL MANAGEMENT

9-01 Responsibilities and Organization

a. Corps of Engineers. The owner of Cordell Hull Dam is the United States Government, operated through the U.S. Army Corps of Engineers, Nashville District.

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 Cordell Hull 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 Cordell Hull are Engineering and Construction and the Operations Division.

Within the Engineering and Construction Division, the Hydrology and Hydraulics Branch, Water Management Section is the responsible section for all water control activities and 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

Operations Division is responsible for the funding and staffing requirements at Cordell Hull Dam and the Cordell Hull Resource Management Office.

b. Other State or Federal Agencies. The Cordell Hull Wildlife Refuge encompasses about 600 acres along both sides of Cordell Hull reservoir between the State Route 85A

Bridge and the State Route 56 Bridge in Jackson County (Cumberland River Mile [CRM] 349.5 to CRM 357.6). The refuge was created to establish a resident goose population, primarily for Canada Geese, but also for all types of waterfowl.

The Cordell Hull Wildlife Management Area covers 24,893 acres encompassing almost all the land owned by the Corps of Engineers along Cordell Hull Reservoir. The management area was leased by TWRA from the Corps on 15 April 2013 for 25 years (this is the second 25-year lease). It contains between 2,000 and 2,500 farmable acres of land. The intent was to lease this land to local farmers who would grow crops for sale. Lease payments were to be in the form of allowing a portion of the crop to remain unharvested for use by the wildlife. Due to the current poor economic benefits of farming, leases exist for only about 900 to 1,000 acres. Both the Wildlife Refuge and the Wildlife Management Area are managed by TWRA. Except for additional hunting restrictions in the area designated as the Wildlife Refuge, the two areas are essentially managed as one entity.

c. Local 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 Cordell Hull.

9-02 Interagency Coordination

a. Local Press and Corps Bulletins. General information regarding the Cordell Hull project is made available to the public through various websites, which can be accessed through the main website for LRN at https://www.lrn.usace.army.mil/Locations/Dams/Cordell-Hull-Dam/. 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 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. The NWS provides forecasts for Burkesville on an as needed basis during times of high water, at least a daily forecast for Celina located at the confluence of the Obey and Cumberland Rivers as well as for Carthage, just downstream of Cordell Hull dam. 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 NWS Ohio River Forecast Center (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 Cordell Hull drainage basin are split between the Nashville Weather Service Office (OHX) for the portion in Tennessee and the Louisville Weather Service Office (LMK) for areas in Kentucky.

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).

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 all LRN hydropower projects 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 available at http://www.lrn-wc.usace.army.mil/tva_schedule.shtml.

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, NWS 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

There is no non-Federal hydropower at Cordell Hull.

9-06 Reports

LRN Water Management maintains daily operation reports for Cordell Hull. The report shows hourly headwater, tailwater, energy, and discharge information and is known as report 84. An example is provided on Plate IX-1.

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. In addition, Water Management also prepares an Annual Water Quality Report.

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

Exhibit A. Supplementary Pertinent Data

DAM LOCATION

Dam Location

State:	Tennessee
County:	Smith
Nearest Community:	City of Carthage Located 4 miles south of the project
River:	Cumberland
Mile:	313.5
Latitude:	North 36°17'25"
Longitude:	West 85°56'37"

Adjacent Water Control Facilities

Upstream

Wolf Creek Dam, Cumberland River, Mile 460.9

Dale Hollow Dam, Obey River, Mile 7.3

Downstream

Old Hickory Dam, Cumberland River, Mile 216.2

Center Hill Dam, Caney Fork River Mile, 26.6

ORIGINAL AUTHORIZATION AND HISTORY

• Primary Project Purposes	• Authorizing Legislation
Navigation	PL 79-525, River and Harbor Act of 1946
Hydropower	PL 79-525, River and Harbor Act of 1946
Recreation	PL 78-534 Flood Control Act of 1944
• Additional Operating Purposes	
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	Although storage space is not allocated for water supply on either a permanent (PL 85-500) or temporary (PL 78-534) basis, water is being withdrawn for municipal and industrial purposes. Consequently, during drought, consideration is given to keeping the pool level above the supply pipe intakes.
•Construction Dates	
Began	25 May 1963
Closure	4 October 1970
Impoundment	13 March 1973
Inservice	
Dam	February 1973
Lock	March 1973
Power	
Unit 1	August 1973
Unit 2	October 1973
Unit 3	February 1974

PHYSICAL COMPONENTS OF DAM

• Type of Structure		
Combination of concrete gravity and earthfill embankment		
• Dam Section Lengths		
Spillway Section	291 feet	88.7 m
Powerhouse Section	310 feet	94.5 m
Lock Section	168 feet	51.2 m
Embankment Section	468 feet	142.6 m
Right Side Non-overflow section	69 feet	21.0 m
Total Dam Length	1,306 feet	398.0 m
• Structure Elevations		
Embankment	513.0 feet	156.4 m
Top of Gates	505.72 feet	154.1 m
Spillway Crest	464.50 feet	141.6 m
• Outlet Works		
Spillway		
Total Effective Width	225 feet	68.6 m
Tainter Gates		
Number	5	
Width	45 feet	13.7 m
Height	41 feet	12.5 m
Operating Machinery: The operating machinery for the spillway gates consists of electric hoist motors located on the upper level of the dam superstructure, The electric motors are controlled by individual control panels at the same locations. All operations must be performed by an operator out on the top of the structure. There is no provision for gate manipulation from inside the powerhouse.		
• Power Plant		
Type-Kaplan adjustable blade propeller turbines		
Number	3	
Intake		
Width	70.0 feet	21.3 m
Height	39.5 feet	12.0 m
Operating Heads		
Maximum	63 feet	19.2 m
Nominal (normal for design)	44 feet	13.4 m
Minimum	22 feet	6.7 m
Nominal Discharge	30,000 cfs	849.6 cu. m/sec.
Nameplate Power Rating	33.3 MW each (100 MW total)	
Estimated average annual generation	350,000 MWH	

PHYSICAL COMPONENTS OF DAM (continued)		
• Navigation Lock		
Chamber		
Length	400 feet	121.9 m
Width	84 feet	25.6 m
Top of Structure Elevations		
Chamber	512.0 feet	156.1 m
Guide Walls		
Upper	512.0 feet	156.1 m
Lower	480.0 feet	146.3 m
Sills		
Upper	485.0 feet	147.8 m
Lower	429.0 feet	130.8 m
Water Surface Elevations		
Tailwater		
Minimum	442.0 feet	147.8 m
Normal	445.0 feet	135.6 m
Headwater		
Minimum	499.0 feet	152.1 m
Normal	504.0 feet	153.6 m
Lift		
Normal	59 feet	18.0 m
Maximum	63 feet	19.2 m
Average Single Lockage Time	30 minutes	

REAL ESTATE		
• Acquisition		
Fee Holdings	26,109 acres	10,570 hectares
Easement Holdings	474 acres	192 hectares
• Elevation of Taking Line		
At Dam	Elevation 504.0 plus 300 feet or Elevation 510.0, whichever is greater.	
At Upper End	Elevation 504.0 plus 300 feet or Elevation 518.0, whichever is greater.	
Intermediate Areas	Various elevations between 504.0 and 518.0.	

HYDRAULICS AND HYDROLOGY

• Drainage Areas		
Project		
Total	8,096 mi^2	20,967 km^2
Local Uncontrolled (Between Cordell Hull and Wolf Creek & Dale Hollow)	1,372 mi^2	3,553 km^2
Control Point – Carthage, Tennessee		
Total	10,690 mi^2	27,684 km^2
Local Uncontrolled (Between Carthage and Cordell Hull & Center Hill)	420 mi^2	1,088 km^2
Downstream Project – Old Hickory		
Total	11,674 mi^2	30,233 km^2
Local Uncontrolled (Between Old Hickory and Cordell Hull & Center Hill)	1,404 mi^2	3,636 km^2

• Top of Pool Elevations

	Feet		Meters	
	Summer	Winter	Summer	Winter
Surcharge Storage	508.0	508.0	154.8	154.8
Conservation	504.5	501.0	153.8	152.7
Recreation	503.0	N/A	153.3	N/A
Inactive	499.0	499.0	152.1	152.1

• Surface Area	Acres		Hectares	
	Summer	Winter	Summer	Winter
Surcharge Storage	13,920	13,920	5,635	5,635
Conservation	12,200	10,630	4,939	4,303
Recreation	11,500	N/A	4,656	N/A
Inactive	9,820	9,820	3,976	3,976

• Storage Volumes			Cubic Hectometers	
	Summer	Winter	Summer	Winter
Acre Feet				
Surcharge Storage	46,000	86,000	56.7	106.1
Conservation	18,000	20,000	22.2	24.7
Recreation	42,000	0	51.8	0
Inactive	205,000	205,000	252.9	252.9
TOTAL	311,000	311,000	383.6	383.6
Day Second Feet				
Surcharge Storage	23,000	43,000		
Conservation	9,000	10,000		
Recreation	22,000	0		
Inactive	103,000	103,000		
TOTAL	157,000	157,000		

HYDRAULICS AND HYDROLOGY
(Continued)

• Average Outflows (cfs) Period of Record 1973 to 2019

Month	Generation	Spill	Total	Total Cubic Meters/Sec.
Jan	17,787	765	18,552	525
Feb	17,509	1,249	18,757	531
Mar	17,989	2,041	20,030	567
Apr	16,179	1,155	17,334	491
May	13,018	650	13,668	387
Jun	11,086	199	11,285	320
Jul	9,398	299	9,697	275
Aug	9,109	282	9,391	266
Sep	7,659	111	7,770	220
Oct	6,856	110	6,966	197
Nov	8,279	58	8,337	236
Dec	14,601	206	14,807	419
Annual	12,456	594	13,049	370

• Maximum Pool Frequencies

Period of Record	1973 to 2019
2 Year	505.35
5 Year	506.22
10 Year	506.89
25 Year	507.86
50 Year	508.62(508.00)*
100 Year	509.39(508.00)*
200 Year	510.17(508.00)*
Maximum Observed	508.33 (3 May 2010)

*Note 1- Pool elevations based on statistical evaluations. Proper regulation procedures preclude a pool elevation exceeding 508.00.
Note 2- Statistics based on annual maximum stage

• Maximum Observed Discharge 121,800 cfs (3 May 2010)

ACCESS LOCATIONS		
	River Sailing Line (Mile)*	
• Bridge Crossings		
State Highway 85A	349.5	
State Highway 56	357.6	
State Highway 52	380.8	
		Bank (looking Downstream)
• Industrial Docks		
Gainesboro Port Authority	359.0	L
• Recreation Areas		
Corps of Engineers		
Dam Site	313.7	L
Defeated Creek	316.8	R
Granville	332.5	L
Salt Lick Creek	337.7	R
Roaring River	357.9	L
Celina	380.9	L
City of Gainesboro	356.7	R
Commercial Boat Docks		
Defeated Creek Marina	316.8	R
Granville Marina	331.6	L
Roaring River Marina	357.9	L
Other Access Areas		
Horseshoe Bend	315.6	L
Buffalo	325.5	R
Sullivan Bend	325.5	R
Holliman's Bend	337.1	L
Wartrace Creek	344.0	R
White's Bend	346.1	L
Brimstone Creek	369.2	R

* 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 about the midpoint of the area.

Exhibit B. Standing Instructions to Damtenders

STANDING INSTRUCTIONS CORDELL HULL

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

1. Maintain the headwater elevation within the limits of the conservation pool (elevations 499 to 501 in winter and 503 to 504.5 in summer) and release all water through the turbines as governed by the hydropower generation schedules.
2. If the reservoir level approaches the lower limit of the conservation pool elevations 499 in winter and 503 in summer, reduce or curtail hydropower releases as necessary to prevent the headwater from falling below the seasonal bottom of the conservation pool and notify the power scheduling agency.
3. Limit normal changes in hydropower generation to one unit per hour unless a power emergency necessitates a two unit per hour ramp rate.
4. When increased inflows tend to cause the headwater to rise above the seasonal top of conservation pool, elevations 501 in winter and 504.5 in summer, increase hydropower discharges at no more than two units per hour to maximum turbine capacity as required to return the pool to normal seasonal levels and notify the power scheduling agency.
5. If the headwater continues to rise, supplement turbine capacity discharges with spillway releases at a rate of 5,000 cfs per hour in an effort to stop the rise and return the pool to normal seasonal levels. All gates should be operated at approximately the same opening. If Center Hill should require concurrent increases in spillway discharges, limit combined increases of both projects to a total of 5,000 cfs per hour.
6. To the extent possible, limit flows at Carthage to a maximum of 72,000 cfs.
7. Maintain headwater at or below 508.0 under all circumstances until free flow discharges are attained.
8. When headwater elevations crests, the gate setting existing at the time of the crest should be maintained until the reservoir recedes to the top of conservation pool. Then reduce discharges; however, combined decreased in spillway releases from Cordell Hull and Center Hill are limited to 10,000 cfs per hour.
9. When the reservoir is stabilized within the conservation pool, resume normal operations.

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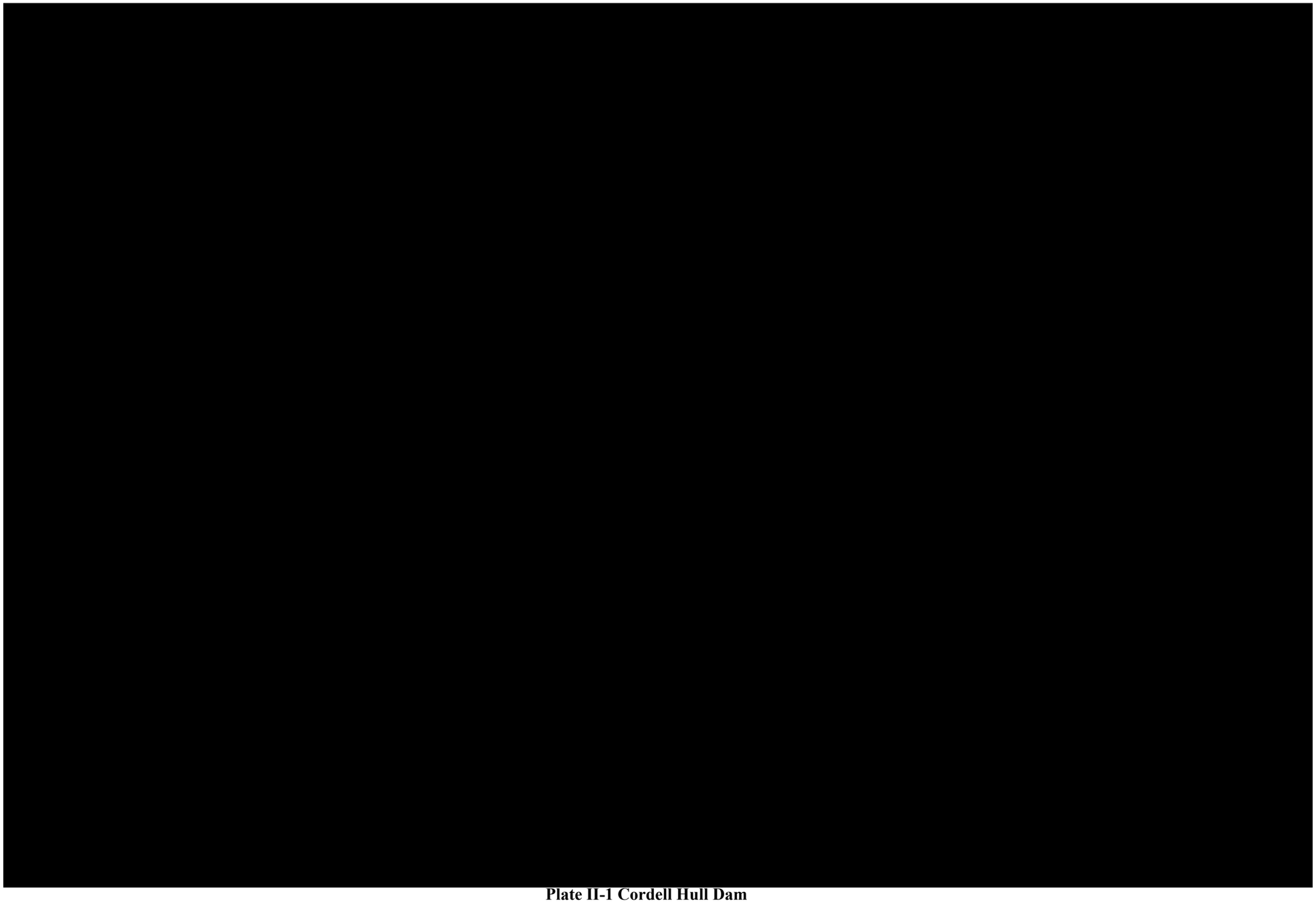

Plate II-1 Cordell Hull Dam

Plate II-2. Cordell Hull Dam Downstream Section

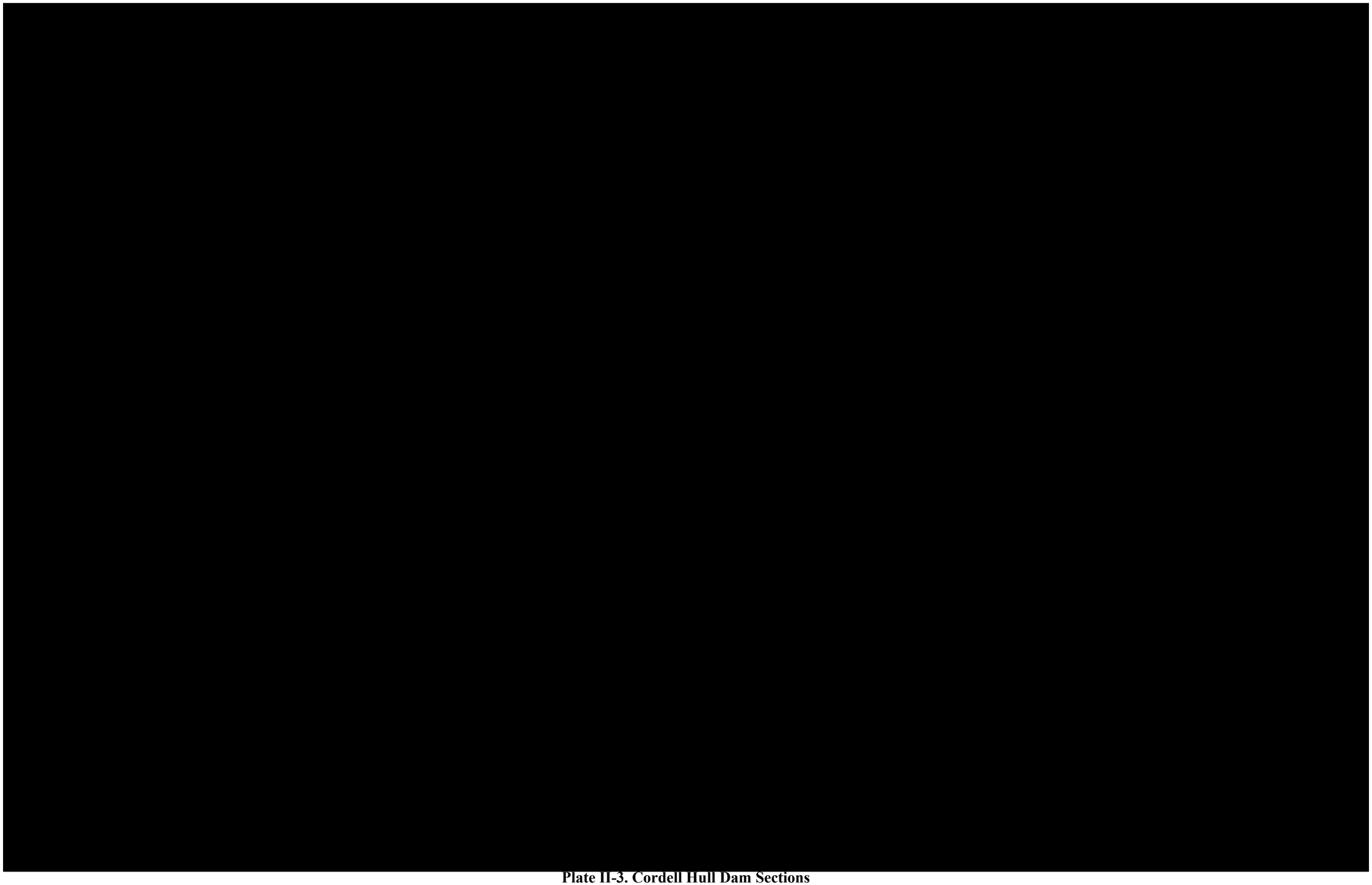

Plate II-3. Cordell Hull Dam Sections

Cumberland River Basin Map

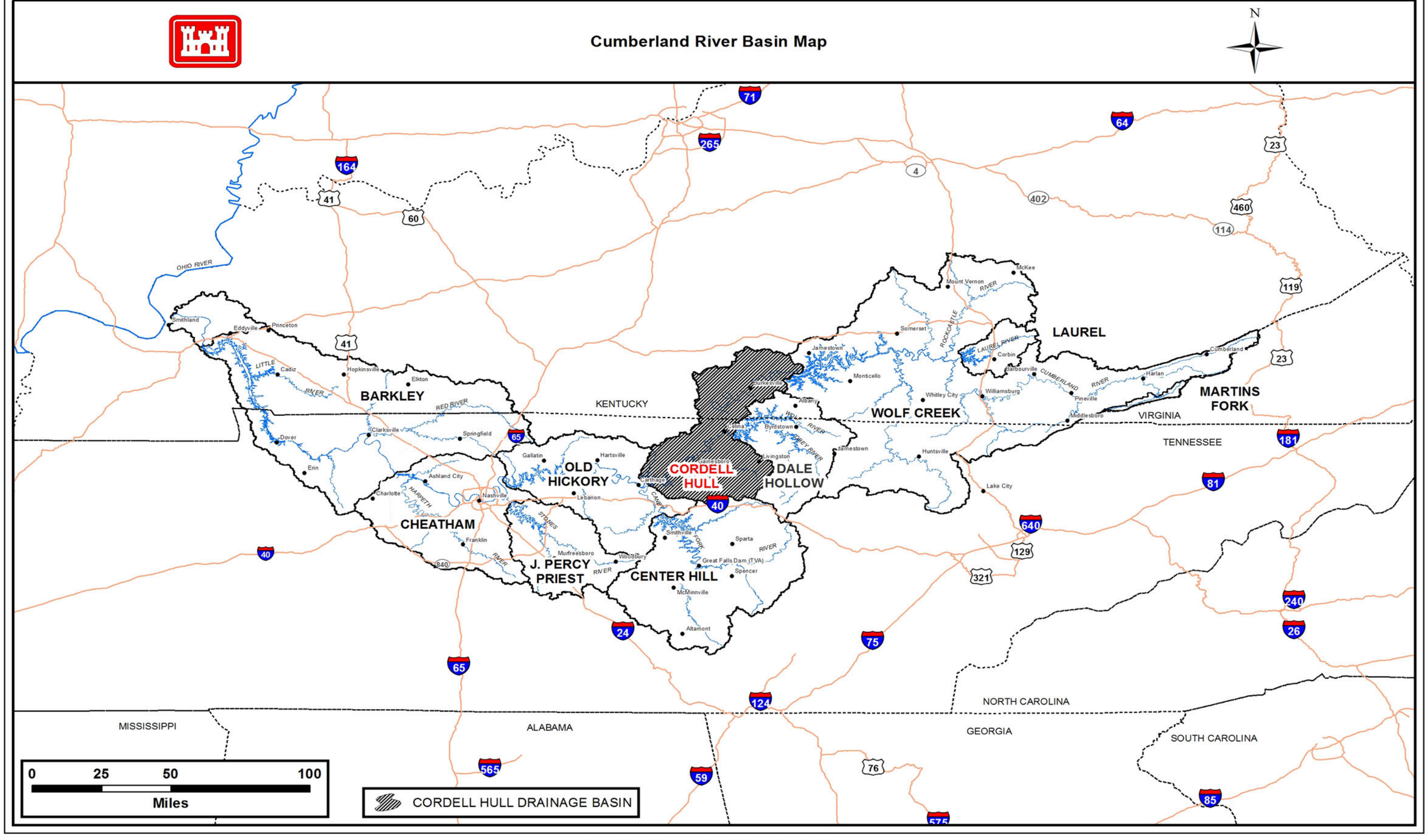

Plate II-4. Cumberland River Basin Map

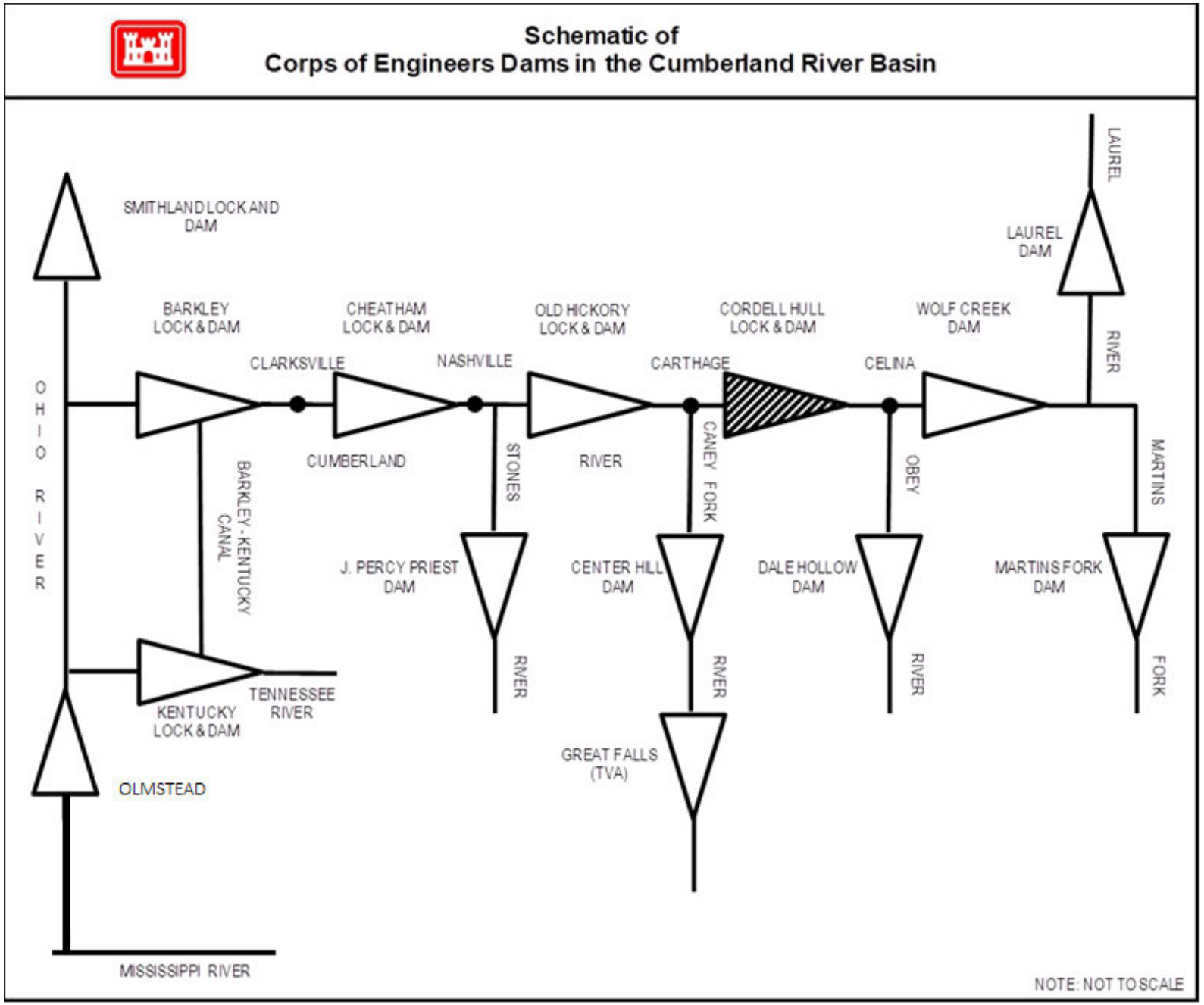

Plate II-5. Schematic of Corps Dams in the Cumberland River Basin

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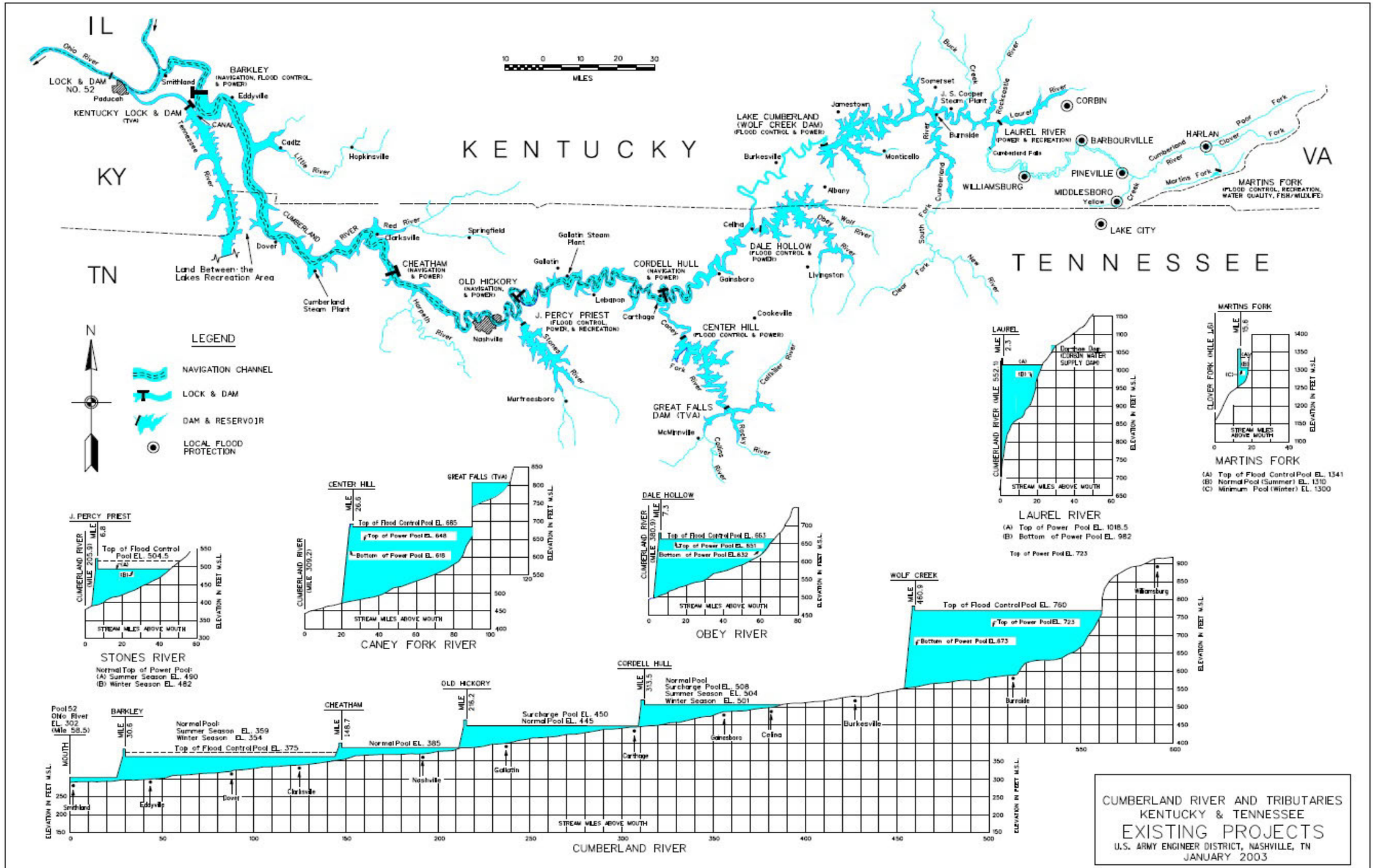

Plate II-6. Profile of Cumberland River

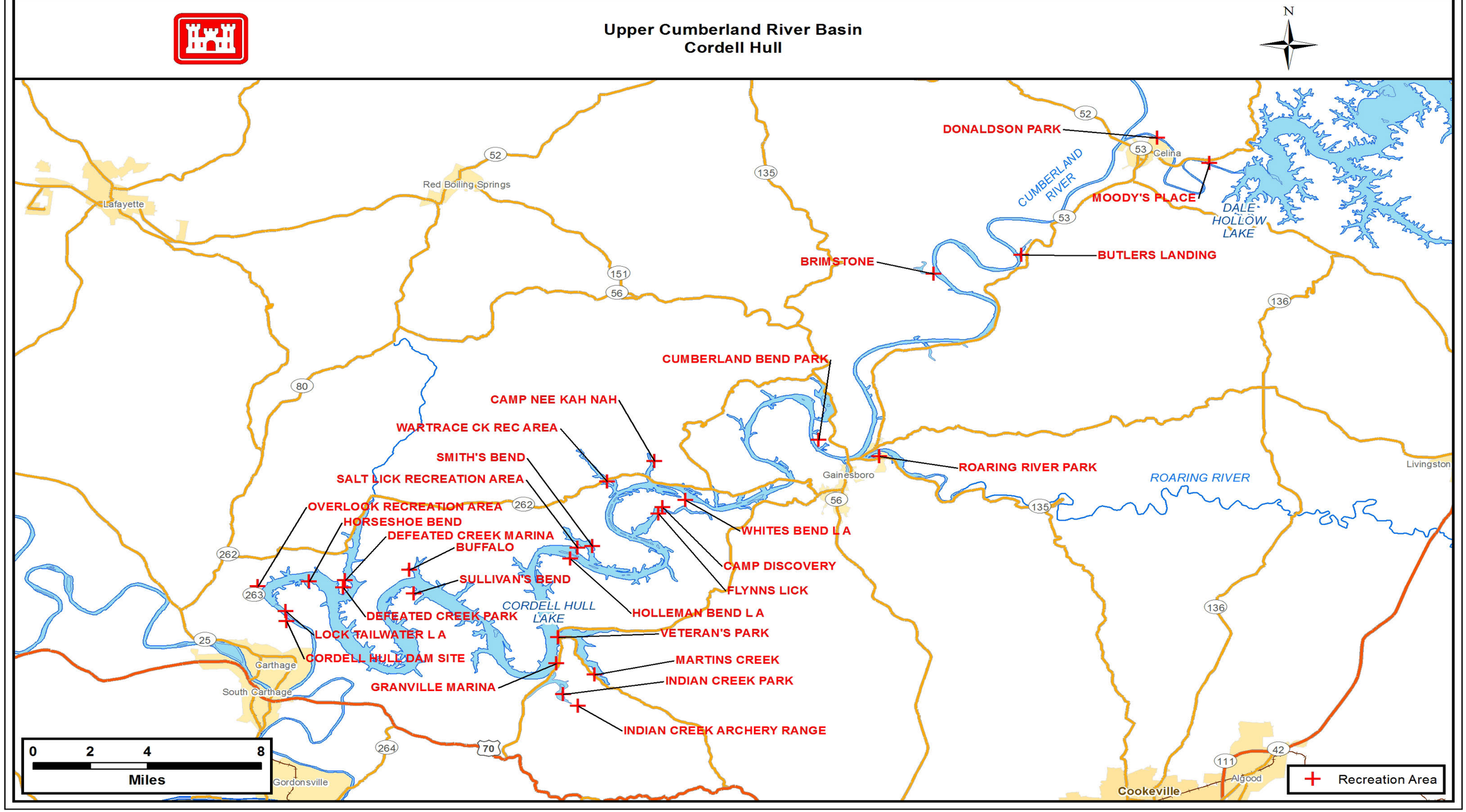

Plate II-7. Cordell Hull Recreation Areas

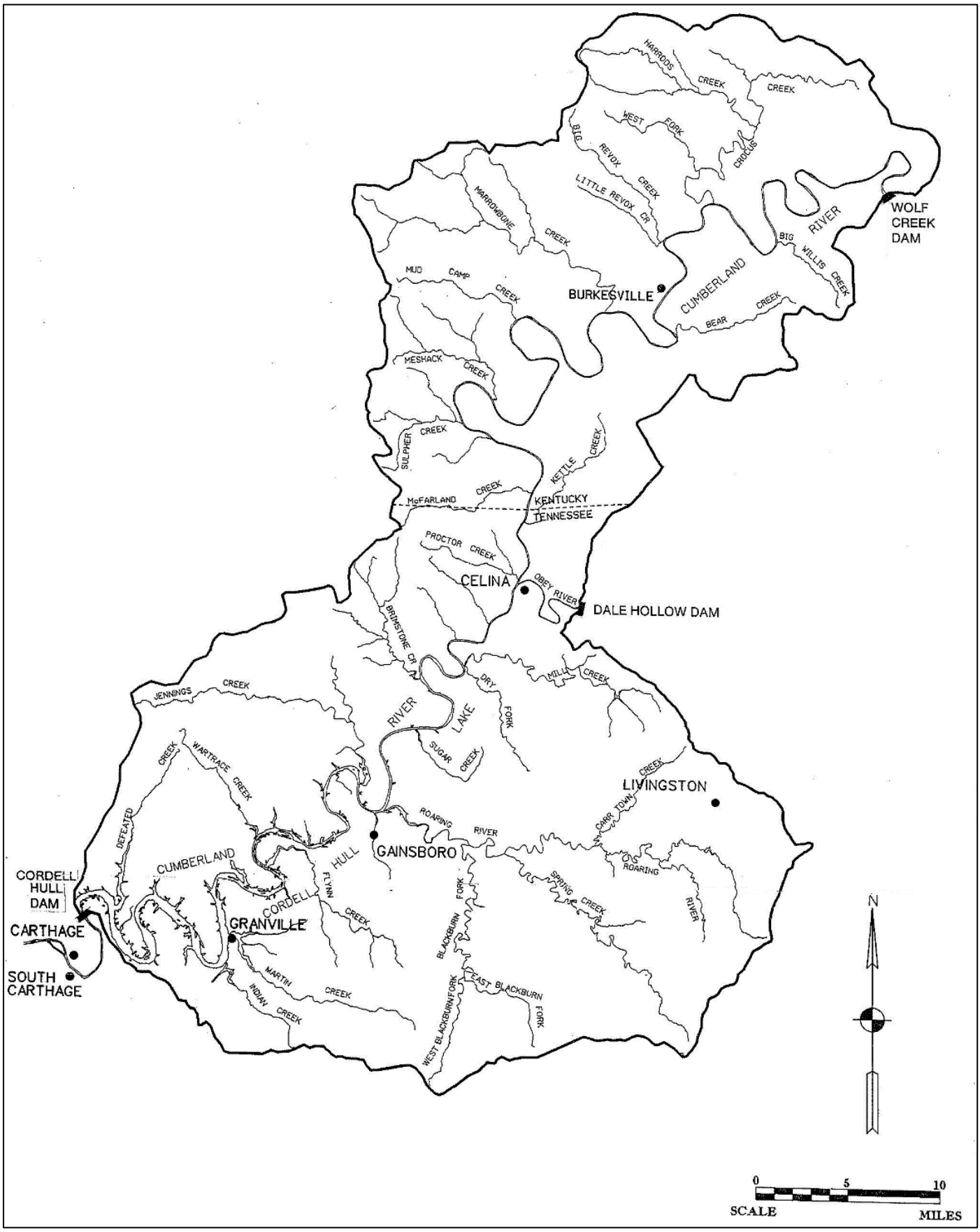

Plate IV-1. Cordell Hull Watershed

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Gage Name	Parameter			
	Precipitation	Stage	Water Quality	Computed Flow
Wolf Creek Dam Tailwater		▲		▲
Cumberland River at Rowena	▲	▲	▲	
Crocus Creek at Amandaville	▲	▲		▲
Cumberland River at Burkesville	▲	▲	▲	▲
Dale Hollow Dam Tailwater		▲	▲	▲
Cumberland River at Celina	▲	▲	▲	▲
Cumberland River at Penitentiary Branch	▲	▲		
Jennings Creek at Whitleyville	▲	▲		▲
Roaring River at Hilham	▲	▲		
Cordell Hull Headwater	▲	▲		
Cordell Hull Tailwater		▲	▲	▲
Albany	▲			
West Fork Obey River near Alpine	▲	▲		▲
Livingston	▲			
Monterey	▲			
Cookeville	▲			
Caney Fork at Stonewall	▲	▲	▲	▲
Cumberland River at Carthage	▲	▲		▲
Lafayette	▲			

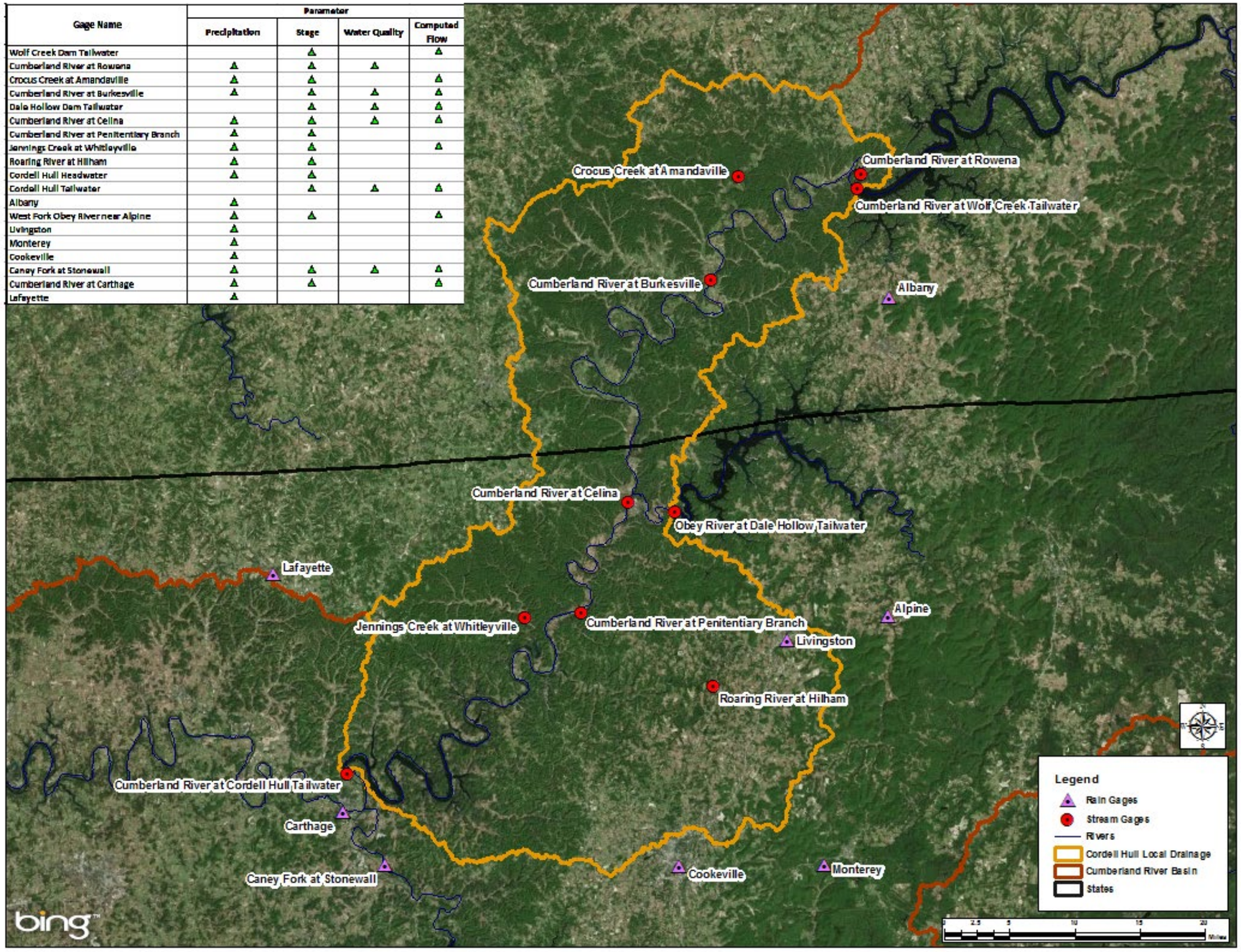

Plate V - 1. Cordell Hull Data Collection Network

LOCATION	PARAMETERS	STREAM	RIVER MILE	DRAINAGE AREA (SQ MI)	DATUM (NAVD88 FT)	FLOOD STAGE (FT)
CORDELL HULL HW	S, P	CUMBERLAND RIVER	313.5	8,095		
CORDELL HULL TW	S, WQ	CUMBERLAND RIVER	313.4			
ROARING RIVER NR HILHAM, TN	S, P	ROARING RIVER		78.7		
CROCUS CREEK NR AMANDAVILLE, KY	S, P	CROCUS CREEK		105.0		
JENNINGS CREEK AT WHITLEYVILLE, TN	S, P	JENNINGS CREEK	4.7	67.4		
CUMBERLAND RIVER AT BURKESVILLE, TN	S, P, T	CUMBERLAND RIVER	422.6	6,020	499.61	43
CUMBERLAND RIVER AT CELINA, TN	S, P, WQ	CUMBERLAND RIVER	380.8	7,307	488.95	40
CUMBERLAND RIVER AT CARTHAGE, TN	S, P	CUMBERLAND RIVER	308.2	10,690	437.27	40
LIVINGSTON, TN	P					

LOCATION	DCP ADDRESS	HANDBOOK 5 CODE	USGS ID	LATITUDE NORTH	LONGITUDE WEST
CORDELL HULL HW	CE24450C	COHT1		[redacted]	[redacted]
CORDELL HULL TW	CE564554	CORT1	03418420	[redacted]	[redacted]
ROARING RIVER NR HILHAM, TN	CE56F6DA	HILT1	03418000	[redacted]	[redacted]
CROCUS CREEK NR AMANDAVILLE, KY	CE0D2758	CRCR1	03414078	[redacted]	[redacted]
JENNINGS CREEK AT WHITLEYVILLE, TN	CE1D9348	JNCT1	03418224	[redacted]	[redacted]
CUMBERLAND RIVER AT BURKESVILLE, TN	CE665052	BRKK2	03414100	[redacted]	[redacted]
CUMBERLAND RIVER AT CELINA, TN	CE56A874	CLAT1	03417500	[redacted]	[redacted]
CUMBERLAND RIVER AT CARTHAGE, TN	CE77F5CE	CTHT1	03425000	[redacted]	[redacted]
LIVINGSTON, TN	CE66A0D6	LVGT1		[redacted]	[redacted]

Plate V - 2. Data Collection Network Table

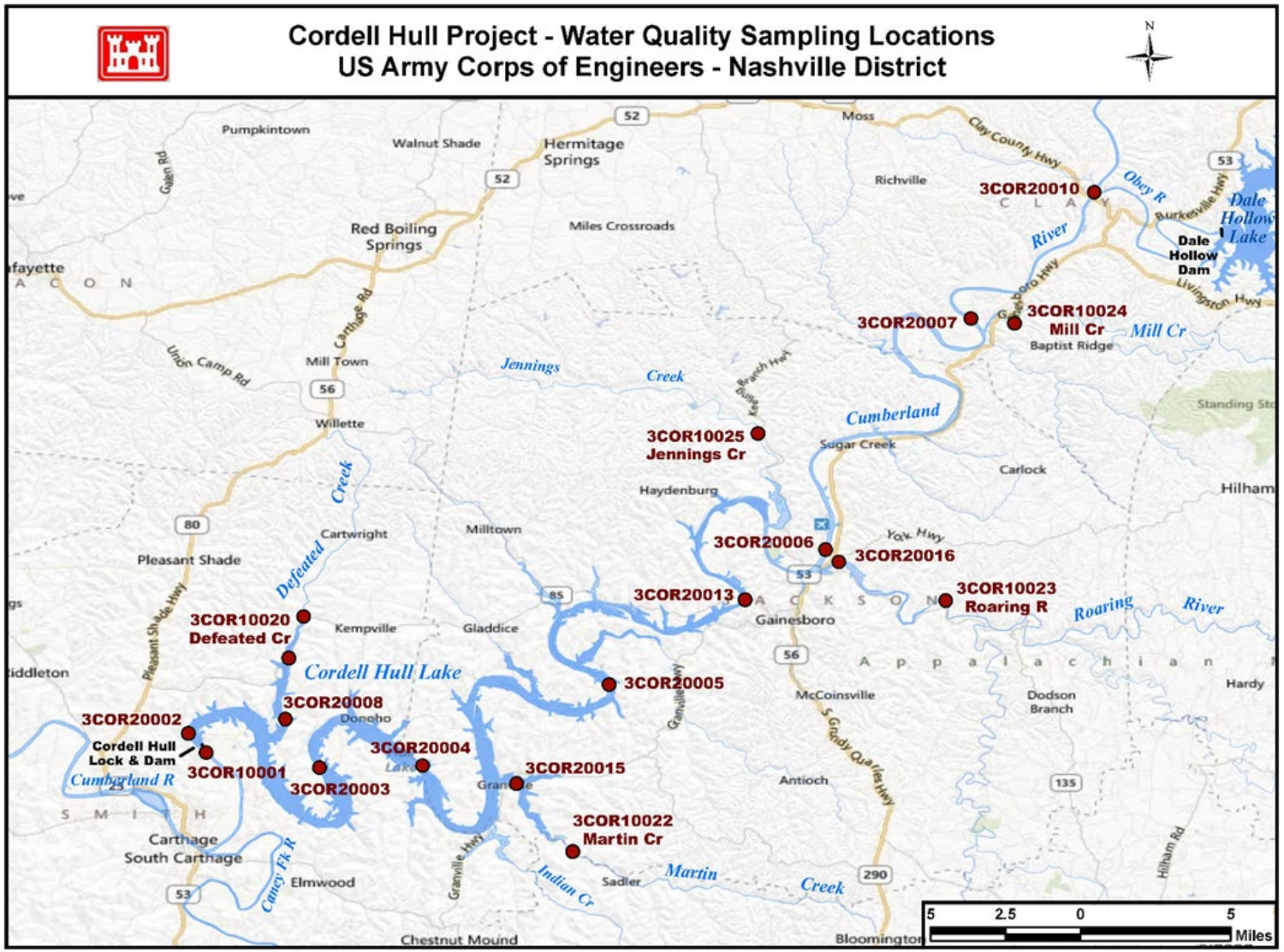

Plate V - 3. Water Quality Station Locations

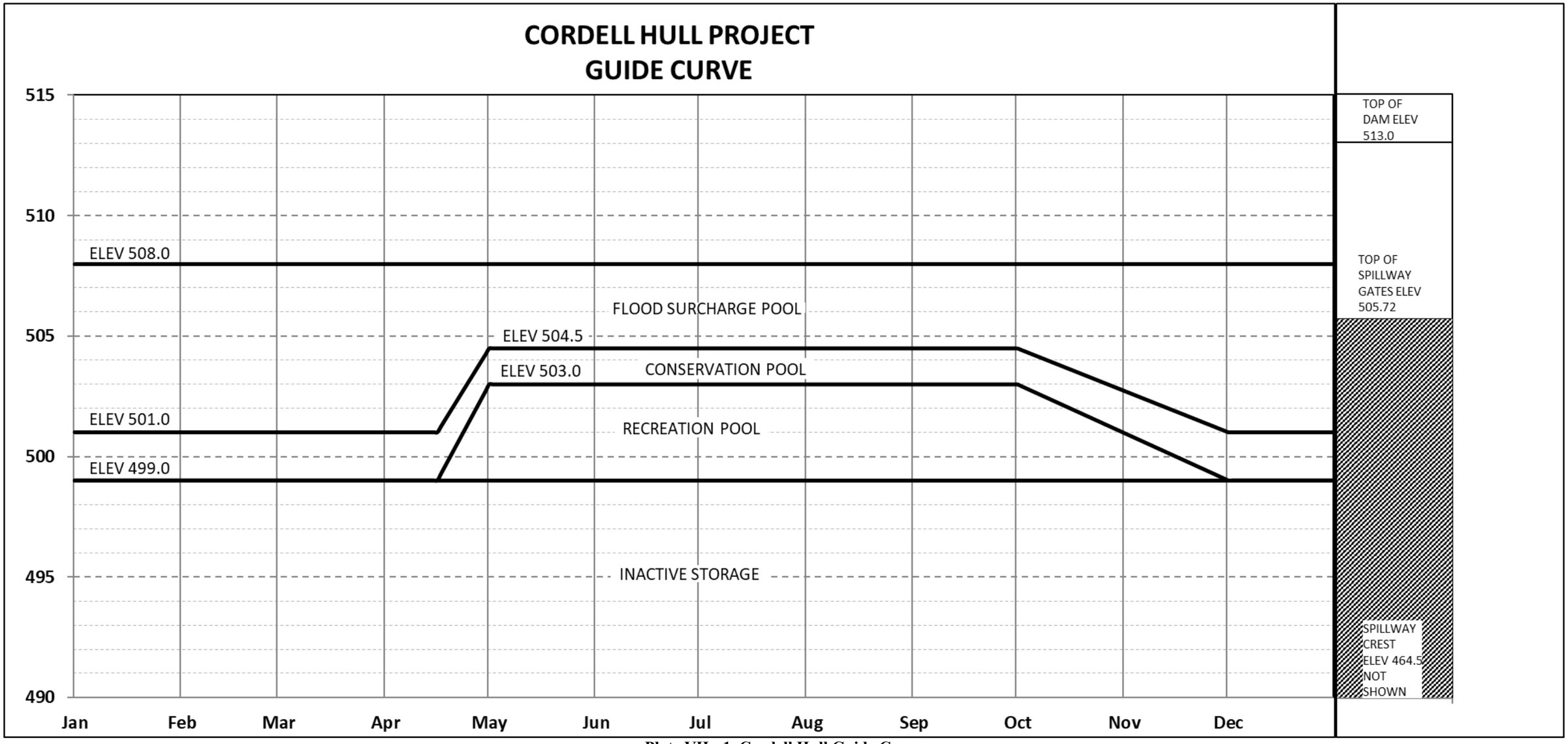

Plate VII - 1. Cordell Hull Guide Curve

CORDELL HULL RESERVOIR
CUMBERLAND RIVER, TENNESSEE
AREA-VOLUME TABLE FOR LEVEL POOL
Mile 313.5 - 385.4

ELEV. M.S.L.	AREA Acres	VOLUME Acre Feet	ELEV. M.S.L.	AREA Acres	VOLUME Acre Feet	ELEV. M.S.L.	AREA Acres	VOLUME Acre Feet
425	16	8	460	1,770	28,200	495	8,340	168,600
6	31	32	1	1,840	30,000	6	8,700	177,100
7	76	85	2	1,900	31,900	7	9,070	185,900
8	144	196	3	1,960	33,800	8	9,430	195,200
9	190	362	4	2,020	35,800	9	9,820	204,800
430	230	572	465	2,070	37,800	500	10,220	214,800
1	264	820	6	2,150	39,900	1	10,630	225,300
2	291	1,100	7	2,230	42,100	2	11,060	236,100
3	332	1,410	8	2,320	44,400	3	11,500	247,400
4	374	1,760	9	2,400	46,800	4	11,960	259,100
435	421	2,160	470	2,490	49,200	505	12,440	271,300
6	464	2,600	1	2,580	51,800	6	12,930	284,000
7	504	3,080	2	2,680	54,400	7	13,430	297,200
8	539	3,610	3	2,800	57,100	8	13,920	310,900
9	572	4,160	4	2,940	60,000	9	14,410	325,000
440	620	4,760	475	3,060	63,000	510	14,910	339,700
1	662	5,400	6	3,230	66,200	1	15,400	354,800
2	698	6,080	7	3,420	69,500	2	15,890	370,500
3	732	6,800	8	3,590	73,000	3	16,390	386,600
4	796	7,560	9	3,790	76,700	4	16,910	403,300
445	857	8,380	480	3,980	80,600	515	17,460	417,350
6	914	9,270	1	4,180	84,600	6	18,460	434,590
7	963	10,200	2	4,380	88,900	7	19,100	452,710
8	1,010	11,200	3	4,590	93,400	8	19,750	471,500
9	1,070	12,200	4	4,810	98,100	9	20,400	490,930
450	1,140	13,300	485	5,030	103,000	520	21,070	511,010
1	1,210	14,500	6	5,280	108,200	1	21,770	531,750
2	1,270	15,700	7	5,540	113,600	2	22,500	553,170
3	1,360	17,100	8	5,830	119,300	3	23,220	575,300
4	1,440	18,500	9	6,140	125,300	4	23,980	598,160
455	1,520	20,000	490	6,480	131,600	525	24,720	621,100
6	1,580	21,500	1	6,830	138,200			
7	1,630	23,100	2	7,200	145,200			
8	1,680	24,800	3	7,580	152,600			
9	1,720	26,500	4	7,960	160,400			
U.S. Army Corps of Engineers								

NOTES: Original areas on Cordell Hull Reservoir maps compiled in 1953 using stereophotogrammetric plotting instruments; flown in 1952; scale 1:10,000; contour interval 5 feet; datum, MSL 1929 Gen. Adj. Capacity determined by arithmetical integration of level pool areas at one-foot increments. Area and capacity data are also available in 15 reaches averaging about 5 miles in length.

Plate VII - 2. Cordell Hull Reservoir Area and Volume Table

CORDELL HULL DAM
SPILLWAY GATE RATING TABLE FOR ONE GATE

GATE OPENING	HEADWATER ELEVATION IN FEET									
	498.0	498.1	498.2	498.3	498.4	498.5	498.6	498.7	498.8	498.9
0.5	830	830	830	830	830	830	830	840	840	840
1	**1,560**	**1,570**	**1,570**	**1,570**	**1,570**	**1,570**	**1,580**	**1,580**	**1,580**	**1,580**
1.5	2,220	2,220	2,230	2,230	2,230	2,240	2,240	2,240	2,250	2,250
2	**2,810**	**2,820**	**2,820**	**2,830**	**2,830**	**2,830**	**2,840**	**2,840**	**2,850**	**2,850**
2.5	3,350	3,360	3,360	3,370	3,370	3,380	3,380	3,390	3,390	3,400
3	**3,840**	**3,850**	**3,860**	**3,860**	**3,870**	**3,870**	**3,880**	**3,890**	**3,890**	**3,900**
3.5	4,310	4,310	4,320	4,330	4,330	4,340	4,350	4,350	4,360	4,370
4	**4,750**	**4,750**	**4,760**	**4,770**	**4,780**	**4,780**	**4,790**	**4,800**	**4,810**	**4,810**
4.5	5,180	5,190	5,200	5,210	5,220	5,220	5,230	5,240	5,250	5,260
5	**5,630**	**5,640**	**5,650**	**5,650**	**5,660**	**5,670**	**5,680**	**5,690**	**5,700**	**5,710**
5.5	6,090	6,100	6,110	6,120	6,130	6,140	6,150	6,160	6,170	6,180
6	**6,580**	**6,590**	**6,600**	**6,610**	**6,620**	**6,630**	**6,640**	**6,650**	**6,660**	**6,670**
6.5	7,080	7,090	7,100	7,110	7,120	7,130	7,150	7,160	7,170	7,180
7	**7,570**	**7,580**	**7,600**	**7,610**	**7,620**	**7,630**	**7,650**	**7,660**	**7,670**	**7,680**
7.5	8,060	8,080	8,090	8,100	8,120	8,130	8,150	8,160	8,170	8,190
8	**8,550**	**8,570**	**8,580**	**8,600**	**8,610**	**8,620**	**8,640**	**8,650**	**8,670**	**8,680**
8.5	9,040	9,050	9,070	9,080	9,100	9,110	9,130	9,140	9,160	9,170
9	**9,520**	**9,530**	**9,550**	**9,570**	**9,580**	**9,600**	**9,610**	**9,630**	**9,650**	**9,660**
9.5	9,990	10,010	10,030	10,040	10,060	10,080	10,100	10,110	10,130	10,150
10	**10,460**	**10,480**	**10,500**	**10,520**	**10,540**	**10,560**	**10,570**	**10,590**	**10,610**	**10,630**
10.5	10,930	10,950	10,970	10,990	11,010	11,030	11,050	11,070	11,090	11,110
11	**11,390**	**11,410**	**11,430**	**11,450**	**11,480**	**11,500**	**11,520**	**11,540**	**11,560**	**11,580**
11.5	11,850	11,870	11,890	11,910	11,940	11,960	11,980	12,000	12,020	12,040
12	**12,300**	**12,320**	**12,350**	**12,370**	**12,390**	**12,410**	**12,440**	**12,460**	**12,480**	**12,500**
12.5	12,750	12,770	12,790	12,820	12,840	12,860	12,890	12,910	12,930	12,960
13	**13,190**	**13,210**	**13,240**	**13,260**	**13,290**	**13,310**	**13,330**	**13,360**	**13,380**	**13,410**
13.5	13,620	13,650	13,670	13,700	13,720	13,750	13,780	13,800	13,830	13,850
14	**14,050**	**14,080**	**14,100**	**14,130**	**14,160**	**14,180**	**14,210**	**14,240**	**14,260**	**14,290**
14.5	14,470	14,500	14,530	14,560	14,590	14,610	14,640	14,670	14,700	14,720
15	**14,890**	**14,920**	**14,950**	**14,980**	**15,010**	**15,040**	**15,070**	**15,090**	**15,120**	**15,150**
15.5	15,300	15,330	15,360	15,390	15,420	15,450	15,480	15,510	15,540	15,570
16	**15,710**	**15,740**	**15,770**	**15,800**	**15,830**	**15,870**	**15,900**	**15,930**	**15,960**	**15,990**
17	16,500	16,540	16,570	16,600	16,640	16,670	16,710	16,740	16,770	16,800
18	**17,270**	**17,310**	**17,350**	**17,380**	**17,420**	**17,450**	**17,490**	**17,520**	**17,560**	**17,600**
19	18,020	18,060	18,100	18,130	18,170	18,210	18,250	18,290	18,320	18,360
20	**18,740**	**18,780**	**18,820**	**18,860**	**18,900**	**18,940**	**18,980**	**19,020**	**19,060**	**19,100**
21	19,430	19,470	19,520	19,560	19,600	19,650	19,690	19,730	19,780	19,820
22	**20,090**	**20,140**	**20,190**	**20,230**	**20,280**	**20,330**	**20,370**	**20,420**	**20,460**	**20,510**
23	20,730	20,780	20,830	20,880	20,930	20,980	21,020	21,070	21,120	21,170
24	**21,330**	**21,390**	**21,440**	**21,490**	**21,540**	**21,600**	**21,650**	**21,700**	**21,750**	**21,800**
25	21,910	21,960	22,020	22,070	22,130	22,180	22,240	22,290	22,350	22,400
26	**22,450**	**22,510**	**22,570**	**22,620**	**22,680**	**22,740**	**22,800**	**22,860**	**22,920**	**22,970**
27	22,950	23,010	23,080	23,140	23,200	23,260	23,330	23,390	23,450	23,510
28	**23,420**	**23,490**	**23,550**	**23,620**	**23,680**	**23,750**	**23,820**	**23,880**	**23,950**	**24,010**
29	23,840	23,910	23,980	24,060	24,130	24,200	24,270	24,330	24,400	24,470
30	**24,220**	**24,300**	**24,370**	**24,450**	**24,520**	**24,600**	**24,670**	**24,750**	**24,820**	**24,890**
31	24,550	24,630	24,710	24,790	24,870	24,950	25,030	25,110	25,190	25,270
32	**24,810**	**24,900**	**24,990**	**25,080**	**25,160**	**25,250**	**25,330**	**25,420**	**25,500**	**25,590**
33	25,000	25,100	25,190	25,290	25,380	25,480	25,570	25,660	25,750	25,850
34						**25,600**	**25,710**	**25,810**	**25,920**	**26,020**
35										
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39										

Plate VII- 3. Spillway Rating Table, Continued

CORDELL HULL DAM
SPILLWAY GATE RATING TABLE FOR ONE GATE

GATE OPENING	HEADWATER ELEVATION IN FEET									
	499.0	499.1	499.2	499.3	499.4	499.5	499.6	499.7	499.8	499.9
0.5	840	840	840	840	840	840	850	850	850	850
1	**1,590**	**1,590**	**1,590**	**1,590**	**1,600**	**1,600**	**1,600**	**1,600**	**1,600**	**1,610**
1.5	2,250	2,260	2,260	2,260	2,270	2,270	2,270	2,280	2,280	2,280
2	**2,860**	**2,860**	**2,860**	**2,870**	**2,870**	**2,880**	**2,880**	**2,890**	**2,890**	**2,890**
2.5	3,400	3,410	3,410	3,420	3,420	3,430	3,430	3,440	3,440	3,450
3	**3,900**	**3,910**	**3,920**	**3,920**	**3,930**	**3,930**	**3,940**	**3,940**	**3,950**	**3,960**
3.5	4,370	4,380	4,390	4,390	4,400	4,410	4,410	4,420	4,430	4,430
4	**4,820**	**4,830**	**4,840**	**4,840**	**4,850**	**4,860**	**4,870**	**4,870**	**4,880**	**4,890**
4.5	5,260	5,270	5,280	5,290	5,300	5,310	5,310	5,320	5,330	5,340
5	**5,720**	**5,730**	**5,740**	**5,740**	**5,750**	**5,760**	**5,770**	**5,780**	**5,790**	**5,800**
5.5	6,190	6,200	6,210	6,220	6,230	6,240	6,240	6,250	6,260	6,270
6	**6,680**	**6,690**	**6,700**	**6,710**	**6,720**	**6,740**	**6,750**	**6,760**	**6,770**	**6,780**
6.5	7,190	7,200	7,210	7,230	7,240	7,250	7,260	7,270	7,280	7,290
7	**7,700**	**7,710**	**7,720**	**7,730**	**7,750**	**7,760**	**7,770**	**7,780**	**7,800**	**7,810**
7.5	8,200	8,210	8,230	8,240	8,250	8,270	8,280	8,290	8,300	8,320
8	**8,700**	**8,710**	**8,720**	**8,740**	**8,750**	**8,770**	**8,780**	**8,800**	**8,810**	**8,820**
8.5	9,190	9,210	9,220	9,240	9,250	9,270	9,280	9,300	9,310	9,330
9	**9,680**	**9,700**	**9,710**	**9,730**	**9,740**	**9,760**	**9,780**	**9,790**	**9,810**	**9,820**
9.5	10,170	10,180	10,200	10,220	10,230	10,250	10,270	10,280	10,300	10,320
10	**10,650**	**10,670**	**10,680**	**10,700**	**10,720**	**10,740**	**10,760**	**10,770**	**10,790**	**10,810**
10.5	11,120	11,140	11,160	11,180	11,200	11,220	11,240	11,260	11,280	11,300
11	**11,600**	**11,620**	**11,640**	**11,660**	**11,680**	**11,700**	**11,720**	**11,740**	**11,760**	**11,780**
11.5	12,060	12,080	12,110	12,130	12,150	12,170	12,190	12,210	12,230	12,250
12	**12,520**	**12,550**	**12,570**	**12,590**	**12,610**	**12,630**	**12,660**	**12,680**	**12,700**	**12,720**
12.5	12,980	13,000	13,030	13,050	13,070	13,100	13,120	13,140	13,160	13,190
13	**13,430**	**13,460**	**13,480**	**13,500**	**13,530**	**13,550**	**13,580**	**13,600**	**13,620**	**13,650**
13.5	13,880	13,900	13,930	13,950	13,980	14,000	14,030	14,050	14,080	14,100
14	**14,320**	**14,340**	**14,370**	**14,400**	**14,420**	**14,450**	**14,470**	**14,500**	**14,530**	**14,550**
14.5	14,750	14,780	14,810	14,830	14,860	14,890	14,910	14,940	14,970	15,000
15	**15,180**	**15,210**	**15,240**	**15,270**	**15,290**	**15,320**	**15,350**	**15,380**	**15,410**	**15,430**
15.5	15,600	15,630	15,660	15,690	15,720	15,750	15,780	15,810	15,840	15,870
16	**16,020**	**16,050**	**16,080**	**16,110**	**16,140**	**16,170**	**16,200**	**16,230**	**16,260**	**16,290**
17	16,840	16,870	16,900	16,940	16,970	17,000	17,030	17,070	17,100	17,130
18	**17,630**	**17,670**	**17,700**	**17,740**	**17,770**	**17,810**	**17,840**	**17,880**	**17,910**	**17,950**
19	18,400	18,440	18,480	18,510	18,550	18,590	18,630	18,660	18,700	18,740
20	**19,140**	**19,180**	**19,220**	**19,260**	**19,300**	**19,340**	**19,380**	**19,420**	**19,460**	**19,500**
21	19,860	19,910	19,950	19,990	20,030	20,080	20,120	20,160	20,200	20,240
22	**20,550**	**20,600**	**20,650**	**20,690**	**20,740**	**20,780**	**20,830**	**20,870**	**20,910**	**20,960**
23	21,220	21,270	21,310	21,360	21,410	21,460	21,510	21,550	21,600	21,650
24	**21,850**	**21,900**	**21,960**	**22,010**	**22,060**	**22,110**	**22,160**	**22,210**	**22,260**	**22,310**
25	22,460	22,510	22,570	22,620	22,670	22,730	22,780	22,830	22,890	22,940
26	**23,030**	**23,090**	**23,150**	**23,200**	**23,260**	**23,320**	**23,370**	**23,430**	**23,490**	**23,540**
27	23,570	23,630	23,690	23,750	23,810	23,870	23,930	23,990	24,050	24,110
28	**24,070**	**24,140**	**24,200**	**24,270**	**24,330**	**24,390**	**24,460**	**24,520**	**24,580**	**24,650**
29	24,540	24,610	24,680	24,750	24,810	24,880	24,950	25,010	25,080	25,150
30	**24,970**	**25,040**	**25,110**	**25,180**	**25,250**	**25,330**	**25,400**	**25,470**	**25,540**	**25,610**
31	25,340	25,420	25,500	25,580	25,650	25,730	25,800	25,880	25,950	26,030
32	**25,670**	**25,750**	**25,840**	**25,920**	**26,000**	**26,080**	**26,160**	**26,240**	**26,320**	**26,400**
33	25,940	26,030	26,110	26,200	26,290	26,380	26,470	26,550	26,640	26,720
34	**26,120**	**26,220**	**26,320**	**26,410**	**26,510**	**26,610**	**26,700**	**26,800**	**26,890**	**26,980**
35						26,730	26,840	26,940	27,050	27,150
36										
37										
38										
39										

Plate VII- 3. Spillway Rating Table, Continued

CORDELL HULL DAM
SPILLWAY GATE RATING TABLE FOR ONE GATE

GATE OPENING	HEADWATER ELEVATION IN FEET									
	500.0	500.1	500.2	500.3	500.4	500.5	500.6	500.7	500.8	500.9
0.5	850	850	850	850	860	860	860	860	860	860
1	**1,610**	**1,610**	**1,610**	**1,620**	**1,620**	**1,620**	**1,620**	**1,630**	**1,630**	**1,630**
1.5	2,290	2,290	2,290	2,300	2,300	2,300	2,310	2,310	2,310	2,320
2	**2,900**	**2,900**	**2,910**	**2,910**	**2,910**	**2,920**	**2,920**	**2,930**	**2,930**	**2,940**
2.5	3,450	3,460	3,460	3,470	3,470	3,480	3,480	3,490	3,490	3,500
3	**3,960**	**3,970**	**3,970**	**3,980**	**3,990**	**3,990**	**4,000**	**4,000**	**4,010**	**4,010**
3.5	4,440	4,450	4,450	4,460	4,470	4,470	4,480	4,490	4,490	4,500
4	**4,900**	**4,900**	**4,910**	**4,920**	**4,930**	**4,930**	**4,940**	**4,950**	**4,950**	**4,960**
4.5	5,350	5,350	5,360	5,370	5,380	5,390	5,390	5,400	5,410	5,420
5	**5,810**	**5,820**	**5,820**	**5,830**	**5,840**	**5,850**	**5,860**	**5,870**	**5,880**	**5,890**
5.5	6,280	6,290	6,300	6,310	6,320	6,330	6,340	6,350	6,360	6,370
6	**6,790**	**6,800**	**6,810**	**6,820**	**6,830**	**6,840**	**6,850**	**6,860**	**6,870**	**6,880**
6.5	7,310	7,320	7,330	7,340	7,350	7,360	7,370	7,390	7,400	7,410
7	**7,820**	**7,830**	**7,850**	**7,860**	**7,870**	**7,880**	**7,890**	**7,910**	**7,920**	**7,930**
7.5	8,330	8,340	8,360	8,370	8,380	8,400	8,410	8,420	8,440	8,450
8	**8,840**	**8,850**	**8,870**	**8,880**	**8,890**	**8,910**	**8,920**	**8,940**	**8,950**	**8,960**
8.5	9,340	9,360	9,370	9,390	9,400	9,420	9,430	9,450	9,460	9,470
9	**9,840**	**9,860**	**9,870**	**9,890**	**9,900**	**9,920**	**9,940**	**9,950**	**9,970**	**9,980**
9.5	10,340	10,350	10,370	10,390	10,400	10,420	10,440	10,450	10,470	10,490
10	**10,830**	**10,840**	**10,860**	**10,880**	**10,900**	**10,920**	**10,930**	**10,950**	**10,970**	**10,990**
10.5	11,310	11,330	11,350	11,370	11,390	11,410	11,430	11,440	11,460	11,480
11	**11,800**	**11,820**	**11,840**	**11,860**	**11,870**	**11,890**	**11,910**	**11,930**	**11,950**	**11,970**
11.5	12,270	12,290	12,310	12,330	12,360	12,380	12,400	12,420	12,440	12,460
12	**12,740**	**12,770**	**12,790**	**12,810**	**12,830**	**12,850**	**12,870**	**12,900**	**12,920**	**12,940**
12.5	13,210	13,230	13,260	13,280	13,300	13,320	13,350	13,370	13,390	13,410
13	**13,670**	**13,700**	**13,720**	**13,740**	**13,770**	**13,790**	**13,810**	**13,840**	**13,860**	**13,880**
13.5	14,130	14,150	14,180	14,200	14,230	14,250	14,280	14,300	14,320	14,350
14	**14,580**	**14,600**	**14,630**	**14,650**	**14,680**	**14,710**	**14,730**	**14,760**	**14,780**	**14,810**
14.5	15,020	15,050	15,080	15,100	15,130	15,160	15,180	15,210	15,240	15,260
15	**15,460**	**15,490**	**15,520**	**15,550**	**15,570**	**15,600**	**15,630**	**15,660**	**15,680**	**15,710**
15.5	15,900	15,920	15,950	15,980	16,010	16,040	16,070	16,100	16,130	16,160
16	**16,320**	**16,350**	**16,380**	**16,410**	**16,440**	**16,470**	**16,500**	**16,530**	**16,560**	**16,590**
17	17,160	17,200	17,230	17,260	17,290	17,320	17,360	17,390	17,420	17,450
18	**17,980**	**18,020**	**18,050**	**18,080**	**18,120**	**18,150**	**18,190**	**18,220**	**18,260**	**18,290**
19	18,770	18,810	18,850	18,880	18,920	18,960	18,990	19,030	19,070	19,100
20	**19,540**	**19,580**	**19,620**	**19,660**	**19,700**	**19,740**	**19,780**	**19,820**	**19,850**	**19,890**
21	20,290	20,330	20,370	20,410	20,450	20,490	20,540	20,580	20,620	20,660
22	**21,000**	**21,050**	**21,090**	**21,140**	**21,180**	**21,220**	**21,270**	**21,310**	**21,360**	**21,400**
23	21,700	21,740	21,790	21,840	21,880	21,930	21,980	22,020	22,070	22,110
24	**22,360**	**22,410**	**22,460**	**22,510**	**22,560**	**22,610**	**22,660**	**22,700**	**22,750**	**22,800**
25	22,990	23,050	23,100	23,150	23,200	23,260	23,310	23,360	23,410	23,460
26	**23,600**	**23,650**	**23,710**	**23,760**	**23,820**	**23,870**	**23,930**	**23,980**	**24,040**	**24,090**
27	24,170	24,230	24,290	24,350	24,410	24,460	24,520	24,580	24,640	24,700
28	**24,710**	**24,770**	**24,830**	**24,900**	**24,960**	**25,020**	**25,080**	**25,140**	**25,200**	**25,260**
29	25,210	25,280	25,350	25,410	25,480	25,540	25,610	25,670	25,740	25,800
30	**25,680**	**25,750**	**25,820**	**25,890**	**25,960**	**26,030**	**26,100**	**26,160**	**26,230**	**26,300**
31	26,100	26,180	26,250	26,330	26,400	26,470	26,540	26,620	26,690	26,760
32	**26,480**	**26,560**	**26,640**	**26,720**	**26,800**	**26,870**	**26,950**	**27,030**	**27,100**	**27,180**
33	26,810	26,890	26,980	27,060	27,140	27,230	27,310	27,390	27,470	27,550
34	**27,070**	**27,160**	**27,260**	**27,350**	**27,440**	**27,520**	**27,610**	**27,700**	**27,790**	**27,880**
35	27,260	27,360	27,460	27,560	27,650	27,750	27,850	27,940	28,040	28,130
36						**27,870**	**27,980**	**28,090**	**28,200**	**28,310**
37										
38										
39										

Plate VII- 3. Spillway Rating Table, Continued

CORDELL HULL DAM
SPILLWAY GATE RATING TABLE FOR ONE GATE

GATE OPENING	HEADWATER ELEVATION IN FEET									
	501.0	501.1	501.2	501.3	501.4	501.5	501.6	501.7	501.8	501.9
0.5	860	860	870	870	870	870	870	870	870	870
1	**1,630**	**1,630**	**1,640**	**1,640**	**1,640**	**1,640**	**1,650**	**1,650**	**1,650**	**1,650**
1.5	2,320	2,320	2,330	2,330	2,330	2,340	2,340	2,340	2,350	2,350
2	**2,940**	**2,940**	**2,950**	**2,950**	**2,960**	**2,960**	**2,960**	**2,970**	**2,970**	**2,980**
2.5	3,500	3,510	3,510	3,520	3,520	3,530	3,530	3,540	3,540	3,550
3	**4,020**	**4,030**	**4,030**	**4,040**	**4,040**	**4,050**	**4,050**	**4,060**	**4,070**	**4,070**
3.5	4,500	4,510	4,520	4,520	4,530	4,540	4,540	4,550	4,560	4,560
4	**4,970**	**4,980**	**4,980**	**4,990**	**5,000**	**5,000**	**5,010**	**5,020**	**5,030**	**5,030**
4.5	5,430	5,430	5,440	5,450	5,460	5,460	5,470	5,480	5,490	5,500
5	**5,890**	**5,900**	**5,910**	**5,920**	**5,930**	**5,940**	**5,950**	**5,950**	**5,960**	**5,970**
5.5	6,380	6,390	6,400	6,410	6,420	6,430	6,440	6,440	6,450	6,460
6	**6,890**	**6,900**	**6,910**	**6,920**	**6,930**	**6,940**	**6,950**	**6,960**	**6,970**	**6,980**
6.5	7,420	7,430	7,440	7,450	7,460	7,470	7,490	7,500	7,510	7,520
7	**7,940**	**7,950**	**7,970**	**7,980**	**7,990**	**8,000**	**8,010**	**8,030**	**8,040**	**8,050**
7.5	8,460	8,470	8,490	8,500	8,510	8,530	8,540	8,550	8,560	8,580
8	**8,980**	**8,990**	**9,010**	**9,020**	**9,030**	**9,050**	**9,060**	**9,070**	**9,090**	**9,100**
8.5	9,490	9,500	9,520	9,530	9,550	9,560	9,580	9,590	9,610	9,620
9	**10,000**	**10,010**	**10,030**	**10,040**	**10,060**	**10,080**	**10,090**	**10,110**	**10,120**	**10,140**
9.5	10,500	10,520	10,540	10,550	10,570	10,590	10,600	10,620	10,630	10,650
10	**11,000**	**11,020**	**11,040**	**11,060**	**11,070**	**11,090**	**11,110**	**11,130**	**11,140**	**11,160**
10.5	11,500	11,520	11,540	11,560	11,570	11,590	11,610	11,630	11,650	11,670
11	**11,990**	**12,010**	**12,030**	**12,050**	**12,070**	**12,090**	**12,110**	**12,130**	**12,150**	**12,170**
11.5	12,480	12,500	12,520	12,540	12,560	12,580	12,600	12,620	12,640	12,660
12	**12,960**	**12,980**	**13,000**	**13,020**	**13,050**	**13,070**	**13,090**	**13,110**	**13,130**	**13,150**
12.5	13,440	13,460	13,480	13,500	13,530	13,550	13,570	13,590	13,610	13,640
13	**13,910**	**13,930**	**13,950**	**13,980**	**14,000**	**14,020**	**14,050**	**14,070**	**14,090**	**14,120**
13.5	14,370	14,400	14,420	14,450	14,470	14,490	14,520	14,540	14,570	14,590
14	**14,830**	**14,860**	**14,880**	**14,910**	**14,930**	**14,960**	**14,990**	**15,010**	**15,040**	**15,060**
14.5	15,290	15,320	15,340	15,370	15,390	15,420	15,450	15,470	15,500	15,520
15	**15,740**	**15,770**	**15,790**	**15,820**	**15,850**	**15,880**	**15,900**	**15,930**	**15,960**	**15,980**
15.5	16,180	16,210	16,240	16,270	16,300	16,330	16,350	16,380	16,410	16,440
16	**16,620**	**16,650**	**16,680**	**16,710**	**16,740**	**16,770**	**16,800**	**16,830**	**16,860**	**16,890**
17	17,480	17,520	17,550	17,580	17,610	17,640	17,670	17,700	17,740	17,770
18	**18,320**	**18,360**	**18,390**	**18,430**	**18,460**	**18,490**	**18,530**	**18,560**	**18,590**	**18,630**
19	19,140	19,180	19,210	19,250	19,280	19,320	19,360	19,390	19,430	19,460
20	**19,930**	**19,970**	**20,010**	**20,050**	**20,090**	**20,120**	**20,160**	**20,200**	**20,240**	**20,280**
21	20,700	20,740	20,780	20,820	20,860	20,900	20,940	20,980	21,030	21,070
22	**21,440**	**21,490**	**21,530**	**21,570**	**21,620**	**21,660**	**21,700**	**21,750**	**21,790**	**21,830**
23	22,160	22,210	22,250	22,300	22,340	22,390	22,440	22,480	22,530	22,570
24	**22,850**	**22,900**	**22,950**	**23,000**	**23,050**	**23,090**	**23,140**	**23,190**	**23,240**	**23,290**
25	23,510	23,570	23,620	23,670	23,720	23,770	23,820	23,870	23,920	23,970
26	**24,150**	**24,200**	**24,260**	**24,310**	**24,370**	**24,420**	**24,470**	**24,530**	**24,580**	**24,630**
27	24,750	24,810	24,870	24,920	24,980	25,040	25,090	25,150	25,210	25,260
28	**25,330**	**25,390**	**25,450**	**25,510**	**25,570**	**25,630**	**25,690**	**25,750**	**25,810**	**25,860**
29	25,860	25,930	25,990	26,060	26,120	26,180	26,250	26,310	26,370	26,430
30	**26,370**	**26,440**	**26,500**	**26,570**	**26,640**	**26,700**	**26,770**	**26,840**	**26,900**	**26,970**
31	26,830	26,900	26,980	27,050	27,120	27,190	27,260	27,330	27,400	27,470
32	**27,260**	**27,330**	**27,410**	**27,480**	**27,560**	**27,630**	**27,710**	**27,780**	**27,860**	**27,930**
33	27,640	27,720	27,800	27,880	27,960	28,040	28,110	28,190	28,270	28,350
34	**27,960**	**28,050**	**28,130**	**28,220**	**28,300**	**28,390**	**28,470**	**28,560**	**28,640**	**28,720**
35	28,230	28,320	28,410	28,500	28,590	28,690	28,780	28,870	28,950	29,040
36	**28,410**	**28,510**	**28,610**	**28,710**	**28,810**	**28,910**	**29,010**	**29,110**	**29,200**	**29,300**
37						29,030	29,150	29,260	29,370	29,470
38										
39										

Sheet 4 of 13

Plate VII- 3. Spillway Rating Table, Continued

CORDELL HULL DAM
SPILLWAY GATE RATING TABLE FOR ONE GATE

GATE OPENING	HEADWATER ELEVATION IN FEET									
	502.0	502.1	502.2	502.3	502.4	502.5	502.6	502.7	502.8	502.9
0.5	870	880	880	880	880	880	880	880	880	890
1	**1,650**	**1,660**	**1,660**	**1,660**	**1,660**	**1,670**	**1,670**	**1,670**	**1,670**	**1,670**
1.5	2,350	2,360	2,360	2,360	2,370	2,370	2,370	2,380	2,380	2,380
2	**2,980**	**2,990**	**2,990**	**2,990**	**3,000**	**3,000**	**3,010**	**3,010**	**3,010**	**3,020**
2.5	3,550	3,560	3,560	3,570	3,570	3,580	3,580	3,590	3,590	3,600
3	**4,080**	**4,080**	**4,090**	**4,090**	**4,100**	**4,110**	**4,110**	**4,120**	**4,120**	**4,130**
3.5	4,570	4,580	4,580	4,590	4,590	4,600	4,610	4,610	4,620	4,630
4	**5,040**	**5,050**	**5,050**	**5,060**	**5,070**	**5,080**	**5,080**	**5,090**	**5,100**	**5,100**
4.5	5,500	5,510	5,520	5,530	5,540	5,540	5,550	5,560	5,570	5,570
5	**5,980**	**5,990**	**6,000**	**6,010**	**6,010**	**6,020**	**6,030**	**6,040**	**6,050**	**6,060**
5.5	6,470	6,480	6,490	6,500	6,510	6,520	6,530	6,540	6,550	6,560
6	**6,990**	**7,000**	**7,010**	**7,020**	**7,030**	**7,040**	**7,050**	**7,060**	**7,070**	**7,080**
6.5	7,530	7,540	7,550	7,560	7,570	7,580	7,600	7,610	7,620	7,630
7	**8,060**	**8,070**	**8,090**	**8,100**	**8,110**	**8,120**	**8,130**	**8,140**	**8,160**	**8,170**
7.5	8,590	8,600	8,620	8,630	8,640	8,650	8,670	8,680	8,690	8,700
8	**9,110**	**9,130**	**9,140**	**9,160**	**9,170**	**9,180**	**9,200**	**9,210**	**9,220**	**9,240**
8.5	9,640	9,650	9,670	9,680	9,690	9,710	9,720	9,740	9,750	9,770
9	**10,150**	**10,170**	**10,180**	**10,200**	**10,220**	**10,230**	**10,250**	**10,260**	**10,280**	**10,290**
9.5	10,670	10,680	10,700	10,720	10,730	10,750	10,770	10,780	10,800	10,810
10	**11,180**	**11,200**	**11,210**	**11,230**	**11,250**	**11,260**	**11,280**	**11,300**	**11,320**	**11,330**
10.5	11,680	11,700	11,720	11,740	11,760	11,770	11,790	11,810	11,830	11,850
11	**12,180**	**12,200**	**12,220**	**12,240**	**12,260**	**12,280**	**12,300**	**12,320**	**12,340**	**12,360**
11.5	12,680	12,700	12,720	12,740	12,760	12,780	12,800	12,820	12,840	12,860
12	**13,170**	**13,190**	**13,210**	**13,230**	**13,260**	**13,280**	**13,300**	**13,320**	**13,340**	**13,360**
12.5	13,660	13,680	13,700	13,720	13,750	13,770	13,790	13,810	13,830	13,850
13	**14,140**	**14,160**	**14,180**	**14,210**	**14,230**	**14,250**	**14,280**	**14,300**	**14,320**	**14,340**
13.5	14,610	14,640	14,660	14,690	14,710	14,730	14,760	14,780	14,810	14,830
14	**15,090**	**15,110**	**15,140**	**15,160**	**15,180**	**15,210**	**15,230**	**15,260**	**15,280**	**15,310**
14.5	15,550	15,580	15,600	15,630	15,650	15,680	15,710	15,730	15,760	15,780
15	**16,010**	**16,040**	**16,060**	**16,090**	**16,120**	**16,150**	**16,170**	**16,200**	**16,230**	**16,250**
15.5	16,470	16,490	16,520	16,550	16,580	16,610	16,630	16,660	16,690	16,720
16	**16,920**	**16,940**	**16,970**	**17,000**	**17,030**	**17,060**	**17,090**	**17,120**	**17,150**	**17,170**
17	17,800	17,830	17,860	17,890	17,920	17,950	17,980	18,020	18,050	18,080
18	**18,660**	**18,690**	**18,730**	**18,760**	**18,790**	**18,830**	**18,860**	**18,890**	**18,920**	**18,960**
19	19,500	19,530	19,570	19,600	19,640	19,670	19,710	19,750	19,780	19,820
20	**20,310**	**20,350**	**20,390**	**20,430**	**20,460**	**20,500**	**20,540**	**20,580**	**20,610**	**20,650**
21	21,110	21,150	21,190	21,230	21,270	21,310	21,350	21,380	21,420	21,460
22	**21,870**	**21,920**	**21,960**	**22,000**	**22,040**	**22,090**	**22,130**	**22,170**	**22,210**	**22,250**
23	22,620	22,660	22,710	22,750	22,800	22,840	22,880	22,930	22,970	23,020
24	**23,330**	**23,380**	**23,430**	**23,480**	**23,520**	**23,570**	**23,620**	**23,660**	**23,710**	**23,760**
25	24,020	24,070	24,120	24,170	24,220	24,270	24,320	24,370	24,420	24,470
26	**24,690**	**24,740**	**24,790**	**24,840**	**24,900**	**24,950**	**25,000**	**25,050**	**25,110**	**25,160**
27	25,320	25,380	25,430	25,490	25,540	25,600	25,650	25,710	25,760	25,820
28	**25,920**	**25,980**	**26,040**	**26,100**	**26,160**	**26,220**	**26,280**	**26,330**	**26,390**	**26,450**
29	26,500	26,560	26,620	26,680	26,740	26,800	26,870	26,930	26,990	27,050
30	**27,030**	**27,100**	**27,170**	**27,230**	**27,300**	**27,360**	**27,430**	**27,490**	**27,550**	**27,620**
31	27,540	27,610	27,680	27,740	27,810	27,880	27,950	28,020	28,090	28,150
32	**28,000**	**28,080**	**28,150**	**28,220**	**28,290**	**28,370**	**28,440**	**28,510**	**28,580**	**28,650**
33	28,430	28,500	28,580	28,660	28,730	28,810	28,890	28,960	29,040	29,110
34	**28,800**	**28,890**	**28,970**	**29,050**	**29,130**	**29,210**	**29,290**	**29,370**	**29,450**	**29,530**
35	29,130	29,220	29,310	29,390	29,480	29,570	29,650	29,740	29,820	29,910
36	**29,400**	**29,490**	**29,580**	**29,680**	**29,770**	**29,860**	**29,950**	**30,040**	**30,140**	**30,230**
37	29,580	29,680	29,790	29,890	29,990	30,090	30,190	30,290	30,390	30,480
38						**30,210**	**30,320**	**30,440**	**30,550**	**30,660**
39										

Plate VII- 3. Spillway Rating Table, Continued

CORDELL HULL DAM
SPILLWAY GATE RATING TABLE FOR ONE GATE

GATE OPENING	HEADWATER ELEVATION IN FEET									
	503.0	503.1	503.2	503.3	503.4	503.5	503.6	503.7	503.8	503.9
0.5	890	890	890	890	890	890	890	890	900	900
1	**1,680**	**1,680**	**1,680**	**1,680**	**1,690**	**1,690**	**1,690**	**1,690**	**1,690**	**1,700**
1.5	2,380	2,390	2,390	2,390	2,400	2,400	2,400	2,410	2,410	2,410
2	**3,020**	**3,030**	**3,030**	**3,030**	**3,040**	**3,040**	**3,050**	**3,050**	**3,050**	**3,060**
2.5	3,600	3,610	3,610	3,610	3,620	3,620	3,630	3,630	3,640	3,640
3	**4,130**	**4,140**	**4,140**	**4,150**	**4,160**	**4,160**	**4,170**	**4,170**	**4,180**	**4,180**
3.5	4,630	4,640	4,650	4,650	4,660	4,660	4,670	4,680	4,680	4,690
4	**5,110**	**5,120**	**5,120**	**5,130**	**5,140**	**5,150**	**5,150**	**5,160**	**5,170**	**5,170**
4.5	5,580	5,590	5,600	5,600	5,610	5,620	5,630	5,640	5,640	5,650
5	**6,060**	**6,070**	**6,080**	**6,090**	**6,100**	**6,110**	**6,120**	**6,120**	**6,130**	**6,140**
5.5	6,570	6,570	6,580	6,590	6,600	6,610	6,620	6,630	6,640	6,650
6	**7,090**	**7,100**	**7,110**	**7,120**	**7,130**	**7,140**	**7,150**	**7,160**	**7,170**	**7,180**
6.5	7,640	7,650	7,660	7,670	7,680	7,690	7,700	7,710	7,730	7,740
7	**8,180**	**8,190**	**8,200**	**8,210**	**8,230**	**8,240**	**8,250**	**8,260**	**8,270**	**8,280**
7.5	8,720	8,730	8,740	8,750	8,770	8,780	8,790	8,800	8,820	8,830
8	**9,250**	**9,260**	**9,280**	**9,290**	**9,300**	**9,320**	**9,330**	**9,340**	**9,360**	**9,370**
8.5	9,780	9,790	9,810	9,820	9,840	9,850	9,870	9,880	9,890	9,910
9	**10,310**	**10,320**	**10,340**	**10,350**	**10,370**	**10,380**	**10,400**	**10,410**	**10,430**	**10,440**
9.5	10,830	10,850	10,860	10,880	10,890	10,910	10,930	10,940	10,960	10,970
10	**11,350**	**11,370**	**11,380**	**11,400**	**11,420**	**11,430**	**11,450**	**11,470**	**11,480**	**11,500**
10.5	11,860	11,880	11,900	11,920	11,940	11,950	11,970	11,990	12,010	12,020
11	**12,370**	**12,390**	**12,410**	**12,430**	**12,450**	**12,470**	**12,490**	**12,510**	**12,520**	**12,540**
11.5	12,880	12,900	12,920	12,940	12,960	12,980	13,000	13,020	13,040	13,060
12	**13,380**	**13,400**	**13,420**	**13,440**	**13,460**	**13,480**	**13,500**	**13,520**	**13,550**	**13,570**
12.5	13,880	13,900	13,920	13,940	13,960	13,980	14,010	14,030	14,050	14,070
13	**14,370**	**14,390**	**14,410**	**14,430**	**14,460**	**14,480**	**14,500**	**14,520**	**14,550**	**14,570**
13.5	14,850	14,880	14,900	14,920	14,950	14,970	14,990	15,020	15,040	15,060
14	**15,330**	**15,360**	**15,380**	**15,410**	**15,430**	**15,460**	**15,480**	**15,500**	**15,530**	**15,550**
14.5	15,810	15,830	15,860	15,880	15,910	15,940	15,960	15,990	16,010	16,040
15	**16,280**	**16,300**	**16,330**	**16,360**	**16,380**	**16,410**	**16,440**	**16,460**	**16,490**	**16,520**
15.5	16,740	16,770	16,800	16,830	16,850	16,880	16,910	16,940	16,960	16,990
16	**17,200**	**17,230**	**17,260**	**17,290**	**17,320**	**17,350**	**17,370**	**17,400**	**17,430**	**17,460**
17	18,110	18,140	18,170	18,200	18,230	18,260	18,290	18,320	18,350	18,380
18	**18,990**	**19,020**	**19,050**	**19,090**	**19,120**	**19,150**	**19,180**	**19,220**	**19,250**	**19,280**
19	19,850	19,880	19,920	19,950	19,990	20,020	20,060	20,090	20,130	20,160
20	**20,690**	**20,730**	**20,760**	**20,800**	**20,840**	**20,870**	**20,910**	**20,950**	**20,980**	**21,020**
21	21,500	21,540	21,580	21,620	21,660	21,700	21,740	21,780	21,820	21,850
22	**22,290**	**22,340**	**22,380**	**22,420**	**22,460**	**22,500**	**22,540**	**22,580**	**22,630**	**22,670**
23	23,060	23,110	23,150	23,190	23,240	23,280	23,320	23,370	23,410	23,460
24	**23,800**	**23,850**	**23,900**	**23,940**	**23,990**	**24,040**	**24,080**	**24,130**	**24,170**	**24,220**
25	24,520	24,570	24,620	24,670	24,720	24,770	24,810	24,860	24,910	24,960
26	**25,210**	**25,260**	**25,310**	**25,370**	**25,420**	**25,470**	**25,520**	**25,570**	**25,620**	**25,670**
27	25,870	25,930	25,980	26,040	26,090	26,140	26,200	26,250	26,310	26,360
28	**26,510**	**26,560**	**26,620**	**26,680**	**26,740**	**26,790**	**26,850**	**26,910**	**26,960**	**27,020**
29	27,110	27,170	27,230	27,290	27,350	27,410	27,470	27,530	27,590	27,650
30	**27,680**	**27,750**	**27,810**	**27,870**	**27,940**	**28,000**	**28,060**	**28,120**	**28,190**	**28,250**
31	28,220	28,290	28,350	28,420	28,490	28,550	28,620	28,690	28,750	28,820
32	**28,720**	**28,790**	**28,860**	**28,930**	**29,000**	**29,070**	**29,140**	**29,210**	**29,280**	**29,350**
33	29,190	29,260	29,340	29,410	29,490	29,560	29,630	29,710	29,780	29,850
34	**29,610**	**29,690**	**29,770**	**29,850**	**29,930**	**30,000**	**30,080**	**30,160**	**30,240**	**30,310**
35	29,990	30,070	30,160	30,240	30,320	30,400	30,490	30,570	30,650	30,730
36	**30,320**	**30,400**	**30,490**	**30,580**	**30,670**	**30,760**	**30,840**	**30,930**	**31,020**	**31,100**
37	30,580	30,680	30,770	30,870	30,960	31,050	31,150	31,240	31,330	31,420
38	**30,760**	**30,870**	**30,970**	**31,080**	**31,180**	**31,280**	**31,380**	**31,480**	**31,580**	**31,680**
39						31,400	31,520	31,630	31,740	31,850

Plate VII- 3. Spillway Rating Table, Continued

CORDELL HULL DAM
SPILLWAY GATE RATING TABLE FOR ONE GATE

GATE OPENING	HEADWATER ELEVATION IN FEET									
	504.0	504.1	504.2	504.3	504.4	504.5	504.6	504.7	504.8	504.9
0.5	900	900	900	900	900	900	900	910	910	910
1	**1,700**	**1,700**	**1,700**	**1,710**	**1,710**	**1,710**	**1,710**	**1,710**	**1,720**	**1,720**
1.5	2,420	2,420	2,420	2,430	2,430	2,430	2,430	2,440	2,440	2,440
2	**3,060**	**3,070**	**3,070**	**3,070**	**3,080**	**3,080**	**3,090**	**3,090**	**3,090**	**3,100**
2.5	3,650	3,650	3,660	3,660	3,670	3,670	3,680	3,680	3,690	3,690
3	**4,190**	**4,190**	**4,200**	**4,210**	**4,210**	**4,220**	**4,220**	**4,230**	**4,230**	**4,240**
3.5	4,700	4,700	4,710	4,710	4,720	4,730	4,730	4,740	4,740	4,750
4	**5,180**	**5,190**	**5,190**	**5,200**	**5,210**	**5,210**	**5,220**	**5,230**	**5,240**	**5,240**
4.5	5,660	5,670	5,670	5,680	5,690	5,700	5,700	5,710	5,720	5,730
5	**6,150**	**6,160**	**6,170**	**6,170**	**6,180**	**6,190**	**6,200**	**6,210**	**6,210**	**6,220**
5.5	6,660	6,670	6,670	6,680	6,690	6,700	6,710	6,720	6,730	6,740
6	**7,190**	**7,200**	**7,210**	**7,220**	**7,230**	**7,240**	**7,250**	**7,260**	**7,270**	**7,280**
6.5	7,750	7,760	7,770	7,780	7,790	7,800	7,810	7,820	7,830	7,840
7	**8,300**	**8,310**	**8,320**	**8,330**	**8,340**	**8,350**	**8,360**	**8,380**	**8,390**	**8,400**
7.5	8,840	8,850	8,870	8,880	8,890	8,900	8,920	8,930	8,940	8,950
8	**9,380**	**9,400**	**9,410**	**9,420**	**9,440**	**9,450**	**9,460**	**9,480**	**9,490**	**9,500**
8.5	9,920	9,940	9,950	9,960	9,980	9,990	10,010	10,020	10,030	10,050
9	**10,460**	**10,470**	**10,490**	**10,500**	**10,520**	**10,530**	**10,550**	**10,560**	**10,580**	**10,590**
9.5	10,990	11,010	11,020	11,040	11,050	11,070	11,080	11,100	11,120	11,130
10	**11,520**	**11,530**	**11,550**	**11,570**	**11,580**	**11,600**	**11,620**	**11,630**	**11,650**	**11,670**
10.5	12,040	12,060	12,080	12,100	12,110	12,130	12,150	12,170	12,180	12,200
11	**12,560**	**12,580**	**12,600**	**12,620**	**12,640**	**12,650**	**12,670**	**12,690**	**12,710**	**12,730**
11.5	13,080	13,100	13,120	13,130	13,150	13,170	13,190	13,210	13,230	13,250
12	**13,590**	**13,610**	**13,630**	**13,650**	**13,670**	**13,690**	**13,710**	**13,730**	**13,750**	**13,770**
12.5	14,090	14,110	14,130	14,150	14,180	14,200	14,220	14,240	14,260	14,280
13	**14,590**	**14,610**	**14,640**	**14,660**	**14,680**	**14,700**	**14,720**	**14,750**	**14,770**	**14,790**
13.5	15,090	15,110	15,130	15,160	15,180	15,200	15,220	15,250	15,270	15,290
14	**15,580**	**15,600**	**15,620**	**15,650**	**15,670**	**15,700**	**15,720**	**15,740**	**15,770**	**15,790**
14.5	16,060	16,090	16,110	16,140	16,160	16,190	16,210	16,240	16,260	16,290
15	**16,540**	**16,570**	**16,590**	**16,620**	**16,650**	**16,670**	**16,700**	**16,720**	**16,750**	**16,770**
15.5	17,020	17,040	17,070	17,100	17,120	17,150	17,180	17,200	17,230	17,260
16	**17,490**	**17,510**	**17,540**	**17,570**	**17,600**	**17,630**	**17,650**	**17,680**	**17,710**	**17,740**
17	18,410	18,440	18,470	18,500	18,530	18,560	18,590	18,620	18,650	18,680
18	**19,310**	**19,350**	**19,380**	**19,410**	**19,440**	**19,470**	**19,510**	**19,540**	**19,570**	**19,600**
19	20,200	20,230	20,260	20,300	20,330	20,370	20,400	20,430	20,470	20,500
20	**21,060**	**21,090**	**21,130**	**21,160**	**21,200**	**21,240**	**21,270**	**21,310**	**21,340**	**21,380**
21	21,890	21,930	21,970	22,010	22,050	22,090	22,120	22,160	22,200	22,240
22	**22,710**	**22,750**	**22,790**	**22,830**	**22,870**	**22,910**	**22,950**	**22,990**	**23,030**	**23,070**
23	23,500	23,540	23,580	23,630	23,670	23,710	23,760	23,800	23,840	23,880
24	**24,270**	**24,310**	**24,360**	**24,400**	**24,450**	**24,490**	**24,540**	**24,580**	**24,630**	**24,670**
25	25,010	25,060	25,100	25,150	25,200	25,250	25,290	25,340	25,390	25,440
26	**25,720**	**25,770**	**25,820**	**25,870**	**25,930**	**25,980**	**26,030**	**26,080**	**26,130**	**26,180**
27	26,410	26,470	26,520	26,570	26,630	26,680	26,730	26,780	26,840	26,890
28	**27,070**	**27,130**	**27,190**	**27,240**	**27,300**	**27,350**	**27,410**	**27,460**	**27,520**	**27,570**
29	27,710	27,770	27,830	27,880	27,940	28,000	28,060	28,120	28,180	28,230
30	**28,310**	**28,370**	**28,430**	**28,500**	**28,560**	**28,620**	**28,680**	**28,740**	**28,800**	**28,860**
31	28,880	28,950	29,010	29,080	29,140	29,210	29,270	29,340	29,400	29,460
32	**29,420**	**29,490**	**29,560**	**29,630**	**29,690**	**29,760**	**29,830**	**29,900**	**29,960**	**30,030**
33	29,920	30,000	30,070	30,140	30,210	30,280	30,350	30,420	30,500	30,570
34	**30,390**	**30,460**	**30,540**	**30,620**	**30,690**	**30,770**	**30,840**	**30,920**	**30,990**	**31,070**
35	30,810	30,890	30,970	31,050	31,130	31,210	31,290	31,370	31,450	31,530
36	**31,190**	**31,270**	**31,360**	**31,440**	**31,530**	**31,610**	**31,700**	**31,780**	**31,860**	**31,940**
37	31,510	31,610	31,700	31,790	31,880	31,960	32,050	32,140	32,230	32,320
38	**31,780**	**31,880**	**31,970**	**32,070**	**32,170**	**32,260**	**32,360**	**32,450**	**32,540**	**32,640**
39	31,960	32,070	32,170	32,280	32,380	32,490	32,590	32,690	32,790	32,890

Plate VII- 3. Spillway Rating Table, Continued

CORDELL HULL DAM
SPILLWAY GATE RATING TABLE FOR ONE GATE

GATE OPENING	HEADWATER ELEVATION IN FEET									
	505.0	505.1	505.2	505.3	505.4	505.5	505.6	505.7	505.8	505.9
0.5	910	910	910	910	910	910	920	920	920	920
1	**1,720**	**1,720**	**1,730**	**1,730**	**1,730**	**1,730**	**1,730**	**1,740**	**1,740**	**1,740**
1.5	2,450	2,450	2,450	2,460	2,460	2,460	2,470	2,470	2,470	2,470
2	**3,100**	**3,100**	**3,110**	**3,110**	**3,120**	**3,120**	**3,120**	**3,130**	**3,130**	**3,140**
2.5	3,700	3,700	3,710	3,710	3,710	3,720	3,720	3,730	3,730	3,740
3	**4,240**	**4,250**	**4,250**	**4,260**	**4,270**	**4,270**	**4,280**	**4,280**	**4,290**	**4,290**
3.5	4,760	4,760	4,770	4,780	4,780	4,790	4,790	4,800	4,810	4,810
4	**5,250**	**5,260**	**5,260**	**5,270**	**5,280**	**5,280**	**5,290**	**5,300**	**5,300**	**5,310**
4.5	5,730	5,740	5,750	5,760	5,760	5,770	5,780	5,790	5,790	5,800
5	**6,230**	**6,240**	**6,250**	**6,260**	**6,260**	**6,270**	**6,280**	**6,290**	**6,300**	**6,300**
5.5	6,750	6,760	6,760	6,770	6,780	6,790	6,800	6,810	6,820	6,830
6	**7,290**	**7,300**	**7,310**	**7,320**	**7,330**	**7,340**	**7,350**	**7,360**	**7,370**	**7,380**
6.5	7,850	7,860	7,870	7,880	7,890	7,910	7,920	7,930	7,940	7,950
7	**8,410**	**8,420**	**8,430**	**8,440**	**8,460**	**8,470**	**8,480**	**8,490**	**8,500**	**8,510**
7.5	8,960	8,980	8,990	9,000	9,010	9,030	9,040	9,050	9,060	9,070
8	**9,520**	**9,530**	**9,540**	**9,550**	**9,570**	**9,580**	**9,590**	**9,610**	**9,620**	**9,630**
8.5	10,060	10,080	10,090	10,100	10,120	10,130	10,150	10,160	10,170	10,190
9	**10,610**	**10,620**	**10,640**	**10,650**	**10,670**	**10,680**	**10,690**	**10,710**	**10,720**	**10,740**
9.5	11,150	11,160	11,180	11,190	11,210	11,220	11,240	11,260	11,270	11,290
10	**11,680**	**11,700**	**11,720**	**11,730**	**11,750**	**11,770**	**11,780**	**11,800**	**11,820**	**11,830**
10.5	12,220	12,230	12,250	12,270	12,290	12,300	12,320	12,340	12,360	12,370
11	**12,750**	**12,760**	**12,780**	**12,800**	**12,820**	**12,840**	**12,860**	**12,870**	**12,890**	**12,910**
11.5	13,270	13,290	13,310	13,330	13,350	13,370	13,380	13,400	13,420	13,440
12	**13,790**	**13,810**	**13,830**	**13,850**	**13,870**	**13,890**	**13,910**	**13,930**	**13,950**	**13,970**
12.5	14,300	14,320	14,340	14,370	14,390	14,410	14,430	14,450	14,470	14,490
13	**14,810**	**14,830**	**14,860**	**14,880**	**14,900**	**14,920**	**14,940**	**14,960**	**14,990**	**15,010**
13.5	15,320	15,340	15,360	15,380	15,410	15,430	15,450	15,480	15,500	15,520
14	**15,820**	**15,840**	**15,860**	**15,890**	**15,910**	**15,930**	**15,960**	**15,980**	**16,010**	**16,030**
14.5	16,310	16,340	16,360	16,380	16,410	16,430	16,460	16,480	16,510	16,530
15	**16,800**	**16,830**	**16,850**	**16,880**	**16,900**	**16,930**	**16,950**	**16,980**	**17,000**	**17,030**
15.5	17,290	17,310	17,340	17,360	17,390	17,420	17,440	17,470	17,500	17,520
16	**17,760**	**17,790**	**17,820**	**17,850**	**17,870**	**17,900**	**17,930**	**17,960**	**17,980**	**18,010**
17	18,710	18,740	18,770	18,800	18,830	18,860	18,890	18,910	18,940	18,970
18	**19,630**	**19,660**	**19,700**	**19,730**	**19,760**	**19,790**	**19,820**	**19,850**	**19,880**	**19,910**
19	20,540	20,570	20,600	20,640	20,670	20,700	20,740	20,770	20,800	20,840
20	**21,420**	**21,450**	**21,490**	**21,520**	**21,560**	**21,590**	**21,630**	**21,670**	**21,700**	**21,740**
21	22,280	22,310	22,350	22,390	22,430	22,460	22,500	22,540	22,580	22,610
22	**23,110**	**23,150**	**23,190**	**23,230**	**23,270**	**23,310**	**23,350**	**23,390**	**23,430**	**23,470**
23	23,930	23,970	24,010	24,050	24,100	24,140	24,180	24,220	24,260	24,310
24	**24,720**	**24,760**	**24,810**	**24,850**	**24,900**	**24,940**	**24,980**	**25,030**	**25,070**	**25,120**
25	25,480	25,530	25,580	25,620	25,670	25,720	25,760	25,810	25,860	25,900
26	**26,220**	**26,270**	**26,320**	**26,370**	**26,420**	**26,470**	**26,520**	**26,570**	**26,620**	**26,670**
27	26,940	26,990	27,040	27,100	27,150	27,200	27,250	27,300	27,360	27,410
28	**27,630**	**27,680**	**27,740**	**27,790**	**27,850**	**27,900**	**27,960**	**28,010**	**28,070**	**28,120**
29	28,290	28,350	28,410	28,460	28,520	28,580	28,640	28,690	28,750	28,810
30	**28,920**	**28,980**	**29,050**	**29,110**	**29,170**	**29,230**	**29,290**	**29,340**	**29,400**	**29,460**
31	29,530	29,590	29,650	29,720	29,780	29,840	29,910	29,970	30,030	30,090
32	**30,100**	**30,170**	**30,230**	**30,300**	**30,360**	**30,430**	**30,500**	**30,560**	**30,630**	**30,690**
33	30,640	30,710	30,780	30,850	30,920	30,990	31,050	31,120	31,190	31,260
34	**31,140**	**31,210**	**31,290**	**31,360**	**31,430**	**31,510**	**31,580**	**31,650**	**31,720**	**31,800**
35	31,600	31,680	31,760	31,840	31,910	31,990	32,070	32,140	32,220	32,290
36	**32,030**	**32,110**	**32,190**	**32,270**	**32,350**	**32,430**	**32,510**	**32,590**	**32,670**	**32,750**
37	32,400	32,490	32,580	32,660	32,750	32,830	32,920	33,000	33,090	33,170
38	**32,730**	**32,820**	**32,910**	**33,010**	**33,100**	**33,190**	**33,280**	**33,370**	**33,460**	**33,540**
39	32,990	33,090	33,190	33,290	33,390	33,480	33,580	33,670	33,770	33,860

Plate VII- 3. Spillway Rating Table, Continued

CORDELL HULL DAM
SPILLWAY GATE RATING TABLE FOR ONE GATE

GATE OPENING	HEADWATER ELEVATION IN FEET									
	506.0	506.1	506.2	506.3	506.4	506.5	506.6	506.7	506.8	506.9
0.5	920	920	920	920	930	930	930	930	930	930
1	**1,740**	**1,740**	**1,750**	**1,750**	**1,750**	**1,750**	**1,750**	**1,760**	**1,760**	**1,760**
1.5	2,480	2,480	2,480	2,490	2,490	2,490	2,500	2,500	2,500	2,500
2	**3,140**	**3,140**	**3,150**	**3,150**	**3,160**	**3,160**	**3,160**	**3,170**	**3,170**	**3,170**
2.5	3,740	3,750	3,750	3,760	3,760	3,770	3,770	3,770	3,780	3,780
3	**4,300**	**4,300**	**4,310**	**4,310**	**4,320**	**4,320**	**4,330**	**4,330**	**4,340**	**4,350**
3.5	4,820	4,820	4,830	4,840	4,840	4,850	4,850	4,860	4,870	4,870
4	**5,320**	**5,320**	**5,330**	**5,340**	**5,340**	**5,350**	**5,360**	**5,360**	**5,370**	**5,380**
4.5	5,810	5,820	5,820	5,830	5,840	5,840	5,850	5,860	5,870	5,870
5	**6,310**	**6,320**	**6,330**	**6,340**	**6,350**	**6,350**	**6,360**	**6,370**	**6,380**	**6,390**
5.5	6,840	6,840	6,850	6,860	6,870	6,880	6,890	6,900	6,910	6,910
6	**7,390**	**7,400**	**7,410**	**7,420**	**7,430**	**7,440**	**7,450**	**7,460**	**7,460**	**7,470**
6.5	7,960	7,970	7,980	7,990	8,000	8,010	8,020	8,030	8,040	8,050
7	**8,520**	**8,530**	**8,550**	**8,560**	**8,570**	**8,580**	**8,590**	**8,600**	**8,610**	**8,620**
7.5	9,090	9,100	9,110	9,120	9,130	9,150	9,160	9,170	9,180	9,190
8	**9,640**	**9,660**	**9,670**	**9,680**	**9,700**	**9,710**	**9,720**	**9,730**	**9,750**	**9,760**
8.5	10,200	10,210	10,230	10,240	10,260	10,270	10,280	10,300	10,310	10,320
9	**10,750**	**10,770**	**10,780**	**10,800**	**10,810**	**10,830**	**10,840**	**10,850**	**10,870**	**10,880**
9.5	11,300	11,320	11,330	11,350	11,360	11,380	11,390	11,410	11,420	11,440
10	**11,850**	**11,860**	**11,880**	**11,900**	**11,910**	**11,930**	**11,950**	**11,960**	**11,980**	**11,990**
10.5	12,390	12,410	12,420	12,440	12,460	12,480	12,490	12,510	12,530	12,540
11	**12,930**	**12,950**	**12,960**	**12,980**	**13,000**	**13,020**	**13,040**	**13,050**	**13,070**	**13,090**
11.5	13,460	13,480	13,500	13,520	13,540	13,550	13,570	13,590	13,610	13,630
12	**13,990**	**14,010**	**14,030**	**14,050**	**14,070**	**14,090**	**14,110**	**14,130**	**14,150**	**14,160**
12.5	14,510	14,530	14,550	14,570	14,590	14,610	14,630	14,660	14,680	14,700
13	**15,030**	**15,050**	**15,070**	**15,090**	**15,120**	**15,140**	**15,160**	**15,180**	**15,200**	**15,220**
13.5	15,540	15,570	15,590	15,610	15,630	15,660	15,680	15,700	15,720	15,740
14	**16,050**	**16,080**	**16,100**	**16,120**	**16,150**	**16,170**	**16,190**	**16,220**	**16,240**	**16,260**
14.5	16,560	16,580	16,600	16,630	16,650	16,680	16,700	16,730	16,750	16,770
15	**17,060**	**17,080**	**17,110**	**17,130**	**17,160**	**17,180**	**17,210**	**17,230**	**17,260**	**17,280**
15.5	17,550	17,580	17,600	17,630	17,650	17,680	17,710	17,730	17,760	17,780
16	**18,040**	**18,070**	**18,090**	**18,120**	**18,150**	**18,170**	**18,200**	**18,230**	**18,250**	**18,280**
17	19,000	19,030	19,060	19,090	19,120	19,150	19,180	19,210	19,230	19,260
18	**19,950**	**19,980**	**20,010**	**20,040**	**20,070**	**20,100**	**20,130**	**20,160**	**20,190**	**20,220**
19	20,870	20,900	20,940	20,970	21,000	21,030	21,070	21,100	21,130	21,160
20	**21,770**	**21,810**	**21,840**	**21,880**	**21,910**	**21,950**	**21,980**	**22,020**	**22,050**	**22,090**
21	22,650	22,690	22,730	22,760	22,800	22,840	22,870	22,910	22,950	22,980
22	**23,510**	**23,550**	**23,590**	**23,630**	**23,670**	**23,710**	**23,750**	**23,780**	**23,820**	**23,860**
23	24,350	24,390	24,430	24,470	24,510	24,550	24,600	24,640	24,680	24,720
24	**25,160**	**25,200**	**25,250**	**25,290**	**25,340**	**25,380**	**25,420**	**25,470**	**25,510**	**25,550**
25	25,950	26,000	26,040	26,090	26,130	26,180	26,230	26,270	26,320	26,360
26	**26,720**	**26,770**	**26,810**	**26,860**	**26,910**	**26,960**	**27,010**	**27,050**	**27,100**	**27,150**
27	27,460	27,510	27,560	27,610	27,660	27,710	27,760	27,810	27,860	27,910
28	**28,170**	**28,230**	**28,280**	**28,330**	**28,390**	**28,440**	**28,490**	**28,550**	**28,600**	**28,650**
29	28,860	28,920	28,970	29,030	29,090	29,140	29,200	29,250	29,310	29,360
30	**29,520**	**29,580**	**29,640**	**29,700**	**29,760**	**29,820**	**29,880**	**29,930**	**29,990**	**30,050**
31	30,160	30,220	30,280	30,340	30,400	30,460	30,530	30,590	30,650	30,710
32	**30,760**	**30,820**	**30,890**	**30,950**	**31,020**	**31,080**	**31,150**	**31,210**	**31,270**	**31,340**
33	31,330	31,400	31,470	31,530	31,600	31,670	31,740	31,800	31,870	31,940
34	**31,870**	**31,940**	**32,010**	**32,080**	**32,150**	**32,220**	**32,290**	**32,360**	**32,430**	**32,500**
35	32,370	32,440	32,520	32,590	32,670	32,740	32,820	32,890	32,960	33,040
36	**32,830**	**32,910**	**32,990**	**33,070**	**33,150**	**33,230**	**33,300**	**33,380**	**33,460**	**33,540**
37	33,260	33,340	33,420	33,510	33,590	33,670	33,750	33,830	33,920	34,000
38	**33,630**	**33,720**	**33,810**	**33,900**	**33,980**	**34,070**	**34,160**	**34,240**	**34,330**	**34,420**
39	33,960	34,050	34,150	34,240	34,330	34,420	34,510	34,610	34,700	34,790

Plate VII- 3. Spillway Rating Table, Continued

CORDELL HULL DAM
SPILLWAY GATE RATING TABLE FOR ONE GATE

GATE OPENING	HEADWATER ELEVATION IN FEET									
	507.0	507.1	507.2	507.3	507.4	507.5	507.6	507.7	507.8	507.9
0.5	930	930	930	930	940	940	940	940	940	940
1	**1,760**	**1,770**	**1,770**	**1,770**	**1,770**	**1,770**	**1,780**	**1,780**	**1,780**	**1,780**
1.5	2,510	2,510	2,510	2,520	2,520	2,520	2,530	2,530	2,530	2,530
2	**3,180**	**3,180**	**3,190**	**3,190**	**3,190**	**3,200**	**3,200**	**3,210**	**3,210**	**3,210**
2.5	3,790	3,790	3,800	3,800	3,810	3,810	3,820	3,820	3,830	3,830
3	**4,350**	**4,360**	**4,360**	**4,370**	**4,370**	**4,380**	**4,380**	**4,390**	**4,390**	**4,400**
3.5	4,880	4,880	4,890	4,900	4,900	4,910	4,910	4,920	4,930	4,930
4	**5,380**	**5,390**	**5,400**	**5,400**	**5,410**	**5,420**	**5,420**	**5,430**	**5,440**	**5,440**
4.5	5,880	5,890	5,900	5,900	5,910	5,920	5,930	5,930	5,940	5,950
5	**6,390**	**6,400**	**6,410**	**6,420**	**6,430**	**6,430**	**6,440**	**6,450**	**6,460**	**6,460**
5.5	6,920	6,930	6,940	6,950	6,960	6,970	6,980	6,980	6,990	7,000
6	**7,480**	**7,490**	**7,500**	**7,510**	**7,520**	**7,530**	**7,540**	**7,550**	**7,560**	**7,570**
6.5	8,060	8,070	8,080	8,090	8,100	8,110	8,120	8,130	8,140	8,150
7	**8,640**	**8,650**	**8,660**	**8,670**	**8,680**	**8,690**	**8,700**	**8,710**	**8,720**	**8,730**
7.5	9,210	9,220	9,230	9,240	9,250	9,270	9,280	9,290	9,300	9,310
8	**9,770**	**9,790**	**9,800**	**9,810**	**9,820**	**9,840**	**9,850**	**9,860**	**9,870**	**9,890**
8.5	10,340	10,350	10,360	10,380	10,390	10,400	10,420	10,430	10,440	10,460
9	**10,900**	**10,910**	**10,930**	**10,940**	**10,960**	**10,970**	**10,980**	**11,000**	**11,010**	**11,030**
9.5	11,460	11,470	11,490	11,500	11,520	11,530	11,550	11,560	11,580	11,590
10	**12,010**	**12,030**	**12,040**	**12,060**	**12,070**	**12,090**	**12,110**	**12,120**	**12,140**	**12,150**
10.5	12,560	12,580	12,590	12,610	12,630	12,640	12,660	12,680	12,700	12,710
11	**13,110**	**13,120**	**13,140**	**13,160**	**13,180**	**13,190**	**13,210**	**13,230**	**13,250**	**13,270**
11.5	13,650	13,670	13,680	13,700	13,720	13,740	13,760	13,780	13,800	13,810
12	**14,180**	**14,200**	**14,220**	**14,240**	**14,260**	**14,280**	**14,300**	**14,320**	**14,340**	**14,360**
12.5	14,720	14,740	14,760	14,780	14,800	14,820	14,840	14,860	14,880	14,900
13	**15,240**	**15,270**	**15,290**	**15,310**	**15,330**	**15,350**	**15,370**	**15,390**	**15,410**	**15,430**
13.5	15,770	15,790	15,810	15,830	15,860	15,880	15,900	15,920	15,940	15,960
14	**16,280**	**16,310**	**16,330**	**16,350**	**16,380**	**16,400**	**16,420**	**16,450**	**16,470**	**16,490**
14.5	16,800	16,820	16,850	16,870	16,890	16,920	16,940	16,960	16,990	17,010
15	**17,310**	**17,330**	**17,360**	**17,380**	**17,410**	**17,430**	**17,460**	**17,480**	**17,500**	**17,530**
15.5	17,810	17,840	17,860	17,890	17,910	17,940	17,960	17,990	18,020	18,040
16	**18,310**	**18,340**	**18,360**	**18,390**	**18,420**	**18,440**	**18,470**	**18,500**	**18,520**	**18,550**
17	19,290	19,320	19,350	19,380	19,410	19,430	19,460	19,490	19,520	19,550
18	**20,250**	**20,290**	**20,320**	**20,350**	**20,380**	**20,410**	**20,440**	**20,470**	**20,500**	**20,530**
19	21,200	21,230	21,260	21,290	21,330	21,360	21,390	21,420	21,460	21,490
20	**22,120**	**22,150**	**22,190**	**22,220**	**22,260**	**22,290**	**22,330**	**22,360**	**22,390**	**22,430**
21	23,020	23,060	23,090	23,130	23,170	23,200	23,240	23,280	23,310	23,350
22	**23,900**	**23,940**	**23,980**	**24,020**	**24,060**	**24,090**	**24,130**	**24,170**	**24,210**	**24,250**
23	24,760	24,800	24,840	24,880	24,920	24,960	25,000	25,040	25,080	25,120
24	**25,600**	**25,640**	**25,680**	**25,720**	**25,770**	**25,810**	**25,850**	**25,900**	**25,940**	**25,980**
25	26,410	26,450	26,500	26,540	26,590	26,630	26,680	26,720	26,770	26,810
26	**27,200**	**27,250**	**27,290**	**27,340**	**27,390**	**27,440**	**27,480**	**27,530**	**27,580**	**27,620**
27	27,960	28,010	28,060	28,110	28,160	28,210	28,260	28,310	28,360	28,410
28	**28,700**	**28,760**	**28,810**	**28,860**	**28,910**	**28,970**	**29,020**	**29,070**	**29,120**	**29,170**
29	29,420	29,470	29,530	29,580	29,640	29,690	29,750	29,800	29,860	29,910
30	**30,110**	**30,170**	**30,220**	**30,280**	**30,340**	**30,400**	**30,450**	**30,510**	**30,570**	**30,620**
31	30,770	30,830	30,890	30,950	31,010	31,070	31,130	31,190	31,250	31,310
32	**31,400**	**31,460**	**31,530**	**31,590**	**31,650**	**31,720**	**31,780**	**31,840**	**31,900**	**31,970**
33	32,000	32,070	32,140	32,200	32,270	32,330	32,400	32,470	32,530	32,600
34	**32,570**	**32,640**	**32,710**	**32,780**	**32,850**	**32,920**	**32,990**	**33,060**	**33,130**	**33,200**
35	33,110	33,180	33,260	33,330	33,400	33,480	33,550	33,620	33,690	33,760
36	**33,610**	**33,690**	**33,770**	**33,840**	**33,920**	**34,000**	**34,070**	**34,150**	**34,220**	**34,300**
37	34,080	34,160	34,240	34,320	34,400	34,480	34,560	34,640	34,720	34,790
38	**34,500**	**34,590**	**34,670**	**34,750**	**34,840**	**34,920**	**35,010**	**35,090**	**35,170**	**35,250**
39	34,880	34,970	35,060	35,150	35,230	35,320	35,410	35,500	35,590	35,670

Plate VII- 3. Spillway Rating Table, Continued

CORDELL HULL DAM
SPILLWAY GATE RATING TABLE FOR ONE GATE

GATE OPENING	HEADWATER ELEVATION IN FEET									
	508.0	508.1	508.2	508.3	508.4	508.5	508.6	508.7	508.8	508.9
0.5	940	940	940	950	950	950	950	950	950	950
1	**1,780**	**1,790**	**1,790**	**1,790**	**1,790**	**1,790**	**1,800**	**1,800**	**1,800**	**1,800**
1.5	2,540	2,540	2,540	2,550	2,550	2,550	2,560	2,560	2,560	2,560
2	**3,220**	**3,220**	**3,220**	**3,230**	**3,230**	**3,240**	**3,240**	**3,240**	**3,250**	**3,250**
2.5	3,830	3,840	3,840	3,850	3,850	3,860	3,860	3,870	3,870	3,870
3	**4,400**	**4,410**	**4,410**	**4,420**	**4,420**	**4,430**	**4,430**	**4,440**	**4,450**	**4,450**
3.5	4,940	4,940	4,950	4,960	4,960	4,970	4,970	4,980	4,980	4,990
4	**5,450**	**5,460**	**5,460**	**5,470**	**5,480**	**5,480**	**5,490**	**5,500**	**5,500**	**5,510**
4.5	5,950	5,960	5,970	5,980	5,980	5,990	6,000	6,000	6,010	6,020
5	**6,470**	**6,480**	**6,490**	**6,500**	**6,500**	**6,510**	**6,520**	**6,530**	**6,540**	**6,540**
5.5	7,010	7,020	7,030	7,040	7,040	7,050	7,060	7,070	7,080	7,090
6	**7,580**	**7,590**	**7,600**	**7,610**	**7,620**	**7,620**	**7,630**	**7,640**	**7,650**	**7,660**
6.5	8,160	8,170	8,180	8,190	8,200	8,210	8,220	8,230	8,240	8,250
7	**8,750**	**8,760**	**8,770**	**8,780**	**8,790**	**8,800**	**8,810**	**8,820**	**8,830**	**8,840**
7.5	9,320	9,340	9,350	9,360	9,370	9,380	9,390	9,410	9,420	9,430
8	**9,900**	**9,910**	**9,920**	**9,940**	**9,950**	**9,960**	**9,970**	**9,990**	**10,000**	**10,010**
8.5	10,470	10,480	10,500	10,510	10,520	10,540	10,550	10,560	10,580	10,590
9	**11,040**	**11,050**	**11,070**	**11,080**	**11,100**	**11,110**	**11,130**	**11,140**	**11,150**	**11,170**
9.5	11,610	11,620	11,640	11,650	11,670	11,680	11,700	11,710	11,730	11,740
10	**12,170**	**12,190**	**12,200**	**12,220**	**12,230**	**12,250**	**12,260**	**12,280**	**12,300**	**12,310**
10.5	12,730	12,750	12,760	12,780	12,800	12,810	12,830	12,840	12,860	12,880
11	**13,280**	**13,300**	**13,320**	**13,340**	**13,350**	**13,370**	**13,390**	**13,410**	**13,420**	**13,440**
11.5	13,830	13,850	13,870	13,890	13,910	13,920	13,940	13,960	13,980	14,000
12	**14,380**	**14,400**	**14,420**	**14,440**	**14,460**	**14,470**	**14,490**	**14,510**	**14,530**	**14,550**
12.5	14,920	14,940	14,960	14,980	15,000	15,020	15,040	15,060	15,080	15,100
13	**15,460**	**15,480**	**15,500**	**15,520**	**15,540**	**15,560**	**15,580**	**15,600**	**15,620**	**15,640**
13.5	15,990	16,010	16,030	16,050	16,070	16,100	16,120	16,140	16,160	16,180
14	**16,510**	**16,540**	**16,560**	**16,580**	**16,600**	**16,630**	**16,650**	**16,670**	**16,690**	**16,720**
14.5	17,040	17,060	17,080	17,110	17,130	17,150	17,180	17,200	17,220	17,250
15	**17,550**	**17,580**	**17,600**	**17,630**	**17,650**	**17,680**	**17,700**	**17,720**	**17,750**	**17,770**
15.5	18,070	18,090	18,120	18,140	18,170	18,190	18,220	18,240	18,270	18,290
16	**18,570**	**18,600**	**18,630**	**18,650**	**18,680**	**18,710**	**18,730**	**18,760**	**18,780**	**18,810**
17	19,580	19,600	19,630	19,660	19,690	19,720	19,740	19,770	19,800	19,830
18	**20,560**	**20,590**	**20,620**	**20,650**	**20,680**	**20,710**	**20,740**	**20,770**	**20,800**	**20,830**
19	21,520	21,550	21,580	21,620	21,650	21,680	21,710	21,740	21,780	21,810
20	**22,460**	**22,500**	**22,530**	**22,560**	**22,600**	**22,630**	**22,670**	**22,700**	**22,730**	**22,770**
21	23,380	23,420	23,460	23,490	23,530	23,560	23,600	23,640	23,670	23,710
22	**24,290**	**24,320**	**24,360**	**24,400**	**24,440**	**24,480**	**24,510**	**24,550**	**24,590**	**24,630**
23	25,170	25,210	25,250	25,290	25,330	25,370	25,410	25,440	25,480	25,520
24	**26,020**	**26,070**	**26,110**	**26,150**	**26,190**	**26,230**	**26,280**	**26,320**	**26,360**	**26,400**
25	**26,860**	**26,900**	**26,950**	**26,990**	**27,040**	**27,080**	**27,120**	**27,170**	**27,210**	**27,260**
26	**27,670**	**27,720**	**27,760**	**27,810**	**27,860**	**27,900**	**27,950**	**28,000**	**28,040**	**28,090**
27	28,460	28,510	28,560	28,610	28,660	28,710	28,750	28,800	28,850	28,900
28	**29,230**	**29,280**	**29,330**	**29,380**	**29,430**	**29,480**	**29,530**	**29,580**	**29,640**	**29,690**
29	29,970	30,020	30,070	30,130	30,180	30,230	30,290	30,340	30,400	30,450
30	**30,680**	**30,740**	**30,790**	**30,850**	**30,910**	**30,960**	**31,020**	**31,070**	**31,130**	**31,190**
31	31,370	31,430	31,490	31,550	31,610	31,660	31,720	31,780	31,840	31,900
32	**32,030**	**32,090**	**32,150**	**32,220**	**32,280**	**32,340**	**32,400**	**32,460**	**32,520**	**32,580**
33	32,660	32,730	32,790	32,860	32,920	32,980	33,050	33,110	33,180	33,240
34	**33,260**	**33,330**	**33,400**	**33,470**	**33,530**	**33,600**	**33,670**	**33,740**	**33,800**	**33,870**
35	33,830	33,900	33,980	34,050	34,120	34,190	34,260	34,330	34,400	34,470
36	**34,370**	**34,450**	**34,520**	**34,590**	**34,670**	**34,740**	**34,820**	**34,890**	**34,960**	**35,030**
37	34,870	34,950	35,030	35,110	35,180	35,260	35,340	35,420	35,490	35,570
38	**35,340**	**35,420**	**35,500**	**35,580**	**35,660**	**35,740**	**35,830**	**35,910**	**35,990**	**36,070**
39	35,760	35,850	35,930	36,020	36,100	36,190	36,270	36,360	36,440	36,530

Plate VII- 3. Spillway Rating Table, Continued

CORDELL HULL DAM
SPILLWAY GATE RATING TABLE FOR ONE GATE

GATE OPENING	HEADWATER ELEVATION IN FEET									
	509.0	509.1	509.2	509.3	509.4	509.5	509.6	509.7	509.8	509.9
0.5	950	950	960	960	960	960	960	960	960	960
1	**1,800**	**1,810**	**1,810**	**1,810**	**1,810**	**1,810**	**1,820**	**1,820**	**1,820**	**1,820**
1.5	2,570	2,570	2,570	2,580	2,580	2,580	2,580	2,590	2,590	2,590
2	**3,250**	**3,260**	**3,260**	**3,270**	**3,270**	**3,270**	**3,280**	**3,280**	**3,280**	**3,290**
2.5	3,880	3,880	3,890	3,890	3,900	3,900	3,910	3,910	3,920	3,920
3	**4,460**	**4,460**	**4,470**	**4,470**	**4,480**	**4,480**	**4,490**	**4,490**	**4,500**	**4,500**
3.5	5,000	5,000	5,010	5,010	5,020	5,030	5,030	5,040	5,040	5,050
4	**5,510**	**5,520**	**5,530**	**5,530**	**5,540**	**5,550**	**5,550**	**5,560**	**5,570**	**5,570**
4.5	6,030	6,030	6,040	6,050	6,050	6,060	6,070	6,080	6,080	6,090
5	**6,550**	**6,560**	**6,570**	**6,570**	**6,580**	**6,590**	**6,600**	**6,610**	**6,610**	**6,620**
5.5	7,100	7,100	7,110	7,120	7,130	7,140	7,150	7,150	7,160	7,170
6	**7,670**	**7,680**	**7,690**	**7,700**	**7,710**	**7,720**	**7,730**	**7,740**	**7,740**	**7,750**
6.5	8,260	8,270	8,280	8,290	8,300	8,310	8,320	8,330	8,340	8,350
7	**8,850**	**8,860**	**8,880**	**8,890**	**8,900**	**8,910**	**8,920**	**8,930**	**8,940**	**8,950**
7.5	9,440	9,450	9,460	9,480	9,490	9,500	9,510	9,520	9,530	9,540
8	**10,020**	**10,040**	**10,050**	**10,060**	**10,070**	**10,090**	**10,100**	**10,110**	**10,120**	**10,130**
8.5	10,600	10,620	10,630	10,640	10,660	10,670	10,680	10,700	10,710	10,720
9	**11,180**	**11,200**	**11,210**	**11,220**	**11,240**	**11,250**	**11,270**	**11,280**	**11,290**	**11,310**
9.5	11,760	11,770	11,790	11,800	11,810	11,830	11,840	11,860	11,870	11,890
10	**12,330**	**12,340**	**12,360**	**12,370**	**12,390**	**12,400**	**12,420**	**12,440**	**12,450**	**12,470**
10.5	12,890	12,910	12,930	12,940	12,960	12,980	12,990	13,010	13,030	13,040
11	**13,460**	**13,470**	**13,490**	**13,510**	**13,530**	**13,540**	**13,560**	**13,580**	**13,590**	**13,610**
11.5	14,020	14,030	14,050	14,070	14,090	14,110	14,120	14,140	14,160	14,180
12	**14,570**	**14,590**	**14,610**	**14,630**	**14,650**	**14,660**	**14,680**	**14,700**	**14,720**	**14,740**
12.5	15,120	15,140	15,160	15,180	15,200	15,220	15,240	15,260	15,280	15,300
13	**15,660**	**15,680**	**15,710**	**15,730**	**15,750**	**15,770**	**15,790**	**15,810**	**15,830**	**15,850**
13.5	16,200	16,230	16,250	16,270	16,290	16,310	16,330	16,350	16,380	16,400
14	**16,740**	**16,760**	**16,780**	**16,810**	**16,830**	**16,850**	**16,870**	**16,900**	**16,920**	**16,940**
14.5	17,270	17,290	17,320	17,340	17,360	17,390	17,410	17,430	17,460	17,480
15	**17,800**	**17,820**	**17,850**	**17,870**	**17,890**	**17,920**	**17,940**	**17,970**	**17,990**	**18,010**
15.5	18,320	18,340	18,370	18,390	18,420	18,440	18,470	18,490	18,520	18,540
16	**18,840**	**18,860**	**18,890**	**18,910**	**18,940**	**18,970**	**18,990**	**19,020**	**19,040**	**19,070**
17	19,860	19,880	19,910	19,940	19,970	20,000	20,020	20,050	20,080	20,110
18	**20,860**	**20,890**	**20,920**	**20,950**	**20,980**	**21,010**	**21,030**	**21,060**	**21,090**	**21,120**
19	21,840	21,870	21,900	21,930	21,960	22,000	22,030	22,060	22,090	22,120
20	**22,800**	**22,830**	**22,870**	**22,900**	**22,930**	**22,970**	**23,000**	**23,030**	**23,070**	**23,100**
21	23,740	23,780	23,810	23,850	23,880	23,920	23,950	23,990	24,020	24,060
22	**24,660**	**24,700**	**24,740**	**24,780**	**24,810**	**24,850**	**24,890**	**24,920**	**24,960**	**25,000**
23	25,560	25,600	25,640	25,680	25,720	25,760	25,800	25,840	25,880	25,920
24	**26,440**	**26,480**	**26,530**	**26,570**	**26,610**	**26,650**	**26,690**	**26,730**	**26,770**	**26,820**
25	27,300	27,340	27,390	27,430	27,480	27,520	27,560	27,610	27,650	27,690
26	**28,140**	**28,180**	**28,230**	**28,270**	**28,320**	**28,360**	**28,410**	**28,460**	**28,500**	**28,550**
27	28,950	29,000	29,040	29,090	29,140	29,190	29,240	29,280	29,330	29,380
28	**29,740**	**29,790**	**29,840**	**29,890**	**29,940**	**29,990**	**30,040**	**30,090**	**30,140**	**30,190**
29	30,500	30,550	30,610	30,660	30,710	30,770	30,820	30,870	30,920	30,970
30	**31,240**	**31,300**	**31,350**	**31,410**	**31,460**	**31,520**	**31,570**	**31,630**	**31,680**	**31,740**
31	31,960	32,010	32,070	32,130	32,190	32,240	32,300	32,360	32,420	32,470
32	**32,640**	**32,700**	**32,760**	**32,830**	**32,890**	**32,950**	**33,010**	**33,070**	**33,130**	**33,190**
33	33,300	33,370	33,430	33,490	33,560	33,620	33,680	33,750	33,810	33,870
34	**33,940**	**34,000**	**34,070**	**34,130**	**34,200**	**34,270**	**34,330**	**34,400**	**34,460**	**34,530**
35	34,540	34,610	34,680	34,750	34,810	34,880	34,950	35,020	35,090	35,160
36	**35,110**	**35,180**	**35,250**	**35,320**	**35,400**	**35,470**	**35,540**	**35,610**	**35,680**	**35,750**
37	35,640	35,720	35,800	35,870	35,950	36,020	36,100	36,170	36,250	36,320
38	**36,150**	**36,230**	**36,310**	**36,380**	**36,460**	**36,540**	**36,620**	**36,700**	**36,780**	**36,850**
39	36,610	36,690	36,780	36,860	36,940	37,020	37,110	37,190	37,270	37,350

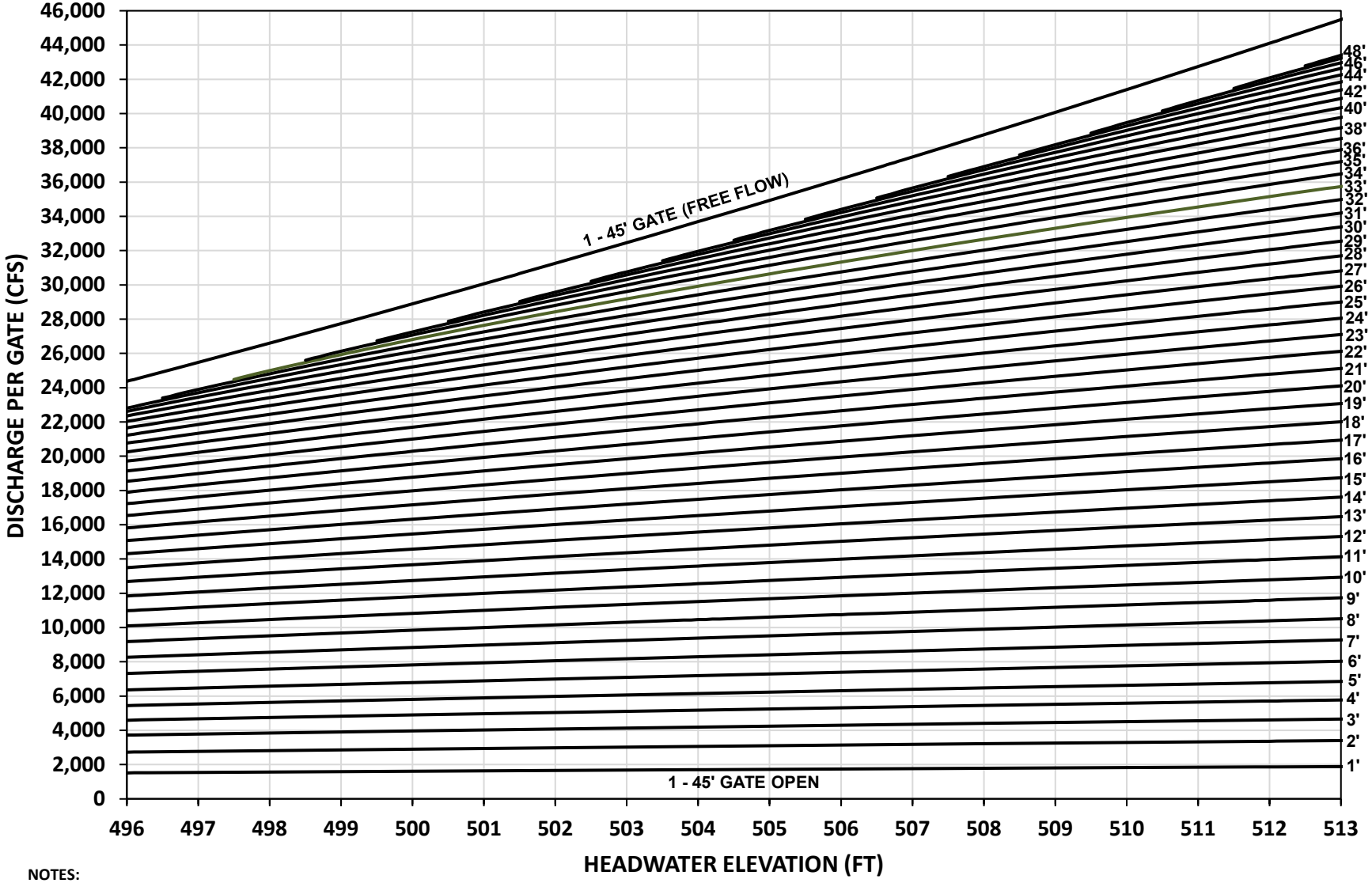
Plate VII- 3. Spillway Rating Table, Continued

CORDELL HULL DAM
FREE FLOW RATING TABLE FOR ONE GATE

HEADWATER ELEVATION	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
498	**26,600**	**26,710**	**26,820**	**26,940**	**27,050**	**27,170**	**27,280**	**27,390**	**27,510**	**27,620**
499	27,740	27,850	27,970	28,080	28,200	28,310	28,430	28,540	28,660	28,780
500	**28,890**	**29,010**	**29,130**	**29,240**	**29,360**	**29,480**	**29,590**	**29,710**	**29,830**	**29,950**
501	30,070	30,180	30,300	30,420	30,540	30,660	30,780	30,900	31,020	31,140
502	**31,260**	**31,380**	**31,500**	**31,620**	**31,740**	**31,860**	**31,980**	**32,100**	**32,220**	**32,340**
503	32,460	32,590	32,710	32,830	32,950	33,070	33,200	33,320	33,440	33,560
504	**33,690**	**33,810**	**33,930**	**34,060**	**34,180**	**34,310**	**34,430**	**34,560**	**34,680**	**34,800**
505	34,930	35,050	35,180	35,310	35,430	35,560	35,680	35,810	35,940	36,060
506	**36,190**	**36,320**	**36,440**	**36,570**	**36,700**	**36,820**	**36,950**	**37,080**	**37,210**	**37,340**
507	37,460	37,590	37,720	37,850	37,980	38,110	38,240	38,370	38,500	38,630
508	**38,760**	**38,890**	**39,020**	**39,150**	**39,280**	**39,410**	**39,540**	**39,670**	**39,810**	**39,940**
509	40,070	40,200	40,330	40,470	40,600	40,730	40,860	41,000	41,130	41,260
510	**41,400**	**41,530**	**41,660**	**41,800**	**41,930**	**42,070**	**42,200**	**42,340**	**42,470**	**42,610**
511	42,740	42,880	43,010	43,150	43,290	43,420	43,560	43,690	43,830	43,970
512	**44,100**	**44,240**	**44,380**	**44,520**	**44,650**	**44,790**	**44,930**	**45,070**	**45,210**	**45,350**
513	45,480	45,620	45,760	45,900	46,040	46,180	46,320	46,460	46,600	46,740
514	**46,880**	**47,020**	**47,160**	**47,300**	**47,440**	**47,590**	**47,730**	**47,870**	**48,010**	**48,150**
515	48,290	48,430	48,580	48,720	48,860	49,000	49,150	49,290	49,430	49,570
516	**49,720**	**49,860**	**50,000**	**50,150**	**50,290**	**50,430**	**50,580**	**50,720**	**50,870**	**51,010**
517	51,150	51,300	51,440	51,590	51,730	51,880				

Sheet 13 of 13

Plate VII- 3. Spillway Rating Table, Continued



NOTES:

1. GATE OPENING REPRESENTS THE DISTANCE OF TRAVEL FROM GATE SEAT ALONG THE ARC OF THE SPILLWAY GATE.

2. THERE ARE A TOTAL OF 5 SPILLWAY GATES

3. TOP OF SURCHARGE POOL IS ELEVATION 508.0

Plate VII - 3. Spillway Rating Curves

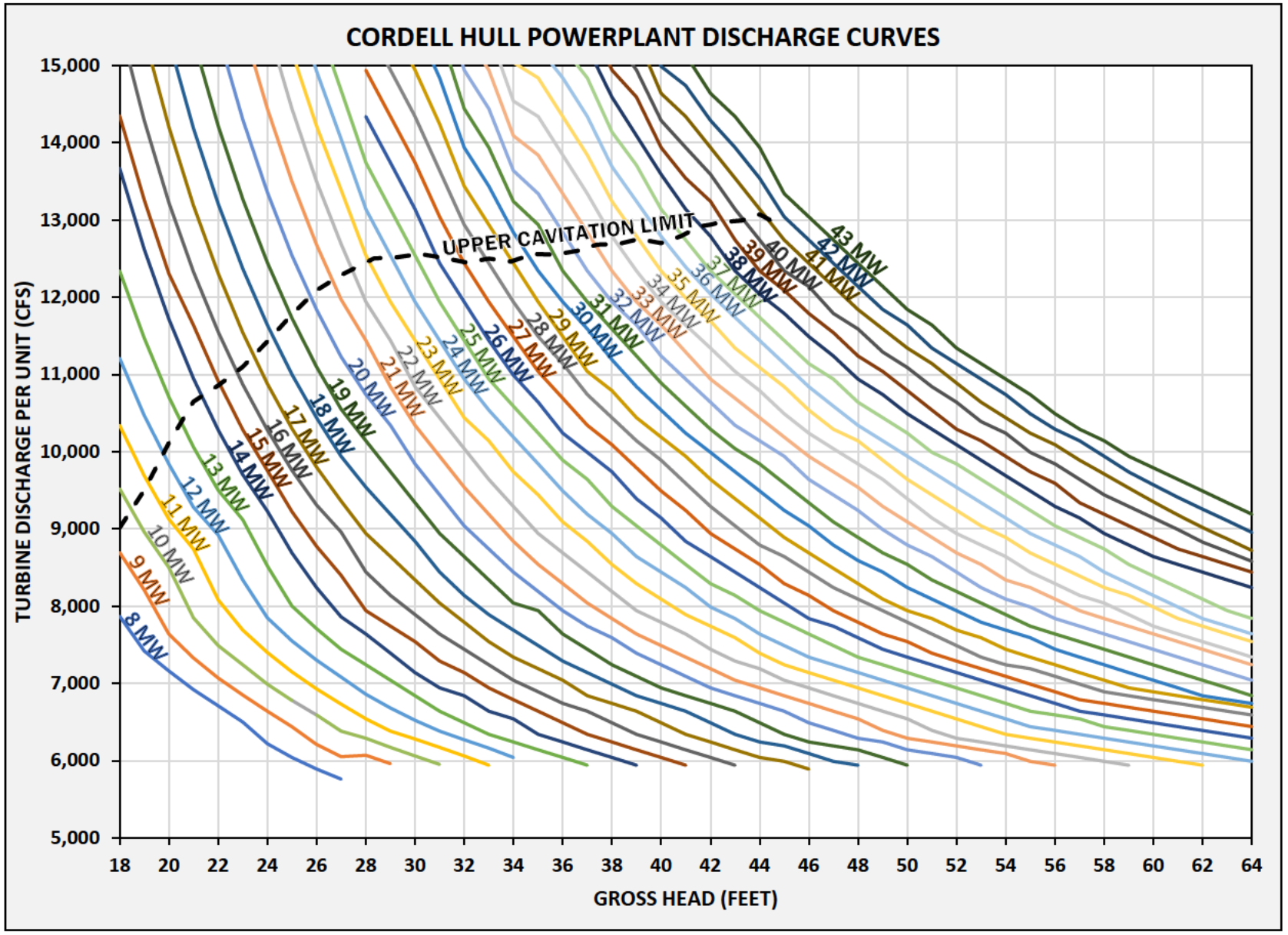


Plate VII - 5. Turbine Discharge Curves

MEGA WATTS																		
HEAD	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
18	7870	8695	9520	10340	11210	12340	13670	14350	15530	16760	18300							
19	7420	8210	8960	9690	10470	11470	12620	13260	14290	15390	16690	18200						
20	7160	7640	8500	9130	9840	10710	11720	12310	13230	14210	15330	16640	18140					
21	6920	7330	7850	8740	9280	10060	10950	11640	12330	13190	14190	15340	16670	18200				
22	6710	7070	7490	8080	8920	9500	10280	10915	11550	12310	13210	14220	15400	16770	18200			
23	6500	6850	7240	7690	8340	9120	9700	10285	10870	11540	12370	13270	14300	15520	16760	17540	18350	
24	6220	6640	6990	7400	7850	8520	9230	9755	10280	10880	11640	12450	13360	14440	15520	16280	17060	17820
25	6040	6440	6780	7150	7550	8000	8690	9225	9760	10300	11000	11730	12540	13500	14440	15180	15930	16640
26	5890	6210	6590	6930	7300	7710	8240	8775	9310	9800	10440	11100	11840	12680	13500	14220	14930	15600
27	5760	6050	6380	6730	7080	7440	7860	8400	8960	9360	9940	10550	11230	11970	12690	13390	14050	14680
28		6070	6290	6540	6860	7240	7640	7940	8440	8940	9540	10140	10740	11440	11940	12540	13140	13740
29		5960	6170	6380	6680	7040	7390	7740	8140	8640	9190	9740	10340	10840	11440	11940	12540	13140
30			6060	6280	6520	6840	7140	7540	7890	8340	8840	9340	9840	10340	10840	11440	11940	12540
31			5950	6170	6380	6640	6940	7290	7640	8040	8440	8940	9440	9940	10440	10940	11440	11940
32				6060	6270	6490	6840	7140	7440	7790	8140	8640	9040	9540	10040	10440	10940	11440
33				5940	6160	6340	6640	6940	7240	7540	7890	8340	8740	9190	9640	10140	10540	10940
34					6040	6240	6540	6790	7040	7340	7690	8040	8440	8840	9290	9740	10190	10590
35						6140	6340	6640	6890	7190	7490	7940	8190	8540	8940	9440	9840	10240
36						6040	6240	6490	6740	7040	7290	7640	7940	8290	8690	9090	9490	9890
37						5940	6140	6340	6640	6840	7140	7440	7740	8040	8440	8840	9190	9640
38							6040	6240	6490	6740	6990	7240	7590	7840	8190	8540	8940	9290
39							5940	6140	6340	6640	6840	7090	7390	7640	7940	8290	8640	9040
40								6040	6240	6490	6740	6940	7240	7490	7790	8090	8440	8790
41								5940	6140	6340	6640	6840	7090	7340	7640	7890	8240	8540
42									6040	6240	6490	6740	6940	7190	7440	7740	7990	8290
43									5940	6140	6340	6640	6840	7040	7290	7590	7840	8140
44										6040	6240	6490	6740	6940	7190	7390	7640	7940
45										5990	6190	6340	6640	6840	7040	7240	7490	7790
46										5890	6090	6240	6490	6740	6940	7140	7340	7640
47											5990	6190	6390	6640	6840	7040	7240	7490
48											5940	6140	6290	6540	6740	6940	7140	7340
49												6040	6240	6390	6640	6840	7040	7240
50												5940	6140	6290	6540	6740	6940	7140
51													6090	6240	6390	6640	6840	7040
52													6040	6190	6290	6540	6740	6940
53													5940	6140	6240	6440	6640	6840
54														6090	6190	6340	6540	6740
55														5990	6140	6290	6440	6640
56														5940	6090	6240	6390	6590
57															6040	6190	6340	6540
58															5990	6140	6290	6440
59															5940	6090	6240	6390
60																6040	6190	6340
61																5990	6140	6290
62																5940	6090	6240
63																	6040	6190
64																	5990	6140

Plate VII - 6. Turbine Discharge Table

MEGA WATTS																		
HEAD	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**
28	14340	14940	15540	16140	16740	17340												
29	13740	14340	14940	15540	16140	16740	17340											
30	13140	13740	14340	14940	15540	16140	16740	17340										
31	12440	13040	13640	14240	14840	15440	16040	16640	17240									
32	11940	12440	12940	13440	13940	14440	14940	15440	15940	16440								
33	11440	11940	12440	12940	13440	13940	14440	14940	15440	15940	16440							
34	10990	11490	11940	12440	12840	13240	13640	14090	14540	15040	15540	16040						
35	10640	11040	11490	11940	12340	12940	13340	13840	14340	14840	15240	15640	16040					
36	10240	10690	11140	11490	11940	12340	12840	13340	13840	14340	14840	15240	15640	16040				
37	9990	10340	10740	11040	11590	11940	12340	12840	13340	13840	14340	14840	15240	15690	16140			
38	9740	10090	10440	10790	11190	11590	11940	12340	12790	13240	13690	14140	14590	14940	15390	15840	16290	16740
39	9390	9790	10140	10440	10840	11240	11640	11940	12340	12790	13240	13710	14090	14590	14940	15390	15840	16390
40	9140	9490	9890	10190	10540	10890	11240	11640	11940	12340	12790	13140	13590	13940	14290	14640	14990	15340
41	8840	9240	9590	9940	10240	10590	10940	11290	11640	11990	12390	12740	13140	13540	13940	14340	14740	15140
42	8640	8940	9290	9640	9990	10290	10640	10940	11340	11690	12040	12340	12790	13240	13590	13940	14290	14640
43	8440	8740	9040	9390	9740	10040	10340	10690	11040	11340	11740	12040	12340	12740	13140	13540	13940	14340
44	8240	8540	8790	9140	9490	9840	10140	10440	10790	11090	11440	11740	12040	12340	12740	13140	13540	13940
45	8040	8290	8640	8890	9240	9590	9940	10190	10490	10840	11140	11440	11790	12090	12340	12740	13040	13340
46	7840	8140	8440	8690	9040	9340	9640	9940	10240	10540	10840	11140	11490	11790	12140	12440	12740	13040
47	7740	7940	8240	8490	8790	9090	9440	9740	10040	10290	10590	10940	11240	11540	11790	12140	12440	12740
48	7590	7790	8090	8290	8590	8890	9240	9540	9840	10140	10340	10640	10940	11240	11590	11840	12140	12440
49	7440	7640	7940	8090	8440	8690	8990	9290	9640	9890	10140	10440	10740	11040	11290	11590	11840	12140
50	7340	7540	7790	7940	8240	8540	8790	9090	9390	9640	9940	10240	10490	10790	11090	11340	11640	11840
51	7240	7390	7640	7840	8090	8340	8640	8890	9140	9440	9740	9990	10290	10540	10840	11140	11340	11640
52	7140	7290	7490	7690	7940	8190	8440	8690	8940	9240	9540	9840	10090	10290	10640	10890	11140	11340
53	7040	7190	7340	7590	7790	8040	8240	8540	8790	9040	9340	9640	9890	10140	10390	10640	10940	11140
54	6940	7090	7240	7440	7690	7890	8090	8340	8640	8890	9140	9440	9690	9940	10240	10440	10740	10940
55	6840	6990	7190	7340	7590	7740	7990	8240	8440	8690	8940	9240	9490	9740	9990	10240	10490	10740
56	6740	6890	7090	7240	7440	7640	7840	8090	8290	8540	8790	9040	9290	9590	9840	10090	10290	10490
57	6640	6790	6990	7140	7340	7540	7740	7940	8140	8390	8640	8890	9140	9340	9640	9890	10140	10290
58	6590	6740	6890	7040	7240	7440	7640	7840	8040	8240	8440	8740	8940	9190	9440	9710	9940	10140
59	6540	6690	6840	6940	7140	7340	7540	7740	7890	8140	8290	8540	8790	9040	9290	9530	9735	9940
60	6490	6640	6790	6890	7040	7240	7440	7640	7740	7990	8140	8390	8640	8890	9140	9350	9570	9790
61	6440	6590	6740	6840	6940	7140	7340	7540	7640	7840	7990	8240	8540	8740	8990	9180	9410	9640
62	6390	6540	6690	6790	6840	7040	7240	7440	7540	7740	7840	8090	8440	8640	8830	9020	9255	9490
63	6340	6490	6640	6740	6790	6940	7140	7340	7440	7640	7740	7940	8340	8540	8705	8870	9105	9340
64	6290	6440	6590	6690	6740	6840	7040	7240	7340	7540	7640	7840	8240	8440	8580	8720	8955	9190

Plate VII - 6. Turbine Discharge Table, Continued

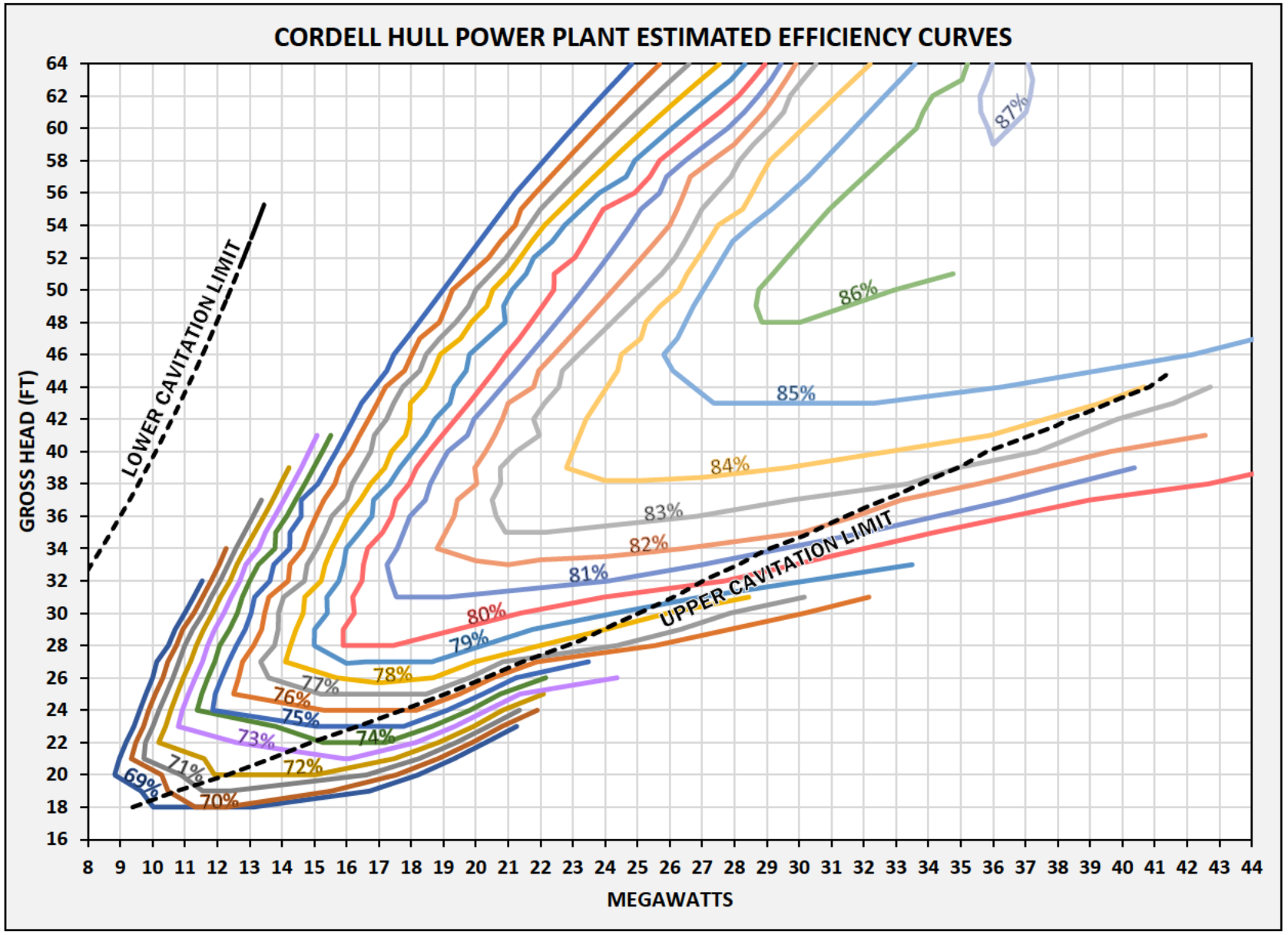


Plate VII - 7. Estimated Unit Efficiency

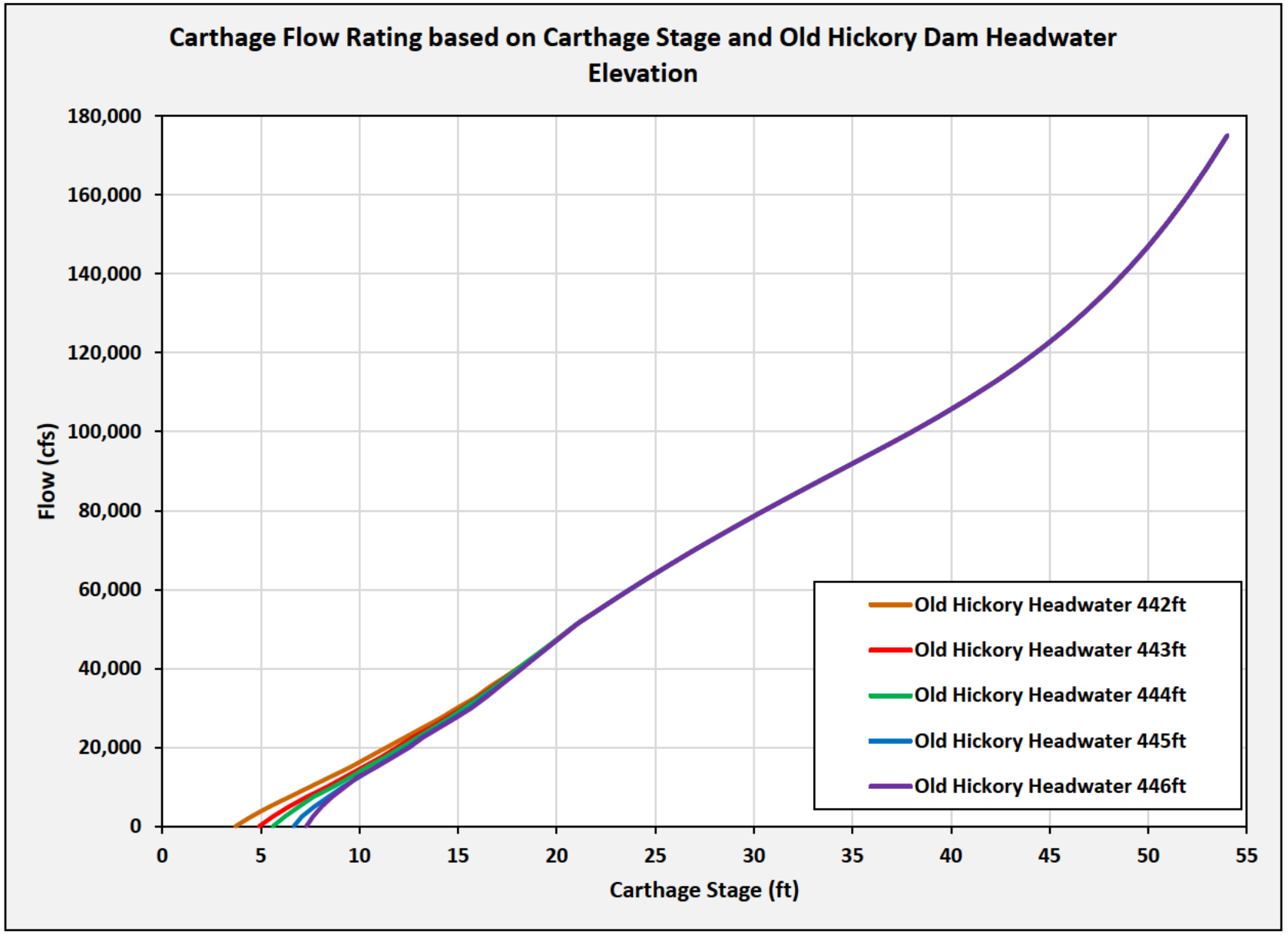


Plate VII - 8. Carthage Rating Curve

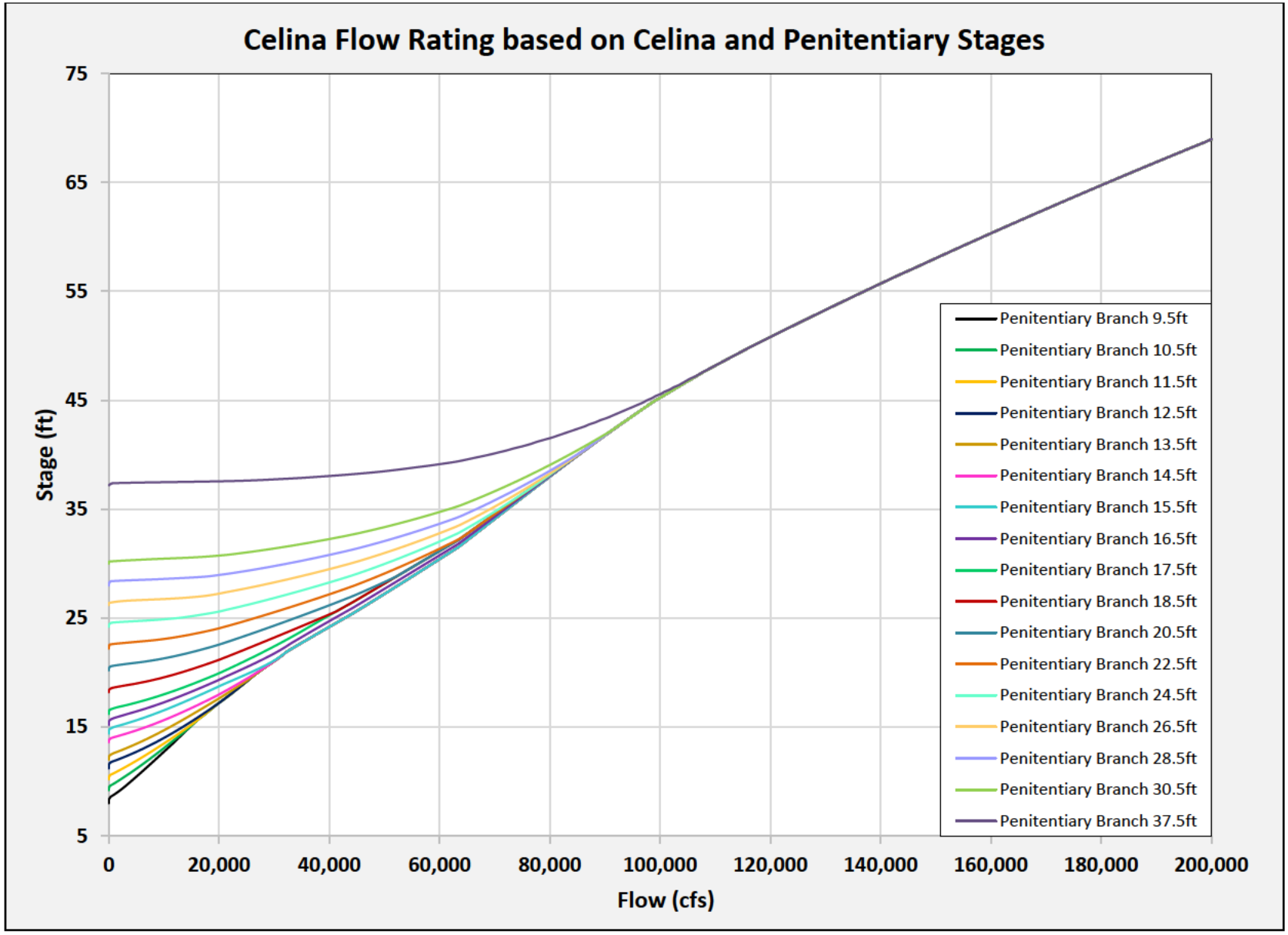


Plate VII - 9. Celina Rating Curve

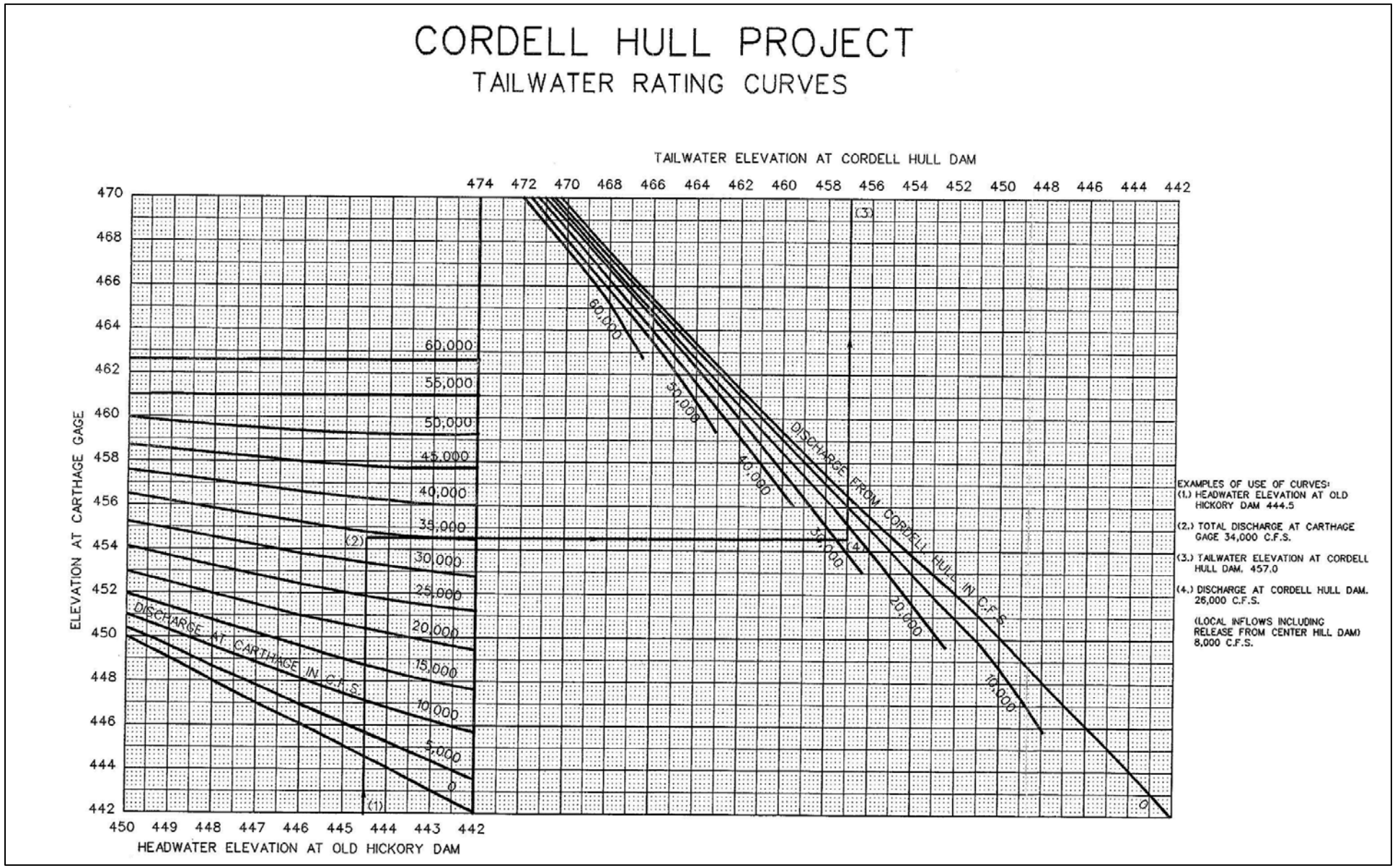


Plate VII - 10. Tailwater Rating Curves

CORDELL HULL RESERVOIR
IMPACTS OF POOL LEVELS ON RECREATION AND NATURAL RESOURCES

TOP OF SUMMER POOL - ELEVATION 504.5
BOTTOM OF SUMMER POOL - ELEVATION 503.0
BOTTOM OF WINTER POOL - ELEVATION 499.0

WATER BASED FACILITIES		INITIAL IMPACT (A) ELEVATION 501.0 (2 feet below bottom of summer pool)			MAJOR IMPACT (B) ELEVATION 496.0 (7 feet below bottom of summer pool)			SEVERE IMPACT (C) ELEVATION 496.0 (7.0 feet below bottom of summer pool)		
Type	Number	Usable	Marginal or Unusable	Percent Reduction	Usable	Marginal or Unusable	Percent Reduction	Usable	Marginal or Unusable	Percent Reduction
Beaches	9	0	9	100%	Same as Severe Impact			0	9	100%
Boat Ramps	20	20	0	0%				0	20	100%
Marinas	2	2	0	0%				0	2 (D)	100%
Wet Moorage at Marinas	103	103	0	0%				0	103	100%
Private Docks	0	-	-	N/A				-	-	N/A
Public Water Intakes	2	2	0	0%				2	0	0%
Industrial Water Intakes	0	-	-	N/A				-	-	N/A
Water Surface Acreage	11,960	10,600	1,360	11%				8,500	3,460	29%

Plate VII - 41. Impacts of Low Pool Levels

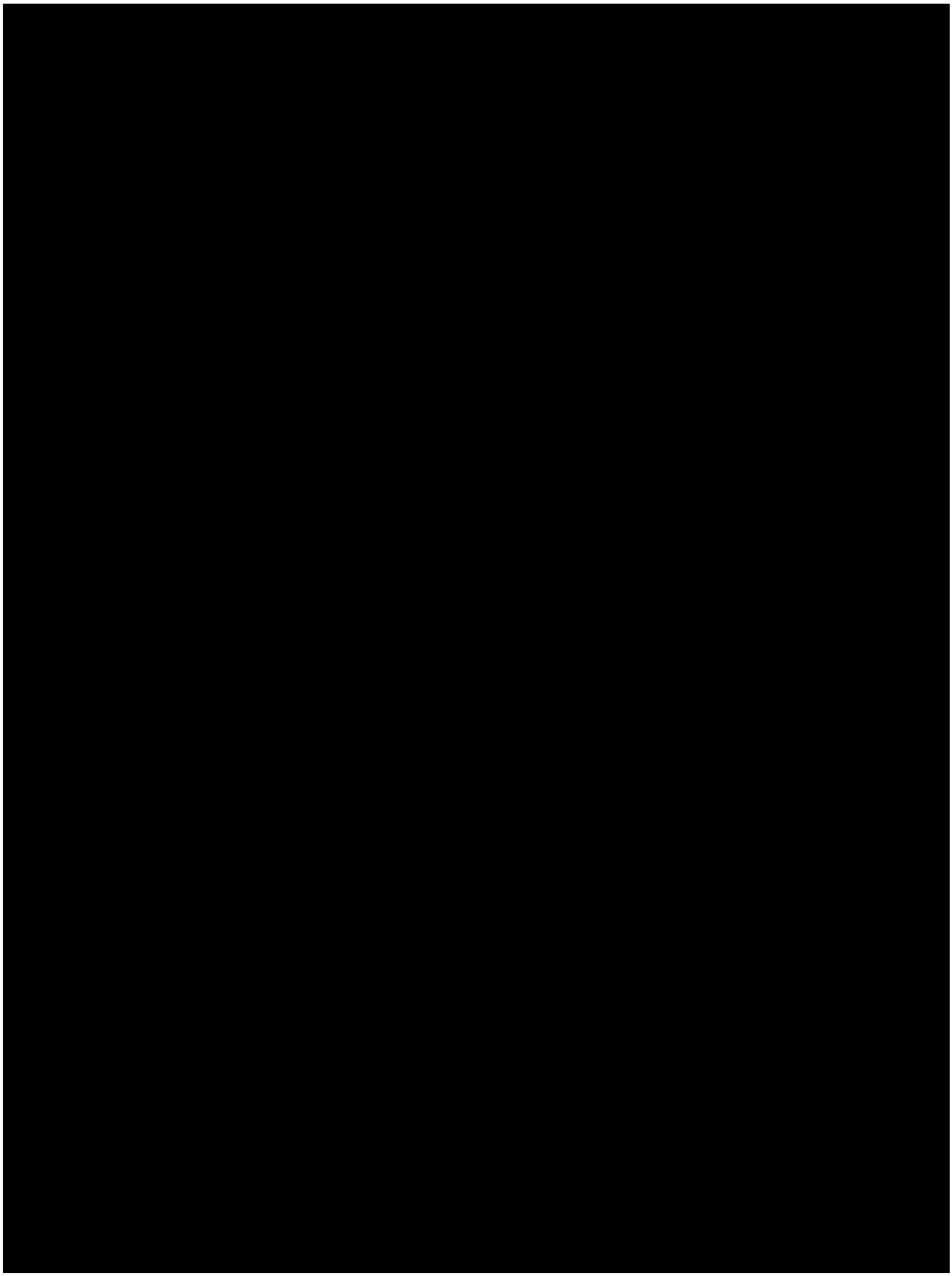


Plate VII - 52. Water Supply Intakes, TN

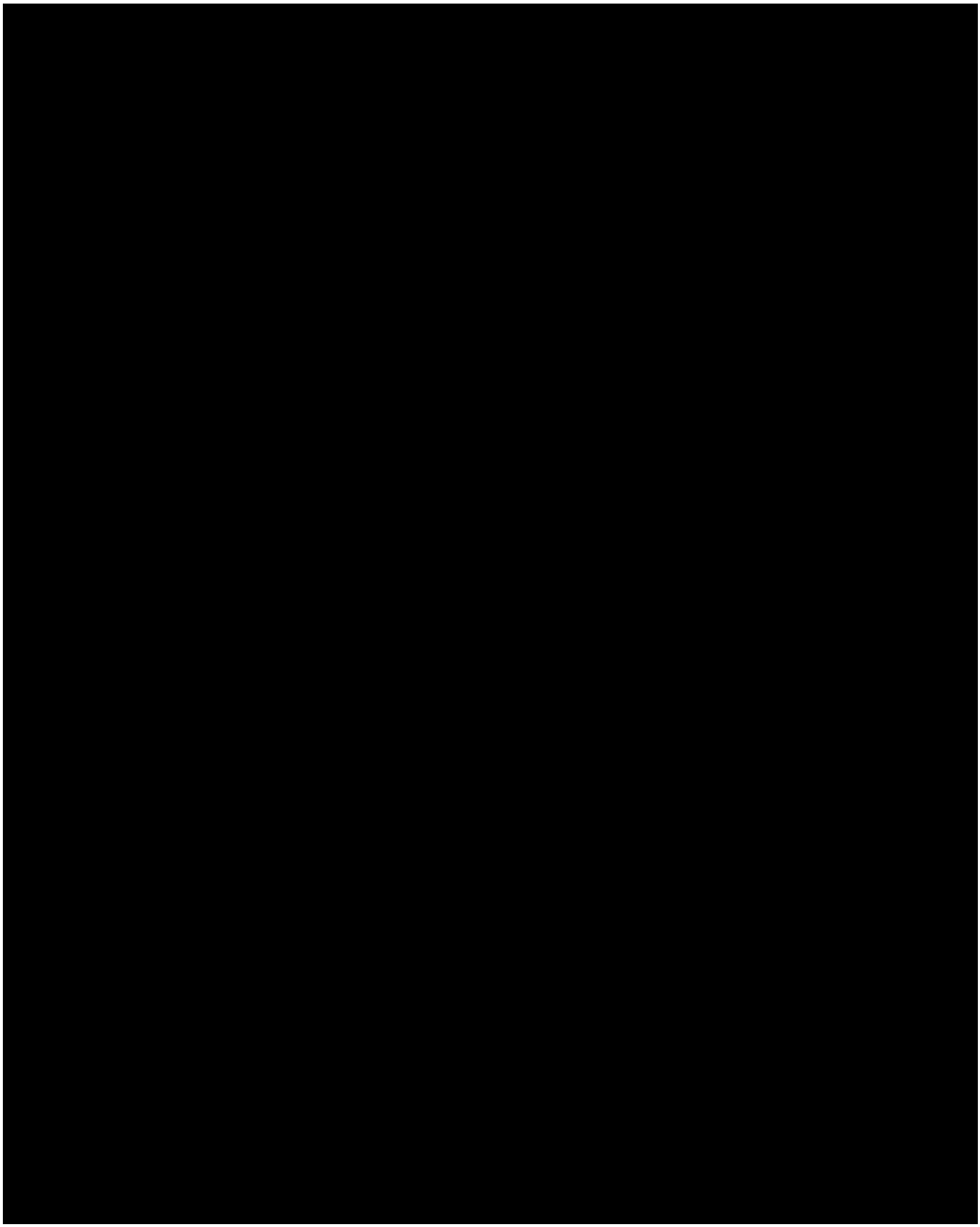


Plate VII - 63. Water Supply Intakes, KY

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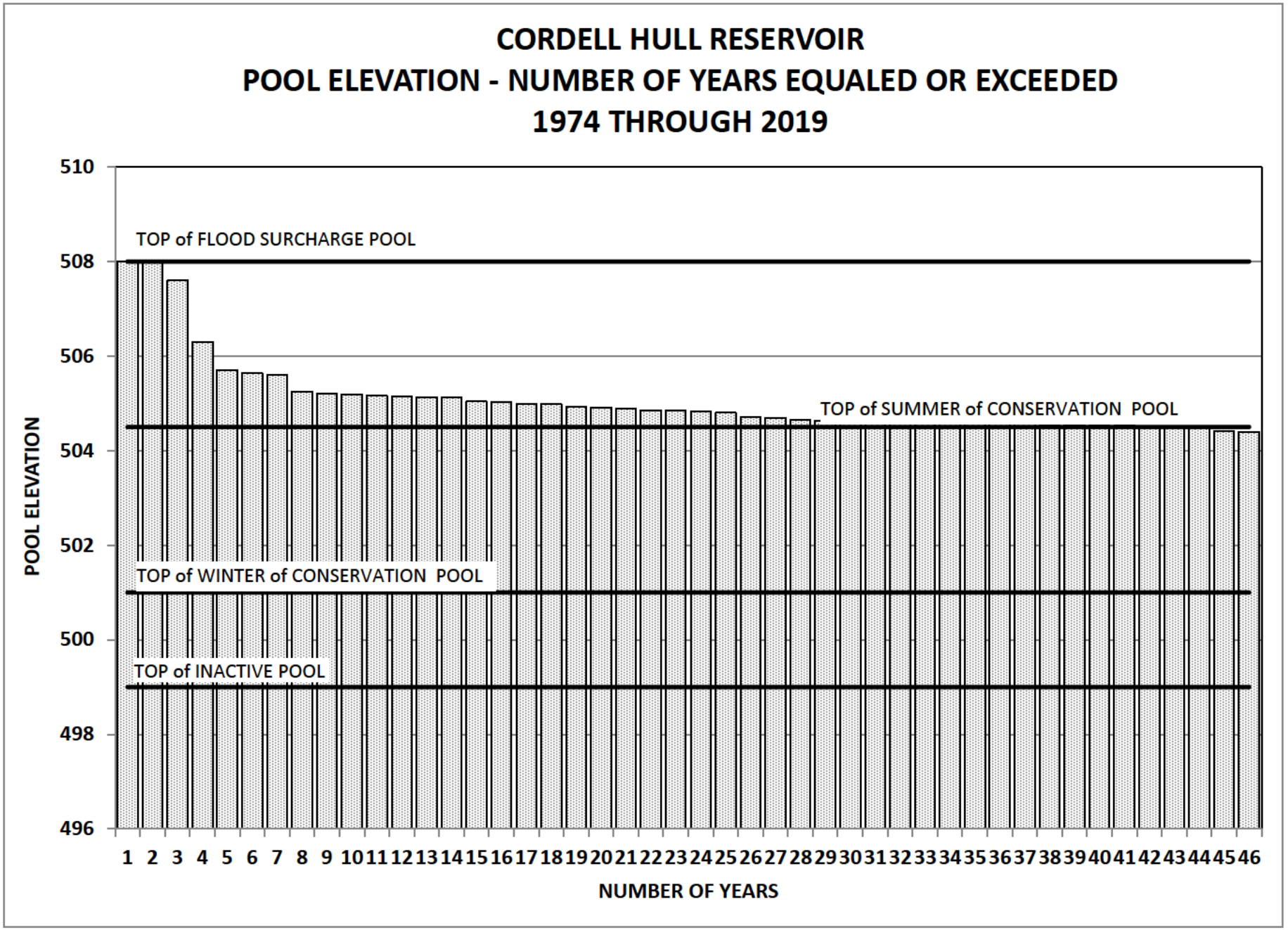

Plate VIII - 1. Pool Elevation Chart, Number of Years Equaled or Exceeded

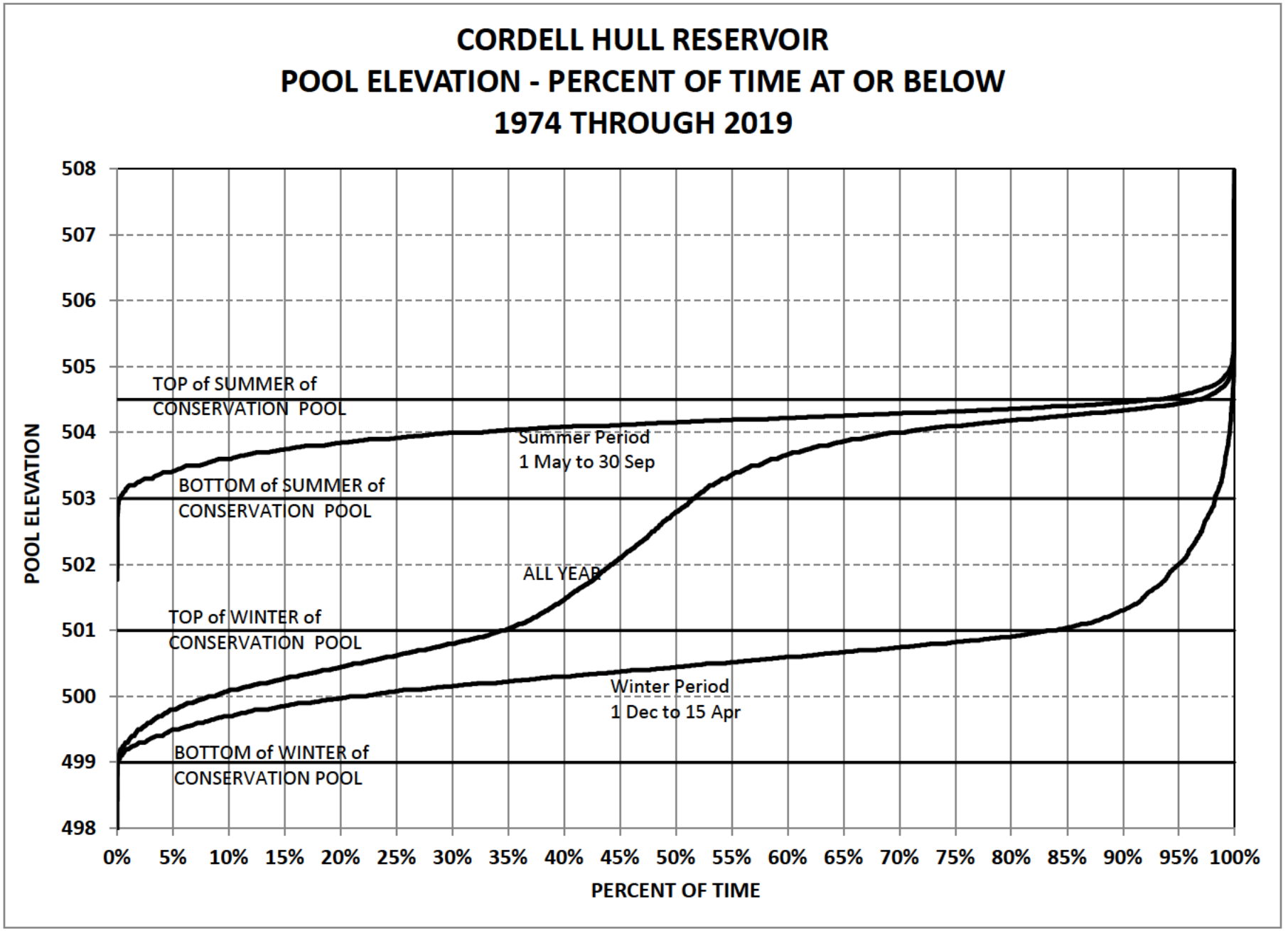

Plate VIII - 2. Pool Elevation Chart, Percent of Time at or Below

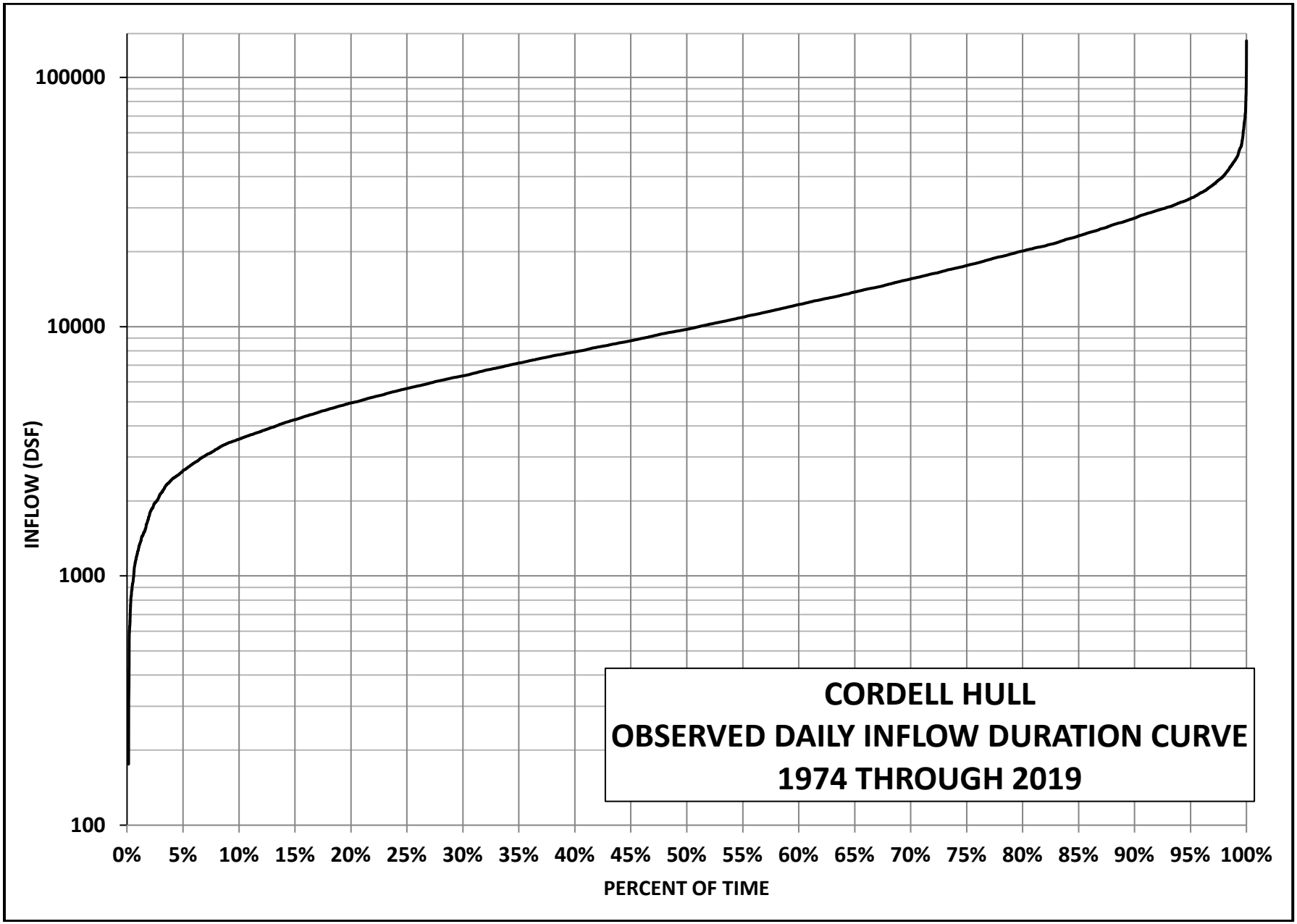

Plate VIII - 3. Observed Inflow Duration Curve

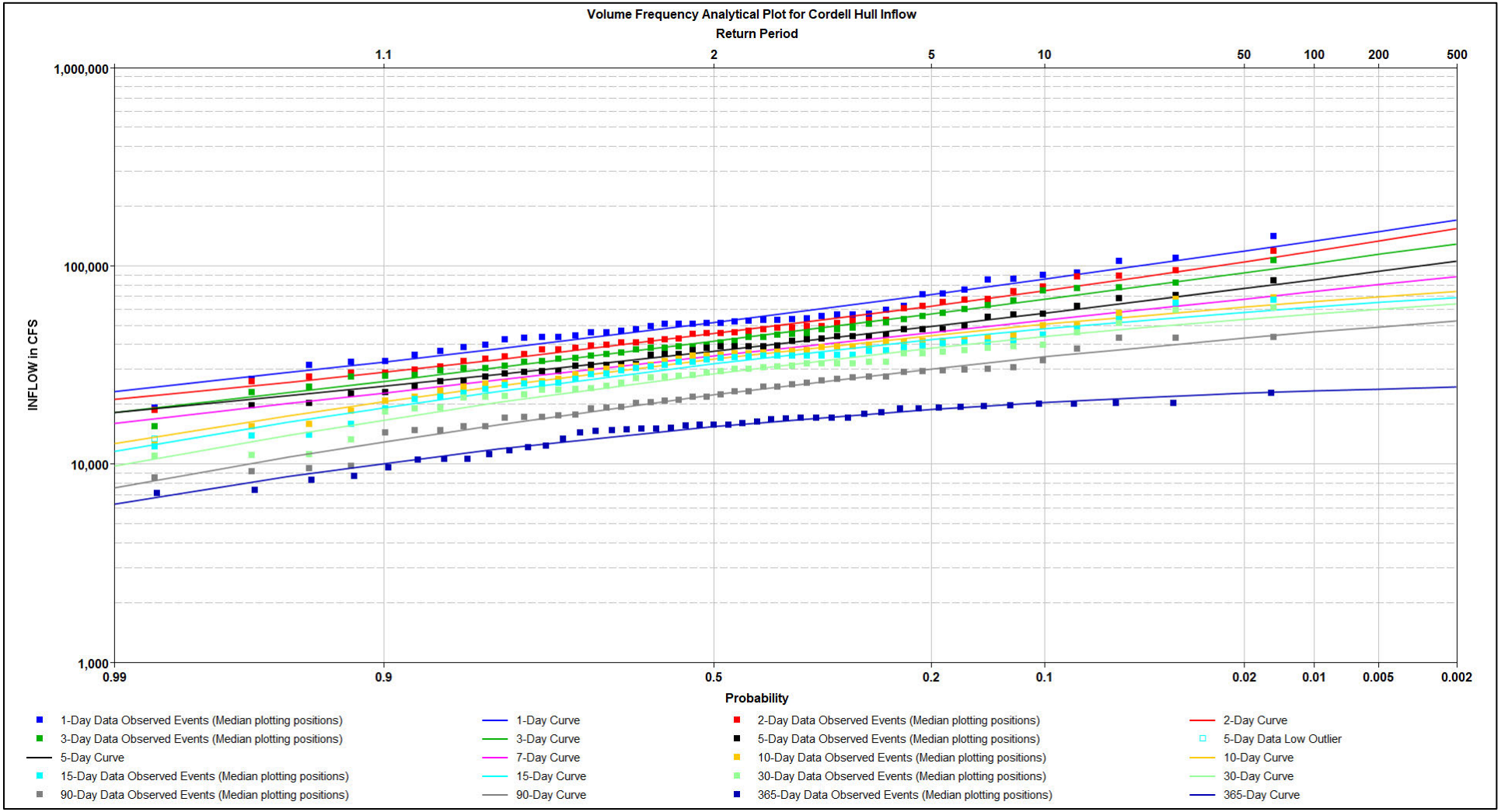

Plate VIII - 4. Volume Frequency Analytical Plot

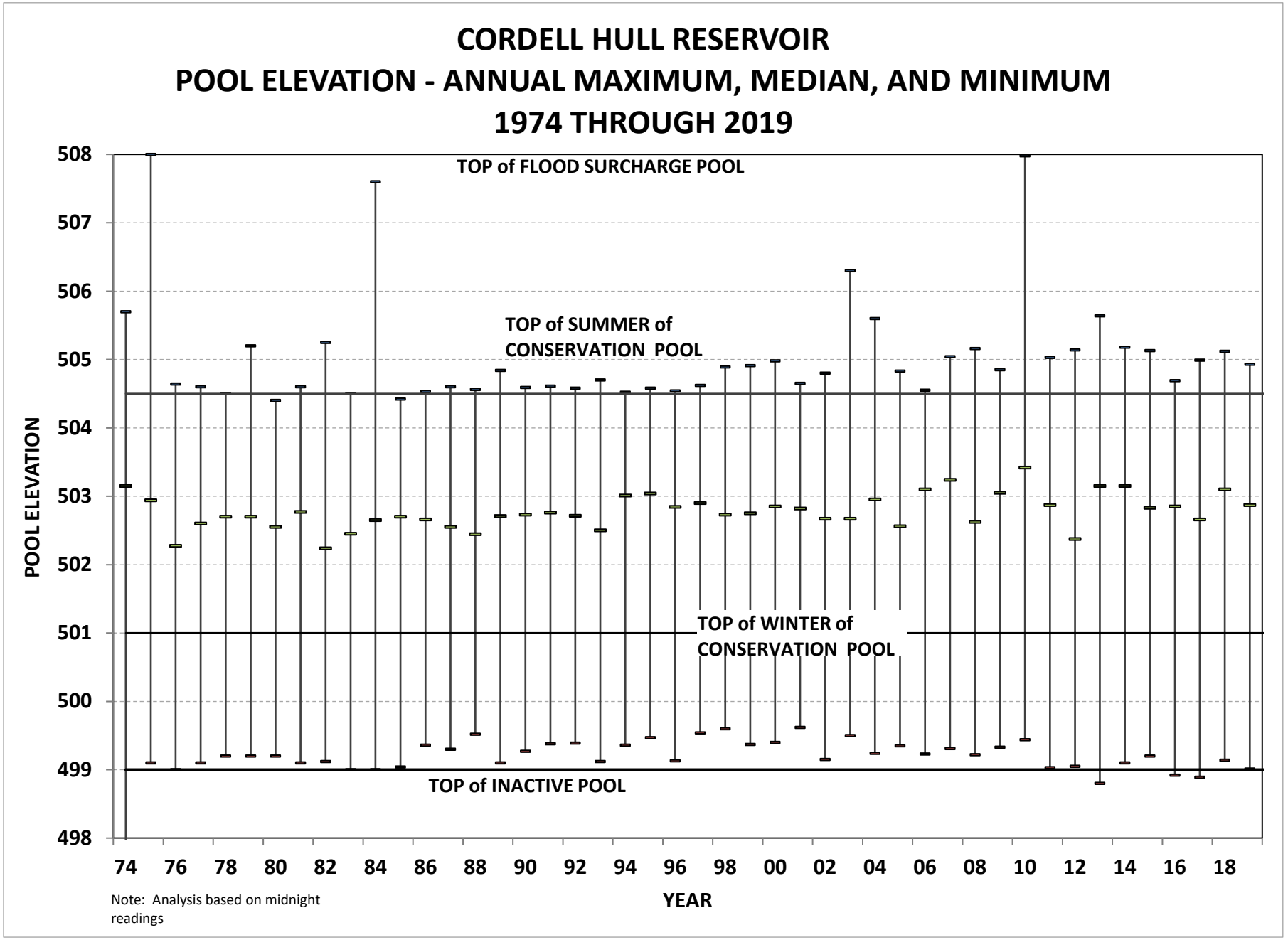

Plate VIII - 5. Pool Elevation Chart, Annual Maximum, Median and Minimum

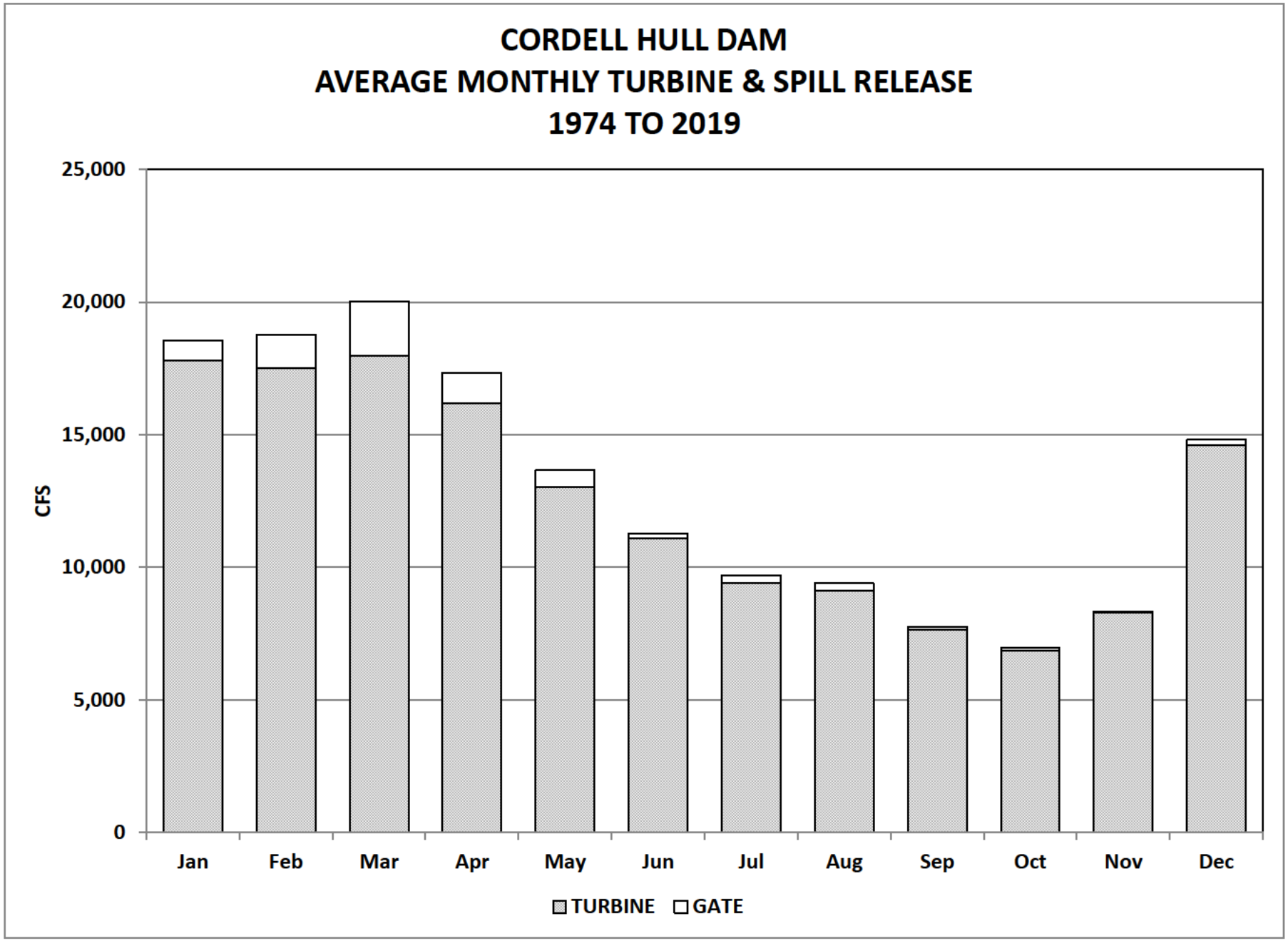

Plate VIII - 6. Discharge Chart, Monthly Average Turbine and Spill

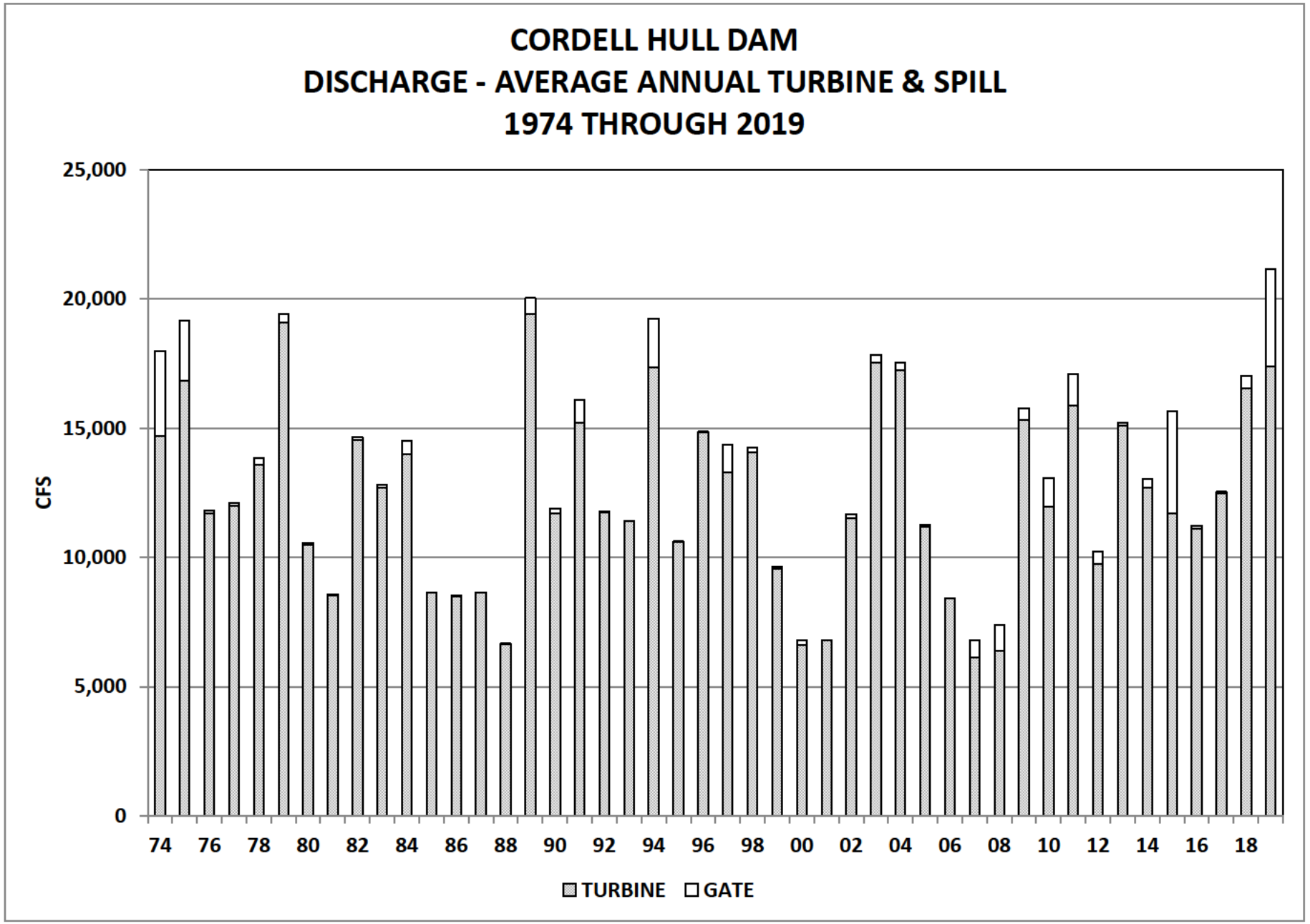

Plate VIII - 7. Discharge Chart, Annual Average Turbine and Spill

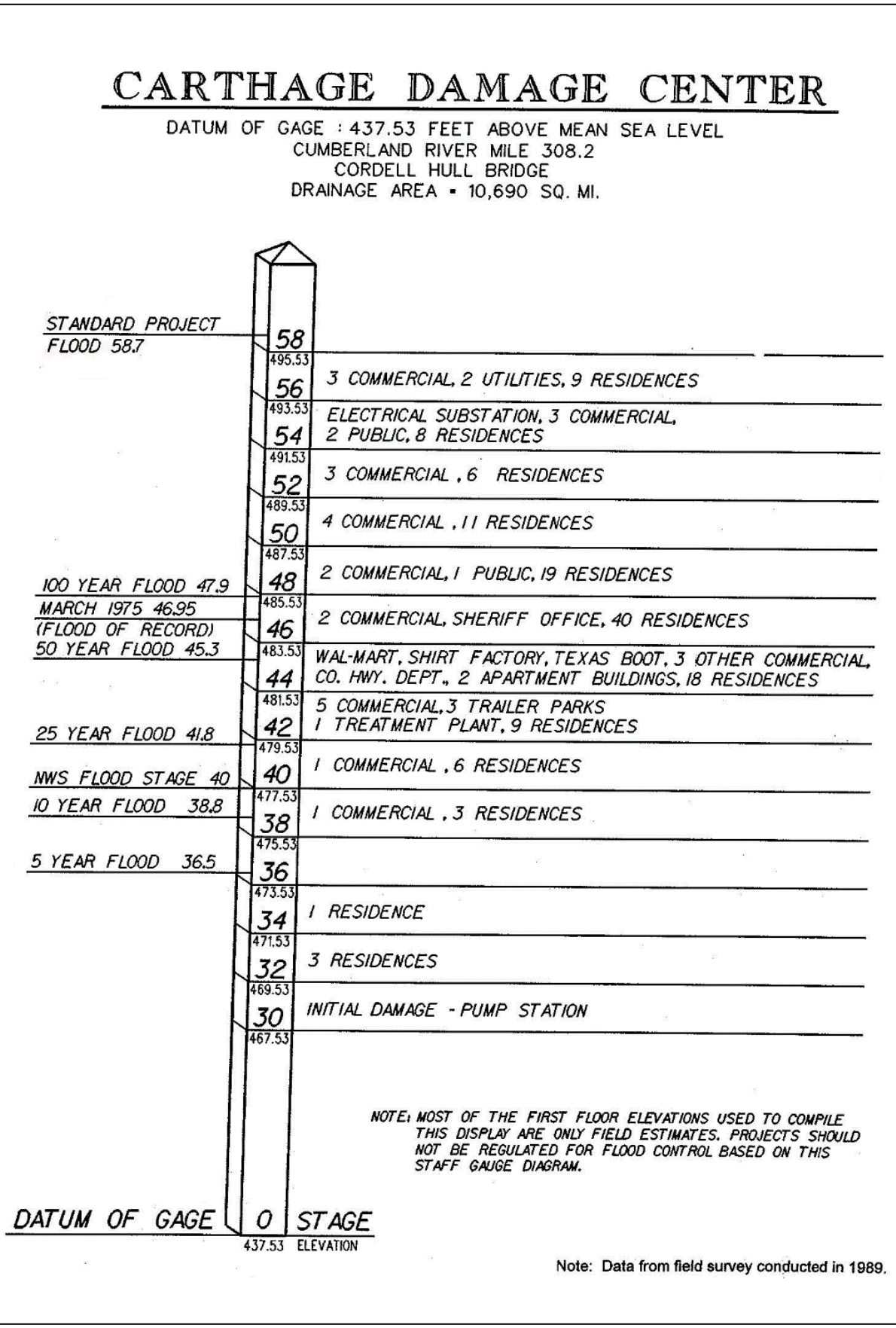

Plate VIII - 8. Carthage Damage Center Information

VALUE TO THE NATION FAST FACTS

USACE RECREATION 2019 LAKE REPORT
CORDELL HULL DAM AND RESERVOIR

Natural and recreational resources at USACE lakes provide social, economic and environmental benefits for all Americans. The following information highlights some of the benefits related to USACE's role in managing natural and recreational resources in Cordell Hull Dam and Reservoir.

LAKE DESCRIPTION

Project Name: Cordell Hull Dam and Reservoir
USACE District: Nashville District
USACE Division: Great Lakes & Ohio River
State: Tennessee
Watershed: Cumberland

SOCIAL BENEFITS

Facilities in FY 2019

- 27 recreation areas
- 93 picnic sites
- 451 camping sites
- 12 playgrounds
- 6 swimming areas
- 14 trails
- 46 trail miles
- 5 fishing docks and piers
- 28 boat ramps
- 192 marina slips

Public Outreach in FY 2019

- 11,811 public outreach contacts

Visits (person-days/nights) in FY 2019

- 884,931 in total
- 132,406 picnickers
- 245,018 campers/overnight visitors
- 195,784 swimmers
- 72,373 walkers/hikers/joggers
- 148,929 boaters
- 251,720 sightseers
- 87,977 anglers
- 26,158 special event attendees
- 30,581 others

Benefits in Perspective

By providing opportunities for active recreation, USACE lakes help combat one of the most significant of the nation's health problems: lack of physical activity.

Recreational programs and activities at USACE lakes also help strengthen family ties and friendships; provide opportunities for children to develop personal skills, social values, and self-esteem; and increase water safety.

ECONOMIC BENEFITS

Economic Data in FY 2019

Visitation per year resulted in:

- $ 30,993,205 in visitor spending within 30 miles of the USACE lake
- $ 16,130,834 in sales within 30 miles of the USACE lake
- 258 jobs within 30 miles of the USACE lake
- $ 6,729,240 in labor income within 30 miles of the USACE lake
- $ 9,071,636 in value added within 30 miles of the USACE lake
- $ 7,748,216 in National Economic Development Benefits

With multiplier effects, visitor trip spending resulted in:

- $ 24,739,150 in total sales
- 328 jobs
- $ 9,342,321 in labor income
- $ 13,466,476 in value added (wages & salaries, payroll benefits, profits, rents, and indirect business taxes)

Benefits in Perspective

The money spent by visitors to USACE lakes on trip expenses adds to the local and national economies by supporting jobs and generating income. Visitor spending represents a sizable component of the economy in many communities around USACE lakes.

How these numbers were calculated.

ENVIRONMENTAL BENEFITS

Resources in FY 2019

- 19,283 land acres
- 11,893 water acres
- 310 shoreline miles

Benefits in Perspective

Recreation experiences increase motivation to learn more about the environment; understanding and awareness of environmental issues; and sensitivity to the environment.

Source: US Army Corps of Engineers, Institute for Water Resources
https://www.iwr.usace.army.mil/Missions/Value-to-the-Nation/

Plate **VIII - 9**. **Recreation Report**

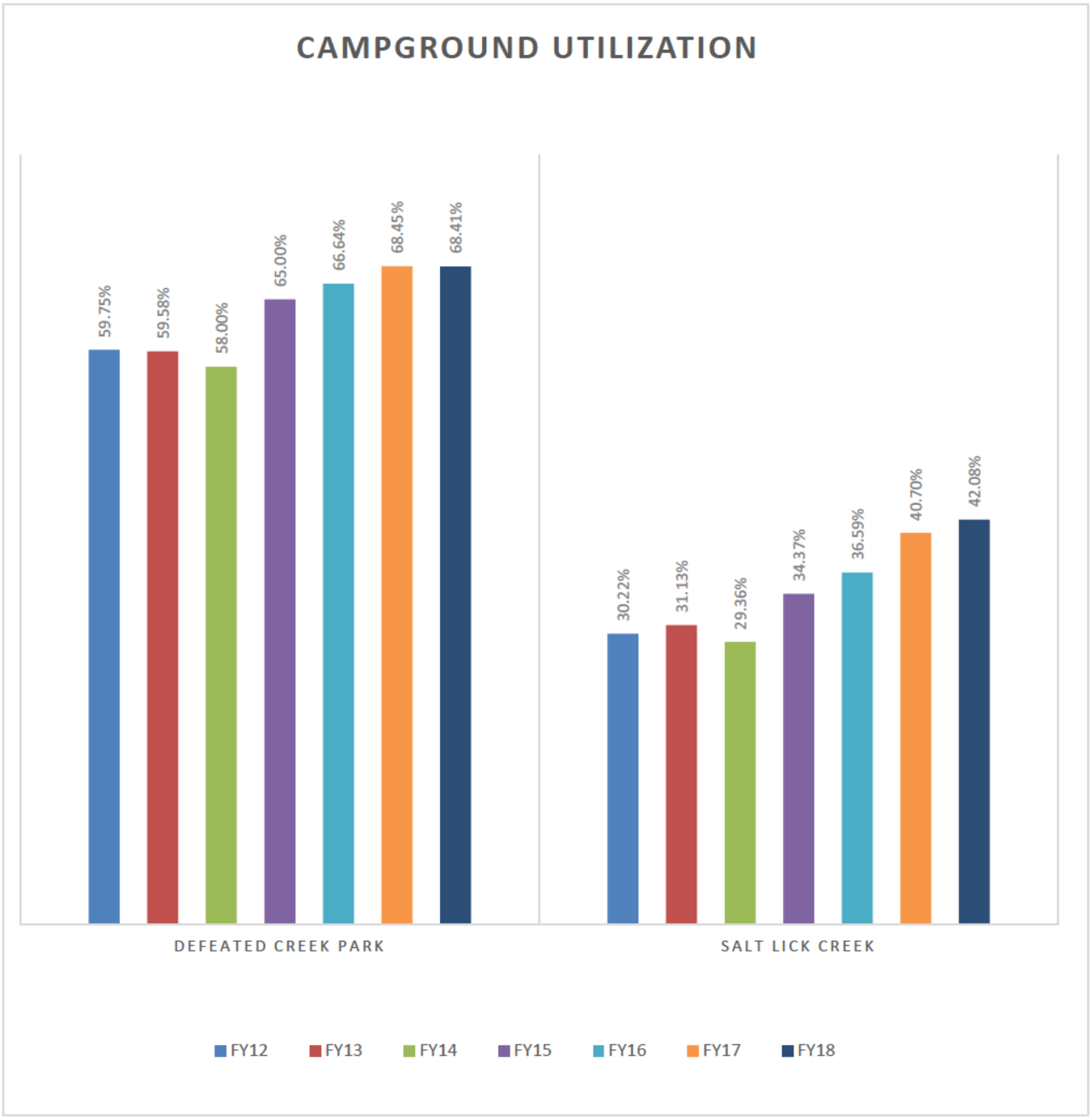

Plate VIII - 10. Campground Utilization Data

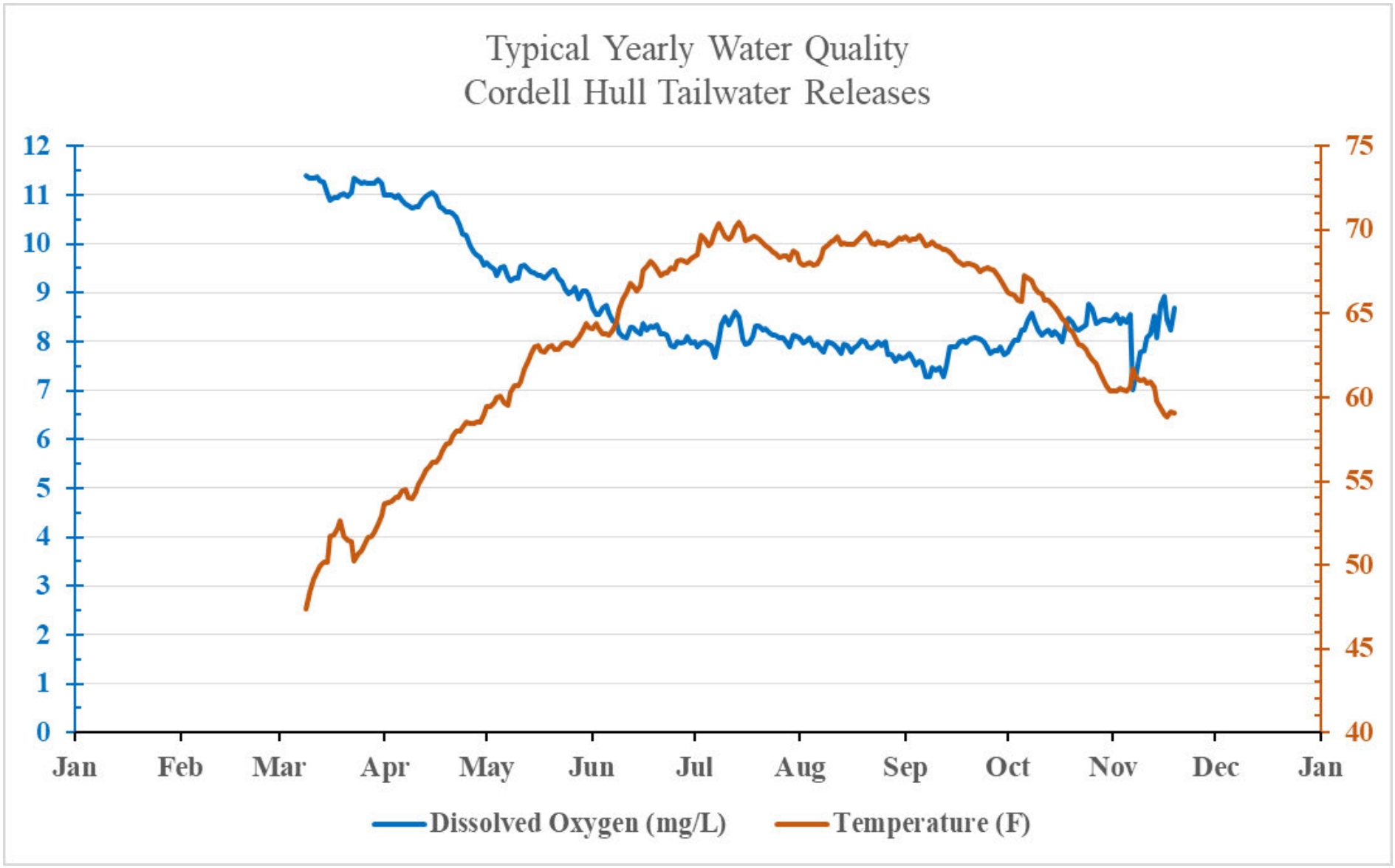

Plate VIII - 11. Typical Tailwater Water Quality

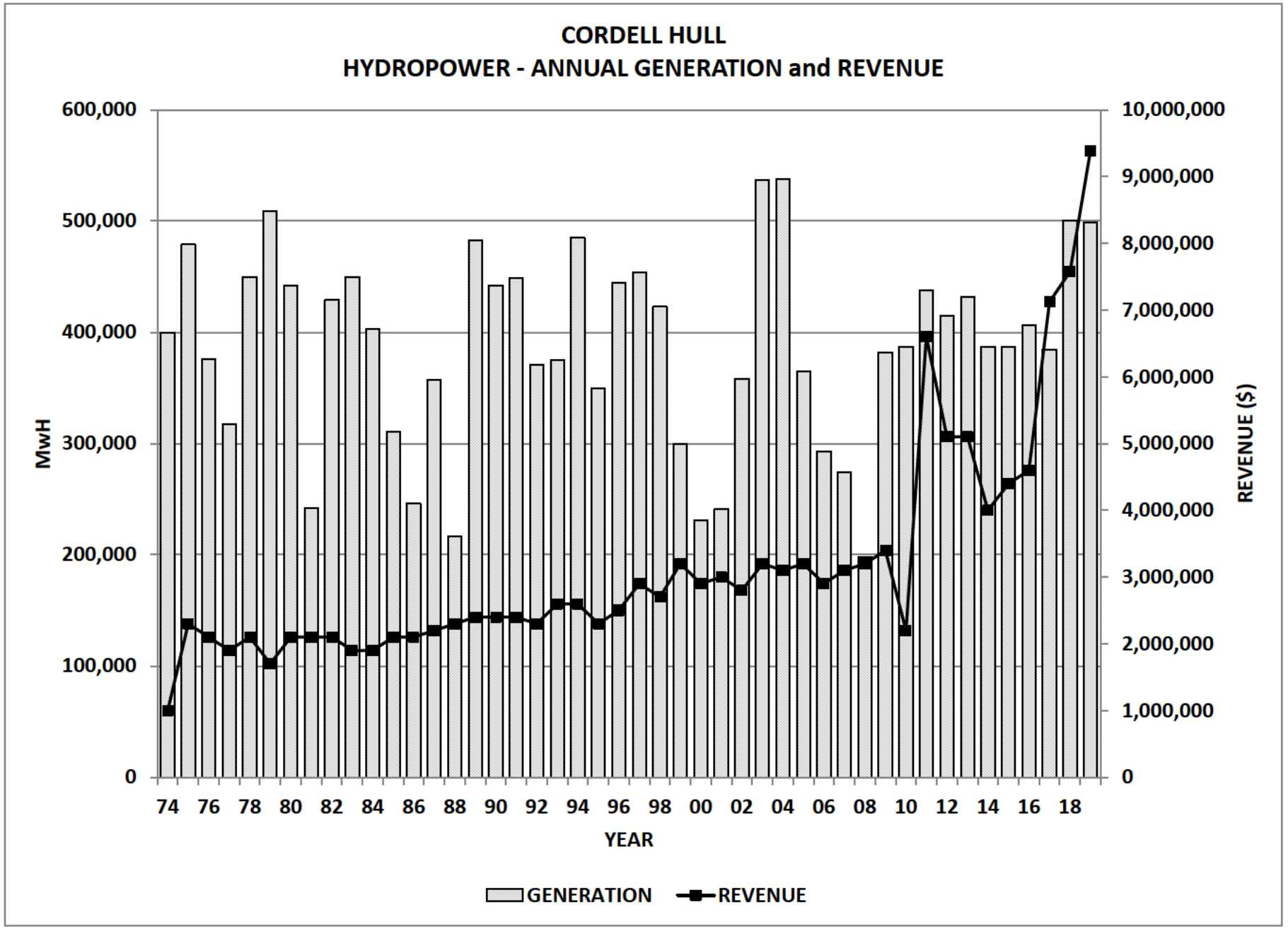

Plate VIII - 12. Hydropower Chart, Annual Generation and Revenue

SUMMARY OF CORDELL HULL 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)
1974	350	400	14	1.8	398	1.0	0.26
1975	350	479	37	1.7	477	2.3	0.48
1976	350	376	7	1.8	374	2.1	0.55
1977	350	317	-9	1.9	315	1.9	0.62
1978	350	450	29	2.2	447	2.1	0.47
1979	350	509	45	2.2	507	1.7	0.34
1980	350	442	26	2.0	440	2.1	0.47
1981	350	242	-31	2.1	240	2.1	0.89
1982	350	429	23	2.1	426	2.1	0.49
1983	350	450	29	2.1	448	1.9	0.42
1984	350	403	15	2.5	400	1.9	0.48
1985	350	311	-11	2.0	309	2.1	0.69
1986	350	246	-30	2.2	244	2.1	0.88
1987	350	357	2	2.3	354	2.2	0.63
1988	350	217	-38	2.4	214	2.3	1.06
1989	350	483	38	2.4	481	2.4	0.50
1990	350	442	26	2.2	439	2.4	0.55
1991	350	449	28	2.4	447	2.4	0.54
1992	350	371	6	3.1	368	2.3	0.62
1993	350	375	7	3.1	372	2.6	0.69
1994	350	485	39	3.1	483	2.6	0.53
1995	350	350	0	2.8	348	2.3	0.68
1996	350	445	27	3.1	442	2.5	0.58
1997	350	454	30	3.0	452	2.9	0.64
1998	350	423	21	3.1	421	2.7	0.64
1999	350	300	-14	2.6	298	3.2	1.07
2000	350	231	-34	3.1	230	2.9	1.39
2001	350	241	-31	2.9	238	3.0	1.50
2002	350	358	2	3.1	355	2.8	0.85
2003	350	537	53	3.1	534	3.2	0.72
2004	350	538	54	3.1	535	3.1	0.64
2005	350	365	4	3.1	362	3.2	0.72
2006	350	293	-16	2.9	290	2.9	1.35
2007	350	274	-22	3.0	273	3.1	1.15
2008	350	198	-43	2.9	195	3.2	1.63
2009	350	382	9	2.8	380	3.4	0.90
2010	350	387	11	2.0	386	2.2	0.57
2011	350	438	25	2.8	435	6.6	1.53
2012	350	415	19	2.7	413	5.1	1.25
2013	350	432	23	2.8	429	5.1	1.18
2014	350	387	11	2.8	384	4.0	1.03
2015	350	387	11	2.9	384	4.4	1.14
2016	350	406	16	2.9	403	4.6	1.13
2017	350	384	10	2.8	381	7.1	1.86
2018	350	501	43	3.1	498	7.6	1.53
2019	350	498	42	3.0	495	9.4	1.90

Plate VIII - 13. Hydropower Table, Annual Generation and Revenue

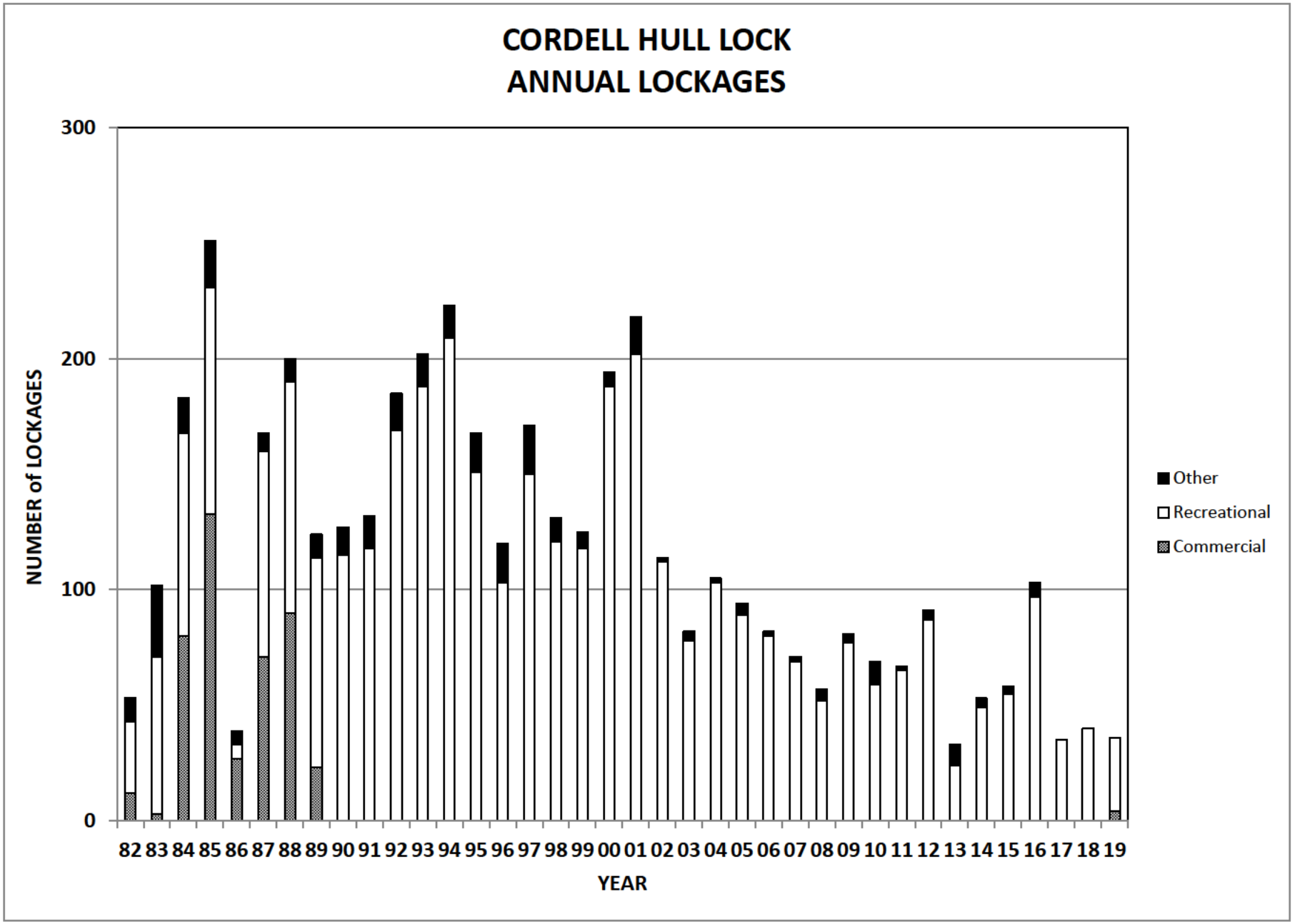

Plate VIII - 14. Navigation Chart, Annual Lockages

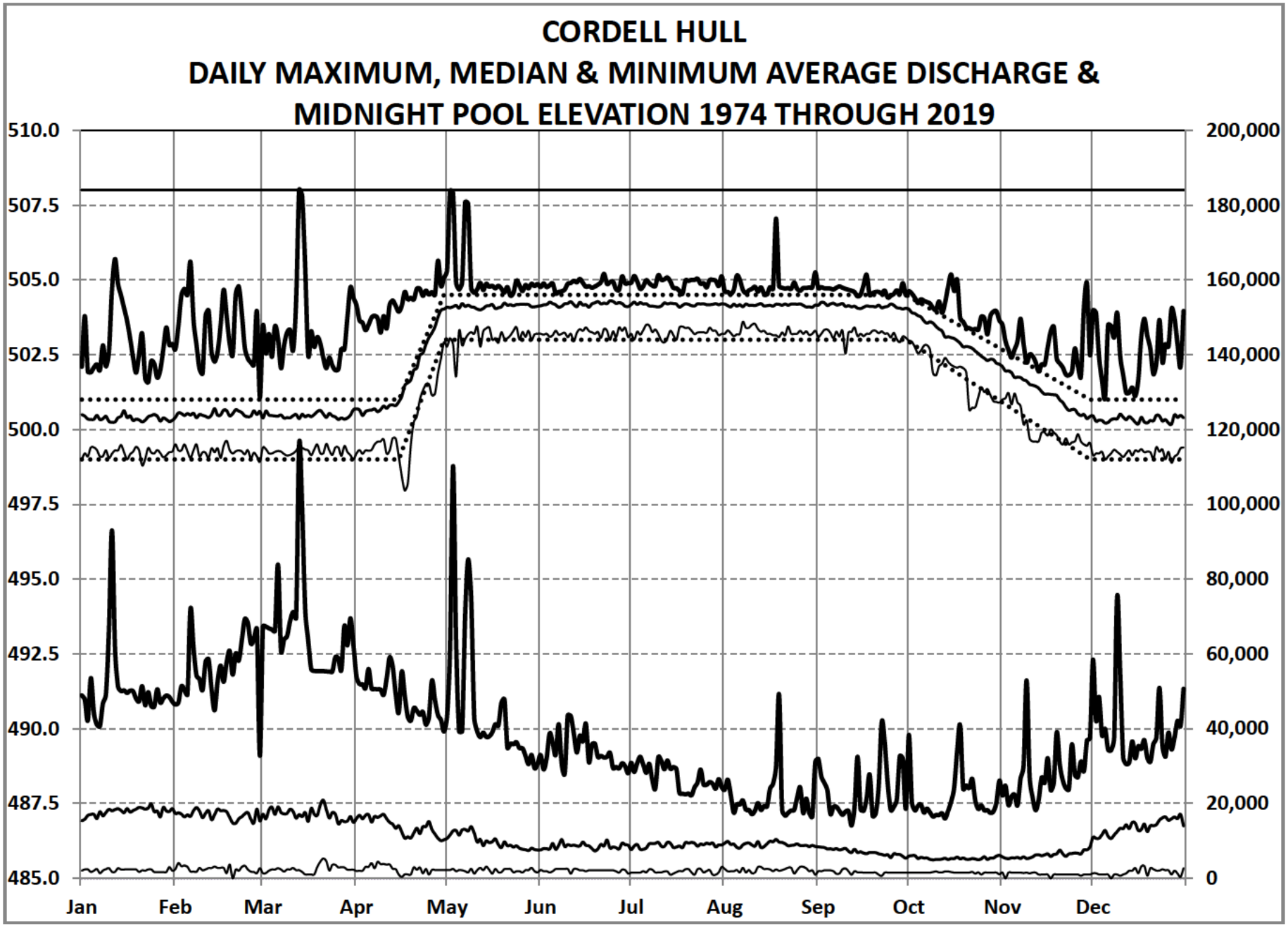

Plate VIII - 15. Cordell Hull Maximum, Median & Minimum Daily Avg. Discharges & Pool Elevations

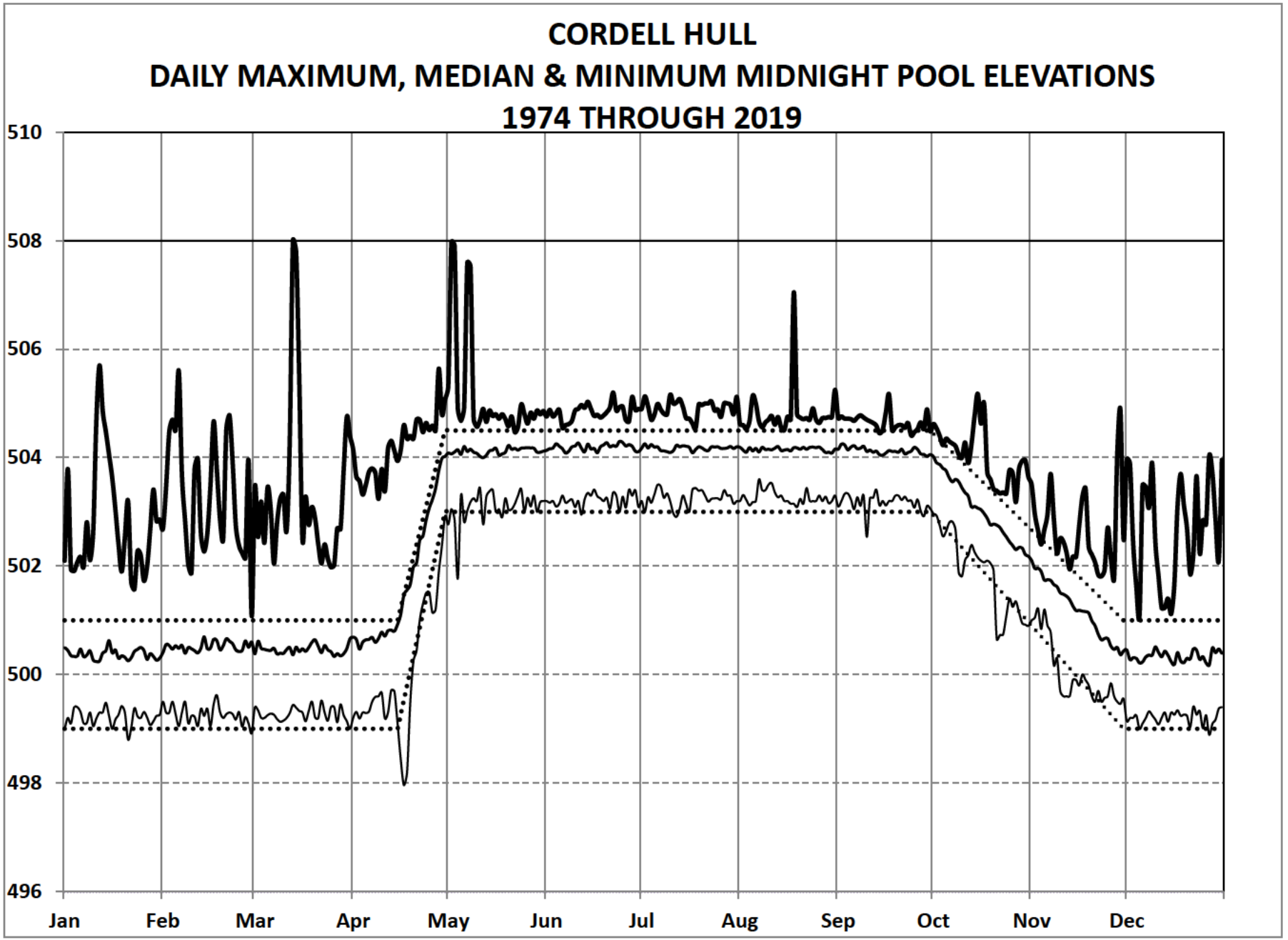

Plate VIII - 16. Cordell Hull Daily Maximum, Median & Minimum Pool Elevations

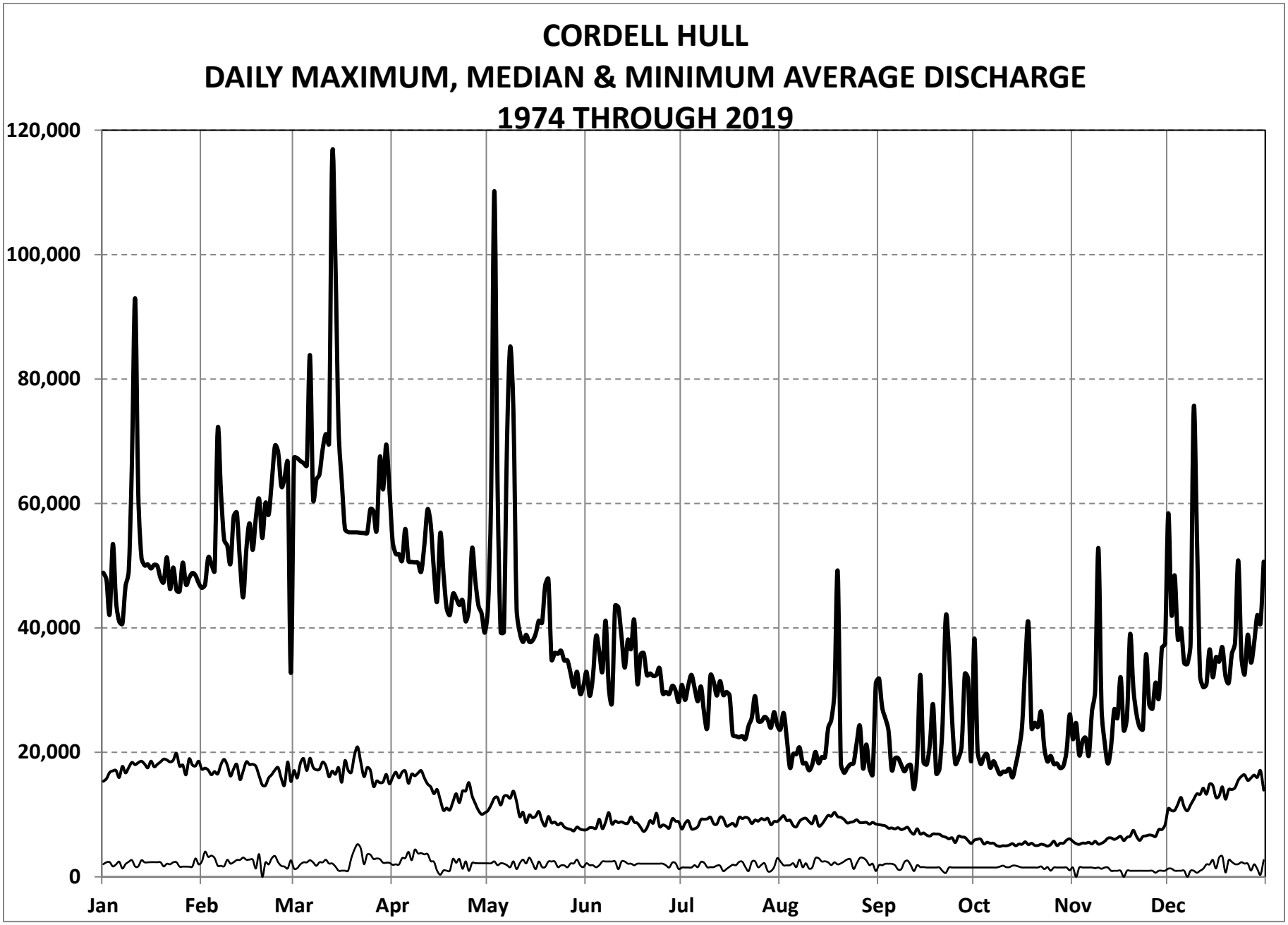

Plate VIII - 17. Cordell Hull Maximum, Median & Minimum Daily Average Discharges

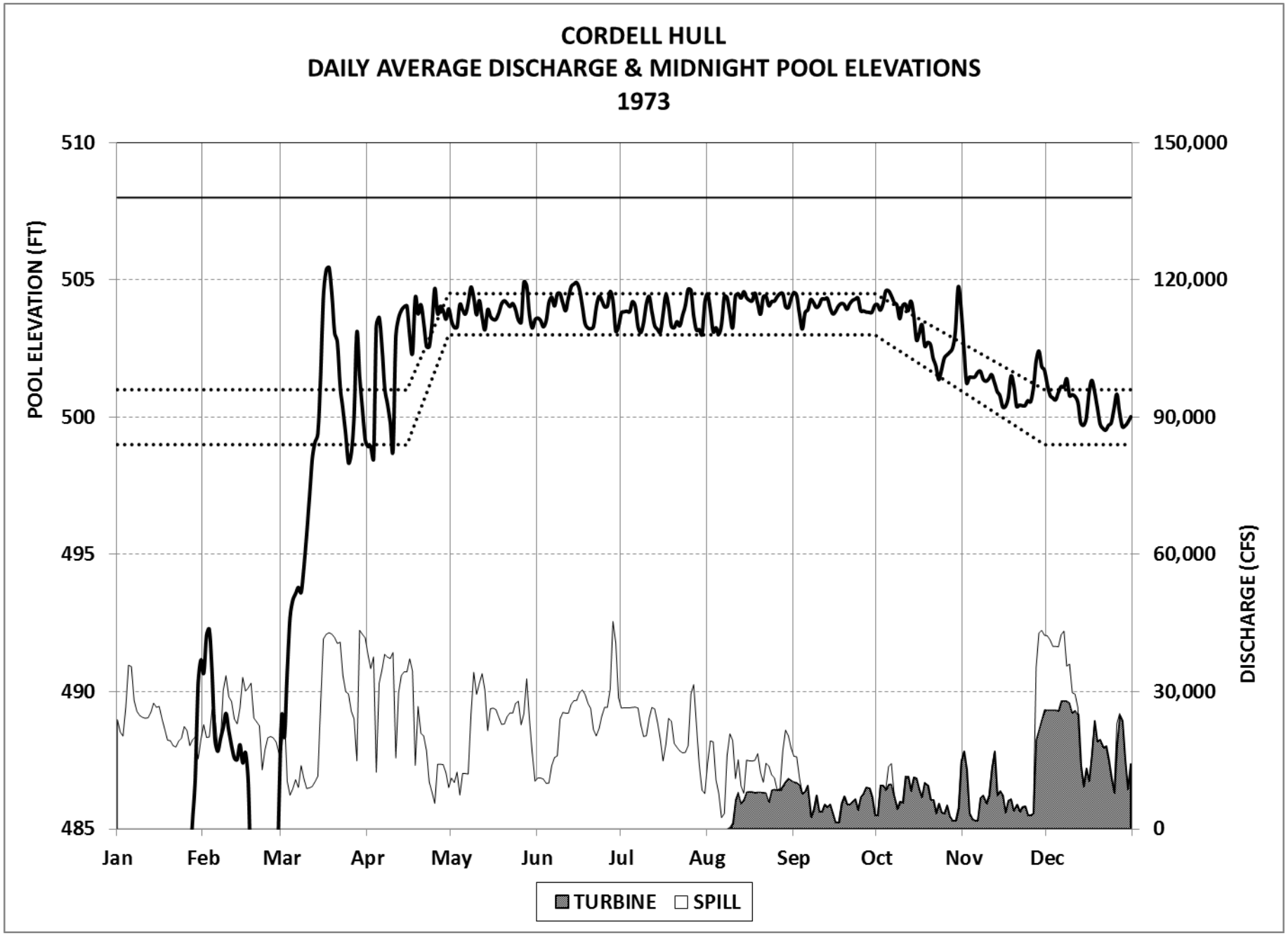

Plate VIII - 18. Historical Pool Elevations and Discharges, 1973

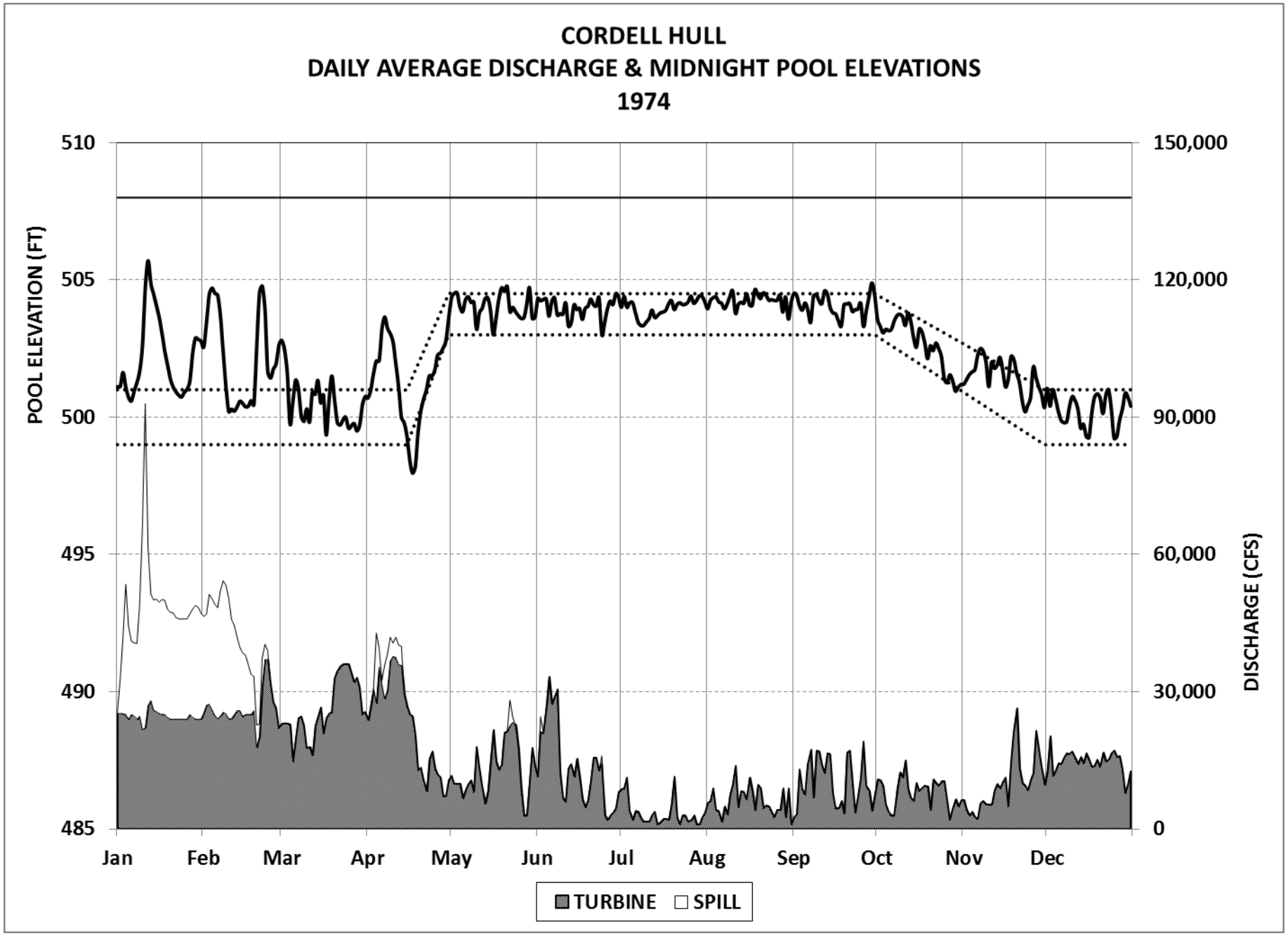

Plate VIII - 19. Historical Pool Elevations and Discharges, 1974

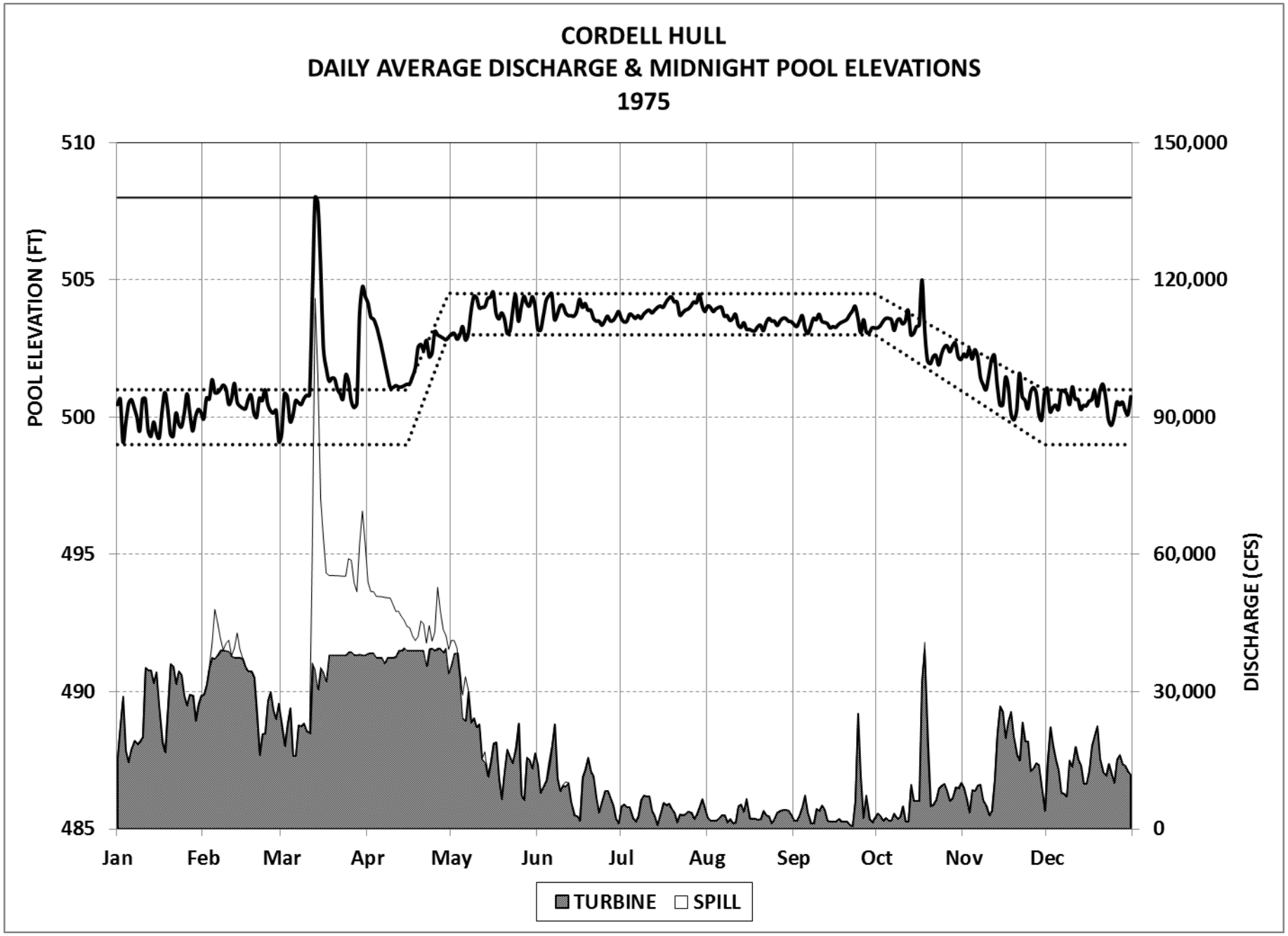

Plate VIII - 20. Historical Pool Elevations and Discharges, 1975

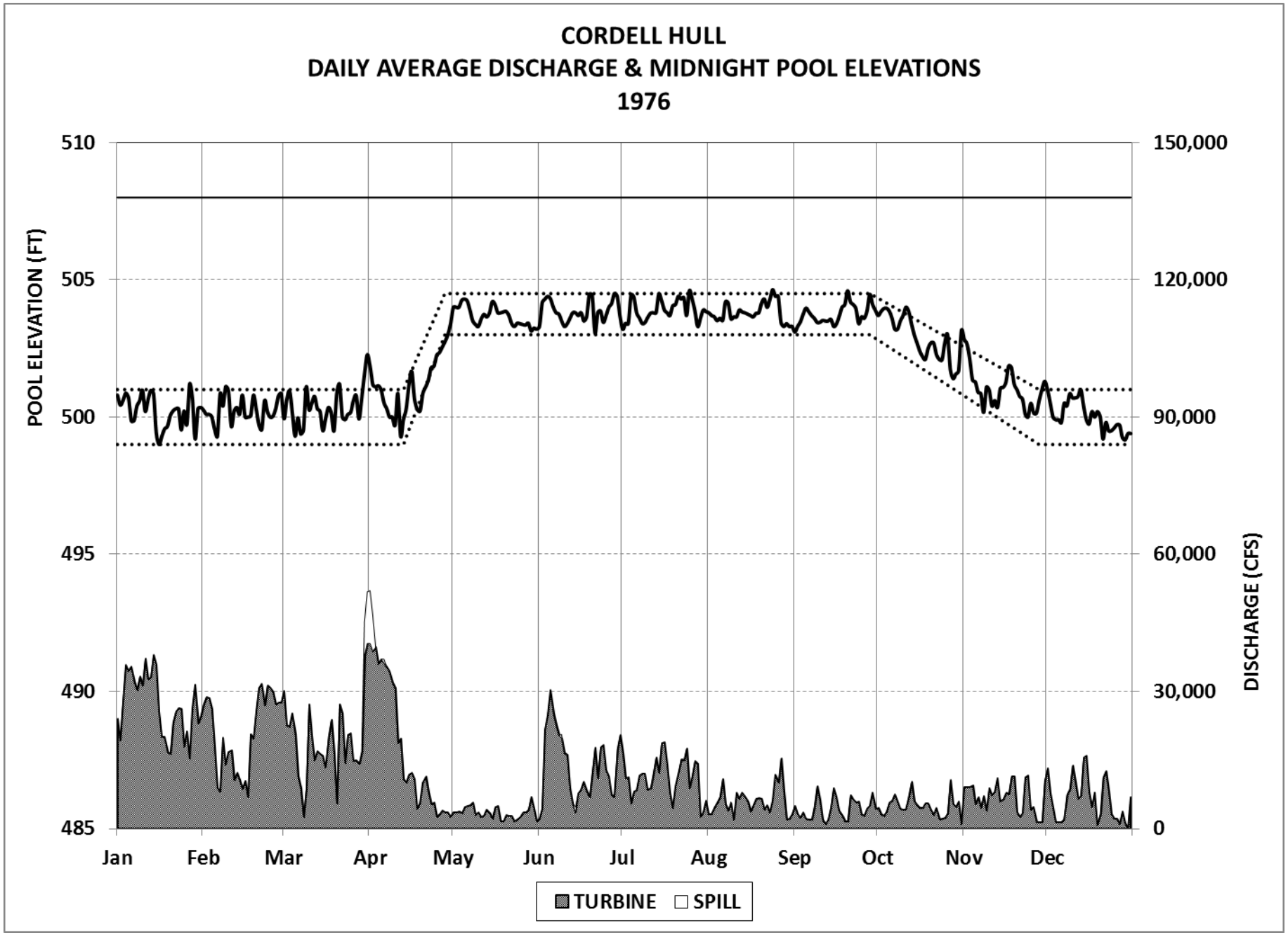

Plate VIII - 21. Historical Pool Elevations and Discharges, 1976

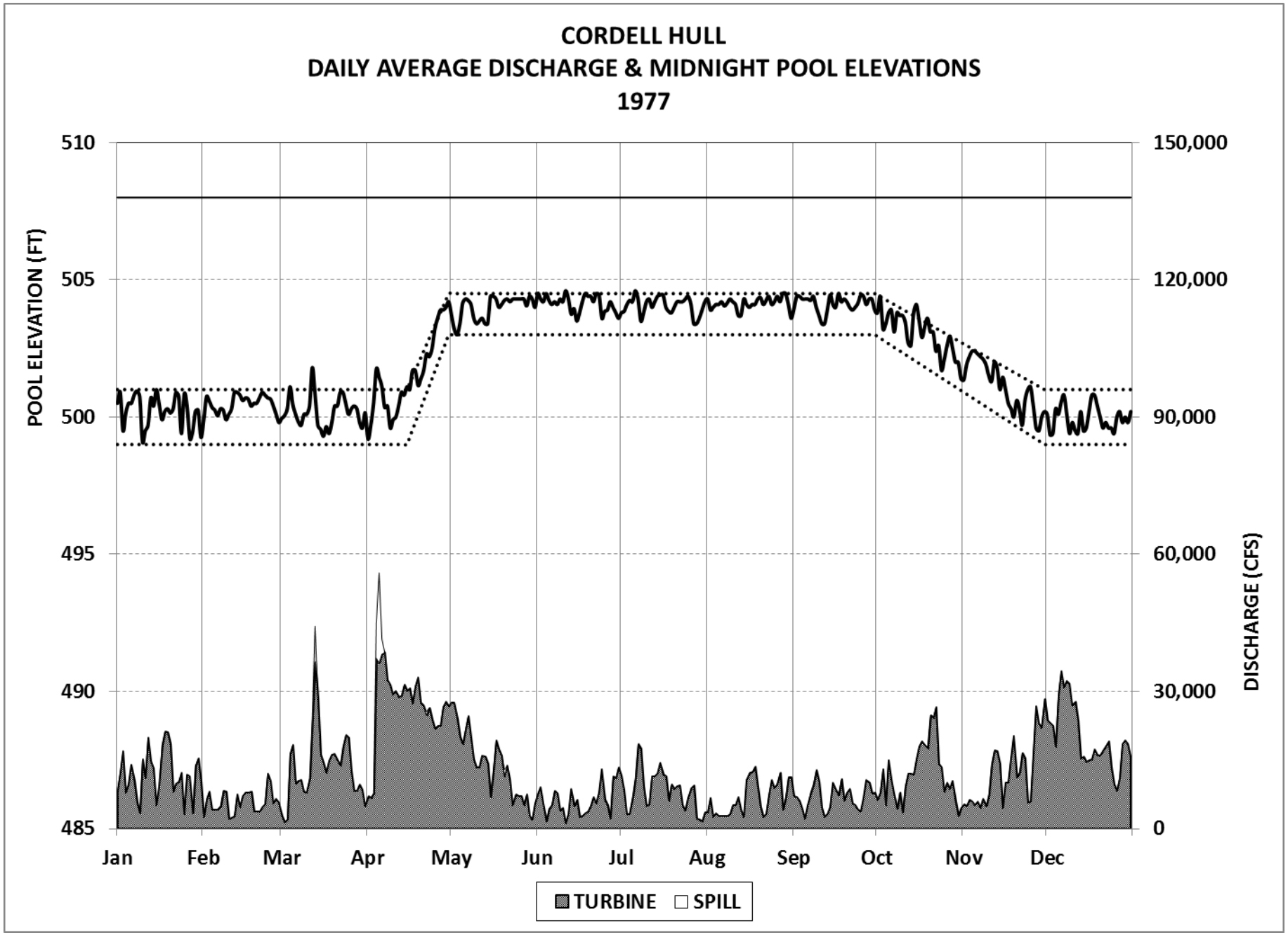

Plate VIII - 22. Historical Pool Elevations and Discharges, 1977

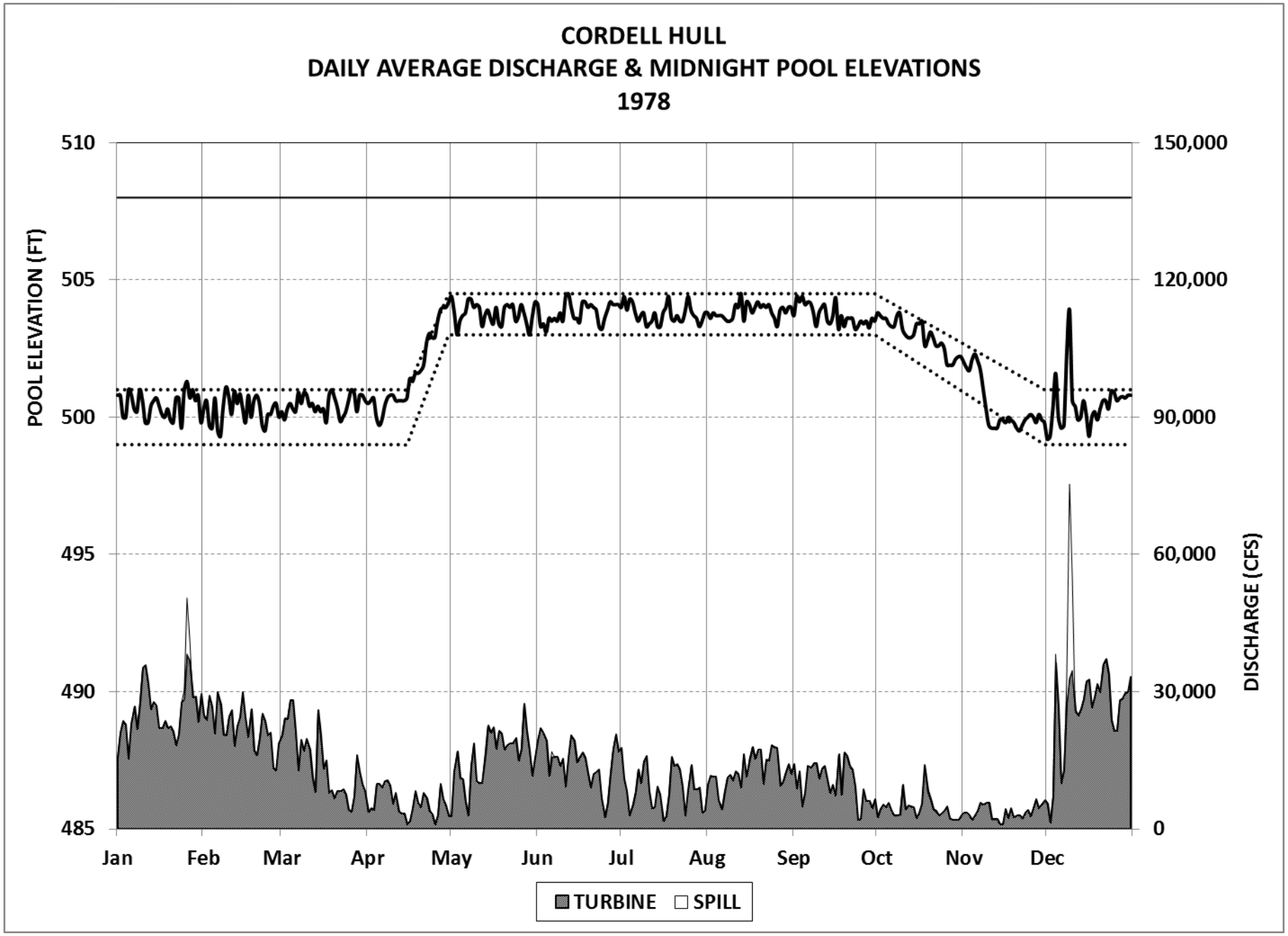

Plate VIII - 23. Historical Pool Elevations and Discharges, 1978

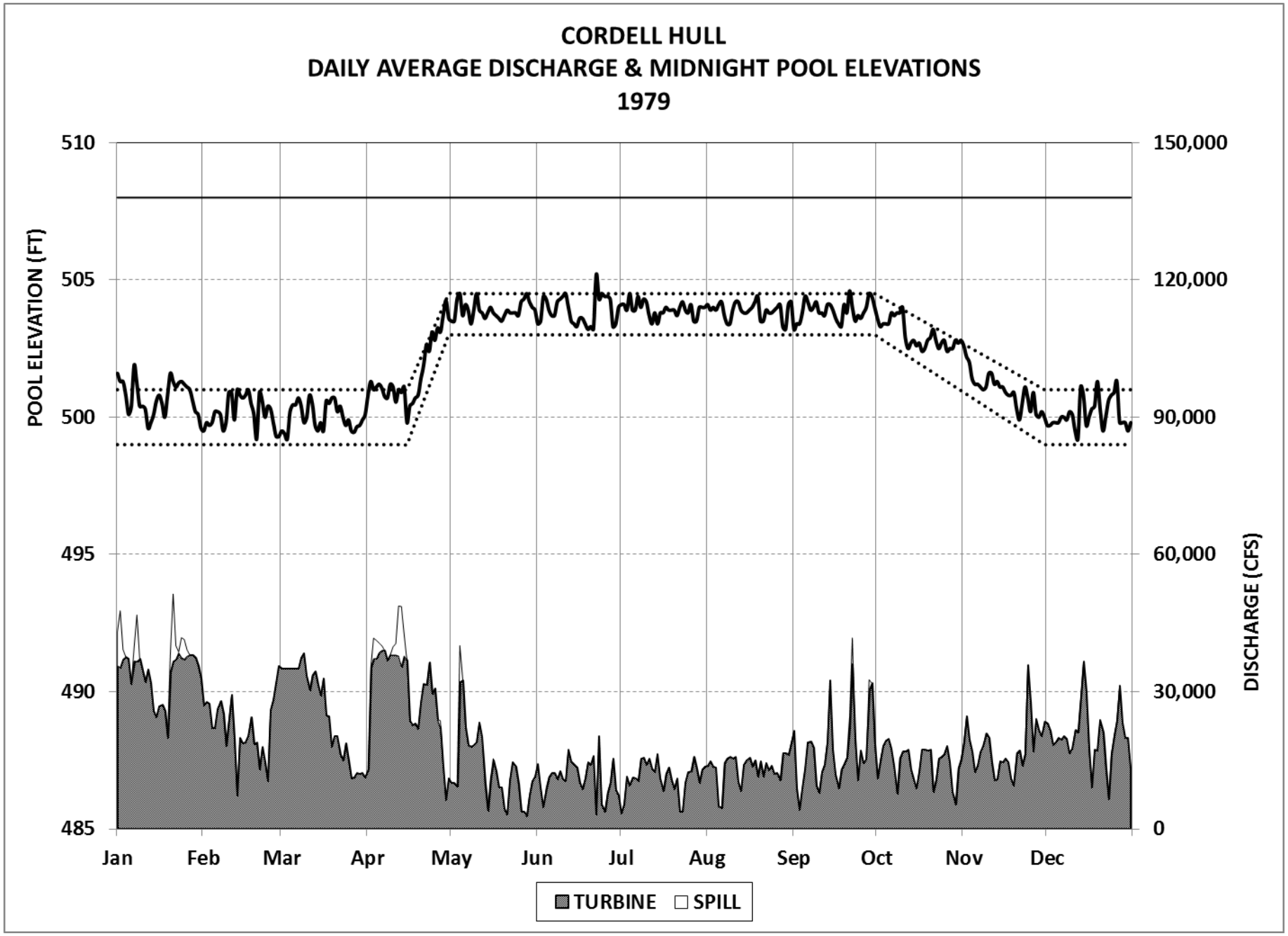

Plate VIII - 24. Historical Pool Elevations and Discharges, 1979

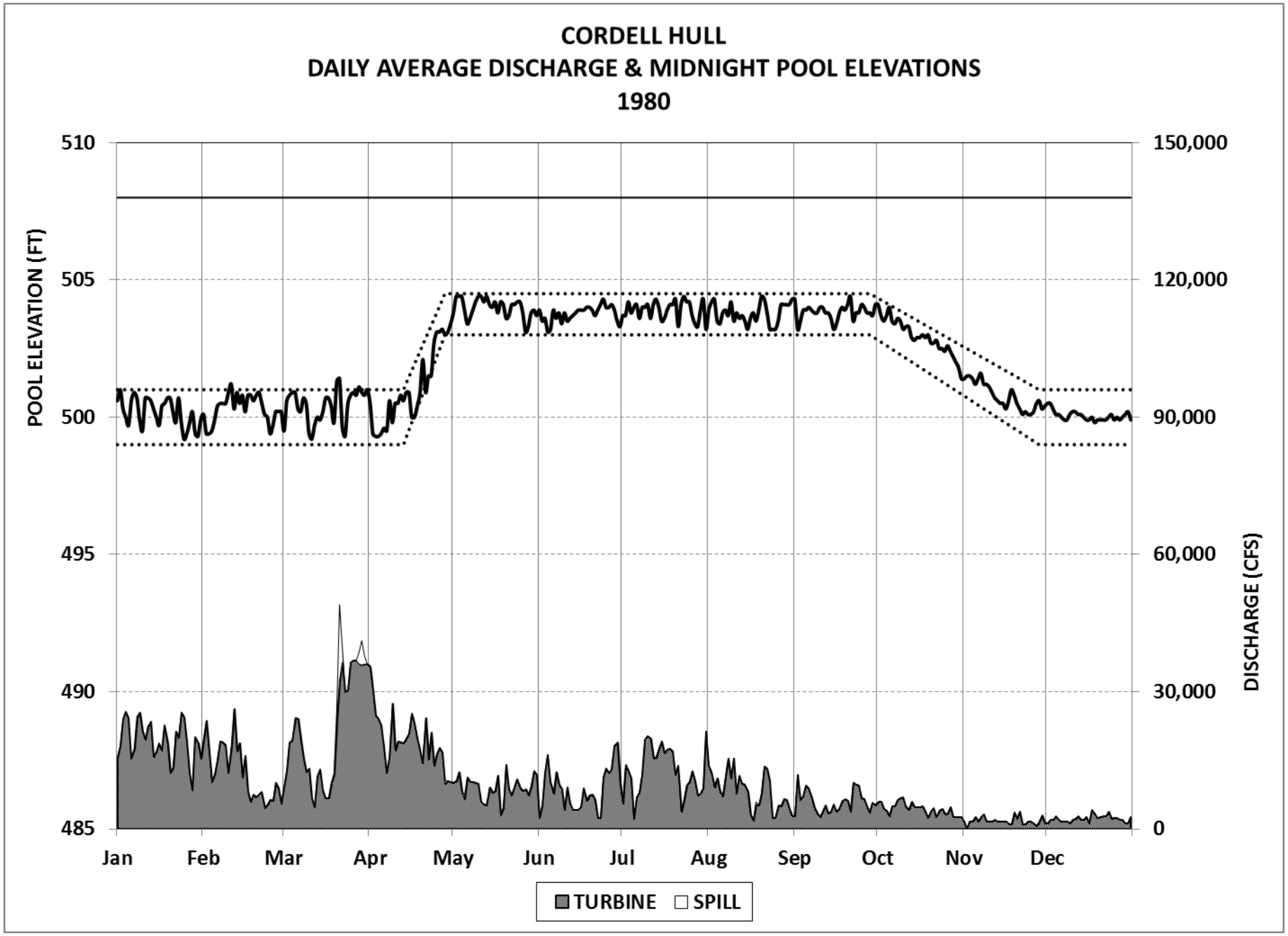

Plate VIII - 25. Historical Pool Elevations and Discharges, 1980

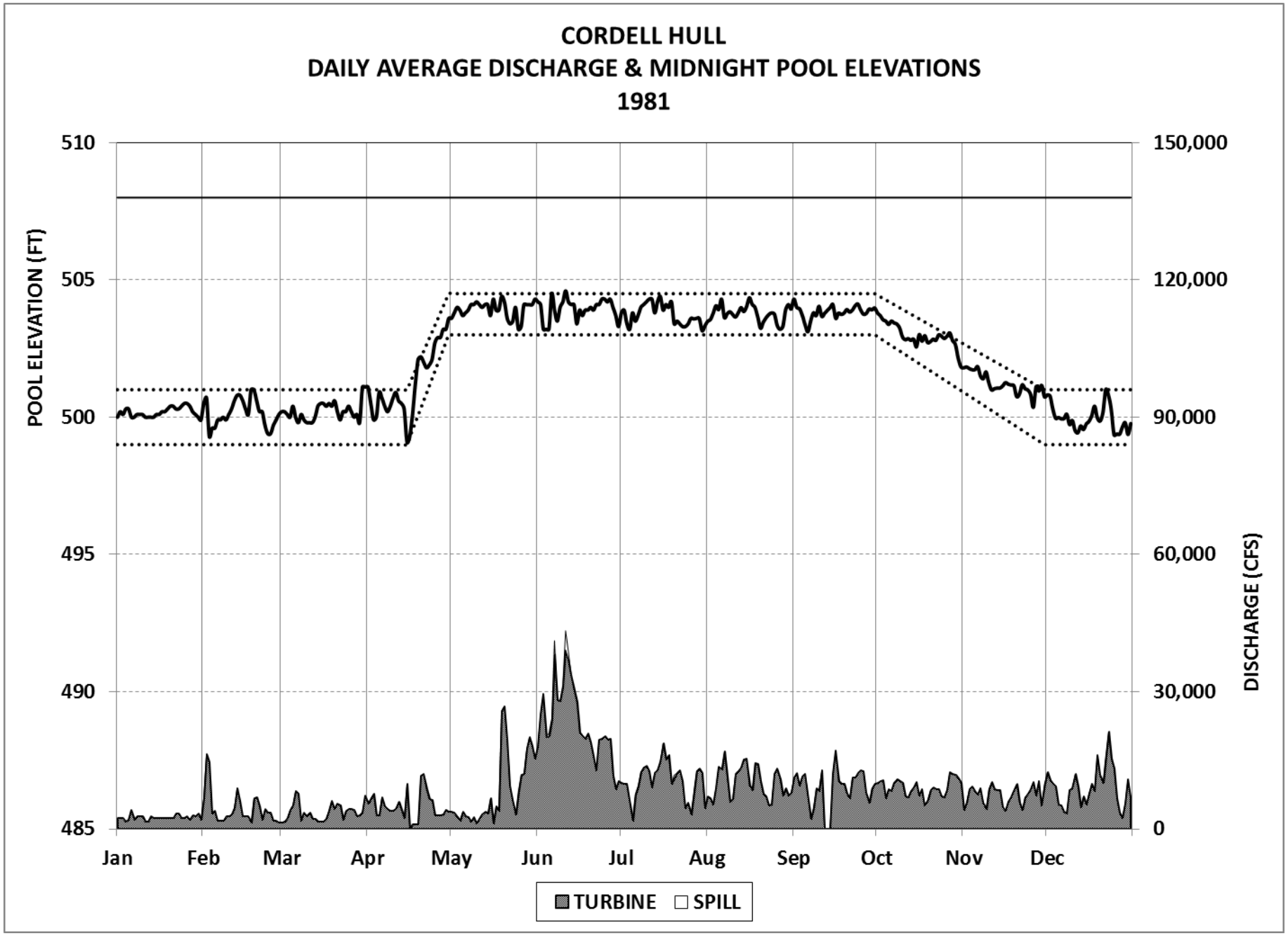

Plate VIII - 26. Historical Pool Elevations and Discharges, 1981

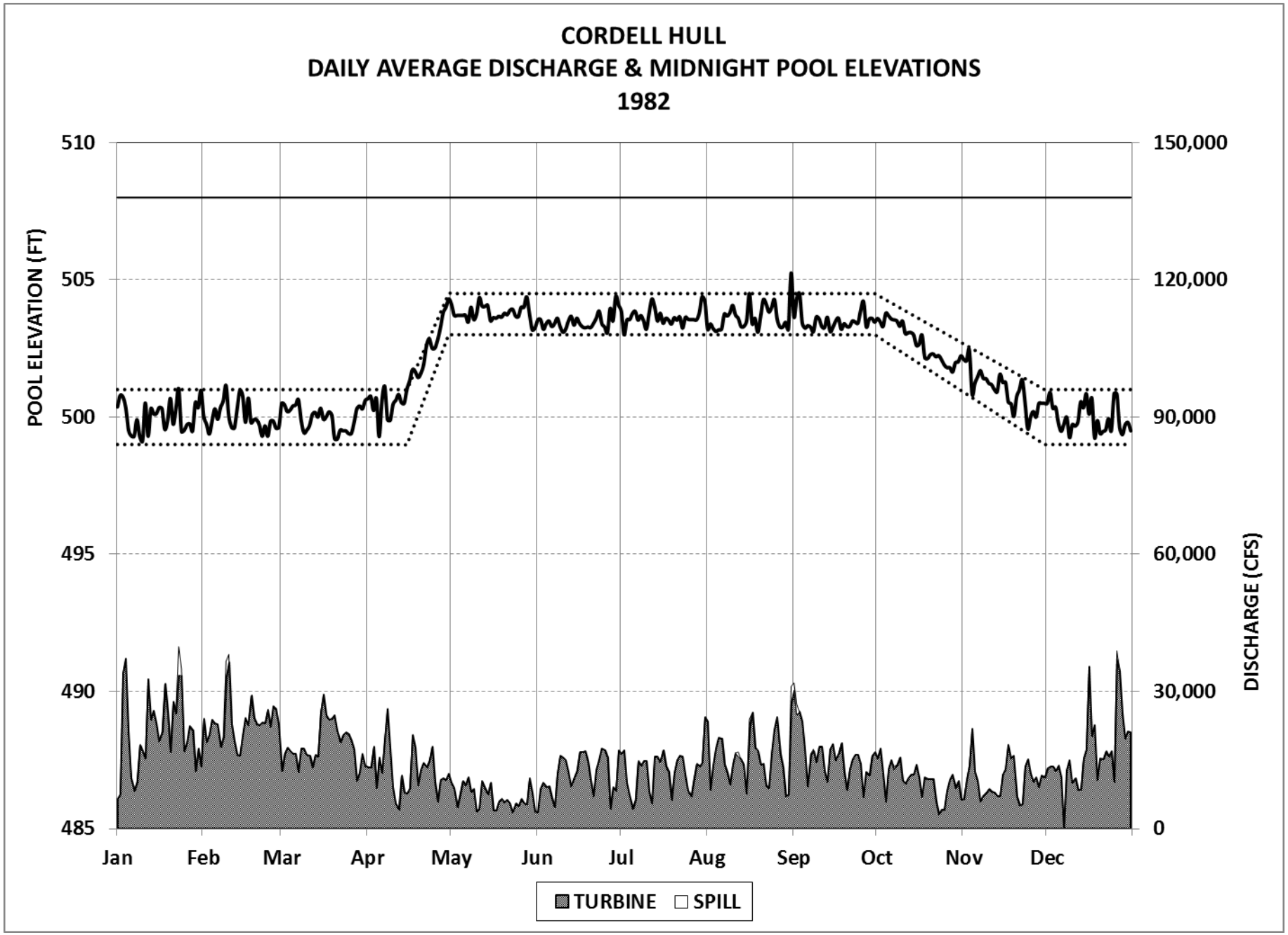

Plate VIII - 27. Historical Pool Elevations and Discharges, 1982

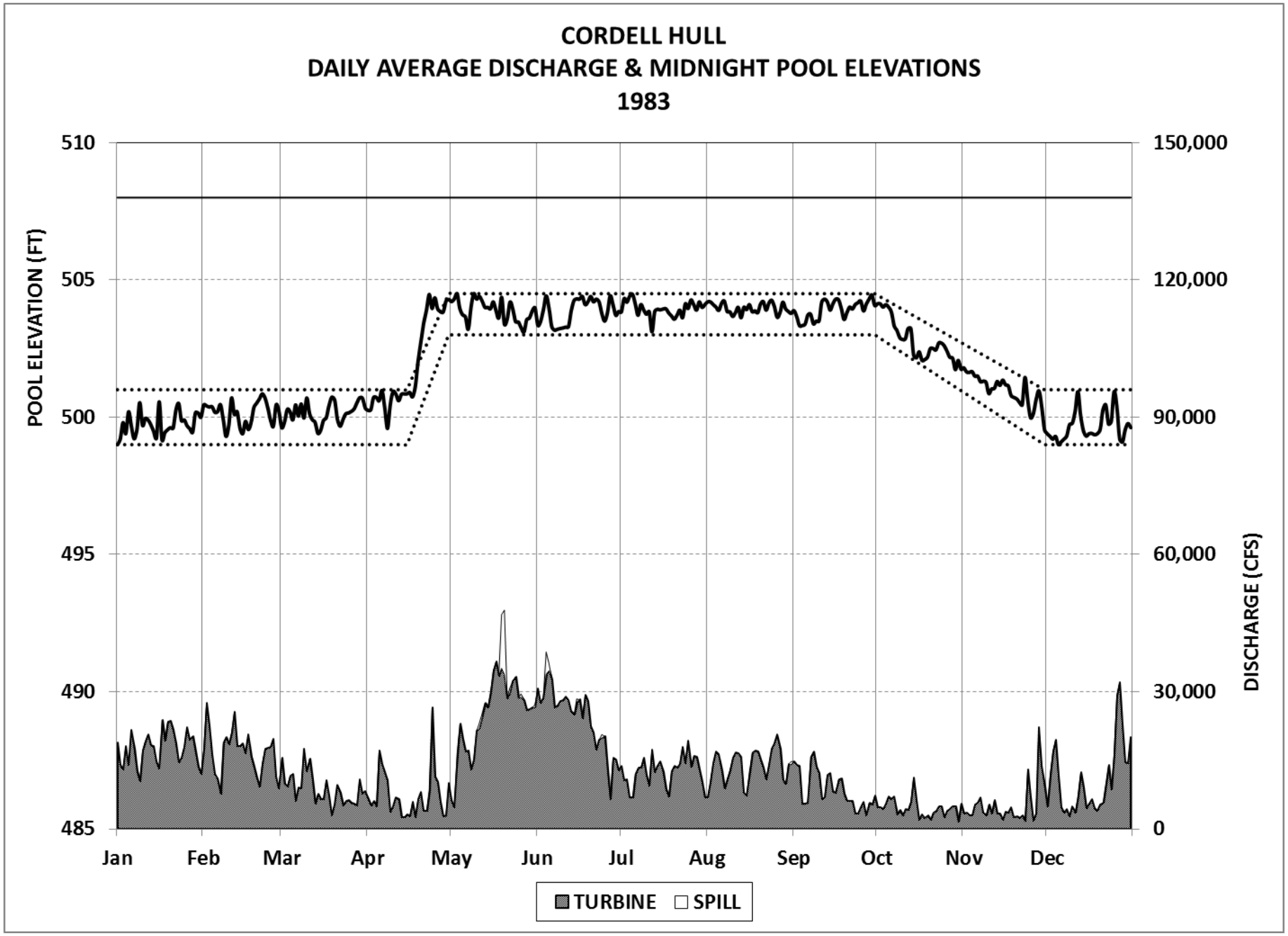

Plate VIII - 28. Historical Pool Elevations and Discharges, 1983

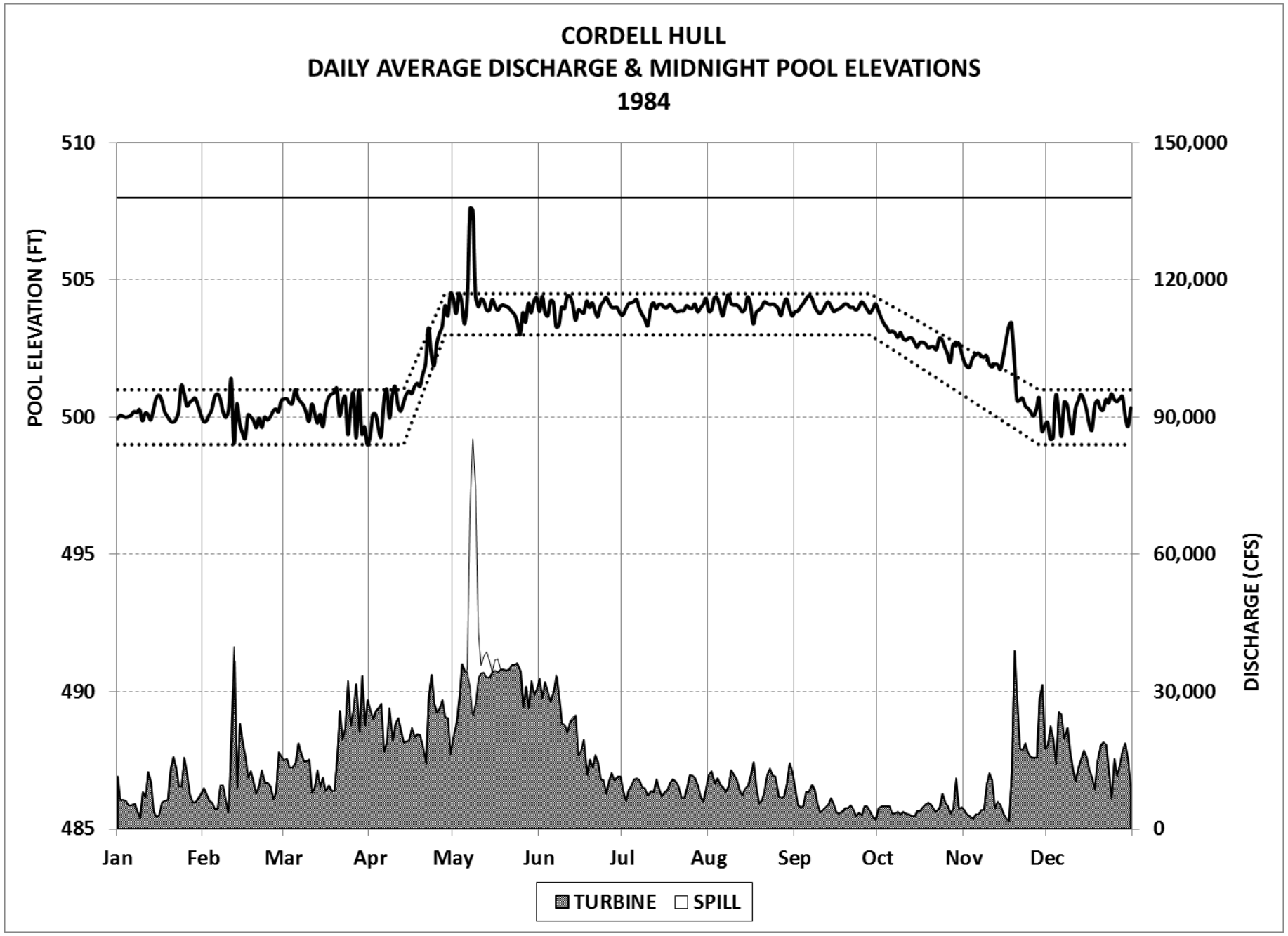

Plate VIII - 29. Historical Pool Elevations and Discharges, 1984

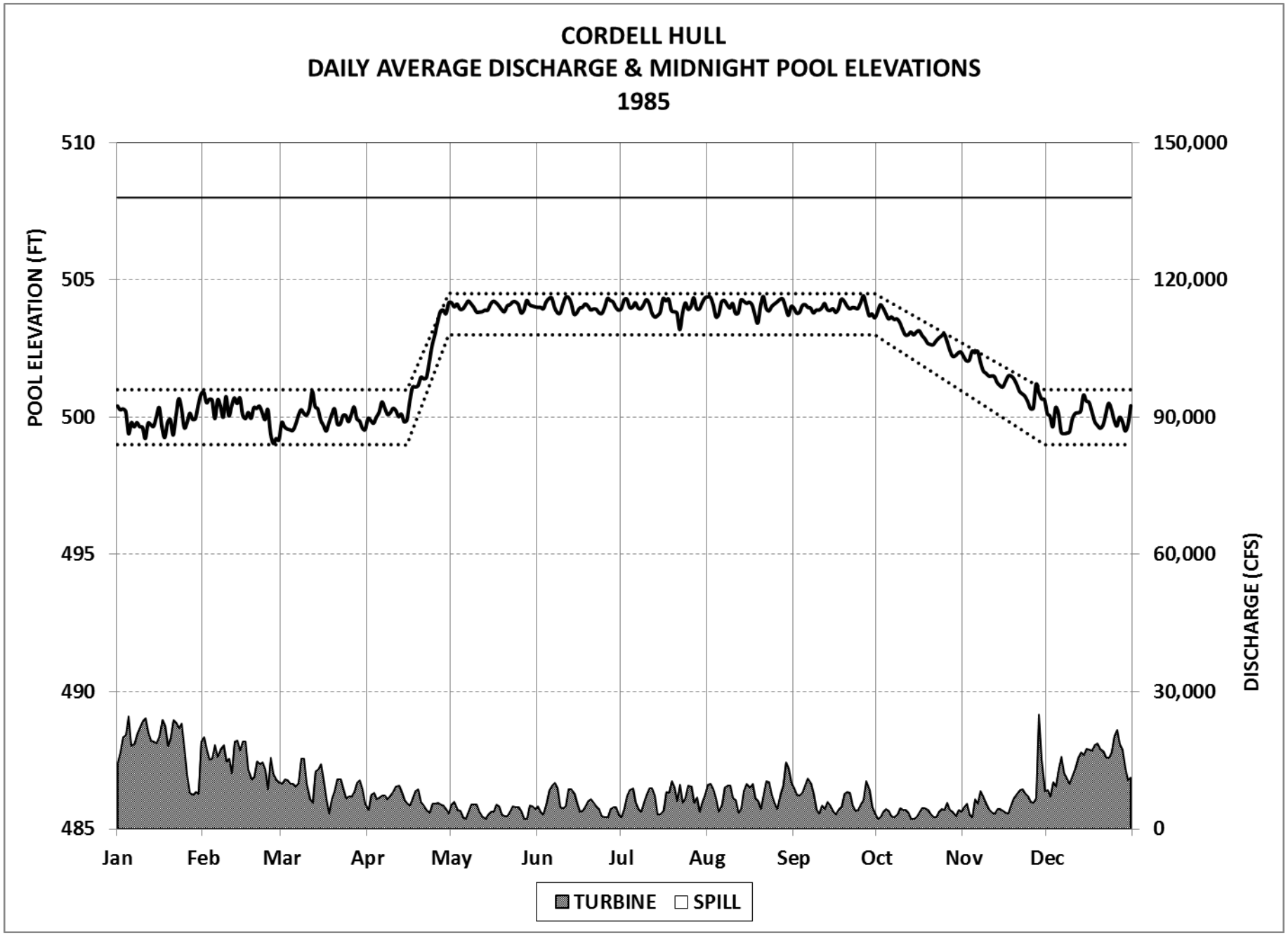

Plate VIII - 30. Historical Pool Elevations and Discharges, 1985

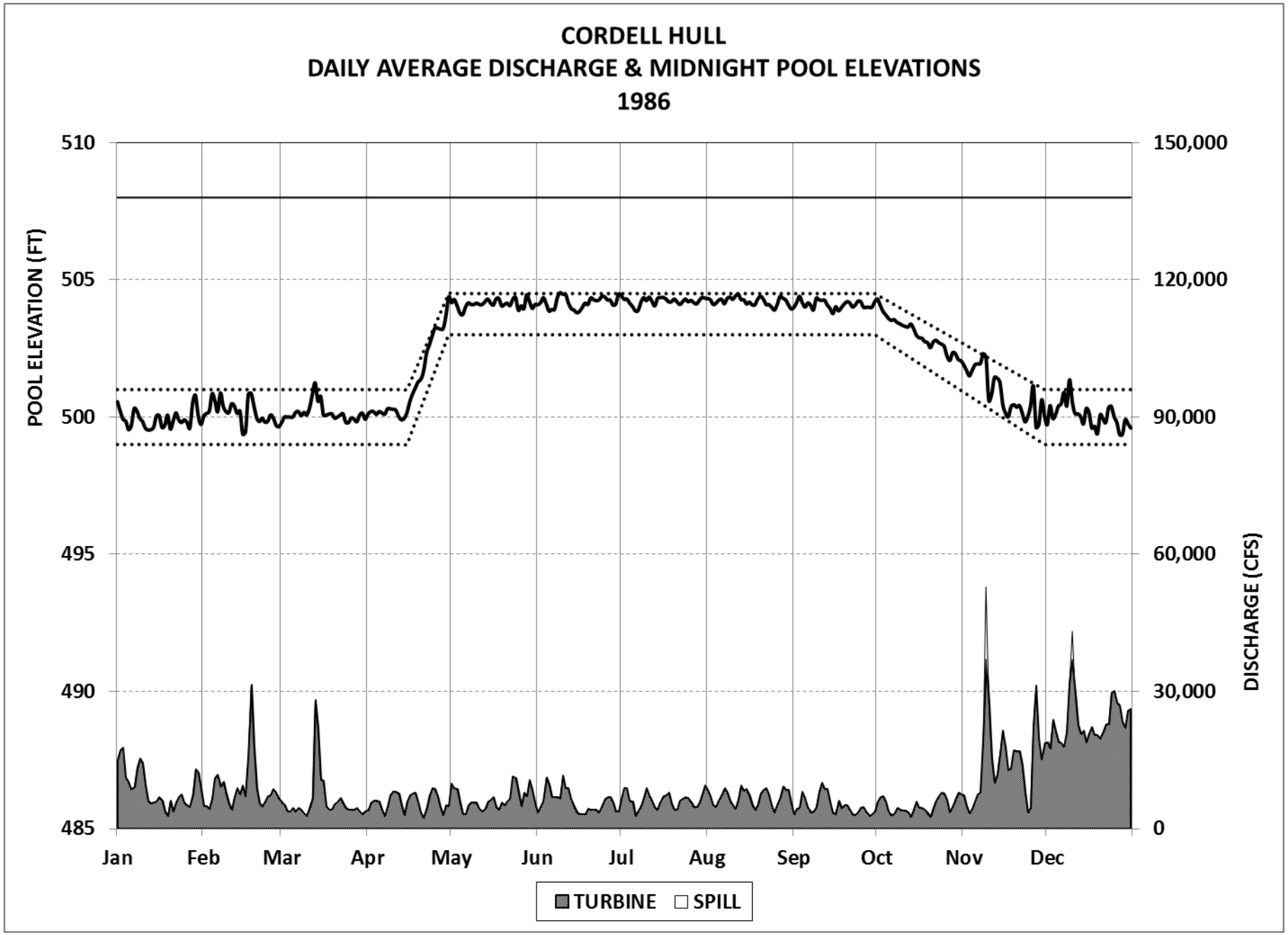

Plate VIII - 31. Historical Pool Elevations and Discharges, 1986

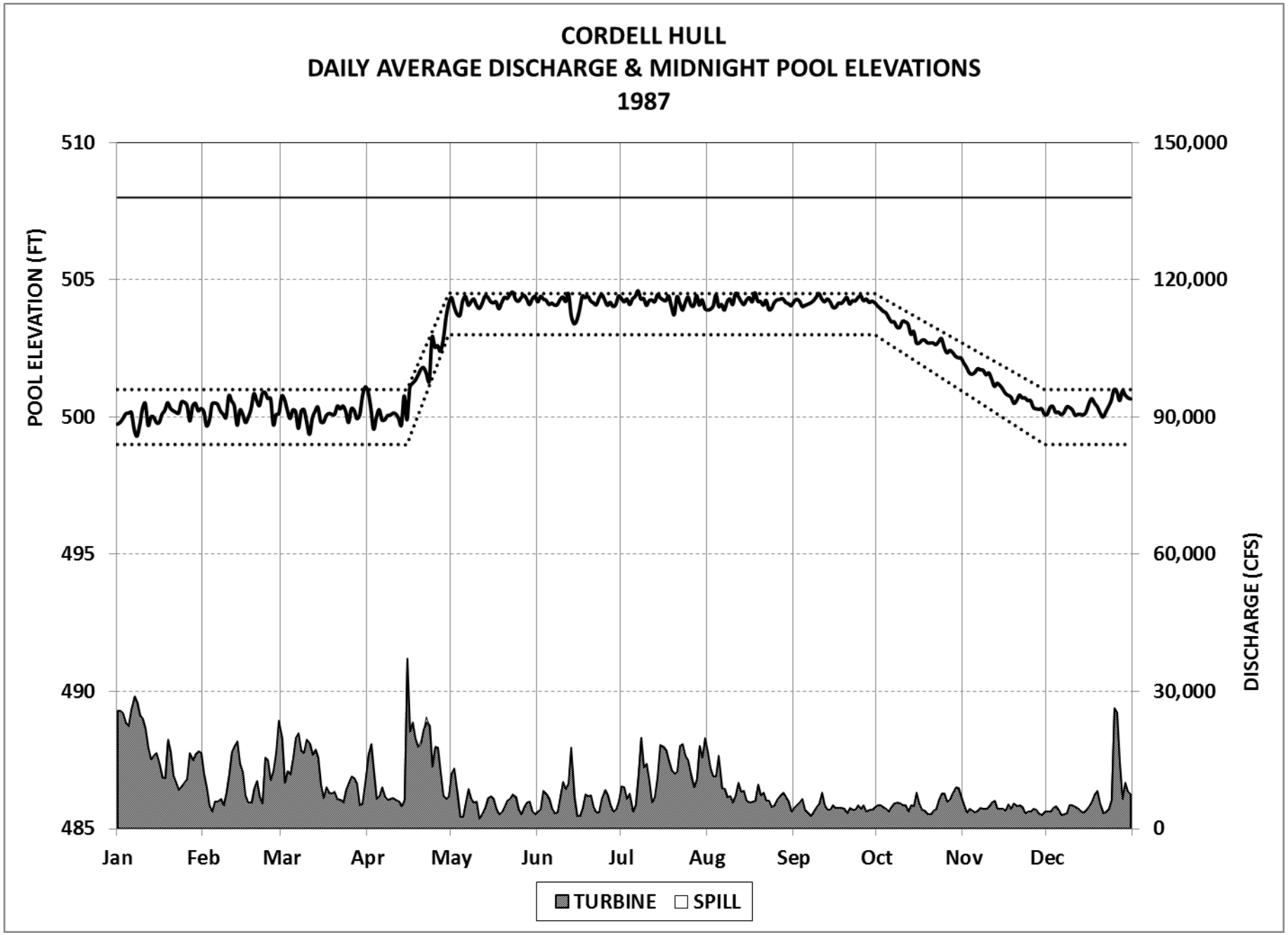

Plate VIII - 32. Historical Pool Elevations and Discharges, 1987

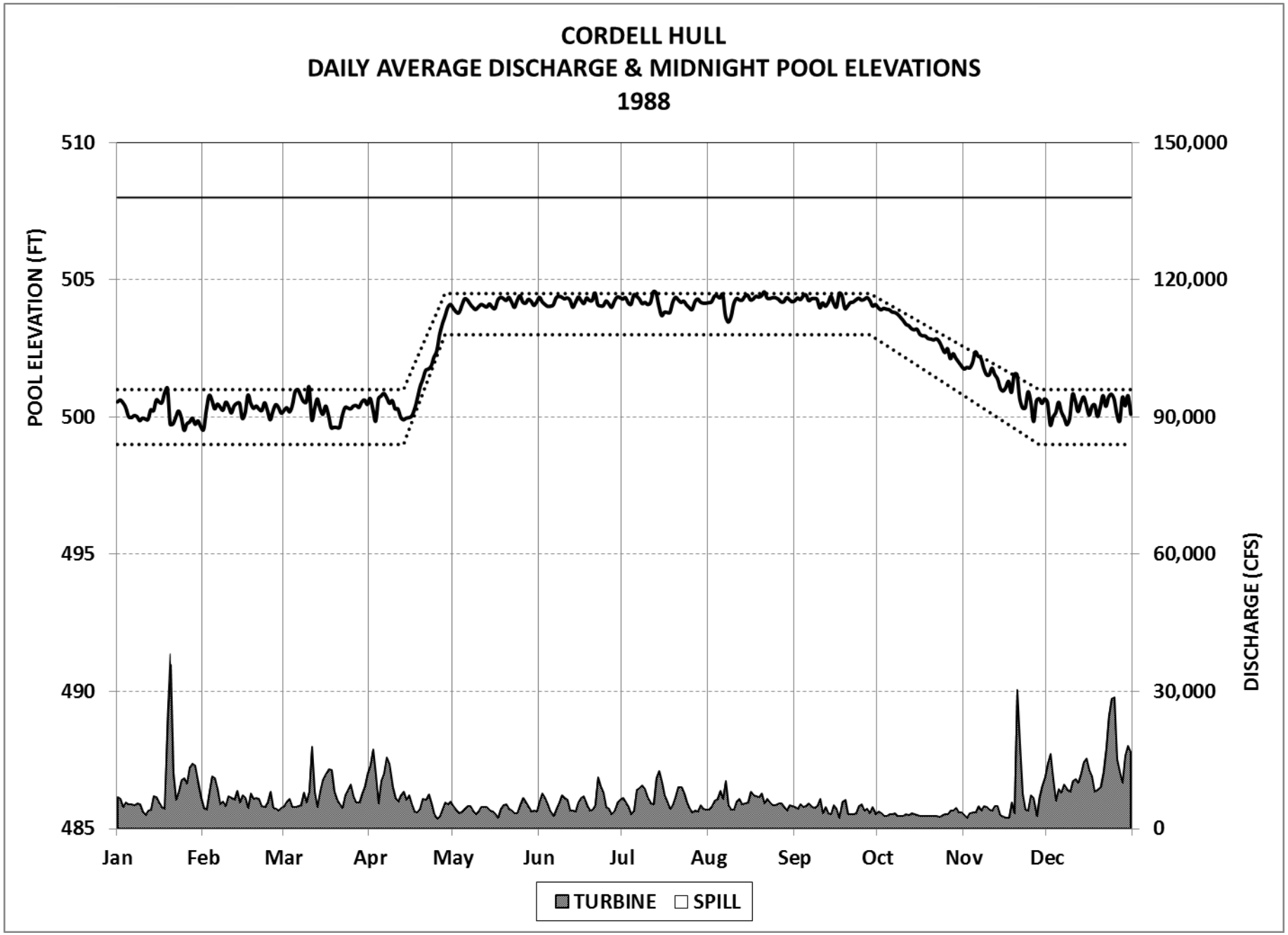

Plate VIII - 33. Historical Pool Elevations and Discharges, 1988

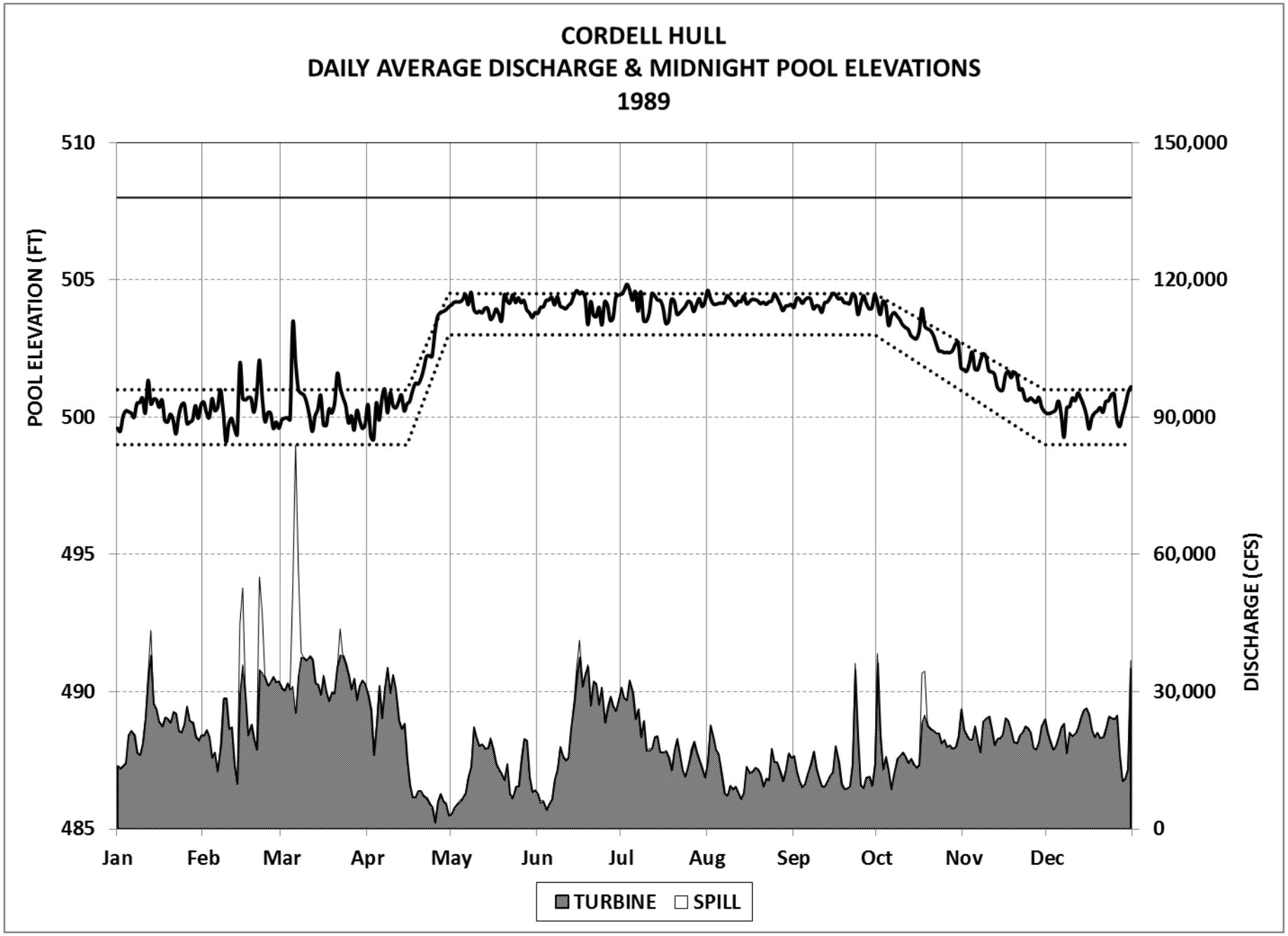

Plate VIII - 34. Historical Pool Elevations and Discharges, 1989

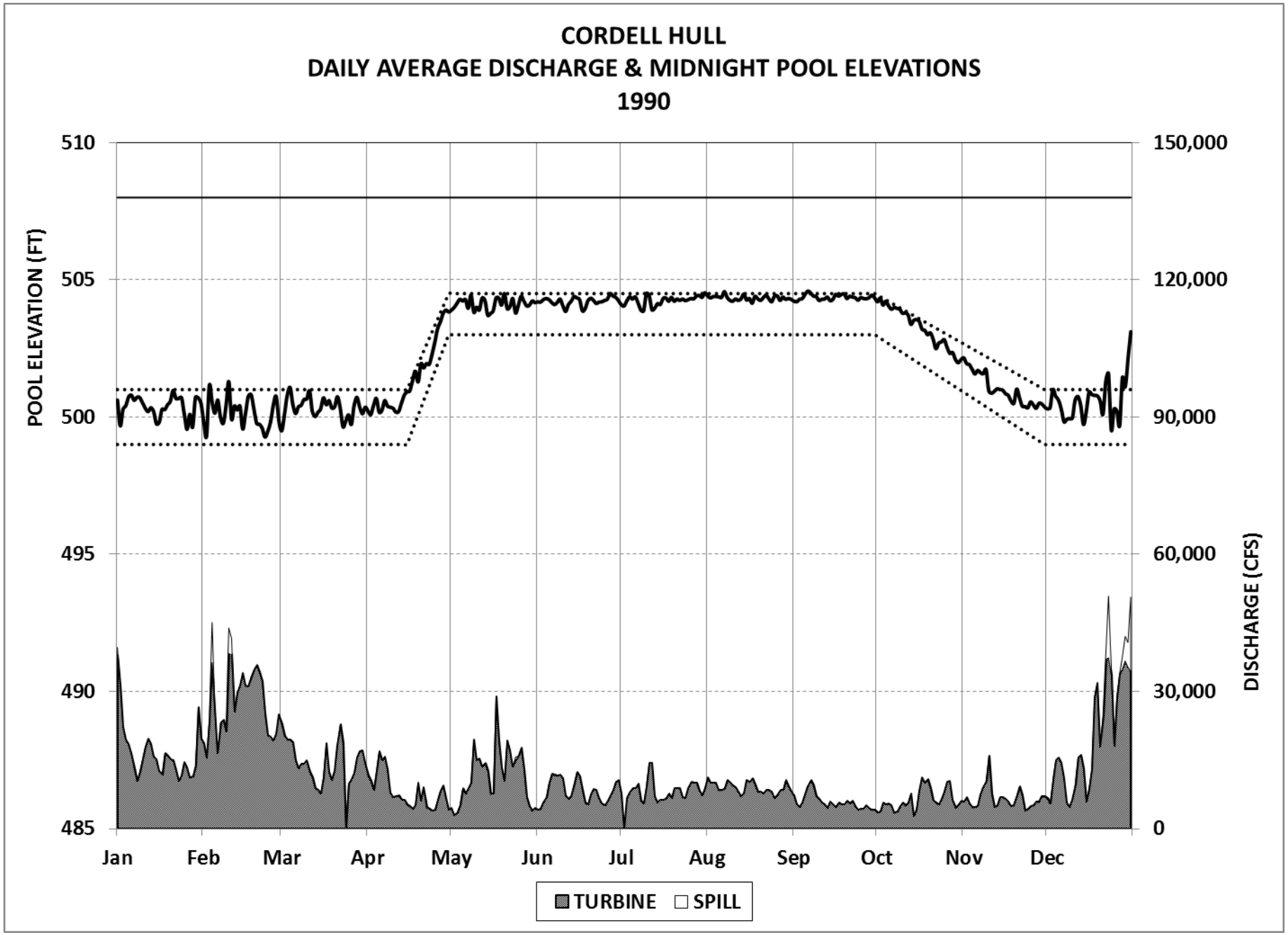

Plate VIII - 35. Historical Pool Elevations and Discharges, 1990

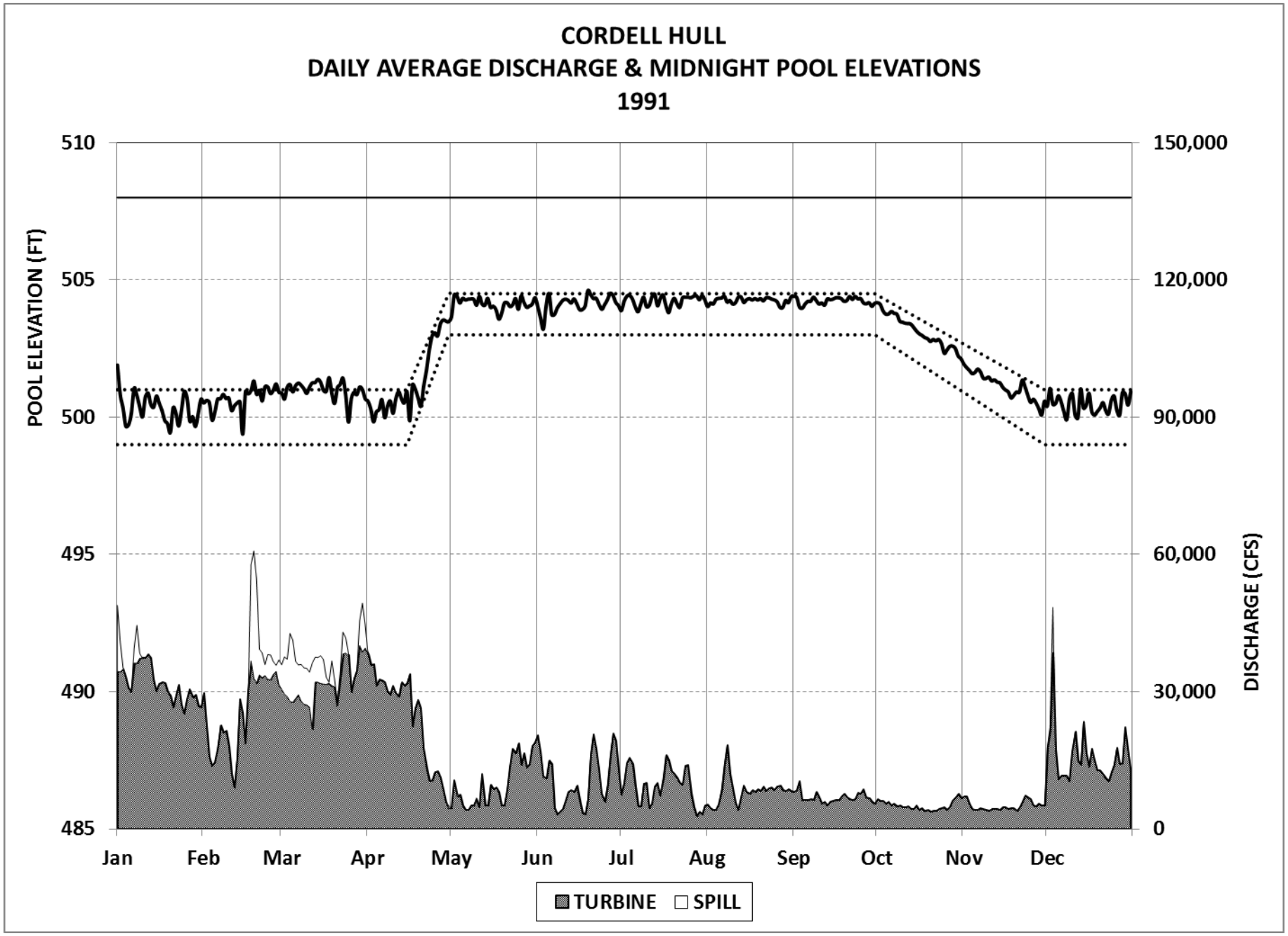

Plate VIII - 36. Historical Pool Elevations and Discharges, 1991

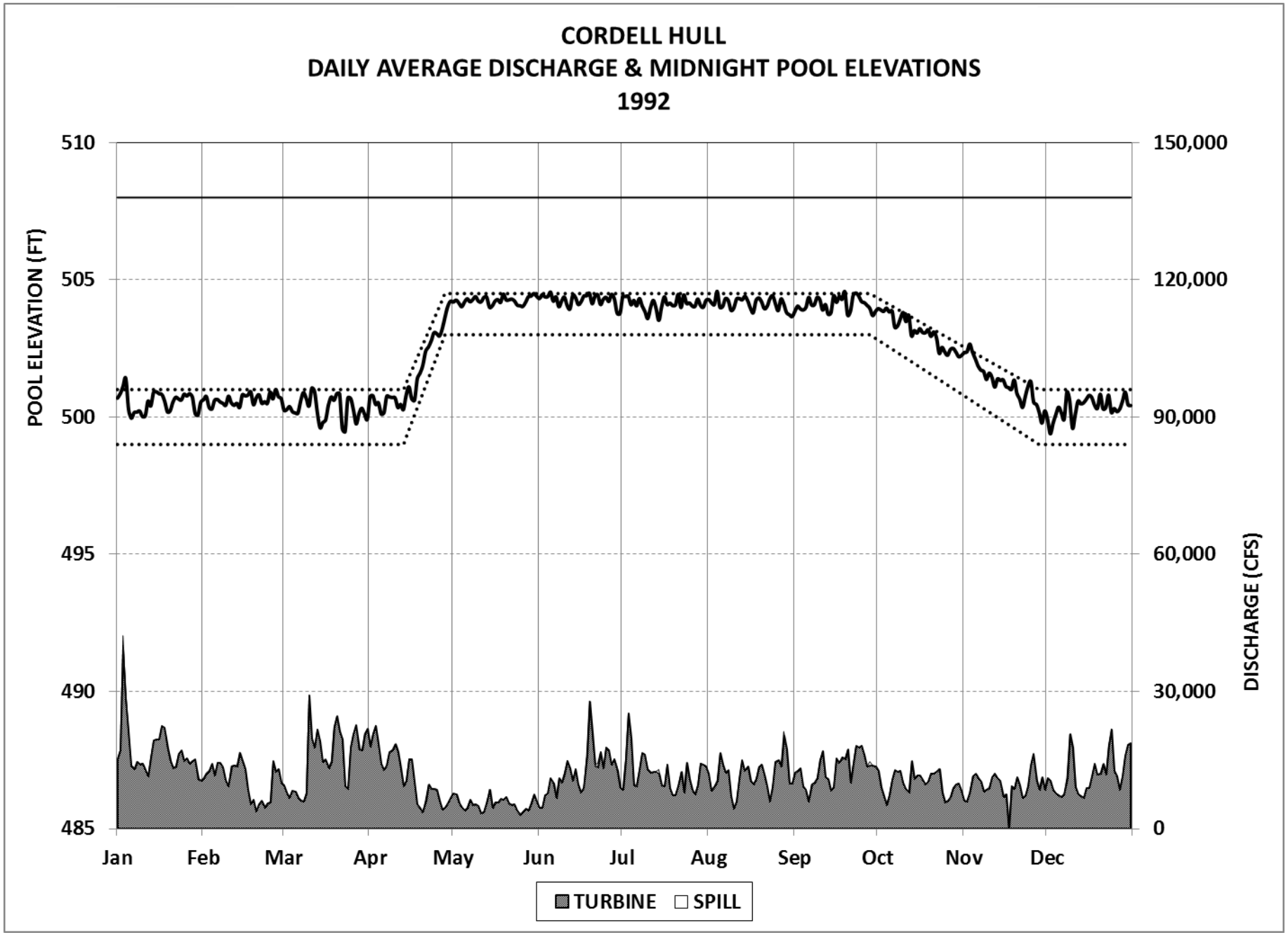

Plate VIII - 37. Historical Pool Elevations and Discharges, 1992

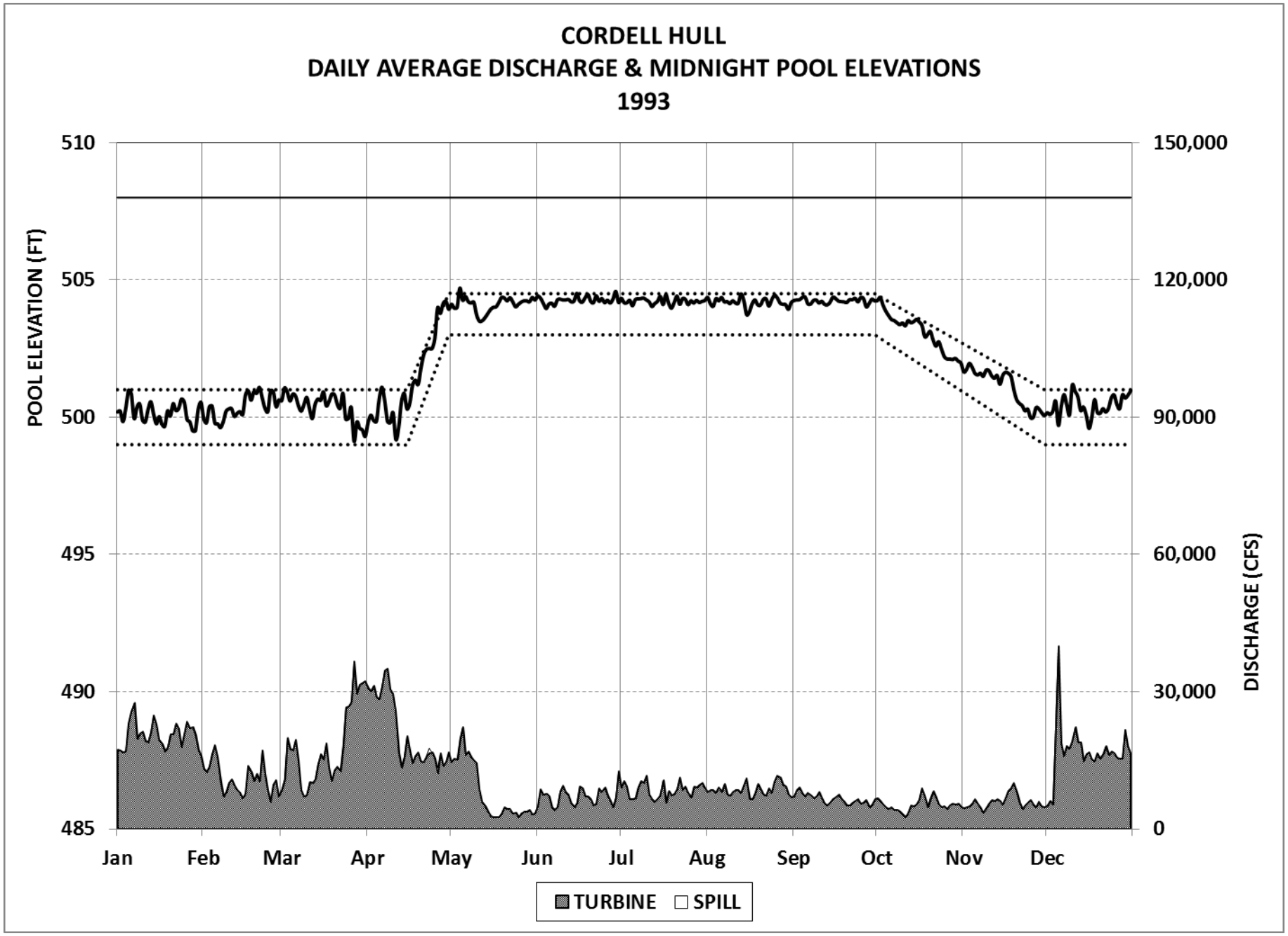

Plate VIII - 38. Historical Pool Elevations and Discharges, 1993

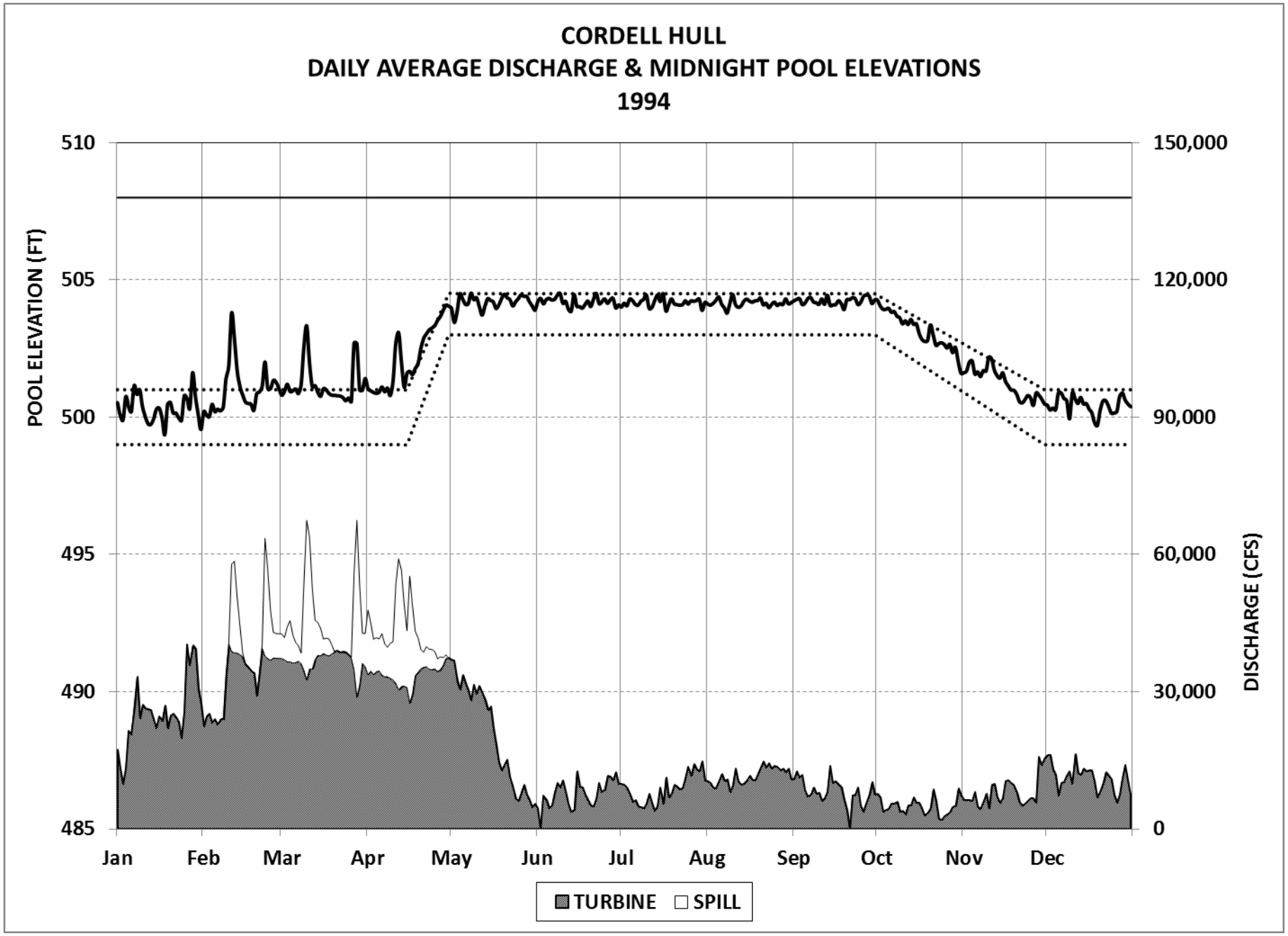

Plate VIII - 39. Historical Pool Elevations and Discharges, 1994

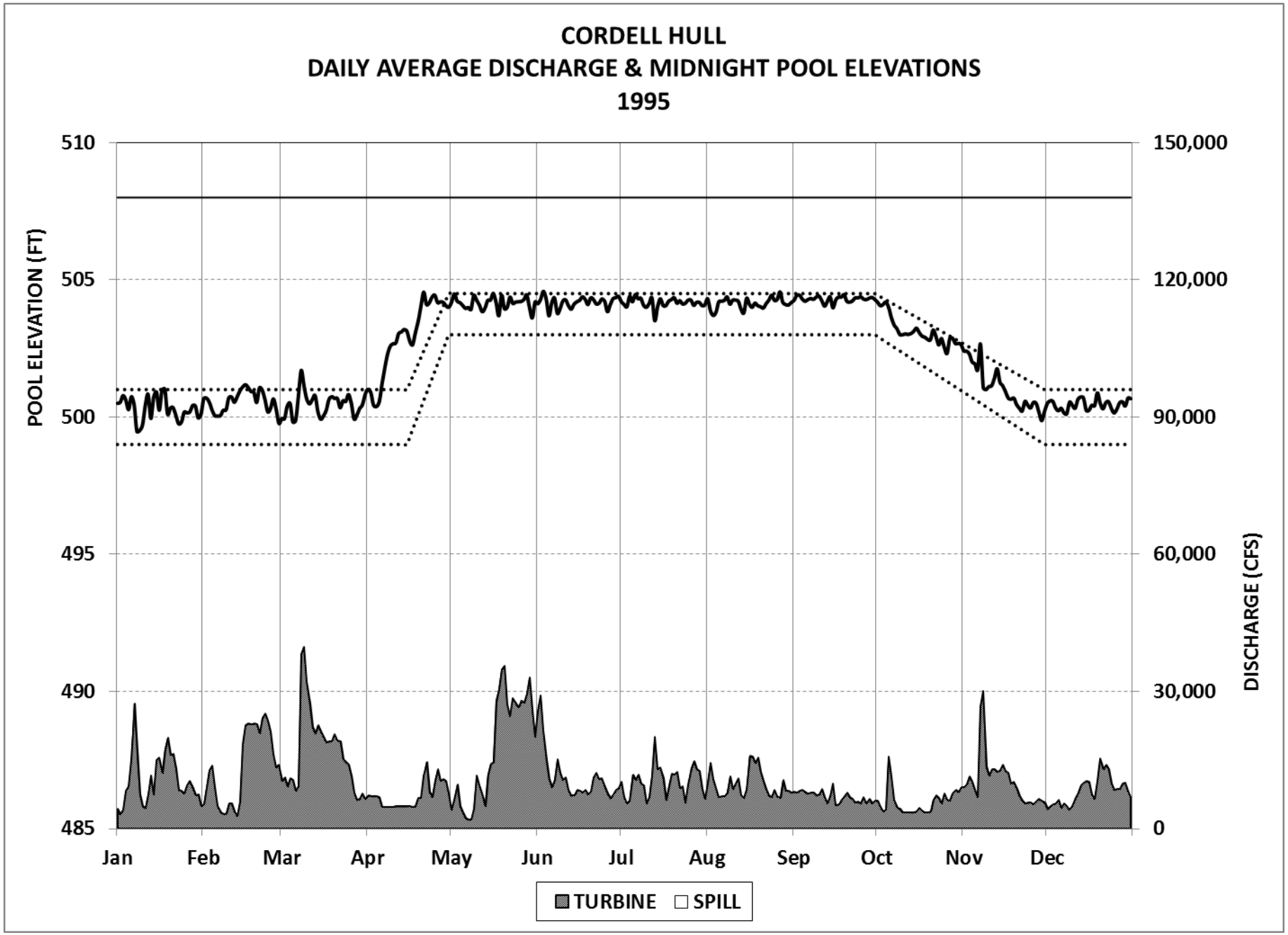

Plate VIII - 40. Historical Pool Elevations and Discharges, 1995

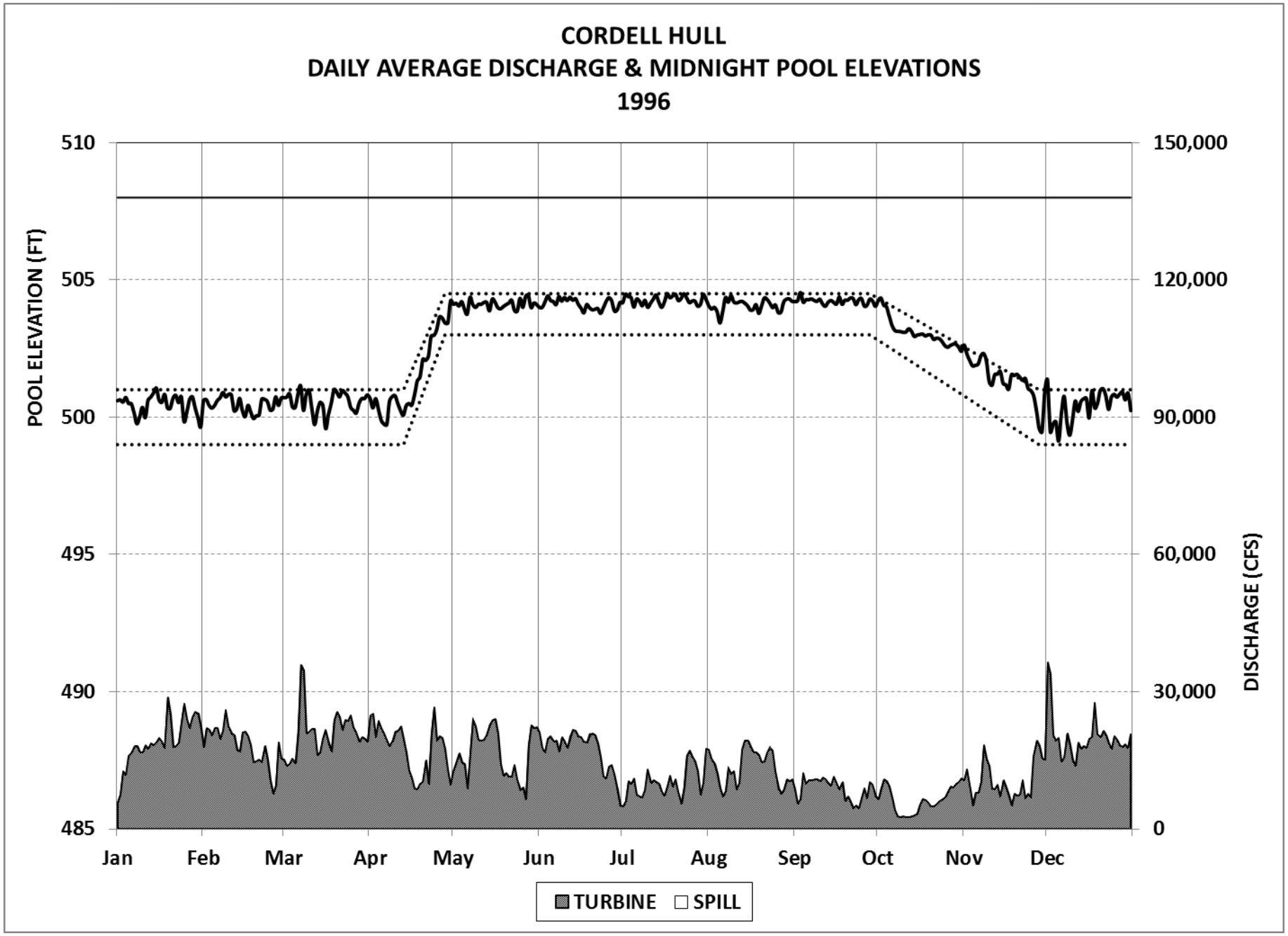

Plate VIII - 41. Historical Pool Elevations and Discharges, 1996

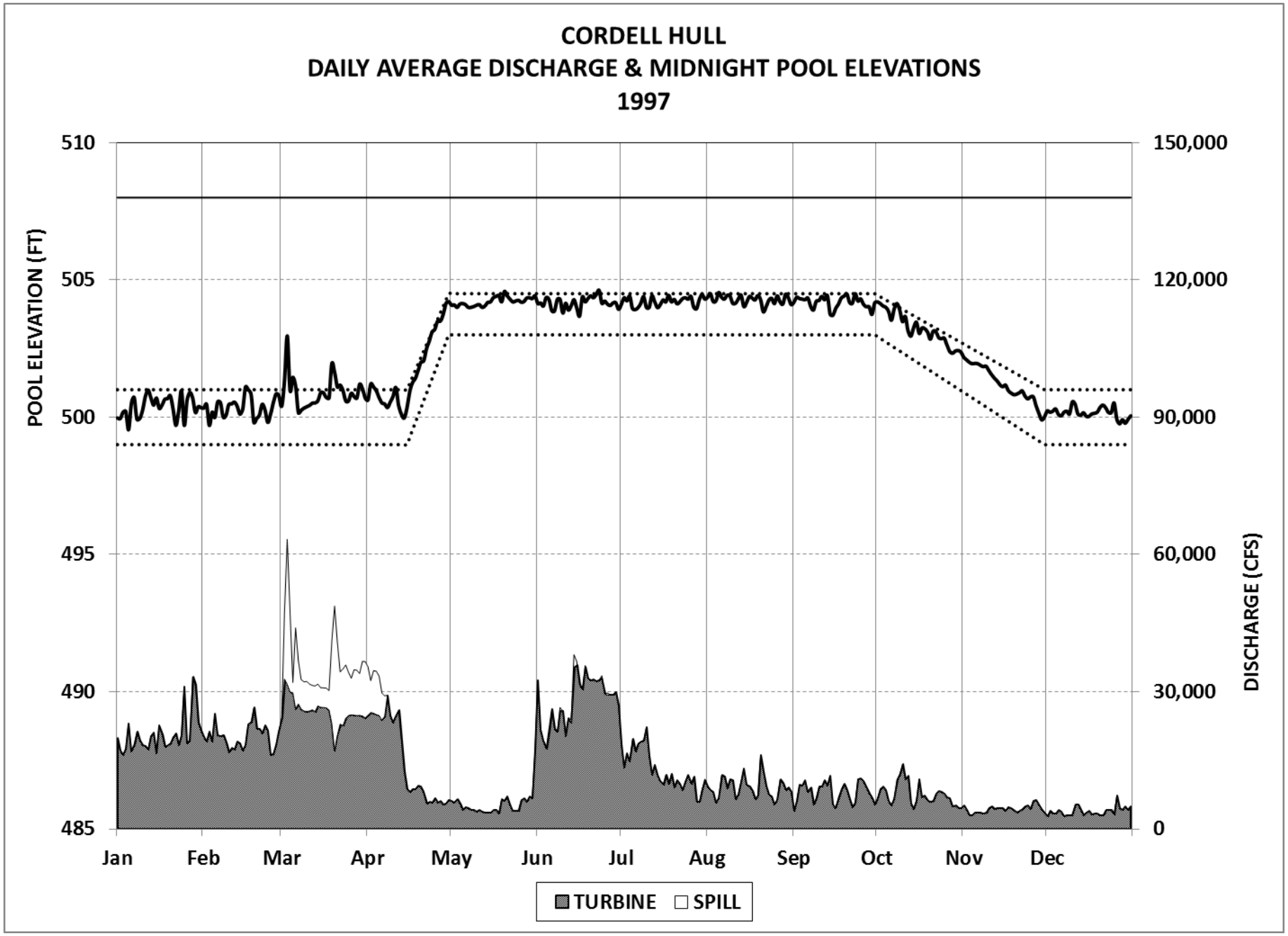

Plate VIII - 42. Historical Pool Elevations and Discharges, 1997

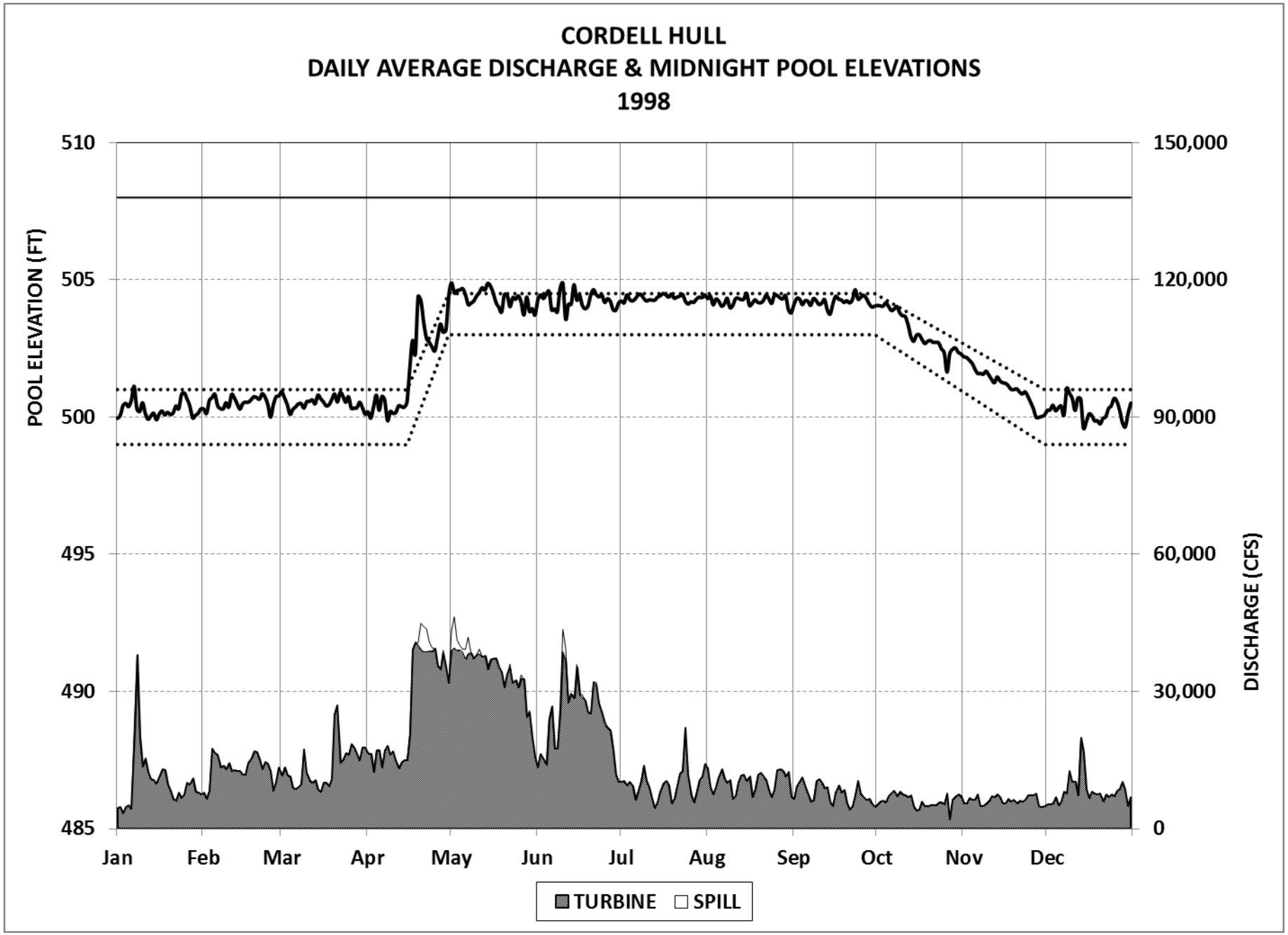

Plate VIII - 43. Historical Pool Elevations and Discharges, 1998

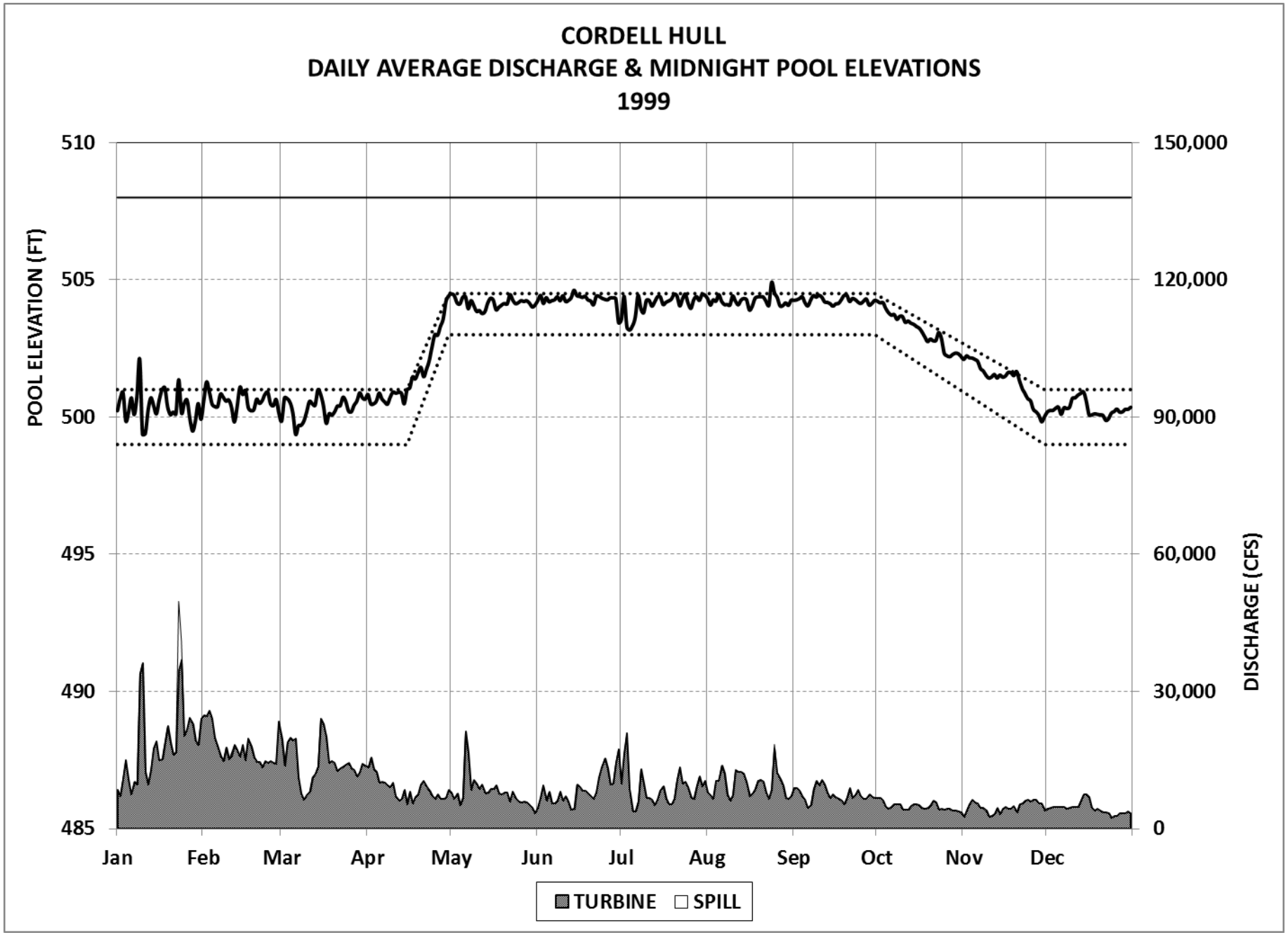

Plate VIII - 44. Historical Pool Elevations and Discharges, 1999

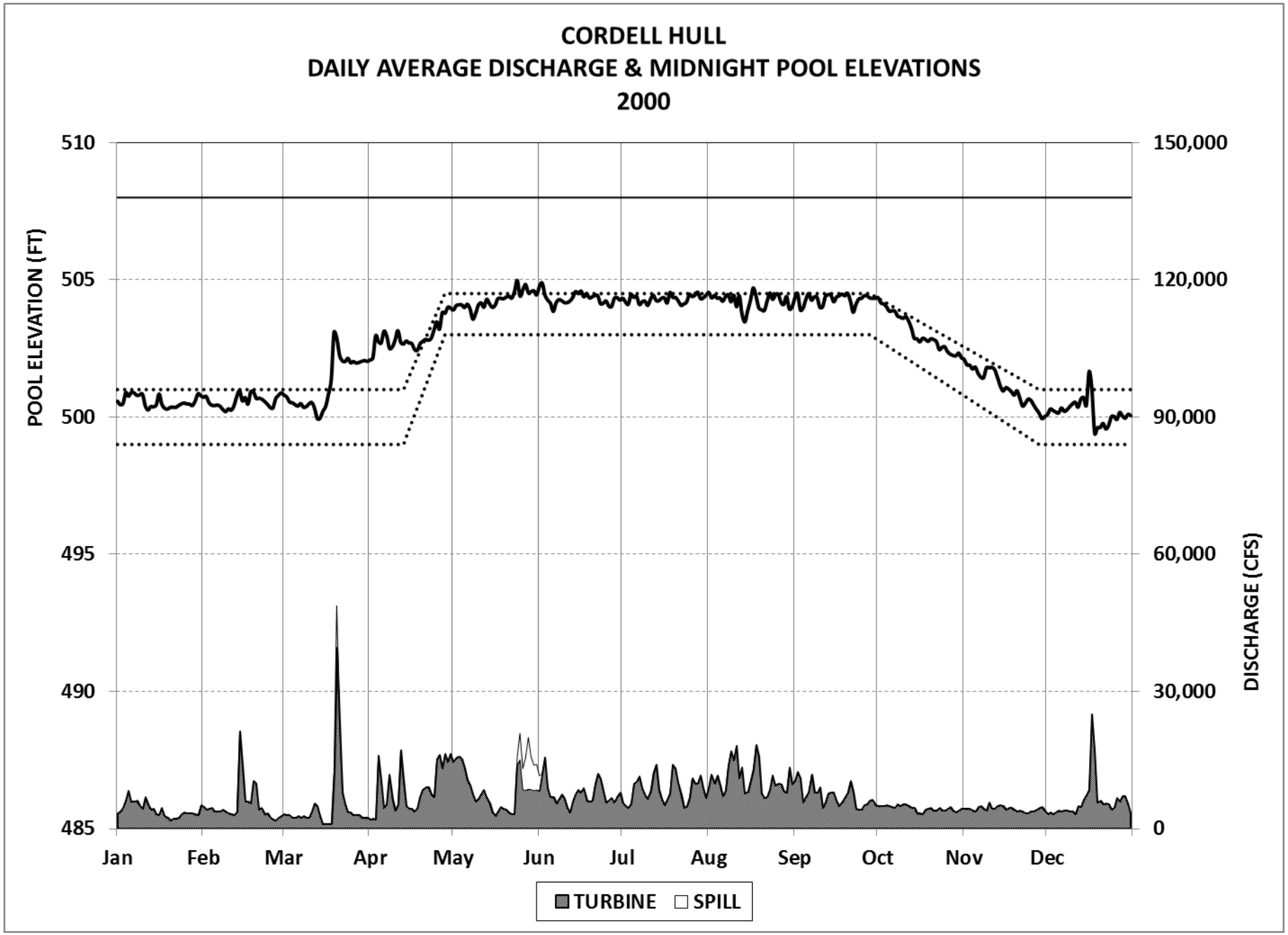

Plate VIII - 45. Historical Pool Elevations and Discharges, 2000

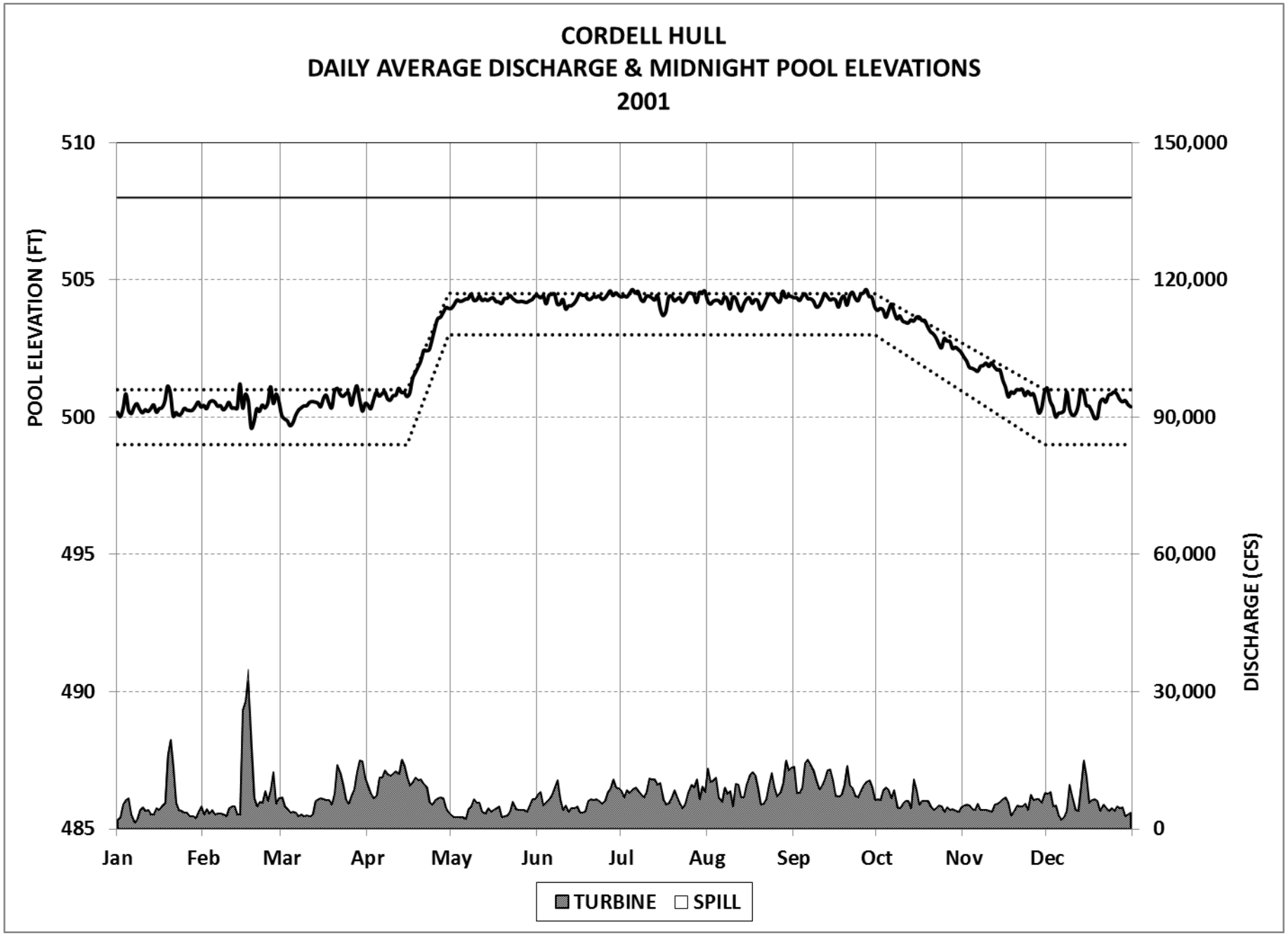

Plate VIII - 46. Historical Pool Elevations and Discharges, 2001

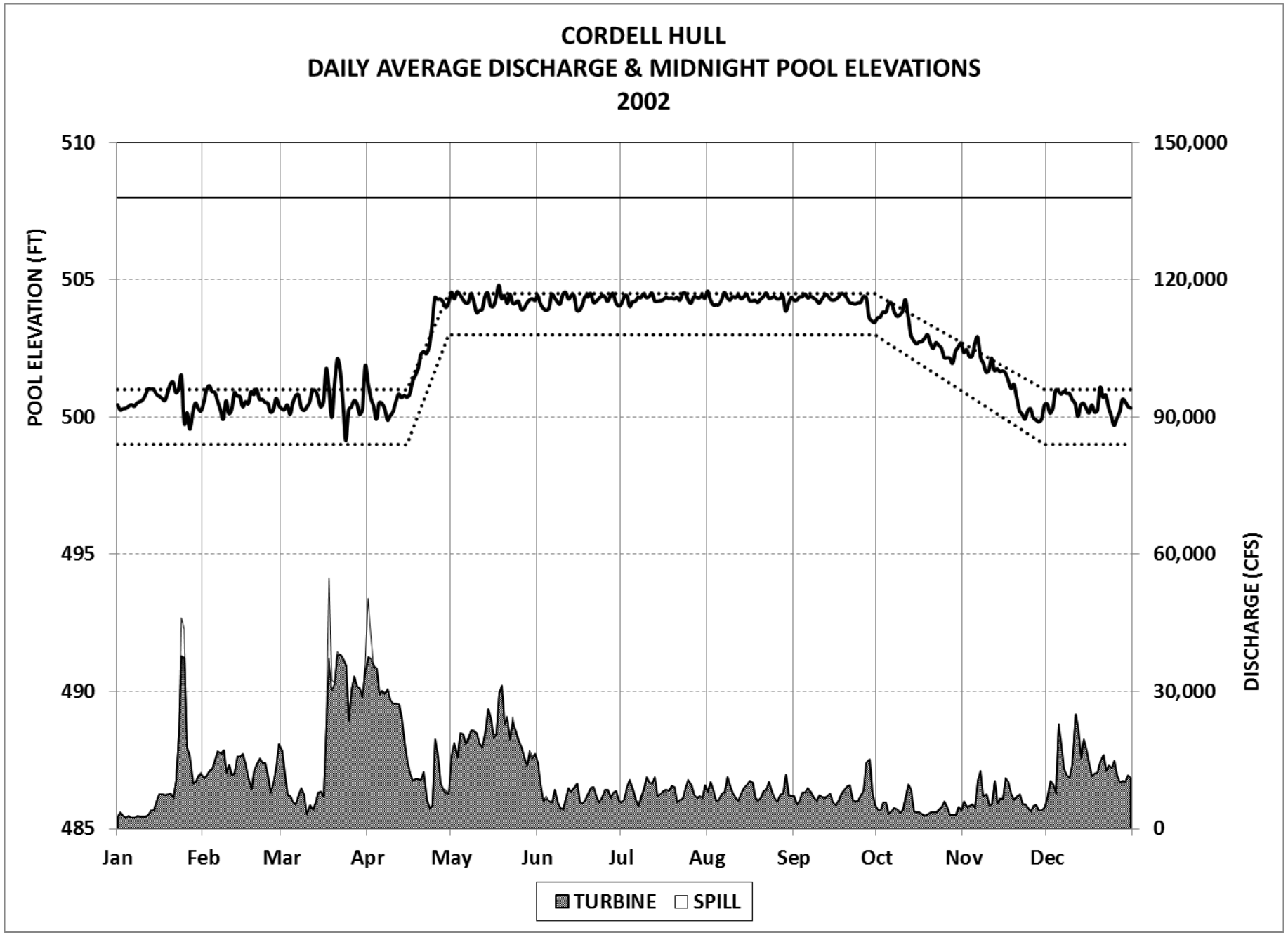

Plate VIII - 47. Historical Pool Elevations and Discharges, 2002

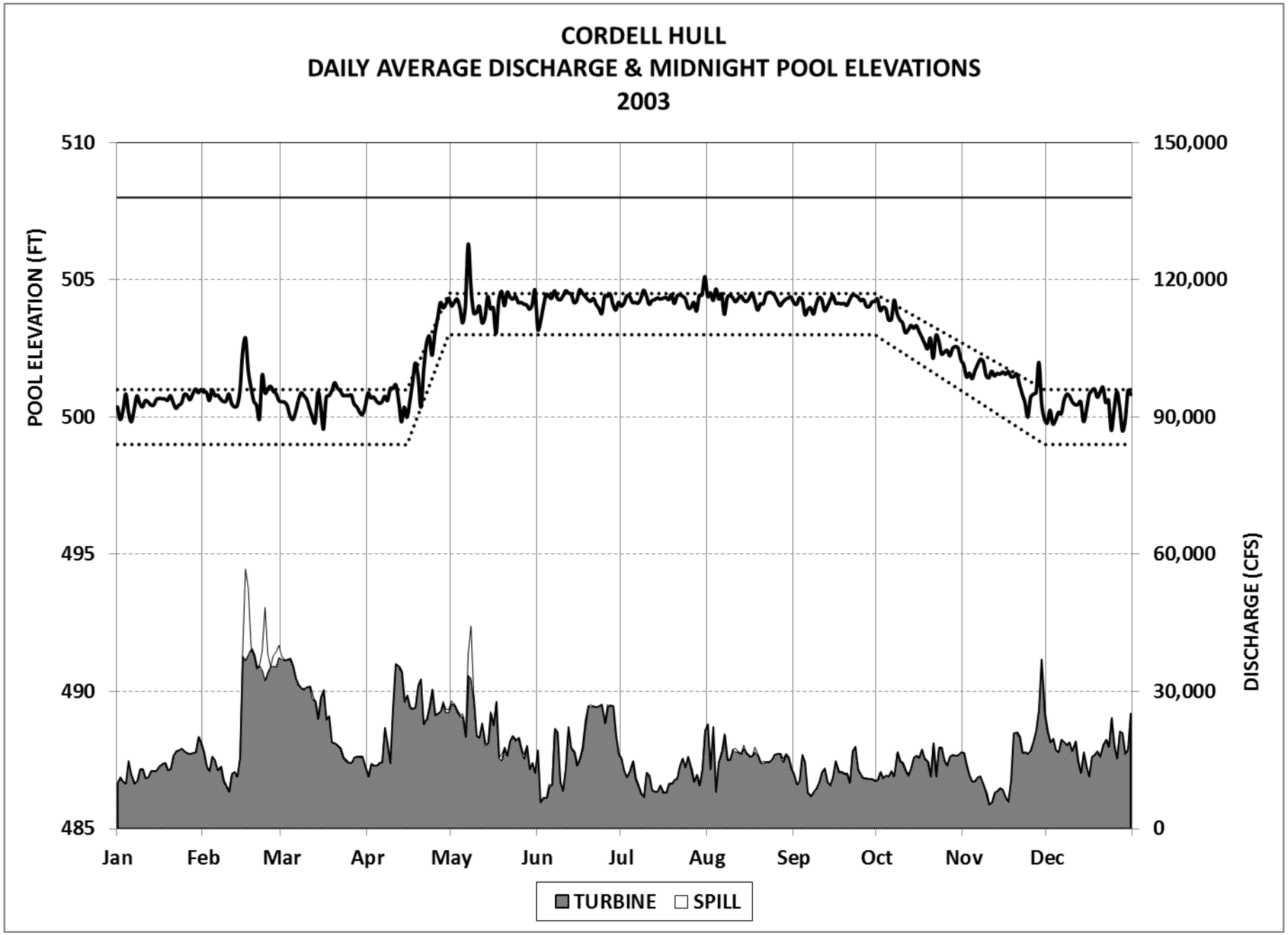

Plate VIII - 48. Historical Pool Elevations and Discharges, 2003

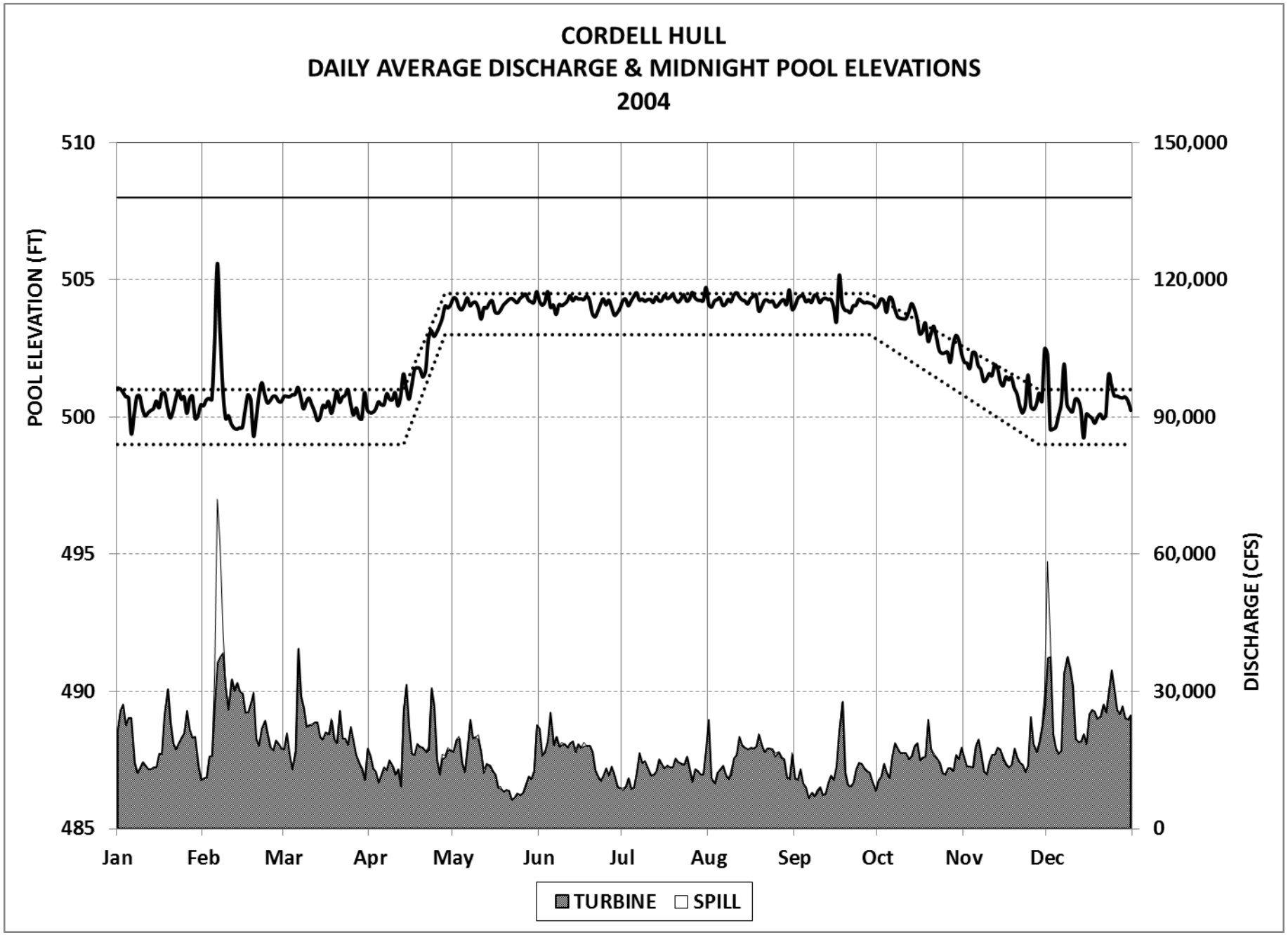

Plate VIII - 49. Historical Pool Elevations and Discharges, 2004

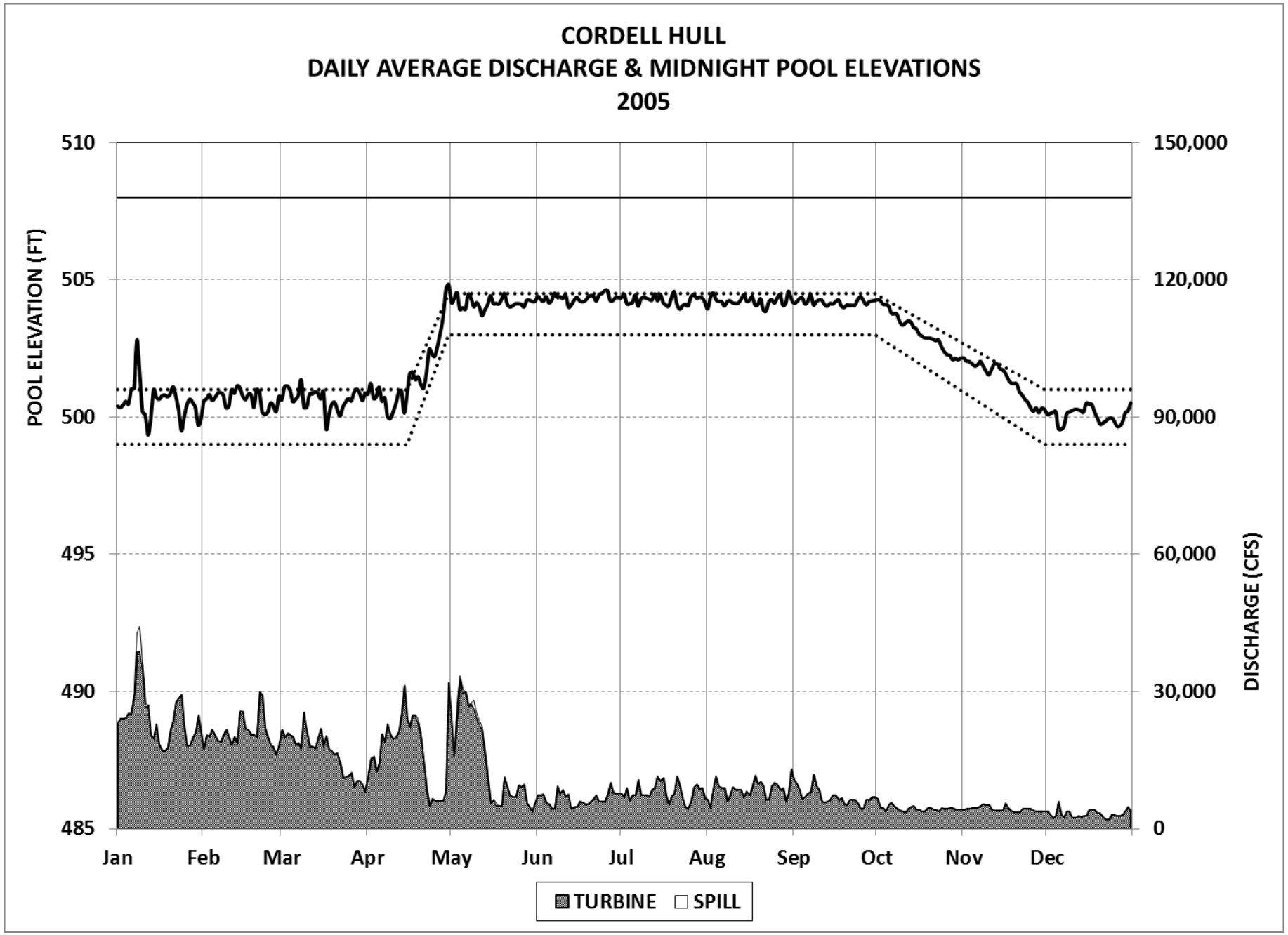

Plate VIII - 50. Historical Pool Elevations and Discharges, 2005

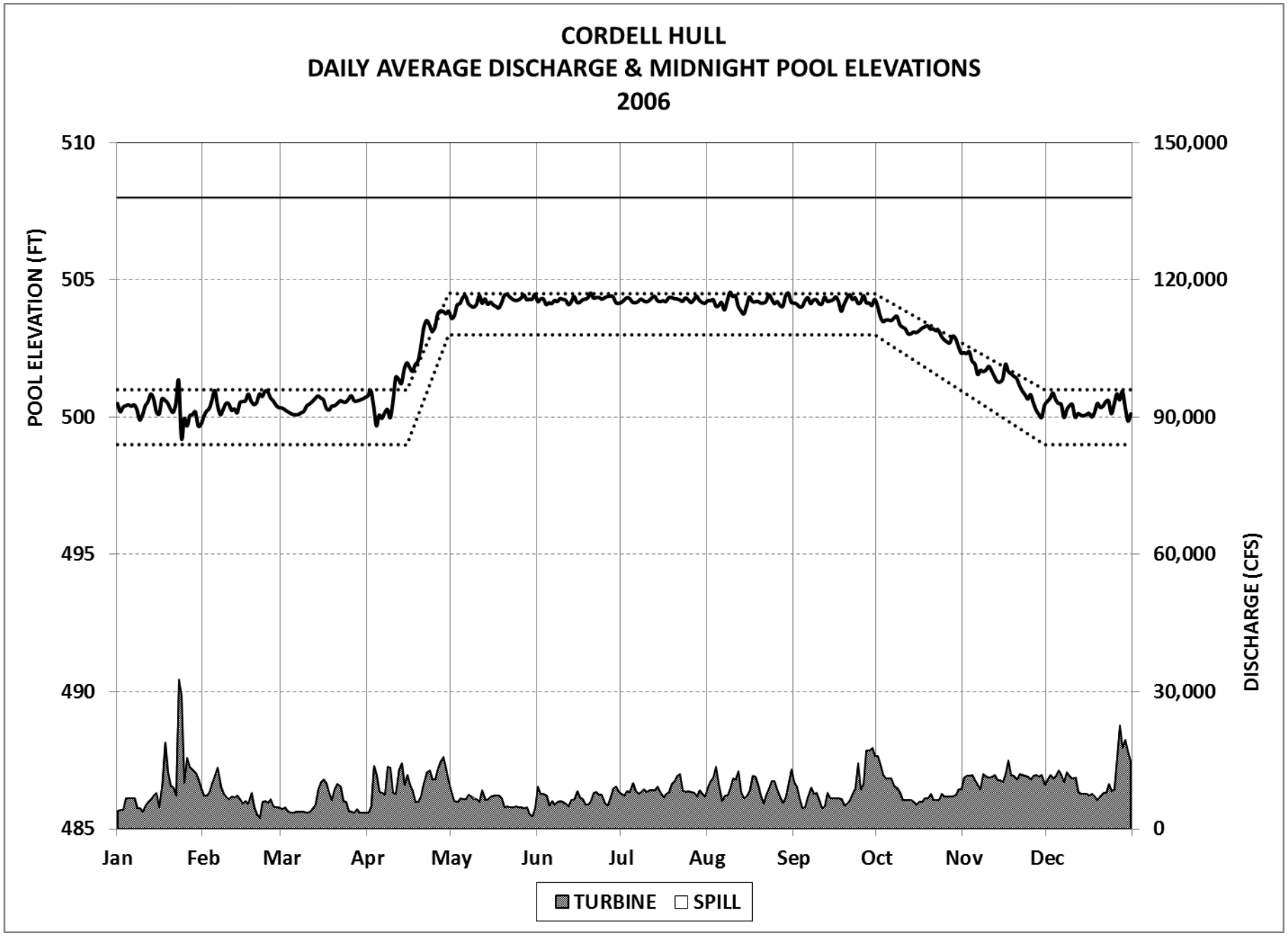

Plate VIII - 51. Historical Pool Elevations and Discharges, 2006

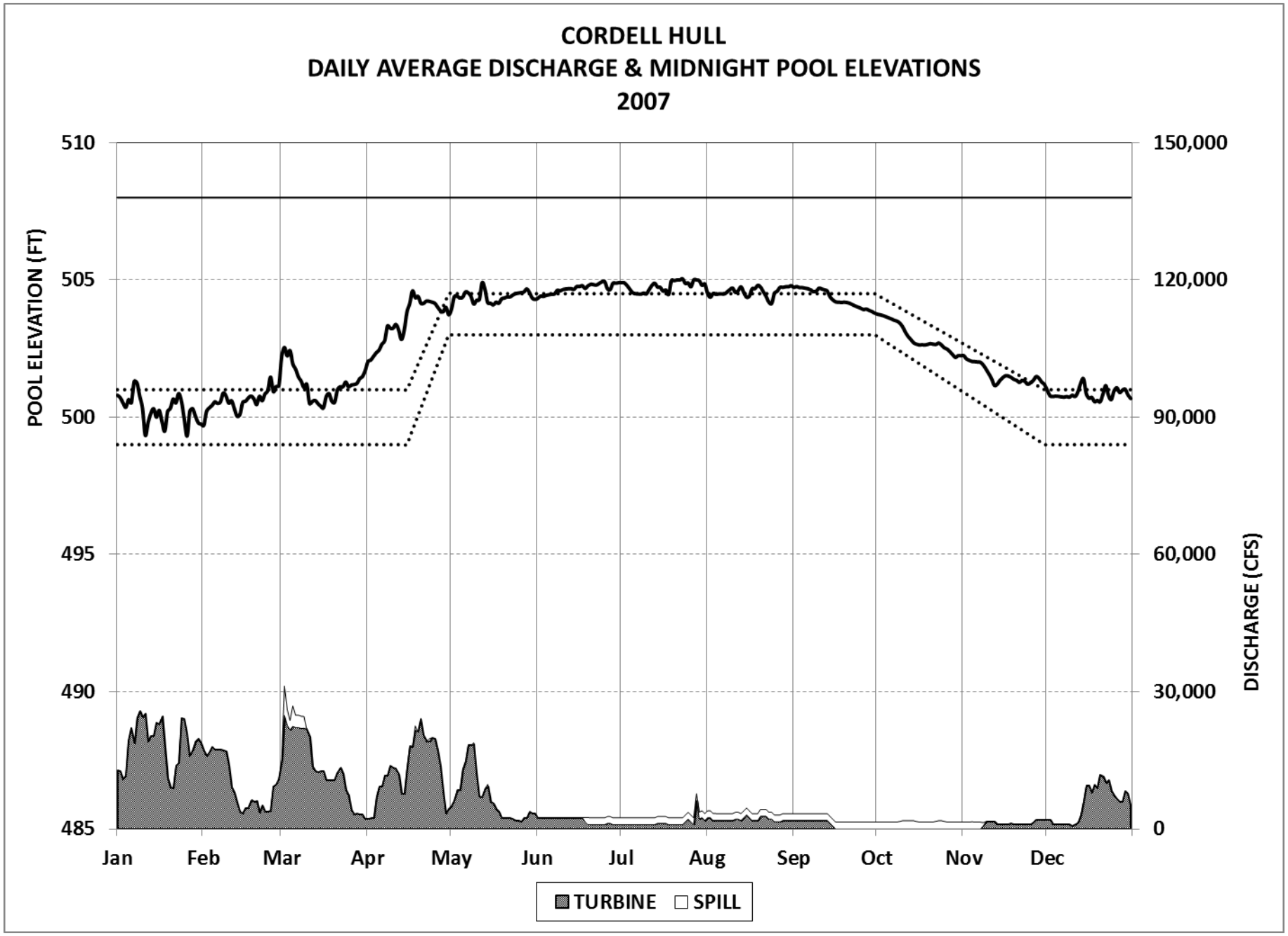

Plate VIII - 52. Historical Pool Elevations and Discharges, 2007

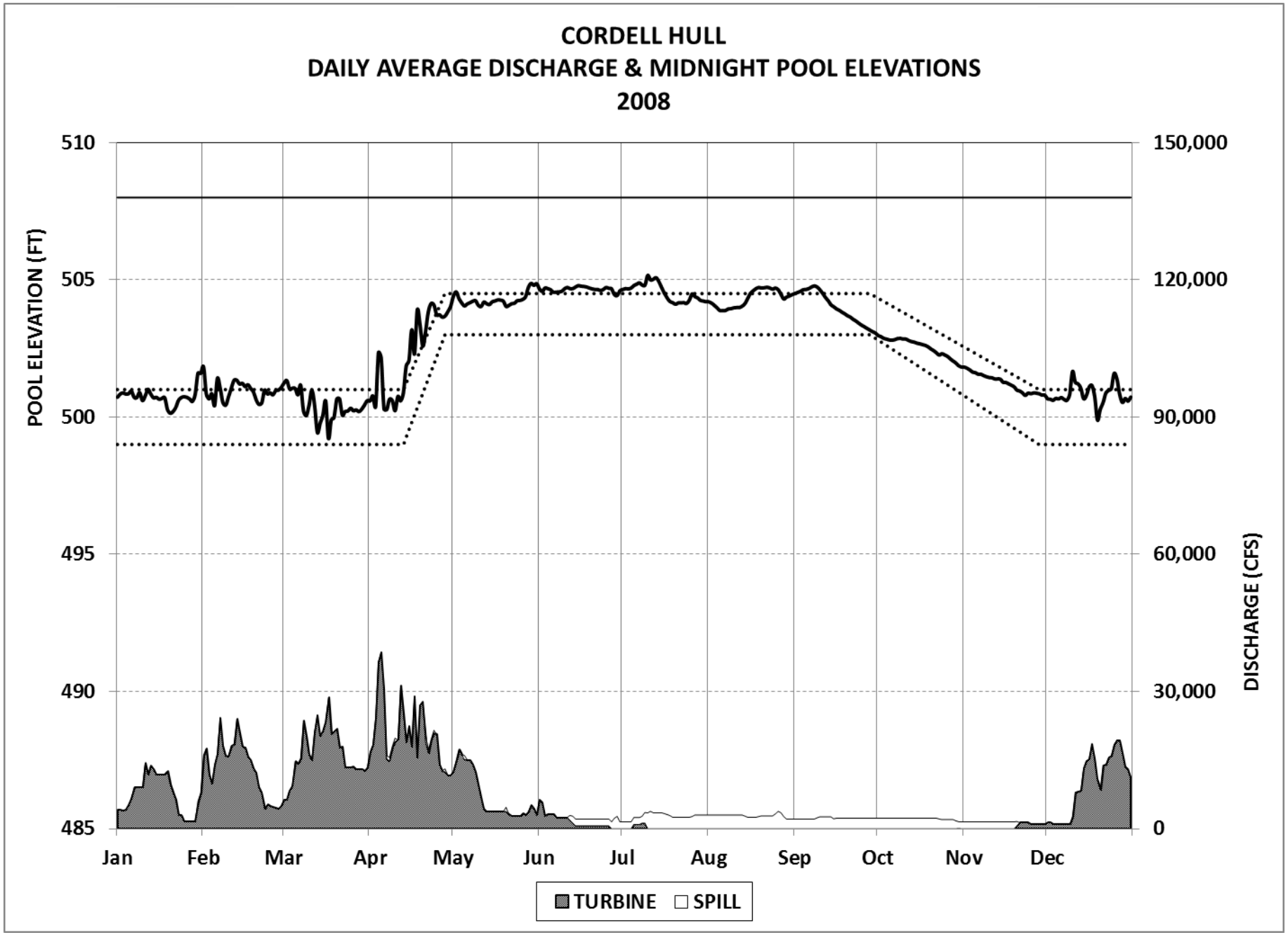

Plate VIII - 53. Historical Pool Elevations and Discharges, 2008

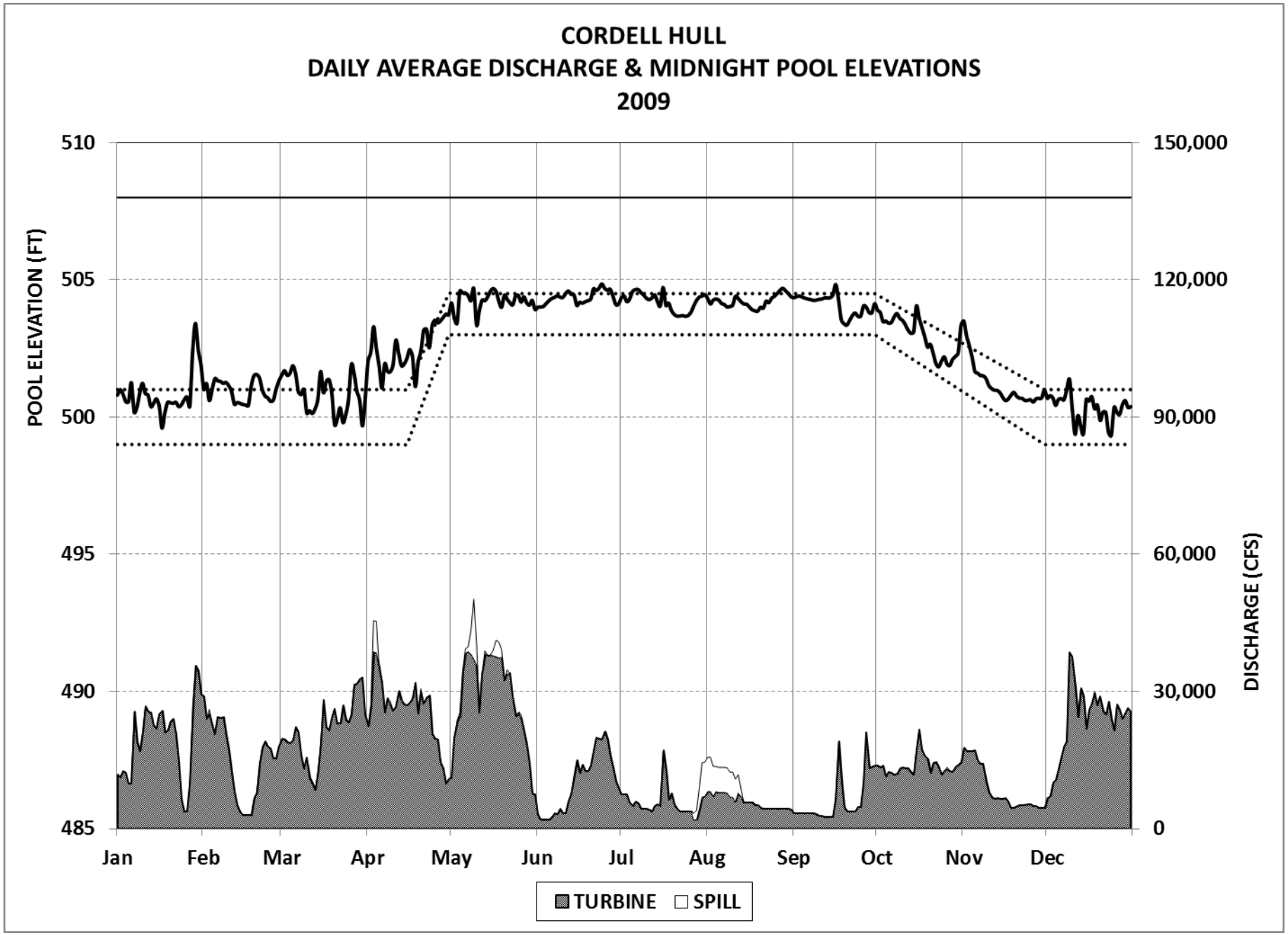

Plate VIII - 54. Historical Pool Elevations and Discharges, 2009

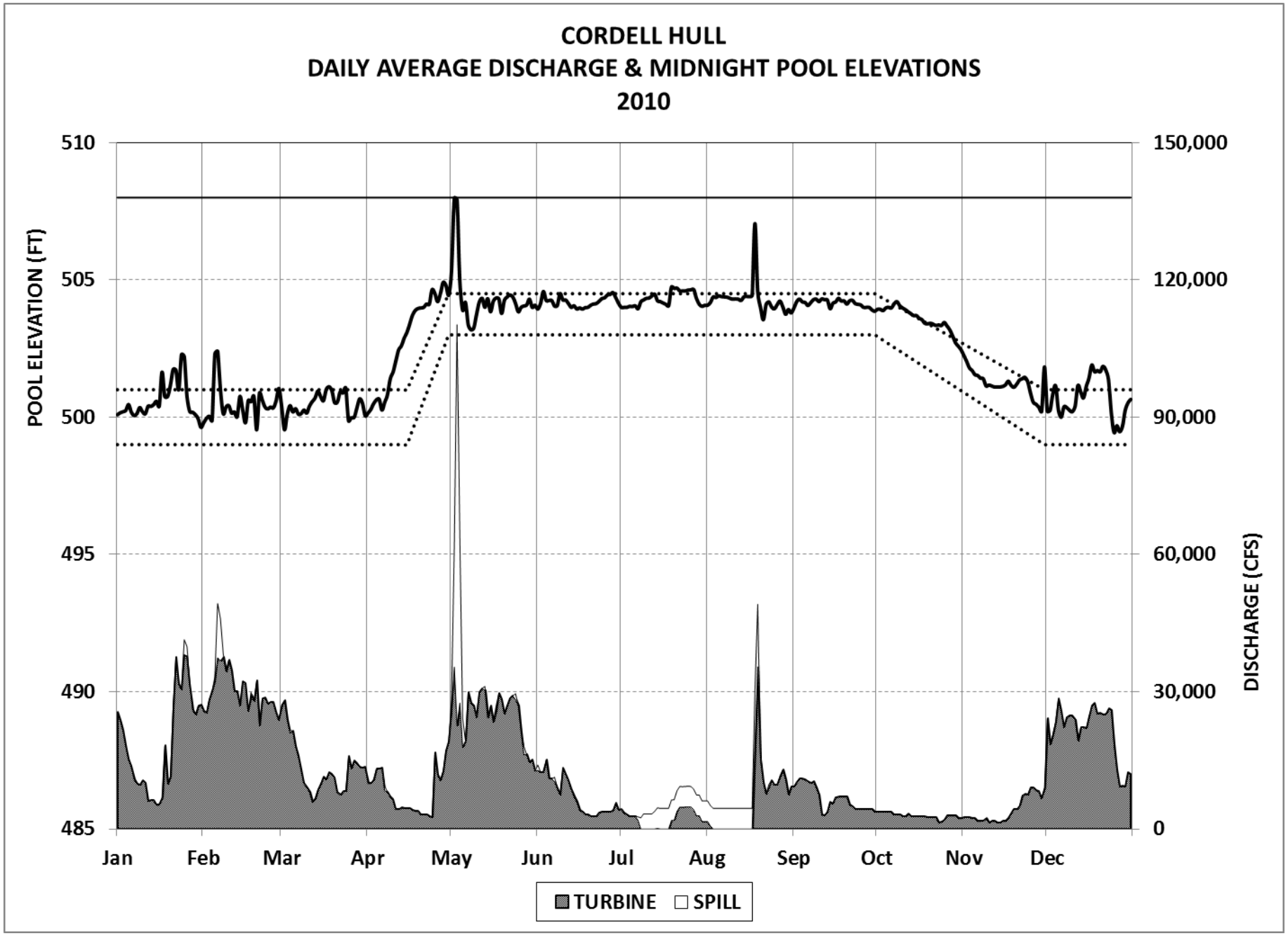

Plate VIII - 55. Historical Pool Elevations and Discharges, 2010

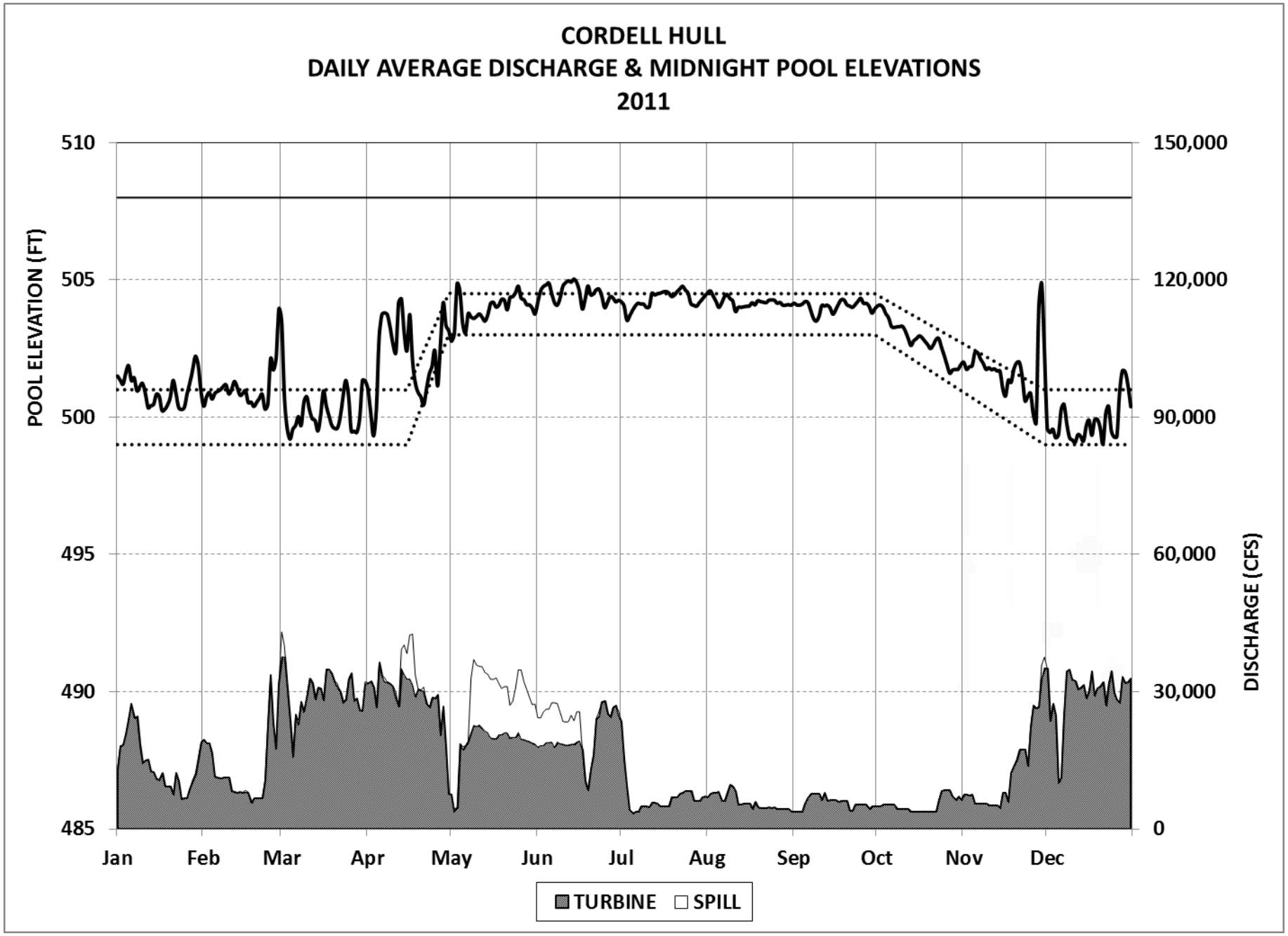

Plate VIII - 56. Historical Pool Elevations and Discharges, 2011

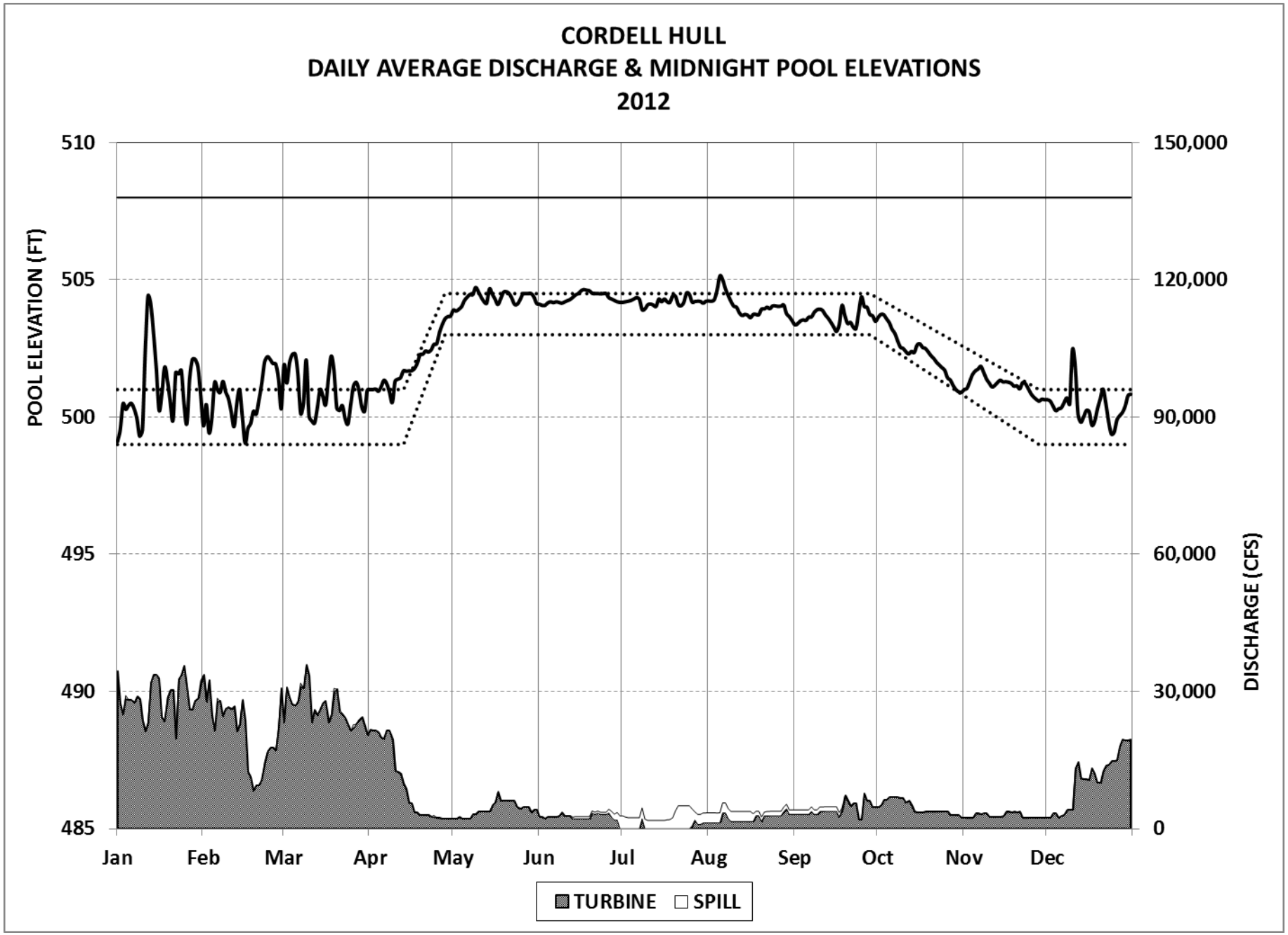

Plate VIII - 57. Historical Pool Elevations and Discharges, 2012

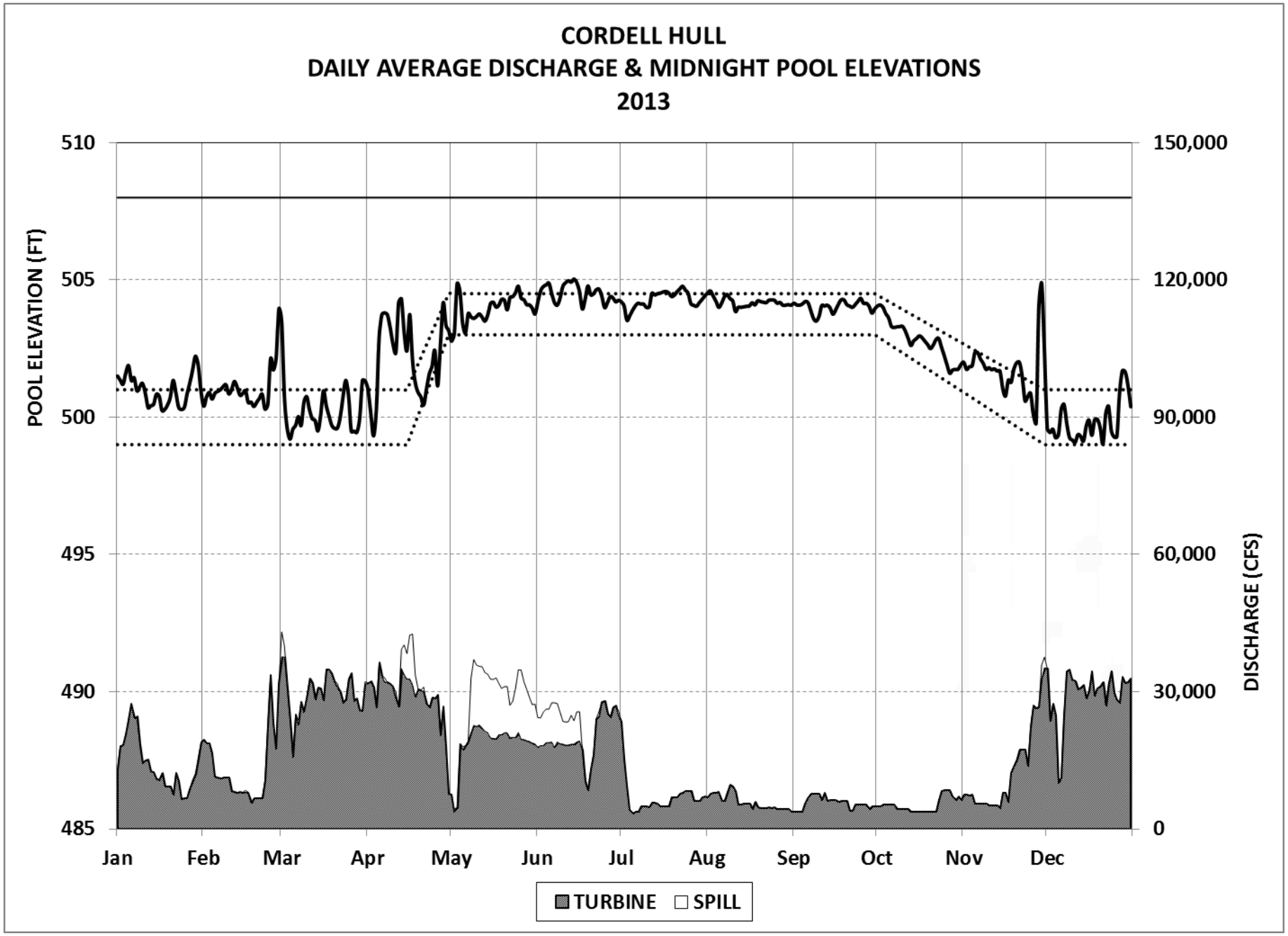

Plate VIII - 58. Historical Pool Elevations and Discharges, 2013

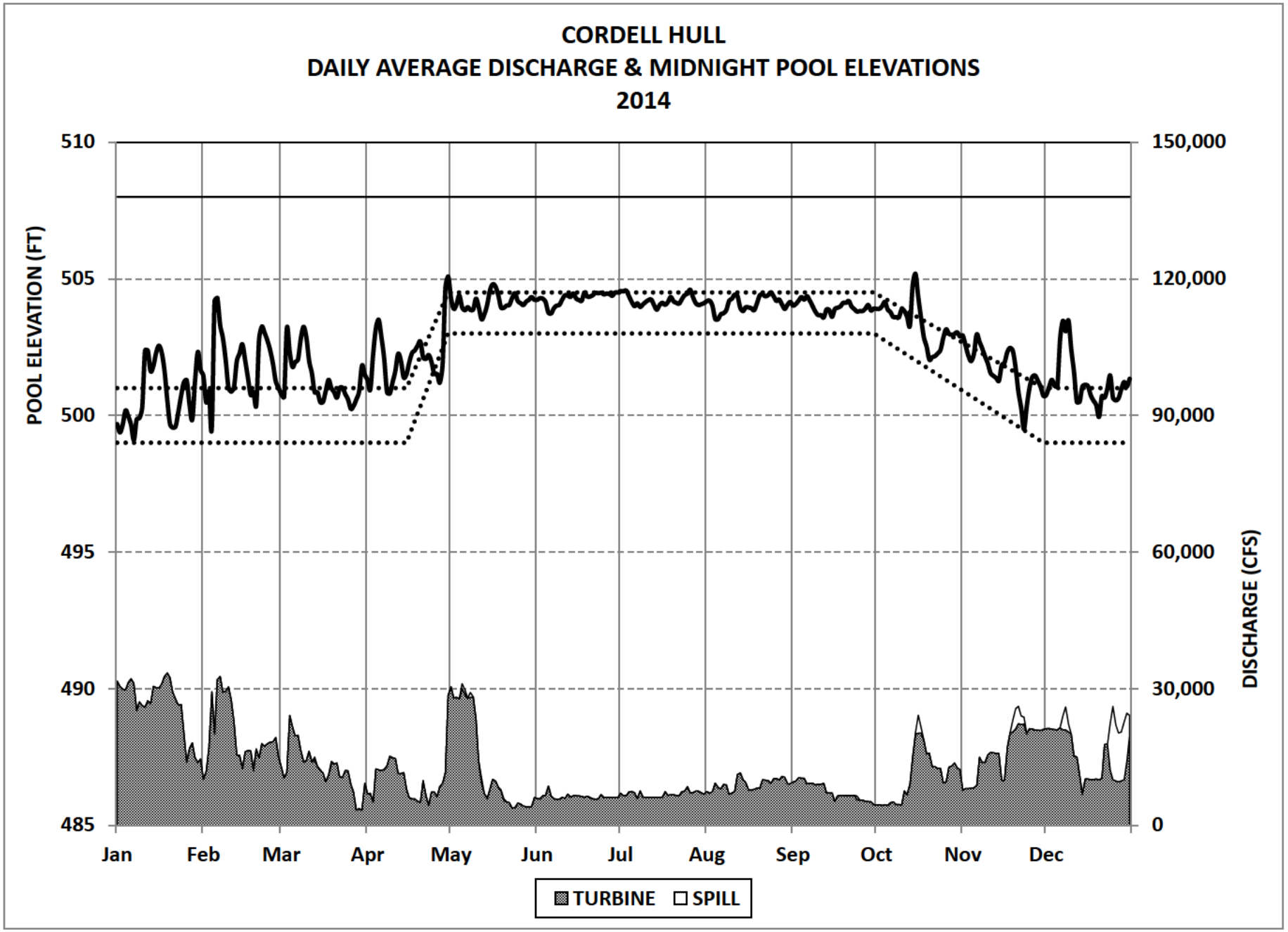

Plate VIII - 59. Historical Pool Elevations and Discharges, 2014

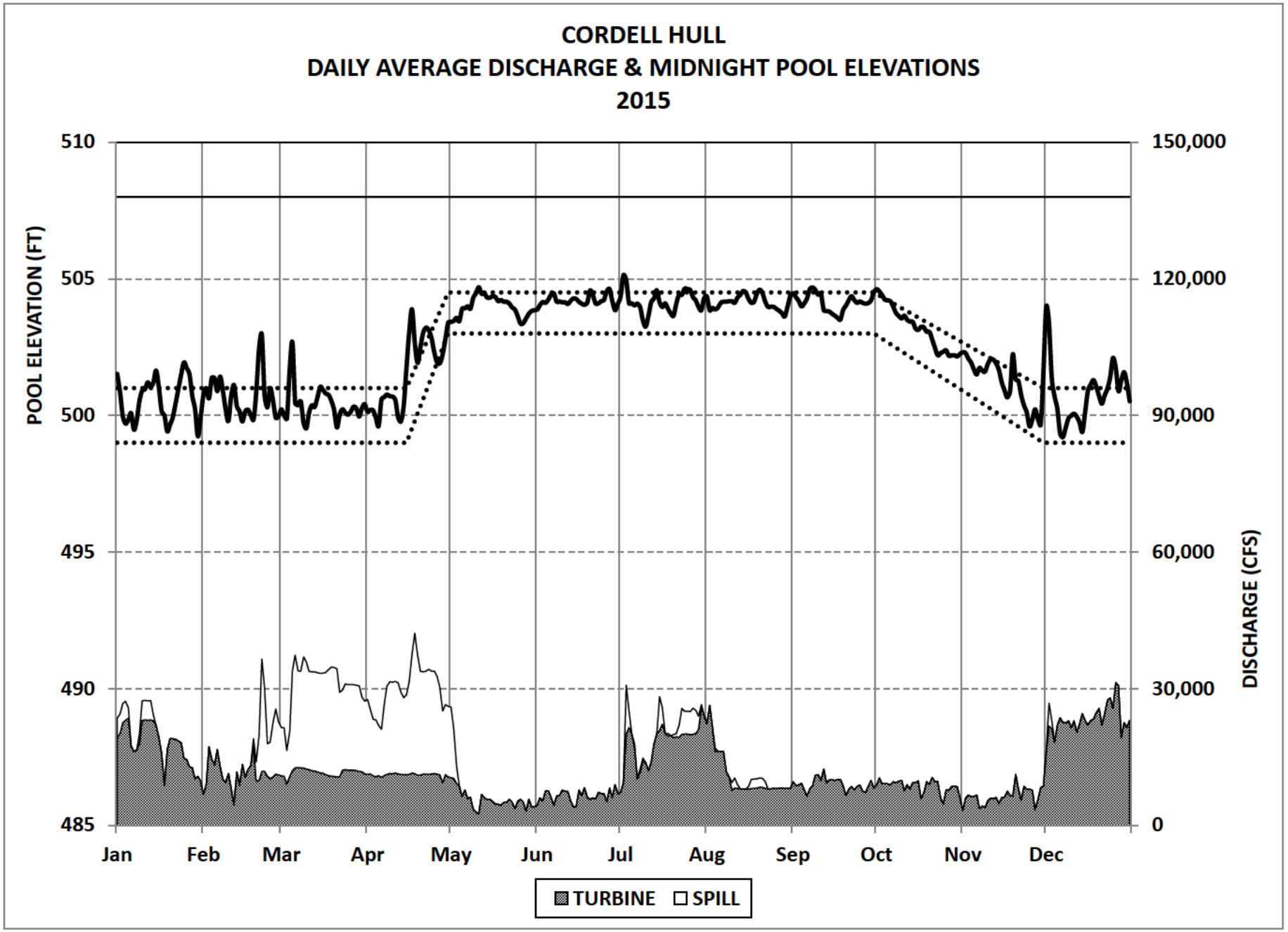

Plate VIII - 60. Historical Pool Elevations and Discharges, 2015

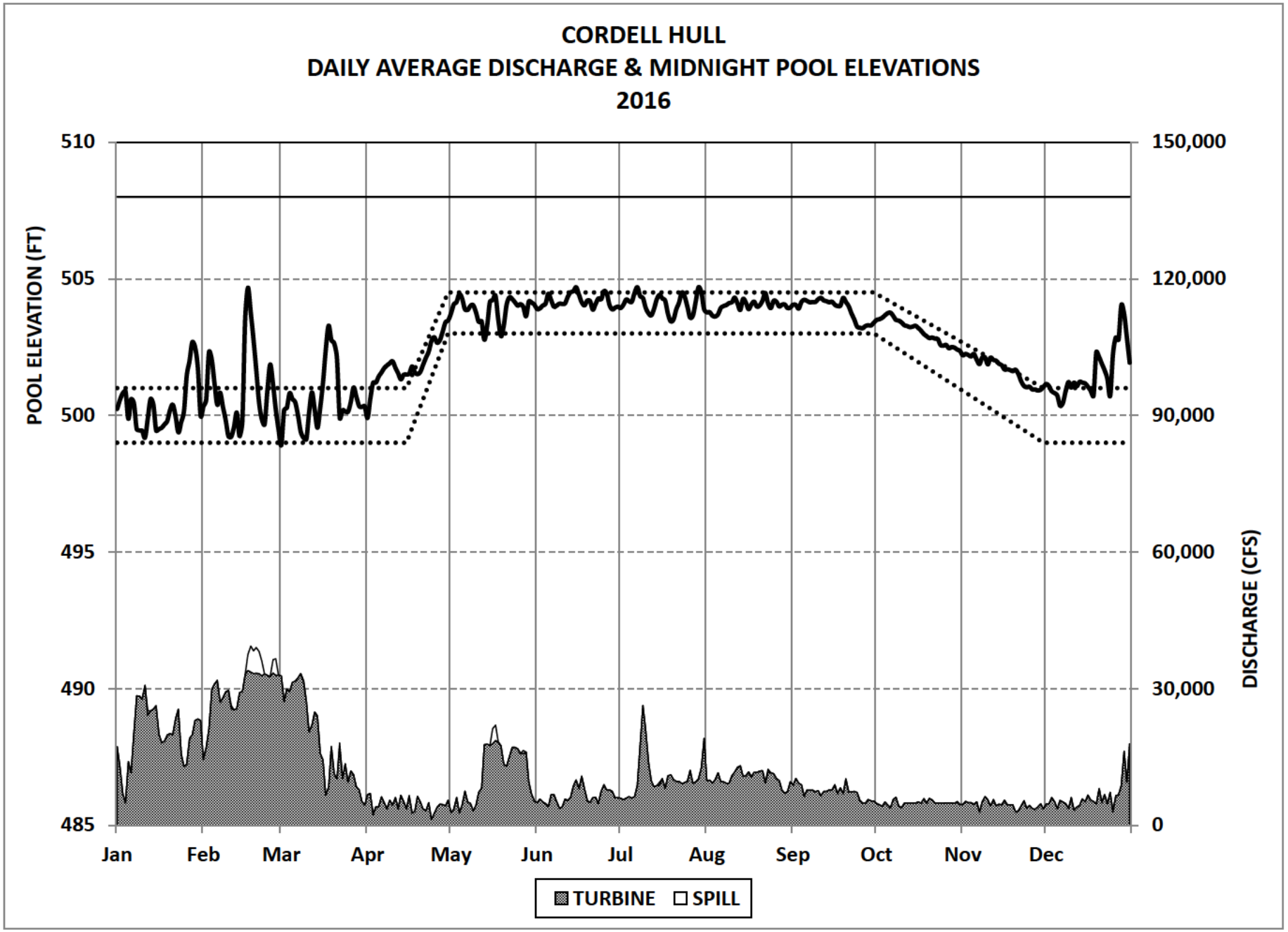

Plate VIII - 61. Historical Pool Elevations and Discharges, 2016

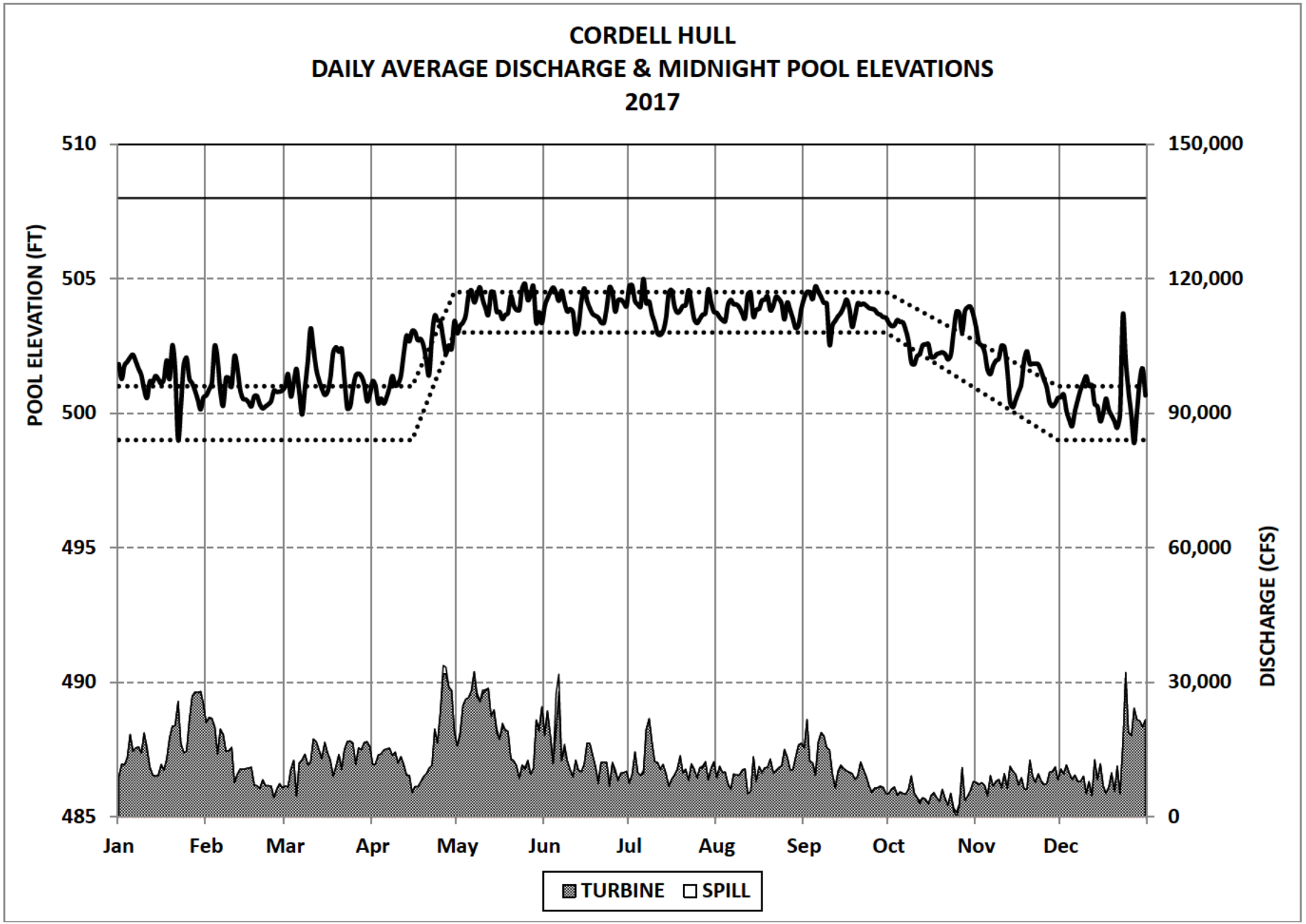

Plate VIII - 62. Historical Pool Elevations and Discharges, 2017

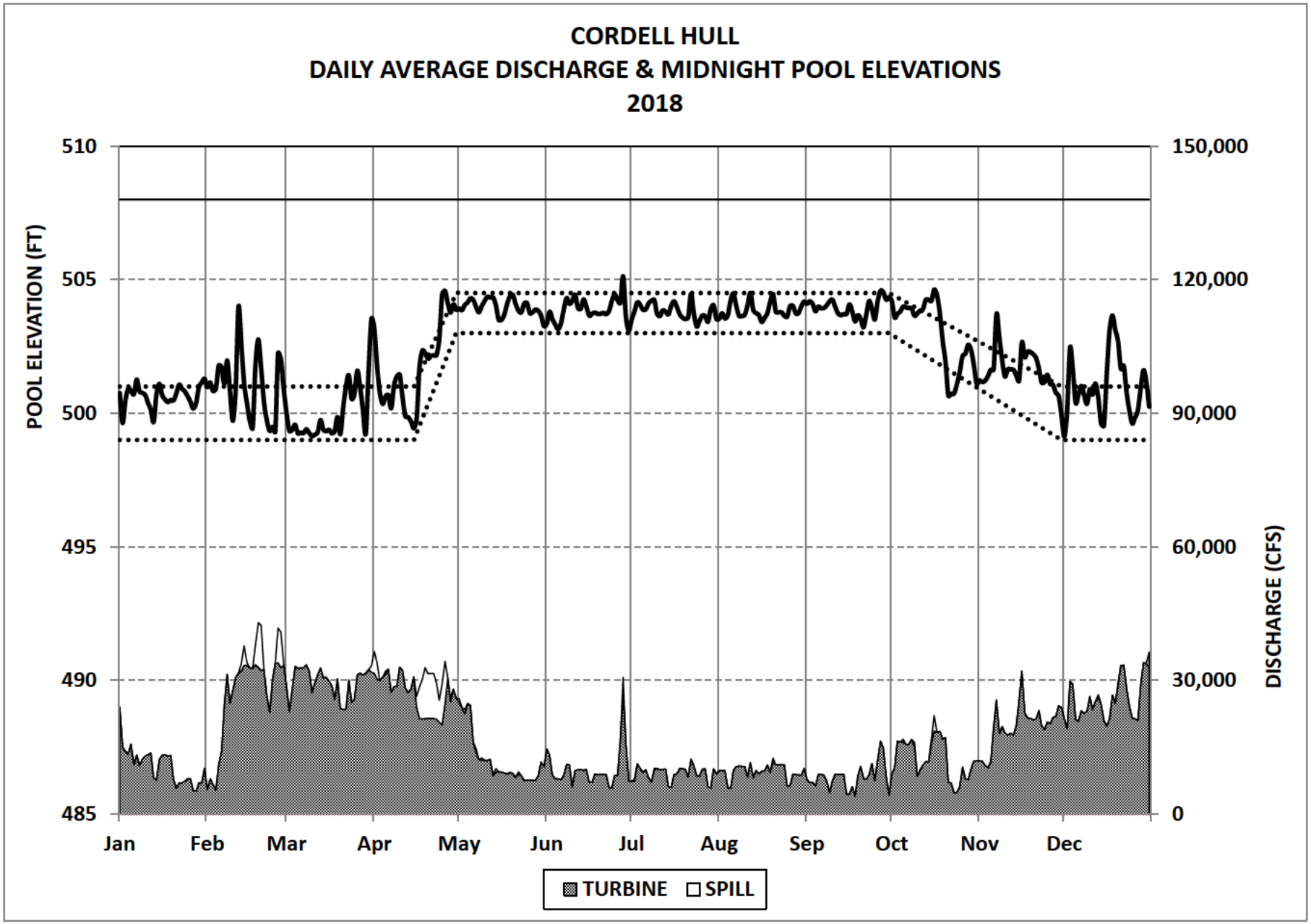

Plate VIII - 63. Historical Pool Elevations and Discharges, 2018

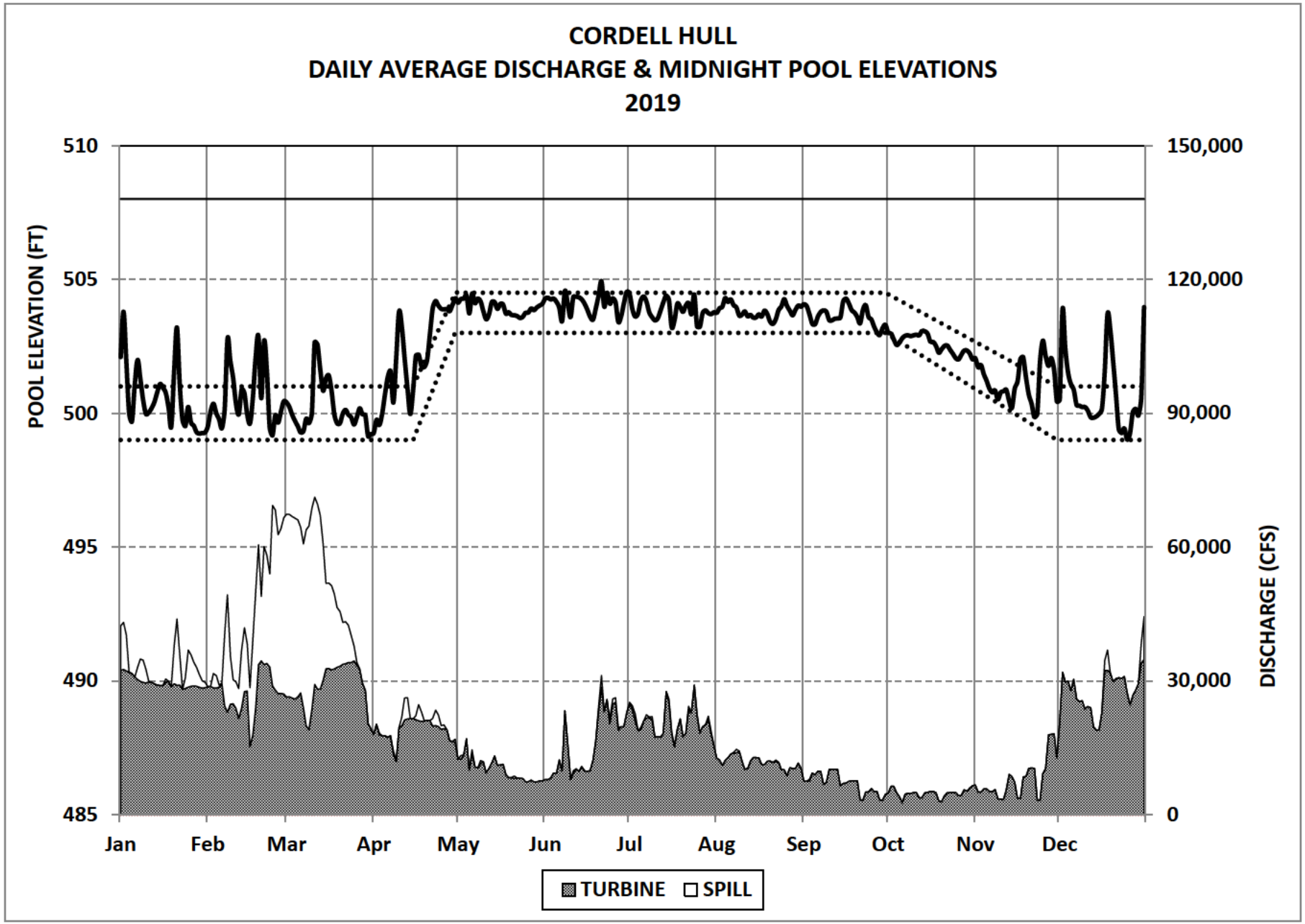

Plate VIII - 64. Historical Pool Elevations and Discharges, 2019

Cordell Hull Dam

01MAR2017 CORDELL HULL LOCK AND DAM PROJECT OPERATIONS DAILY REPORT
ELEV (FT); FLOW (CFS)

TIME	MW	POOL	TAIL	TURBINE	SPILLWAY	TOTAL	INFLOW
0100	0	500.88	446.98	0	0	0	
0200	0	500.90	446.60	0	0	0	
0300	0	500.93	446.23	0	0	0	
0400	0	500.96	445.96	0	0	0	
0500	33	500.83	447.43	8,020	0	8,020	
0600	66	500.56	450.06	17,100	0	17,100	
M-6A	99			4,187	0	4,187	-1,961
0700	66	500.56	450.96	17,460	0	17,460	
0800	66	500.47	451.47	17,700	0	17,700	
0900	66	500.30	451.70	17,900	0	17,900	
1000	33	500.52	449.92	8,530	0	8,530	
1100	0	500.64	447.84	0	0	0	
1200	0	500.75	446.85	0	0	0	
6A-N	231			10,265	0	10,265	14,293
1300	0	500.72	446.52	0	0	0	
1400	0	500.80	446.20	0	0	0	
1500	0	500.83	445.83	0	0	0	
1600	0	500.90	445.70	0	0	0	
1700	33	500.73	447.33	8,020	0	8,020	
1800	66	500.59	450.39	17,220	0	17,220	
N-6P	99			4,207	0	4,207	815
1900	66	500.60	451.40	17,620	0	17,620	
2000	66	500.62	452.02	17,900	0	17,900	
2100	66	500.55	452.65	18,240	0	18,240	
2200	33	500.79	451.69	8,830	0	8,830	
2300	0	500.89	450.39	0	0	0	
2400	0	501.00	449.40	0	0	0	
6P-M	231			10,432	0	10,432	19,123
24H TOT	660						
24H AVE		500.72	448.81	7,272	0	7,272	8,067
24H MAX		501.00	452.65	18,240	0	18,240	
24H MIN		500.30	445.70	0	0	0	

MID STORAGE, KDSF = 113.57 ENERGY FACTOR(MWH/TURBINE) = 91

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Plate IX - 1. Example Report 84

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Plate X - 1. Key Contact Telephone List

- **CORPS OF ENGINEERS, NASHVILLE DISTRICT (LRN)**

ENGINEERING-CONSTRUCTION DIVISION

Chief, [redacted]

Hydrology and Hydraulics Branch

Chief, [redacted]

Water Management Section

Chief, [redacted]

OPERATIONS DIVISION

Chief, [redacted]

Emergency Management Branch

Chief, [redacted]

Hydropower Branch

Chief, [redacted]

Supervisory Engineer, [redacted]

Natural Resources Management Branch

Chief, [redacted]

Navigation Branch

Chief, [redacted]

Hydropower Plants

Barkley
Center Hill
Cheatham
Cordell Hull
Dale Hollow
J. Percy Priest
Laurel
Old Hickory
Wolf Creek

Locks

Barkley
Cheatham
Old Hickory
Cordell Hull

Resource Managers

Barkley
Center Hill

Cheatham [redacted]
Cordell Hull [redacted]
Dale Hollow
J. Percy Priest
Laurel
Martins Fork
Old Hickory
Wolf Creek [redacted]
*Natural Resources Specialist (Park Ranger)

Public Affairs Office (PAO)

Chief, [redacted] [redacted]

Dam Safety Program Manager

[redacted] [redacted]

Levee Safety Program Manager

[redacted] [redacted]

- **CORPS OF ENGINEERS, GREAT LAKES AND OHIO RIVER DIVISION (LRD)**

Water Management Division

Chief, [redacted] [redacted]
Lead Hydraulic Engineer, [redacted] [redacted]

- **CORPS OF ENGINEERS, LOUISVILLE DISTRICT (LRL)**

Water Management, [redacted]

- **CORPS OF ENGINEERS, HUNTINGTON (LRH)**

Water Management, [redacted]

- **CORPS OF ENGINEERS, PITTSBURGH (LRP)**

Water Management, [redacted]

- **TENNESSEE VALLEY AUTHORITY (TVA)**

River Scheduling (Knoxville)

General Manager, [redacted] [redacted]
Senior Manager, [redacted]
Manager, [redacted] [redacted]
Preschedule Desk
Kentucky/Barkley Forecaster Desk

Power System Operations (Chattanooga)

Scheduling [redacted]
Balancing Authority

- **SOUTHEASTERN POWER ADMINISTRATION (SEPA)**

  Assistant Administrator for Power Resources
  [redacted] [redacted]

  Lead Power Systems Operator
  [redacted] [redacted]

- **EAST KENTUCKY POWER COOPERATIVE (EKPC)**

General Office Number [redacted]

- **NATIONAL WEATHER SERVICE (NWS)**

  Weather Forecast Office (WFO), Nashville Office
  Meteorologist in Charge, [redacted]
  Service Hydrologist, [redacted] [redacted]

  WFO, Louisville Office
  Service Hydrologist, [redacted] [redacted]

  WFO, Paducah Office
  Service Hydrologist, [redacted] [redacted]

  WFO, Jackson Office
  General Office Number [redacted]

  Ohio River Forecasting Center (OHRFC)
  Hydrologist in Charge, [redacted]
  Development & Ops Hydrologist, [redacted]
  Service Coordination Hydrologist, [redacted] [redacted]

  Lower Mississippi Forecasting Center (LMRFC)
  General Office Number [redacted]

- **US GEOLOGICAL SURVEY (USGS)**

  Kentucky Office
  Commonwealth Director, [redacted] [redacted]

  Tennessee Office
  Assistant Director, [redacted] [redacted]

- **TENNESSEE WILDLIFE RESOURCES AGENCY (TWRA)**

  Region 2 Office (Nashville) [redacted]

- **KENTUCKY DEPARTMENT OF FISH AND WILDLIFE RESOURCES**

  Frankfort Office [redacted]

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Appendix 1

Carthage Control Flow Update
Engineering Analysis

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