HUNGRY HORSE DAM
SOUTH FORK FLATHEAD RIVER, MONTANA

WATER CONTROL MANUAL

US Army Corps of Engineers
Seattle District

October 2022

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U.S. ARMY CORPS OF ENGINEERS, SEATTLE DISTRICT
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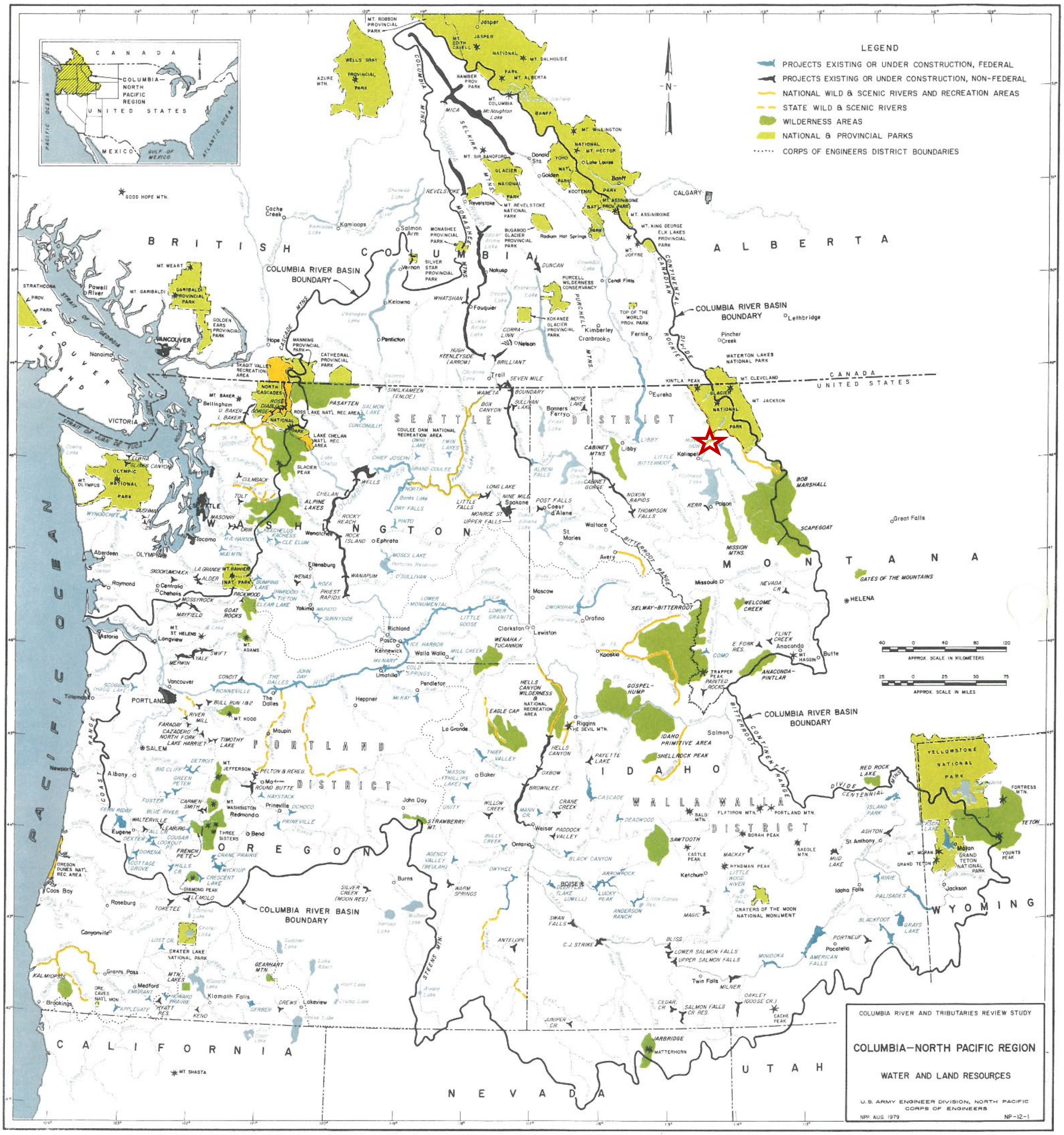
AERIAL VIEW OF HUNGRY HORSE DAM ON THE SOUTH FORK FLATHEAD RIVER, MONTANA



MAP - COLUMBIA – NORTH PACIFIC REGION. Hungry Horse Dam indicated by red star. Detailed map of Flathead Lake above Hungry Horse Dam is provided in Plate 2-1.

NOTICE TO USERS OF THIS MANUAL

Regulations specify that this water control manual be published in loose-leaf form and only those portions requiring changes will be revised and distributed. This copy should be preserved in good condition so that inserts can be made to keep the manual current.

REVISIONS TO THIS MANUAL

As a continuing program, portions of this manual may occasionally be revised and updated. Pertinent information will be revised when changes become evident; likewise, changes in the plan of operation or in the project development will be reported. Whenever revisions are made, new pages containing the revised material will be issued to holders of the manual.

WATER MANAGEMENT ASSISTANCE PERSONNEL

In the event that unusual conditions arise during duty or non-duty hours, contact can be made by telephone using the following numbers:

[redacted]

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TABLES

PLATES

Number

EXHIBITS

Number

ACRONYMS AND ABBREVIATIONS

AA	Action Agencies
AF	Acre-feet
BiOp	Biological Opinion
BMP	Best Management Practice
BPA	Bonneville Power Administration
CBT	Columbia Basin Telecommunications Network
CENWD-PDW	Water Management, Corps, Northwestern Division
CENWD-PDW-H	Hydrologic Engineering and Power Branch, Corps, Northwestern Division
CENWD-PDW-R	Reservoir Regulation, Northwestern Division
CENWS	Seattle District, U.S. Army Corps of Engineers
CENWD	Northwestern Division, U.S. Army Corps of Engineers
CENWP	Portland District, U.S. Army Corps of Engineers
CENWW	Walla Walla District, U.S. Army Corps of Engineers
cfs	Cubic Feet per Second
CHPS	Community Hydrologic Prediction System
CROHMS	Columbia River Operational Hydromet Management
CRT	Columbia River Treaty
COOP	Continuity of Operations
Corps	U.S. Army Corps of Engineers
CSKT	Confederated Salish and Kootenai Tribes
CWMS	Corps Water Management System
DCP	Drought Contingency Plan
EAP	Emergency Action Plan
El	Elevation
ESA	Endangered Species Act
ESP	Ensemble Streamflow Prediction
FCRPS	Federal Columbia River Power System
FRM	Flood Risk Management
GOES	Geostationary Operational Environmental Satellite System
hp	Horsepower
IRRM	Interim Risk Reduction Measures
kVA	Kilovolt-ampere
kW	Kilowatt
MDFW&P	Montana Department of Fish, Wildlife, and Parks
MOD	motor operated disconnect
NAVD	North American Vertical Datum
NFP	Normal Full Pool
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPS	North Pacific Division, Seattle District (former usage)
NRCS	Natural Resources Conservation Service
NWPCC	Northwest Power and Conservation Council
NWPP	Northwest Power Pool (former usage)
NWSRFS	National Weather Service River Forecast System
PMF	Probable Maximum Flood
PNCA	Pacific Northwest Coordination Agreement
PUD	Public Utility District

RCC	Reservoir Control Center
RM	River Mile
RWCDS	Regional Water Control Data System
SDF	Spillway Design Flood
SFTP	Secure File Transfer Protocol
SOP	Standard Operating Procedure
TDG	Total Dissolved Gas
TMT	Technical Management Team
TUSV	Total Usable Storage Volume
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WCDS	Water Control Data System
WCM	Water Control Manual
WDFW	Washington Department of Fish and Wildlife
WSF	Water Supply Forecast
WPP	Western Power Pool
VARQ FC	Variable Discharge Flood Control (former usage)
VARQ FRM	Variable Discharge Flood Risk Management

PERTINENT DATA

LOCATION OF DAMSITE

County, State	Flathead, Montana
River	South Fork Flathead River
Distance above Mouth of South Fork Flathead River	5.2 RM
Distance above Flathead Lake	50.9 RM
Distance above Mouth of Flathead River	153.9 RM

PROJECT AUTHORIZATION

Dam and Reservoir Authorized by Public Law 329, 78th Congress, Second Session, 5 June 1944.

HYDROLOGIC DATA

Drainage Area	1,654 mi^2
Average Annual Discharge (9-1929-1999; 71 years)	3,537 cfs
Minimum Daily Discharge (8-6-95)**1**/, regulated	56 cfs
Minimum Daily Discharge (12/35), unregulated	206 cfs
Maximum Discharge (1916 flood of record)	46,200 cfs
Maximum Regulated Peak Discharge (07/1954)	32,500 cfs

HYDRAULIC DATA

Minimum Normal Pool Elevation	3,336 ft
Average Annual Minimum Pool Elevation	3,466.7 ft
Top of Dam Elevation	3,565 ft
Normal Full Pool Elevation	3,560 ft
Maximum Normal Flood Control Pool.	3,560 ft
Minimum Recorded Reservoir Elevation (1-13-53)[1]	3,466.7 ft
Maximum Recorded Reservoir Elevation (7-3-55)	3,561.4 ft
Minimum Flow at HGH and Columbia Falls	*See Table 7-2*
Maximum Ramp-Up and Ramp-Down Rates at HGH	*See Table 7-3 and 7-4*
Maximum Spillway Discharge (Top of Dam)	50,000 cfs
Probable Maximum Flood (PMF) General Storm Inflow	267,500 cfs
PMF General Storm (GS) Outflow	21,695 cfs
PMF GS Pool change	El 3,516 ft to El 3,535.67 ft
PMF Local Storm Inflow	41,225 cfs
PMF Outflow PMF Outflow	58,700 cfs
PMF Maximum Reservoir Elevation	3,562.3 ft
Standard Project Flood	Not Available

[1] Minimum discharges and forebay elevations listed above are the lowest since the initial filling of the reservoir. Lower discharges and elevations during the initial reservoir filling are not reported because they are unrepresentative of the project's present operation.

All elevations in this manual are referenced to National Geodetic Vertical Datum (NGVD) of 1929.

RESERVOIR STORAGE POOL NAME	ELEVATION FEET	GROSS STORAGE[2] ACRE FEET
Minimum Operating Pool	3,336 ft	485,153
Normal Full Pool (NFP)	3,560 ft	3,467,178
Maximum Pool (top of dam)	3,565 ft	3,586,783
Top of Inactive Storage Pool	3,336 ft	485,153
Top of Dead Storage Pool	3,196 ft	37,131
Bottom of Dead Storage (approx.)	3,107 ft	0

POOL STORAGE CONTENTS POOL NAME	ELEVATION RANGE FEET	STORAGE ACRE FEET
Gross Storage	El 3,107 to El 3,565	3,586,783
Active Joint Use Storage	El 3,336 to El 3,560	2,982,025
Surcharge Storage[3]	El 3,560 to El 3,565	119,605
Inactive Storage	El 3,196 to El 3,336	448,022
Dead Storage	El 3,107 to El 3,196	37,131

LAKE SURFACE AREA AND LENGTH

Surface area:
- at El 3,565 ft.................... 23,800 acres
- at El 3,560 ft.................... 22,500 acres
- at El 3,336 ft.................... 5,600 acres

Reservoir Length .... 34 mi

DAM

Type	Concrete Arch
Height	564 ft
Upstream Radius	1,200 ft
Top of Dam Elevation	3,565 ft
Crest Length	2,115 ft
Width At Top of Dam (29.85 ft roadway plus 2 sidewalks)	39.0 ft
Maximum Base Width	355 ft

[2] Reference Table 2-1 in the table section of this manual for storage contents. No embankment storage is included in this data.
[3] Surcharge storage between NFP and top of dam used during rare floods only.

SPILLWAY SEGMENT

Type...Concrete Lined "Morning Glory" Shaft
Location ....Tunnel through right Abutment (50-degree angle to the horizontal)
Crest elevation ....3,548 ft
Length ....1,125 ft
Tunnel Diameter (variable).. 24.50 ft to 34.79 ft
Control .... 19.51 m dia. x 3.66 m high (64 ft dia. x 12 ft high) Hollow Floating Ring Gate
Maximum Rise of Ring Gate .... 12 ft
Maximum Discharge (Ring Gate seated at El 3,548 ft, with maximum reservoir El 3,565 ft
.... 50,000 cfs
Note: All diameters are inside diameters.

OUTLET WORKS

Number 3
Type (each)...................................... 2.44 m (8 ft) dia. steel pipe with a trashrack and intake stoplog
Length .... 660 ft each
Control (each) .... 8 ft dia., ring-follower gate & 8 ft dia. Hollow Jet Valve
Intake Center Line Elevation .... El 3,200 ft
Max. 3-unit Discharge at El 3,565 ft.. 13,740 cfs

SELECTIVE WITHDRAWAL SYSTEM

Number of Units .... 4 (1 at each Penstock Intake)
Location ....Between Trashracks and Penstock Intakes (Attached to Trashracks)
Type .... Semicircular, reinforced rolled structural steel Temperature
Control Points .... Instrument installed in Tailwater Bay
Each unit is comprised of three bulkheads as follows:

Control gate bulkhead (upper)

Height 30.48 m (100 ft)
Maximum Elevation (Top of Gate) .... 3,538.5 ft
Normal Operating Travel Range .... 100 ft
Hydraulically Operated Slide Gates (Located within Bulkhead)
    Number per Bulkhead.. 5
    Height.. 7 ft
    Width...5 ft
Stationary Bulkhead (3 Sections)
    Height (Lower Section) .... 40 ft
    Height (Center Section).. 40 ft
    Height (Upper Section).. 20 ft
    Bulkhead Elevations: ....Top El 3,437.5 ft
    .... Bottom El 3,337.5 ft
Relief Gate Bulkhead (Lowest Bulkhead)
    Height... 37.23 ft
    Bulkhead Elevations, Top.. El 3,437.5 ft
    Bulkhead Elevations, Bottom... El 3,300.27 ft

HYDROELECTRIC FACILITIES

POWERHOUSE

Location .... Downstream toe of Dam, Center of River Channel
Length .... 393.5 ft
Width .... 76 ft
Height. .... 150 ft Foundation to Roof
Maximum Output (4 units at NFP) .... 428,000 kW
Maximum Discharge (4 units at El 3,555 ft) .... 11,956 cfs

PENSTOCKS

Number 4
Intake Center Line Elevation .... El 3,319 ft
Maximum Diameter .... l3.5 ft
Length .... 490 ft
Penstock Angle with Horizontal .... 53 degrees
Penstock Control at Intake .... Fixed -Wheel Gates

TURBINES

Manufactured By .... Allis-Chalmers Mfg. Co
Number and Type .... 4-Francis Vertical Runner
Rated Net Head (Design Head) .... 400 ft
Net Head Range .... 260 ft to 479 ft
Average Head .... 445 ft
"Best Gate" Output at rated net head (1 unit) .... 90,000 hp
"Full Gate" Output at rated net head (1 unit) .... 112,000 hp
Maximum output at NFP (limited by generator capacity) (1 unit) .... 143,400 hp

GENERATORS

Manufactured By .... General Electric Manufacturing Company
Number 4
Nameplate Capacity .... 107,000 kVA @ 0.95 Power Factor
Date on Line .... October 1, 1952 first-July 23, 1953 last
Rewind Date .... 1990-1993 by General Electric Company.

VERTICAL DATUM CONVERSION

Elevations in this Water Control Manual are given in the vertical datum NGVD29. The following table lists the conversion factor used to convert elevations from NGVD29 to NAVD88 at selected locations. To convert from NGVD29 to NAVD88, add the conversion factor to the elevation. Conversion factors were calculated using the Coordinate Conversion and Transformation Tool (https://geodesy.noaa.gov/NCAT/) from the National Geodetic Survey of the National Oceanic and Atmospheric Administration (NOAA).

	Conversion Factor
Location	**Feet**
SF Flathead River above Twin Creek (USGS 12359800)	3.83
SF Flathead River near Columbia Falls (USGS 12362500)	4.16
Hungry Horse Dam, Top of Dam	4.19

SECTION 1. INTRODUCTION

1.01 Authorization for Manual. This manual is prepared in accordance with applicable policies, regulations, and laws regarding the preparation of Water Control Manuals including where applicable direction pursuant to Section 7 of the Flood Control Act of 1944 (33 U.S.C 709). Specific U.S. Army Corps of Engineer Regulations and Manuals used to prepare the manual include the following:

- **ER 1110-2-240, Water Control Management, paragraph 2-4.c.(3)**, dated 30 May 2016, which assigns to District Engineers the responsibility for development of plans and manuals for operation of reservoirs.
- **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 content of Water Control Manuals (WCM).
- **ER 1110-2-8156, Preparation of Water Control Manuals**, dated 30 September 2018, which provides specifications on WCM content and format.
- **NWDR 1110-2-6, Deviation Requests for Approved Water Control Manuals**, dated 1 May 2015, provides guidelines concerning deviations from approved WCMs and delegates deviation authority to the chief, Columbia Basin Water Management Division (CENWD-PDW).
- **ER 1110-2-8160, Policies for Referencing Project Elevation Grades to Nationwide Vertical Datums,** establishes U.S. Army Corps of Engineers policies for referencing project elevation grades to nationwide vertical datums established by the U.S. Department of Commerce and is a requirement in ER 1110-2-8156.

1.02 Purpose and Scope. This manual presents the reservoir regulation plan for Hungry Horse Dam and Reservoir (HGH) which is owned operated by the Bureau of Reclamation. This manual shall be used as a reference document for higher authority and as a guidance manual for Corps staff involved in project activities. Detailed information describing local sub-basins, project features, data collection facilities, forecasting procedures, reservoir regulation plans, and the effects of regulation are provided in this manual.

1.03 Related Manuals and Reports.

- "The Columbia River Basin Master Water Control Manual," prepared by the Corps' Northwestern Division (NWD), dated December 1984.
- "Columbia River System Operations – Final Environmental Impact Statement", dated July 2020. Bonneville Power Administration, U.S. Bureau of Reclamation, and U.S. Army Corps of Engineers.
- "Columbia River System Operations – Environmental Impact Statement Record of Decision", dated September 2020. Bonneville Power Administration, U.S. Bureau of Reclamation, and U.S. Army Corps of Engineers.
- "Hungry Horse Dam and Reservoir Water Control Manual", dated June 2005. U.S. Army Corps of Engineers, Northwestern Division. This manual supersedes the 2005 WCM.
- "Columbia River Basin Water Management Plan," Bonneville Power Administration, U.S. Bureau of Reclamation, and U.S. Army Corps of Engineers, developed annually.
- "Endangered Species Act - Section 7 Consultation Biological Opinion U.S. Fish and Wildlife Service Reference: 01EWFW00-2017-F-1650, Columbia River System Operations and Maintenance of 14 Federal Dams and Reservoirs," United States Fish and Wildlife Service, 24 July 2020.

- "Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the Continued Operation and Maintenance of the Columbia River System," National Marine Fisheries Service, 24 July 2020.
- "Water Reliability in the West – 2021 SECURE Water Act Report", dated January 2021. Reclamation (Bureau of Reclamation). Prepared for United States Congress. Denver, CO: Bureau of Reclamation, Policy and Administration.
- "Hungry Horse Reservoir – Water Quality Report", CRSO EIS Supporting Document, dated May 2020. U.S. Army Corps of Engineers – Northwestern Division, Bureau of Reclamation – Pacific Northwest Region.
- "Hungry Horse Reservoir – Sediment Quality Report", CRSO EIS Supporting Document, dated August 2020. U.S. Army Corps of Engineers – Northwestern Division, Bureau of Reclamation – Pacific Northwest Region.
- "Hungry Horse Powerplant Modernization and Overhaul Project: Final Environmental Assessment", dated November 2018. Reclamation (Bureau of Reclamation).
- "Record of Decision for Upper Columbia Alternative Flood Control and Fish Operations – Final Environmental Impact Statement", dated August 2009. Reclamation (Bureau of Reclamation).
- "Hungry Horse Project", dated 1995. Stene, Eric A. Reclamation (Bureau of Reclamation).
- Design memoranda, operating manuals and other reports of interest concerning the project are available in the Reclamation offices in Boise, Idaho and Denver, Colorado.

- Other operating reports and bulletins of interest concerning the project are available in the USACE Seattle District office.

<u>1.04 Project Owner.</u> HGH is owned by the U.S. Bureau of Reclamation.

<u>1.05 Operating Agency.</u> HGH is operated and maintained by the U.S. Bureau of Reclamation.

<u>1.06 Regulating Agency.</u> Section 7 of the Flood Control Act of 1944 directs the Secretary of the Army to prescribe regulations for the use of storage allocated for flood control (flood risk management in today's terminology). The responsibility for prescribing such regulations governing the use of storage allocated for flood risk management at HGH is delegated to the Corps' Northwestern Division (NWD). The NWD coordinates and cooperates with many other agencies and groups to accomplish effective flood control regulation. Flood risk management regulation for HGH is implemented by the Division Reservoir Control Center (CENWD-PDW-R) in conjunction with Reclamation's water management staff in the Boise, Idaho office. Details of this coordination are discussed in the Master Water Control Manual and in this water control manual. Other than flood risk management, regulation for all other purposes at HGH is the responsibility of Reclamation.

<u>1.07 Vertical Datum.</u> Per the U.S. Army Corps of Engineers Engineering Regulations listed above, structures for inland flood risk management, navigation, and water control systems (to include levees, floodwalls, multipurpose hydropower projects, locks and dams, and non-tidal inland navigation systems), designed or constructed flood protection or navigation clearance grades, hydraulic or hydrodynamic water surface profiles, river or pool stages, and stream gages in inland flood risk and water control systems shall be accurately referenced to the NSRS (e.g., NAVD88).

For clarity in this document, vertical elevations listed in this manual are referenced to the original project vertical datum of NGVD 1929 and the datum conversion factors to the NAVD88 vertical datum are included in the Pertinent Data section.

SECTION 2. DESCRIPTION OF PROJECT

2.01 Location. The HGH project is located in Flathead County, Montana on the South Fork Flathead River (S.F. Flathead River) at RM 5.2, approximately 8 miles east-southeast of Columbia Falls, Montana. The dam site is situated in the southern half of Section 22, Township 30 North, Range 19 West, Montana Principal Meridian. West Side Road (NF-895) parallels the west side of the reservoir to the reservoir southern terminus. East Side Road (NF-38) parallels the east side of the reservoir and intersects the West Side Road about 5.3 miles southeast of the reservoir's southern terminus. The center of the dam is located at a latitude/longitude of 48°20'28.7"N, 114°00'45.9"W. The project location and vicinity are shown on Plate 2-1.

2.02 Purpose. HGH is a unit of the comprehensive water resource development of the Columbia River Basin. The project was authorized by the Act of June 5, 1944, 78th Congress, Second Session, 58 Stat. 270, and Public Law 85-428 (May 29, 1958), 72 Stat. 147. The project is subject to the Federal reclamation laws and authorized for power generation, flood control, irrigation, in-stream flow regulation, navigation, and other beneficial uses. Streamflow regulation to support protected fish stocks locally and downstream on the Columbia River is now provided to ensure compliance with the Endangered Species Act of 1973 (ESA) as amended. Reclamation is not actively delivering for irrigation, though a recent water rights settlement allocates 90,000 acre-feet of storage for the beneficial use of the Confederated Salish and Kootenai Tribes. No storage or reservoir releases are specifically provided in consideration of downstream navigation to date.

The project provides up to 2.98 million acre-feet (MAF) of reservoir space for flood risk management (the U.S. Army Corps of Engineers has transitioned from using the term "flood control" to "flood risk management" in accordance with *Memorandum for Commanders, Major Subordinate Commands, "USACE National Flood Risk Management Program Initial Guidance," 5 October 2009*). Since 2002, HGH dam operations for flood risk management and hydropower have been managed using a procedure called Variable Discharge Flood Control (VARQ FC) that allows for the variable release of water during the refill period based on observed reservoir elevations, seasonal water supply forecasts (WSF), and estimated durations of flood risk management.

Fish and wildlife conservation and streamflow regulation at HGH are of critical importance because of the efforts of the U.S. to protect and conserve fish species pursuant to the ESA and commitments to Tribal Nations. While VARQ FC operations improve flow conditions for ESA-listed species, water releases at HGH are also managed through direct instream flow requirements on the South Fork Flathead River to support minimum flow requirements on the mainstem Flathead River at Columbia Falls that aid downstream fish spawning habitat. Minimum flows in the South Fork Flathead River downstream of HGH are based on WSF data and range from a minimum of 400 cfs for drier water year forecasts to 900 cfs for wetter water year forecasts as long as Columbia Falls minimums are maintained between 3,200 cfs to 3,500 cfs depending on the water supply forecast.

2.03 Physical Components. The following are the major components of HGH:

- Reservoir
- Concrete arch dam
- Powerhouse
- Spillway
- Outlet works (outlets, selective withdrawal system)

- Incidental facilities (recreation, miscellaneous buildings and facilities)

A general layout of the project structures is shown in Plate 2-2. Details are provided below:

a) Reservoir. The reservoir formed by HGH contains active storage of 2,982,025 AF between minimum pool El 3,336 ft and Normal Full Pool (NFP) El 3,560 ft. Inactive storage of 448,022 AF between the penstocks at El 3,319 ft and the sluice outlets at El 3,200 ft is not accessible for hydropower but could be drafted for use in case of special conditions such as an extreme snowpack or for maintenance. Refer to the Pertinent Data for additional reservoir data. At NFP El 3,560 ft the reservoir is 34 miles long, 3.5 miles wide at the widest point, and about 500 feet deep at the deepest point. Surface area at NFP is 22,500 acres. The project gross storage provided in Table 2-1 is based on 1969 data (unadjusted for embankment storage), and supplemental data points from a few more recent surveys.

b) Dam. The dam is a variable-thickness concrete arch structure with a consistent upstream radius of 1,200 ft, see Plate 2-2. The height of the dam from the lowest excavation of the foundation to crest El 3,565.0 ft is 564 ft and the crest length is 2,115 ft. The top of the dam is 39 ft wide with a 30 ft wide roadway and 3 ft high concrete parapet on each side of the roadway. The upstream concrete parapet would provide minor wind-wave protection if a flood fills the reservoir to the level of the dam crest. The base width of the dam varies up to a maximum of 355 ft.

c) Spillway. A "morning glory" spillway shaft is located in the reservoir near the right abutment immediately upstream of the dam (see Plate 2-3). It consists of a 1,125 ft long concrete-lined shaft located between the intake at El 3,560 ft and a bend in the shaft at El 3,073.5 ft and a nearly horizontal shaft 566 ft in length from the bend to the outlet portal at invert El 3,072.5 ft. The spillway shaft forms an angle of 50° (to the horizontal) between the intake and the bend, then becomes nearly horizontal for 566 ft between the bend and the outlet portal. The shaft has a circular cross-section with a variable diameter of 24.5 ft to 34.8 ft, except for a horseshoe section near the outlet. A hollow annular-ring gate 64 ft in diameter and 12 ft high regulates spillway discharge. The gate can be raised and lowered up to 12 ft between El 3,548 ft and El 3,560 ft. The ring gate floats in a circular concrete well filled with water from the reservoir. Maximum spillway discharge is 50,000 cfs at El 3,565 ft.

d) Outlet Works.

(1) Outlets. Three 8 ft diameter, steel-lined outlets each at inlet El 3,200 ft extend through the dam to a valve house located on the right bank of the tailrace about 200 ft downstream from the dam, see Plate 2-4. An 8 ft diameter, ring-follower gate and an 8 ft diameter, hollow jet valve control each outlet. A trash rack is provided at the intake of each outlet. A bulkhead gate at the entrance to each intake is provided to close the outlet for maintenance of the outlet and ring-follower gates. The three gates are operated by a 150-ton gantry crane located on top of the dam. The outlets have a combined maximum discharge capacity of approximately 13,740 cfs at 100% gate opening at reservoir El 3,565 ft. The ring-follower gate must be operated either fully open or closed. When closed, the ring-follower gate completely shuts off flow and allows the hollow jet valve to be set for future use.

(2) Selective Withdrawal System (SWS). A SWS is attached to each penstock trash rack immediately in front of the penstock intake. Details for the SWS are displayed on Plates 2-5 and 2-6. The SWS is used to select and mix reservoir water to provide temperature-controlled project outflow that is suitable for downstream fish habitat. The SWS

consists of three separate bulkhead sections, each operated in a separate guide slot. Dimensions of the gates and bulkheads are provided in the SWS section of the Pertinent Data.

The lowest bulkhead, installed in the inner guide slot immediately in front of the penstock intake, is a relief valve for the unit. The middle bulkhead is composed of three solid stationary sections stacked atop each other in the middle gate slot. Total height of the bulkhead is 100 ft. The bottom of the lowest section sets on a pad at El 3,337.50 ft on top of the relief valve. The top bulkhead is installed in the outer guide slot and is the only adjustable bulkhead used for temperature-control operations. This bulkhead is 100 ft in height with five hydraulically operated slide gates near mid-section. The outer guide slot permits the hoist-controlled bulkhead to be raised or lowered in front of the stationary middle bulkhead allowing selection of water from any point in the top 100 ft of the system. Water enters through the slide gates or through the top of the open chamber between the bulkhead and the dam face. The SWS is normally operated from June through September and is deactivated at other times by raising and dogging the bulkheads to the top of the dam. Temperature control schedules in Table 2-2 provide minimum, optimum, and maximum temperature values for the control period.

e) [redacted]

TABLE 2-3

POWERPLANT PERFORMANCE (ONE TO FOUR UNITS)

[redacted]

[redacted]

[redacted] [redacted]

[redacted] [redacted]

[redacted] [redacted]

[redacted]

[redacted] [redacted]

[redacted] [redacted]

[redacted] [redacted]

f) Forebay and Tailwater Gages.

(1) Forebay Gage. Reservoir elevations are available in the powerhouse by telephone and computer from the USGS gage, Hungry Horse Reservoir near Hungry Horse, MT (gage number 12362000). [redacted]

(2) Tailwater Gage. [redacted]

2.04 Related Control Facilities. The project contains administration offices, a maintenance shop located within the powerhouse, [redacted]

Protection against ice build-up on the spillway intake and penstock trash racks is provided by a compressed-air bubbler system (see Plates 2-7 and 2-8). The stirring and mixing action of the rising air bubbles induces a strong upward flow of relatively warm water which either melts the ice already formed or prevents its formation.

The South Fork Flathead River watershed is mountainous and heavily wooded, and logging operations in the area are a constant source of debris accumulation. Debris collected at the dam by a floating boom anchored across the reservoir is periodically hauled onto the beach and burned.

2.05 Real Estate Acquisition. All lands surrounding HGH above El 3,565.0 ft are owned by the U.S. Forest Service (USFS). A Memorandum of Agreement between the USFS and Reclamation, dated March 12, 1969, provides for development and administration of lands in the reservoir area in accordance with the Reservoir Area Management Plan developed jointly by Reclamation and the USFS, see Exhibit 2-1.

2.06 Public Facilities. Recreation facilities operated in conjunction with the project include a covered viewing platform and a visitor center building located near the dam. All land above the high-water line of the reservoir at El 3,565.0 ft is within the Flathead National Forest. A list of available public facilities at the reservoir is provided in Table 2-4 and shown on Plate 2-9.

- Hungry Horse Dam Visitor Center. The U.S. Bureau of Reclamation operates the Hungry Horse Dam Visitor Center and provides opportunities for cooperative interpretation of the Hungry Horse Reservoir and the surrounding environment.
- Fisheries. Hungry Horse Reservoir contains a resident bull trout population and supports an intact native fish assemblage.
- Boat Launching Facilities. Several boat ramps (see Table 2-4) around the reservoir are provided for public use and are owned and maintained by the US Forest Service (USFS).
- Campgrounds/Cabin. The USFS operates multiple campgrounds and one cabin around the reservoir that combined provide over 100 accommodation sites (see Table 2-4).
- Off-Road Recreation. The Hungry Horse Off-Highway Vehicle Area contains 71 acres of motorized trail-riding.
- Winter Recreation. The Anna Creek Cabin can be booked during winter months and is only accessible via ungroomed access roads.

TABLE 2-4
PUBLIC FACILITIES

Facility Type(s)	Facility Name	Details
Campground	Emery Bay	28 sites, Boat Ramp, Tent/RV/Trailer
Campground	Lost Johnny Point	21 sites, Boat Ramp, Tent/RV/Trailer
Campground	Doris Creek	9 sites, Boat Ramp, Tent/RV/Trailer
Campground	Lid Creek	23 sites, Boat Ramp, Tent/RV/Trailer
Campground	Riverside	3 sites, Boat Ramp, Tent/RV/Trailer
Campground	Murray Bay	20 sites, Boat Ramp, Tent/RV/Trailer
Campground	Devil's Corkscrew	4 sites (primitive), Boat Ramp
Campground	Elk Island	7 sites (primitive), Boat Access Only
Campground	Fire Island	4 sites (primitive), Boat Access Only
Campground	Lakeview	5 sites (primitive)
Campground	Peters Creek	6 sites (primitive)
Boat Launch	Abbot Bay	2 miles east of Hungry Horse Dam
Boat Launch	Canyon Creek Landing	East side of reservoir, off NFD 38.
Boat Launch	Crossover	East side of reservoir near upstream end
Cabin	Anna Creek	15 Max Occupants

SECTION 3. HISTORY OF PROJECT

3.01 Authorization for Project. The HGH project was authorized by Act of June 5, 1944, 78th Congress, Second Session, 58 Stat. 270, "for the purpose of irrigation and reclamation of arid lands, for controlling floods, improving navigation, regulating the flow of the South Fork of the Flathead River, for the generation of electric energy, and for other beneficial uses primarily in the State of Montana but also in downstream areas .... " (see Exhibit 3-1). In Public Law 85-428 (1958), Congress amended the authorization to provide that the HGH Project "shall be subject to the Federal reclamation laws."

3.02 Planning and Design. The HGH site was one of several sites along the South Fork Flathead River considered by federal agencies in the early 20th century during water resource investigations for flood control and power generation. The United States Geological Survey (USGS) initiated the first investigations of the project site in 1921 and conducted field investigations with engineers and geologists between 1934-1936. The USGS's findings were published in 1944 in USGS Water Supply Paper No. 866-B, and it was determined that the location was suitable for a high concrete dam with leakage from the reservoir area appearing to be improbable.

The Corps began investigations in 1931 to identify a dam site in the vicinity of Devil's Elbow, about 4 mi above the mouth of the South Fork Flathead River and about l mi downstream from the present HGH location. In 1933, their findings were reported in House Document 103, 73rd Congress, 1st Session, Volume 4, pages 607-608, and 802-803.

On June 5, 1944, Congress authorized Reclamation to construct HGH, with congressional committee reports stressing urgency in creating regulation for Columbia River basin waterways to increase power production downstream at Grand Coulee and Bonneville dams. In 1945, Reclamation began detailed investigations into the sizing and location of the dam. The selected site for the Hungry Horse Reservoir included inundating many USFS facilities, and an agreement between Reclamation and USFS on February 25, 1947 dictated that Reclamation would rebuild or relocate the affected facilities. The maximum useable and feasible storage capacity was set at 3.5 MAF in an April 11, 1947 report prepared jointly by Reclamation and BPA for the Secretary of the Interior.

3.03 Construction. Preliminary construction on the HGH project began on November 3, 1947 with the excavation of the diversion tunnel in the right abutment of the dam site. Diversion of the South Fork Flathead River began on June 30, 1948, with the first dynamite blast for HGH construction occurring on July 10, 1948 and the first concrete placed September 7, 1949. Construction on the spillways and dam structure continued through 1950 and 1951. The diversion tunnel was closed on September 21, 1951 and the reservoir began to fill. President Harry Truman threw the switch to start power generation at 11:35am on October 1, 1952. The fourth and last generator in the HGH powerhouse went online on July 23, 1953. In 1995, a selective withdrawal system was installed at each penstock intake to control the temperature of waters released by the powerhouse. The system was implemented to maintain suitable water temperatures in dam releases for downstream fish. Generators were upgraded and overhauled between 1990 and 1993. As a result, the capacity of each unit was increased from 71,220 kW (95,509 hp) to 107,000 kW (143,490 hp). Conversion work for remote powerhouse generation control between HGH and Grand Coulee began in 1994. The switchyard was rebuilt in 1995. Installation of new 230 kV transformers and solid-state relay equipment was completed in 1998. Major construction contracts for HGH are listed in Table 3-1.

The power plant at HGH began an extensive modernization effort in Fiscal Year (FY) 2018. The work is intended to bring the facilities up to current industry standards. The work will include the full overhaul or replacement of governors, exciters, fixed-wheel gates, and turbines; a generator rewind; overhaul of the selective withdrawal system; and recoating the penstocks. The cranes that service the power plant will also be refurbished or replaced, and the power plant building will be brought up to modern fire protection standards. The power plant overhaul will limit the number of turbines available to generate power during one of the years of the modernization. The limited number of turbines will not affect the amount of water released from the dam due to the use of the dam outlets for any water releases during that time period. The full modernization effort is expected to take 10 years to complete.

3.04 Related Projects.

a) Flathead River System. Seli'š Ksanka Qlispe' (SKQ) Dam (formerly Kerr Dam) is a 205 ft tall concrete gravity-arch dam located downstream of HGH on the Flathead River at the outlet of Flathead Lake. The dam generates hydroelectricity and provides flood risk management, irrigation, and recreational opportunities. The project is owned by the Confederated Salish and Kootenai Tribes and operated by Energy Keepers Inc. In 2015, Kerr Dam was renamed to Seli'š Ksanka Qlispe' Dam (SKQ). See Section 4.11 for more information on SKQ Dam.

b) Columbia River System. HGH is an integral project of the Columbia River system. Operation is coordinated with other system projects. See references listed in Section 1.03 for more detailed information on the relationship between Hungry Horse and Columbia River system operations.

3.05 Dam Safety History/Issues. The Hungry Horse Dam has a Dam Safety Priority Rating (DSPR) of 4 (Low to Moderate Priority). The key justification for this rating is that the annualized failure probability is below the Public Protection Guidelines, which indicates decreasing justification to reduce risks. The total annualized life loss and the uncertainty associated with the life loss exceeds the guideline value for justifying taking action to reduce or better understand the risk. However, the annualized failure probability is very low with the risk being driven by the high potential life loss.

The total risk is driven by two potential failure modes (PFMs), one static and one seismic PFM. Both PFMs are related to sliding of a large block on the left abutment foundation under either static or seismic conditions.

3.06 Principal Regulation Issues. The principal regulation issue for HGH is related to changes in flow timing and quantity downstream that have resulted in changes to water quality, nutrients, and habitat. Impairment of fish habitat below the dam has been generally due to the low temperature of the water released through the turbines, high total dissolved gas (TDG) levels, and low sediment load.

The cold-water condition affected both the S.F. Flathead River below the dam and the Flathead River from the confluence with the S.F. Flathead River downstream to Flathead Lake. As a result, the selective withdrawal system was completed in 1995 to regulate the temperature of water released from the reservoir. This system has provided HGH operators with the ability to better approximate the natural temperature regime in the river downstream of the dam.

TDG concerns have developed downstream of the dam on the S.F. Flathead River and upstream of the confluence with the Flathead River, with the supersaturated gases potentially have deleterious effects on fish. Discharge from the hollow-jet valves in the outlet works (see Section

2.03) in particular increases TDG due to the high pressure and velocity of the water exiting the valves. HGH operators attempt to adjust releases when feasible to lower downstream TDG levels when the state standard of 110 percent is exceeded.

The regulation of flows on the S.F. Flathead River has altered the sediment transport through the reach, with the restriction of high flows to flush the accumulated fine sediment and the trapping of coarse sediment material behind the dam both contributing to degraded fish and invertebrate habitat downstream.

The implementation of VARQ FC operations in 2002 has allowed fish augmentation flows downstream of the dam to be integrated with flood risk management needs. The updated operational curves have generally resulted in higher springtime flows that more closely mimic the natural conditions. These higher flows somewhat alleviate the fine sediment issue and provide for the flushing of the accumulated fines downstream.

TABLE 3-1

DAM AND POWERHOUSE CONSTRUCTION CONTRACTS

SPEC.	CONTRACT	CONTRACTOR	WORK ITEM	AMOUNT($)
DC-1743		J.J. Reese & Seaboard Surety Co.	Reservoir clearing	not available
R1-HH-10	174R-1184	Coleman H. Dykes	Reservoir clearing	not available
R1-HH-11	12R-1224	Wixon & Crowe	Reservoir clearing	not available
R1-HH-11	174R-1225	J.H. Trisdale	Reservoir clearing	not available
DC-2122	12R-17953	General-Shea-Morrison Co.	Dam, powerhouse, roads, and parking	47,657,000
DS-3020	12R-19092	Willamette Iron & Steel Co.	125-ton gantry crane	not available
DS-2113	12R-18101	Allis Chalmers Mfg. Co.	4 main turbines	not available
DS-2113	12R-18100	Woodward Governor Co.	Governors	not available
DS-2108	12R-18098	General Electric Co.	Generators	4,457,000
DS-2379	12R-18405	Westinghouse Electric Corp.	Transformers	not available
DC-3282	12R-19385	Grafe-Shirley-Lane	Powerplant, switcyard, mechanicals	1,900,000
	not available		Selective withdrawal system	not available
	1425-4-SI-10-6680	Ryan Co.	New transformers	5,483,000

SECTION 4. WATERSHED CHARACTERISTICS

4.01 General Characteristics. The Flathead River with its three main tributaries, the North Fork (N.F.), Middle Fork (M.F.), and South Fork (S.F.) Flathead Rivers, drains a total area of 9,080 mi^2 into the Clark Fork River near Plains, Montana. The N.F. Flathead River drains 1,600 mi^2 which includes the 427 mi^2 portion in British Columbia known as the Flathead River in Canada. The M.F. Flathead River rises along the Continental Divide in Montana and drains 1,132 mi^2 on its generally north-northwestward route of 90 mi to its confluence with the Flathead River at RM 158.3. The S.F. Flathead River drains 1,670 mi^2, including 1,654 mi^2 of the watershed above Hungry Horse Dam (HGH). Originating in the south end of the Bob Marshall Wilderness, the S.F. Flathead River begins at the confluence of Youngs Creek and Danaher Creek and flows approximately 65.4 mi, in generally the north-northwestward direction to the head of the HGH reservoir at RM 39.2. The S.F. Flathead River then passes through the 34 mi long HGH reservoir to HGH dam at RM 5.2 in the same general north-northwestward direction to a confluence with the Flathead River at RM 148.7. From this confluence, the Flathead River flows southward to Flathead Lake at RM 103, through the 31 mi long Flathead Lake to the controlled outlet at SKQ Dam at RM 72, then westward to a confluence with the Clark Fork River at RM 245. Drainage areas for the mainstem and major tributaries of the Upper Flathead River system are listed in Table 4-1.

TABLE 4-1
FLATHEAD RIVER BASIN – DRAINAGE AREAS

	Montana	Canada	Total
Subdivision	mi^2	mi^2	mi^2
Flathead River (mainstem)	4,678		4,678
N.F. Flathead	1,173	427	1,600
M.F. Flathead	1,132		1,132
S.F. Flathead	1,670		1,670
Totals	8,653	427	9,080

4.02 Topography. The Flathead River above Flathead Lake drains rugged and mountainous watersheds along the west slopes of the Continental Divide. Elevations range from 2,893 ft at Flathead Lake to 10,182 ft at Mt. Stimson with a number of peaks above 8,000 ft. Runoff below Flathead Lake occurs mostly from terrain below 6,000 ft. Broad, flat valleys are located adjacent to the Flathead River south of the town of Columbia Falls, Montana.

4.03 Geology and Soils. The Upper Flathead Valley lies entirely within the Rocky Mountain Trench, which, in this area, is the result of deep structural lowering of the underlying rock and glacial and fluvial erosion. This part of the trench was glaciated several times during the Pleistocene Ice Age by an extensive tongue of continental ice. Some visible effects of the glaciation are streamlined hills that border the trench and, in some areas, rise above the trench floor. Glacial outwash and lake deposits are extensive in this region. A large morainal dam was formed at the southern margin of the glacial ice south of Flathead Lake. When the ice withdrew, a large lake formed in the trench north of the original moraine. Substantial deposits of sand, silts, and clays, with occasional gravel layers, were deposited in this area. River and glacial cutting through these deposits formed the shallow inner valley of the upper Flathead. The geologic sequence along the upper Flathead above Kalispell (revealed by drilling) generally consists of overbank silt and fine sand underlain by river sands and gravels to depths varying from 15 ft to 30 ft. Below this rather shallow fluvial stratum is a series of thinly-bedded fine sands, silts, and clays which are part of the glacial lake sequence. The overbank silts are missing in some localized areas.

4.04 Sediment. During high flows in the three forks of the upper Flathead River, considerable erosion takes place, undermining banks, roads, and portions of the railroad along the M.F. Flathead River. Sediment deposition in Hungry Horse Reservoir has made no noticeable change in the storage capacity of the reservoir. Sediment concentration values measured during the 1965-1967 winter periods at the USGS stream gage station, Flathead River at Columbia Falls, varied from a maximum of 980 mg/l to a minimum of 1 mg/l on several days during most sampling periods. The sediment load varied from a maximum daily load of 140,000 tons to a minimum daily load of 4 tons.

4.05 Climate.

a) General. The Flathead River basin is influenced by a modified west coast marine and continental climate. The climate varies with elevation and proximity to mountain ranges. In the mountainous regions, the influence of the Continental Divide is greater than the maritime influence, and heavy showers and occasional cloudbursts occur in May, June, and July. Marine influences are strongest during the winter and cause most of the winter snowfall when warm moist air from the Pacific Ocean is cooled by orographic lifting over the mountains in the upper basin or by frontal contact with Arctic air masses. Tables 4-2, 4-3, and 4-4 (see Tables section) list the pertinent climate gages, stream gages, and snow gages/courses, respectively. Plates 4-1, 4-2, and 4-3 show the locations of these gages.

TABLE 4-2
HUNGRY HORSE REGIONAL CLIMATE GAGES

Index	Station Name	State	COOP ID	Elevation (ft NGVD29)	Period of Record
1	Bigfork 13 S	MT	240755	2,910	1938 - Act.
2	Creston	MT	242104	2,940	1949 - Act.
3	Hungry Horse Dam	MT	244328	3,160	1948 - Act.
4	Kalispell	MT	244563	2,971	1896 – Act.
5	Lindbergh Lake	MT	245043	4,500	1959 - Act.
6	Olney	MT	246218	3,170	1962 - Act.
7	Polebridge	MT	246615	3,520	1948 - Act.
8	Polson	MT	246635	2,390	1906 - 2015
9	SKQ (Polson Kerr) Dam	MT	246640	2,730	1952 - Act.
10	Saint Ignatius	MT	247286	2,900	1948 - Act.
11	Swan Lake	MT	248087	3,190	1948 - 2011
12	West Glacier	MT	248809	3,154	1949 - Act.
13	Whitefish	MT	248902	3,100	1948 - Act.

Source for climate data is www.ncei.noaa.gov

TABLE 4-3
HUNGRY HORSE REGIONAL USGS STREAM GAGES

Index	Station No.	Station Name	Area (sq. mi)	Available Data	Period of Record
1	12355000	Flathead River at Flathead, BC	429	D, GH	1929 – Act.
2	12355500	N.F. Flathead River nr Columbia Falls	1,556	D, GH, WT	1910 – Act.
3	12358500	M.F. Flathead River nr West Glacier	1,125	D, GH	1939 – Act.
4	12359800	S.F. Flathead River above Twin Creek nr Hungry Horse	1,159	D, GH	1964 – Act.
5	12362000	Hungry Horse Reservoir nr Hungry Horse	1,654	GH	1951 – Act.
6	12362500	S.F. Flathead River nr Columbia Falls	1,668	D, GH, WT	1911 – Act.
7	12363000	Flathead River at Columbia Falls	4,473	D, GH, WT	1922 – Act.
8	12365000	Stillwater river nr Whitefish	558	D	1930 – Act.
9	12366000	Whitefish River near Kalispell	170	D, GH	1928 – Act.
10	12370000	Swan River nr Bigfork	672	D, GH	1922 – Act.
11	12371500	Flathead Lake at Somers	7,086	GH	1928 - 1998
12	12372000	Flathead River nr Polson	7,079	D, GH	1907 – Act.
13	12388700	Flathead River at Perma	9,024	D, GH, WT	1983 – Act.

Source for stream gage data is https://waterdata.usgs.gov/nwis/rt.
D = discharge, GH = gage height, WT = water temperature, T = turbidity

b) Temperature. Seasonal variation in temperature is substantial. High elevations experience frost in every month of the year, but in general the lower elevation valleys are frost-free in June, July, and August. Extreme temperatures reached a maximum of 105° F on August 4, 1961 in Kalispell and a minimum of -53° F on January 7, 1937 at Seeley Lake RS. Table 4-5 shows average and extreme temperatures by month for representative stations in the basin.

TABLE 4-5
AVERAGE AND EXTREME TEMPERATURES BY MONTH (°F), FLATHEAD REGION

Station*	Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AVG
Hungry Horse Dam (1948-2020)	Avg Max	29.6	34.7	42.5	52.7	63.8	71.5	81.3	80.1	67.7	52.4	38.0	31.1	53.8
	Avg Min	16.2	18.4	23.4	31.4	39.4	46.0	51.0	49.9	41.9	33.5	25.8	19.4	33.0
	Mean	22.9	26.5	32.9	42.0	51.4	58.7	66.1	65.0	54.8	43.0	31.9	25.2	43.4
	Highest	56	62	69	86	95	102	103	102	97	81	64	59	---
	Lowest	-40	-34	-26	2	12	26	34	21	20	4	-20	-28	---
Kalispell (1896-2020)	Avg Max	29.1	34.2	43.4	55.0	64.4	71.2	81.0	79.7	68.3	54.8	39.3	30.9	54.5
	Avg Min	14.6	17.4	24.1	31.9	39.4	45.5	49.4	47.7	40.0	31.5	24.6	17.9	32.1
	Mean	21.8	25.8	33.8	43.5	51.9	58.4	65.2	63.7	54.1	43.2	32.0	24.4	43.3
	Highest	56	64	73	85	95	102	104	105	99	86	69	58	---
	Lowest	-38	-36	-29	-8	17	26	30	30	7	-4	-28	-35	---
Polson (1907-2014)	Avg Max	31.6	36.4	45.2	56.0	65.0	72.6	82.2	80.9	69.1	56.2	41.6	33.8	56.0
	Avg Min	19.5	21.9	27.3	34.2	40.8	47.6	53.0	52.1	44.3	36.0	27.7	22.4	35.6
	Mean	25.5	29.2	36.3	45.1	52.9	60.1	67.6	66.5	56.7	46.1	34.6	28.1	45.8
	Highest	58	66	74	84	91	98	104	101	93	83	71	62	---
	Lowest	-30	-27	-10	-1	17	26	32	31	16	1	-21	-25	---
Seeley Lake RS (1937-2020)	Avg Max	30.3	37.5	44.4	53.9	63.8	71.2	82.1	81.6	71.0	57.2	39.9	31.1	55.3
	Avg Min	9.2	12.8	18.7	26.9	34.3	40.7	43.6	41.9	35.6	29.6	21.6	13.1	27.3
	Mean	19.8	25.2	31.5	40.4	49.0	55.9	62.8	61.7	53.2	43.4	30.7	22.1	41.3
	Highest	55	62	73	86	93	95	102	101	94	85	65	57	---
	Lowest	-53	-45	-42	-1	13	23	28	24	15	-10	-31	-44	---
Swan Lake (1963-2011)	Avg Max	30.8	37.7	45.5	55.4	65.2	71.8	81.2	80.4	69.2	55.9	39.4	30.3	55.4
	Avg Min	15.6	18.3	23.0	28.9	35.7	41.7	44.4	43.1	36.5	29.7	23.8	16.5	29.8
	Mean	23.2	28.0	34.3	42.2	50.3	56.7	62.8	61.8	52.7	42.8	31.6	23.5	42.6
	Highest	53	57	76	86	92	94	100	103	98	83	70	55	---
	Lowest	-36	-28	-19	5	18	24	28	26	17	-2	-10	-40	---
West Glacier (1948-2020)	Avg Max	29.2	34.3	42.4	53.2	64.3	71.4	80.1	78.9	67.4	52.8	37.8	30.0	53.6
	Avg Min	16.1	18.4	23.5	30.2	37.6	44.1	48.0	46.9	39.5	32.2	25.4	18.7	31.8
	Mean	22.7	26.4	33.0	41.7	50.9	57.8	64.0	62.9	53.4	42.5	31.6	24.3	42.7
	Highest	55	58	66	83	90	98	99	100	100	79	67	52	---
	Lowest	-35	-32	-30	0	13	24	27	26	18	-3	-29	-36	---

**Values taken from NOAA's National Center for Environmental Information, www.ncei.noaa.gov;*

c) Precipitation. Topographic conditions in the basin have a great influence on the basin's precipitation. The heaviest amounts of precipitation occur in the mountainous regions when moist air rises over the many ranges. The recorded mean annual precipitation in the Flathead basin varies from about 15.3 inches at Polson to about 33.1 inches at Hungry Horse Dam. Precipitation data is shown in Table 4-6 and Table 4-7.

TABLE 4-6
MEAN MONTHLY PRECIPITATION (INCHES)

Station*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Hungry Horse Dam	3.31	2.37	2.49	2.33	2.59	3.28	1.61	1.61	2.19	3.01	3.59	3.49	31.31
Kalispell	1.40	0.99	1.00	1.07	1.73	2.28	1.09	1.06	1.24	1.09	1.40	1.44	15.65
Polson	1.00	0.83	0.94	1.27	1.96	2.30	1.01	1.07	1.37	1.20	1.18	1.15	15.28
Seeley Lake RS	2.51	1.71	1.42	1.27	1.80	2.24	1.00	1.07	1.27	1.40	2.12	2.38	19.61
Swan Lake	3.23	2.18	2.06	1.58	2.44	2.92	1.31	1.75	1.95	2.20	3.15	3.36	28.12
West Glacier	3.41	2.35	2.17	1.92	2.57	3.41	1.61	1.48	2.01	2.60	3.17	3.27	29.46

**Values taken from NOAA's National Center for Environmental Information, www.ncei.noaa.gov;*
See Table 4-7 for Period of Climate Summary for each site.

TABLE 4-7
PRECIPITATION SUMMARY DATA

Station*	Elev (ft)	Period of Climate Summary (Water Year)	Annual Precipitation (inches)			Annual Snowfall (inches)
			Mean	Greatest	Least	Mean
Hungry Horse Dam	3,160	1948-2020†	31.31	49.94	16.52	62.1
Kalispell	2,971	1896-2020†	15.65	25.23	4.94	55.5
Polson	2,390	1907-2014	15.28	21.61	10.17	28.90
Seeley Lake RS	4,100	1937-2020†	19.61	31.03	5.45	113.1
Swan Lake	3,190	1964-2011	28.12	37.73	21.08	124.9
West Glacier†	3,154	1949-2020†	29.46	42.16	13.02	127.3

** Values taken from NOAA's National Center for Environmental Information, www.ncei.noaa.gov;*
†Station currently active

d) Evaporation. Evaporation in the lower portions of the Flathead River basin averages about 35 inches to 40 inches per year. Monthly evaporation amounts for Hungry Horse Reservoir are shown in Table 4-8.

TABLE 4-8
EVAPORATION DATA – HUNGRY HORSE DAM[1]

Reservoir Elevation (ft NGVD29)	Monthly Evaporation in cfs											
	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
3580	N/A	25.7	35.6	52.4	66.9	78.9	80.3	82.8	58.1	31.0	25.2	N/A
3560	N/A	24.8	33.9	49.2	62.8	73.6	74.9	77.4	54.5	29.6	24.2	N/A
3540	N/A	23.9	32.1	46.2	58.2	68.2	69.4	71.6	50.9	28.3	23.4	N/A
3520	N/A	23.0	30.4	43.4	54.0	62.9	64.1	66.2	47.7	27.1	22.4	N/A
3500	N/A	22.1	28.7	40.6	50.2	57.8	59.0	61.1	44.5	25.7	21.6	N/A
3480	N/A	21.2	27.2	37.8	46.5	53.1	54.3	56.0	41.4	24.4	20.8	N/A
3460	N/A	20.4	25.7	35.1	43.0	48.8	49.7	51.3	38.4	23.2	19.9	N/A
3440	N/A	19.6	24.3	32.6	39.6	44.7	45.8	46.9	35.5	22.1	19.1	N/A
3420	N/A	18.8	23.1	30.3	36.3	41.1	42.0	43.0	32.8	21.1	18.4	N/A
3400	N/A	18.1	21.9	28.1	33.3	37.5	38.4	39.1	30.2	20.2	17.7	N/A
3380	N/A	17.5	20.8	26.1	30.5	34.4	35.2	35.8	28.0	19.2	17.1	N/A
3360	N/A	16.9	19.7	24.2	28.2	31.5	32.3	33.0	26.0	18.4	16.6	N/A
3340	N/A	16.5	18.7	22.7	26.2	29.0	29.6	30.3	24.3	17.7	16.2	N/A
3320	N/A	16.0	18.0	21.5	24.4	26.9	27.4	28.0	22.8	17.1	15.8	N/A
3300	N/A	15.7	17.5	20.5	23.2	25.0	25.4	26.1	21.7	16.6	15.5	N/A

[1]*Values taken from Chart 4-1 in 2005 manual. Notes indicate that values are derived from BPA – Branch of Power Resources, Water Utilization Section, April 11, 1949 and based on USBR data for Ninepipe Reservoir. The months of January and December were not provided in Chart 4-1.*

e) Snow. Most of the precipitation during the fall and winter months occurs as snowfall. The annual snowfall varies from less than an inch in the lowest elevations to more than 200 inches in the mountains. Values of precipitation and snowfall are summarized in Table 4-7.

f) Wind. In the NOAA 2018 Local Climatological Data Annual Summary for Kalispell, MT (https://www.ncei.noaa.gov/pub/data/lcd/annual/2018/01201813GPI.pdf), the maximum 2-minute wind speed at this location for the period of record was 48 mph, which occurred on several instances. The maximum 3-second wind speed at this location for the period of record was 75 mph, which occurred in October 2009. The mean speed over a 35-year period of record varies monthly from 4.1 mph to 7.0 mph, with an annual average of 5.4 mph.

g) Climate Change. The Corps Climate Preparedness and Resilience Policy Statement (27 June 2014), states that the Corps will integrate climate change preparedness and resilience planning and actions in all activities for the purpose of enhancing the resilience of our built and natural water-resource infrastructure to reduce the potential vulnerabilities of that infrastructure to the effects of climate change and variability. Extensive climate assessments have been performed in this region and have been published in the latest EIS for the Columbia River System. Chapter 4 of the EIS includes the results and conclusions from these studies.

A summary of observed trends in primary and secondary climate variables in the Columbia River Basin indicates that temperatures have increased over the period of record and are expected to continue to increase. As a result of these rising temperatures, other aspects of the environment are changing as well, such as receding glaciers, diminishing snow cover, shrinking sea ice, rising sea levels, and increasing atmospheric water vapor. According to the 2017 Fourth National Climate Assessment Volume 1, annual trends of earlier spring snow melt and reduced snowpack in the Columbia River Basin is likely to decline, winter streamflows will tend to increase, peak seasonal snowmelt will tend to occur earlier in the spring and summer flows will likely decrease.

A summary of projected trends in primary and secondary climate variables in the Columbia River Basin for the 2020-to-2049-time frame (referred to as the 2030's) was presented in the RMJOC 2018 Report as follows:

Temperatures in the region have warmed about 1.5 degrees Fahrenheit since the 1970s. They are expected to warm another 1 to 4 degrees Fahrenheit by the 2030's.
Warming in the region is likely to be greatest in the interior with a greater range of possible outcomes. Less pronounced warming is projected near the coast.
Future precipitation trends are more uncertain, but a general upward trend is likely for the rest of the twenty-first century, particularly in the winter months. Already dry summers could become drier.
Average winter snowpacks are very likely to decline over time as more winter precipitation falls as rain instead of snow, especially on the United States side of the Columbia River Basin.
By the 2030's, higher average fall and winter flows, earlier peak spring runoff, and longer periods of low summer flows are very likely.

The projected changes in precipitation along with a warming climate could have profound implications on both magnitude and seasonality of future streamflows for hydroregulation operations and planning. The cumulative streamflow projections in the upper Columba River Basin near HGH show modest change through the 2030s, largely because winter precipitation is projected to continue to fall as snow for some time. However, studies still project increased temperatures and annual precipitation, and changes in the spring and early summer streamflow. Some projections indicate higher spring freshet peaks, which tend to occur 1 or 2 weeks earlier. Nearly all projections indicate decreased volume of flow in summer months. At the headwater of the Pend Oreille River, projected changes in inflows to Hungry Horse Dam are relatively modest by the 2030s, with slightly earlier timing and intensified high flows in winter and early spring. The Water Control Plans are reviewed periodically and updated as needed to manage climate change and variability impacts.

4.06 Storms and Floods.

a) General. Historical records are available for eight floods prior to the beginning of flood control by HGH which would have caused flooding along the upper Flathead due to uncontrolled runoff, even if the project had been in operation for flood control. In addition, flooding occurred in 1954 and 1964 with HGH in operation. Data for these floods are shown in Table 4-9.

Flooding along the southern portion of the upper Flathead flood plain is influenced by the water level of Flathead Lake, which is controlled 4.5 river miles downstream of the natural lake outlet by SKQ Dam. Because of natural restrictions in the Flathead Lake outlet channel, flows cannot be released fast enough during infrequent large floods to keep the lake surface below El 2,893 ft, and hence backwater affects the water surface in the river upstream of the lake.

b) 1964 Flood. The 1964 flood far exceeded all other recorded floods on the upper Flathead River. On 7-8 June, runoff from extremely intense rain and a melting snowpack combined to send rivers and streams, already at near bankfull stages, to unprecedented flood heights. The N.F. Flathead River above its confluence with the M.F. Flathead River reached a peak flow of 69,100 cfs. This flow was approximately double the next highest peak experienced during the period of record with the exception of the 1995 flood, which had a peak flow of 59,200 cfs. The M.F. Flathead River near West Glacier reached a peak of approximately 140,000 cfs, which is more than double the next highest peak in the period of record. Peak inflow to Hungry Horse Reservoir, estimated at 78,000 cfs, was completely impounded by the project, except for minimum outflow requirements. The flood hydrograph from the 1964 flood is shown on Plate 4-4.

c) Other Large Floods. The next two greatest known floods on the Flathead River occurred in 1894 and 1948. Both floods were due to snowmelt, although some significant contribution from rain occurred in 1948. The flood hydrograph from the 1948 flood is shown on Plate 4-5. A tabulation of the 10 highest floods on the Flathead River at Columbia Falls gage is shown in Table 4-9. The ten highest May – September recorded runoff volumes for the Flathead River at Columbia Falls gages are listed in Table 4-10. Plate 4-6 shows the 1972 flood regulation at Hungry Horse Reservoir.

TABLE 4-9
TEN HIGHEST KNOWN FLOODS – FLATHEAD RIVER AT COLUMBIA FALLS, MT

Order	Date of Discharge	Regulated cfs	Unregulated cfs
1	June 1964	176,000	245,000
2	June 1894	---	142,000
3	June 1975	77,600	105,000
4	June 1995	66,000	---
5	June 1974	65,900	104,000
6	May 1948	---	102,000
7	May 1997	60,800	101,600
8	May 1928	---	101,000
9	June 1933	---	91,200
10	May 1932	---	89,800

[1]The 1894 flood discharge was estimated from historical information.
[2]Unregulated discharge for the 1964, 1974, 1975, and 1997 floods were estimated by the Corps-NWD using the SSARR hydraulic computer model

TABLE 4-10
TEN HIGHEST RECORDED RUNOFF VOLUMES (MAY – SEPTEMBER)
– FLATHEAD RIVER AT COLUMBIA FALLS, MT (1949-2020)

Order	Water Year	Volume (1,000 acre-ft)
1	2011[R]	8,077
2	1954[R]	7,855
3	1974[R]	7,717
4	1997[R]	7,297
5	1950[N]	7,236
6	1972[R]	7,225
7	1959[R]	7,121
8	1964[R]	7,088
9	1991[R]	7,026
10	1975[R]	6,849

Code: N = natural R = regulated

<u>4.07 Runoff Characteristics.</u> Flathead River natural streamflows are typically low during the winter snow-accumulation period and high during the spring snowmelt runoff. Spring runoff usually begins in April or early May with the melting of the low elevation snowpack. The snowmelt runoff usually peaks in late May or early June as warmer temperatures cause basin-wide melting. A slow recession normally occurs during the late summer and fall as the high-level snowpack is gradually depleted. Occasionally, a heavy rainstorm moves through the basin during the snowmelt period adding to the runoff before cooler temperatures reduce the snowmelt contribution. Such an occurrence impacted the May 1948 and June 1964 flood peaks. Table 4-11 gives mean monthly streamflow data for six of the principal gages in the Flathead River basin. Daily discharge hydrographs for the stations, S.F. Flathead River above Twin Creek near Hungry Horse, S.F. Flathead River near Columbia Falls, N.F. Flathead River near Columbia Falls, and

Flathead River at Columbia Falls are shown on Plates 4-7 to 4-10, respectively. Daily reservoir elevations for Hungry Horse Reservoir are shown on Plate 4-11.

TABLE 4-11
FLATHEAD RIVER – MEAN MONTHLY STREAMFLOWS
(CFS)

Stream Name	S.F. Flathead River	S.F. Flathead River	M.F. Flathead River	N.F. Flathead River	Flathead River	Flathead River
Location	above Twin Creek nr Hungry Horse	nr Columbia Falls	nr West Glacier	nr Columbia Falls	at Columbia Falls	nr Polson
USGS Gage No.	12359800	12362500	12358500	12355500	12363000	12372000
Drainage area (sq mi)	1,159	1,668	1,125	1,556	4,473	7,079
Period of Record	1965 - 2018	1911 - 2019	1939 - 2019	1910 - 2019	1922 - 2019	1907 - 2018
Oct	554	2,452	1,029	1,161	4,801	6,571
Nov	652	2,368	1,231	1,259	5,027	7,312
Dec	514	3,203	923	925	5,198	8,231
Jan	479	3,351	717	765	4,962	8,262
Feb	520	3,144	728	742	4,750	7,829
Mar	612	3,125	974	969	5,218	7,086
Apr	2,586	4,831	3,321	3,347	12,057	9,812
May	7,868	6,264	9,550	9,722	26,057	22,779
Jun	8,126	6,015	9,932	9,972	26,243	30,915
Jul	2,602	3,398	3,889	3,989	11,431	16,469
Aug	729	2,327	1,318	1,583	5,351	7,106
Sep	544	2,416	908	1,133	4,537	5,974
Mean Annual	2,310	3,498	2,892	3,002	9,806	11,567
Max Annual	2,988	5,326	4,076	4,721	14,090	17,160
Min Annual	1,175	1,012	1,437	1,383	5,335	5,197
Max Daily	29,500	40,800	92,700	58,000	158,000	82,100
Min Daily	135	7.3	189	190	850	32
Runoff (CFSM)	1.99	2.10	2.57	1.93	2.19	1.63
Peak Flow	50,900	46,200	140,000	69,100	176,000	110,000
Date of Peak Flow	6/8/1964	6/19/1916	6/9/1964	6/9/1964	6/9/1964	6/1894

4.08 Water Quality. The water use classifications for the Flathead River drainage were obtained from Montana Secretary of State website at:

http://www.mtrules.org/gateway/ChapterHome.asp?Chapter=17%2E30

The pertinent information is listed in Chapter 30, Sub-Chapter 6, Rule 17.30.608 entitled, "Water-Use Classifications-Flathead River Drainage". These classifications have an effective date of 13 May 2017. The definitions of the classifications are provided in Rules 621 through 629 of the above referenced document. The classifications for the Flathead River drainage are given below. A description of the Montana surface water classification and designated beneficial uses is provided in Table 4-12.

TABLE 4-12
MONTANA SURFACE WATER CLASSIFICATIONS AND DESIGNATED BENEFICIAL USES

Classification	Designated Uses
A-Closed	Waters classified A-Closed are to be maintained suitable for drinking, culinary and food processing purposes after simple disinfection
A-1	Waters classified A-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities.
B-1	Waters classified B-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply
B-2	Waters classified B-2 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-3	Waters classified B-3 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-1	Waters classified C-1 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-2	Waters classified C-2 are to be maintained suitable for bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-3	Waters classified C-3 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers. The quality of these waters is naturally marginal for drinking, culinary and food processing purposes, agriculture and industrial water supply
I	The goal of the State of Montana is to have these waters fully support the following uses: drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

Flathead River drainage above Flathead Lake. This area is listed as B-1 with the following exceptions:

- Essex Creek drainage to the Essex water supply intake: A-Closed
- Stillwater River (mainstem) from Logan Creek to the Flathead River: B-2
- Whitefish Lake and its tributaries: A-1
- Whitefish River (mainstem) from the outlet of Whitefish Lake to the Stillwater River: B-2
- Haskill Creek drainage to the Whitefish water supply intake: A-1
- Ashley Creek (mainstem) from Smith Lake to bridge crossing on the airport road about one mile south of Kalispell: B-2
- Ashley Creek (mainstem) from bridge crossing on airport road to the Flathead River: C-2
- The mainstems of the north and middle forks of the Flathead River above their junction: A-1

Classified B-1 waters require conventional treatment before drinking and culinary and food processing and are marginally acceptable for the propagation of salmonid fishes and associated aquatic life. Applicable Montana water quality standards for these B waters are found in Administrative rule(s): 17.30.623, 17.30.624 and 17.30.625, which include qualitative and quantitative provisions for bacteria, color, dissolved oxygen, pH, turbidity, temperature (and change in temperature rates), solids & oils, toxics as well as non-degradation of receiving water stipulations.

4.09 Channel and Floodway Characteristics. The Flathead River from Columbia Falls to Flathead Lake follows a meandering course through a broad floodplain varying from 1 mile to 4 miles wide. In general, the left bank restricts the floodplain width resulting in little difference between the extents of small and large floods. The right bank floodplain from Columbia Falls to Kalispell is a gently rolling landscape which gradually rises with distance from the river. As a result, the floodplain increases in size with the increase in flood discharge. Flooding immediately upstream of Flathead Lake is aggravated by backwater effects when the lake is at an elevated level. There is a robust groundwater response to high discharge at Columbia Falls gage and high Lake level. This adds to agricultural flooding, even though in many cases there is no surface water connection between the damaged area and the river. Between Kalispell and Flathead Lake, the Flathead River channel is deep with a large flood-carrying capacity, particularly at low lake stages. The slope of the Flathead River in this reach varies from 5 to 7 ft/mi. Average velocities in the channel and overbank during the 1964 flood ranged between 3 to 8 ft/s. Average overbank velocities vary widely depending on depth and location but are generally less than 3 ft/s. There are a few low levees along the right bank and some minor bank protection between Kalispell and Flathead Lake. The only significant obstruction to streamflow in the upper Flathead is the embankment approach to the U.S. Highway 2 bridge east of Kalispell.

The primary area of potential flood damages in the Flathead River is between Columbia Falls and Flathead Lake. Residential and commercial damages are concentrated in an area adjacent to the city of Kalispell, and agricultural damages are predominantly upstream and downstream of this area. USACE, USGS, NOAA and local entities have developed flood inundation mapping for a range of scenarios on the Flathead. The maps provide a tool to assist in visualizing the river versus lake relationship to flooding and are posted online at https://fim.wim.usgs.gov/fim/.

Considerable damage can occur around Flathead Lake for large volume floods that raise the level of the lake above El 2,893 ft. Discharge-Damage and Stage-Damage conditions for the Flathead

River and Flathead Lake, corresponding to discharges and stages at the gages, Flathead River at Columbia Falls and Flathead Lake at Somers, respectively, are listed in Tables 4-13 and 4-14 and are shown on Plates 4-12 and 4-13. Plate 4-14 shows the effect of backwater from Flathead Lake on Flathead River discharge damage levels measured at the streamgage, Flathead River at Columbia Falls. This curve applies mainly in the river reach from Kalispell to the Lake where Lake backwater is a factor. The official National Weather Service (NWS) flood stage for the Flathead River at Columbia Falls of 13 ft corresponds to a discharge of about 44,100 cfs. Plate 4-14 indicates this relationship is valid for Flathead Lake levels up to El 2,893.2 ft with higher lake stages requiring reduced discharges to avoid flood damages. The discharge-damage relationship is uncertain between 13 ft and 14 ft which corresponds to discharges of 44,100 cfs and 51,100 cfs, respectively. For this reason, Reclamation will regulate the Flathead River at Columbia Falls to 13 ft whenever it is possible if Flathead Lake is at or above the top foot of its operating elevation (above El 2892 ft.). Plate 4-14 is used by NWD and Reclamation to determine the combination of flows at Columbia Falls and Flathead Lake stage that cause damage to local areas above Flathead Lake.

TABLE 4-13
FLOOD DAMAGE CONDITIONS RELATED TO THE GAGE, FLATHEAD RIVER AT COLUMBIA FALLS, MT

Stage (feet)	Character of Flooding
13.0 (SKQ >2892 ft)	1. Flood stage defined by National Weather.
14.0 (SKQ < 2892 ft)	1. Spruce Park flooded. Evergreen area starting to flood through Spruce Park.
	2. Isolation of some valley-bottom homes imminent.
16.0	1. Farmlands and buildings in the vicinity of Kalispell, Creston, and Foys Bend flooded. Many homes isolated.
	2. Low-lying county and farm roads submerged in several places but still passable. Erosion of roadbeds and shoulders taking place, especially by swift-flowing tributary floodwaters (Logan Creek, Stillwater River, Whitefish River). County roads in vicinity of Foys Bend impassable. (Note: Flathead Lake levels will affect flooding south of Kalispell.)
17.5	1. Flooding begins in lowlands near Columbia Falls. Begin evacuation of affected residents.
	2. Evacuation of families inf flooded area east of Kalispell necessary.
	3. Many secondary roads impassable, but no main highways threatened.
19.0	1. Highway 93 between Kalispell and Somers flooded in three places to depths ranging from 1.5 ft to 3.5 ft; 1.5 ft of water over the deck of the Ashley Creek bridge. Secondary roads generally impassable.
	2. Lower floors and basements of many buildings throughout the valley submerged. Additional evacuations necessary.
	3. Kalispell city water supply pumping plant surrounded by floodwaters, and in danger of being flooded. City park flooded. Total area flooded is about 20,000 acres.
	4. Riverbanks, farmland, bridge abutments, levees subject to erosion.
21.1	1. Few buildings in the floodplain above Flathead Lake remain above water, and damage to farmlands, equipment, and livestock is extensive.
	2. Complete evacuation of flood-vulnerable buildings in Flathead Valle.
	3. Main highways are generally passable, but detours are necessary in some places.
	4. Kalispell water supply plant flooded and inoperable.
22.5	1. Highway damage as follows: a. U.S. No. 93, Somers to Kalispell, flooded in places from a few inches to 5 ft deep. b. U.S. No. 2, Kalispell to West Glacier, flooded 4 ft deep just northeast of Kalispell and 1.5 ft deep in Bad Rock Canyon about 2 miles east of Columbia Falls. c. State Highway 37 under 2 ft of water just east of Flathead River Bridge at Columbia Falls. d. Secondary roads extensively flooded throughout the valley above Flathead Lake and generally impassable. e. Many county timber bridges destroyed or damaged.
	2. Burlington Northern Santa Fe Railway spur line to Kalispell flooded up to 4 inches deep for 2,600 ft about 1 mile north of Kalispell.

NOTE: NWS Flood Stage is 13 ft but during a flood event the target stage will be either 13 ft or 14 ft dependent on Flathead Lake elevation.

TABLE 4-14
FLOOD DAMAGE CONDITIONS RELATED TO THE GAGE, FLATHEAD LAKE AT SOMERS, MT

Stage (feet)	Character of Flooding
2,893.0	1. Zero damage.
2,896.0	1. Planing mill yard in Somers partly flooded.
	2. Evacuation of most lakeshore residents should begin. Building, gardens, pumps, and other project adjacent to Lake are probably flooded.
	3. Levees along north lakeshore between Somers and Big Fork in critical condition, and would probably fail in the event of a strong wind.
2,898.0	1. Planing mill at Somers shut down.
	2. Levees at north end of Lake have generally failed, resulting in extensive inundation of developed farmlands and buildings.
	3. State fish hatchery threatened with extensive damage.
	4. Complete evacuation of flood-vulnerable buildings around Lake should be accomplished.
2,900.0	1. Considerable damage to highways, U.S. 93 along west side of Lake flooded 3 to 5 inches near Lakeshore, Dayton, and Elmo.
	2. South end of Somers inundated.
	3. Hatching and rearing facilities at State fish hatchery flooded.

4.10 Upstream Structures. There are no major dams upstream of HGH on the S.F. Flathead River or on the Flathead River upstream from the S.F. Flathead River.

4.11 Downstream Structures. The principal dam in the Flathead basin downstream from HGH is SKQ Dam at the outlet of Flathead Lake. Additional information on SKQ Dam is provided below. A list of primary downstream dams and reservoirs downstream from HGH is given in Table 4-15.

SKQ Dam. SKQ Dam was constructed for the generation of hydroelectric power. On May 23, 1930, (amended July 17, 1936), the Federal Power Commission (FPC) (now the Federal Energy Regulatory Commission) (FERC) issued a license to the Rocky Mountain Power Company, a subsidiary of the Montana Power Company (MPC), to construct and operate Kerr Dam. The dam and first generating units began commercial operation in 1939. Present installed capacity is 185 MW. On July 17, 1985, FERC issued a joint 50-year operating license for the Kerr Project (Project No. 5) to MPC and the Confederated Salish and Kootenai Tribes (CSKT). The joint license provides that MPC is to operate the project for the first 30 years, and the CKST would have the option of acquiring and operating the project for the remaining 20 years of the license term. In 1999, Pennsylvania Power and Light (PPL) purchased Kerr Dam. PPL is known as "PPL Montana, LLC" where LLC means Limited Liability Company. In 2015 the CSKT and their company, Energy Keepers Incorporated, exercised their right to acquire the dam. Additional operating details for Kerr Dam (now SKQ dam) are listed below.

- Article 23 of the initial license authorized MPC to regulate Flathead Lake between El 2,883 ft and 2,893 ft, which contains active storage of 1,219,000 ac-ft. The lake has a surface area of 126,000 acres at El 2,893 ft.
- A "Memorandum of Understanding" between MPC and the Corps, dated May 31, 1962, and amended on October 15, 1965, provides for the seasonal flood control regulation of Flathead Lake as follows: (1) The Licensee and the Corps of Engineers will cooperate in exchanging data and coordinating operations for flood control. (2) Conditions permitting, the lake will be drawn down to El 2,883 ft, the minimum level under the license, by April 15th and will be raised to El 2,890 ft by Memorial Day (May 30th) and to El 2,893 ft, the maximum level under the license, by June 15th. (3) When the lake reaches El 2,886 ft in a moderate or major flood year, the Licensee will gradually open the Kerr spill gates to maintain free flow and will not close the gates until after the danger of exceeding El 2,893 ft has passed.

- By Order issued February 24, 1996, the FPC ordered: "Until further order of the Commission, the principles and procedures for regulation of Flathead Lake contained in the aforesaid memorandum of understanding are approved and prescribed under Article 21 of the license for the Montana Power Company's Kerr development, Project No. 5."

TABLE 4-15
EXISTING DOWNSTREAM DAMS AND RESERVOIRS

Project Name	River	Owner Operator	Construction Completed	Purpose (1)	Usable Storage (acre-feet)
Albeni Falls	Pend Oreille	USACE Seattle District	1955	F, P, R	1,155,000
Bonneville Dam and Lake	Columbia	USACE Portland District	1938	P, N	Run of River
Boundary Dam and Lake	Pend Oreille	City of Seattle	1967	P	Run of River
Box Canyon Dam and Lake	Pend Oreille	Pend Oreille County PUD	1955	P	Run of River
Cabinet Gorge	Clark Fork	Avista Corp	1953	P	Run of River
Chief Joseph Dam and Rufus Wood Lake	Columbia	USACE Seattle District	1961	I, R, W	Run of River
The Dalles Dam and Lake Celilo	Columbia	USACE Portland District	1960	P, N	Run of River
Grand Coulee Dam and Lake Roosevelt	Columbia	USBR PNW Regional Office	1942	P, F, I	5,349,000
John Day Dam and Lake Umatilla	Columbia	USACE Portland District	1971	F, P, N	530,000
SKQ Dam	Flathead	Confederated Salish and Kootenai Tribes	1938	F, P, R	1,219,000
McNary Dam Lake Wallula	Columbia	USACE Walla Walla District	1957	P, N	Run of River
Noxon Rapids	Clark Fork	Avista Corp	1959	P	Run of River
Priest Rapids Dam and Lake	Columbia	Grant County PUD #2	1961	P, F, R	Run of River
Rock Island Dam and Lake	Columbia	Chelan County PUD #1	1933	P	Run of River
Rocky Reach Dam and Lake	Columbia	Chelan County PUD #1	1961	P, F, R	Run of River
Seven Mile Dam and Lake	Pend Oreille	BC Hydro	1979	P	Run of River
Thompson Falls	Clark Fork	NorthWestern Corp	1915	P	Run of River
Wanapum Dam and Lake	Columbia	Grant County PUD #2	1964	P, F R	Run of River
Waneta Dam and Lake	Pend Oreille	Teck Resources and BC Hydro	1954	P, I	Run of River
Wells Dam and Lake	Columbia	Douglas County PUD #1	1967	P, F, R	Run of River

(1) F = Flood Control, I = Irrigation, P = Power, R = Recreation, N = Navigation, W = Water Quality

4.12 Economic Data.

a) Population. The population of Flathead County increased by 12.3% from 2010 to 2018. Population numbers for Flathead County and some of the larger towns in the basin are shown in Table 4-16.

TABLE 4-16
POPULATION TRENDS

Location	2010	2018	Population Percent Change
Flathead County	90,927	102,106	12.3%
Kalispell, MT	20,045	23,938	19.4%
Whitefish, MT	6,392	7,870	23.1%
Polson, MT	4,581	5,018	9.5%
Columbia Falls, MT	4,710	5,575	18.4%
Ronan, MT	1,871	2,088	11.6%

Source: U.S. Census Bureau

b) Agriculture. Flathead Valley is a diversified farming area. Most of the county's 800 farms are located in the Flathead Valley and are small to medium in size. Principal sources of income are beef cattle, dairy, wheat, barley, hay, sweet cherries, and seed potatoes. Raising of Christmas trees and the production of holiday decorations are also profitable industries.

c) Industry. Traditional industries in Flathead County are aluminum processing and lumber and wood products.

d) Flood Damage. Hungry Horse plays an important role in flood control and recreation for Flathead County, as well as meeting the growing power needs in the Pacific Northwest. Computations for damages prevented have not been consistently developed prior to 2016;

however, flood damages prevented data is available for 2016-2020. The flood damages prevented data are based on a consistent method for allocating damages prevented between reservoirs and levees, as well as distributing damages prevented amongst upstream reservoirs. The methods have been used for the annual flood damage reduction reports submitted to Congress. For information purposes, the 2016-2020 data are provided in Table 4-17. All damages prevented values are in 2020 dollars.

TABLE 4-17.
FLOOD DAMAGES PREVENTED HUNGRY HORSE (SYSTEM FLOOD CONTROL) (2020 COST LEVEL)[1]

Year	Real ($1,000)
2016	27
2017	181,246
2018	34,478
2019	1,845
2020	37,367

[1]Information provided by HQUSACE from Annual Flood Damage Reduction Report to Congress
Note: Damages prevented include system FRM benefits downstream to the mouth of the Columbia River. Prices have been updated to 2020 Fiscal Year.

SECTION 5. DATA COLLECTION AND COMMUNICATION NETWORKS

5.01 Hydrometeorological Stations.

a) Facilities. In Section 4 of this manual, there are 56 hydrometeorological gages listed in Tables 4-2, 4-3, and 4-4 that are within the Pend Oreille River Basin. These include 13 climate gages managed by the National Oceanic and Atmospheric Administration (NOAA), 13 stream and lake gages managed by the United States Geological Survey (USGS), and 30 Snow telemetry (SNOTEL) stations or snow course/aerial markers managed by the Natural Resources Conservation Service (NRCS). All pertinent reporting climate, stream gage, and snow measurement stations are shown on Plates 4-1, 4-2, and 4-3, respectively. Some stream gaging stations are equipped with automated water quality and/or water temperature sensors. Table 4-3 indicates which data types are available at each gaging station. The Water Survey of Canada operates and maintains stream gaging stations in the portion of the Flathead River Basin which lies in Canada.

b) Reporting. A water stage recorder equipped with a remote indicator is installed in the powerhouse at Hungry Horse Dam. This gage is maintained by the USGS and has been recording since WY 1952. Data collected at this gage is reported to the closest hundredth of a foot and can be found at https://waterdata.usgs.gov/nwis/rt.

c) Maintenance. Weather stations are operated and maintained by NOAA. The NRCS operates and maintains SNOTEL stations in and around the basin. The USGS operates and maintains stream gages in the United States portion of the Flathead River Basin, and the Water Survey of Canada provides the same service for stream gages in the portion of the Flathead River Basin in Canada.

5.02 Water Quality Stations.

a) Facilities. Real-time water quality samples and/or data (available seasonally March through September, or until forecast spills are completed) are obtained downstream of Hungry Horse Dam. The station is co-located with the stream gage located downstream of Hungry Horse Dam. Table 5-1 provides details regarding the data collection parameters at this station. Automated equipment at this station collects, stores, and transmits data that are specific to total dissolved gas (TDG), water temperature, and barometric pressure.

TABLE 5-1
WATER QUALITY STATIONS

Station Name	Station Location	Location Description	Parameters [a]	Latitude (NAD83)	Longitude (NAD83)
HGHM	South Fork Flathead River near Columbia Falls, below Hungry Horse Dam	Stream	A	48.3566	-114.0379

a. Parameters:
A = Total Gas Saturation, Total Dissolved Gas, Water Temperature, Barometric Pressure

b) Reporting. Data are collected at the automated station from March through September in 15-minute increments and transmitted hourly to the Corps' Regional Water Control Data System (RWCDS) database and Reclamation's Boise office for archival. These data are posted to the Corps' public access water management website at: https://www.nwd.usace.army.mil/CRWM/Water-Quality/.

c) Maintenance. Maintenance at the automated station is performed at least every two weeks. Station maintenance typically consists of calibrating, cleaning, and servicing of the equipment. Instruments are removed after September 15, serviced, and then stored until the next monitoring season.

5.03 Sediment Stations. No formal sedimentation program is currently underway at Hungry Horse. As discussed in Section 4.04, sediment deposition at Hungry Horse Reservoir has made no noticeable change in the storage capacity of the reservoir. If signs of sediment accumulation become apparent, a program may be activated.

5.04 Recording Hydrologic Data. Hydrologic information is recorded as it is received by the Corps' Water Management offices as follows:

a) Regional Water Control Data System (RWCDS). The Corps' hydrometeorological data management policies and procedures for Hungry Horse Dam are based on the Corps' RWCDS, a regional water resources data management program. The RWCDS is a system that collects, acquires, stores and computes data for real-time modeling and decision support for water control in the Corps' Northwestern Division. The Northwestern RWCDS consists of three geographic nodes and is operated regionally by the following Corps' Water Management offices: Northwestern Division (CENWD), Portland District (CENWP), Seattle District (CENWS) and Walla Walla District (CENWW).

CENWS uses RWCDS for management of hydrometeorological data associated with reservoir regulation and water resource projects within their jurisdiction. It should be noted that prior to about 2010, the RWCDS was known as the Water Control Data System (WCDS).

The Corps' Hydrologic Engineering Center report, Water Control Data System (WCDS), Past, Present, and Future, RD #39, dated September 1995, describes the WCDS as follows: "The WCDS is an automated information system that supports the Corps of Engineer water control mission including the hardware, software, manpower, and other resources required to acquire, develop, maintain, and operate the system. The WCDS includes the collection, acquisition, retrieval, verification, storage, display, transmission, dissemination, interpretation, and archival of data and information needed to carry out the water control mission of the Corps... A suite of software gives users the ability to display, manipulate, disseminate, interpret, and transmit this information throughout the Corps and to numerous other interested users."

b) Data Processing and Storage. Currently in Seattle District, data processing and storage occurs with the RWCDS/Corps Water Management System (CWMS) system. The CWMS is a decision support system that can expand and enhance the information readily available to USACE regulators who must make decisions about operation of Federal water management facilities or who must monitor and approve such decisions made by operation partners.

The RWCDS VMs allow users to retrieve and review CROHMS data for reporting, viewing, and editing. In the RWCDS system, data is collected via various means (i.e., SFTP, GOES satellite, Columbia Basin Telecommunications network (CBT) and web messenger) into the regional Data Exchange VMs (RWCDS DX1 and RWCDS DX2). The Data Acquisition (DA) system collects and transfers data into the CWMS database (an Oracle database), at which point data corrections and computations are made as needed. Data are distributed via the Data Dissemination (DD) system, which is used to generate and publish reports.

The CENWD RWCDS system consists of three mostly identical nodes (CENWP, CENWS, and CENWW) that are synchronized for Continuity of Operations (COOP) purposes. The file systems on each node are kept mostly identical to the others by synchronizing the file system on a schedule and installing the same versions and configurations of each software package. The databases are kept consistent by using a 3-way bi-directional replication scheme.

Available streamflow and elevation data for the South Fork Flathead Watershed can be viewed by CENWS-RCC staff in graphical or tabular formats on Corps-issued computers. Data posted to the Corps' public website can be viewed in graphical or tabular format by the public for up to seven days, although more historic data can be obtained by Corps staff from the CWMS Oracle database query tool. In addition to the CWMS database, the USGS maintains a permanent record of data collected at all gage stations that they operate and maintain. The USGS' public website at https://waterdata.usgs.gov/nwis/rt provides access to nearly all available gage data, except for some special cases that require special handling.

5.05 Communication Network. The main source of communication with Hungry Horse Dam is via commercial telephone. The CBT is also used to issue instructions and schedules during flood events. The Corps also receives hourly and daily data through the CBT system.

5.06 Communication with Hungry Horse Dam Project. Communications with Hungry Horse Dam is accomplished primarily by telephone (see contact references in Pertinent Data section). Communications are coordinated through Reclamation's operations staff.

a) Between Regulating Office and Project Office. If the normal channels listed above are not available, communication with Hungry Horse Dam may be established via satellite phone system or Very High Frequency (VHF) radio system.

b) Between Regulating / Project Office and Others. Power generation schedules from BPA to HGH and other powerplants are communicated over a Dial Automatic Telephone Switching (DATS) microwave line. BPA operates a microwave circuit into the powerhouse for control of its 115 kV circuit breakers.

5.07 Project Reporting Instructions. Instrumentation is available at the Hungry Horse powerhouse for readout of forebay and tailwater elevations, air temperature, precipitation, and standard power generation parameters. Project outflow, forebay and tailwater elevations, spillway flow, powerhouse discharge, and power generation data are transmitted.

Hungry Horse Dam staff also record the following daily parameters: reservoir elevation, reservoir content, reservoir inflow and outflow, Flathead Lake elevation, Flathead River flow, tailwater elevations, maximum and minimum temperatures, and precipitation.

5.08 Warnings. The Hungry Horse Dam Emergency Action Plan (EAP) provides notification protocol for special operations and emergencies.

SECTION 6. HYDROLOGIC FORECASTS

<u>6.01 General.</u> Reclamation is responsible for the routine regulation of Hungry Horse. Separate spring snowmelt runoff forecasts for Hungry Horse are prepared by Reclamation, Natural Resources Conservation Services (NRCS) and the National Weather Service's (NWS) Northwest River Forecast Center (NWRFC) coordinates their forecasts with the snowpack estimates from National Resources Conservation Service (NRCS). Reclamation considers both forecasts in their reservoir management decision process along with Reclamation's in-house forecasts to determine the water supply runoff for the project. All the forecast procedures in this paragraph are described later in this section.

a) <u>Role of USACE.</u> The Corps' Northwestern Division Reservoir Control Center (CENWD-PDW-R) coordinates with the NWRFC on a daily basis during winter and spring flood seasons and is primarily responsible for providing reservoir regulation guidance for Hungry Horse during periods of flooding with close coordination with Reclamation. At times when special streamflow regulation is required to meet at-site and downstream discharge requirements, regulation assistance to Reclamation is available from NWRFC and CENWD-PDW-R. These two organizations. support Reclamation by providing flood risk management (FRM) forecasts for Hungry Horse, conducting special hydrologic investigations, coordinating with state agencies and the public to address water resources concerns and conflicts relating to FRM, and by providing support to CENWD in case of special requests or problems. The Corps' Northwestern Division, Hydrologic Engineering and Power Branch (CENWD-PDW-H) supports the NWRFC during the spring snowmelt runoff season by investigating special runoff conditions throughout the Columbia River system including the Flathead River and Hungry Horse Reservoir modeling.

b) Role of Other Agencies. Reclamation is the owner and operator of Hungry Horse and is responsible for the project's routine regulation.

The NWRFC is the agency primarily responsible for weather and streamflow forecasting in the Pacific Northwest. The NWRFC Portland office is staffed throughout the year and provides information and support assistance in case of emergency.

6.02 Flood Condition Forecasts. Reclamation revised their forecasting procedures used to develop the May – September volume runoff forecast for Hungry Horse during water year 2021. Reclamation began implementing a Variable Discharge Flood Control (VARQ FC) procedure in 2002. The minimum FRM space requirement of 250,000 acre-ft with VARQ FC allows for storage at the dam to be used during winter rain events. During the winter drawdown period (January – April), in years when flooding is not forecasted, VARQ FC operations allow HGH greater reliability to provide spring and summer flow augmentation for fish. In years with high runoff conditions, VARQ FC operations require drafting HGH to the same elevation at the end of April.

a) Requirements. Reclamation produces 1st of month water supply forecasts from January through June for the May-September runoff forecast used in the calculation of drawdown criteria from January through April as well as VARQ flows in May and June. Data for the forecasts can use but will not be limited to the following stations in Table 6-1 depending on the equation and the month.

TABLE 6-1. SNOTEL, PRECIPITATION AND CLIMATIC VARIABLES USED TO DEVELOP HUNGRY HORSE DAM'S INFLOW FORECAST

Snow Water Equivalent														
			Jan-Jul		Feb-Jul		Mar-Jul		Apr-Jul		May-Jul		Jun-Jul	
Site	Period of Record	Elevation	Data Date	r2	Data Date	r2	Data Date	r2	Data Date	r2	Data Date	r2	Data Date	r2
Badger Pass	Oct-80	6900	1-Jan	0.22	1-Feb	0.41	1-Mar	0.52	1-Apr	0.61	1-May	0.76	1-Jun	0.79
Emery Creek	Oct-80	4350	1-Jan	0.16	1-Feb	0.32	1-Mar	0.45	1-Apr	0.62	1-May	0.67	1-May	0.54
Flattop Mountain	Oct-80	6300	1-Jan	0.19	1-Feb	0.41	1-Mar	0.56	1-Apr	0.71	1-May	0.80	1-Jun	0.79
Hand Creek	Oct-80	5035	1-Jan	0.25	1-Feb	0.42	1-Mar	0.52	1-Apr	0.59	1-Apr	0.61	1-May	0.52
Moss Peak	Oct-80	6780	1-Jan	0.24	1-Feb	0.44	1-Mar	0.61	1-Apr	0.69	1-May	0.74	1-Jun	0.78
Mount Lockhart	Oct-80	6400	1-Jan	0.44	1-Feb	0.56	1-Mar	0.64	1-Apr	0.68	1-May	0.72	1-Jun	0.82
Noisy Basin	Oct-80	6040	1-Jan	0.39	1-Feb	0.47	1-Mar	0.62	1-Apr	0.66	1-May	0.74	1-Jun	0.76
North Fork Jocko	Oct-80	6330	1-Jan	0.35	1-Feb	0.43	1-Mar	0.60	1-Apr	0.76	1-May	0.86	1-Jun	0.78
Pike Creek	Oct-80	5930	1-Jan	0.23	1-Feb	0.42	1-Mar	0.63	1-Apr	0.72	1-May	0.78	1-Jun	0.76
Precipitation														
			Jan-Jul		Feb-Jul		Mar-Jul		Apr-Jul		May-Jul		Jun-Jul	
Site	Period of Record	Elevation	Data Date	r2	Data Date	r2	Data Date	r2	Data Date	r2	Data Date	r2	Data Date	r2
Seeley Lake R.S.	Dec-1936	4100	Oct-Dec	0.32	Oct-Jan	0.43	Oct-Feb	0.55	Oct-Mar	0.56	Dec-Mar	0.51	Dec-Mar	0.40
Swan Lake R.S.	Oct-1938	3190	Oct-Dec	0.31	Oct-Jan	0.45	Oct-Feb	0.43	Nov-Mar	0.44	Nov-Apr	0.50	Nov-Apr	0.47
West Glacier, MT	Jan-1931	3154	Oct-Dec	0.32	Oct-Jan	0.44	Oct-Feb	0.46	Nov-Mar	0.48	Nov-Apr	0.52	Dec-Apr	0.46
Climatic Indices														
			Jan-Jul		Feb-Jul		Mar-Jul		Apr-Jul		May-Jul		Jun-Jul	
Site	Period of Record	Elevation	Data Date	r2	Data Date	r2	Data Date	r2	Data Date	r2	Data Date	r2	Data Date	r2
SOI	Jan-1951	NA	Prev Jun+Jul	0.40	Prev Jun+Jul	0.20	Prev Jun+Jul	0.21	Prev Jun+Jul	0.21	Prev Jun+Jul	0.21	Prev Jun+Jul	0.19

b) Methods. Reclamation uses the following procedures to develop an adopted forecast for each month's forecasts. The multivariate linear regression analysis that was described in detail in the 2005 Water Control Manual will still be calculated monthly but will be run parallel with the equations that are correlated using both the Z-Score process and Principal Components Regression. Reclamation will look at multiple runoff forecast products developed internally, the NWRFC Ensemble Streamflow Predictions, NRCS, soil moisture and other hydrometeorological indicators in determining which forecast to adopt. Using all those tools Reclamation produces a final May-September runoff for each month from January through June. Please reference Reclamation's current and future forecast reports submitted to the Columbia River Forecast Group which can be made available if requested.

6.03 Conservation Purpose Forecasts. There are no conservation purpose forecasts for Hungry Horse Dam.

6.04 Short and Long Range Forecasts. Northwest River Forecast Center uses the Community Hydrologic Prediction Systems (CHPS) National Weather Service River Forecasting Center computer programs to forecast streamflow and runoff for the Columbia and Flathead River Basins.

The CHPS is a modular forecast system that allows users to select from various models or algorithms to simulate hydrologic conditions for a particular river basin. This program is used to forecast short- and long-range streamflows at specified control points in the basin for a selected number of days into the future on the basis of initial and anticipated hydrometeorological conditions and reservoir regulation plans.

Short-range forecasts of streamflow, up to 10 days in advance, are based upon current observed data, forecasts of meteorological conditions which affect snowmelt and/or precipitation rates, and routing through natural storage or controlled reservoirs. Short-range forecasts of daily streamflows are especially significant during the spring runoff in the Columbia and Flathead basins to identify potential flood conditions and problems. The actual flood regulation of individual projects in the Columbia River system as a whole is based on short-to-medium-range forecasts of streamflow and reservoir conditions.

The Single Trace Procedure (STP) long-range forecasts, up to 120 days in advance, involve extending the short-range forecasts by adding additional daily forecasts using basin means or extremes of climatological data to define future weather conditions. The primary purpose of the long-range forecasts is to define runoff under certain specified conditions to determine the effect on reservoir filling schedules and downstream peak discharge potentials to see if the current regulation plans should be revised. During the snowmelt period, indexes of the snowpack water volume and the aerial extent of the snowpack may require adjustment if forecast values do not verify.

a) Requirements. These forecasts utilize NRCS SNOTEL and snow gage data collected during the winter snow accumulation along with 10-day precipitation and temperature forecasts. Input to the 10- and 120-day forecasts includes antecedent soil moisture, snowpack and precipitation data, observed streamflows, and quantitative precipitation and temperature forecasts.

b) Methods. The NWRFC develops streamflow forecasts for select locations on the Columbia River and its tributary rivers using CHPS. As was described previously, CHPS is made up of hydrologic models including: the Sacramento Soil Moisture model, the Snow-17 Accumulation and Ablation model, the API model, routing algorithms, and reservoir regulation schemes. This program is used to forecast project inflows and flows at specified control points in the basin on the basis of initial and anticipated hydrometeorological conditions and reservoir regulation plans. Forecast values are normally printed in 6-hour intervals for the short-range forecast and a combination of 6-hour and daily periods for the 120-day forecast. Results of the short and long-range forecasts are considered in finalizing the peak annual discharge and seasonal volume runoff forecasts, and these forecasts are accessible to various users, including the Corps' Seattle District and Northwestern Division offices.

6.05 Drought Forecasts. Reclamation uses, but is not limited to, streamflow projections developed by the NWRFC and historical streamflow amounts to forecast Hungry Horse Dam operations during droughts. The streamflows determined to best represent the current conditions in the Flathead River system are then run through Reclamation's regulation spreadsheet or Riverware model of the basin to set project releases.

6.06 Water Quality Forecasting. There is no water quality forecasting conducted for Hungry Horse Dam.

SECTION 7. WATER CONTROL PLAN

7.01 General Objectives. Hungry Horse Dam and Reservoir (HGH) is operated as part of a coordinated system known as the Columbia River System (CRS). The CRS includes 14 dams and their associated reservoirs, two of which are operated by Reclamation: HGH and Grand Coulee Dam. The U.S. Army Corps of Engineers (Corps), U.S. Bureau of Reclamation (Reclamation) and Bonneville Power Administration (BPA), termed the "Action Agencies"[4], manage the operation and maintenance of the CRS according to each Agency's authorities to meet the multiple purposes of the CRS. The water control plan for HGH is provided to document the guidelines and procedures established to efficiently and effectively accomplish the project's primary operating objectives. HGH is operated for flood risk management (FRM), hydropower, and fish and wildlife conservation. Although authorized for irrigation the irrigation operations and delivery component has not been developed; a recent water rights settlement allocates 90,000 acre-feet of storage for the beneficial use of the Confederated Salish and Kootenai Tribes. At-site operation for navigation is authorized but not implemented.

HGH is a cyclic storage project that normally drafts from September through April for flood risk management for the Flathead Valley and lower Columbia River and refills from May through June. Flows and water levels are controlled to provide benefits to ESA listed salmon in the lower Columbia River and local fish in the Flathead River downstream from HGH.

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[4] Reference to Reclamation, the Corps, and BPA as the "Action Agencies" is consistent with ESA terminology. Reference to these agencies may also be referred to as the "co-lead agencies", which is consistent with NEPA terminology, and was used in the CRSO Environmental Impact Statement (EIS).

Reclamation, through its regional office in Boise, ID coordinates the preparation of plans and schedules for FRM, hydropower, and fish and wildlife conservation with special emphasis on Endangered Species Act (ESA)-listed fish species. This includes involvement in the preparation of seasonal runoff forecasts for the South Fork Flathead River watershed, preparation of storage evacuation and refill schedules for HGH, and preparation of hydropower data for the annual Power Data Submittal (PDS) to the Western Power Pool (WPP)[5], Coordination Contract Committee staff who administer the Pacific Northwest Coordination Agreement (PNCA). Reclamation may at times coordinate with the National Weather Service-Northwest River Forecast Center (NWRFC), Corps, BPA, PNCA staff, US Fish and Wildlife Service (USFWS), Montana Fish, Wildlife and Parks (MFWP), National Marine Fisheries Service (NMFS) and others to assure conformity of the seasonal operation at HGH with respect to FRM, hydropower, and fish and wildlife resources within the CRS. Additional interagency coordination can be found in Section 9-2.

Changes in the operation and regulation of dams and reservoirs in the system affect electric power generation in the Pacific Northwest. Prior to 1980, the CRS was operated generally for FRM and hydropower, with fish and wildlife a secondary consideration. However, in 1980, the Pacific Northwest Electric Power Planning and Conservation Act of December 5, 1980 (Northwest Power Act) was passed to require equitable treatment of fish and wildlife impacts when operating the Federal Columbia River Power System (FCRPS)[6]. Since then, multiple species have also been listed under the Endangered Species Act (ESA) as either "threatened" or "endangered" and identified as being affected by the ongoing operation of the CRS.

[5] Formerly known as the Northwest Power Pool (NWPP)
[6] The FCRPS is known as the transmission facilities and the federal electric generating project they interconnect, which includes the CRS projects in addition to projects in the Snake, Willamette, and other subbasins.

Implementation of the Biological Opinions in the CRS is coordinated annually and in-season through the Technical Management Team (TMT) and is described in more detail in Section 7.08.

7.02 Constraints. The following operating limits for HGH are provided to identify essential criteria for HGH's primary seasonal operations involving FRM, hydropower, and fish and wildlife conservation, and secondary purposes. Constraints for operation for fish and wildlife, including minimum flows, summer draft target flows and ramping rates, are included in Section 7.08.

A general layout of the project structures is shown in Plate 2-2. Details are provided below:

a) Reservoir Elevations.

- Normal Reservoir Operating Range……………….…………El 3,466.7 ft – 3,560 ft
- Normal Full Pool……………………………………………………El 3,560 ft
- Surcharge Flood Control Pool[7]……………………………………………El 3,561ft

  Minimum Reservoir Elevation…………………………………….…………El 3,336 ft

b) Minimum Discharge at HGH for Local Flooding, Hydropower, and Emergencies. HGH releases may be decreased to 300 cfs for local FRM. The absolute minimum flow in case of emergency is 145 cfs. To maintain power system reliability, Reclamation attempts to keep two units running at their speed-no-load discharge of about 300 cfs.

c) Reservoir Filling and Drafting Limits. A maximum daily drawdown limit of 1.5 ft is implemented in response to geologists' recommendation (soft constraint).

d) Maximum Regulated Change in Discharge at HGH. Please see Sec 7.08 for ramping rates.[8] Maximum discharge target to meet BiOp schedules should be limited to powerhouse

[7] Surcharge above 3,560 ft will be approved by the C-PN Regional Director prior to operating above the normal full pool.
[8] Non-flood regulation

insofar as possible. This discharge could be higher depending on actual inflows, refill conditions, or other reasons.

At other times if necessary and as practical (channel capacity)………………… 20,000 cfs

e) Flood Stage at Flathead River at Columbia Falls.

- National Weather Service Flood Stage .... 13 ft

Note: Insofar as possible FRM operations start at 13 ft (approximately 44,300 cfs) if the stage at Flathead Lake is in the top foot (El 2,892-2,893 ft). The flood stage is 14 feet (approximately 51,000 cfs) when Flathead Lake's elevation is more than 1 foot below full pool (2,892 feet or lower). The discharge corresponding to the NWS flood stage is derived from the USGS rating table #16 for the Flathead River at Columbia Falls, see Table 7-1. The differing stages that are targeted during a flood event come from a combination of high Flathead Lake stage and high discharge on the Flathead River at Columbia Falls which will cause backwater flooding between Flathead Lake and Kalispell.

f) Maximum Regulated Pool Elevation on December 31st.

- 250,000 AF below NFP .... 3,549.2 ft

7.03 Overall Plan for Water Control Management. The storage regulation of the project can be generally categorized into four periods: the fall period (October – December), a storage evacuation period (January – April), a refill period (May – June), and the summer period (July – September). These four periods serve as a general guide for annual operations and reflect the current operating regime at the time this water control manual was written. The following subsections provide more detail on the operations in each period.

a) Fall Period (October – December). The operation at Hungry Horse during October through December targets the minimum flows established in the BiOps and described in Section

7.08. Other operations that may require releases higher than minimum flows include, but not limited to, FRM, controlling the fill of the reservoir, maintenance activities, or power generation.

b) Storage Evacuation Period (January – April). Beginning in January and, generally, lasting through April, the project is regulated to end of month elevation targets that are provided by CENWD-PDW. The elevation targets are meant to create storage space for the upcoming spring runoff while also providing the mainstem of the Columbia River with additional water for power generation. End of month targets are set by the Storage Reservation Diagram as calculated using Reclamation's first of month forecast that is usually issued in the first three working days of the month. The Variable Discharge Flood Risk Management Storage Reservoir Diagram VARQ FRM SRD (Plate 7-1) is used to calculate the space requirement that is translated into an end of month elevation target. If not operating for the storage evacuation or FRM, the project may be operating to minimum flows or for power generation as requested, maintenance needs, and coordinated with BPA. VARQ FRM is described in further detail in Section 7.05.

c) Refill Period (May – June). On April 30, HGH is typically at its lowest seasonal elevation to capture the high flows from spring runoff and reduce downstream flooding. The project is required to maintain the storage space until refill is initiated. However, in the case of an increasing water supply forecast, an additional draft of the reservoir may be required in May. The Flood Control Refill Curve[9] (FCRC) should only be used as a guide for operations; operators should use forecasts and current hydrological conditions to determine

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[9] The FCRC defines the lower limit of reservoir drawdown that allows for refill with a 95 percent assurance.

an appropriate elevation. After the initiation of refill has been declared by the Corps Northwestern Division, the project will be regulated to the VARQ FRM Operating procedure in Section 7.05. Releases set by VARQ FRM can be adjusted based on short term forecasts to control or increase the rate of refill as necessary or if the stage at Columbia Falls, MT is expected to go above a stage of 13 ft (or 14 ft if Flathead Lake is not in its top foot). The project should be regulated to an elevation to keep enough space in the reservoir for summer precipitation events and to allow for the capability to finish off refill during the summer.

d) Summer Period (July – September). After the refill period, releases should be set to meet the 30 September reservoir elevation objective per the 2020 NMFS BiOp to deliver flow augmentation for downstream fish based on the HGH water supply forecast. The 30 September elevation objective allows water managers to balance local resident fish priorities in the upper basin with downstream flow augmentation for the Columbia River. In some years the project may fail to refill; in those years the project may be drafted below the September 30 elevation objectives if needed to satisfy minimum flow requirements.

7.04 Standing Instructions to Project Operator. Operations of the physical facilities to accomplish water management objectives are the responsibility of HGH dam personnel. Such operations will be in accordance with the HGH operations and maintenance manuals.

7.05 Flood Risk Management. HGH provides FRM for spring floods in the Flathead River basin, as measured at Columbia Falls, MT, below the project and on the lower Columbia River. Seasonal storage operations at HGH are conducted for FRM and fish habitat considerations, and there are hydropower benefits from additional water passing through the system in the winter. Coordination of FRM includes the following activities:

- Reclamation calculates the monthly water supply forecast and meets Corps FRM requirements and other considerations such as minimum flows. The Northwestern Division Hydrologic Engineering and Power Branch (CENWD-PDW-H) establishes flood risk management requirements.
- Reclamation and the Corps coordinate FRM for Columbia Falls, MT and to meet requirements for the lower Columbia River using the variable discharge procedure (VARQ FRM).
- Reclamation will coordinate with the Technical Management Team (TMT), described in Section 7.08 and Section 9.02, on matters that pertain to compliance with the BiOps.
- In the event of a major system flood event, the project will be operated in accordance with the NWD Emergency System Flood Risk Management Protocol. Under this protocol, during a major system flood event CENWD-PDW has the lead role for coordinating system flood risk management operations.

a) Flood Risk Management Regulation. FRM at HGH follows the VARQ FRM procedure (see Exhibit 7-1) to meet system and local FRM objectives. In some circumstances, project flood risk operations needed for local and system FRM may conflict. In this case, Reclamation and the Corps of Engineers Northwestern Division (CENWD) offices will work together to balance operations and risk. This will be informed by available data and based on professional engineering judgment by Reclamation, CENWD-PDW-H and CENWD-PDW-R. The required flood storage for risk reduction in the lower Columbia, and for local FRM, can be determined from the VARQ FRM storage reservation diagram on Plate 7-1. If control for the lower Columbia River overrides control for the Columbia Falls, MT, HGH project releases will be regulated to limit the stage at Columbia Falls, MT to 13 or 14 ft depending on the level of Flathead Lake, insofar as possible. The ability to regulate to those stages is dependent upon tributary streamflows between HGH and Columbia Falls, MT, available storage capacity at HGH project, backwater effects at Columbia Falls, MT due to Flathead Lake, and the Seli'š Ksanka Qlispe' Dam (SKQ) maximum-discharge constraint due to the physical channel restrictions at the downstream end of Flathead Lake. The following sections describe generally the FRM procedures, and more details can be found in Exhibit 7-1.

b) FRM Annual Operations.

- Storage Evacuation Period (December – April). The reservoir is required to be below El 3,555 feet (0.10 MAF of space) from October 31 through November 30 and below El 3,549.2 feet (0.25 MAF of space) by December 31. After December 31st and through about April 30th the primary storage evacuation is completed to provide storage for the upcoming spring runoff. There are several calculations that are incorporated throughout this period to guide evacuation of storage. Reclamation generally drafts Hungry Horse Reservoir below the required FRM elevations to meet minimum flow requirements at Columbia Falls for resident ESA-listed fish. In water years when minimum flows do not draft the reservoir below the required FRM elevations, HGH operates in accordance with the VARQ FRM SRD (Plate 7-1).
- Storage Reservation Diagram. The VARQ FRM SRD (Plate 7-1) guides the evacuation of space that is needed for controlling spring runoff in the Flathead Basin and in the lower Columbia River. FRM space is a function of Reclamation's May-September water supply forecast. Following evacuation (typically by April 30), Hungry Horse Reservoir is typically at its lowest seasonal elevation to capture the high flows during spring runoff

and to reduce the risk of downstream flooding; the project is required to maintain this space until the initiation of refill. During evacuation and up until the initiation of refill, outflows should be limited to hydraulic capacity of the powerhouse to the best extent possible. However, situations such as the loss of hydraulic capacity or rapidly changing forecasts may require spill to meet FRM requirements.

- VARQ Outflow Diagram. The VARQ Outflow Diagram, Plate 7-2, defines the project's variable outflow during the refill period. Variable outflows for May 1st-June 30th are a function of the May-September volume runoff forecasts and adjustments in accordance with VARQ operating rules and procedures contained in the VARQ Operating Procedures for HGH, Exhibit 7-1. These adjustments are based on guidelines for system and local FRM, minimum flows at HGH and Columbia Falls, refill procedures, flow augmentation in the lower Columbia River, and ramping rates. As a result, actual discharge from the project may vary slightly from the outflows indicated in Plate 7-2. The variable outflow diagram provides the highest regulated outflows during the lowest volume runoff events when additional water supply is especially beneficial for fish.
- Flood Control Refill Curve (FCRC). The FCRC has no ending date and is plotted daily to chart the progress of the seasonal runoff. In wetter years, completion of refill can be delayed until mid-July. A blank copy of a typical table used to record the runoff conditions for the FCRC is shown in Plate 7-3.

c) Reservoir Overfill-Surcharge Storage and Spillway Operating Policy. Surcharge options are pursuant to the Regional Surcharge Policy. Reclamation's Regional Director in Boise must authorize surcharge storage operation. Whenever the pool fills to the normal maximum flood pool (NFP), El 3,560 ft, and significant inflow continues to occur, the 1ft of surcharge may be used. The maximum rate of release during the surcharge operation should not exceed the estimated maximum mean daily rate of inflow to the reservoir during the surcharge period.

d) Spillway Operation. Discharge at HGH is normally released through the four powerhouse units and the three hollow jet valves except during emergencies or the occurrence of an extremely large flood when spillway releases could be required. Discharges are constrained to a maximum of 20 kcfs due to dam access and public safety issues. The normal high water surface of the reservoir is established at El 3,560 ft, which is the top level of the spillway gate in the raised position. The combination of discharge outlets and surcharge described above have been sufficient for all floods to date, and the spillway at HGH has yet to be used except for testing purposes.

At the top of the dam El 3,565 ft the capacity of the hollow jet valves and ring gate are approximately 13,700 cfs and 50,000 cfs respectively for a total discharge of about 72,700 cfs with the 9,000 cfs of powerhouse capacity.

7.06 Recreation. While HGH is not authorized for recreation and there is no specific reservoir regulation associated with the purpose, the public does enjoy recreational opportunities provided by the reservoir as well as at the tailwater fishery downstream. The reservoir has 10 boat ramps available for public use. Operators should be cognizant of potential recreation taking place below the dam, specifically during large flow changes, where notification of the public through a press release may be warranted prior to active FRM seasons.

7.07 Water Quality. The Hungry Horse project is operated, where possible, to limit exceedance of Montana Department of Environmental Quality standards for temperature and total dissolved gas.

a) Temperature. Per an agreement with Montana Fish, Wildlife & Parks (MFWP), the use of a selective withdrawal system (SWS) is required. Hungry Horse has a deep storage reservoir that retains water for several months, allowing for temperature stratification (water arranged in layers that vary in temperature). This stratification provides the ability to operate the dam, through selective withdrawal, to meet downstream water temperature objectives. The Hungry Horse Reservoir thermally stratifies in the summer and can provide some downstream water temperature management through use of the SWS. The SWS is required to be operated from June to end of September but is typically operated into November when the reservoir becomes isothermal and the benefits of SWS operations are diminished.

Water temperature probes are located in the reservoir, generator turbine scroll case, and at the downstream gaging station. These temperatures are used to control the gate openings on the selective withdrawal system for controlling downstream water temperatures to mitigate impacts to downstream fish habitat where possible. These gates are used to provide warmer epilimnetic water (water layer near the surface of a lake or reservoir that is warmer in the summer) to the river during the summer period when the reservoir is stratified. By agreement with MFWP, Reclamation operates the gates to achieve a temperature regime in the river that is as similar as possible to natural conditions. The purpose of this manipulation is to prevent the very cool (4°C hypolimnetic waters) from suppressing the primary and secondary production in the river and to prevent the cold-water plume, which formerly extended downstream in the mainstem Flathead River, from acting as an attractant to non-native lake trout moving from Flathead Lake upstream, which may increase the predation pressure on native cutthroat and bull trout.

b) Total Dissolved Gas (TDG). Montana State TDG standards are 110 percent. Exceeding this standard is a possibility throughout the year. The Hungry Horse Project is operated to minimize spill and the resultant generation of TDG pursuant to a National Pollution Discharge Elimination System permit issued by the Montana Department of Environmental Quality.

7.08 Fish and Wildlife. There are currently two BiOps that contain certain objectives that the operation of HGH should meet. The first is for local fish species: the 2020 USFWS BiOp titled, "Endangered Species Act - Section 7 Consultation Biological Opinion U.S. Fish and Wildlife Service Reference: 01EWFW00-2017-F-1650, Columbia River System Operations and Maintenance of 14 Federal Dams and Reservoirs," dated July 24, 2020, replaced the 2000 and 2006 USFWS BiOps. The other is for anadromous species on the CRS: the 2020 NMFS BiOp titled, "Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response, Continued Operation and Maintenance of the Columbia River System," dated July 24, 2020, replaced the 2019 NMFS BiOp.

Please refer to current Biological Opinions for updated information on ESA operations. Operations can also change as coordinated in the Technical Management Team (TMT) annual Water Management Plan or as coordinated in-season through TMT. The Action Agencies will continue to work collaboratively with regional sovereign parties to adaptively manage the implementation of system operations related to fish through various policy and technical teams, collectively referred to as the Regional Forum. The primary component of the Region Forum that focuses on fish operations is the TMT.

The TMT is an inter-agency technical group comprised of sovereign representatives responsible for making in-season recommendations to the Action Agencies, or AAs (Corps, BPA, and Reclamation) on dam and reservoir operations in an effort to meet the expectations of the applicable BiOps (listed above) and accommodate changing conditions, such as water supply, fish migration, water quality and maintenance issues. The TMT consists of representatives from the Action Agencies, NMFS, USFWS, the states of Oregon, Washington, Idaho, and Montana, and Tribal sovereigns. The TMT develops the Water Management Plan annually to describe the plan to operate the Columbia River System consistently with the most recent BiOps.

This section describes how to implement BiOp discharge and ramping rate requirements from the current BiOps described above, which is subject to change as consultation documents, including BiOps, are updated. The following are the minimum flows, the summer draft target, and ramping rates which are included (by reference)[10] in the 2020 BiOps:

a) <u>End-of September Sliding Scale Target.</u> During summer operation (July-September) draft to a target elevation of 3,540 feet to 3,550 feet (20 feet to 10 feet from full) by September 30, which is based on the Hungry Horse Project May water supply forecast for May through September. Table 7-1 shows the end of September Targets based on Reclamation's Hungry Horse May water supply forecast. However, if the project fails to refill, especially during drought years, minimum flow requirements may draft the reservoir below the end of September target elevation.

[10] The 2020 USFWS BiOp and the 2020 NMFS BiOp both state that additional specificity and a more detailed description of the Proposed Action can be found in the BA and in the associated BA clarification letter from the Action Agencies, and that BA, and associated clarification letter, are incorporated by reference.

TABLE 7-1. HUNGRY HORSE END OF SEPTEMBER ELEVATION TARGETS (SLIDING SCALE)

Hungry Horse May-September inflow forecast (KAF)	Hungry Horse forebay target on Sept 30 (ft)
< 1410	3540
1410 - 1580	Interpolate between 3540-3550
> 1580	3550

Reclamation attempts to minimize any secondary peak in the lower Columbia River resulting from the fish flow augmentation described above. Reduction of the second peak can be achieved by starting the fish flow augmentation discharges when flood control operations are complete, setting releases so that flows at Columbia Falls follow a more normal recession hydrograph, and completing all flow augmentation water by August 31st.

b) Minimum Flows. There are two minimum flow requirements for Hungry Horse Dam. One is for the South Fork of the Flathead River below the project, the second is for Columbia Falls on the mainstem Flathead River located just downstream from the confluence of the South Fork with the mainstem. The minimum flows for both sites are determined monthly based on the Reclamation WSF for the inflows to Hungry Horse for the period April 1 through August 31. These minimum flows are determined monthly starting with the January forecast, and then set for the remainder of the year based on the March final runoff forecast. The minimum flow requirements generally govern Hungry Horse discharges in the fall unless the static FRM levels require discharges greater than the minimum flow to maintain the required space in the reservoir through the end of December. The Minimum Normal Discharge at HGH (as measured at the South Fork Gage) and Flathead River at Columbia Falls (Columbia Falls) is presented in Table 7-2.

TABLE 7-2. MINIMUM FLOWS AT HUNGRY HORSE AND COLUMBIA FALLS.

Hungry Horse Apr–Aug inflow forecast (KAF)	Hungry Horse min flow[a] (cfs)	Columbia Falls min flow (cfs)
< 1190	400	3200
1190 - 1790	Interpolate between 400-900	Interpolate between 3200-3500
> 1790	900	3500

a. To prevent or minimize flooding on the Flathead River above Flathead Lake, Hungry Horse discharges can be reduced to a minimum flow of 300 cfs when the stage at Columbia Falls exceeds 13 feet.

c) Ramping Rates. The maximum ramp up and ramp down rates are detailed in Table 7-3 and Table 7-4, respectively. Daily and hourly maximum ramp–up rates for HGH are based on flows at the time of the ramping operation (not daily averages). Each hour in the daily gate change period must comply with the hourly rate criteria. Daily and hourly ramping rates may be exceeded during emergencies to protect public safety or in association with power or transmission emergencies. The listed ramp rates will be followed except if the recommended ramp rate causes a turbine unit(s) to operate in the rough zone (a zone of chaotic flow in which all parts of a unit are subject to increased vibration).

TABLE 7-3. DAILY AND HOURLY MAXIMUM RAMP UP RATES FOR HUNGRY HORSE DAM

Flow Range (measured at Columbia Falls MT[a])	Ramp Up Unit Limit (daily max)	Ramp Up Unit Limit (hourly max)
3200 - 6000 cfs	1800 cfs/day	1000 cfs/hour
>6000 - 8000 cfs	1800 cfs/day	1000 cfs/hour
>8000 - 10000 cfs	3600 cfs/day	1800 cfs/hour
>10000 cfs	No limit	1800 cfs/hour

a. Measured at USGS gage by daily flows, not daily averages, restricted by hourly rates.

TABLE 7-4. DAILY AND HOURLY MAXIMUM RAMP DOWN RATES FOR HUNGRY HORSE DAM

Flow Range (measured at Columbia Falls[a])	Ramp Down Unit Limit (daily max)	Ramp Down Unit Limit (hourly max)
3200 - 6000 cfs	600 cfs/day	600 cfs/hour
>6000 - 8000 cfs	1000 cfs/day	600 cfs/hour
>8000 - 12000 cfs	2000 cfs/day	1000 cfs/hour
>12000 cfs	5000 cfs/day	1800/hour

a. Measured at USGS gage by daily flows, not daily averages, restricted by hourly rates.

7.09 Water Conservation/Water Supply. At-site operation for irrigation is authorized but is not implemented at this time. Reclamation will be working with Confederated Salish and Kootenai Tribes (CSKT) on a recently finalized water compact that allocates to CSKT 90 KAF for future beneficial use out of Hungry Horse.

7.10 Hydroelectric Power. HGH is a major project in the Pacific Northwest coordinated electric power system. The Western Power Pool (WPP) through its PNCA Coordinating Group provides power planning for individual Pool projects and the system as a whole. Reclamation is a member of the WPP.

Although HGH is a cyclic type of project with a large reservoir and powerplant, it is operated primarily as a base-load plant with few peaking events because of the limiting effect of the project's ramping rates and minimum discharge criteria. Hydropower generation at HGH is scheduled by BPA and is remotely controlled by operators from the control room at Grand Coulee Dam and on-site. This system describes the organization and procedures for hydropower regulation of the regional system including HGH.

a) Coordination:

(1) Reclamation. Reclamation routinely develops independent seasonal runoff forecasts and preliminary power generation schedules for HGH, which together with the project's Power Data Submittal (PDS) (see Section 9.02) are submitted to the PNCA Contract Coordination staff each year prior to February 1st. The PDS report includes project operating criteria that apply to the upcoming August 1–July 31 power year such as project minimum flows, flood control elevations, variable draft limits, integrated rule curves, maintenance schedules, and other special requirements.

At least every two weeks, or more often if needed, Reclamation determines the current hydropower capability at HGH based on the reservoir level, regulated streamflows, and powerplant generating efficiencies. This information is furnished to BPA who use it to develop specific generation schedules for HGH. Generation schedules are issued to Reclamation for remote control of generating units at HGH from Grand Coulee Dam.

(2) Bonneville Power Administration. BPA is responsible for coordinating, scheduling, marketing and distributing hydroelectric power generated in the FCRPS. BPA is also linked with other electric power systems outside the Pacific Northwest and routinely coordinates, markets, and exchanges power with these entities. CRS power generation is coordinated by BPA so that the system is operated to optimize power operations within the constraints of the other purposes.

(3) Corps. Section 7 of the Flood Control Act of 1944 directs the Secretary of the Army to prescribe regulations for the use of storage allocated FRM. FRM regulation for HGH is implemented by the Division Reservoir Control Center (CENWD-PDW-R) in conjunction with Reclamation's water management staff in the Boise, Idaho office. This coordination includes routine monitoring of Reclamation’s plans for operation of HGH for non-FRM purposes. FRM requirements at HGH involving VARQ FRM are coordinated by Reclamation and the Corps and forwarded to the PNCA staff. Detailed FRM coordination and support for HGH is available through the Corps’ NWD-RCC and NWD-HE Branches (CENWD-PDW-R and CENWD-PDW-H, respectively).

(4) Western Power Pool (WPP). Reclamation is a member of the WPP. WPP is the coordination group that serves as a forum in the electric industry for reliability and operational adequacy issues in the Northwest. WPP has the primary administrative and

technical responsibility for coordinating seasonal hydropower operations in the Pacific Northwest pursuant to the Pacific Northwest Coordination Agreement (PNCA) (see Section 9.02).

b) Generation. Full capacity of HGH is around 428 MW (~12,000 cfs) at full pool. However, at times, the combined output of generation at Libby and Hungry Horse exceeds the ability of the local transmission system to reliably deliver the output of this project to the wider transmission system. Therefore, BPA has implemented maximum generation limits to maintain stability and meet required standards. BPA sets the allowable generation from Libby and Hungry Horse to balance the amount of generation that can be used to both serve load within the Flathead Valley and transfer generation to the wider transmission system at the same time. There could be ongoing variations in allowable generation based on loads in the Flathead Valley that change throughout the day. Currently, the combined maximum generation limit is 920 MW for heavy load hours and 860 MW for light load hours for the Libby project and Hungry Horse project. Specifically at Hungry Horse, current transmission restrictions limit generation to 310 MW (~9000 cfs). To prevent exceeding the 310 MW generation limit, excess flow is spilled (i.e. flow is passed through the hollow jet valves instead of through the power plant). This process generates TDG and can cause the Flathead River downstream of the dam to exceed Montana's standard of 110% (see Section 7.07).

c) Variable Draft Limits (VDL). VDLs are period-by-period draft limits from January 1 March 31. These are planned limits to Firm Energy Load Carrying Capability (FELCC) generation to protect the ability to refill HGH to its April 10 elevation objective with a 75%

confidence. This operation provides flexibility in generation, FRM objectives and minimum downstream flow requirements for migrating ESA listed fish.

The VDLs are based on:

- The April 10 elevation objective which is calculated from the forecasted March 31 and April 15 FRM elevations
- statistical inflow volumes (75% exceedance for Hungry Horse), and,
- actual downstream flow objectives.

The VDL is not a mandatory draft elevation and operation above the VDL is acceptable as long as it is not a higher elevation than the FRM curve, the Firm Energy Load Carrying Capability (FELCC) is already being met, and at-site and downstream flow objectives are also being served. The latter is achieved by operating between the Upper Rule Curve (URC) as an upper limit and the Variable Draft Limits (VDL) as a lower operating limit for the reservoir and will continue to target April 10th for the calculation. Stream flows, in-season forecasts, and real time conditions determine the exact date that the upper rule curve will be reached in coordination with TMT. The URC is the maximum elevation allowed for FRM and is calculated by using the Storage Reservation Diagram (SRD) developed for VARQ FRM. Reclamation computes Hungry Horse Dam's April 10 elevation by linear interpolation between the March 31 and April 15 forecasted FRM elevations based on the Reclamation March Final for the May - September Water Supply Forecast (WSF).

VDLs are calculated monthly from January through March after updated volume forecasts and FRM elevations have been issued. The VDL at the end of a period (e.g., January 31) is computed to determine the lowest elevation where the outflow requirements and the April 10 elevation objective can be achieved using a 75% probable inflow volume.

For example, Hungry Horse's January VDL is computed as:

- The expected April 10 elevation objective based on January forecast.

a) Minus February 1 to April 10 inflow volume (75% statistical inflow volume).

b) Plus February 1 to April 10 minimum discharge requirement for Columbia Falls.

The statistical inflow volume for Hungry Horse is derived as follows: The 75% probable inflow into Hungry Horse reservoir plus the 75% probable incremental at Columbia Falls. The data used to compute these inflow volumes for Hungry Horse are from the latest modified streamflows.

7.11 Navigation. At-site operation for navigation is authorized but not implemented.

7.12 Drought Contingency Plans. HGH is operated as part of the Columbia River reservoir system under all conditions, including droughts. A detailed DCP for the entire Columbia River system is presented in Section XII of the *Columbia River Basin, Master Water Control Manual,* dated December 1984, and is applicable to HGH. The 30-page DCP is a detailed guideline for operation of the Columbia River reservoir system under adverse streamflow conditions. The plan addresses historical droughts, drought forecasting techniques, drought impacts and operational requirements for the system and individual drought management stations.

As of the writing of this document, an updated Master Water Control Manual is under preparation and may revise the DCP.

7.13 Flood Emergency Action Plans. Reclamation will use the most recent Emergency Action Plan from the C-PN Regional Dam Safety Group.

7.14 Other.

a) Icing Conditions. When frigid temperatures occur, the project's anti-icing bubbler system is used to limit ice buildup in the forebay as much as possible. If minimum flows are maintained during the cold winter periods and ice develops in the river channels, special care must be taken during subsequent HGH release increases. Ice jamming problems can develop downstream causing flooding and scouring of the streambed fish habitat. The project will cooperate with fishery interests in identifying such adverse conditions and operate to avoid icing damage if possible.

7.15 Deviation from Normal Regulation. Reclamation is occasionally requested to authorize, coordinate, and conduct special regulations for HGH and/or the S. F. Flathead River below HGH. Except as noted below, prior approval by Reclamation in cooperation with BPA and the Corps (only if hydropower or FRM is affected) is required for all special regulation affecting HGH.

a) Emergencies. In the event the project's structural integrity is or could be threatened, or if outflows will or could endanger downstream human life or property, the procedures outlined in the Reclamation Publication, Standing Operating Procedures, Emergency Action Plan, are to be followed. Specifically, the plan is to be implemented in the following situations:

(1) Uncontrollable Emergency. Defined as a condition in which the occurrence of a significant hazard to life and property is certain to occur, and no time is available to repair or modify operational procedures to prevent dam failure.

(2) Controllable Emergency. Defined as a condition, not normally encountered in the routine operation of the dam, in which the occurrence of a significant hazard to life and property is possible unless timely repairs and/or modification to operational procedures are conducted. Time must be available to conduct corrective actions.

(3) Post-Earthquake. Condition immediately following a noticeable earthquake at the dam.

(4) Security Alert. Condition at the project caused by an incident that threatens the project

security.

(5) Excessive Release. Releases that exceed routine operational criteria during non-flood periods. The EAP describes procedures and means of initiating operation, repairs, and notifying pertinent parties of the hazard. The procedures have been developed by Reclamation and are updated periodically. Their prompt use is essential for minimizing hazards to affected life and property.

The EAP for HGH also provides procedures to be followed in the event of a security alert and also addresses operational procedures during times of national emergency.

b) Abnormal Conditions. Should a condition(s) occur or appear to be developing, other than those described above, which requires operational modification, the Project Engineer or powerplant operator will promptly contact the project superintendent's office to report the field conditions and receive instructions. BPA and other parties upstream and downstream of the project that are possibly affected by the condition will also be informed as soon as possible. When immediate action is required to protect life and valuable property, the Project Engineer will not wait for instruction. Instructions for the proper response to conditions such as failure of operating facilities, accidents, and power failures are included in the Standard Operating Procedures, Emergency Action Plan on file at HGH.

c) Planned Deviations. Although they are not considered emergencies, situations occasionally occur that require temporary deviations from the normal regulation of the project. Construction activities such as utility stream crossings, bridgework, and other miscellaneous in-stream construction activities account for the majority of deviations. Changes in releases are also sometimes necessary during maintenance for periods from a few hours to a few days, and each request is evaluated based on its own merits.

Consideration is given to upstream watershed conditions, potential flood threat, conditions of the reservoir and river below HGH, and possible alternative measures. In the interest of maintaining good public relations, these requests are satisfied provided there are no adverse effects in overall operation for the project's authorized purposes.

7.16 Rate of Release Change. Please see section 7.08 for normal allowable rate of increase and decrease in releases, as established per the 2020 BiOps.

SECTION 8. EFFECT OF WATER CONTROL PLAN

8.01 General. HGH has operated continuously since its completion in the early 1950s, providing hydropower for the Pacific Northwest and seasonal regulation of the waters of Hungry Horse Reservoir. With reservoir regulation by HGH, spring runoff is stored and released in the summer to increase flows in the mainstem Columbia River to aid in salmon migration and water conditions. Regulated streamflows during the storage evacuation for spring FRM provide water supply for hydropower generation at 20 downstream powerplants (18 American and 2 Canadian plants). Problems developed on the Flathead River below the dam after 1952, notably the decline of the bull trout and west slope cutthroat trout. Colder-than-normal water discharged from the HGH powerplant was the primary cause of degraded habitat and reduced native trout populations. Reclamation responded to the problem by installing and operating a selective withdrawal system at HGH. This system has allowed more control over downstream water temperatures so that a more natural temperature regime can be maintained in the Flathead River below the project.

8.02 Flood Risk Management.

Hungry Horse Dam stores floods in its upstream reservoir, resulting in an increase in reservoir elevation during the flood event, and minimal to no flood damage downstream in the Flathead Valley. The floods evaluated are described in the following subsections.

a) Probable Maximum Flood (PMF). Reclamation's Technical Service Center in Denver, Colorado, published two PMF reports in 2001. The first report, a hydrology report dated August 2001, describes the development of two PMF floods for HGH; a general flood and a local summer flood, based on Hydrometeorological Report (HMR) 57. The second report dated October 2001, routed the two PMF floods through HGH. The two PMF floods are described below.

(1) General Storm PMF. A general snowmelt and rainstorm over the 1,684 mi^2 HGH watershed was derived using HMR 57, June 72-hour rainfall of 16.18 inches and an antecedent snowmelt component of approximately 2.4 inches (snow water equivalent). The PMF inflow peak of 267,500 cfs with a 7-day volume of 629,800 AF was routed through the reservoir resulting in an outflow peak of 21,695 cfs and a reservoir rise from initial El 3,516 ft to El 3,535.67 ft, see Plate 8-1.

(2) Local Storm PMF. A local summer storm over a 553 mi^2 area immediately adjacent to the reservoir was derived using HMR 57 rainfall of 1.98 inches in 6 hours. The resulting routed inflow and outflow peaks are equal at 41,225 cfs, and no change occurred in the initial reservoir El 3,561 ft, see Plate 8-2.

b) Standard Project Flood (SPF). A SPF is not available for HGH, and a SPF investigation is not considered necessary since the PMF outflow described above reduced the S.F. Flathead River discharge to less than the zero-damage discharge in the Flathead Valley.

8.03 Recreation. Summer reservoir levels offer opportunities for summer recreation on the reservoir for boating, swimming, and camping. The U. S. Forest Service (USFS) operates and maintains 16 developed recreation areas located along the reservoir including 2 on islands in the reservoir.

8.04 Water Quality.

a) Water Temperature. Colder-than-normal water discharged from the HGH powerplant was the primary cause of degraded habitat and reduced native trout populations in past years. During the spring and early summer, outflow from HGH is a minor contributor to the overall flow into the Flathead River system. However, as the North Fork Flathead River and Middle Fork Flathead River begin to decrease in natural flow following the seasonal runoff, outflows from the HGH powerhouse begin to increase and outflow from HGH becomes the major input to the main stem Flathead River, causing historical river temperatures to decrease.

Reclamation responded to this problem by installing and operating a selective withdrawal system over the powerhouse penstock intakes. This system allows more control over downstream water temperatures so that a more natural temperature regime can be maintained in the Flathead River below the project. A temperature schedule for HGH during the critical summer months is provided in Table 2-2.

b) Total Dissolved Gasses (TDG). Reclamation has installed TDG monitoring equipment at the USGS S. F. Flathead River gaging station and recorded TDG data are transmitted to HGH and Reclamation's Boise office. The monitoring program provides real-time data to help assure that TDG levels in the S. F. Flathead River below HGH do not exceed the Montana TDG standard of 110% of saturation during periods of spill unless needed for FRM operations.

Dissolved gas levels are recorded at the S. F. Flathead River near Columbia Falls streamgage, located 2.74 km (1.7 mi) below HGH. Exceeding the Montana State TDG standard of 110% is a possibility during the normal flood storage evacuation, the final spring refill of the reservoir, and the July-August 31 release of fish augmentation water.

Voluntary spill does not occur at Hungry Horse Dam. When the project must spill and TDG levels are elevated, the effect is very localized and diminishes on the mainstem Flathead River.

8.05 Fish and Wildlife. The Flathead basin is home to extensive fish and wildlife populations. Fish populations upstream from HGH are relatively unaffected by HGH. Problems with the fishery developed on the Flathead River below the dam after 1952, notably the decline of the bull trout and west slope cutthroat trout due to decreased water temperatures. Bull trout are currently listed as a threatened species. One of the reasons cited for this decline was the Flathead River low water temperature caused by operations of HGH. Also, predation on bull trout increased in the Flathead River due to the lake trout being drawn from the depths of Flathead Lake into the cold-flowing river. West slope cutthroat trout, a species of special concern to the State of Montana, were affected by the unnatural temperature regimes of the Flathead River below HGH. Thermal influences on river water were most significant in the 18-mi reach of river located between the main stem confluences of the S. F. Flathead River and the Stillwater River.

The installation of a selective withdrawal system at HGH in 1995 allows for a more natural temperature regime in the Flathead River below HGH. Fish habitat in the lower reach of the Flathead River has been degraded as a result of the raising of Flathead Lake by Kerr Dam (now SKQ Dam).

Implementation of the new CRSO measure for a Sliding Scale End-of-September Target (see Sec. 7.08) may result in increasing storage in some years for resident fish benefits, this may result in minor reductions in flows downstream of HGH. Higher reservoir elevations in the summer and into the fall months in drier years, as well as reduced summer outflows, are expected to have minor to moderate beneficial effects to food supply, habitat suitability, and spawning fish access into tributaries, especially in dry years.

8.06 Water Conservation/Water Supply. Hungry Horse Dam is authorized but not currently operated for water supply.

<u>8.07 Hydroelectric Power.</u> HGH is essentially operated as a base-load plant because of the ramping rates and minimum flow requirements. Hydroelectric power generation at HGH as reported by BPA is tabulated in Table 8-1. Storage drafted during the seasonal reservoir drawdown is used to generate hydroelectric power at HGH.

TABLE 8-1. HYDROELECTRIC POWER GENERATION AT HGH POWERPLANT

Year	MWH[a]
1998	788,568
1999	897,547
2000	1,023,144
2001	525,346
2002	997,220
2003	737,985
2004	822,461
2005	859,840
2006	1,064,000
2007	931,684
2008	1,119,429
2009	754,919
2010	846,693
2011	1,395,280
2012	1,077,033
2013	993,788
2014	1,088,039
2015	979,019
2016	757,079
2017	1,038,709
2018	1,060,935
2019	679,559
2020	956,134
2021	906,381

[a]Source: BPA

<u>8.08 Navigation.</u> Hungry Horse Dam is not specifically operated for navigation. However, high summer water reservoir levels bring numerous recreational boaters to the lake and region.

<u>8.09 Drought Contingency Plans.</u> Hungry Horse Dam is operated as part of the Columbia River reservoir system under all conditions, including droughts. Refer to the Columbia River system Drought Contingency Plan (DCP) presented in Section XII of the Columbia River Basin, Master Water Control Manual, dated December 1984. The plan addresses historical droughts, drought forecasting techniques, drought impacts, and operational requirements for the system and individual drought management stations. As of the writing of this document, an updated Master Water Control Manual is under preparation and may revise the DCP.

8.10 Flood Emergency Action Plans. Refer to the most recent HGH Emergency Action Plan (EAP). The plan details the responses and notifications required under various states of emergency. The EAP does not in and of itself direct operations at HGH.

8.11 Frequencies.

a) Inflow Probability. The Hungry Horse Reservoir peak inflow frequency curve is shown in Plate 8-3. The volume inflow frequency is shown in Plate 8-4.

b) Regulated Streamflow Characteristics. Operation of HGH as specified in this manual and reflected in Table 8-2 has changed the Flathead River seasonal streamflow characteristics. In general, regulated discharges are much higher than natural flows during the late summer due to the July-August flow augmentation for the lower Columbia River. Natural and regulated discharges from September through November are generally similar to each other. In the case of small floods, regulated discharges are less than natural discharges because of the storage refill. During the fall and winter, the lowest normal regulated minimum flow is 400 cfs whereas natural streamflows of 200 cfs have frequently occurred. Average annual discharge at the Flathead River at Columbia Falls is 9,583 cfs from the CRSO-EIS study, based on the 2010L modified flows. Hydrographs of regulated conditions at the Columbia Falls gage for the 14-month period from July to August of years 1987-1988, 1984-1985, and 1971-1972 reflecting low, average, and high runoff conditions, are shown on Plate 8-5, Plate 8-6, and Plate 8-7, respectively. Average annual discharge for these three periods at the Columbia Falls gage are 6,062 cfs, 9,016 cfs, and 12,105 cfs, respectively. The maximum annual peak discharge frequency curve for regulated flows at the Flathead River at Columbia Falls, Montana is shown on Plate 8-8. This chart is based on the 1928-2008 modified streamflow record of regulated events from the 2020 CRSO-EIS study.

TABLE 8-2. AVERAGE MONTHLY DISCHARGE AT HGH, NATURAL AND REGULATED CONDITION (CFS)

Month	Natural[a]	Regulated[a]
October	1,078	1,978
November	1,389	1,975
December	1,195	2,578
January	1,021	3,241
February	1,034	3,846
March	1,346	4,141
April	4,831	5,786
May	12,557	5,509
June	12,005	4,690
July	3,730	3,207
August	1,079	2,625
September	847	2,631

[a] Data provided by USACE NWD from 2020 CRSO-EIS Study, Preferred Alternative, using 2010L modified streamflow (1928-2008)

The 1964, 1894 and 1975 floods were the three largest known floods in the Flathead River Basin. The 1964 flood was an atypical event caused by intense rain on June 7th and 8th, together with high antecedent streamflows, mountain snowmelt, and abundant soil moisture. The flood was estimated to be a 0.05 percent chance exceedance flood on the Flathead River at Columbia Falls with an estimated regulated discharge of 176,000 cfs, even though flow from the S. F. Flathead River during the flood was completely impounded by HGH, except for minimum outflow requirements. The 1894 flood is estimated to be a 0.5 percent flood on the Columbia River at The Dalles gage. The 1894 flood on the Flathead River at Columbia Falls had an estimated natural discharge of 142,000 cfs and an estimated regulated discharge of 92,000 cfs which is a 0.5 percent flood.

c) Pool Elevation Duration and Frequency. The Hungry Horse Reservoir Summary Elevation Hydrographs are shown in Plate 8-9 and presents pool elevations through the year for 1%, 25%, 75%, 99%, and median exceedance levels.

d) Downstream Control Points. Columbia Falls, Montana, serves as the control point for local FRM operations at the Hungry Horse Project. In 2014, the official flood stage for the Flathead River at Columbia Falls was modified to 13 feet (an approximate flow of 44 kcfs) when the Flathead Lake elevation is in the top 1 foot (El 2,892 to 2,893 feet). The flood stage is 14 feet (approximately 51 kcfs) when the elevation of Flathead Lake is more than 1 foot below full pool (El 2,892 feet or lower). When the Flathead River at Columbia Falls is at or above flood stage or forecasted to be at or above flood stage, outflows from the Hungry Horse Project will be adjusted as necessary (to a minimum discharge of 300 cubic feet per second) as long as enough space exists in the reservoir to manage remaining runoff. The Hungry Horse Project generally starts reducing discharges when flood stage at Columbia Falls begins to exceed 12.5 feet when flood stage criteria is 13 feet, and 13 feet when flood stage criteria is 14 feet. Depending on the remaining runoff volume and available reservoir space, however, the project may not begin reducing discharges until Columbia Falls reaches levels higher than these criteria.

8.12 Other Studies. At HGH, archeological sites have been located within the reservoir area. The USFS is studying the sites and is keeping Reclamation informed. USFS and Reclamation have a continuing responsibility to preserve and protect cultural resource sites or potential sites. During reservoir operation and maintenance activities which could have an effect on cultural resources, HGH's Project Superintendent or the Chief of Operations will notify the Cultural Resources Coordinator and the USFS to investigate any identifiable sites.

SECTION 9. WATER CONTROL MANAGEMENT

9.01 Responsibilities and Organization. HGH is a major project in the system of reservoirs developed to manage and control Columbia River water resources. Extensive planning and coordination of this reservoir system is accomplished to accommodate the diverse ownership, multiple water resource functions, system requirements, and miscellaneous special needs. Involved agencies and details of the coordination process are described below.

a) Principal Agencies and Organizations. The following agencies and regional organizations are involved in planning, scheduling and operating the Columbia River water resource system. Reclamation, Corps, and BPA are referred to as the "Action Agencies" and USFWS and NMFS are referred to as the "Services" when dealing with matters associated with the ESA. See communication plan in the most recent Emergency Action Plan for point of contacts, addresses and telephone numbers for each agency.

b) U.S. Bureau of Reclamation (Reclamation). Reclamation owns and operates HGH for flood risk management (FRM), hydropower, and fish and wildlife conservation. Reclamation is not actively delivering for irrigation from HGH, though a recent water rights settlement allocates 90,000 acre-feet of storage for the beneficial use of the Confederated Salish and Kootenai Tribes. The HGH project office is responsible for the operation and maintenance of all facilities at HGH. Reclamation staff at the Grand Coulee Dam powerhouse remotely controls hydroelectric units at HGH. Reclamation's Facilities Operation and Maintenance, and River & Reservoir Operations Groups in the Regional Office in Boise, Idaho exercises primary staff responsibility over the operation and maintenance of all Reclamation irrigation and power facilities in the Pacific Northwest

Region. The Technical Service Center in Denver, Colorado provides technical support services for operation and maintenance of Reclamation projects. The Center also periodically examines all major structures, performs dam safety studies, reviews dam behavior data, and provides technical advice and assistance in the solution of operating and maintenance problems.

c) U.S. Army Corps of Engineers (Corps). Section 7 of the Flood Control Act of 1944 (58 Stat.890,33 U.S.C. 709) directs the Secretary of the Army to prescribe regulations for flood control (now referred to as flood risk management). Direct responsibility for the regulation of HGH FRM is assigned to the Northwestern Division Office (CENWD) which coordinates and cooperates with many other agencies and groups to accomplish effective and efficient regulation.

In May 1968, the Chief of Engineers approved the formation of a Reservoir Control Center in the North Pacific Division (now Northwestern Division) identified as CENWD-PDW-R and assigned the responsibility for FRM regulation activities in NWD to the Division Engineer. Additional details of the Corps' water management history and organization are provided in the report, Reservoir Control Center, Guidance Memorandum, U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon, January 1972. The Seattle District Hydraulics and Hydrology Branch includes a Reservoir Control Center which is not formally identified but is referred to as NWS-RCC to distinguish it from the Reservoir Control Center (CENWD-PDW-R) in the Northwestern Division office in Portland, Oregon. The NWS-RCC provides flood control regulation at Corps and non-federal dams in western Washington under the direction of CENWD. Seattle District's Water Management Section supports Columbia Basin Water Management (CENWD-

PDW, CENWD-PDW-R, and CENWD-PDW-H) in the FRM regulation at water projects in the Columbia River including HGH by assisting in special reservoir operations, public coordination, preparation of reservoir regulation related studies, and preparation of reservoir regulation manuals.

d) Bonneville Power Administration (BPA). BPA is the marketing agency for power generated at Federal projects in the Pacific Northwest. The agency has constructed and maintains the nation's largest network of long-distance high-voltage transmission lines as part of its power marketing operation. The transmission facilities and the federal electric generating projects they interconnect are known as the Federal Columbia River Power System (FCRPS). A Memorandum of Understanding between Reclamation and BPA documents the policies and procedures for operation of Reclamation's hydroelectric project. This memorandum outlines the operation of HGH within the normal and special project limitations established by Reclamation to generate the maximum amount of electric energy consistent with HGH's authorized purposes. Reclamation coordinates with the BPA Branch of Power Supply and Scheduling on matters that affect power generation. Power is scheduled and dispatched by BPA from the Dittmer Control Center, Vancouver, Washington

e) U.S. Fish and Wildlife Service (USFWS). At the federal level, the USFWS is the agency primarily responsible for ensuring the conservation and management of the nation's wild birds, mammals, and sport fishes for their recreational and economic values. The following are included in the USFWS major program areas: technical assistance to federal, state, and private organizations in the development and administration of sport fish and wildlife management programs; administration and operation of a national system of fish hatcheries engaged in the propagation and distribution of sport fish; and cooperation with other federal and non-federal agencies engaged in water resource development project to determine the effects of such project on fish and wildlife resources and recommend measures for the protection and improvement of these resources.

f) National Marine Fisheries Service (NMFS). NMFS is responsible for the protection, conservation, and recovery of marine and anadromous fish species listed under the ESA. NMFS consults with the Action Agencies on the operation of the Columbia River System and its potential effects on listed marine and anadromous species.

g) Other Agencies and Organizations. Various other agencies at the federal and state level are also involved with or affected by the HGH project. They are listed below.

h) U.S. Forest Service. A Memorandum of Agreement (Contract No. 14-06-100-6461) between the Reclamation and U.S. Forest Service, dated March 12, l969, includes provisions for the administration of the water surface, and recreation area except for the Reclamation Zone. A copy of the memorandum is included as Exhibit 2-1.

i) Montana Department of Natural Resources and Conservation (MDNRC).

(1) Water Rights. As provided by Montana State law, a "Notice of Appropriation" of 3,500,000 AF of water was completed with priority date of June 16, 1947, for the uses identified. Recently, the Confederated Salish and Kootenai Tribes of the Flathead Reservation, the State of Montana, and the United States entered into a Water Rights Compact for storage and use of HGH water for future beneficial use, and a Preliminary Decree was signed by the Montana Water Court on June 9, 2022.

(2) Safety at Dams. A Memorandum of Understanding between the Reclamation and the MDNRC provides reciprocal opportunities for the coordination of the safety-related

aspects of storage dam and reservoir planning, design, construction, operation, and maintenance activities.

j) The Montana Department of Fish, Wildlife, and Parks (MDFW&P). The MDFW&P in the Kalispell, Montana regional office has the primary authority for regulation and management of fish and wildlife resources in Montana. They collect data and conduct studies related to HGH, exchange information with Reclamation, and make recommendations concerning potentially beneficial changes in project regulation.

k) Support Agencies. The following agencies collect data and provide information used in the regulation of HGH.

(1) National Weather Service. The National Weather Service operates weather stations throughout the Flathead Basin. Hydrometerological data from these stations are used for planning and scheduling regulation at HGH. Refer to Section 5 for additional details.

(2) Northwest River Forecast Center (NWRFC). In 1948, the National Weather Service, formerly the U.S. Weather Bureau, was authorized to develop a modern river forecast program for the United States. The Portland NWRFC was established in January 1950 and began limited forecasting in 1951. The NWRFC provides a daily forecast, the 10-day outlook, quantitative precipitation forecasts (October through June), and the current daily satellite summary. Reclamation provides daily hydrometeorological data through the CROHMS communication system which is used by the NWRFC for the Flathead Basin forecasts.

(3) U.S. Geological Survey (USGS). The USGS Water Resources Division collects and processes water quality and quantity records for stations in the Flathead Basin used for

operation and regulation of HGH. Three streamgage stations partially funded by Reclamation through the Cooperative Streamgaging Program are the S. F. Flathead River above Twin Creek near Hungry Horse, S. F. Flathead River near Columbia Falls, and the Flathead River at Columbia Falls. Streamflow, storage, and water quality data obtained from the USGS data collection system are assembled and published by each USGS district office. The district office in Helena, Montana, provides administrative services for USGS facilities in the Flathead Basin in Montana. Assistance is available in case of streamgage operation or maintenance problems. Contact information is included in the most recent Emergency Action Plan.

(4) Natural Resources Conservation Service (NRCS). The NRCS operates snow stations in the Flathead basin that provide data used in water resource management and forecasting. Refer to Section 5 for additional details. The NRCS office in Bozeman, Montana is available for snow-related information. Contact information is included in the most recent Emergency Action Plan.

9.02 Interagency Coordination.

a) Northwest Power and Conservation Council (NWPCC). The Pacific Northwest Electric Power Planning and Conservation Act of December 5, 1980 established an 8 member Pacific Northwest Electric Power Planning Council (now known as the Pacific Northwest Power and Conservation Council (NWPCC) comprised of 2 voting members representing each state, Washington, Oregon, Idaho, and Montana. Although initially governors designated one of their two representatives to serve only 2 years, each member currently serves a term of 3 years. Convinced that regional electric energy planning should be placed firmly in the hands of the people of the Pacific Northwest, Congress made each council member an officer of his respective state. The Council was initially formed in April 1981. The initial tasks of the Council were to (1) adopt a fish and wildlife program by November 15, 1982 and (2) prepare a regional electric power and conservation plan by April 1983. The adopted fish and wildlife program was developed to protect, mitigate, and enhance fish and wildlife, including related spawning grounds on the Columbia River and its tributaries. Under the program, flows of sufficient quality and quantity must be provided between and below hydroelectric facilities to improve production, migration, and fish habitat as required to meet sound biological objectives. The Council's main office is in Portland, Oregon. Contact information is included in the most recent Emergency Action Plan.

b) Western Power Pool (WPP). The WPP is a voluntary organization comprised of major generating utilities serving the Pacific Northwest, British Columbia and Alberta. Smaller, principally non-generating utilities in the region participate indirectly through the member system with which they are interconnected. The Pool, formerly known as the Northwest Power Pool, was originally formed in 1942, when the federal government directed utilities to coordinate operations in support of wartime production.

c) Regional Forum. The Action Agencies perform regional coordination of CRS water management/reservoir regulation, fish passage operations and maintenance activities, fish passage capital improvements and related research, monitoring, and evaluations through the established Regional Forum. The Regional Forum is a system of interacting technical work groups that operate under the direction of the Regional Implementation and Oversight Group (RIOG). The RIOG provides policy level interagency coordination among federal, state, and tribal sovereigns. The group provides resolution for issues elevated by technical work groups, reviews updates to the Fish Operations Plan, and engages during key decision milestones (e.g. Water Management Plan guidance). There are several working groups and teams, including the RIOG, and includes: Technical Management Team, System Configuration Team, Studies Review Work Groups, Fish Facility Design Review Work Group, and Fish Passage Operations. See Figure 9-1 for coordination sequencing and a summary of group responsibilities. The Technical Management Team is the primary group responsible for optimizing passage conditions for juvenile and adult anadromous salmonids and resident fish, and a description of agency team members and team responsibilities is included below.

d) Technical Management Team. The TMT is an inter-agency technical group comprised of sovereign representatives responsible for making in-season recommendations to the AAs (Corps, BPA, and Reclamation) on dam and reservoir operations in an effort to meet the expectations of the applicable BiOps (listed above) and accommodate changing conditions, such as water supply, fish migration, water quality and maintenance issues. The TMT includes representatives from Tribal sovereigns and states. The AAs develop, and TMT reviews, the Water Management Plan annually to describe the plan to operate the Columbia River System consistently with the most recent BiOps.

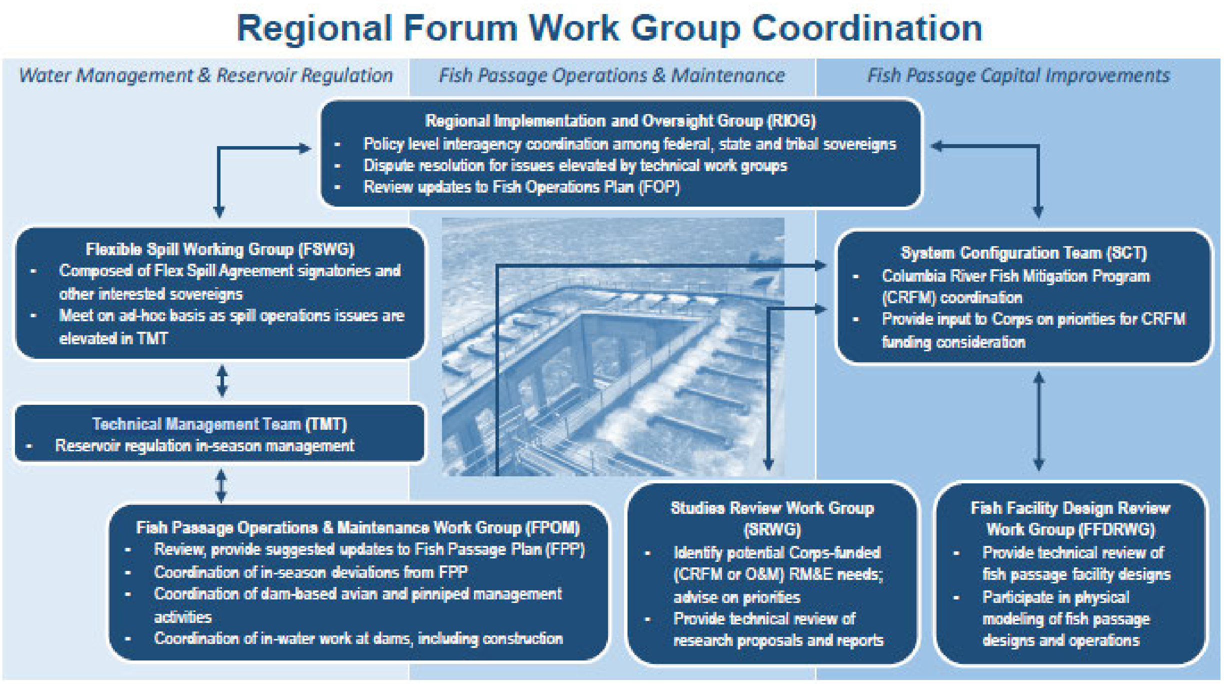


FIGURE 9-1. REGIONAL FORUM WORK GROUP COORDINATION.

<u>9.03 Interagency Agreements.</u>

a) <u>Columbia River Treaty (CRT).</u> In 1964 a treaty was ratified by the governments of Canada and the United States which provided for the development of storage reservoirs in Canada, and cooperative measures for hydroelectric power generation and flood risk management which make possible other benefits as well. As part of the treaty, Canada was required to build three large storage dams (Duncan, Keenleyside, and Mica) on the upper reaches of the Columbia River in British Columbia. The Treaty also granted the United States permission to build Libby Dam on the Kootenai River in Montana (called Kootenay River in Canada). The Canadian reservoirs provide improved streamflow in both countries, and the Treaty requires Canada to operate these reservoirs on a coordinated basis with the United States, and for the United States to compensate Canada for a portion of those benefits, or certain other costs depending on the operation.

The coordinated operations and most other duties of the Treaty are implemented by entities from each country. The United States Entity is comprised of the administrator of BPA and the CENWD Commander. The Canadian entity includes British Columbia Hydro, the provincial power-marketing corporation.

b) Pacific Northwest Coordination Agreement (PNCA). The PNCA is the formal contract of the WPP for coordinating the seasonal operation of the generating resources of the member systems for the best utilization of their collective reservoir storage. The agreement became effective on January 4, 1965 and was updated in December 1995 (effective August 1, 2003). Parties to the PNCA coordinate the operation of their respective systems to (1) entitle each system to its optimum firm load-carrying capability, (2) provide optimum firm load-carrying capability for the coordinated system, and (3) produce the optimum amount of usable secondary energy for each system consistent with the PNCA objectives.

9.04 Commissions, River Authorities, Compacts, and Committees. See Section 9.02 for entities who share interest in river basin water control activities.

9.05 Non-Federal Hydropower. There are no applicable non-federal hydropower facilities associated with HGH.

9.06 Reports. Many reports are available online from the home page for the Columbia Basin Water Management Division, Northwestern Division, U.S. Army Corps of Engineers: https://www.nwd.usace.army.mil/CRWM/.

Table 2-1. HGH Gross Storage in Acre Feet (AF) [CENWS-EC-TB-HH/JAN 2003, see Note on Sheet 15]

ELEV.	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3107	-	-	-	-	-	-	-	-	1	1
3108	1	1	1	1	1	1	1	1	1	1
3109	1	1	1	1	1	1	1	1	1	1
3110	1	1	1	1	1	1	1	1	1	1
3111	1	1	1	1	1	1	1	1	1	1
3112	1	1	1	1	1	1	1	1	1	1
3113	1	1	1	1	1	1	1	1	1	1
3114	1	2	2	2	2	2	2	2	2	2
3115	2	2	2	2	2	2	2	2	2	2
3116	2	2	2	2	2	2	2	2	2	2
3117	2	3	3	3	3	3	3	3	3	3
3118	3	3	3	3	3	3	3	3	3	3
3119	4	4	4	4	4	4	4	4	4	4
3120	4	4	4	4	4	5	5	5	5	5
3121	5	5	5	5	5	5	6	6	6	6
3122	6	6	6	6	6	6	7	7	7	7
3123	7	7	7	7	8	8	8	8	8	8
3124	8	9	9	9	9	9	9	9	10	10
3125	10	10	10	11	11	11	11	11	11	12
3126	12	12	12	13	13	13	13	13	14	14
3127	14	14	15	15	15	15	16	16	16	17
3128	17	17	17	18	18	18	19	19	19	20
3129	20	20	21	21	21	22	22	23	23	23
3130	24	24	25	25	26	26	26	27	27	28
3131	28	29	29	30	30	31	31	32	33	33
3132	34	34	35	35	36	37	37	38	39	39
3133	40	41	41	42	43	44	44	45	46	47
3134	48	49	49	50	51	52	53	54	55	56
3135	57	58	59	60	61	62	63	64	65	66
3136	67	69	70	71	72	74	75	76	78	79
3137	80	82	83	85	86	88	89	91	92	94
3138	96	97	99	101	102	104	106	108	110	112

Table 2-1. HGH Gross Storage in Acre Feet (AF) [CENWS-EC-TB-HH/JAN 2003, see Note on Sheet 15]

ELEV.	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3139	114	116	118	120	122	124	126	128	131	133
3140	135	138	140	142	145	147	150	153	155	158
3141	161	164	167	169	172	175	179	182	185	188
3142	191	195	198	202	205	209	212	216	220	224
3143	228	232	236	240	244	248	253	257	262	266
3144	271	276	280	285	290	295	301	306	311	317
3145	322	328	334	340	345	352	358	364	370	377
3146	383	390	397	404	411	418	426	433	441	448
3147	456	464	472	481	489	498	506	515	524	533
3148	543	552	562	572	582	592	602	613	624	635
3149	646	657	669	680	692	704	717	729	742	755
3150	768	782	795	809	824	836	653	866	883	896
3151	914	930	946	963	980	997	1,014	1,032	1,050	1,069
3152	1,087	1,107	1,126	1,146	1,166	1,186	1,207	1,228	1,250	1,271
3153	1,294	1,316	1,340	1,363	1,387	1,411	1,436	1,461	1,487	1,513
3154	1,539	1,566	1,594	1,622	1,650	1,679	1,708	1,738	1,769	1,600
3155	1,831	1,863	1,896	1,929	1,963	1,998	2,033	2,068	2,104	2,141
3156	2,179	2,217	2,256	2,295	2,336	2,377	2,418	2,461	2,504	2,548
3157	2,592	2,638	2,684	2,731	2,779	2,828	2,877	2,927	2,979	3,031
3158	3,084	3,138	3,193	3,249	3,306	3,364	3,423	3,483	3,544	3,606
3159	3,669	3,734	3,799	3,866	3,933	4,002	4,073	4,144	4,217	4,290
3160	4,366	4,442	4,520	4,599	4,680	4,762	4,845	4,930	5,017	5,104
3161	5,194	5,285	5,378	5,472	5,568	5,665	5,765	5,866	5,969	6,073
3162	6,179	6,288	6,398	6,510	6,624	6,740	6,859	6,979	7,101	7,225
3163	7,352	7,481	7,612	7,745	7,881	8,019	8,160	8,303	8,448	8,596
3164	8,747	8,901	9,056	9,215	9,376	9,541	9,708	9,878	10,051	10,227
3165	10,407	10,589	10,775	10,964	11,156	11,351	11,550	11,753	11,959	12,168
3166	12,381	12,599	12,819	13,044	13,272	13,505	13,742	13,983	14,228	14,477
3167	14,731	14,989	15,252	15,519	15,791	16,068	16,350	16,636	16,928	17,224
3168	17,526	17,573	17,620	17,668	17,715	17,763	17,810	17,858	17,906	17,954
3169	18,002	18,051	18,099	18,148	18,196	18,245	18,294	18,343	18,393	18,442
3170	18,491	18,541	18,591	18,641	18,691	18,741	18,791	18,842	18,892	18,943

Table 2-1. HGH Gross Storage in Acre Feet (AF) [CENWS-EC-TB-HH/JAN 2003, see Note on Sheet 15]

ELEV.	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3171	18,994	19,045	19,096	19,147	19,199	19,250	19,302	19,354	19,406	19,458
3172	19,510	19,563	19,615	19,668	19,721	19,773	19,827	19,880	19,933	19,987
3173	20,040	20,094	20,148	20,202	20,256	20,311	20,365	20,420	20,475	20,530
3174	20,585	20,640	20,696	20,751	20,807	20,863	20,919	20,975	21,031	21,088
3175	21,144	21,201	21,258	21,315	21,372	21,430	21,487	21,545	21,603	21,661
3176	21,719	21,777	21,836	21,894	21,953	22,012	22,071	22,130	22,190	22,249
3177	22,309	22,369	22,429	22,489	22,550	22,610	22,671	22,732	22,793	22,854
3178	22,915	22,977	23,039	23,101	23,163	23,225	23,287	23,350	23,412	23,475
3179	23,538	23,601	23,665	23,728	23,792	23,856	23,920	23,984	24,049	24,113
3180	24,178	24,243	24,308	24,373	24,439	24,504	24,570	24,636	24,702	24,768
3181	24,835	24,902	24,968	25,036	25,103	25,170	25,238	25,305	25,373	25,441
3182	25,510	25,578	25,647	25,716	25,785	25,854	25,924	25,993	26,063	26,133
3183	26,203	26,273	26,344	26,415	26,486	26,557	26,628	26,699	26,771	26,843
3184	26,915	26,987	27,060	27,133	27,205	27,278	27,352	27,425	27,499	27,572
3185	27,647	27,721	27,795	27,870	27,945	28,020	28,095	28,170	28,246	28,322
3186	28,398	28,474	28,551	28,627	28,704	28,781	28,859	28,936	29,014	29,091
3187	29,170	29,248	29,326	29,405	29,484	29,563	29,643	29,722	29,802	29,882
3188	29,962	30,043	30,123	30,204	30,285	30,367	30,448	30,530	30,612	30,694
3189	30,777	30,859	30,942	31,025	31,108	31,192	31,276	31,360	31,444	31,528
3190	31,613	31,698	31,783	31,868	31,954	32,040	32,126	32,212	32,298	32,385
3191	32,472	32,559	32,647	32,734	32,822	32,910	32,999	33,087	33,176	33,265
3192	33,354	33,444	33,534	33,624	33,714	33,805	33,895	33,986	34,078	34,169
3193	34,261	34,353	34,445	34,538	34,630	34,723	34,817	34,910	35,004	35,098
3194	35,192	35,286	35,381	35,476	35,571	35,667	35,763	35,859	35,955	36,051
3195	36,148	36,245	36,343	36,440	36,538	36,636	36,735	36,833	36,932	37,031
3196	37,131	37,230	37,330	37,431	37,531	37,632	37,733	37,834	37,936	38,037
3197	38,140	38,242	38,345	38,448	38,551	38,654	38,758	38,862	38,967	39,071
3198	39,176	39,281	39,387	39,493	39,598	39,705	39,812	39,918	40,026	40,133
3199	40,241	40,349	40,457	40,566	40,675	40,784	40,893	41,003	41,113	41,223
3200	41,334	41,445	41,556	41,668	41,780	41,892	42,005	42,117	42,231	42,344
3201	42,456	42,572	42,686	42,800	42,915	43,031	43,146	43,262	43,378	43,494
3202	43,611	43,729	43,846	43,964	44,081	44,200	44,319	44,438	44,557	44,676

Table 2-1. HGH Gross Storage in Acre Feet (AF) [CENWS-EC-TB-HH/JAN 2003, see Note on Sheet 15]

ELEV.	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3203	44,797	44,917	45,037	45,158	45,279	45,401	45,523	45,645	45,768	45,891
3204	46,014	46,138	46,261	46,386	46,510	46,635	46,760	46,886	47,012	47,138
3205	47,264	47,391	47,518	47,646	47,774	47,902	48,031	48,160	48,289	48,419
3206	48,549	48,679	48,810	48,941	49,072	49,204	49,336	49,469	49,601	49,734
3207	49,868	50,002	50,136	50,271	50,406	50,541	50,677	50,813	50,949	51,086
3208	51,223	51,361	51,499	51,637	51,775	51,915	52,054	52,194	52,334	52,474
3209	52,615	52,757	52,898	53,040	53,182	53,325	53,469	53,612	53,756	53,900
3210	54,045	54,190	54,336	54,482	54,628	54,775	54,922	55,069	55,217	55,365
3211	55,514	55,663	55,812	55,962	56,112	56,263	56,414	56,565	56,718	56,870
3212	57,022	57,176	57,329	57,483	57,637	57,792	57,947	58,103	58,259	58,415
3213	58,572	58,729	58,887	59,045	59,203	59,363	59,522	59,682	59,842	60,002
3214	60,164	60,325	60,487	60,650	60,812	60,976	61,140	61,304	61,468	61,633
3215	61,799	61,965	62,131	62,298	62,465	62,633	62,801	62,969	63,139	63,308
3216	63,478	63,649	63,819	63,991	64,162	64,335	64,508	64,681	64,855	65,028
3217	65,203	65,378	65,554	65,730	65,906	66,083	66,261	66,438	66,617	66,796
3218	66,975	67,155	67,335	67,516	67,697	67,879	68,061	68,244	68,427	68,611
3219	68,795	68,980	69,165	69,351	69,537	69,724	69,911	70,099	70,287	70,475
3220	70,665	70,855	71,045	71,235	71,427	71,618	71,811	72,003	72,197	72,391
3221	72,585	72,780	72,975	73,171	73,368	73,565	73,762	73,960	74,159	74,358
3222	74,558	74,758	74,958	75,160	75,361	75,564	75,767	75,970	76,174	76,378
3223	76,584	76,790	76,995	77,202	77,409	77,617	77,826	78,035	78,244	78,454
3224	78,665	78,876	79,088	79,300	79,513	79,727	79,941	80,155	80,371	80,586
3225	80,803	81,020	81,237	81,455	81,674	81,893	82,113	82,333	82,555	82,776
3226	82,999	83,222	83,445	83,669	83,893	84,119	84,345	84,571	84,798	85,026
3227	85,254	85,483	85,712	85,943	86,173	86,405	86,637	86,869	87,103	87,336
3228	87,571	87,806	88,042	88,278	88,515	88,753	88,991	89,230	89,470	89,710
3229	89,951	90,192	90,434	90,677	90,920	91,165	91,410	91,655	91,901	92,147
3230	92,395	92,643	92,892	93,141	93,391	93,642	93,894	94,145	94,399	94,652
3231	94,906	95,161	95,416	95,673	95,929	96,187	96,445	96,704	96,964	97,224
3232	97,485	97,655	97,824	97,994	98,164	98,335	98,506	98,677	98,848	99,020
3233	99,192	99,365	99,537	99,710	99,883	100,057	100,231	100,405	100,579	100,754
3234	100,929	101,105	101,280	101,456	101,632	101,809	101,986	102,163	102,341	102,518

Table 2-1. HGH Gross Storage in Acre Feet (AF) [CENWS-EC-TB-HH/JAN 2003, see Note on Sheet 15]

ELEV.	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3235	102,697	102,875	103,054	103,233	103,412	103,592	103,772	103,952	104,133	104,313
3236	104,495	104,677	104,858	105,041	105,223	105,406	105,589	105,772	105,956	106,140
3237	106,325	106,510	106,694	106,880	107,065	107,252	107,438	107,624	107,812	107,999
3238	108,187	108,375	108,563	108,752	108,940	109,130	109,320	109,509	109,700	109,890
3239	110,081	110,272	110,464	110,656	110,848	111,041	111,234	111,427	111,621	111,814
3240	112,009	112,204	112,398	112,594	112,789	112,985	113,182	113,378	113,575	113,772
3241	113,970	114,168	114,366	114,565	114,764	114,964	115,164	115,363	115,564	115,765
3242	115,966	116,168	116,369	116,571	116,774	116,977	117,180	117,384	117,588	117,792
3243	117,997	118,202	118,407	118,613	118,819	119,025	119,232	119,439	119,647	119,854
3244	120,063	120,272	120,480	120,690	120,899	121,110	121,320	121,531	121,742	121,953
3245	122,165	122,378	122,590	122,803	123,016	123,230	123,445	123,659	123,874	124,089
3246	124,305	124,521	124,737	124,954	125,171	125,388	125,606	125,824	126,043	126,262
3247	126,481	126,701	126,921	127,142	127,362	127,584	127,806	128,028	128,250	128,473
3248	128,696	128,920	129,144	129,368	129,593	129,818	130,044	130,270	130,496	130,722
3249	130,950	131,178	131,405	131,634	131,862	132,091	132,321	132,551	132,781	133,012
3250	133,243	133,475	133,706	133,939	134,171	134,404	134,638	134,872	135,106	135,341
3251	135,576	135,812	136,048	136,264	136,521	136,758	136,996	137,234	137,472	137,711
3252	137,950	138,190	138,430	138,671	138,911	139,153	139,395	139,637	139,880	140,122
3253	140,366	140,610	140,854	141,099	141,344	141,590	141,836	142,082	142,329	142,576
3254	142,824	143,072	143,321	143,570	143,819	144,069	144,320	144,570	144,821	145,073
3255	145,325	145,578	145,830	146,084	146,337	146,592	146,847	147,102	147,357	147,613
3256	147,870	148,127	148,384	148,642	148,900	149,159	149,418	149,678	149,938	150,198
3257	150,459	150,721	150,982	151,245	151,507	151,771	152,035	152,299	152,564	152,828
3258	153,094	153,360	153,626	153,893	154,160	154,428	154,697	154,966	155,235	155,504
3259	155,775	156,046	156,316	156,588	156,860	157,133	157,406	157,679	157,953	158,227
3260	158,503	158,778	159,054	159,330	159,607	159,884	160,162	160,440	160,719	160,998
3261	161,278	161,559	161,839	162,121	162,402	162,684	162,967	163,250	163,534	163,817
3262	164,102	164,388	164,673	164,959	165,246	165,533	165,821	166,109	166,397	166,686
3263	166,976	167,266	167,557	167,848	168,139	168,432	168,725	169,017	169,311	169,605
3264	169,900	170,195	170,491	170,787	171,084	171,381	171,679	171,977	172,276	172,575
3265	172,875	173,176	173,476	173,778	174,079	174,382	174,686	174,989	175,293	175,597
3266	175,902	176,208	176,514	176,821	177,128	177,436	177,744	178,053	178,363	178,672

Table 2-1. HGH Gross Storage in Acre Feet (AF) [CENWS-EC-TB-HH/JAN 2003, see Note on Sheet 15]

ELEV.	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3267	178,983	179,294	179,605	179,917	160,230	180,543	180,857	181,171	181,486	181,801
3268	182,117	182,434	182,750	183,068	183,386	183,705	184,024	184,343	184,664	184,984
3269	185,306	185,628	185,950	186,274	186,597	186,922	187,247	187,571	187,898	188,224
3270	188,551	188,879	189,207	189,536	189,865	190,195	190,525	190,856	191,188	191,520
3271	191,853	192,187	192,520	192,855	193,189	193,525	193,862	194,198	194,536	194,873
3272	195,212	195,552	195,891	196,232	196,572	196,914	197,257	197,599	197,942	198,286
3273	198,631	198,976	199,321	199,668	200,015	200,362	200,711	201,059	201,409	201,758
3274	202,109	202,460	202,812	203,165	203,517	203,871	204,226	204,580	204,936	205,291
3275	205,648	206,006	206,363	206,722	207,081	207,441	207,802	208,162	208,524	208,886
3276	209,249	209,613	209,977	210,342	210,707	211,074	211,441	211,807	212,176	212,544
3277	212,914	213,284	213,654	214,026	214,397	214,770	215,143	215,516	215,891	216,266
3278	216,642	217,019	217,395	217,773	218,151	218,531	218,911	219,290	219,672	220,053
3279	220,436	220,819	221,202	221,587	221,971	222,357	222,744	223,130	223,519	223,906
3280	224,296	224,686	225,076	225,467	225,858	226,251	226,645	227,038	227,433	227,827
3281	228,223	228,620	229,017	229,415	229,813	230,213	230,613	231,014	231,415	231,817
3282	232,220	232,624	233,028	233,433	233,838	234,245	234,652	235,059	235,468	235,876
3283	236,286	236,698	237,108	237,520	237,933	238,346	238,761	239,175	239,591	240,007
3284	240,424	240,842	241,260	241,680	242,099	242,520	242,942	243,363	243,786	244,210
3285	244,634	245,060	245,485	245,912	246,339	246,767	247,196	247,625	248,056	248,486
3286	248,918	249,351	249,784	250,218	250,652	251,088	251,525	251,961	252,399	252,837
3287	253,277	253,717	254,158	254,600	255,042	255,485	255,929	256,373	256,819	257,265
3288	257,712	258,160	258,608	259,058	259,507	259,959	260,411	260,863	261,316	261,770
3289	262,225	262,681	263,137	263,595	264,052	264,511	264,971	265,431	265,892	266,354
3290	266,817	267,281	267,745	268,211	268,676	269,143	269,611	270,079	270,549	271,018
3291	271,489	271,961	272,433	272,907	273,381	273,856	274,333	274,808	275,286	275,764
3292	276,243	276,724	277,204	277,686	276,168	278,652	279,136	279,620	280,107	280,593
3293	281,081	281,570	282,058	282,549	283,039	283,531	284,024	284,517	285,012	285,507
3294	286,003	286,500	286,998	287,496	287,995	288,496	288,998	289,499	290,003	290,506
3295	291,011	291,517	292,023	292,531	293,039	293,548	294,059	294,569	295,081	295,593
3296	296,107	296,473	296,839	297,206	297,572	297,940	298,309	298,677	299,046	299,415
3297	299,785	300,156	300,526	300,897	301,268	301,641	302,014	302,386	302,760	303,133
3298	303,508	303,883	304,258	304,634	305,010	305,387	305,765	306,142	306,520	306,898

Table 2-1. HGH Gross Storage in Acre Feet (AF) [CENWS-EC-TB-HH/JAN 2003, see Note on Sheet 15]

ELEV.	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3299	307,278	307,658	308,037	308,418	308,798	309,180	309,562	309,944	310,327	310,710
3300	311,094	311,479	311,863	312,248	312,634	313,020	313,407	313,794	314,182	314,569
3301	314,958	315,347	315,736	316,127	316,516	316,908	317,300	317,691	318,084	318,476
3302	318,870	319,264	319,658	320,053	320,448	320,844	321,240	321,637	322,034	322,432
3303	322,830	323,229	323,628	324,028	324,428	324,829	325,231	325,631	326,034	326,436
3304	326,840	327,244	327,647	328,053	328,457	328,863	329,270	329,676	330,084	330,490
3305	330,899	331,308	331,717	332,127	332,537	332,948	333,359	333,771	334,183	334,595
3306	335,009	335,423	335,837	336,252	336,667	337,083	337,499	337,916	338,334	338,751
3307	339,170	339,589	340,008	340,428	340,848	341,269	341,692	342,113	342,536	342,958
3308	343,382	343,807	344,231	344,656	345,081	345,508	345,935	346,362	346,790	347,218
3309	347,647	348,077	348,506	348,937	349,368	349,799	350,232	350,664	351,097	351,530
3310	351,965	352,400	352,835	353,271	353,707	354,144	354,582	355,019	355,458	355,896
3311	356,337	356,777	357,217	357,659	358,100	358,543	358,986	359,429	359,873	360,316
3312	360,762	361,208	361,654	362,101	362,547	362,996	363,444	363,893	364,342	364,792
3313	365,243	365,694	366,145	366,598	367,050	367,504	367,958	368,412	368,867	369,322
3314	369,779	370,236	370,693	371,151	371,609	372,069	372,528	372,988	373,449	373,909
3315	374,372	374,835	375,297	375,761	376,225	376,690	377,155	377,620	378,087	378,554
3316	379,021	379,490	379,958	380,428	380,897	381,368	381,839	382,310	382,783	383,255
3317	383,729	384,204	384,677	385,153	385,628	386,104	386,582	387,059	387,537	388,015
3318	388,495	388,975	389,455	389,937	390,417	390,900	391,383	391,866	392,350	392,835
3319	393,320	393,806	394,292	394,779	395,266	395,755	396,244	396,733	397,223	397,713
3320	398,205	398,698	399,189	399,682	400,176	400,670	401,166	401,660	402,157	402,653
3321	403,151	403,649	404,147	404,647	405,146	405,647	406,148	406,649	407,152	407,654
3322	408,158	408,663	409,167	409,672	410,178	410,685	411,192	411,700	412,209	412,717
3323	413,227	413,738	414,249	414,761	415,272	415,785	416,300	416,813	417,329	417,843
3324	418,359	418,877	419,393	419,912	420,430	420,950	421,470	421,990	422,512	423,033
3325	423,556	424,079	424,603	425,127	425,652	426,178	426,705	427,231	427,759	428,287
3326	428,816	429,346	429,876	430,407	430,938	431,471	432,004	432,537	433,072	433,606
3327	434,142	434,679	435,215	435,753	436,291	436,830	437,370	437,909	438,451	438,991
3328	439,535	440,078	440,621	441,165	441,709	442,256	442,802	443,348	443,896	444,444
3329	444,993	445,543	446,093	446,644	447,196	447,748	448,302	448,855	449,410	449,964
3330	450,520	451,077	451,633	452,192	452,750	453,309	453,870	454,429	454,992	455,552

Table 2-1. HGH Gross Storage in Acre Feet (AF) [CENWS-EC-TB-HH/JAN 2003, see Note on Sheet 15]

ELEV.	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3331	456,116	456,680	457,243	457,808	458,373	456,940	459,507	460,074	460,642	461,210
3332	461,781	462,352	462,922	463,494	464,066	464,640	465,214	465,788	466,363	466,939
3333	467,516	468,094	468,671	469,251	469,830	470,410	470,992	471,573	472,156	472,738
3334	473,322	473,908	474,492	475,079	475,665	476,253	476,842	477,430	478,020	478,609
3335	479,201	479,794	480,386	480,979	481,573	482,168	482,764	483,360	483,957	484,554
3336	485,153	485,693	486,232	486,772	487,313	487,855	488,397	488,939	489,483	490,026
3337	490,571	491,117	491,662	492,209	492,755	493,303	493,852	494,400	494,950	495,499
3338	496,050	496,602	497,153	497,706	498,258	498,812	499,367	499,921	500,478	501,033
3339	501,590	502,148	502,705	503,264	503,823	504,383	504,944	505,504	506,067	506,628
3340	507,192	507,756	508,319	508,885	509,450	510,016	510,584	511,150	511,719	512,286
3341	512,856	513,427	513,996	514,568	515,139	515,712	516,286	516,859	517,434	518,008
3342	518,584	519,161	519,737	520,315	520,892	521,472	522,052	522,631	523,212	523,793
3343	524,376	524,959	525,541	526,126	526,710	527,295	527,882	528,468	529,055	529,643
3344	530,232	530,810	531,388	531,968	532,546	533,127	533,709	534,290	534,873	535,455
3345	536,039	536,624	537,208	537,794	538,379	538,966	539,554	540,141	540,730	541,319
3346	541,910	542,501	543,091	543,684	544,275	544,869	545,463	546,057	546,653	547,247
3347	547,845	548,442	549,039	549,638	550,236	550,836	551,437	552,037	552,639	553,241
3348	553,844	554,449	555,052	555,658	556,262	556,869	557,476	558,083	558,692	559,300
3349	559,910	560,521	561,131	561,743	562,354	562,968	563,582	564,195	564,810	565,425
3350	566,042	566,659	567,276	567,895	568,513	569,133	569,754	570,374	570,996	571,617
3351	572,241	572,866	573,489	574,114	574,739	575,366	575,994	576,620	577,249	577,878
3352	578,508	579,125	579,742	580,360	580,978	581,598	582,218	582,838	583,460	584,081
3353	584,704	585,327	585,950	586,576	587,200	587,826	588,454	589,080	589,709	590,336
3354	590,966	591,597	592,226	592,858	593,488	594,122	594,756	595,389	596,024	596,659
3355	597,295	597,932	598,569	599,207	599,845	600,485	601,125	601,765	602,407	603,048
3356	603,692	604,336	604,979	605,624	606,269	606,916	607,563	608,210	608,858	609,507
3357	610,157	610,808	611,458	612,110	612,762	613,415	614,070	614,723	615,380	616,034
3358	616,692	617,350	618,006	618,666	619,324	619,985	620,647	621,307	621,970	622,632
3359	623,296	623,961	624,625	625,291	625,957	626,625	627,293	627,961	628,631	629,300
3360	629,971	630,633	631,294	631,957	632,618	633,283	633,948	634,612	635,279	635,944
3361	636,612	637,280	637,948	638,618	639,287	639,959	640,631	641,301	641,975	642,648
3362	643,323	643,998	644,672	645,349	646,026	646,704	647,383	648,062	648,742	649,422

Table 2-1. HGH Gross Storage in Acre Feet (AF) [CENWS-EC-TB-HH/JAN 2003, see Note on Sheet 15]

ELEV.	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3363	650,104	650,786	651,468	652,153	652,835	653,521	654,207	654,893	655,581	656,268
3364	656,957	657,646	658,335	659,027	659,717	660,410	661,104	661,796	662,491	663,185
3365	663,882	664,579	665,275	665,973	666,671	667,371	668,072	668,772	669,475	670,176
3366	670,879	671,584	672,288	672,994	673,698	674,406	675,114	675,822	676,531	677,240
3367	677,952	678,664	679,374	680,088	680,800	681,515	682,231	682,945	683,662	684,379
3368	685,098	685,807	686,516	687,227	687,938	688,651	689,364	690,077	690,791	691,505
3369	692,223	692,940	693,656	694,374	695,092	695,812	696,533	697,253	697,975	698,697
3370	699,421	700,145	700,869	701,595	702,320	703,048	703,776	704,504	705,233	705,962
3371	706,695	707,427	708,158	708,891	709,624	710,359	711,095	711,830	712,568	713,304
3372	714,043	714,783	715,522	716,263	717,003	717,746	718,490	719,232	719,977	720,722
3373	721,469	722,216	722,963	723,712	724,460	725,211	725,962	726,712	727,465	728,217
3374	728,971	729,727	730,481	731,238	731,993	732,752	733,511	734,269	735,030	735,790
3375	736,553	737,316	738,078	738,842	739,606	740,372	741,139	741,905	742,674	743,442
3376	744,212	744,967	745,721	746,478	747,233	747,991	748,751	749,508	750,269	751,028
3377	751,790	752,553	753,315	754,079	754,842	755,609	756,376	757,141	757,909	758,677
3378	759,446	760,217	760,986	761,759	762,530	763,303	764,078	764,851	765,627	766,403
3379	767,180	767,959	768,736	769,516	770,295	771,076	771,859	772,641	773,424	774,208
3380	774,993	775,779	776,565	777,352	778,140	778,929	779,719	780,509	781,300	782,092
3381	782,885	783,679	784,473	785,269	786,064	786,862	787,659	788,457	789,258	790,056
3382	790,858	791,660	792,462	793,266	794,069	794,875	795,681	796,486	797,295	798,102
3383	798,912	799,723	800,532	801,344	802,155	802,969	803,784	804,597	805,414	806,229
3384	807,047	807,858	808,668	809,481	810,293	811,106	811,921	812,736	813,552	814,368
3385	815,186	816,005	816,823	817,643	818,463	819,286	820,108	820,931	821,756	822,579
3386	823,406	824,234	825,060	825,889	826,717	827,547	828,379	829,210	830,042	830,875
3387	831,710	832,545	833,380	834,217	835,054	835,893	836,732	837,571	838,413	839,253
3388	840,097	840,934	841,770	842,608	843,446	844,287	845,129	845,969	846,812	847,654
3389	848,498	849,343	850,188	851,036	851,882	852,731	853,580	854,429	855,280	856,130
3390	856,984	857,838	858,691	859,547	860,401	861,258	862,117	862,974	863,834	864,693
3391	865,555	866,417	867,278	868,143	869,006	869,871	870,739	871,605	872,473	873,340
3392	874,211	875,070	875,929	876,789	877,649	878,512	879,375	880,237	881,102	881,967
3393	882,834	883,702	884,568	885,437	886,306	887,177	888,049	888,920	889,794	890,667
3394	891,542	892,418	893,293	894,171	895,049	895,928	896,808	897,688	898,571	899,451

Table 2-1. HGH Gross Storage in Acre Feet (AF) [CENWS-EC-TB-HH/JAN 2003, see Note on Sheet 15]

ELEV.	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3395	900,335	901,221	902,105	902,992	903,876	904,765	905,655	906,543	907,433	908,323
3396	909,216	910,096	910,974	911,856	912,735	913,619	914,503	915,385	916,271	917,155
3397	918,042	918,930	919,817	920,707	921,596	922,487	923,379	924,271	925,165	926,058
3398	926,954	927,850	928,746	929,644	930,541	931,442	932,342	933,243	934,146	935,047
3399	935,952	936,856	937,761	938,669	939,574	940,483	941,393	942,301	943,213	944,123
3400	945,037	945,938	946,838	947,739	948,641	949,545	950,451	951,355	952,261	953,167
3401	954,076	954,985	955,894	956,804	957,714	958,628	959,542	960,454	961,369	962,284
3402	963,201	964,120	965,037	965,956	966,875	967,797	968,719	969,641	970,564	971,488
3403	972,414	973,341	974,267	975,195	976,123	977,053	977,985	978,915	979,848	980,780
3404	981,715	982,638	983,560	984,483	985,407	986,334	987,261	988,187	989,116	990,043
3405	990,974	991,906	992,836	993,770	994,702	995,636	996,573	997,507	998,445	999,382
3406	1,000,322	1,001,261	1,002,201	1,003,143	1,004,084	1,005,028	1,005,972	1,006,916	1,007,863	1,008,808
3407	1,009,757	1,010,706	1,011,653	1,012,604	1,013,554	1,014,507	1,015,461	1,016,414	1,017,368	1,018,323
3408	1,019,280	1,020,226	1,021,171	1,022,120	1,023,067	1,024,016	1,024,967	1,025,916	1,026,869	1,027,820
3409	1,028,774	1,029,729	1,030,683	1,031,640	1,032,596	1,033,554	1,034,514	1,035,472	1,036,434	1,037,394
3410	1,038,356	1,039,320	1,040,283	1,041,249	1,042,214	1,043,181	1,044,149	1,045,116	1,046,087	1,047,056
3411	1,046,028	1,049,001	1,049,972	1,050,948	1,051,921	1,052,898	1,053,875	1,054,851	1,055,831	1,056,809
3412	1,057,790	1,058,762	1,059,732	1,060,706	1,061,678	1,062,654	1,063,630	1,064,606	1,065,583	1,066,561
3413	1,067,540	1,066,522	1,069,501	1,070,484	1,071,465	1,072,450	1,073,435	1,074,419	1,075,406	1,076,392
3414	1,077,382	1,078,371	1,079,360	1,080,351	1,081,342	1,082,335	1,083,331	1,084,323	1,085,320	1,086,314
3415	1,087,313	1,088,311	1,089,310	1,090,310	1,091,310	1,092,312	1,093,317	1,094,318	1,095,324	1,096,328
3416	1,097,336	1,098,335	1,099,331	1,100,333	1,101,332	1,102,335	1,103,339	1,104,340	1,105,346	1,106,350
3417	1,107,357	1,108,364	1,109,371	1,110,381	1,111,389	1,112,401	1,113,414	1,114,425	1,115,440	1,116,452
3418	1,117,469	1,118,486	1,119,501	1,120,521	1,121,539	1,122,560	1,123,582	1,124,602	1,125,626	1,126,648
3419	1,127,674	1,128,700	1,129,725	1,130,754	1,131,780	1,132,811	1,133,842	1,134,872	1,135,906	1,136,936
3420	1,137,972	1,138,997	1,140,021	1,141,048	1,142,075	1,143,103	1,144,133	1,145,162	1,146,194	1,147,225
3421	1,148,258	1,149,292	1,150,326	1,151,363	1,152,398	1,153,436	1,154,475	1,155,514	1,156,555	1,157,595
3422	1,158,638	1,159,681	1,160,725	1,161,770	1,162,815	1,163,863	1,164,911	1,165,959	1,167,009	1,168,059
3423	1,169,111	1,170,164	1,171,217	1,172,272	1,173,327	1,174,383	1,175,441	1,176,499	1,177,558	1,178,618
3424	1,179,679	1,180,732	1,181,781	1,182,835	1,183,886	1,184,942	1,185,999	1,187,053	1,188,112	1,189,167
3425	1,190,228	1,191,290	1,192,348	1,193,412	1,194,472	1,195,538	1,196,604	1,197,667	1,198,736	1,199,801
3426	1,200,871	1,201,942	1,203,010	1,204,083	1,205,153	1,206,228	1,207,304	1,208,377	1,209,455	1,210,530

Table 2-1. HGH Gross Storage in Acre Feet (AF) [CENWS-EC-TB-HH/JAN 2003, see Note on Sheet 15]

ELEV.	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3427	1,211,609	1,212,690	1,213,768	1,214,850	1,215,930	1,217,014	1,218,100	1,219,182	1,220,270	1,221,350
3426	1,222,444	1,223,522	1,224,600	1,225,680	1,226,758	1,227,840	1,228,925	1,230,006	1,231,091	1,232,174
3429	1,233,262	1,234,350	1,235,436	1,236,527	1,237,615	1,238,707	1,239,799	1,240,891	1,241,986	1,243,079
3430	1,244,177	1,245,274	1,246,370	1,247,469	1,248,568	1,249,669	1,250,772	1,251,872	1,252,978	1,254,080
3431	1,255,186	1,256,295	1,257,400	1,258,509	1,259,617	1,260,729	1,261,841	1,262,951	1,264,065	1,265,179
3432	1,266,295	1,267,402	1,268,506	1,269,615	1,270,722	1,271,833	1,272,944	1,274,054	1,275,168	1,276,279
3433	1,277,395	1,278,512	1,279,625	1,280,744	1,281,861	1,282,982	1,284,102	1,285,222	1,286,346	1,287,467
3434	1,288,592	1,289,719	1,290,842	1,291,971	1,293,098	1,294,229	1,295,359	1,296,489	1,297,622	1,298,752
3435	1,299,888	1,301,025	1,302,158	1,303,296	1,304,433	1,305,574	1,306,714	1,307,853	1,308,997	1,310,137
3436	1,311,283	1,312,418	1,313,552	1,314,689	1,315,826	1,316,965	1,318,106	1,319,244	1,320,387	1,321,527
3437	1,322,673	1,323,817	1,324,960	1,326,109	1,327,254	1,328,404	1,329,554	1,330,703	1,331,855	1,333,006
3438	1,334,160	1,335,315	1,336,469	1,337,626	1,338,782	1,339,941	1,341,102	1,342,260	1,343,424	1,344,583
3439	1,345,749	1,346,914	1,348,076	1,349,245	1,350,410	1,351,580	1,352,750	1,353,919	1,355,091	1,356,263
3440	1,357,437	1,358,601	1,359,764	1,360,929	1,362,093	1,363,262	1,364,431	1,365,599	1,366,769	1,367,938
3441	1,369,112	1,370,286	1,371,459	1,372,634	1,373,808	1,374,987	1,376,186	1,377,344	1,378,524	1,379,704
3442	1,380,887	1,382,072	1,383,254	1,384,440	1,385,624	1,386,813	1,388,003	1,389,190	1,390,380	1,391,570
3443	1,392,764	1,393,959	1,395,152	1,396,347	1,397,542	1,398,741	1,399,941	1,401,138	1,402,339	1,403,539
3444	1,404,743	1,405,936	1,407,125	1,408,320	1,409,512	1,410,709	1,411,905	1,413,101	1,414,301	1,415,497
3445	1,416,699	1,417,902	1,419,101	1,420,306	1,421,509	1,422,716	1,423,922	1,425,128	1,426,338	1,427,545
3446	1,428,757	1,429,970	1,431,179	1,432,394	1,433,607	1,434,825	1,436,041	1,437,258	1,438,478	1,439,695
3447	1,440,917	1,442,140	1,443,360	1,444,586	1,445,809	1,447,037	1,448,264	1,449,490	1,450,721	1,451,948
3448	1,453,181	1,454,405	1,455,629	1,456,855	1,458,079	1,459,309	1,460,539	1,461,766	1,462,998	1,464,229
3449	1,465,462	1,466,697	1,467,931	1,469,168	1,470,402	1,471,643	1,472,882	1,474,120	1,475,362	1,476,603
3450	1,477,847	1,479,069	1,480,329	1,481,573	1,482,814	1,484,060	1,485,307	1,486,552	1,487,801	1,489,048
3451	1,490,300	1,491,549	1,492,797	1,494,048	1,495,299	1,496,552	1,497,806	1,499,060	1,500,316	1,501,572
3452	1,502,830	1,504,088	1,505,344	1,506,602	1,507,860	1,509,122	1,510,385	1,511,646	1,512,909	1,514,172
3453	1,515,440	1,516,705	1,517,969	1,519,236	1,520,501	1,521,772	1,523,043	1,524,311	1,525,583	1,526,855
3454	1,528,130	1,529,404	1,530,674	1,531,950	1,533,224	1,534,502	1,535,780	1,537,057	1,538,338	1,539,616
3455	1,540,899	1,542,180	1,543,461	1,544,744	1,546,027	1,547,314	1,548,601	1,549,887	1,551,176	1,552,464
3456	1,553,755	1,555,045	1,556,334	1,557,627	1,558,917	1,560,213	1,561,509	1,562,802	1,564,100	1,565,397
3457	1,566,697	1,567,998	1,569,295	1,570,598	1,571,897	1,573,202	1,574,508	1,575,811	1,577,119	1,578,424
3458	1,579,734	1,581,045	1,582,352	1,583,664	1,584,974	1,586,289	1,587,604	1,588,917	1,590,235	1,591,550

Table 2-1. HGH Gross Storage in Acre Feet (AF) [CENWS-EC-TB-HH/JAN 2003, see Note on Sheet 15]

ELEV.	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3459	1,592,870	1,594,191	1,595,510	1,596,833	1,598,154	1,599,481	1,600,807	1,602,131	1,603,460	1,604,786
3460	1,606,117	1,607,451	1,608,780	1,610,116	1,611,448	1,612,786	1,614,125	1,615,460	1,616,802	1,618,139
3461	1,619,483	1,620,829	1,622,174	1,623,521	1,624,867	1,626,218	1,627,570	1,628,920	1,630,273	1,631,625
3462	1,632,981	1,634,343	1,635,702	1,637,064	1,638,425	1,639,791	1,641,158	1,642,523	1,643,890	1,645,257
3463	1,646,629	1,648,005	1,649,379	1,650,758	1,652,134	1,653,515	1,654,895	1,656,275	1,657,659	1,659,041
3464	1,660,428	1,661,820	1,663,211	1,664,605	1,665,998	1,667,394	1,668,792	1,670,188	1,671,588	1,672,987
3465	1,674,389	1,675,798	1,677,205	1,678,614	1,680,023	1,681,436	1,682,851	1,684,263	1,685,678	1,687,093
3466	1,688,512	1,689,937	1,691,359	1,692,786	1,694,210	1,695,639	1,697,068	1,698,496	1,699,928	1,701,359
3467	1,702,794	1,704,232	1,705,670	1,707,111	1,708,551	1,709,996	1,711,440	1,712,884	1,714,331	1,715,777
3468	1,717,226	1,718,681	1,720,130	1,721,587	1,723,040	1,724,499	1,725,959	1,727,415	1,728,878	1,730,337
3469	1,731,802	1,733,269	1,734,733	1,736,200	1,737,666	1,739,138	1,740,611	1,742,081	1,743,555	1,745,027
3470	1,746,505	1,747,982	1,749,457	1,750,937	1,752,414	1,753,898	1,755,381	1,756,862	1,758,348	1,759,831
3471	1,761,320	1,762,807	1,764,291	1,765,781	1,767,269	1,768,761	1,770,253	1,771,745	1,773,241	1,774,733
3472	1,776,233	1,777,729	1,779,221	1,780,720	1,782,216	1,783,718	1,785,218	1,786,719	1,788,224	1,789,724
3473	1,791,232	1,792,735	1,794,236	1,795,744	1,797,247	1,798,755	1,800,264	1,801,771	1,803,285	1,804,795
3474	1,806,309	1,807,819	1,809,328	1,810,841	1,812,352	1,813,869	1,815,385	1,816,901	1,818,420	1,819,938
3475	1,821,459	1,822,975	1,824,491	1,826,010	1,827,529	1,829,050	1,830,573	1,832,095	1,833,621	1,835,145
3476	1,836,673	1,838,196	1,839,719	1,841,244	1,842,769	1,844,298	1,845,827	1,847,356	1,848,888	1,850,419
3477	1,851,954	1,853,483	1,855,010	1,856,543	1,858,072	1,859,609	1,861,145	1,862,678	1,864,217	1,865,752
3478	1,867,294	1,868,830	1,870,363	1,871,904	1,873,440	1,874,981	1,876,524	1,878,063	1,879,611	1,881,153
3479	1,882,701	1,884,243	1,885,783	1,887,330	1,888,873	1,890,420	1,891,970	1,893,516	1,895,069	1,896,618
3480	1,898,172	1,899,721	1,901,270	1,902,821	1,904,372	1,905,928	1,907,484	1,909,038	1,910,596	1,912,154
3481	1,913,714	1,915,270	1,916,824	1,918,382	1,919,939	1,921,502	1,923,064	1,924,625	1,926,189	1,927,753
3482	1,929,320	1,930,882	1,932,443	1,934,007	1,935,570	1,937,137	1,938,705	1,940,273	1,941,843	1,943,413
3483	1,944,987	1,946,555	1,948,120	1,949,692	1,951,260	1,952,833	1,954,408	1,955,979	1,957,558	1,959,132
3484	1,960,712	1,962,286	1,963,857	1,965,434	1,967,008	1,968,589	1,970,170	1,971,748	1,973,331	1,974,911
3485	1,976,497	1,978,077	1,979,654	1,981,237	1,982,817	1,984,403	1,985,990	1,987,573	1,989,163	1,990,749
3486	1,992,341	1,993,927	1,995,511	1,997,100	1,998,686	2,000,280	2,001,873	2,003,462	2,005,058	2,006,650
3487	2,008,248	2,009,843	2,011,432	2,013,030	2,014,622	2,016,222	2,017,823	2,019,419	2,021,022	2,022,621
3488	2,024,227	2,025,828	2,027,428	2,029,031	2,030,633	2,032,241	2,033,849	2,035,455	2,037,065	2,038,673
3489	2,040,286	2,041,897	2,043,505	2,045,117	2,046,727	2,048,344	2,049,961	2,051,576	2,053,194	2,054,811
3490	2,056,433	2,058,055	2,059,674	2,061,296	2,062,917	2,064,544	2,066,172	2,067,797	2,069,425	2,071,053

Table 2-1. HGH Gross Storage in Acre Feet (AF) [CENWS-EC-TB-HH/JAN 2003, see Note on Sheet 15]

ELEV.	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3491	2,072,686	2,074,319	2,075,950	2,077,585	2,079,217	2,080,856	2,082,495	2,084,131	2,085,772	2,087,412
3492	2,089,056	2,090,701	2,092,343	2,093,993	2,095,638	2,097,288	2,098,940	2,100,589	2,102,245	2,103,896
3493	2,105,553	2,107,211	2,108,868	2,110,529	2,112,189	2,113,855	2,115,520	2,117,183	2,118,851	2,120,517
3494	2,122,187	2,123,861	2,125,531	2,127,207	2,128,880	2,130,559	2,132,240	2,133,916	2,135,599	2,137,279
3495	2,138,964	2,140,654	2,142,337	2,144,029	2,145,718	2,147,412	2,149,106	2,150,798	2,152,497	2,154,190
3496	2,155,891	2,157,593	2,159,295	2,161,000	2,162,702	2,164,413	2,166,122	2,167,828	2,169,540	2,171,251
3497	2,172,966	2,174,684	2,176,399	2,178,118	2,179,836	2,181,560	2,183,285	2,185,007	2,186,732	2,188,457
3498	2,190,188	2,191,920	2,193,648	2,195,383	2,197,114	2,198,852	2,200,591	2,202,326	2,204,068	2,205,806
3499	2,207,551	2,209,297	2,211,039	2,212,788	2,214,533	2,216,284	2,218,034	2,219,784	2,221,539	2,223,291
3500	2,225,049	2,226,807	2,228,563	2,230,323	2,232,082	2,233,844	2,235,609	2,237,372	2,239,139	2,240,905
3501	2,242,674	2,244,445	2,246,213	2,247,987	2,249,757	2,251,534	2,253,310	2,255,084	2,256,865	2,258,643
3502	2,260,426	2,262,209	2,263,988	2,265,774	2,267,556	2,269,344	2,271,134	2,272,920	2,274,712	2,276,501
3503	2,278,297	2,280,091	2,281,881	2,283,681	2,285,475	2,287,274	2,289,076	2,290,874	2,292,680	2,294,481
3504	2,296,288	2,298,094	2,299,896	2,301,707	2,303,512	2,305,324	2,307,137	2,308,946	2,310,765	2,312,577
3505	2,314,396	2,316,213	2,318,027	2,319,848	2,321,667	2,323,490	2,325,313	2,327,136	2,328,964	2,330,788
3506	2,332,618	2,334,448	2,336,273	2,338,105	2,339,934	2,341,769	2,343,603	2,345,436	2,347,275	2,349,111
3507	2,350,953	2,352,794	2,354,629	2,356,473	2,358,313	2,360,160	2,362,006	2,363,851	2,365,702	2,367,547
3508	2,369,401	2,371,251	2,373,101	2,374,954	2,376,803	2,378,662	2,380,520	2,382,374	2,384,234	2,386,094
3509	2,387,957	2,389,819	2,391,678	2,393,543	2,395,404	2,397,272	2,399,139	2,401,005	2,402,877	2,404,746
3510	2,406,621	2,408,493	2,410,363	2,412,238	2,414,108	2,415,988	2,417,867	2,419,742	2,421,624	2,423,504
3511	2,425,389	2,427,272	2,429,149	2,431,036	2,432,918	2,434,807	2,436,696	2,438,582	2,440,476	2,442,363
3512	2,444,260	2,446,153	2,448,041	2,449,937	2,451,832	2,453,730	2,455,628	2,457,526	2,459,429	2,461,328
3513	2,463,234	2,465,136	2,467,034	2,468,942	2,470,843	2,472,751	2,474,660	2,476,566	2,478,481	2,480,389
3514	2,482,304	2,484,216	2,486,123	2,488,040	2,489,950	2,491,867	2,493,786	2,495,701	2,497,625	2,499,543
3515	2,501,467	2,503,388	2,505,307	2,507,230	2,509,153	2,511,079	2,513,007	2,514,934	2,516,865	2,518,794
3516	2,520,728	2,522,658	2,524,586	2,526,519	2,528,451	2,530,386	2,532,323	2,534,259	2,536,199	2,538,138
3517	2,540,081	2,542,020	2,543,958	2,545,900	2,547,841	2,549,789	2,551,735	2,553,680	2,555,630	2,557,578
3518	2,559,530	2,561,478	2,563,425	2,565,379	2,567,329	2,569,283	2,571,239	2,573,193	2,575,155	2,577,112
3519	2,579,074	2,581,034	2,582,987	2,584,951	2,586,910	2,588,876	2,590,841	2,592,804	2,594,775	2,596,739
3520	2,598,712	2,600,682	2,602,647	2,604,620	2,606,588	2,608,563	2,610,538	2,612,510	2,614,490	2,616,466
3521	2,618,449	2,620,428	2,622,402	2,624,384	2,626,361	2,628,346	2,630,332	2,632,314	2,634,303	2,636,288
3522	2,638,280	2,640,268	2,642,255	2,644,246	2,646,232	2,648,229	2,650,224	2,652,215	2,654,214	2,656,211

Table 2-1. HGH Gross Storage in Acre Feet (AF) [CENWS-EC-TB-HH/JAN 2003, see Note on Sheet 15]

ELEV.	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3523	2,658,212	2,660,209	2,662,205	2,664,205	2,666,204	2,668,207	2,670,211	2,672,215	2,674,222	2,676,228
3524	2,678,239	2,680,245	2,682,250	2,684,262	2,686,270	2,688,282	2,690,296	2,692,308	2,694,328	2,696,343
3525	2,698,363	2,700,381	2,702,395	2,704,414	2,706,431	2,708,455	2,710,481	2,712,502	2,714,528	2,716,553
3526	2,718,585	2,720,612	2,722,635	2,724,666	2,726,692	2,728,725	2,730,760	2,732,791	2,734,829	2,736,863
3527	2,738,904	2,740,941	2,742,976	2,745,015	2,747,050	2,749,096	2,751,140	2,753,180	2,755,227	2,757,273
3528	2,759,323	2,761,375	2,763,422	2,765,474	2,767,525	2,769,582	2,771,633	2,773,682	2,775,735	2,777,787
3529	2,779,843	2,781,904	2,783,960	2,786,025	2,788,084	2,790,151	2,792,210	2,794,268	2,796,334	2,798,395
3530	2,800,460	2,802,530	2,804,599	2,806,672	2,808,744	2,810,820	2,812,891	2,814,958	2,817,033	2,819,103
3531	2,821,181	2,823,260	2,825,337	2,827,423	2,829,504	2,831,589	2,833,670	2,835,749	2,837,832	2,839,914
3532	2,842,001	2,844,093	2,846,179	2,848,277	2,850,367	2,852,464	2,854,557	2,856,645	2,858,738	2,860,829
3533	2,862,928	2,865,029	2,867,128	2,869,232	2,871,334	2,873,440	2,875,542	2,877,639	2,879,748	2,881,848
3534	2,883,956	2,886,069	2,888,177	2,890,293	2,892,404	2,894,523	2,896,634	2,898,743	2,900,860	2,902,973
3535	2,905,090	2,907,212	2,909,332	2,911,460	2,913,584	2,915,712	2,917,835	2,919,953	2,922,080	2,924,201
3536	2,926,331	2,928,465	2,930,594	2,932,731	2,934,864	2,937,004	2,939,137	2,941,267	2,943,403	2,945,536
3537	2,947,675	2,949,818	2,951,960	2,954,106	2,956,251	2,958,400	2,960,545	2,962,685	2,964,832	2,966,975
3538	2,969,126	2,971,282	2,973,432	2,975,588	2,977,741	2,979,903	2,982,057	2,984,209	2,986,366	2,988,521
3539	2,990,680	2,992,845	2,995,005	2,997,176	2,999,339	3,001,510	3,003,676	3,005,837	3,008,002	3,010,166
3540	3,012,339	3,014,512	3,016,684	3,018,865	3,021,040	3,023,220	3,025,395	3,027,568	3,029,746	3,031,922
3541	3,034,104	3,036,290	3,038,471	3,040,660	3,042,844	3,045,037	3,047,221	3,049,403	3,051,590	3,053,775
3542	3,055,966	3,058,161	3,060,354	3,062,552	3,064,749	3,066,950	3,069,147	3,071,338	3,073,537	3,075,732
3543	3,077,934	3,080,138	3,062,341	3,084,552	3,086,757	3,088,968	3,091,173	3,093,376	3,095,585	3,097,791
3544	3,100,003	3,102,220	3,104,431	3,106,654	3,108,869	3,111,092	3,113,306	3,115,518	3,117,739	3,119,955
3545	3,122,175	3,124,401	3,126,624	3,128,853	3,131,080	3,133,312	3,135,539	3,137,760	3,139,993	3,142,218
3546	3,144,451	3,146,685	3,148,918	3,151,159	3,153,395	3,155,636	3,157,871	3,160,105	3,162,344	3,164,581
3547	3,166,822	3,169,069	3,171,311	3,173,565	3,175,809	3,178,063	3,180,311	3,182,553	3,184,801	3,187,047
3548	3,189,301	3,191,557	3,193,811	3,196,070	3,198,327	3,200,589	3,202,846	3,205,098	3,207,361	3,209,616
3549	3,211,879	3,214,144	3,216,407	3,218,675	3,220,941	3,223,212	3,225,481	3,227,745	3,230,014	3,232,281
3550	3,234,557	3,236,834	3,239,106	3,241,390	3,243,665	3,245,948	3,248,226	3,250,499	3,252,780	3,255,056
3551	3,257,341	3,259,627	3,261,911	3,264,204	3,266,491	3,268,784	3,271,071	3,273,356	3,275,650	3,277,938
3552	3,280,231	3,282,530	3,284,823	3,287,128	3,289,424	3,291,729	3,294,029	3,296,323	3,298,625	3,300,922
3553	3,303,228	3,305,539	3,307,845	3,310,155	3,312,464	3,314,781	3,317,090	3,319,396	3,321,711	3,324,020
3554	3,326,335	3,328,655	3,330,973	3,333,296	3,335,617	3,337,944	3,340,264	3,342,583	3,344,907	3,347,229

Table 2-1. HGH Gross Storage in Acre Feet (AF) **[CENWS-EC-TB-HH/JAN 2003, see Note on Sheet 15]**

ELEV.	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3555	3,349,556	3,351,888	3,354,215	3,356,551	3,358,881	3,361,220	3,363,549	3,365,877	3,368,213	3,370,544
3556	3,372,880	3,375,221	3,377,560	3,379,908	3,382,251	3,384,599	3,386,941	3,389,277	3,391,626	3,393,965
3557	3,396,314	3,398,664	3,401,012	3,403,369	3,405,720	3,408,077	3,410,427	3,412,776	3,415,134	3,417,486
3558	3,419,843	3,422,205	3,424,562	3,426,928	3,429,288	3,431,657	3,434,020	3,436,378	3,438,740	3,441,101
3559	3,443,471	3,445,842	3,448,207	3,450,578	3,452,947	3,455,325	3,457,693	3,460,059	3,462,434	3,464,803
3560	3,467,178	3,469,558	3,471,932	3,474,315	3,476,693	3,479,079	3,481,460	3,483,835	3,486,215	3,488,592
3561	3,490,980	3,493,361	3,495,736	3,498,116	3,500,494	3,502,882	3,505,260	3,507,635	3,510,020	3,512,398
3562	3,514,782	3,517,172	3,519,556	3,521,948	3,524,335	3,526,731	3,529,121	3,531,505	3,533,898	3,536,285
3563	3,538,682	3,541,080	3,543,475	3,545,877	3,548,276	3,550,680	3,553,079	3,555,475	3,557,880	3,560,280
3564	3,562,685	3,565,095	3,567,499	3,569,909	3,572,316	3,574,733	3,577,144	3,579,549	3,581,959	3,584,366
3565	3,586,783									

Note: Data for this storage table was downloaded from the hydromet database of the USBR Project Operations Group in Boise, Idaho, in January 2003 which is presently used by Reclamation for real-time operations at HGH. The table is based on a typed table dated August 1969 which is considered the "official" project storage table. Minor differences between the database table and this table (table 2-1) are due to different interpolations between the listed database values. The differences are insignificant in the range between minimum pool El 3,336 ft and normal full pool El 3,560 ft, i.e. generally less than 4 acre feet difference in this range (RJB/01-11-03).

TABLE 2-2 HUNGRY HORSE DAM & RESERVOIR SELECTIVE WITHDRAWAL SYSTEM--OUTLET TEMPERATURE (°F)

DATE	TEMPERATURE			DATE	TEMPERATURE			DATE	TEMPERATURE			DATE	TEMPERATURE		
	MIN	OPT.	MAX		MIN	OPT.	MAX		MIN	OPT.	MAX		MIN	OPT.	MAX
1-Jun	46	49	53	1-Jul	54	57	61	1-Aug	56	60	64	1-Sep	53	57	60
2-Jun	46	50	53	2-Jul	54	57	61	2-Aug	56	60	64	2-Sep	53	57	60
3-Jun	46	50	53	3-Jul	54	58	61	3-Aug	56	60	64	3-Sep	53	56	60
4-Jun	47	50	54	4-Jul	54	58	61	4-Aug	56	60	64	4-Sep	53	56	60
5-Jun	47	51	54	5-Jul	54	58	62	5-Aug	56	60	64	5-Sep	53	56	60
6-Jun	47	51	54	6-Jul	55	58	62	6-Aug	56	60	64	6-Sep	53	56	60
7-Jun	47	51	55	7-Jul	55	58	62	7-Aug	56	60	64	7-Sep	52	56	60
8-Jun	48	51	55	8-Jul	55	58	62	8-Aug	56	60	63	8-Sep	52	56	59
9-Jun	48	52	55	9-Jul	55	59	62	9-Aug	56	60	63	9-Sep	52	56	59
10-Jun	48	52	55	10-Jul	55	59	62	10-Aug	56	60	63	10-Sep	52	55	59
11-Jun	49	52	56	11-Jul	55	59	62	11-Aug	56	60	63	11-Sep	52	55	59
12-Jun	49	53	56	12-Jul	55	59	63	12-Aug	56	60	63	12-Sep	51	55	59
13-Jun	49	53	56	13-Jul	56	59	63	13-Aug	56	59	63	13-Sep	51	55	58
14-Jun	49	53	57	14-Jul	56	59	63	14-Aug	56	59	63	14-Sep	51	55	58
15-Jun	50	53	57	15-Jul	56	59	63	15-Aug	56	59	63	15-Sep	51	55	58
16-Jun	50	54	57	16-Jul	56	60	63	16-Aug	55	59	63	16-Sep	51	55	58
17-Jun	50	54	57	17-Jul	56	60	63	17-Aug	55	59	63	17-Sep	51	54	58
18-Jun	51	54	58	18-Jul	56	60	63	18-Aug	55	59	62	18-Sep	51	54	58
19-Jun	51	54	58	19-Jul	56	60	63	19-Aug	55	59	62	19-Sep	50	54	58
20-Jun	51	55	58	20-Jul	56	60	64	20-Aug	55	59	62	20-Sep	50	54	57
21-Jun	51	55	58	21-Jul	56	60	64	21-Aug	55	58	62	21-Sep	50	54	57
22-Jun	52	55	59	22-Jul	56	60	64	22-Aug	55	58	62	22-Sep	50	54	57
23-Jun	52	55	59	23-Jul	56	60	64	23-Aug	55	58	62	23-Sep	50	53	57
24-Jun	52	56	59	24-Jul	56	60	64	24-Aug	55	58	62	24-Sep	50	53	57
25-Jun	52	56	60	25-Jul	56	60	64	25-Aug	54	58	62	25-Sep	50	53	57
26-Jun	53	56	60	26-Jul	56	60	64	26-Aug	54	58	61	26-Sep	49	53	57
27-Jun	53	56	60	27-Jul	56	60	64	27-Aug	54	58	61	27-Sep	49	53	56
28-Jun	53	56	60	28-Jul	56	60	64	28-Aug	54	58	61	28-Sep	49	53	56
29-Jun	53	57	60	29-Jul	56	60	64	29-Aug	54	57	61	29-Sep	49	53	56
30-Jun	52	57	61	30-Jul	56	60	64	30-Aug	54	57	61	30-Sep	49	53	56
				31-Jul	56	60	64	31-Aug	53	57	61				

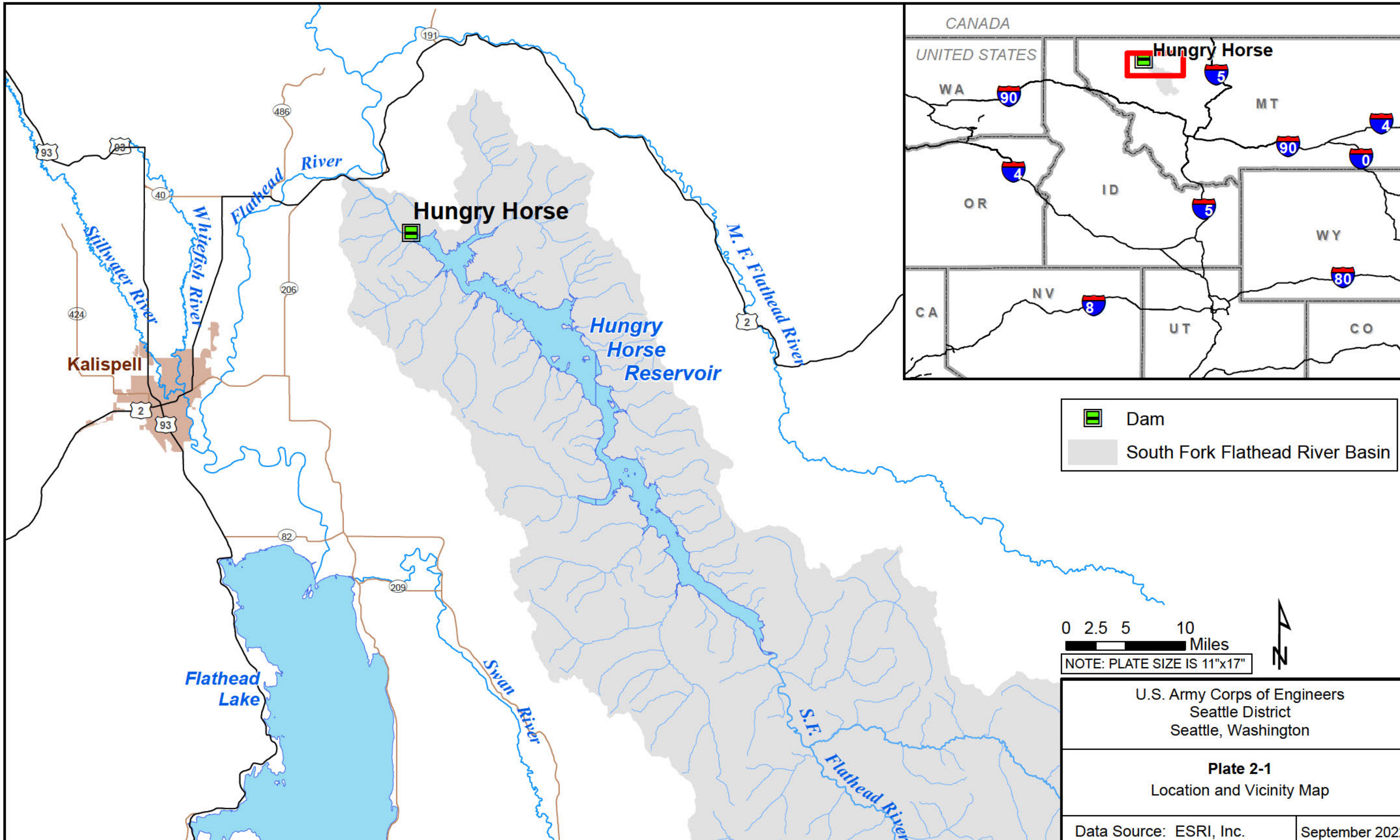
Note. Table based on data from Reclamation, Boise Office, Project Operations (HGH WCM - 2005)

TABLE 4-4
HUNGRY HORSE REGIONAL SNOW GAGES & SNOW COURSES

Index	Station Name [1]	Station Type	Station ID	Elevation (ft NGVD29)	Period of Record
1	Badger Pass	SNOTEL	BADM8	6,900	1968 – Act.
2	Bisson Creek	SNOTEL	BISM8	4,920	1988 – Act.
3	Emery Creek	SNOTEL	EMCM8	4,350	1977 – Act.
4	Flattop Mtn	SNOTEL	FTMM8	6,300	1970 – Act.
5	Hand Creek	SNOTEL	HANM8	5,035	1976 – Act.
6	Kraft Creek	SNOTEL	KRCM8	4,750	1979 – Act.
7	Moss Peak	SNOTEL	MSPM8	6,780	1961 – Act.
8	Noisy Basin	SNOTEL	NOIM8	6,040	1975 – Act.
9	North Fork Jocko	SNOTEL	NFJM8	6,330	1961 – Act.
10	Blacktail Mtn	SNOTEL	1144	5,650	2010 – Act.
11	North Fork Jocko	Snow Course/Aerial Marker	13B07	6,330	1941 – Act.
12	Fatty Creek	Snow Course/Aerial Marker	13B04	5,500	1961 – Act.
13	Upper Holland Lake	Snow Course/Aerial Marker	13B05	6,200	1948 – Act.
14	Holbrook	Snow Course/Aerial Marker	13B13	4,530	1951 – Act.
15	Spotted Bear Mountain	Snow Course/Aerial Marker	13B02	5,900	1948 – Act.
16	Trinkus Lake	Snow Course/Aerial Marker	13B01	6,100	1949 – Act.
17	Bassoo Peak	Snow Course/Aerial Marker	14B03	5,150	1961 – Act.
18	Blacktail	Snow Course/Aerial Marker	14B04	5,650	1987 – Act.
19	Truman Creek	Snow Course/Aerial Marker	14A18	4,060	1981 – Act.
20	Ashley Divide	Snow Course/Aerial Marker	14A19	4,820	1981 – Act.

Index	Station Name [1]	Station Type	Station ID	Elevation (ft NGVD29)	Period of Record
21	Desert Mountain	Snow Course/Aerial Marker	13A02	5,600	1937 – Act.
22	Griffin Creek Divide	Snow Course/Aerial Marker	14A09	5,150	1960 – Act.
23	Logan Creek	Snow Course/Aerial Marker	14A05	4,300	1937 – Act.
24	Chicken Creek	Snow Course/Aerial Marker	14A15	4,060	1977 – Act.
25	Hell Roaring Divide	Snow Course/Aerial Marker	14A03	5,770	1942 – Act.
26	Herrig Junction	Snow Course/Aerial Marker	14A16	4,850	1961 – Act.
27	Stryker Basin	Snow Course/Aerial Marker	14A17	6,180	1977 – Act.
28	Kishenehn	Snow Course/Aerial Marker	14A06	3,890	1946 – Act.
29	Mineral Creek	Snow Course/Aerial Marker	13A16	4,000	1939 – Act.
30	Brush Creek Timber	Snow Course/Aerial Marker	14A13	5,000	1949 – Act.

Source for snow gage data is https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/water/snowsurvey/



U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 2-1
Location and Vicinity Map

Data Source: ESRI, Inc.	September 2022

[redacted]

U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 2-2

Hungry Horse Dam and Powerplant

Notes:
Source: 2005 HGH WCM

September 2022

[redacted]

U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 2-3

Hungry Horse Dam Spillway

Notes:
Source: 2005 HGH WCM

September 2022

[redacted]

U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 2-4

Hungry Horse Dam Outlets

Notes:
Source: 2005 HGH WCM

September 2022

[redacted]

U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 2-5

Hungry Horse Dam
Selective Withdrawal System

Notes:
Source: 2005 HGH WCM

September 2022

[redacted]

U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 2-6

Hungry Horse Dam
Selective Withdrawal System Elevations

Notes:
Source: 2005 HGH WCM

September 2022

[redacted]

U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 2-7

Hungry Horse Dam
Spillway Ice Prevention Air System

Notes:
Source: 2005 HGH WCM

September 2022

[redacted]

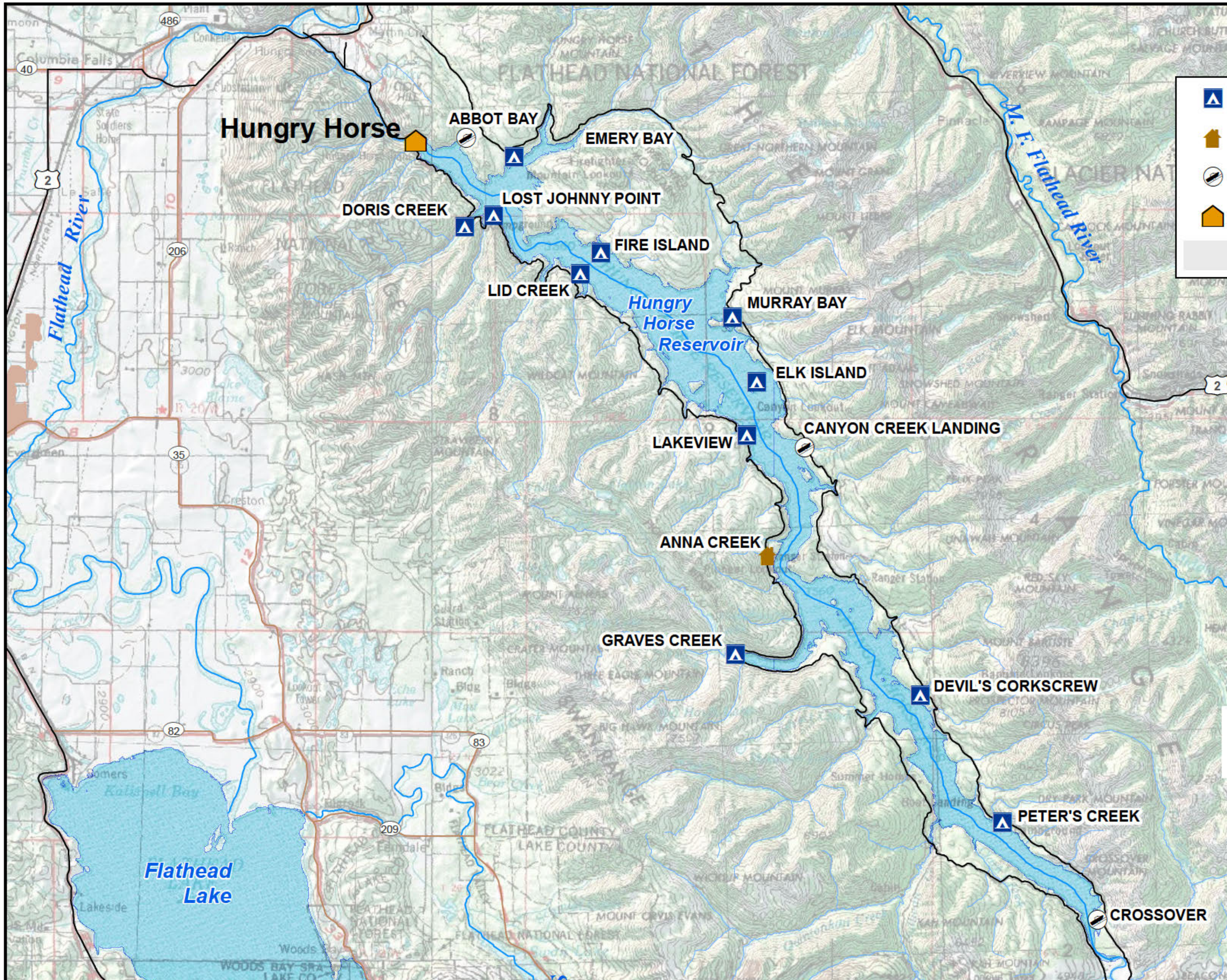
U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 2-8

Hungry Horse Dam
Spillway Ice Prevention Air System Detail

Notes:
Source: 2005 HGH WCM

September 2022



U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 2-9
Public Use Sites

Data Source: ESRI, Inc.

September 2022

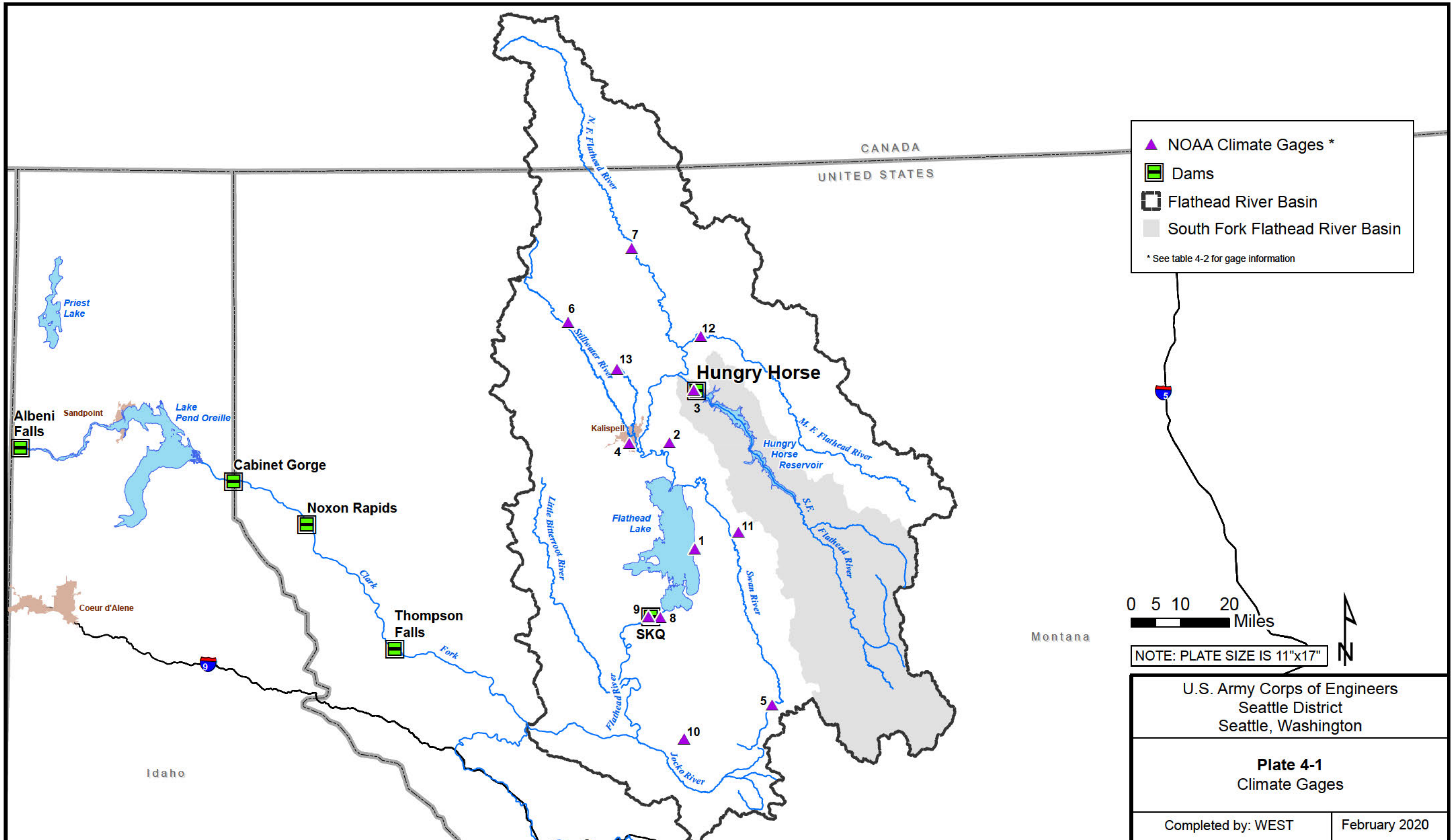
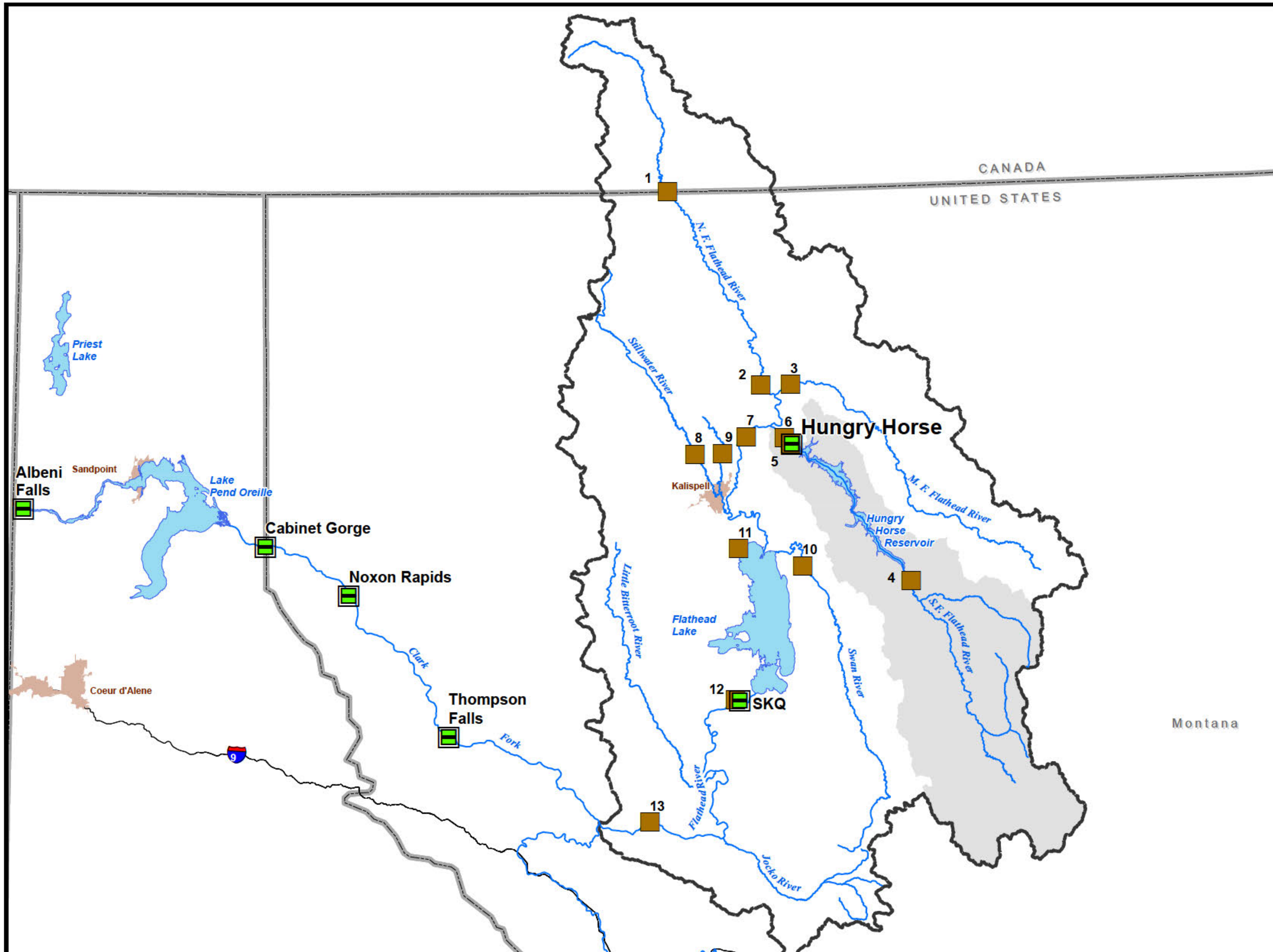

CANADA
UNITED STATES
NOAA Climate Gages *
Dams
Flathead River Basin
South Fork Flathead River Basin
* See table 4-2 for gage information
Priest Lake
Albeni Falls
Sandpoint
Lake Pend Oreille
Cabinet Gorge
Noxon Rapids
Clark Fork
Thompson Falls
Coeur d'Alene
Idaho
Montana
N. F. Flathead River
Stillwater River
Hungry Horse
Kalispell
Hungry Horse Reservoir
M. F. Flathead River
S.F. Flathead River
Flathead Lake
Little Bitterroot River
Swan River
Flathead River
Jocko River
SKQ
1
2
3
4
5
6
7
8
9
10
11
12
13
0 5 10 20
Miles
NOTE: PLATE SIZE IS 11"x17"
N
U.S. Army Corps of Engineers
Seattle District
Seattle, Washington
Plate 4-1
Climate Gages
Completed by: WEST
February 2020

PLATE 4-1

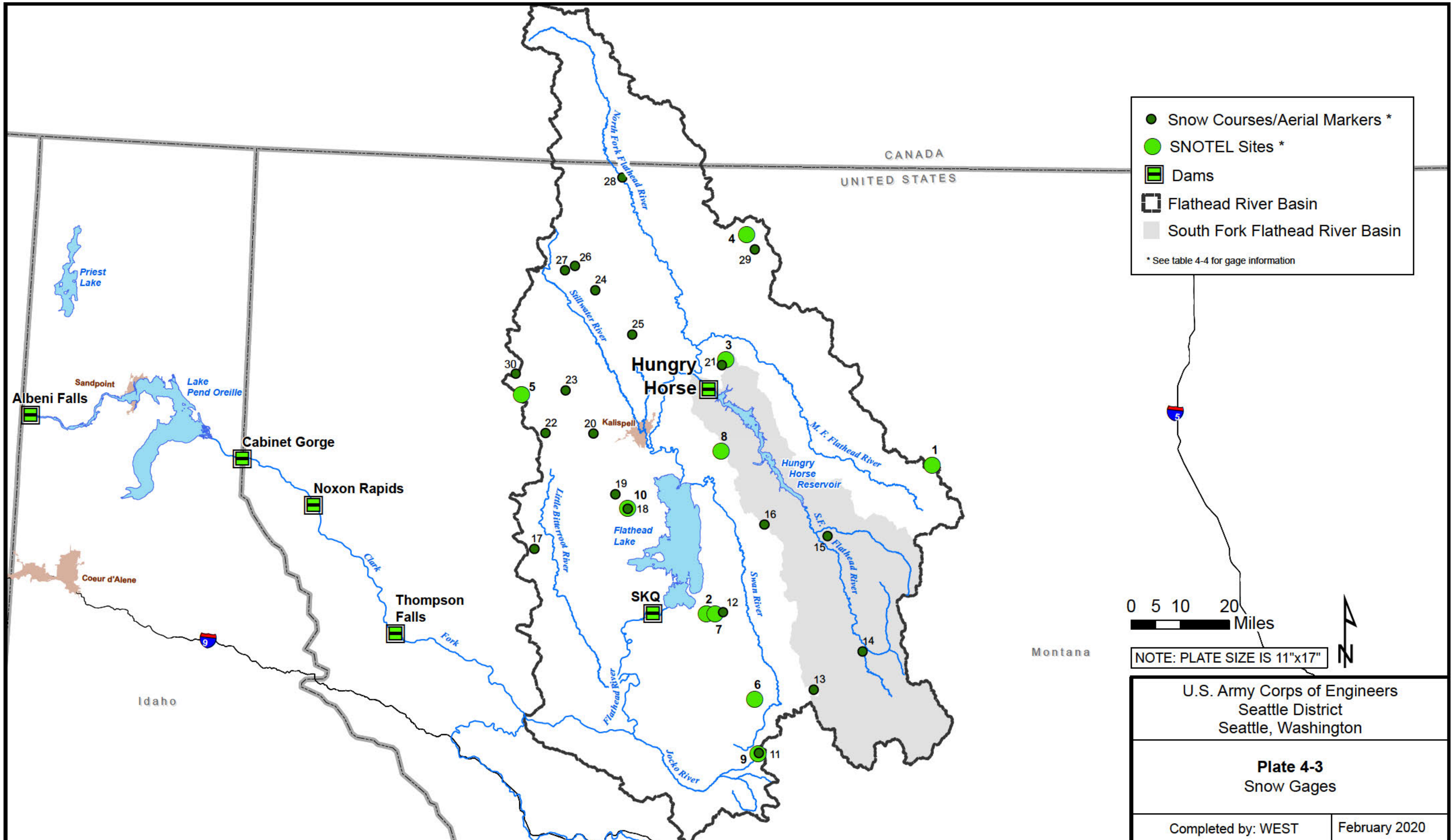


U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 4-2
Stream Gages

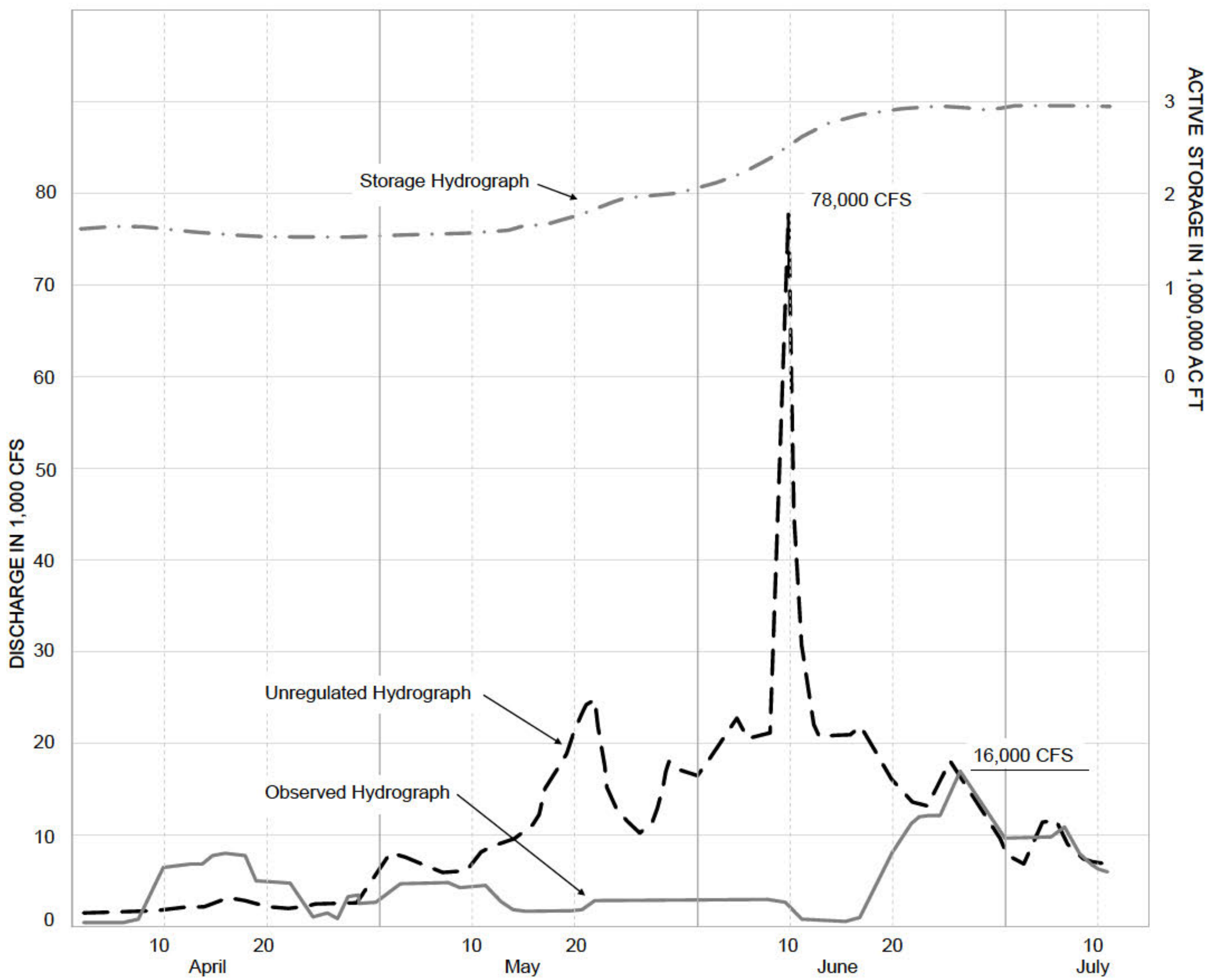
Completed by: WEST | February 2020

PLATE 4-2

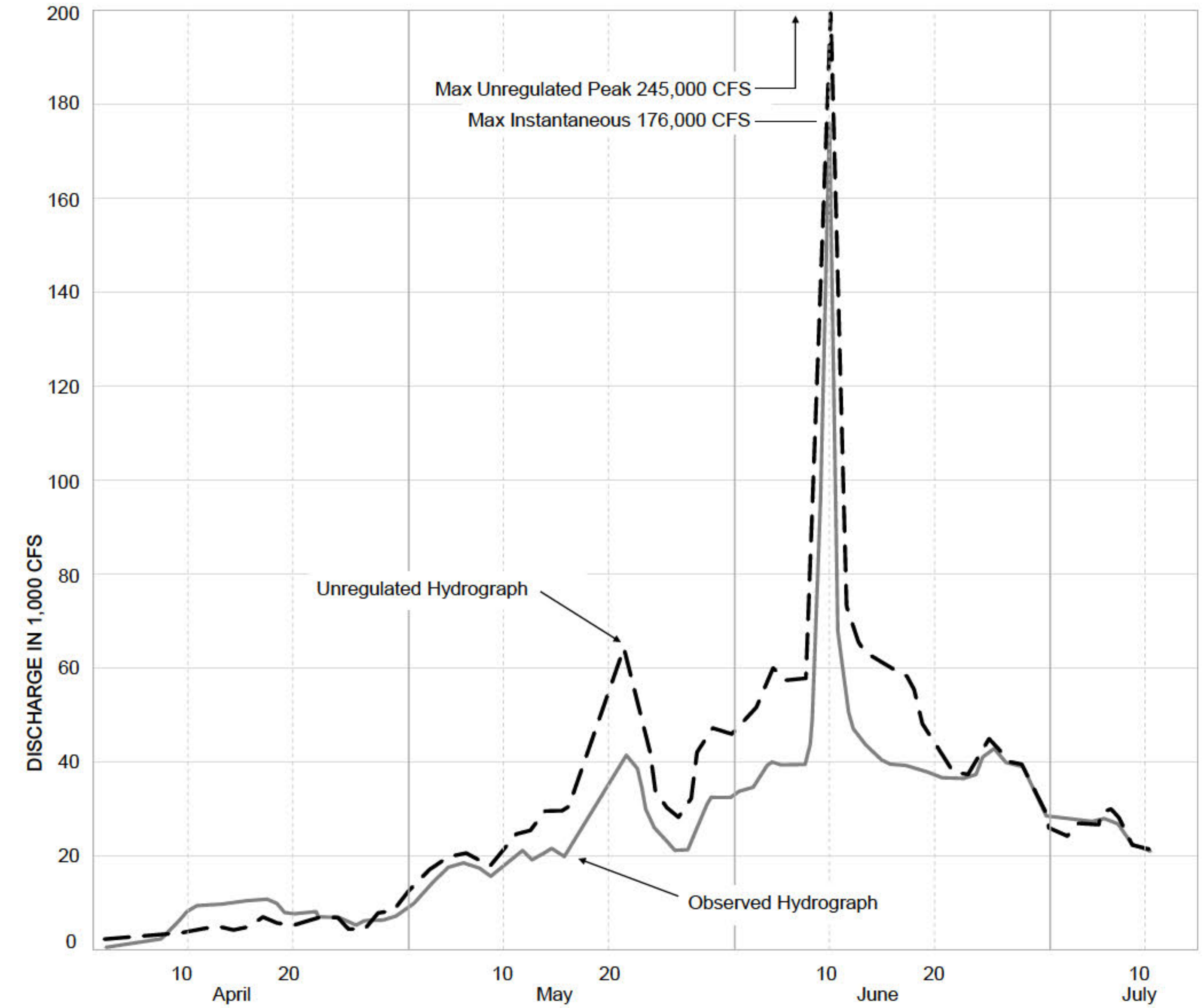


Snow Courses/Aerial Markers *
SNOTEL Sites *
Dams
Flathead River Basin
South Fork Flathead River Basin
* See table 4-4 for gage information
CANADA
UNITED STATES
North Fork Flathead River
Stillwater River
Hungry Horse
Hungry Horse Reservoir
M. F. Flathead River
S.F. Flathead River
Kalispell
Flathead Lake
Little Bitterroot River
Swan River
Flathead River
Jocko River
SKQ
Priest Lake
Sandpoint
Lake Pend Oreille
Albeni Falls
Cabinet Gorge
Noxon Rapids
Clark Fork
Thompson Falls
Coeur d'Alene
Idaho
Montana
0 5 10 20
Miles
NOTE: PLATE SIZE IS 11"x17"
N
U.S. Army Corps of Engineers
Seattle District
Seattle, Washington
Plate 4-3
Snow Gages
Completed by: WEST
February 2020

PLATE 4-3



SOUTH FORK FLATHEAD RIVER NEAR COLUMBIA FALLS, MONTANA



FLATHEAD RIVER AT COLUMBIA FALLS, MONTANA

Note:

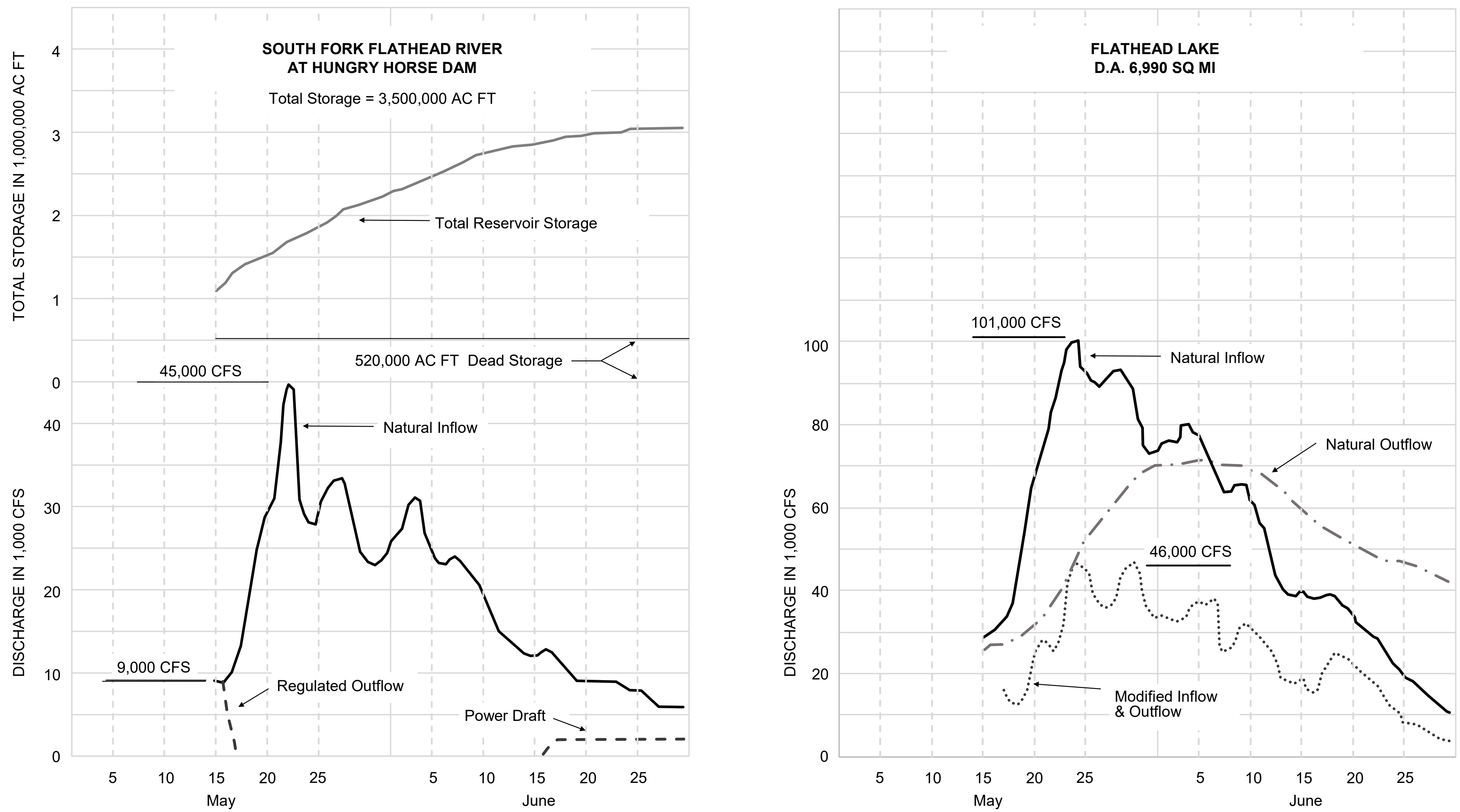
Flow regulated by Hungry Horse Reservoir, 2,982,000 acre-feet total active capacity.

U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

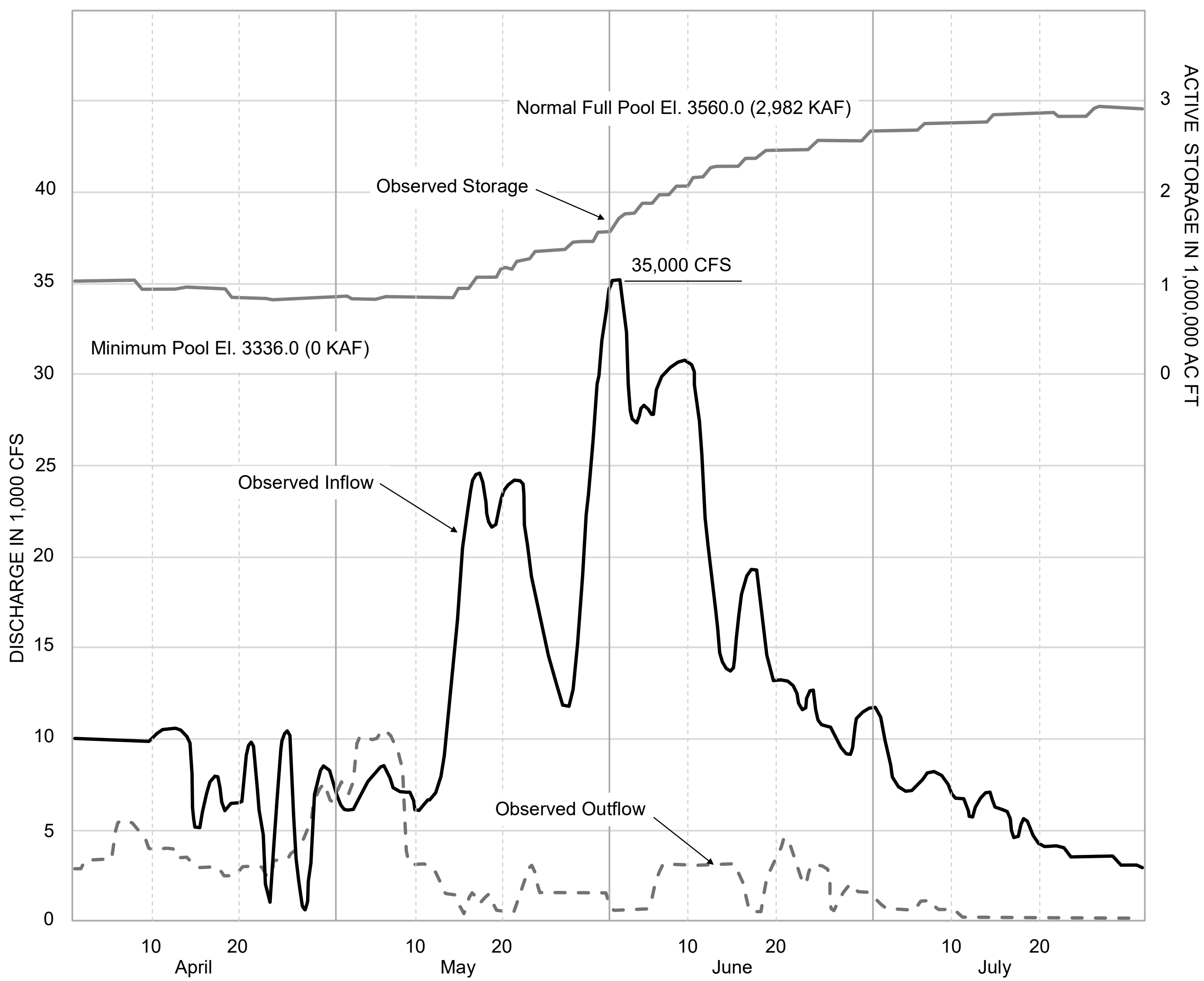
Plate 4-4

Columbia Basin
1964 Flood Regulation

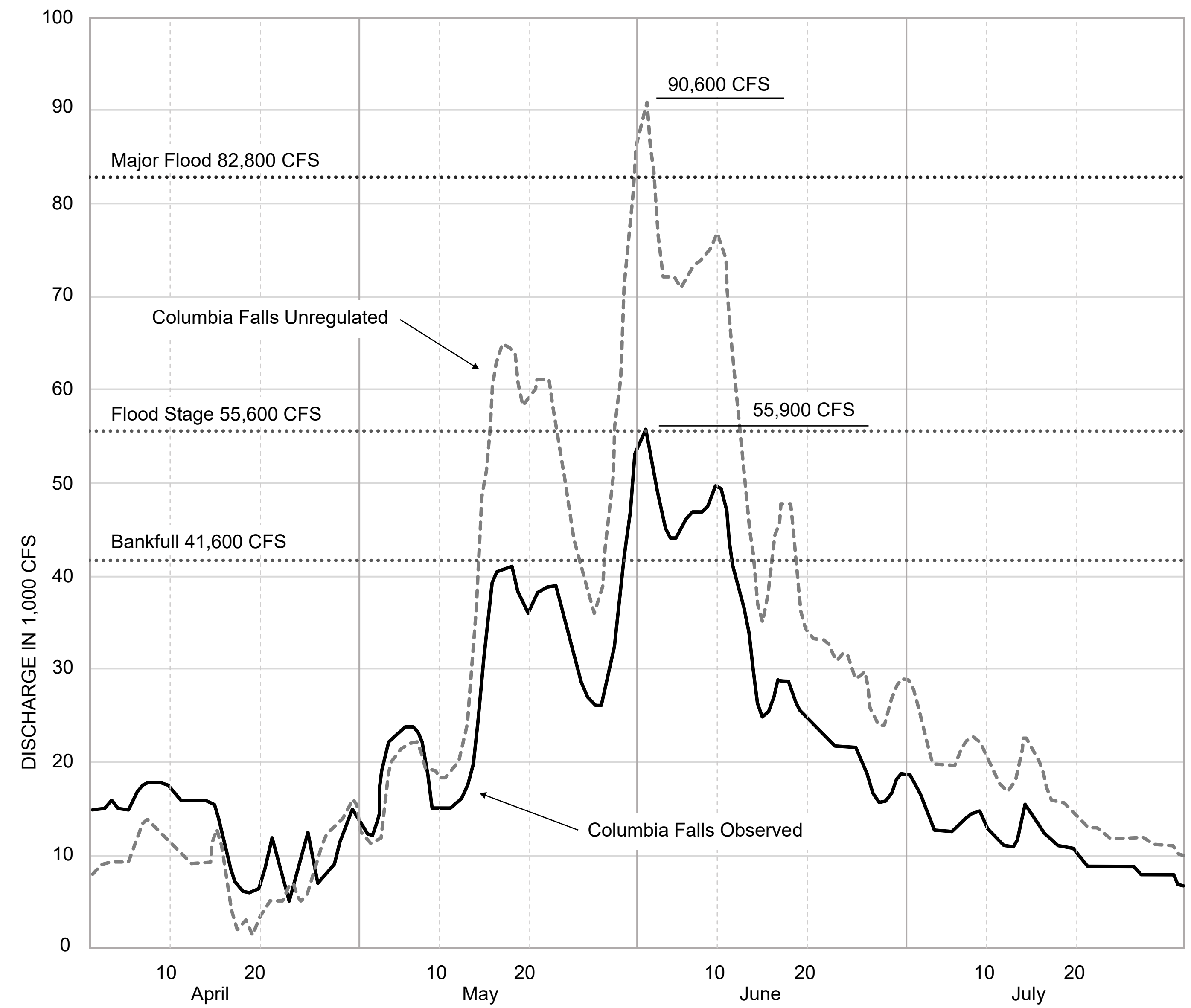
Completed by: WEST	March 2020



U.S. Army Corps of Engineers Seattle District Seattle, Washington	
Plate 4-5 Flood of May-June 1948	
Completed by: WEST	March 2020



SOUTH FORK FLATHEAD RIVER AT HUNGRY HORSE PROJECT, MONTANA



FLATHEAD RIVER AT COLUMBIA FALLS, MONTANA

Notes:

1. Hungry Horse Dam and Reservoir constructed and operated by U.S. Bureau of Reclamation. Reservoir filling began in 1951.
2. The reservoir contains 2,982,025 acre-feet of active storage between elevation 3336.0 and 3560.0 feet.
3. Drainage area 1,654 sq. mi.

Notes:

1. Columbia Falls regulation is provided by a maximum of 2,282,100 acre-feet active storage at Hungry Horse Reservoir.
2. Drainage area 4,473 sq. mi.

U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 4-6

Columbia Basin
1972 Flood Regulation

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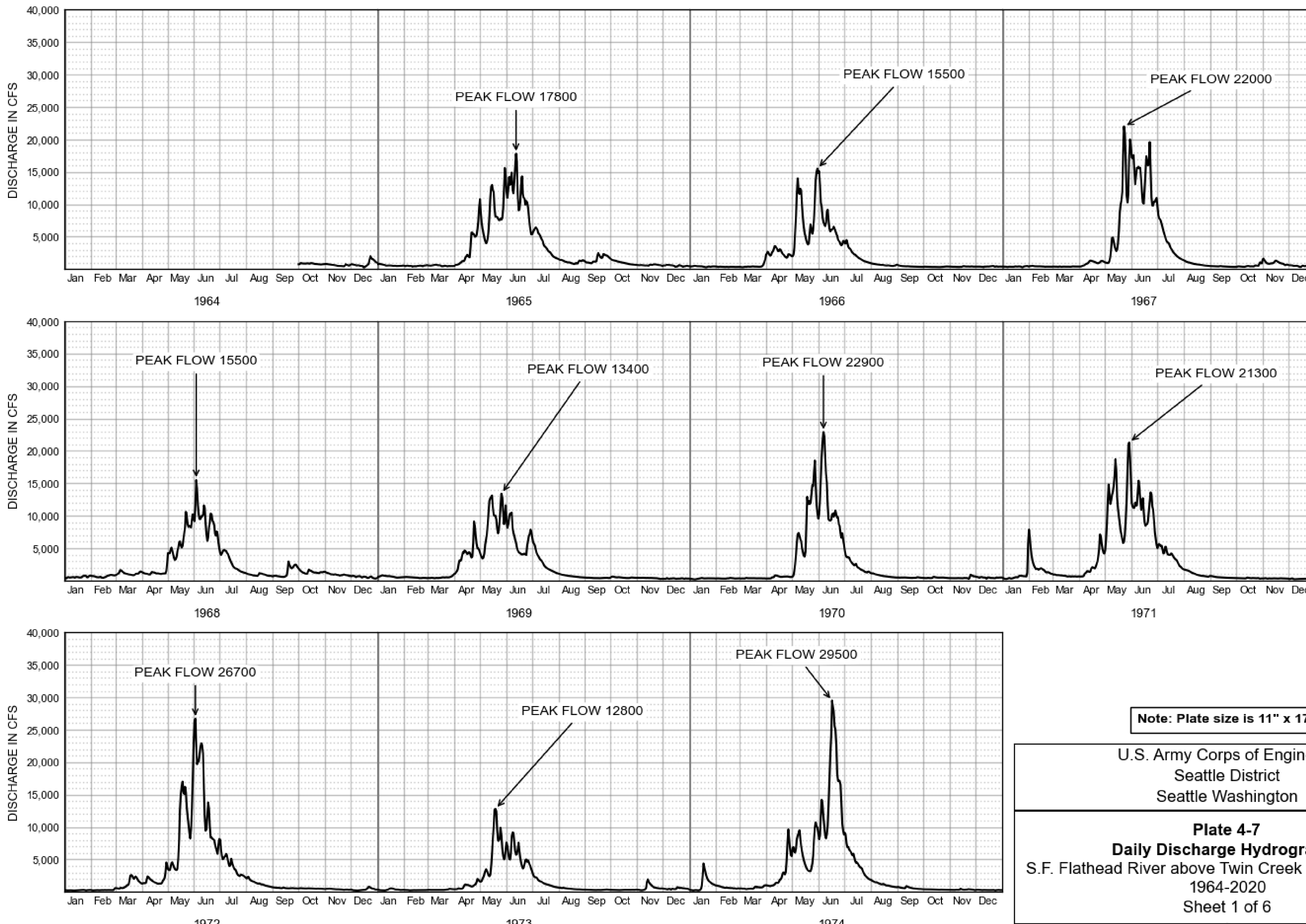
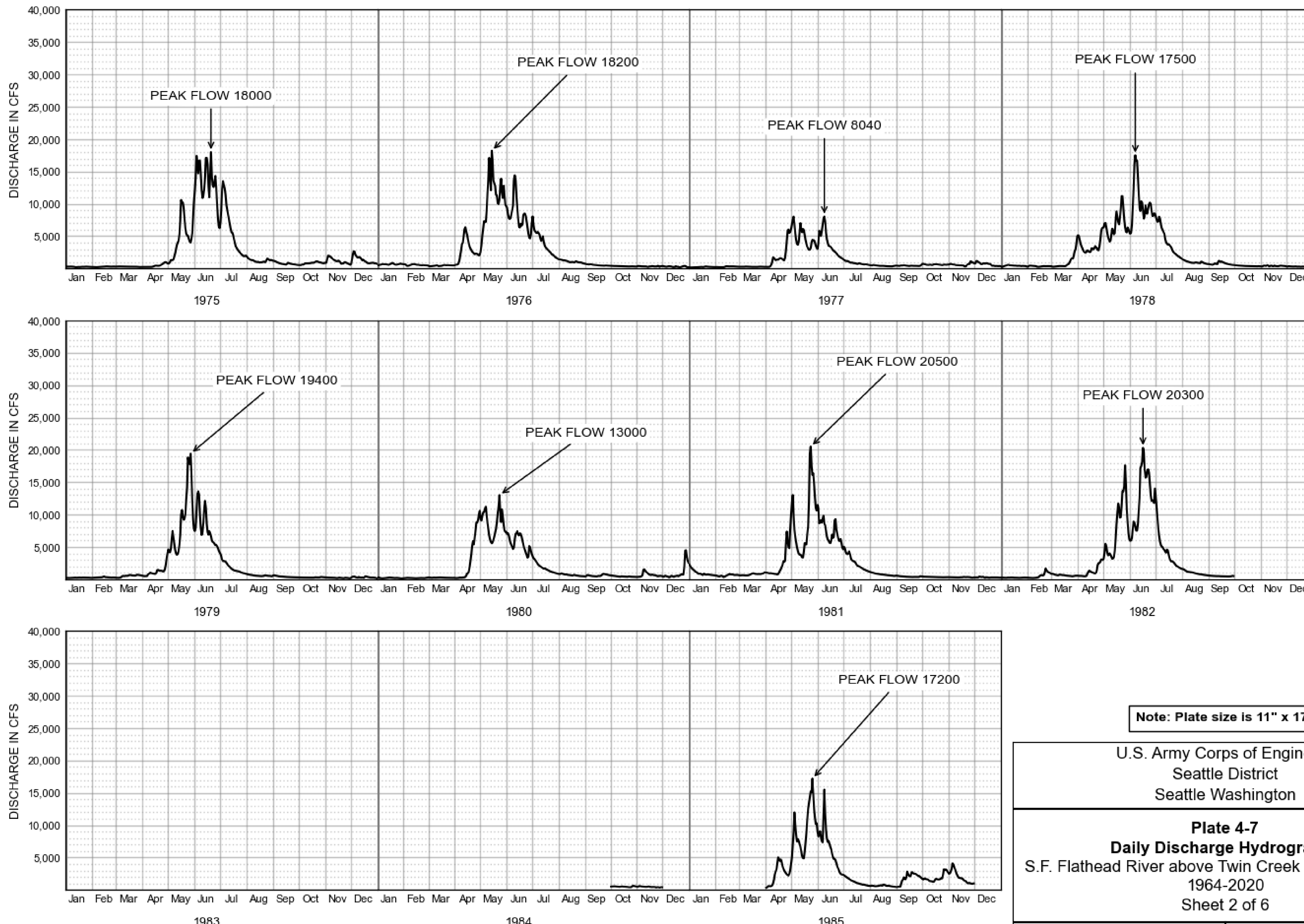


Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-7
Daily Discharge Hydrographs
S.F. Flathead River above Twin Creek nr Hungry Horse
1964-2020
Sheet 1 of 6

Completed by: WEST	March 2021

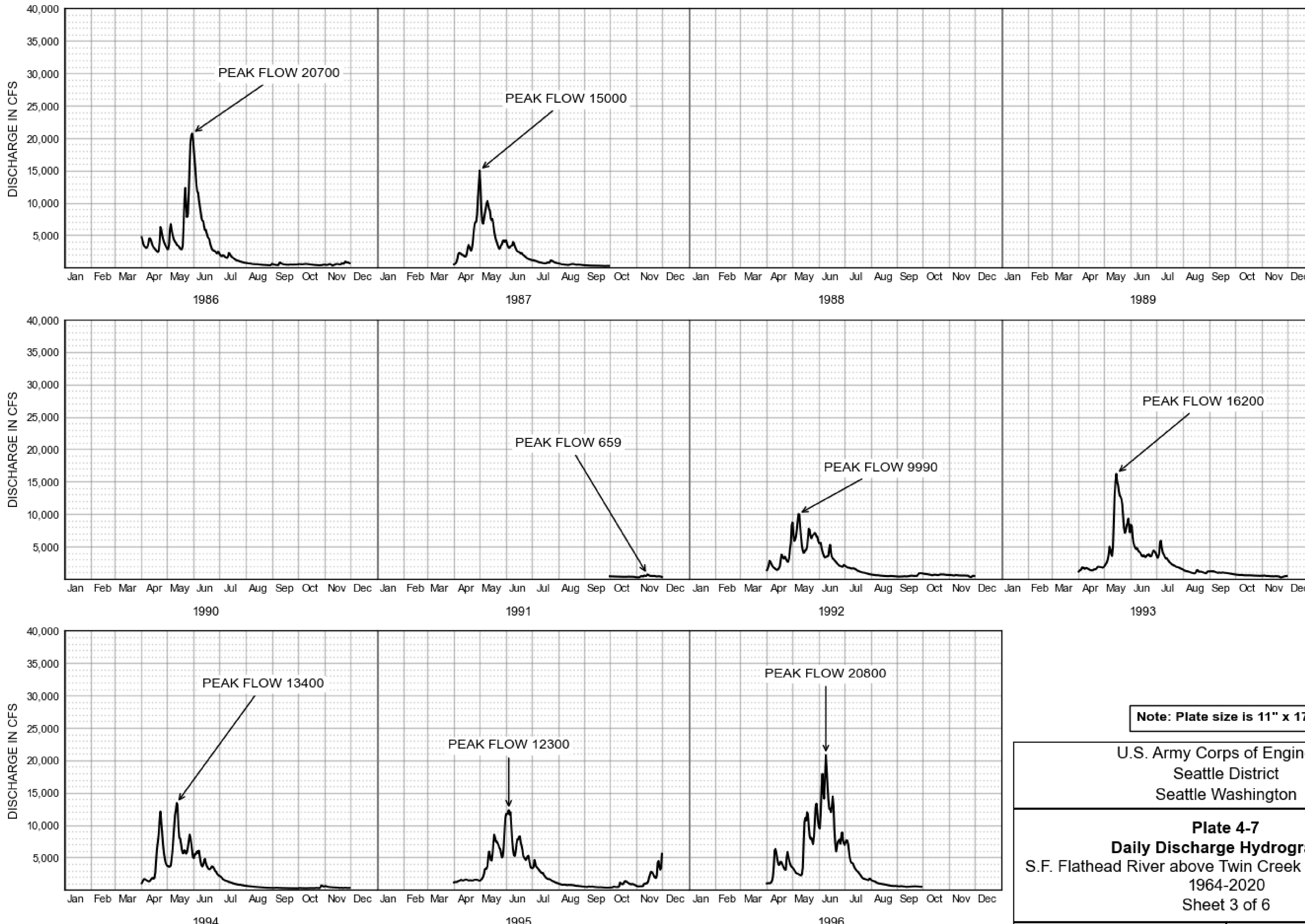


Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-7
Daily Discharge Hydrographs
S.F. Flathead River above Twin Creek nr Hungry Horse
1964-2020
Sheet 2 of 6

Completed by: WEST	March 2021

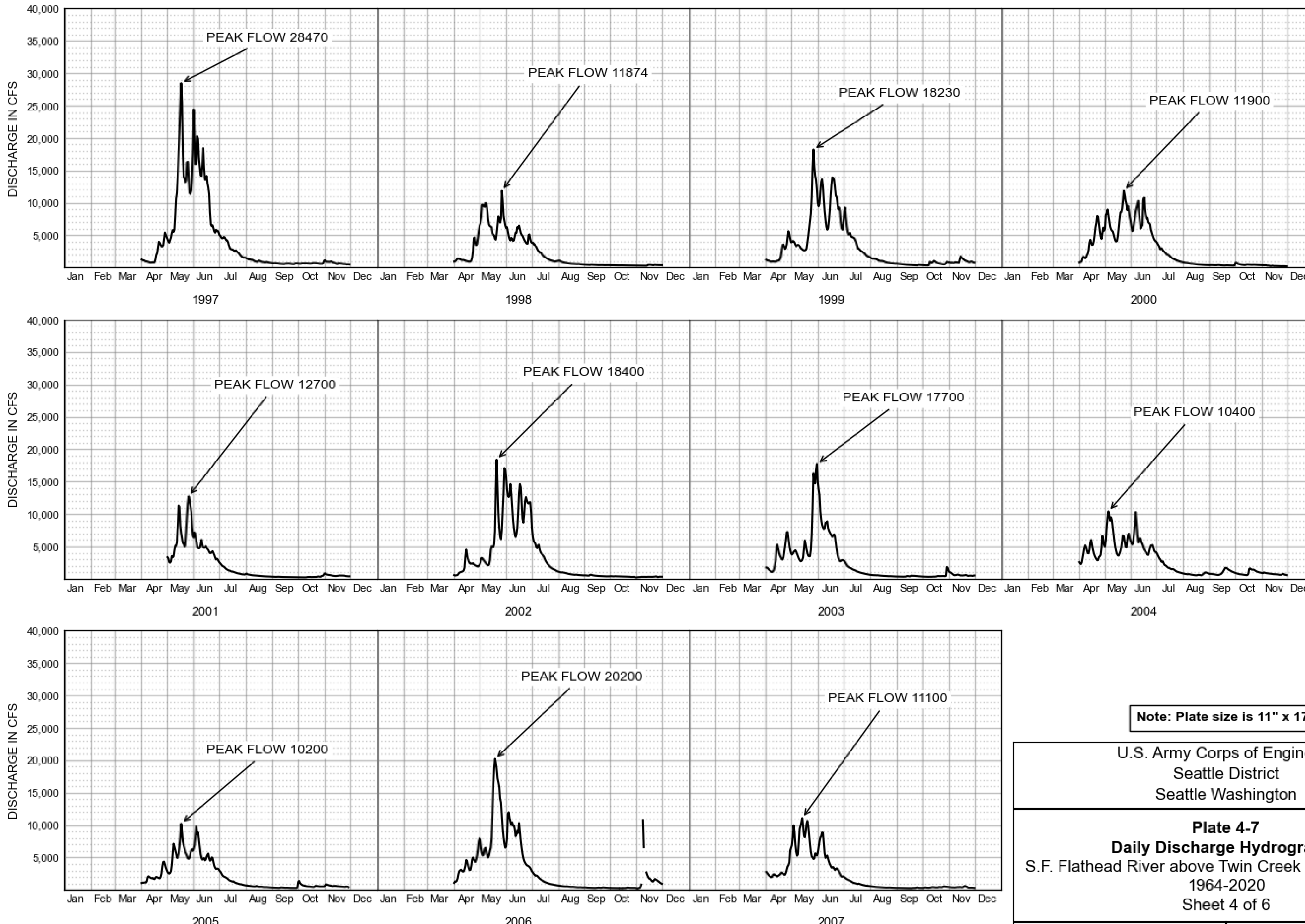


Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-7
Daily Discharge Hydrographs
S.F. Flathead River above Twin Creek nr Hungry Horse
1964-2020
Sheet 3 of 6

Completed by: WEST	March 2021



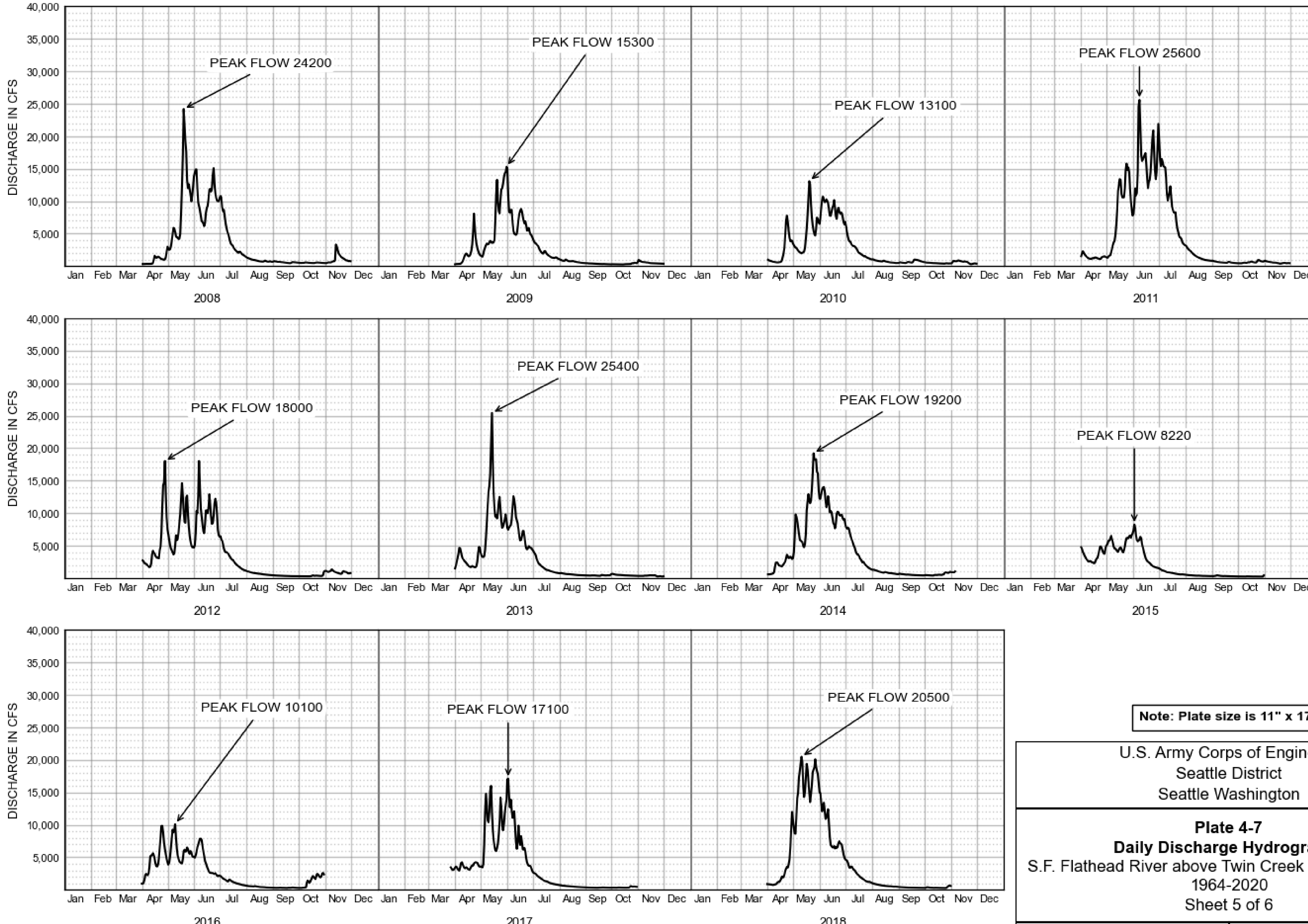
Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-7
Daily Discharge Hydrographs
S.F. Flathead River above Twin Creek nr Hungry Horse
1964-2020
Sheet 4 of 6

Completed by: WEST	March 2021

PLATE 4-7

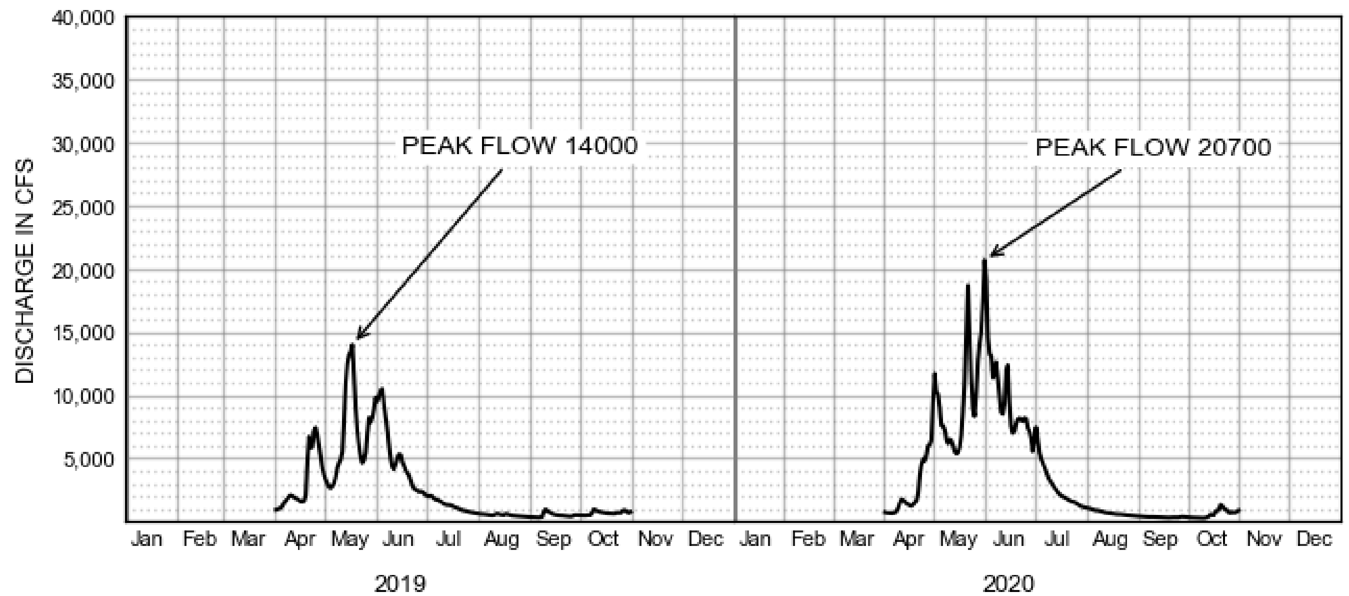


Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-7
Daily Discharge Hydrographs
S.F. Flathead River above Twin Creek nr Hungry Horse
1964-2020
Sheet 5 of 6

Completed by: WEST	March 2021

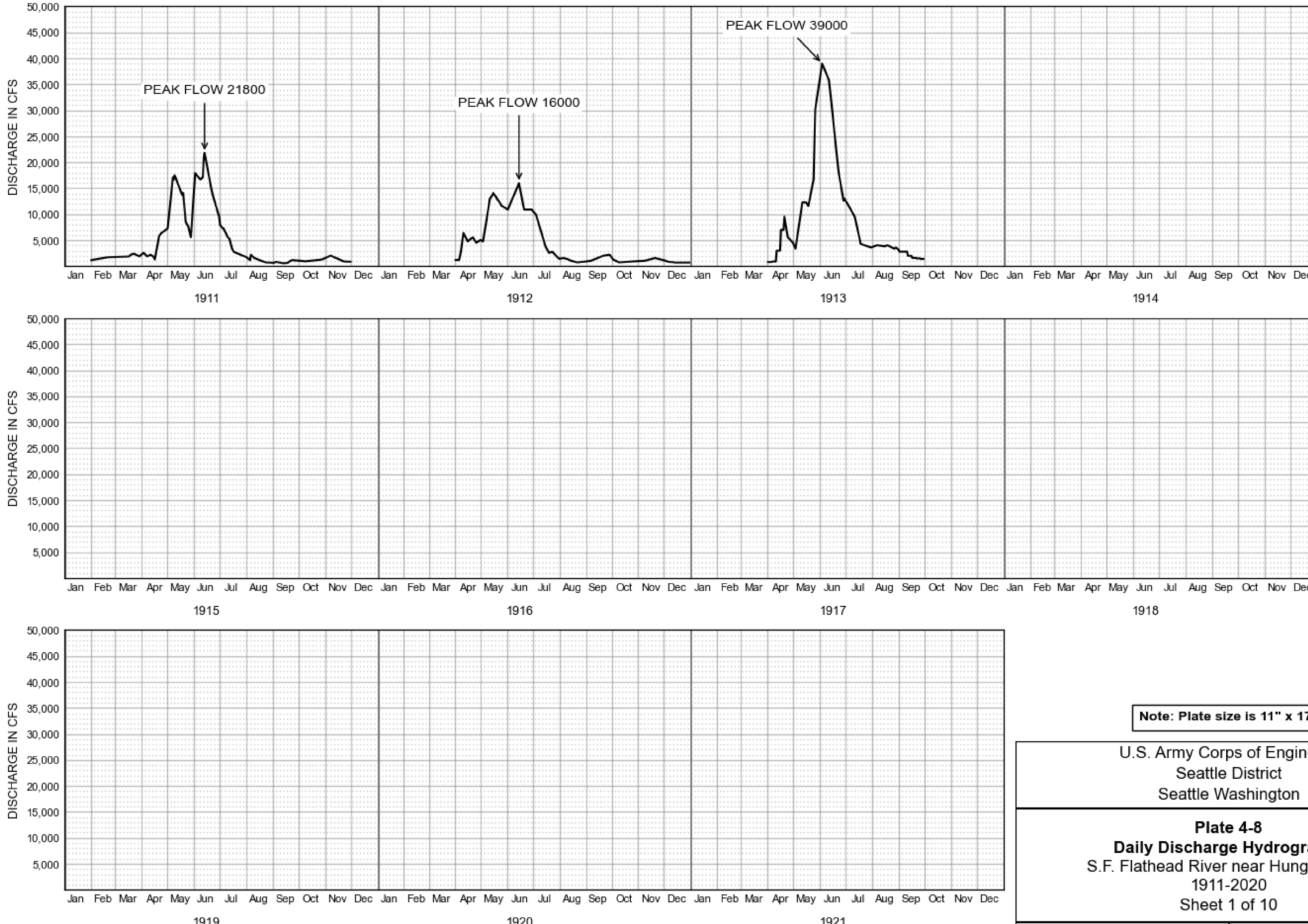


Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-7
Daily Discharge Hydrographs
S.F. Flathead River above Twin Creek nr Hungry Horse
1964-2020
Sheet 6 of 6

Completed by: WEST	March 2021

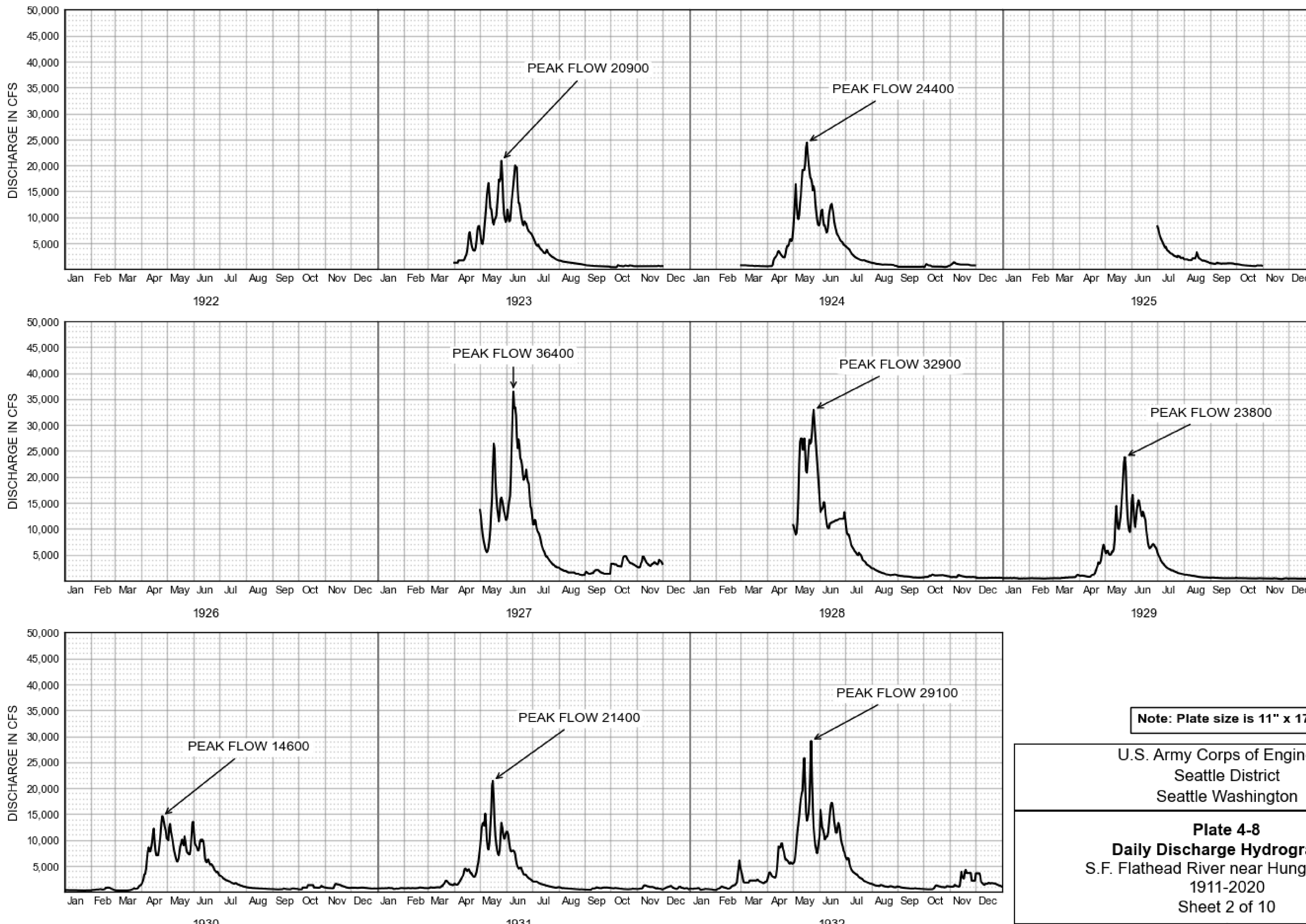


Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-8
Daily Discharge Hydrographs
S.F. Flathead River near Hungry Horse
1911-2020
Sheet 1 of 10

Completed by: WEST	March 2021

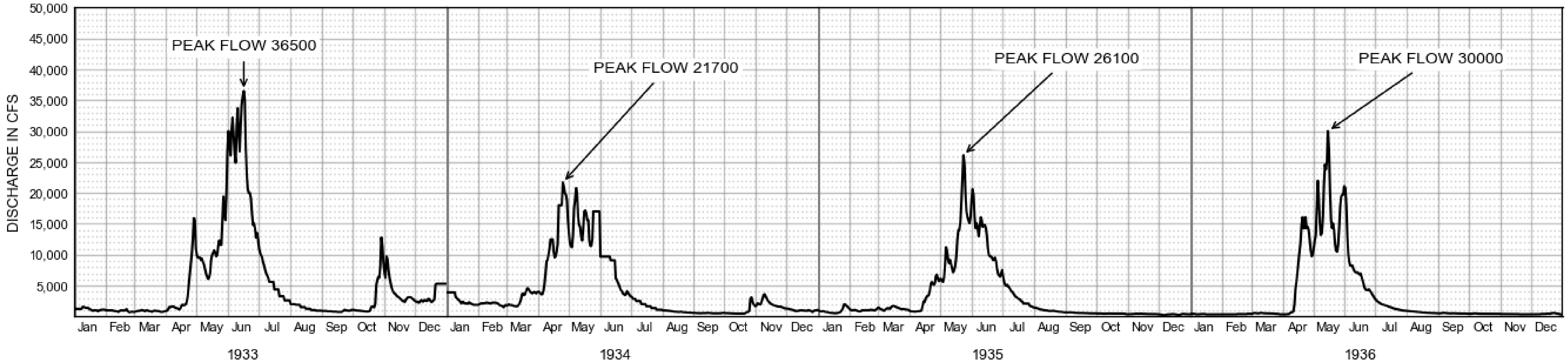


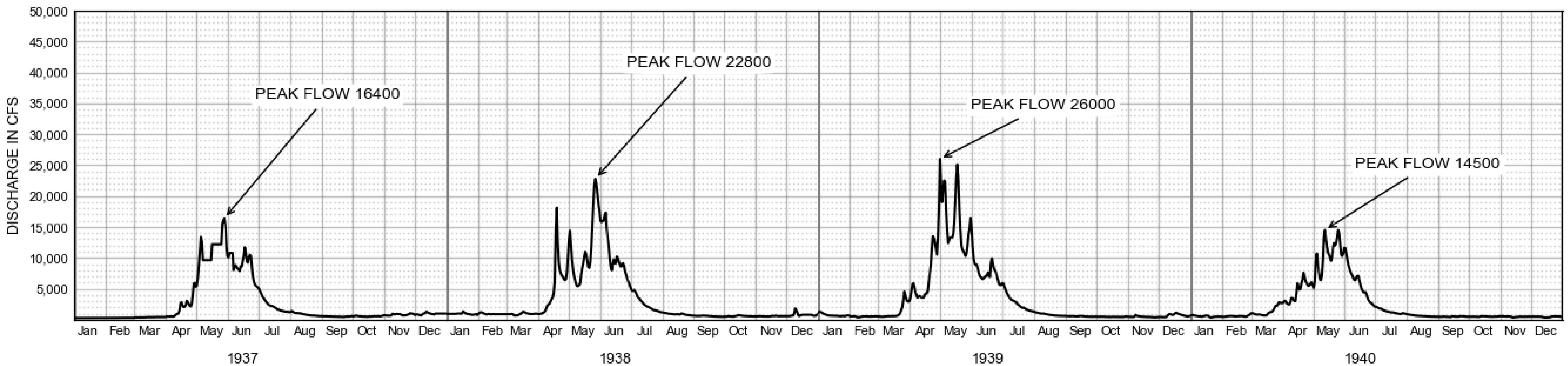
Note: Plate size is 11" x 17"

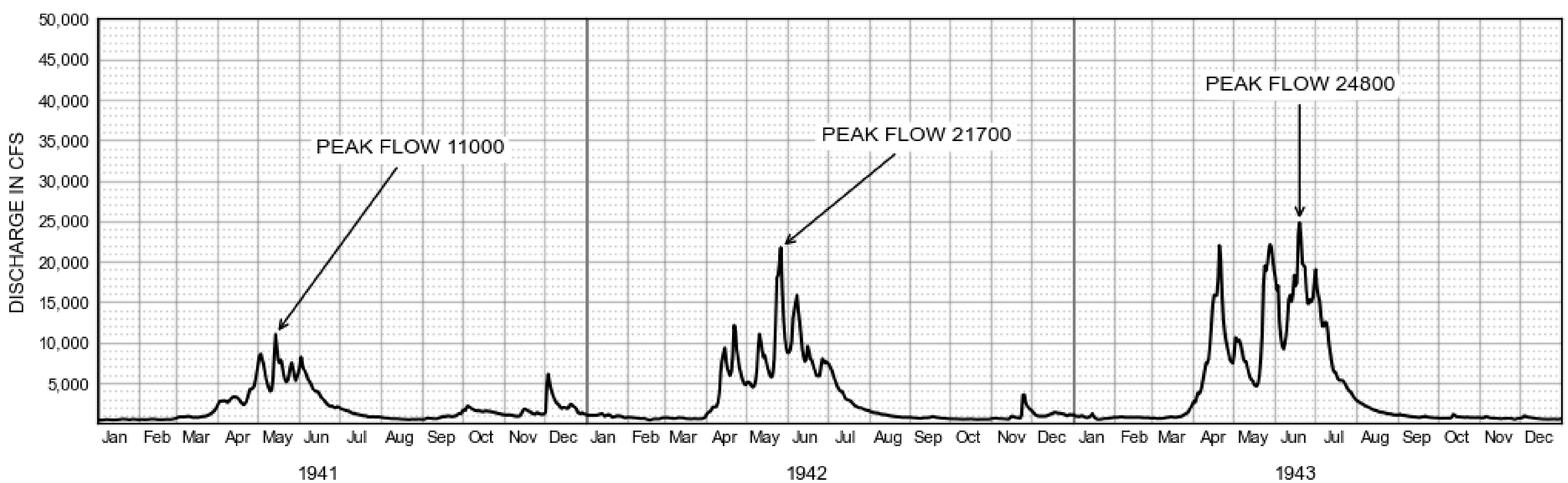
U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-8
Daily Discharge Hydrographs
S.F. Flathead River near Hungry Horse
1911-2020
Sheet 2 of 10

Completed by: WEST	March 2021







Note: Plate size is 11" x 17"

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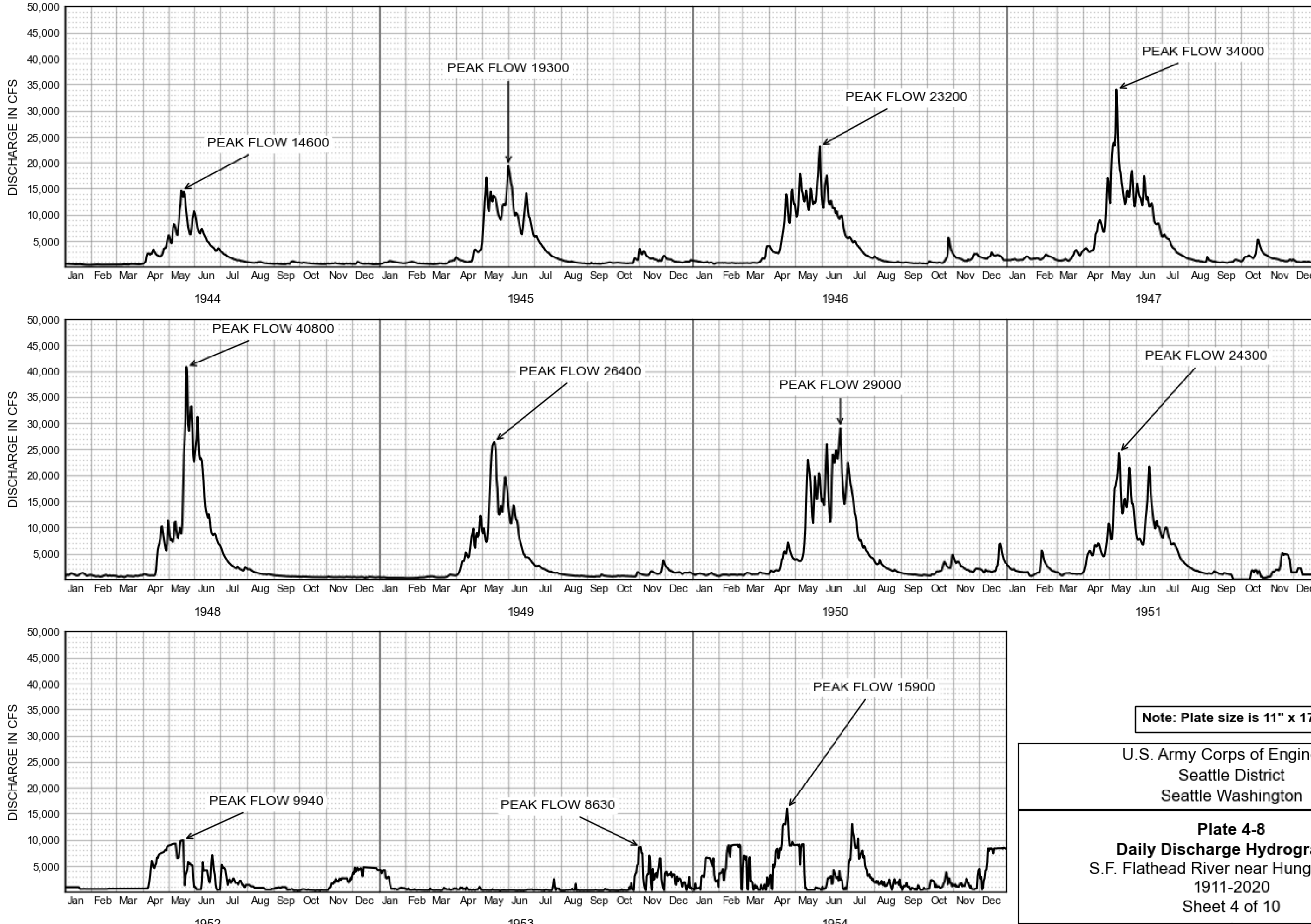
Seattle District
Seattle Washington

Plate 4-8
Daily Discharge Hydrographs
S.F. Flathead River near Hungry Horse
1911-2020
Sheet 3 of 10

Completed by: WEST	March 2021

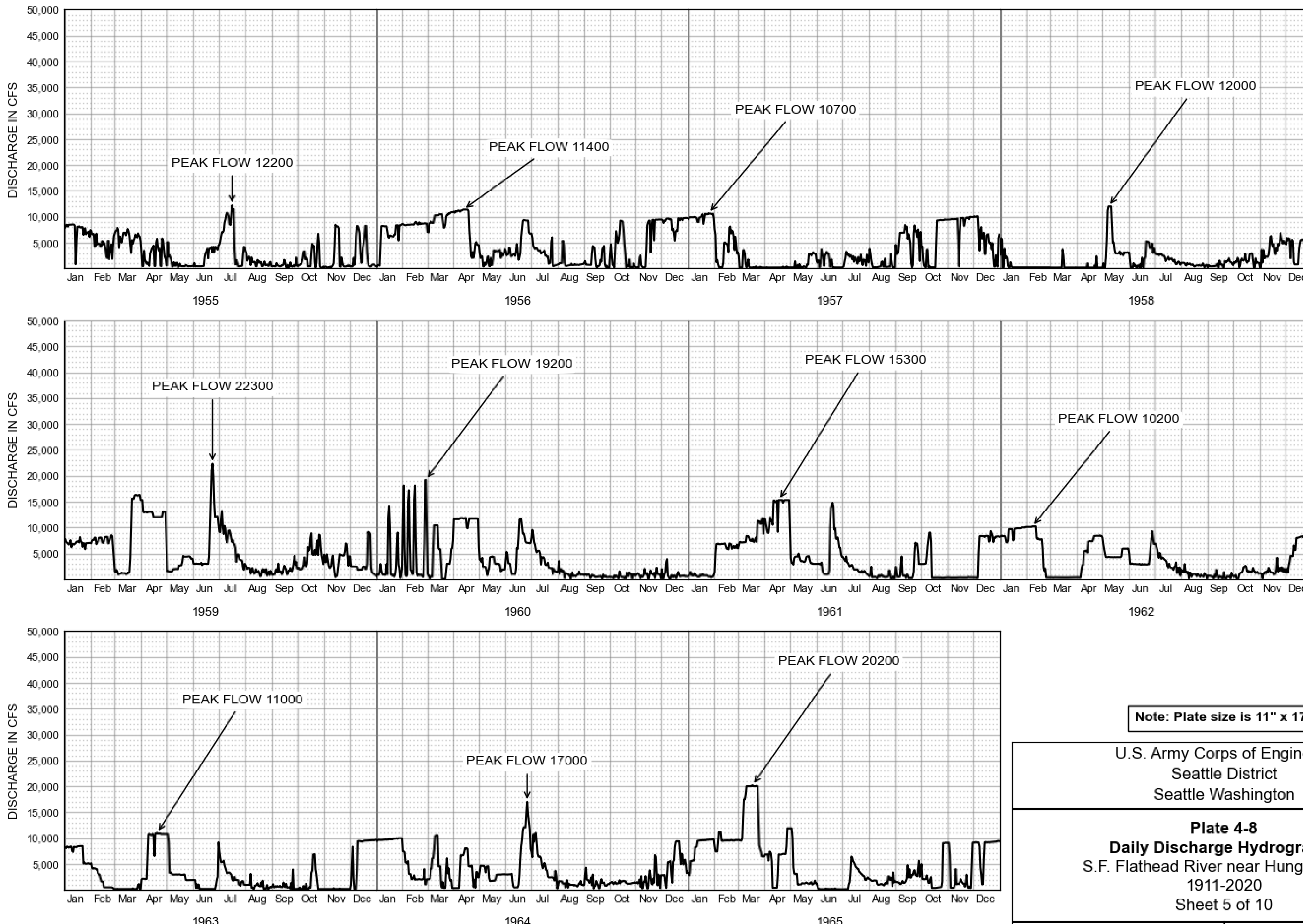


Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-8
Daily Discharge Hydrographs
S.F. Flathead River near Hungry Horse
1911-2020
Sheet 4 of 10

Completed by: WEST	March 2021

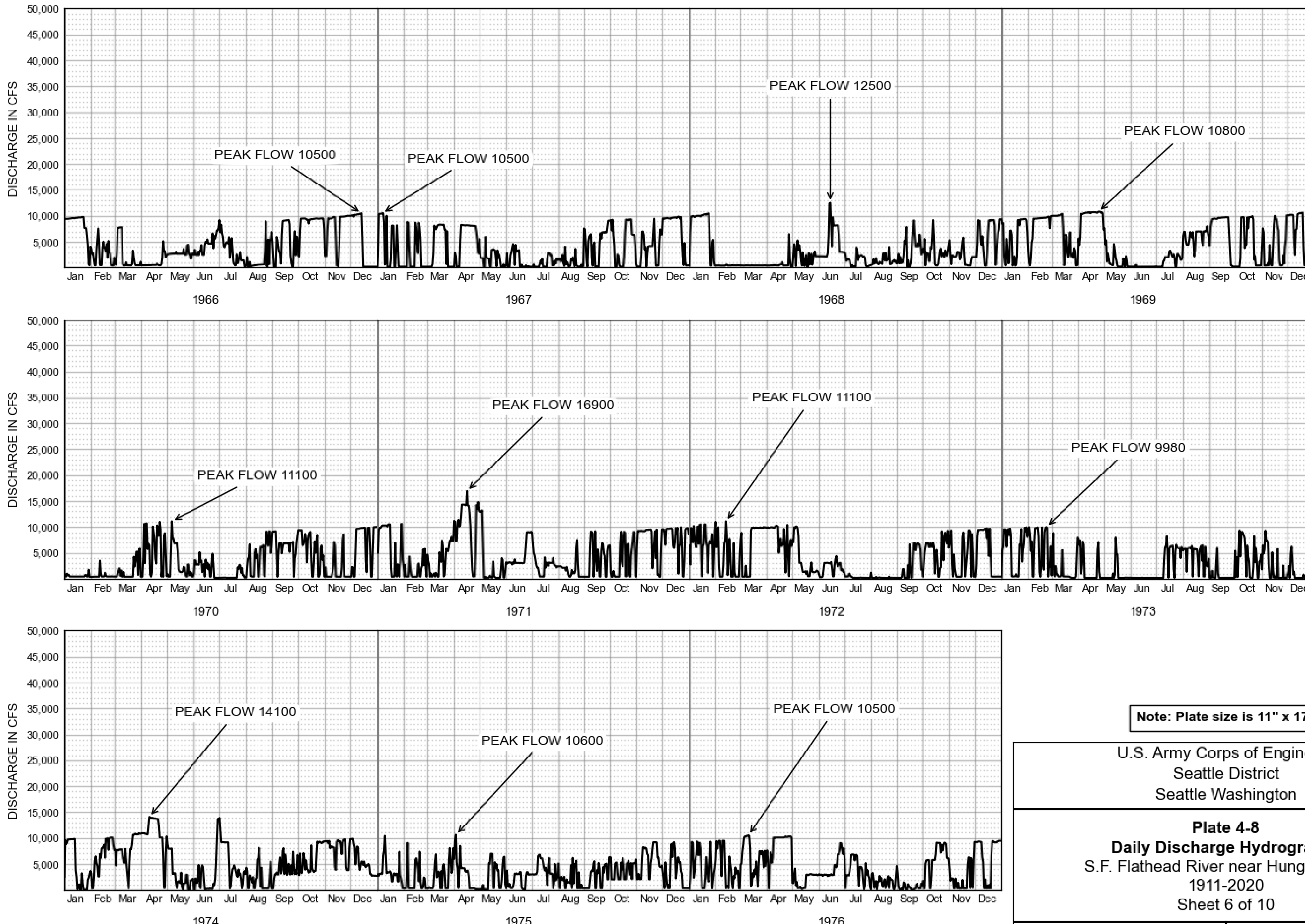


Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-8
Daily Discharge Hydrographs
S.F. Flathead River near Hungry Horse
1911-2020
Sheet 5 of 10

Completed by: WEST	March 2021

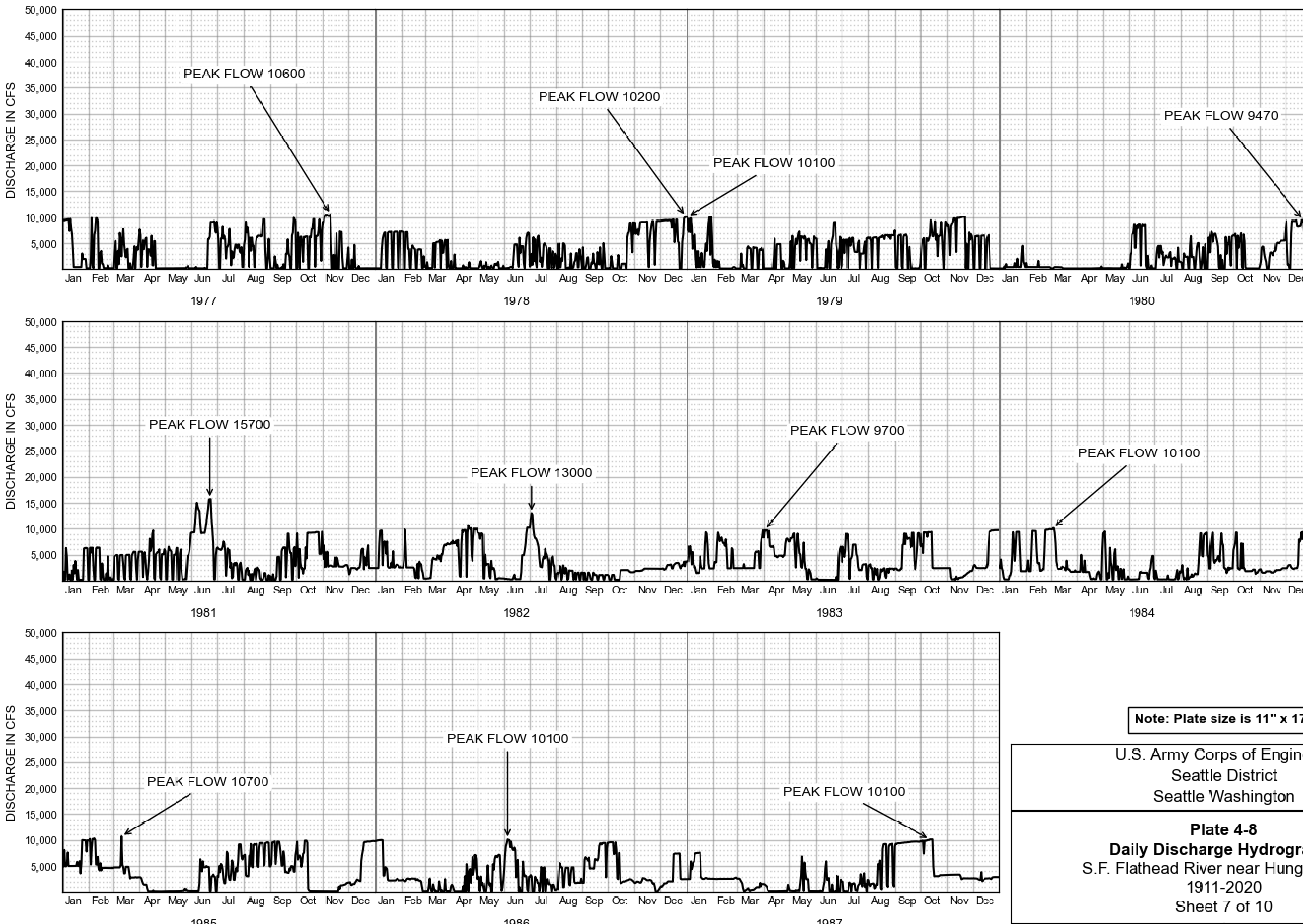


Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-8
Daily Discharge Hydrographs
S.F. Flathead River near Hungry Horse
1911-2020
Sheet 6 of 10

Completed by: WEST	March 2021

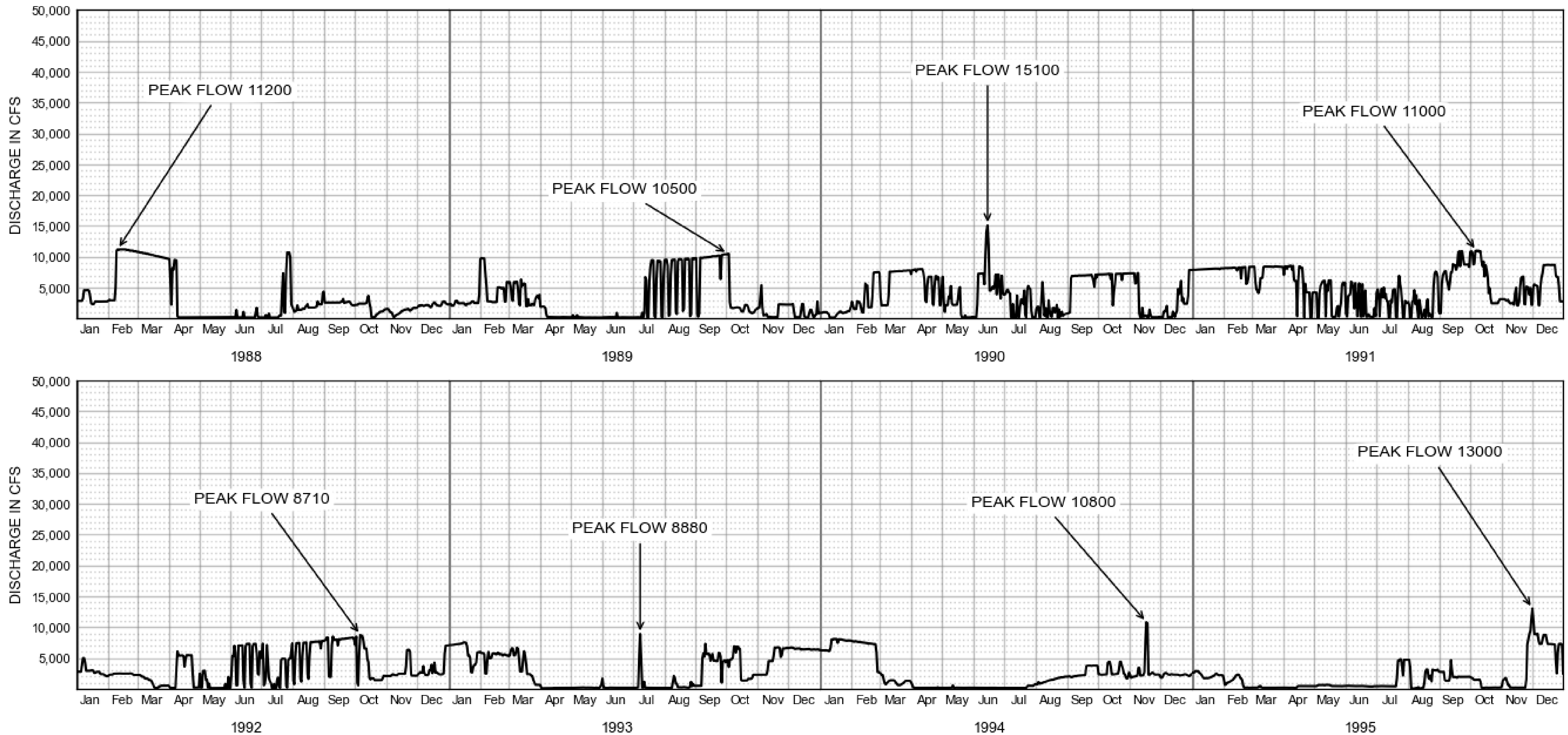


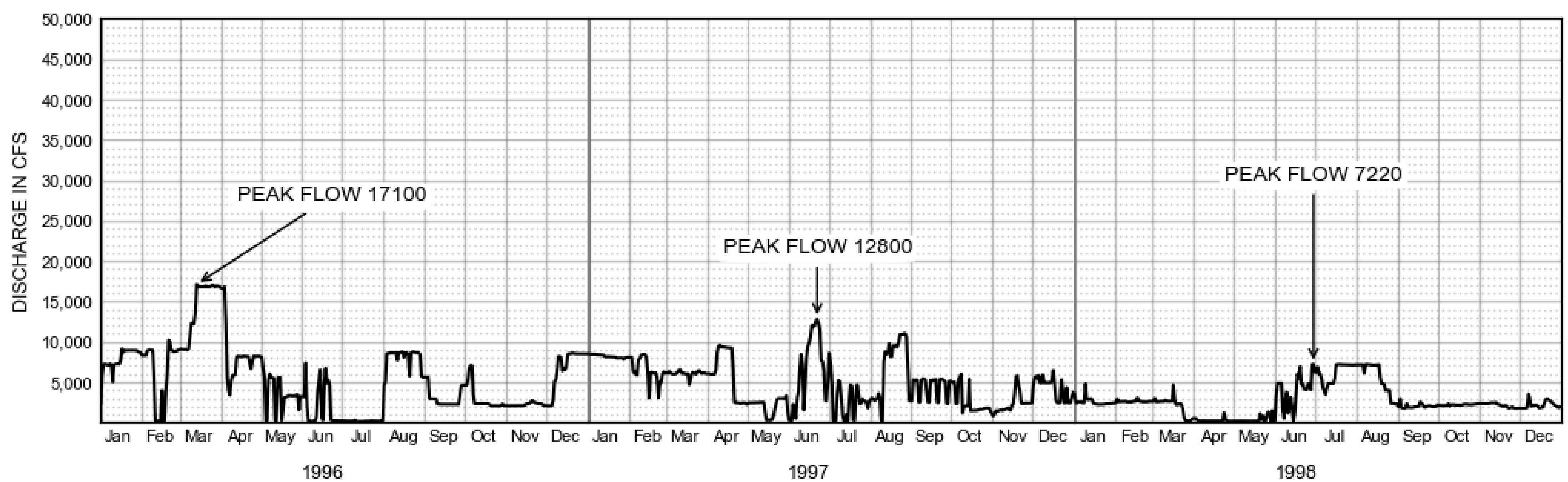
Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-8
Daily Discharge Hydrographs
S.F. Flathead River near Hungry Horse
1911-2020
Sheet 7 of 10

Completed by: WEST	March 2021



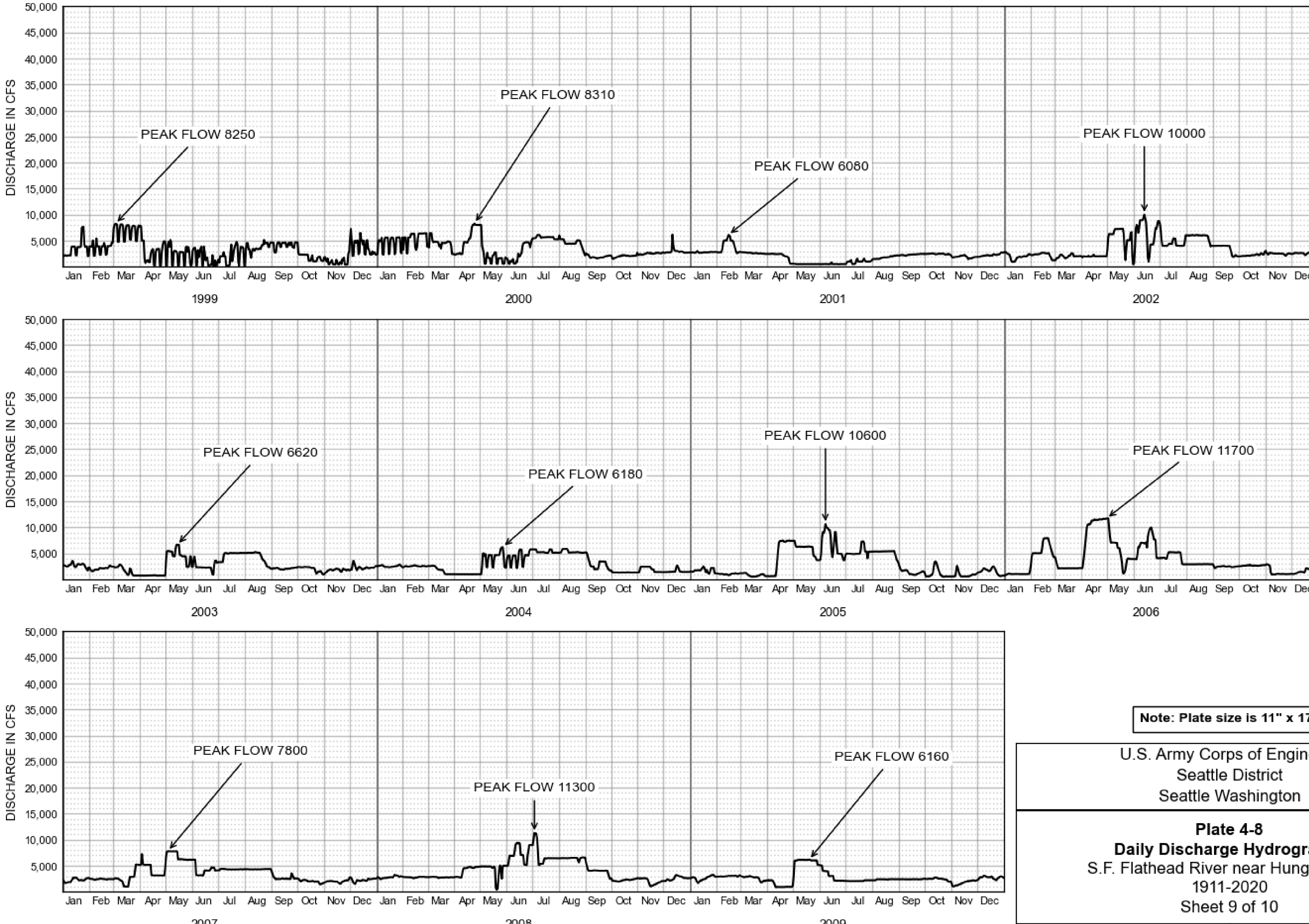


Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-8
Daily Discharge Hydrographs
S.F. Flathead River near Hungry Horse
1911-2020
Sheet 8 of 10

Completed by: WEST	March 2021



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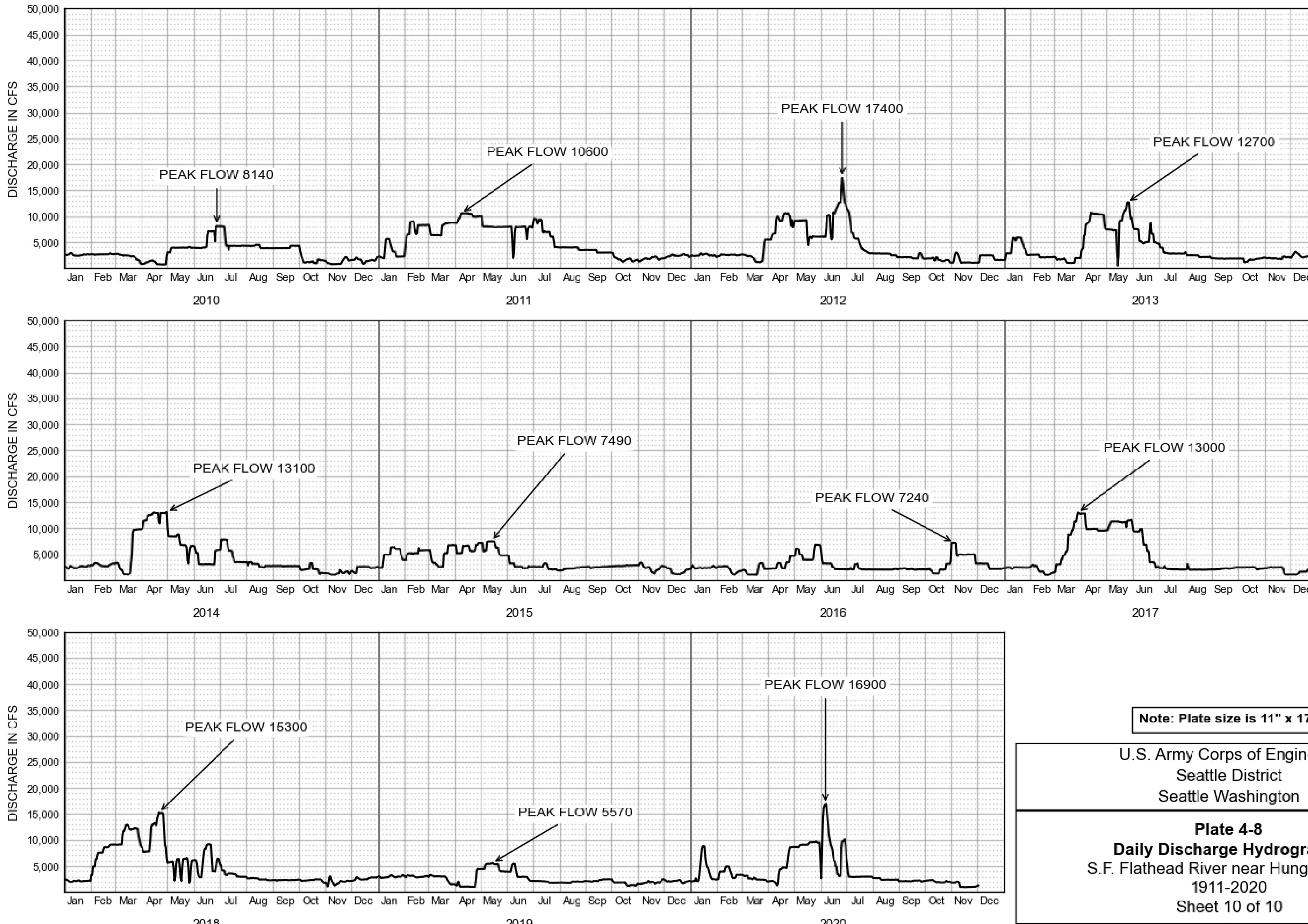
U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-8
Daily Discharge Hydrographs
S.F. Flathead River near Hungry Horse
1911-2020
Sheet 9 of 10

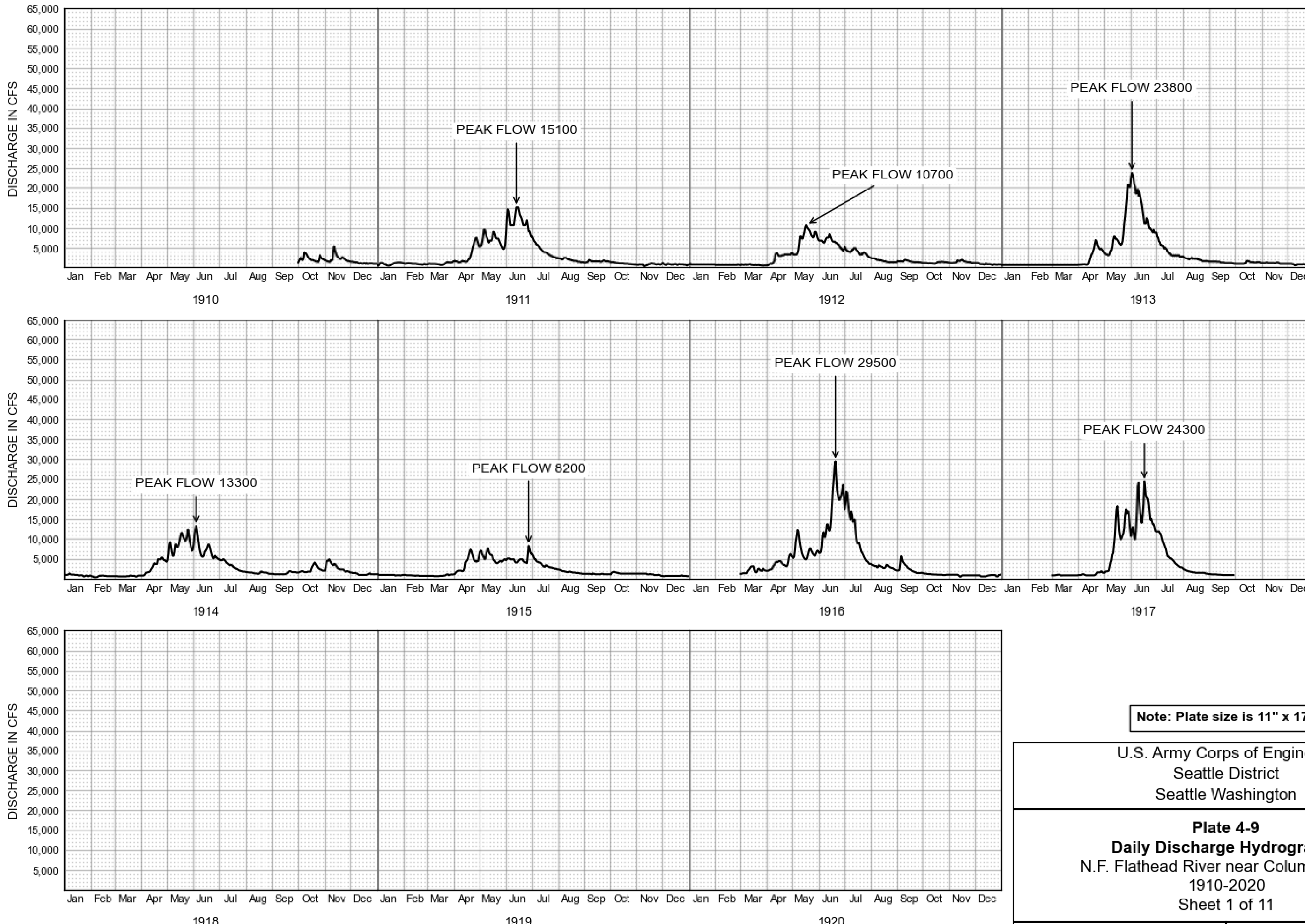
Completed by: WEST	March 2021



Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers Seattle District Seattle Washington	
Plate 4-8 **Daily Discharge Hydrographs** S.F. Flathead River near Hungry Horse 1911-2020 Sheet 10 of 10	
Completed by: WEST	March 2021

PLATE 4-8



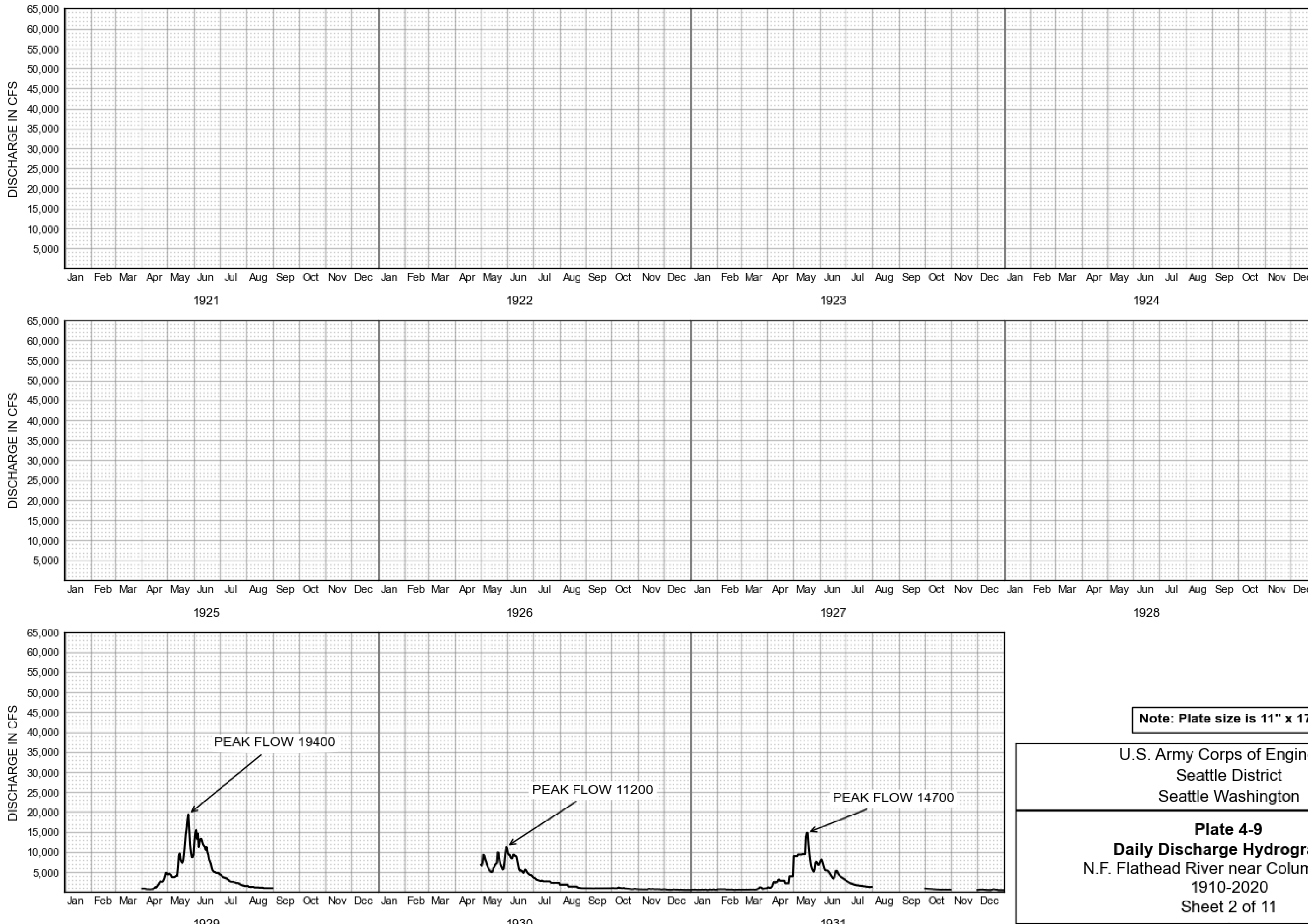
Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-9
Daily Discharge Hydrographs
N.F. Flathead River near Columbia Falls
1910-2020
Sheet 1 of 11

Completed by: WEST	March 2021

PLATE 4-9

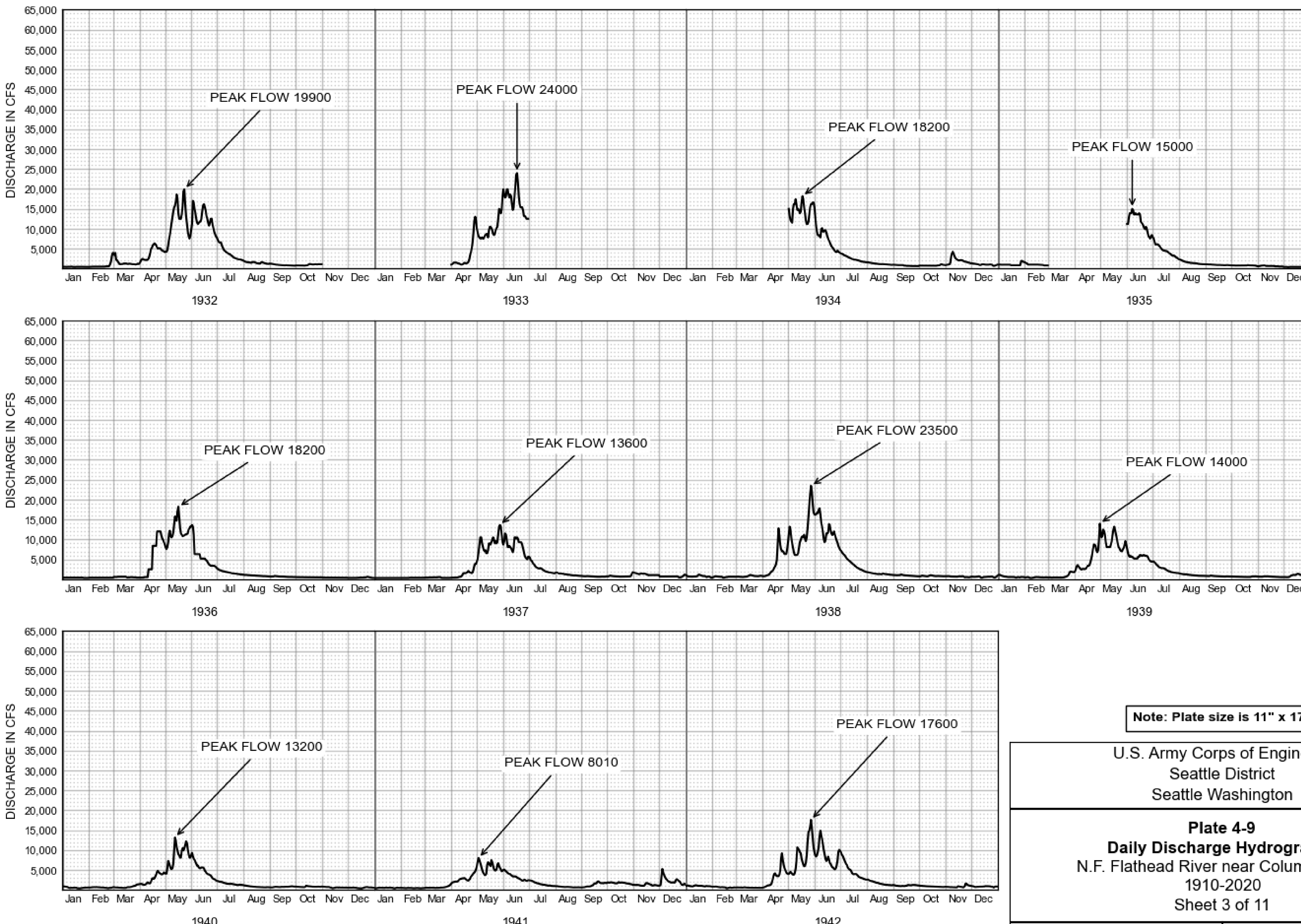


Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-9
Daily Discharge Hydrographs
N.F. Flathead River near Columbia Falls
1910-2020
Sheet 2 of 11

Completed by: WEST	March 2021



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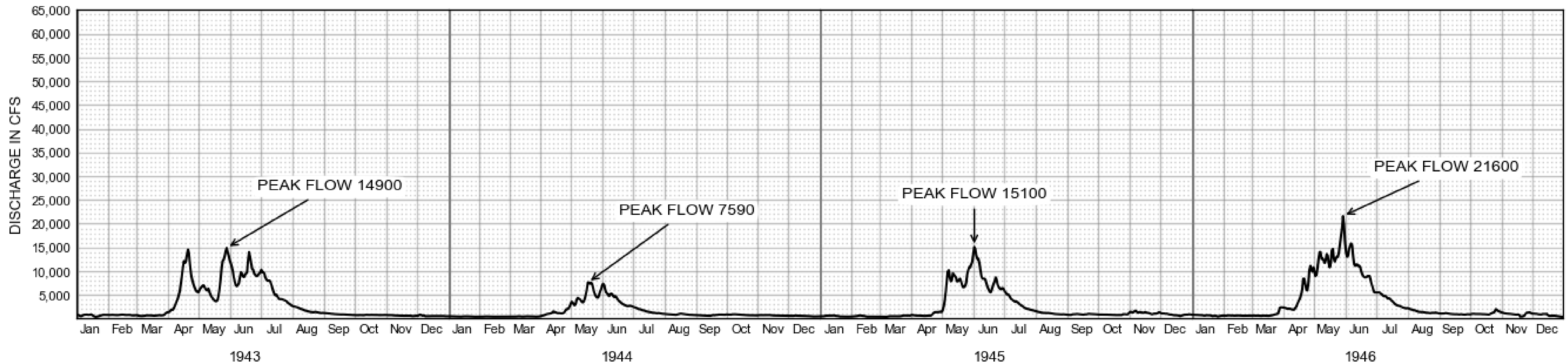
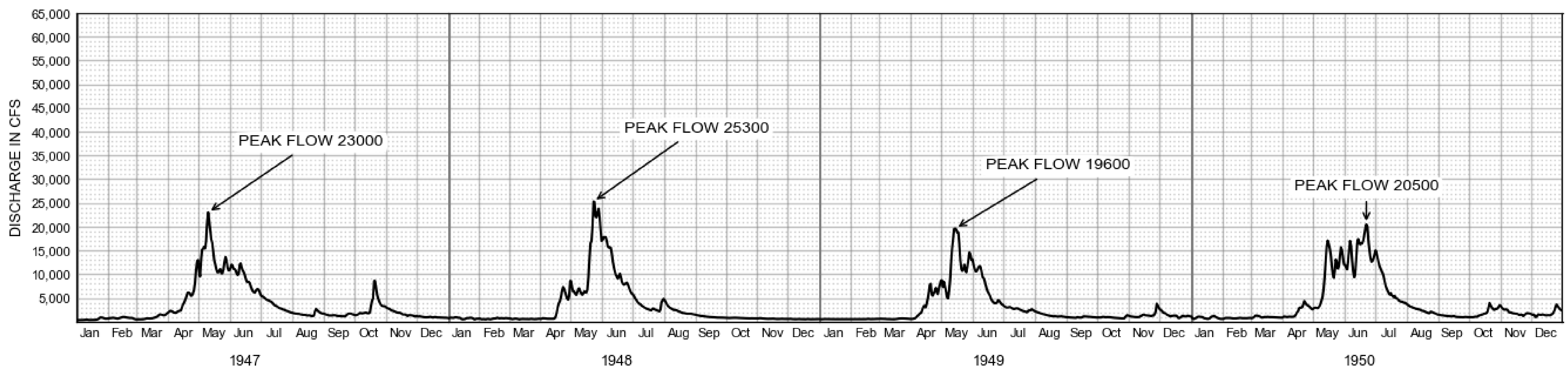
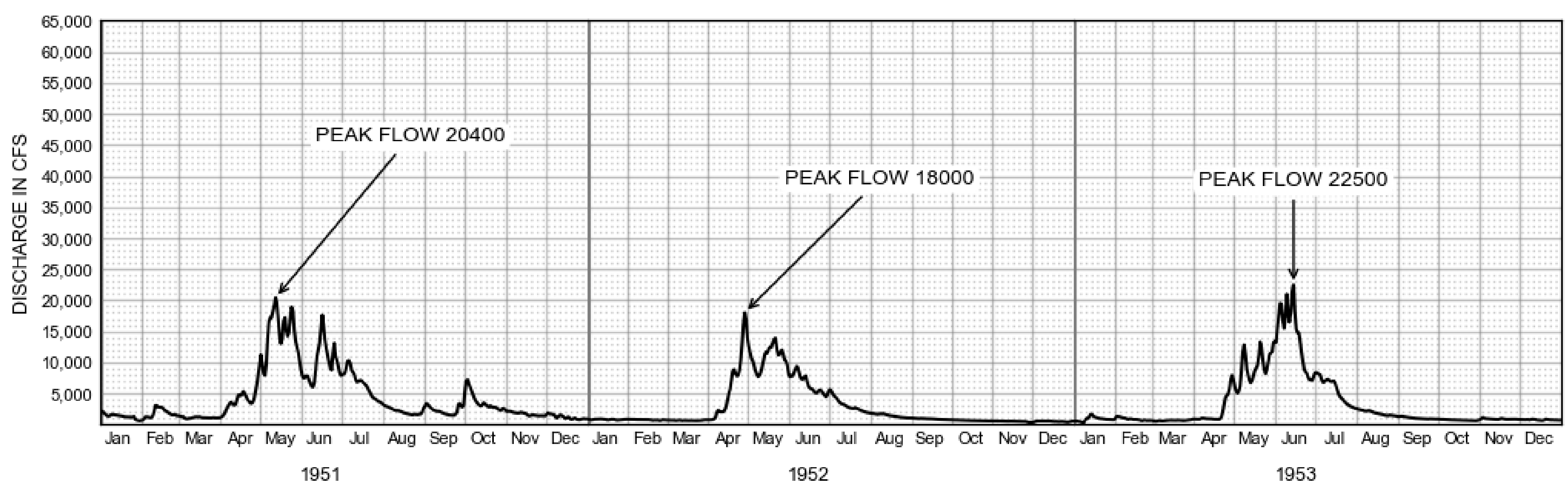
U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-9
Daily Discharge Hydrographs
N.F. Flathead River near Columbia Falls
1910-2020
Sheet 3 of 11

Completed by: WEST	March 2021







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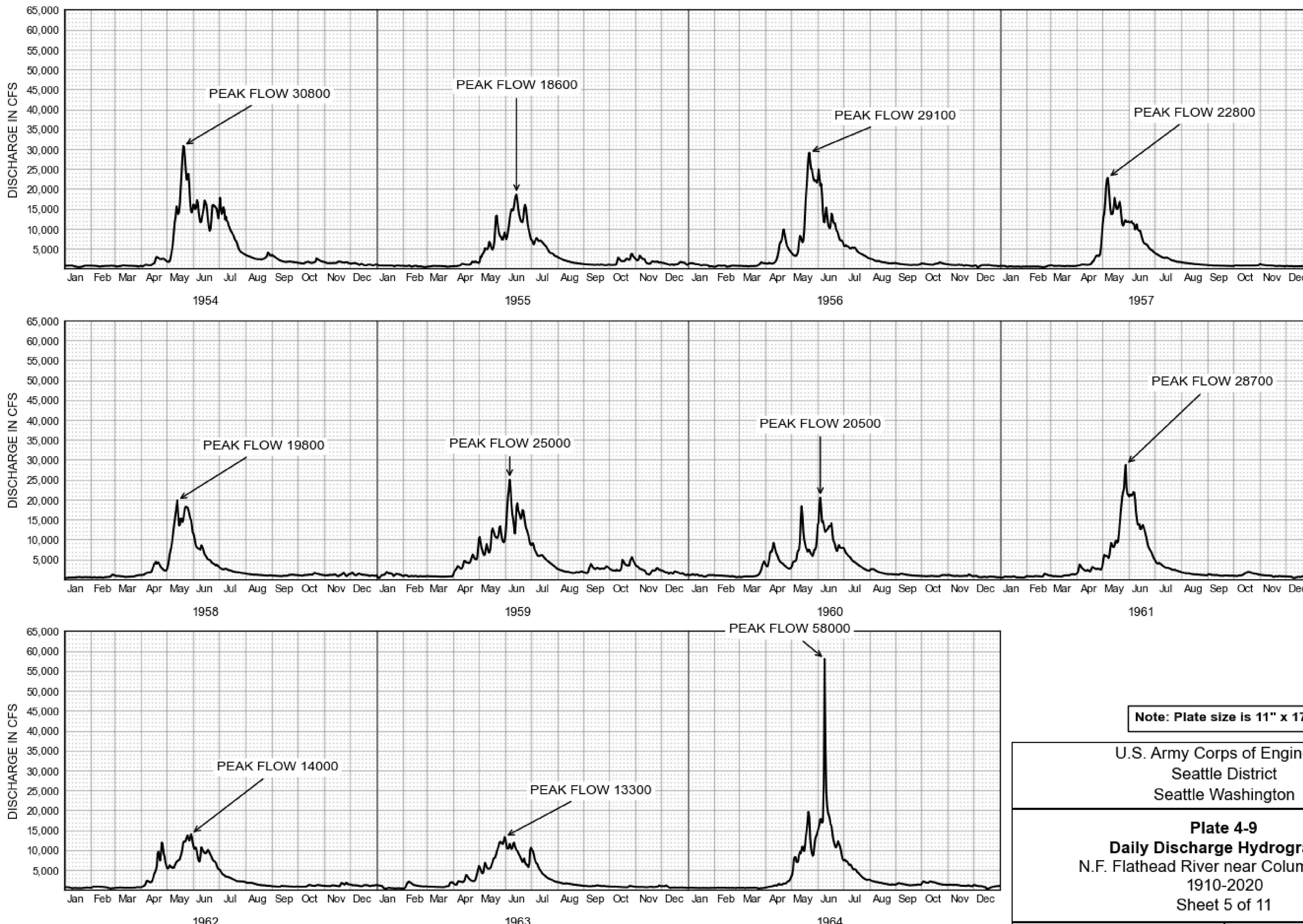
U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-9
Daily Discharge Hydrographs
N.F. Flathead River near Columbia Falls
1910-2020
Sheet 4 of 11

Completed by: WEST	March 2021



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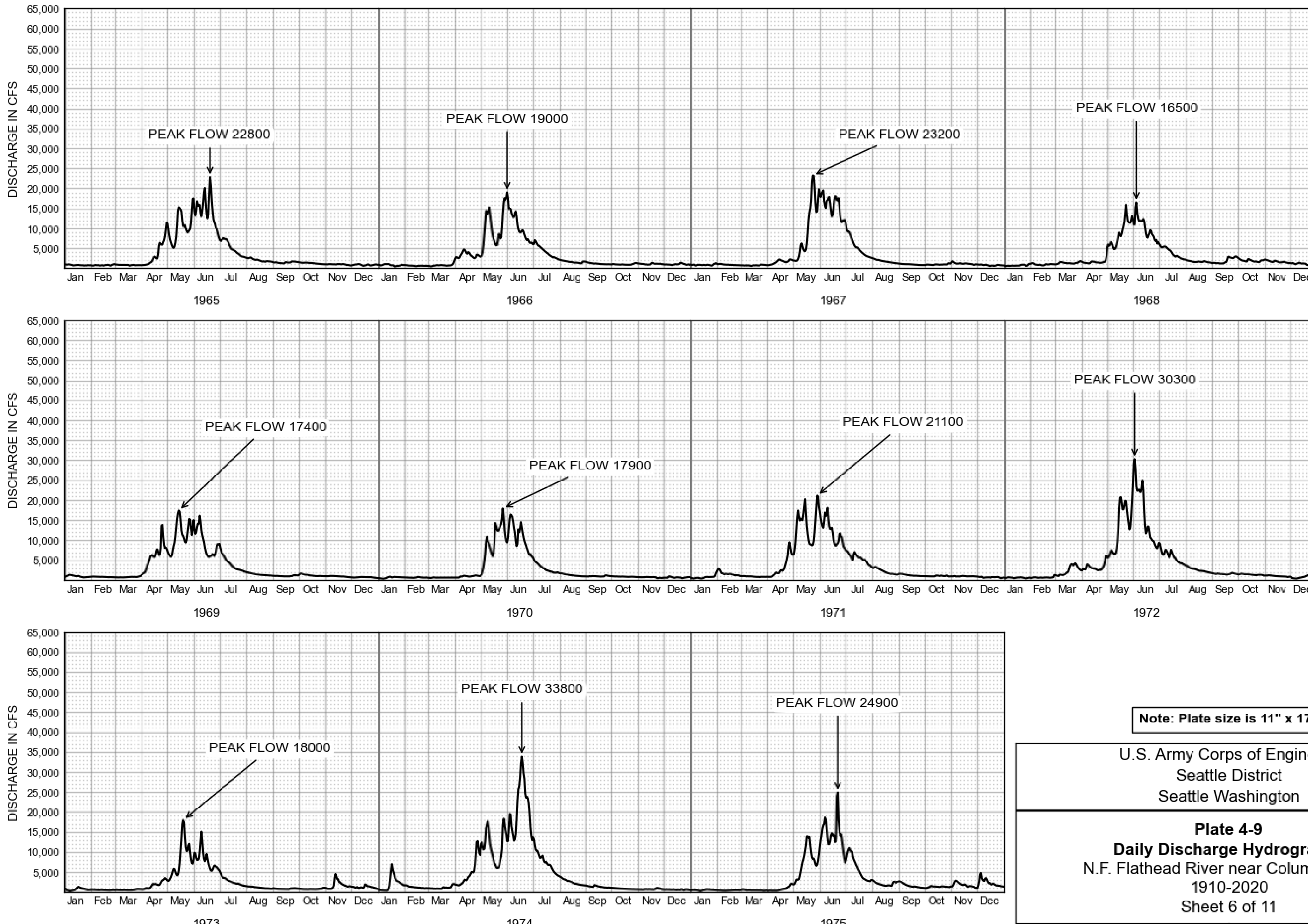
U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-9
Daily Discharge Hydrographs
N.F. Flathead River near Columbia Falls
1910-2020
Sheet 5 of 11

Completed by: WEST	March 2021



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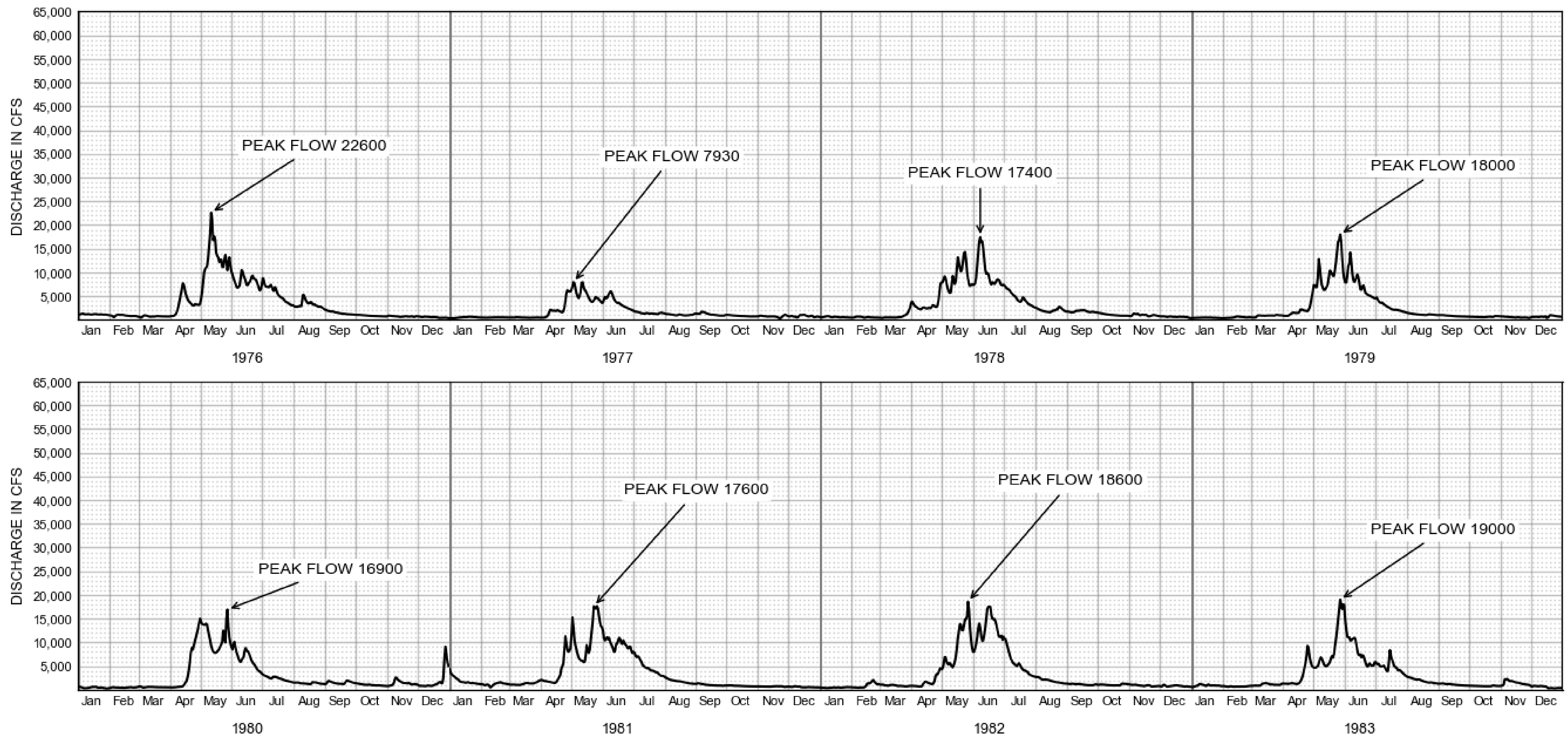
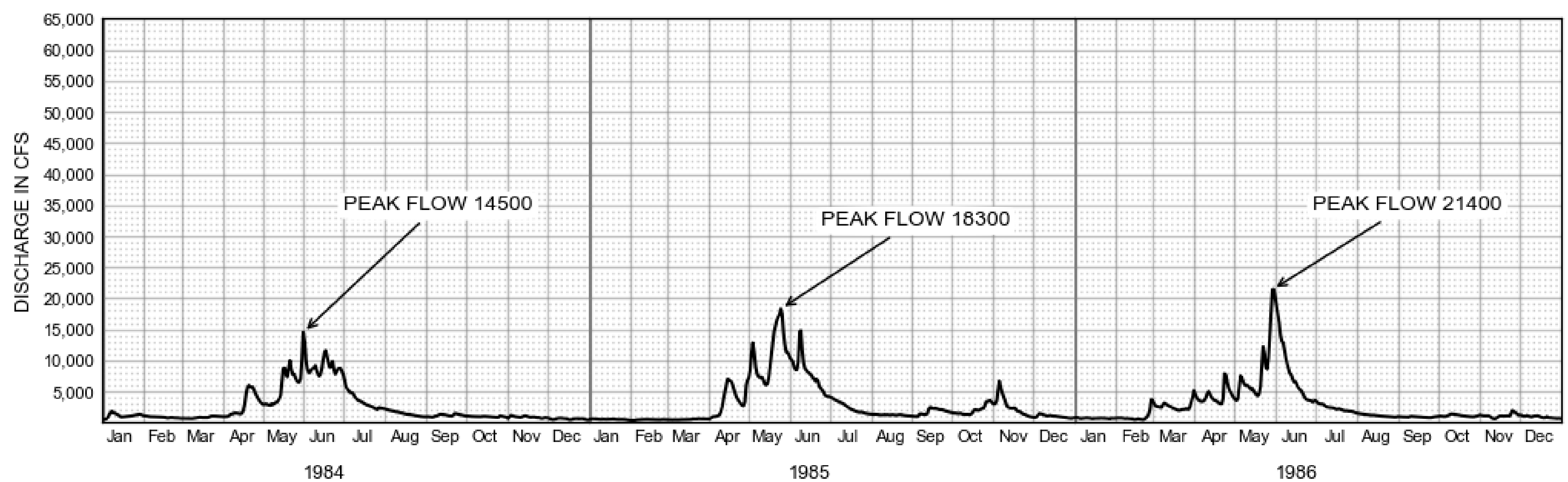
U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-9
Daily Discharge Hydrographs
N.F. Flathead River near Columbia Falls
1910-2020
Sheet 6 of 11

Completed by: WEST	March 2021





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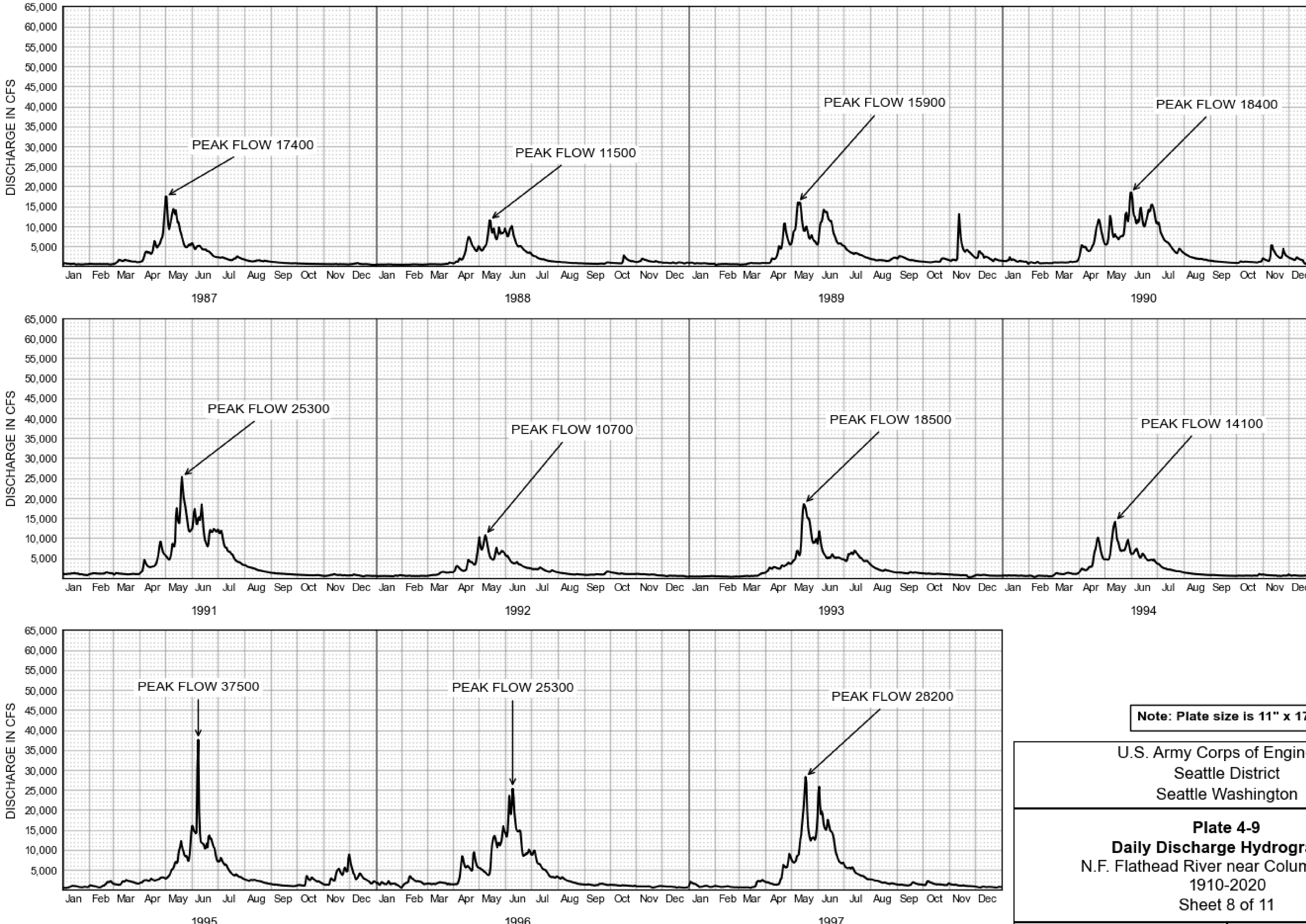
U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-9
Daily Discharge Hydrographs
N.F. Flathead River near Columbia Falls
1910-2020
Sheet 7 of 11

Completed by: WEST	March 2021

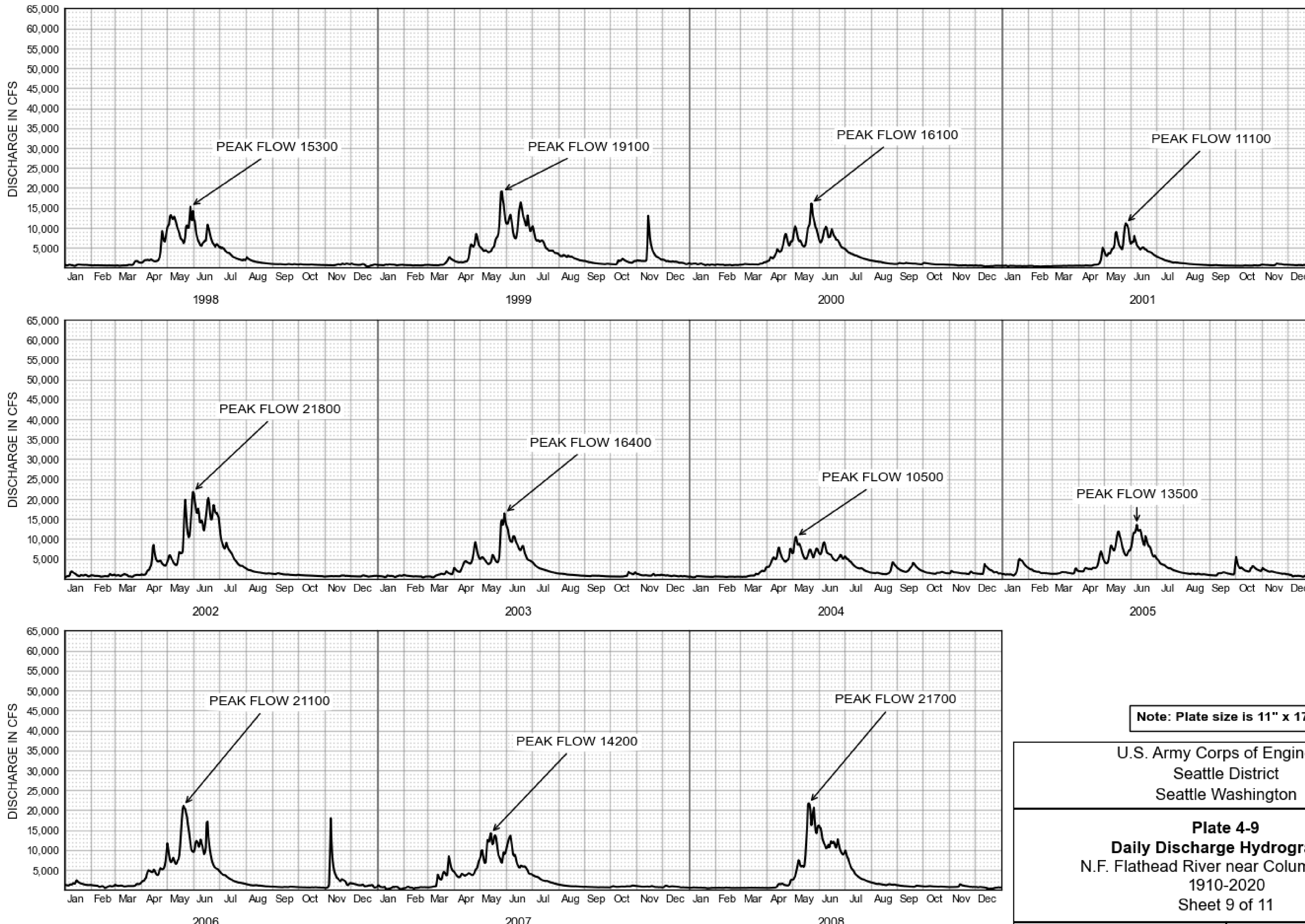


Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-9
Daily Discharge Hydrographs
N.F. Flathead River near Columbia Falls
1910-2020
Sheet 8 of 11

Completed by: WEST	March 2021



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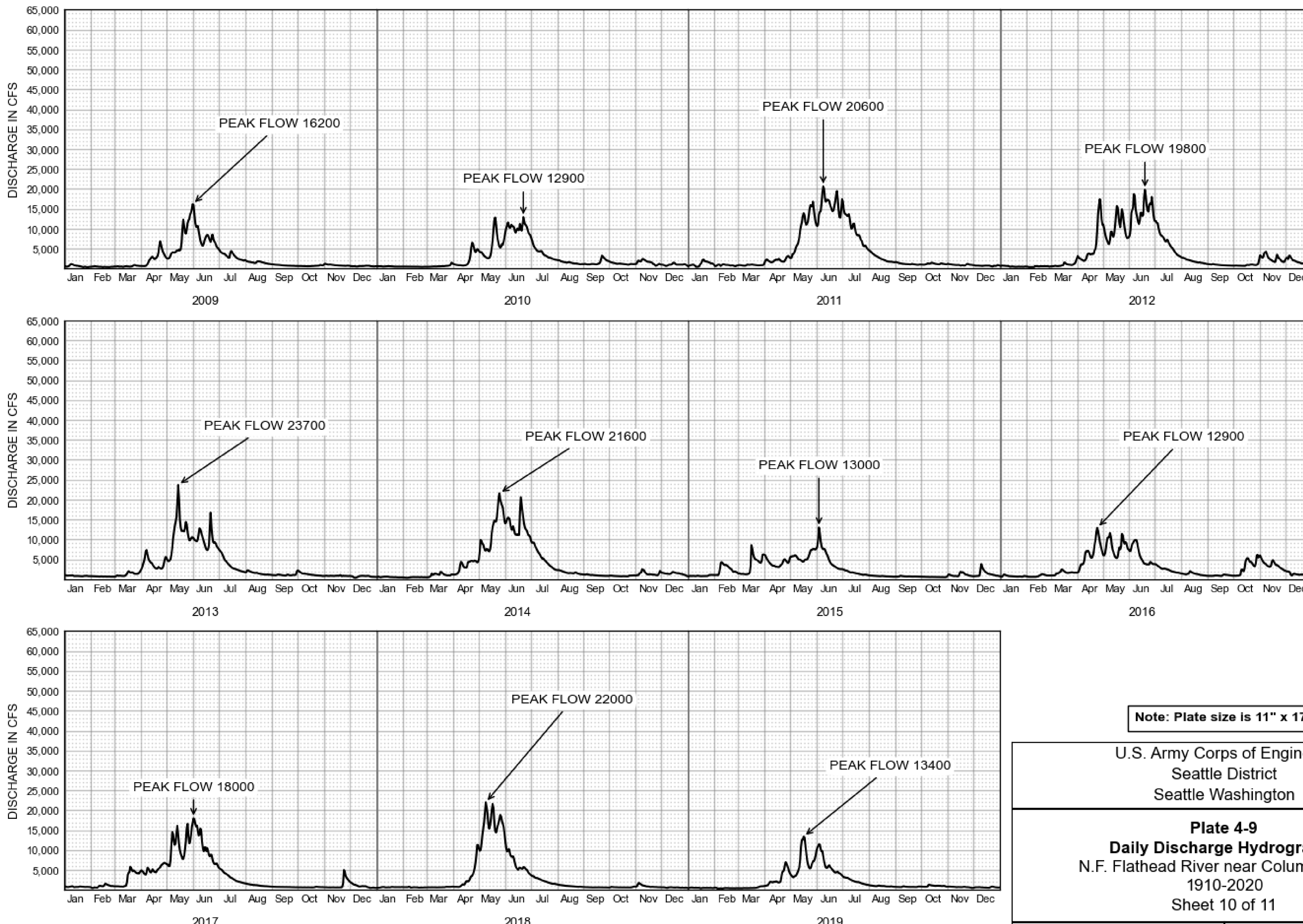
U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-9
Daily Discharge Hydrographs
N.F. Flathead River near Columbia Falls
1910-2020
Sheet 9 of 11

Completed by: WEST	March 2021



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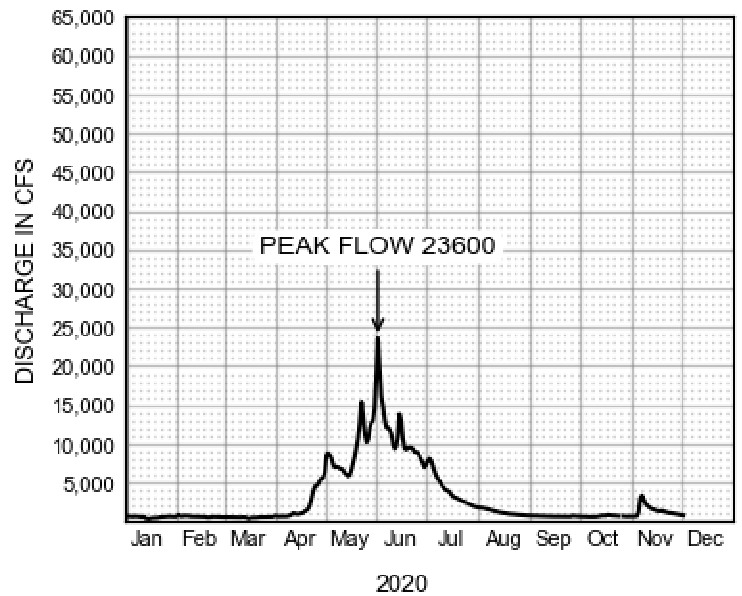
U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-9
Daily Discharge Hydrographs
N.F. Flathead River near Columbia Falls
1910-2020
Sheet 10 of 11

Completed by: WEST	March 2021



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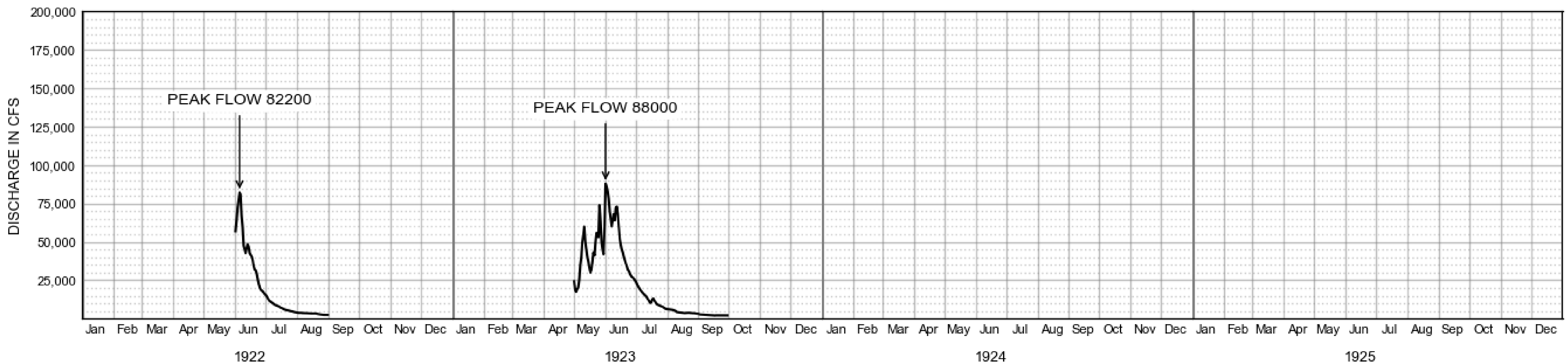
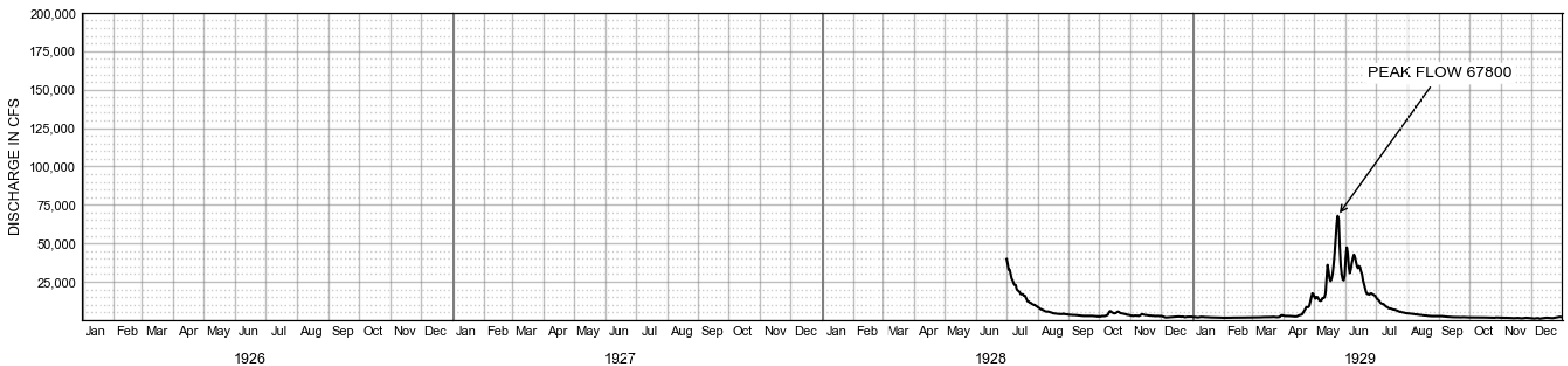
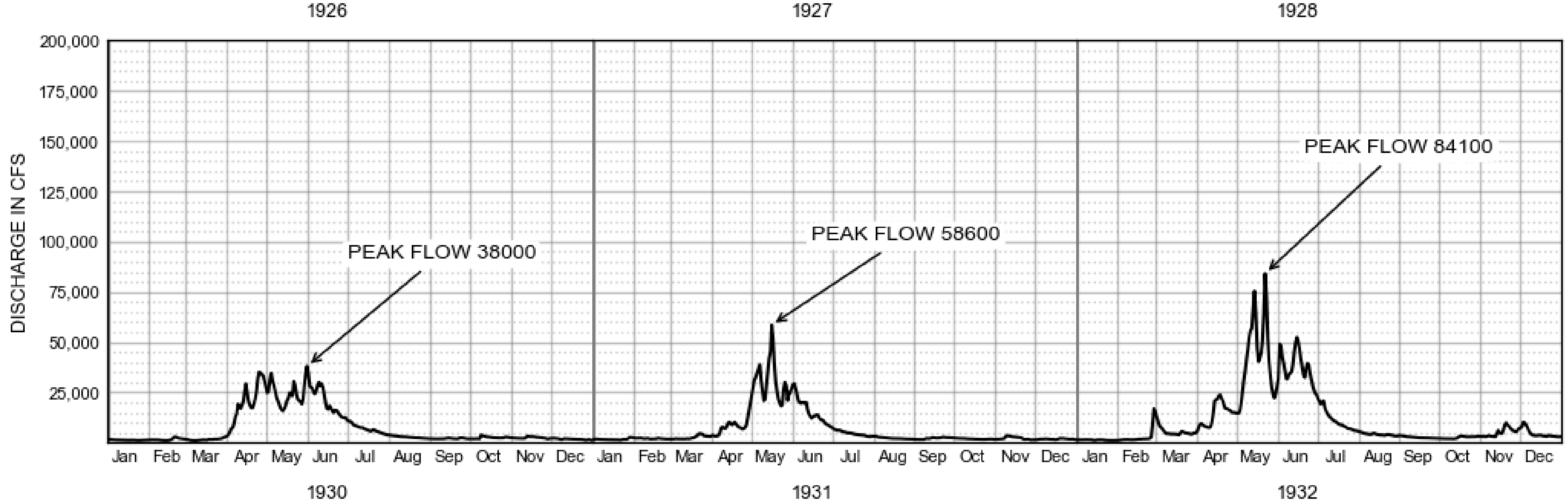
U.S. Army Corps of Engineers Seattle District Seattle Washington	
Plate 4-9 **Daily Discharge Hydrographs** N.F. Flathead River near Columbia Falls 1910-2020 Sheet 11 of 11	
Completed by: WEST	March 2021







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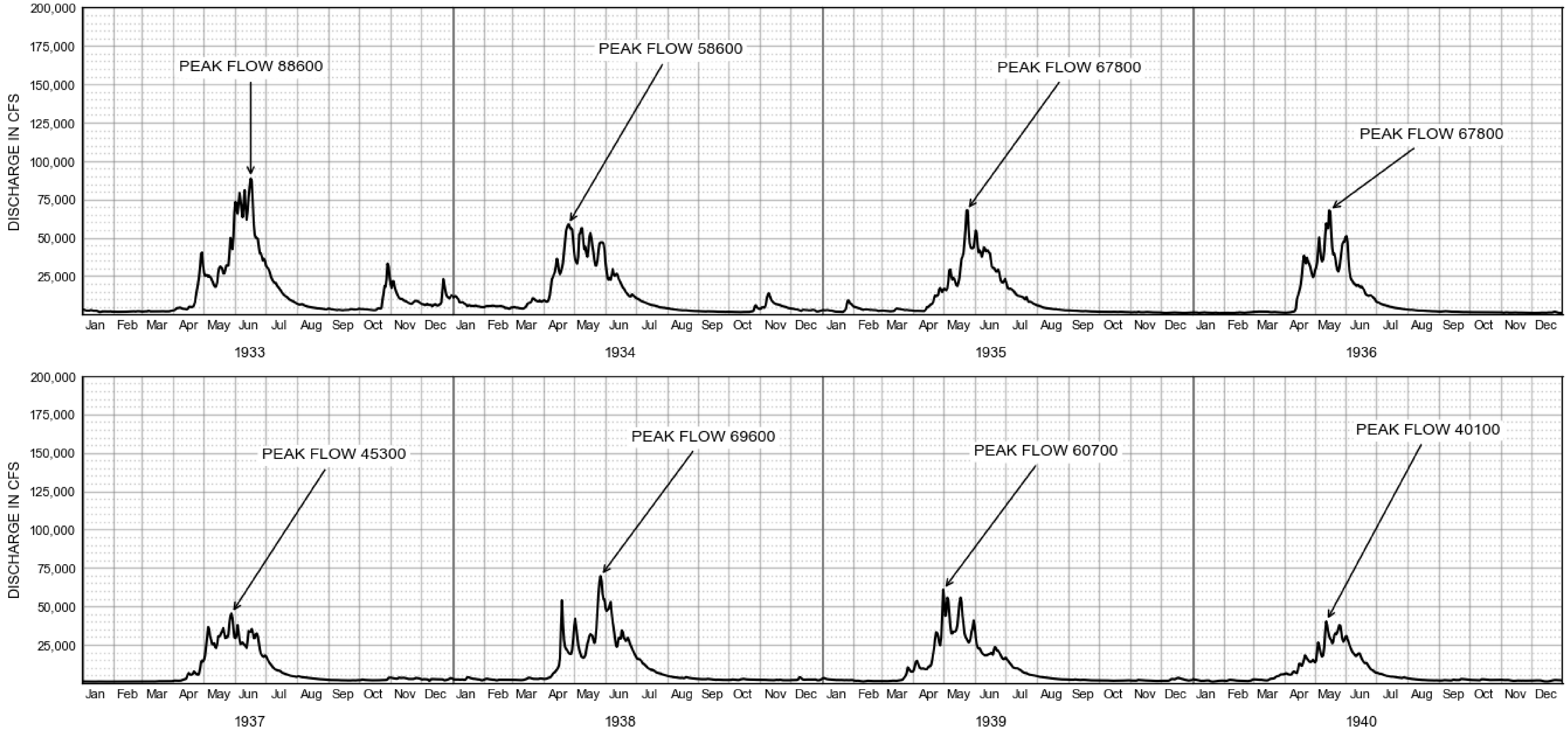
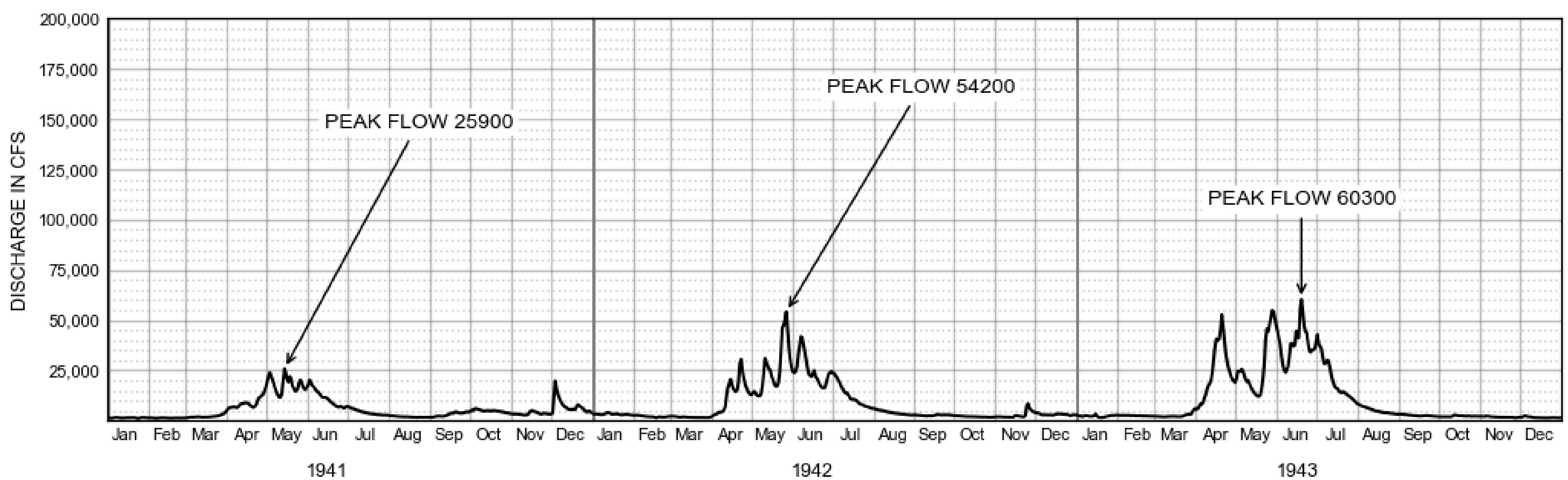
U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-10
Daily Discharge Hydrographs
Flathead River at Columbia Falls
1922-2020
Sheet 1 of 9

Completed by: WEST	March 2021





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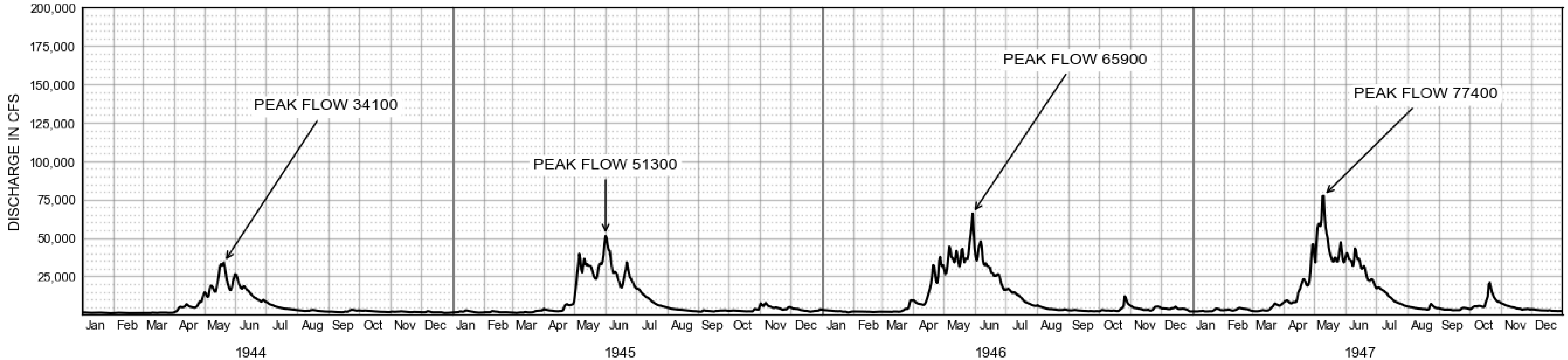
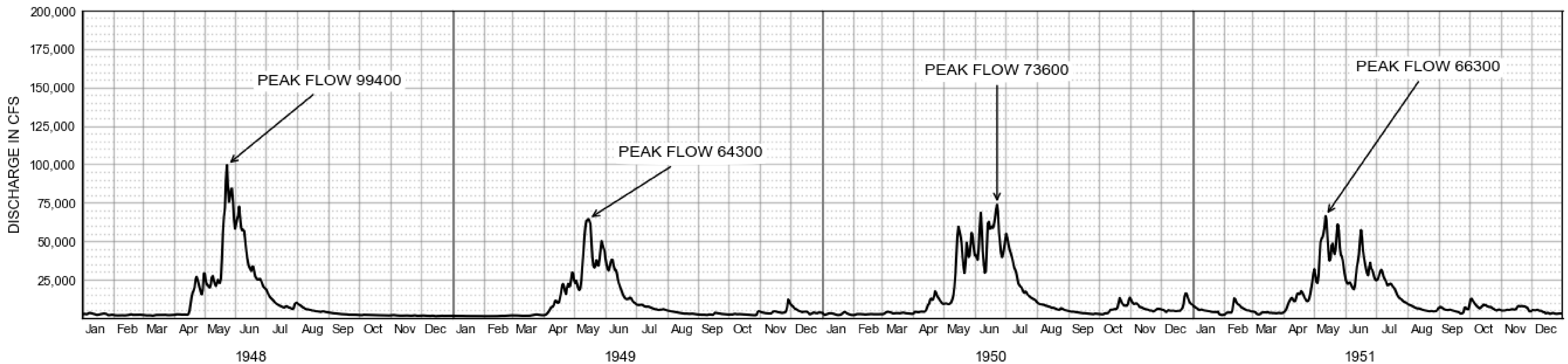
U.S. Army Corps of Engineers
Seattle District
Seattle Washington

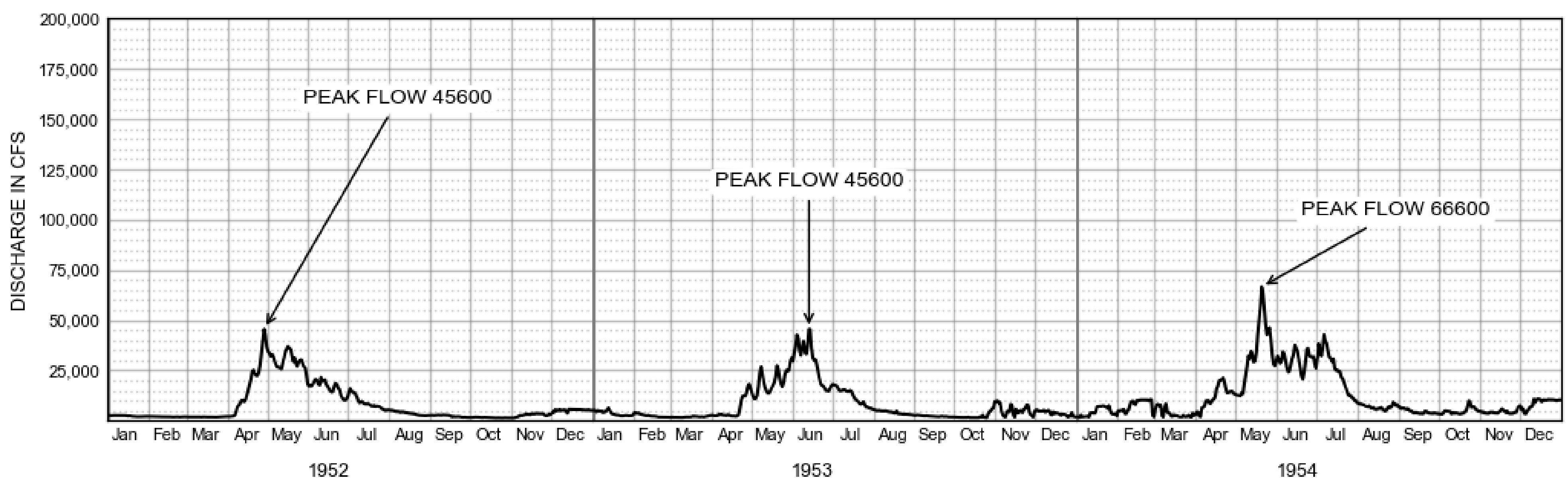
Plate 4-10
Daily Discharge Hydrographs
Flathead River at Columbia Falls
1922-2020
Sheet 2 of 9

Completed by: WEST	March 2021

PLATE 4-10







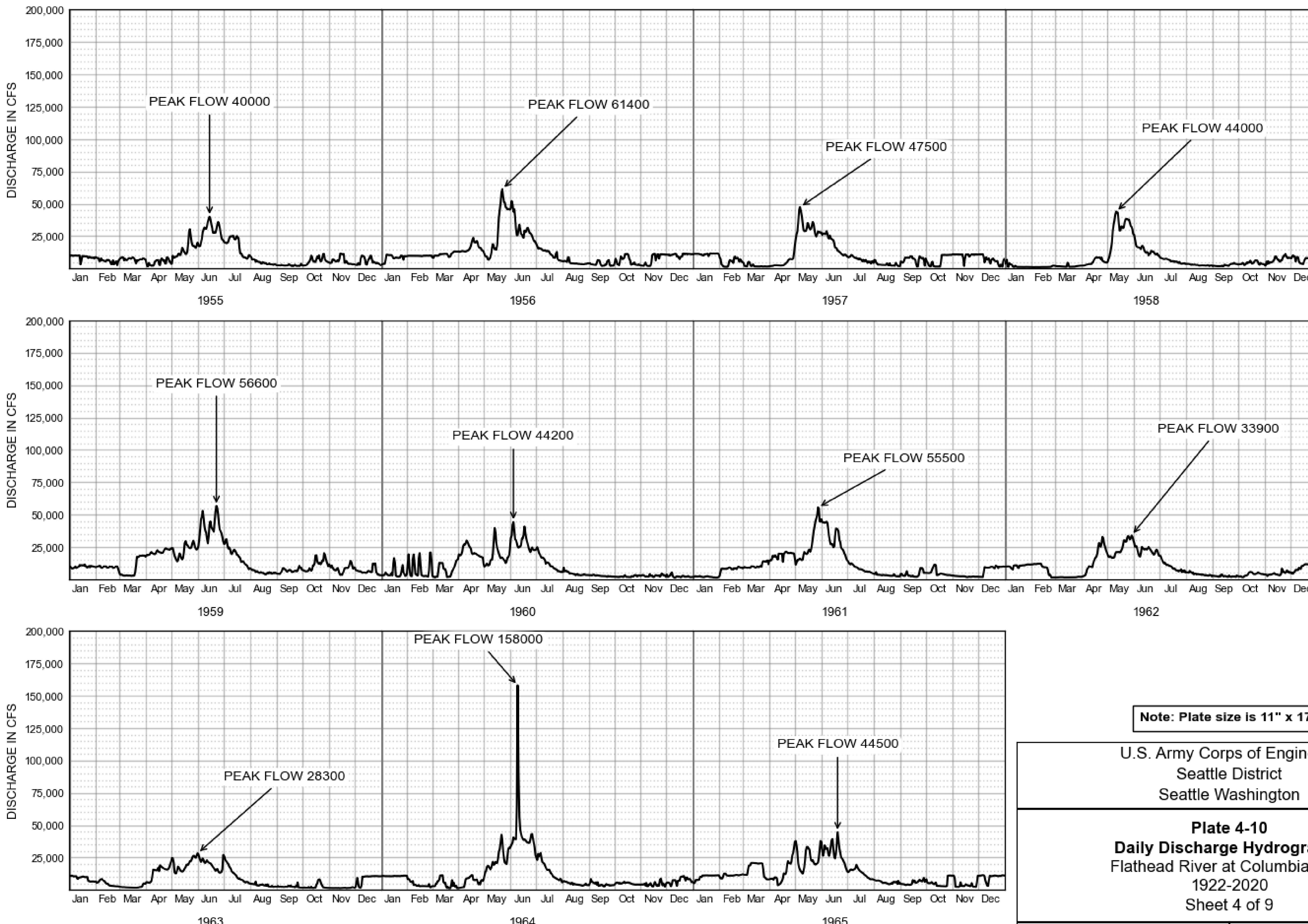
Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-10
Daily Discharge Hydrographs
Flathead River at Columbia Falls
1922-2020
Sheet 3 of 9

Completed by: WEST	March 2021

PLATE 4-10

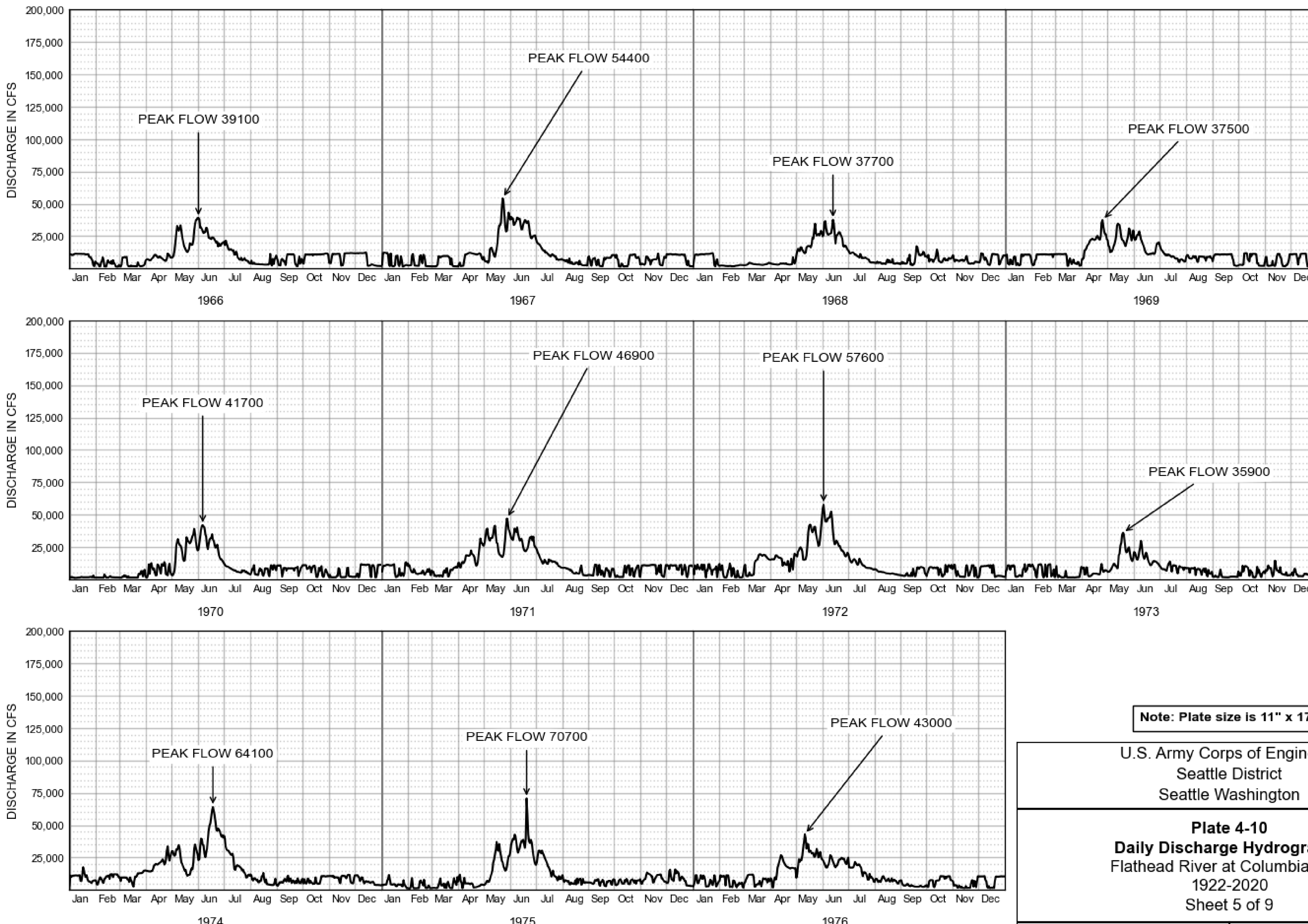


Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-10
Daily Discharge Hydrographs
Flathead River at Columbia Falls
1922-2020
Sheet 4 of 9

Completed by: WEST	March 2021

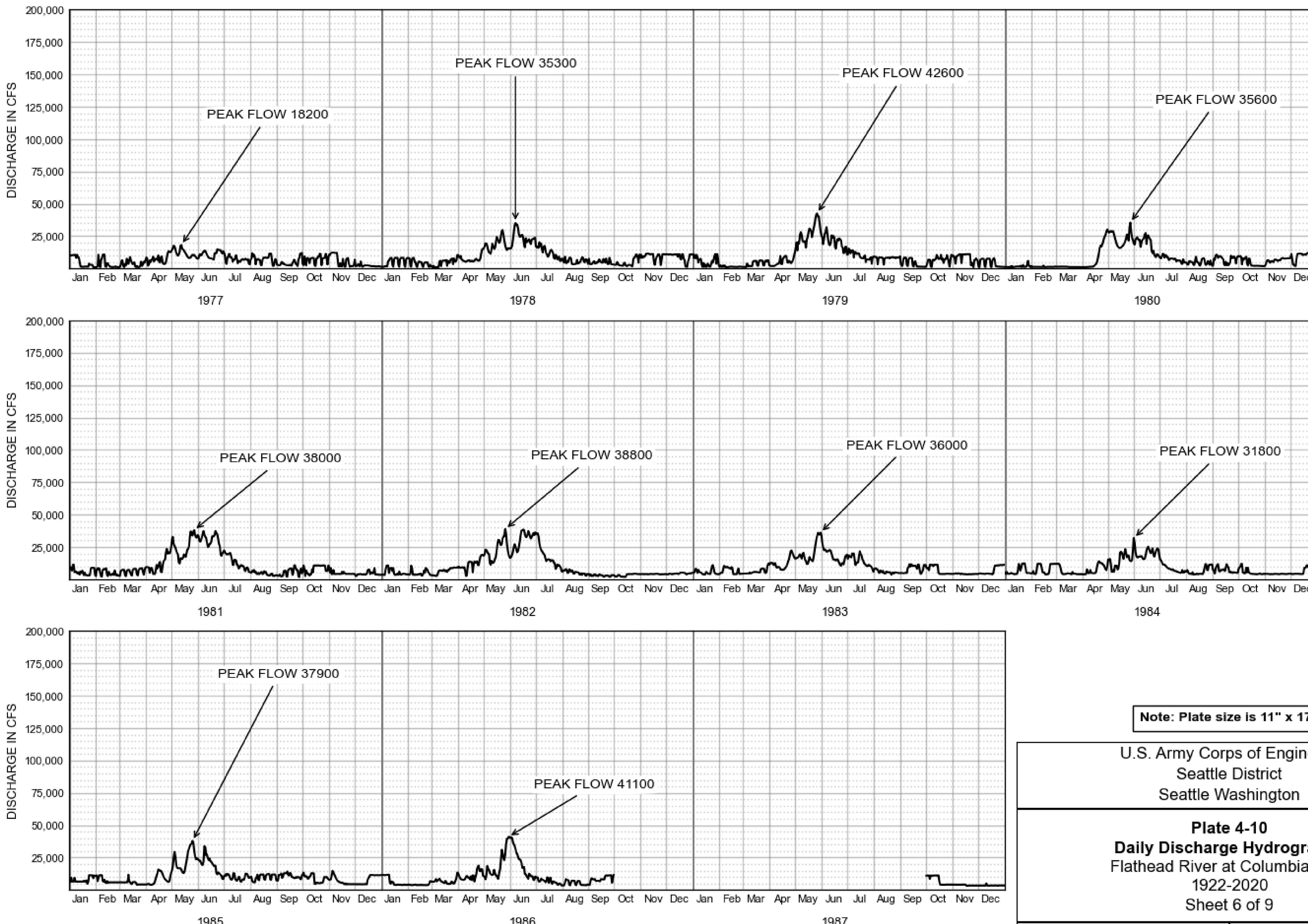


Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-10
Daily Discharge Hydrographs
Flathead River at Columbia Falls
1922-2020
Sheet 5 of 9

Completed by: WEST | March 2021

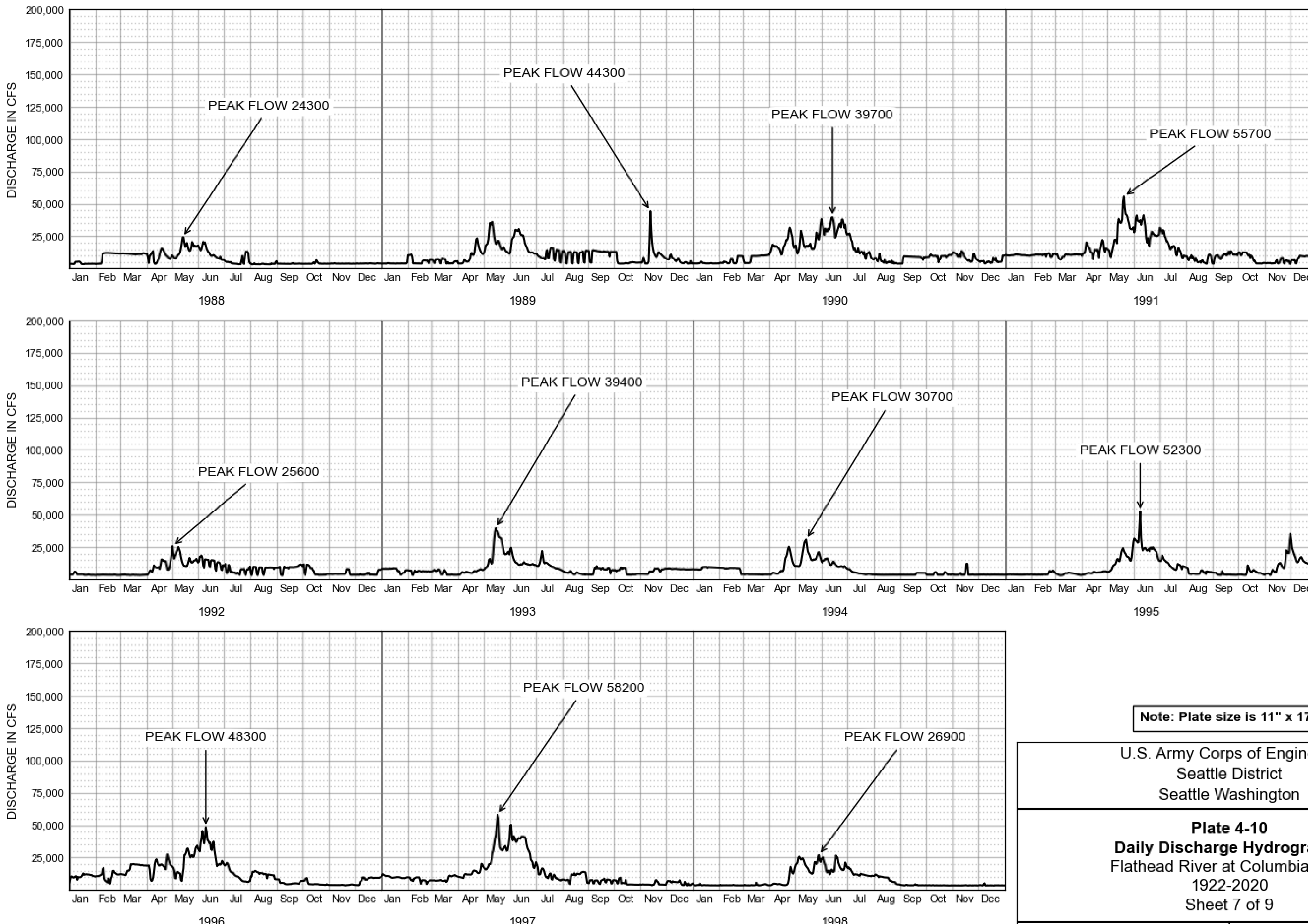


Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-10
Daily Discharge Hydrographs
Flathead River at Columbia Falls
1922-2020
Sheet 6 of 9

Completed by: WEST	March 2021



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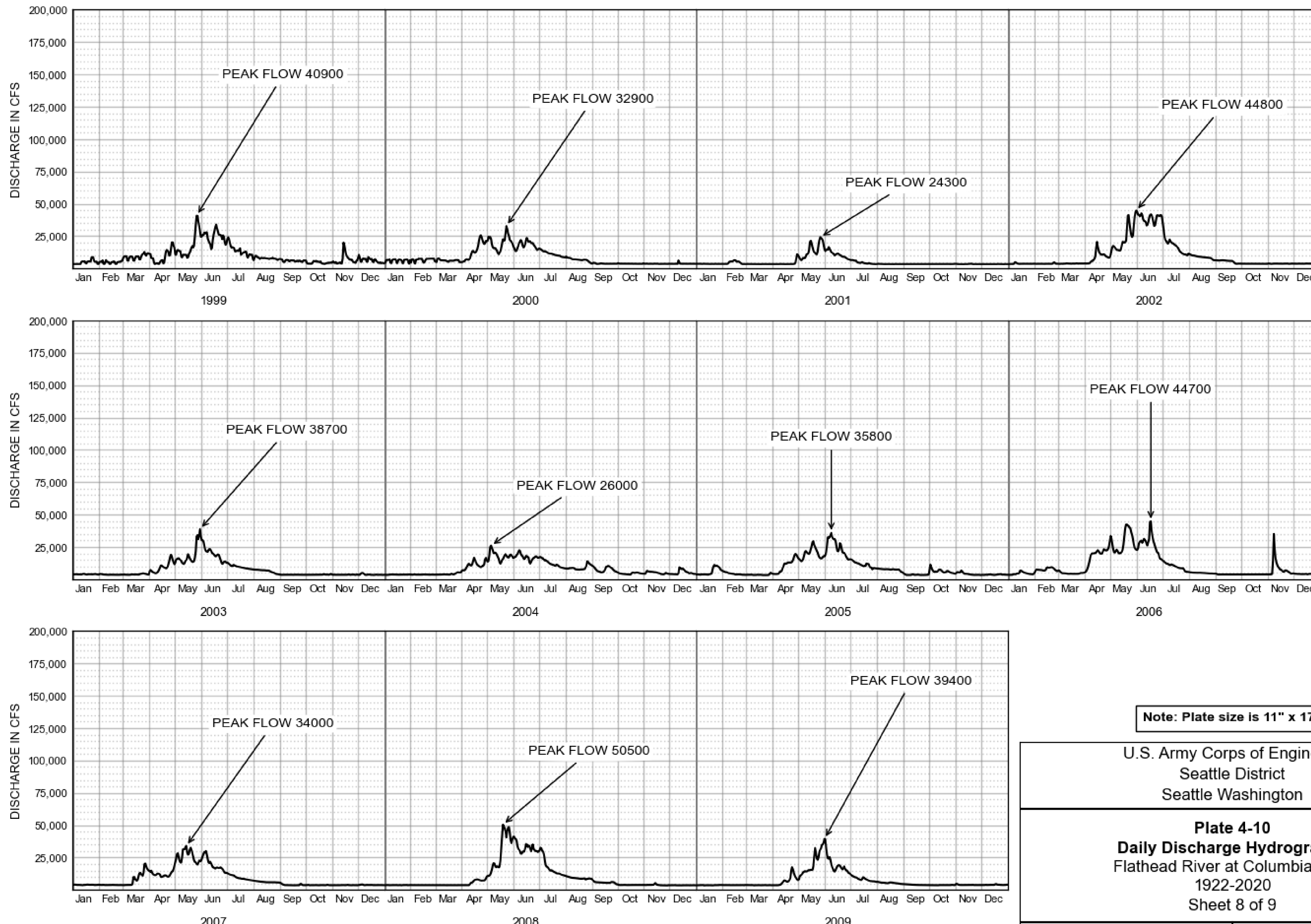
U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-10
Daily Discharge Hydrographs
Flathead River at Columbia Falls
1922-2020
Sheet 7 of 9

Completed by: WEST	March 2021

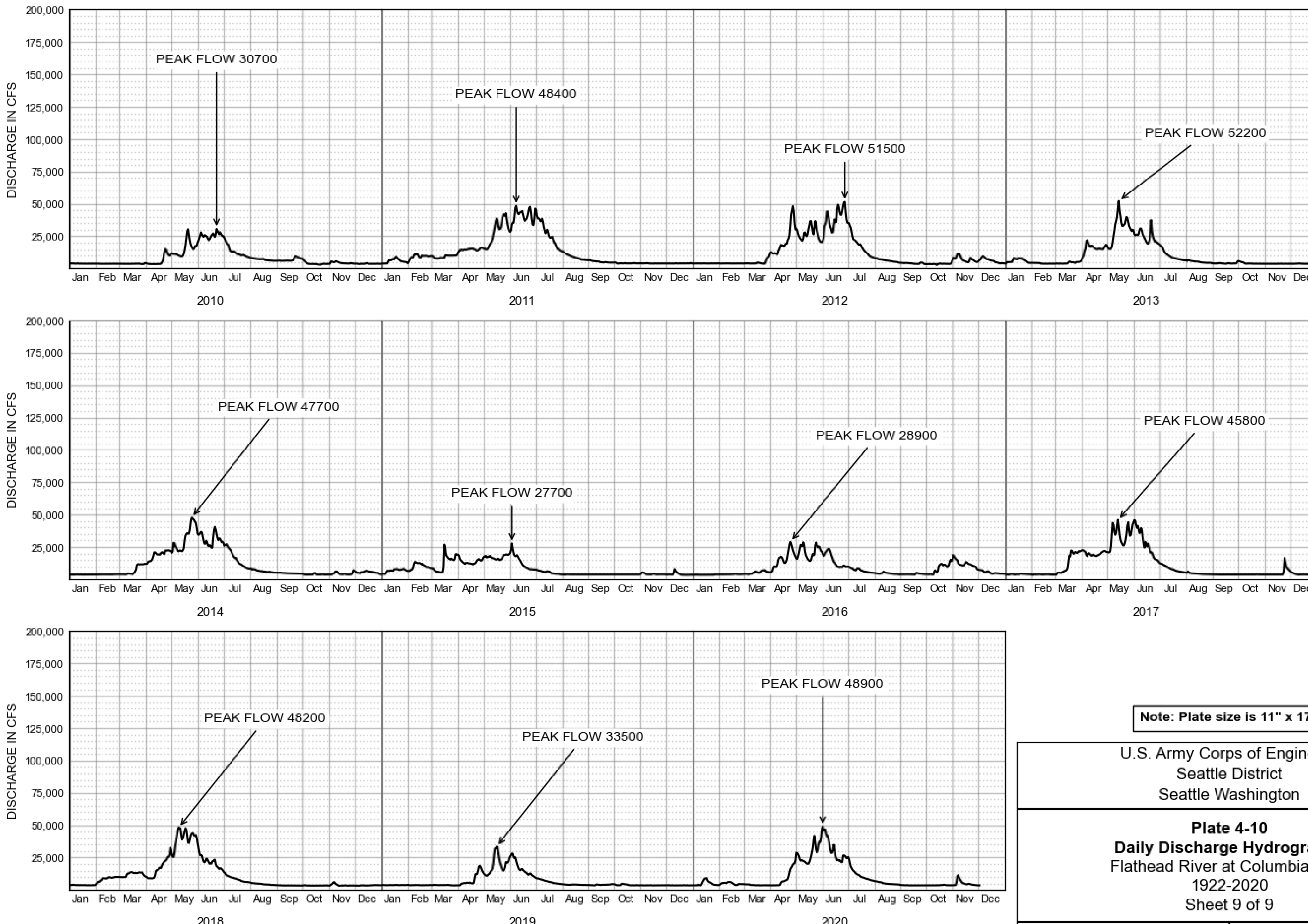


Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-10
Daily Discharge Hydrographs
Flathead River at Columbia Falls
1922-2020
Sheet 8 of 9

Completed by: WEST	March 2021



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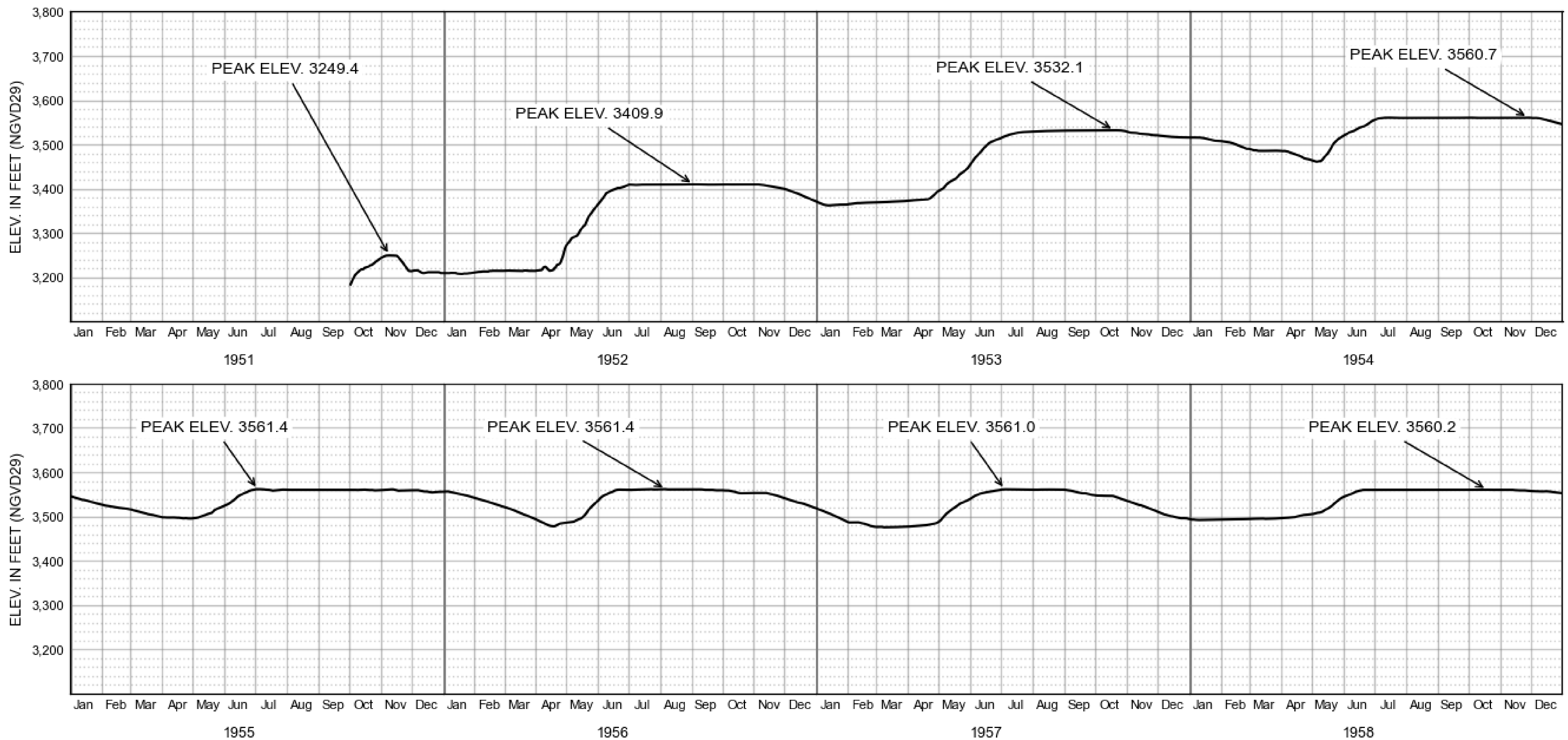
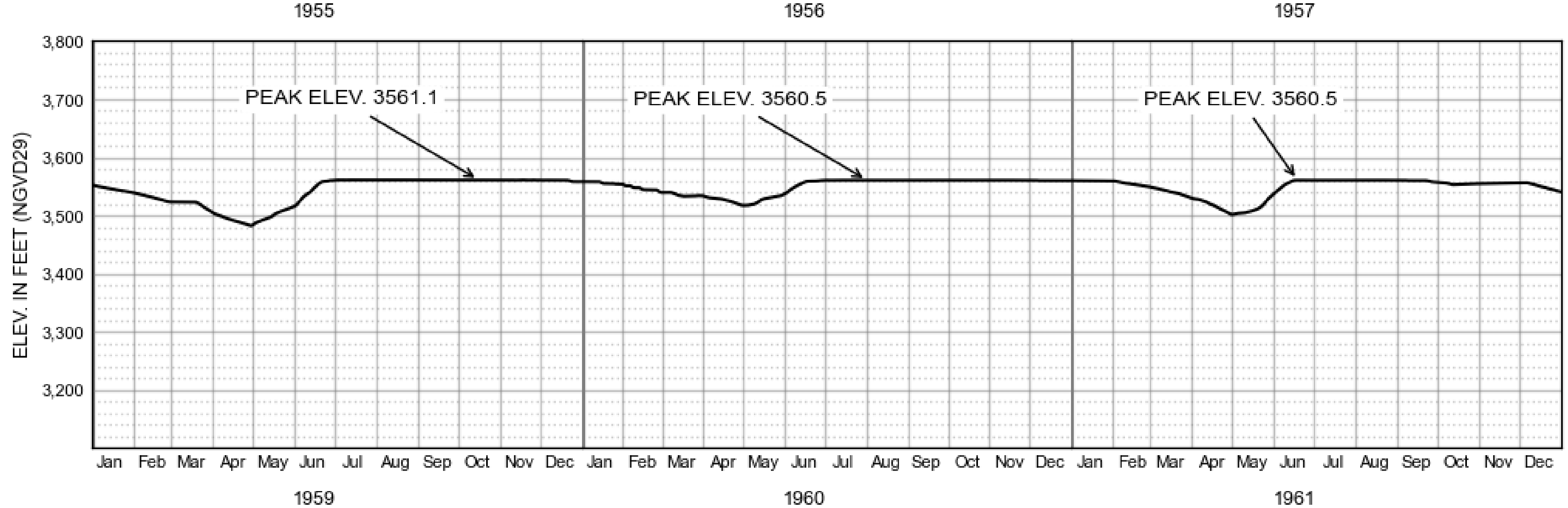
U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-10
Daily Discharge Hydrographs
Flathead River at Columbia Falls
1922-2020
Sheet 9 of 9

Completed by: WEST	March 2021

PLATE 4-10





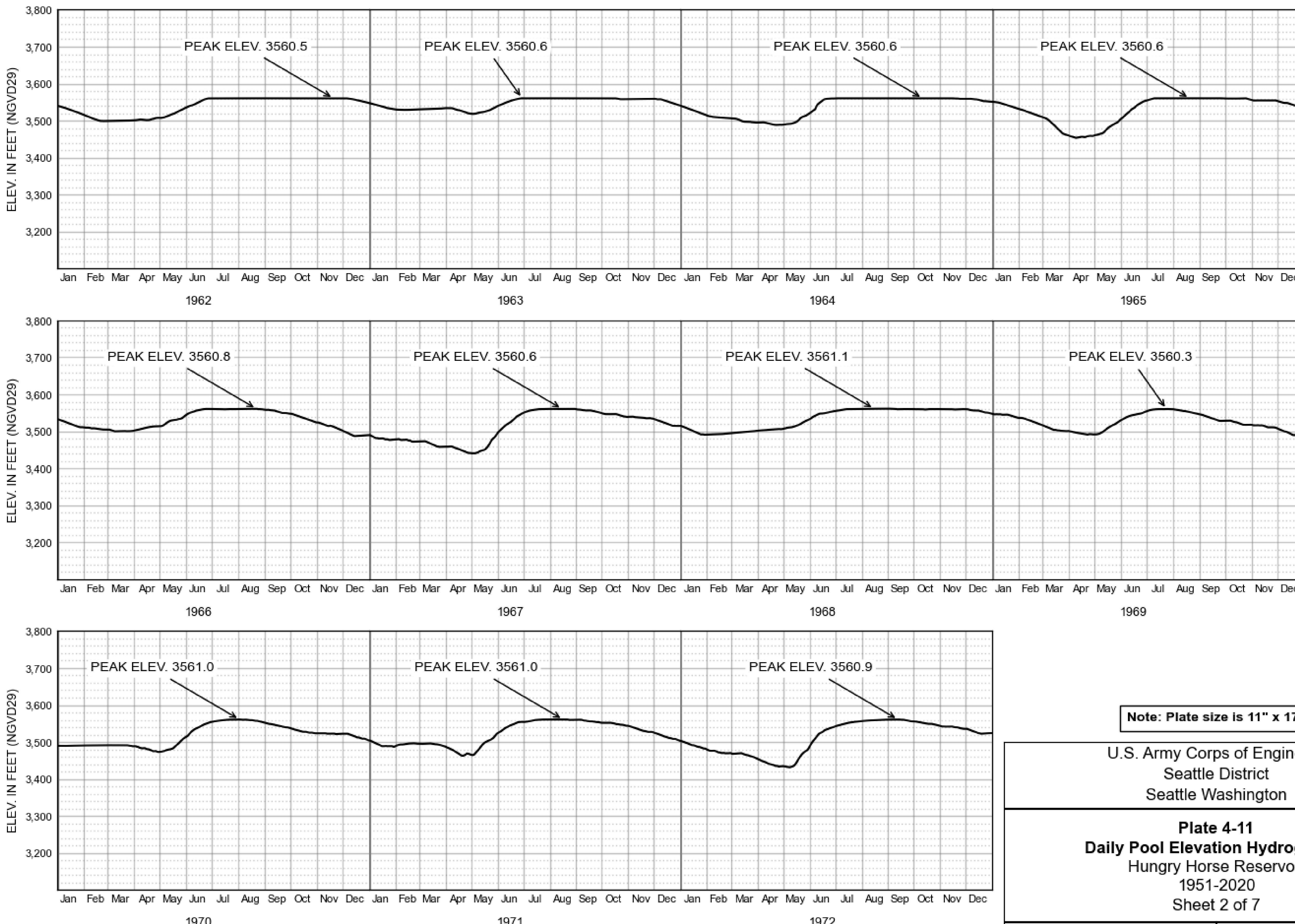
Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-11
Daily Pool Elevation Hydrographs
Hungry Horse Reservoir
1951-2020
Sheet 1 of 7

Completed by: WEST	March 2021

PLATE 4-11



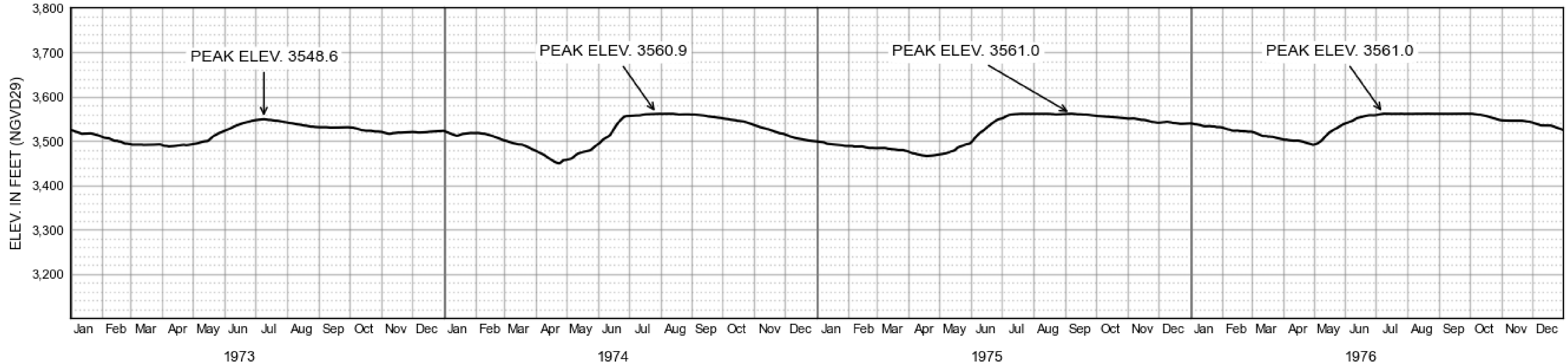
Note: Plate size is 11" x 17"

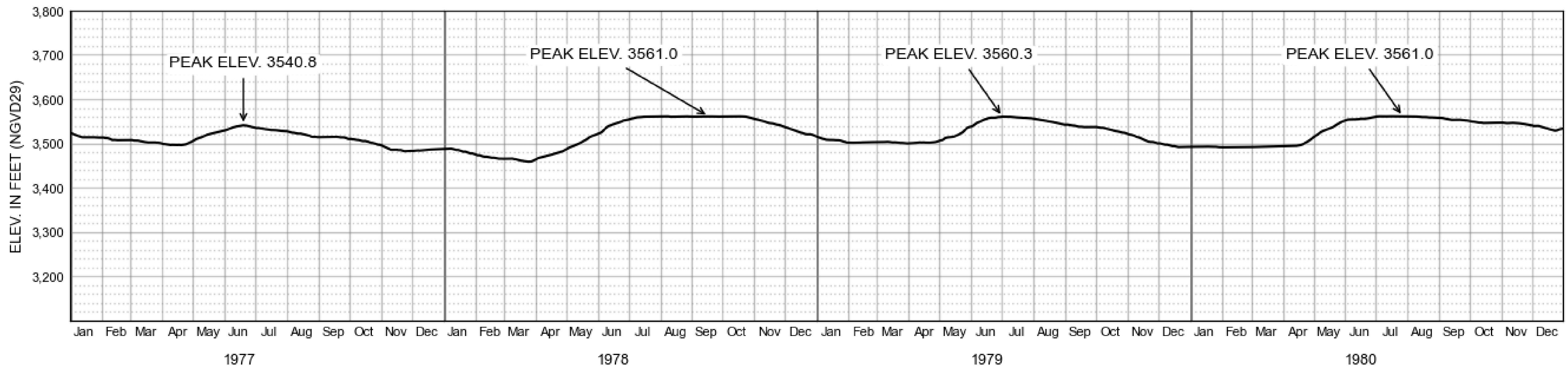
U.S. Army Corps of Engineers
Seattle District
Seattle Washington

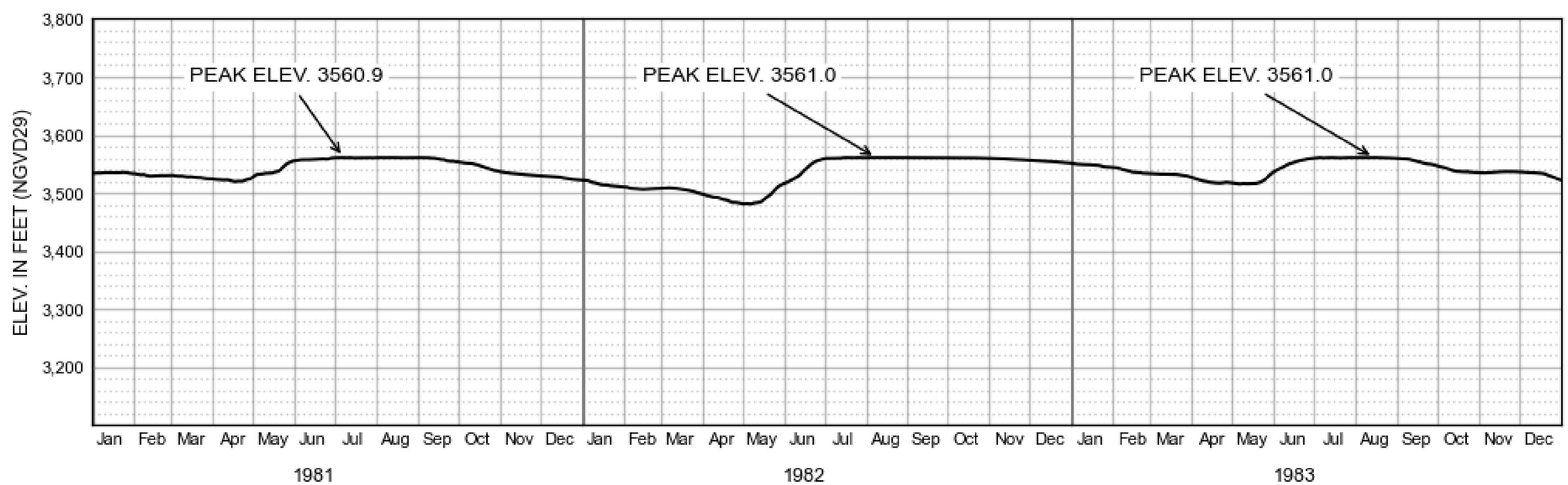
Plate 4-11
Daily Pool Elevation Hydrographs
Hungry Horse Reservoir
1951-2020
Sheet 2 of 7

Completed by: WEST	March 2021

PLATE 4-11





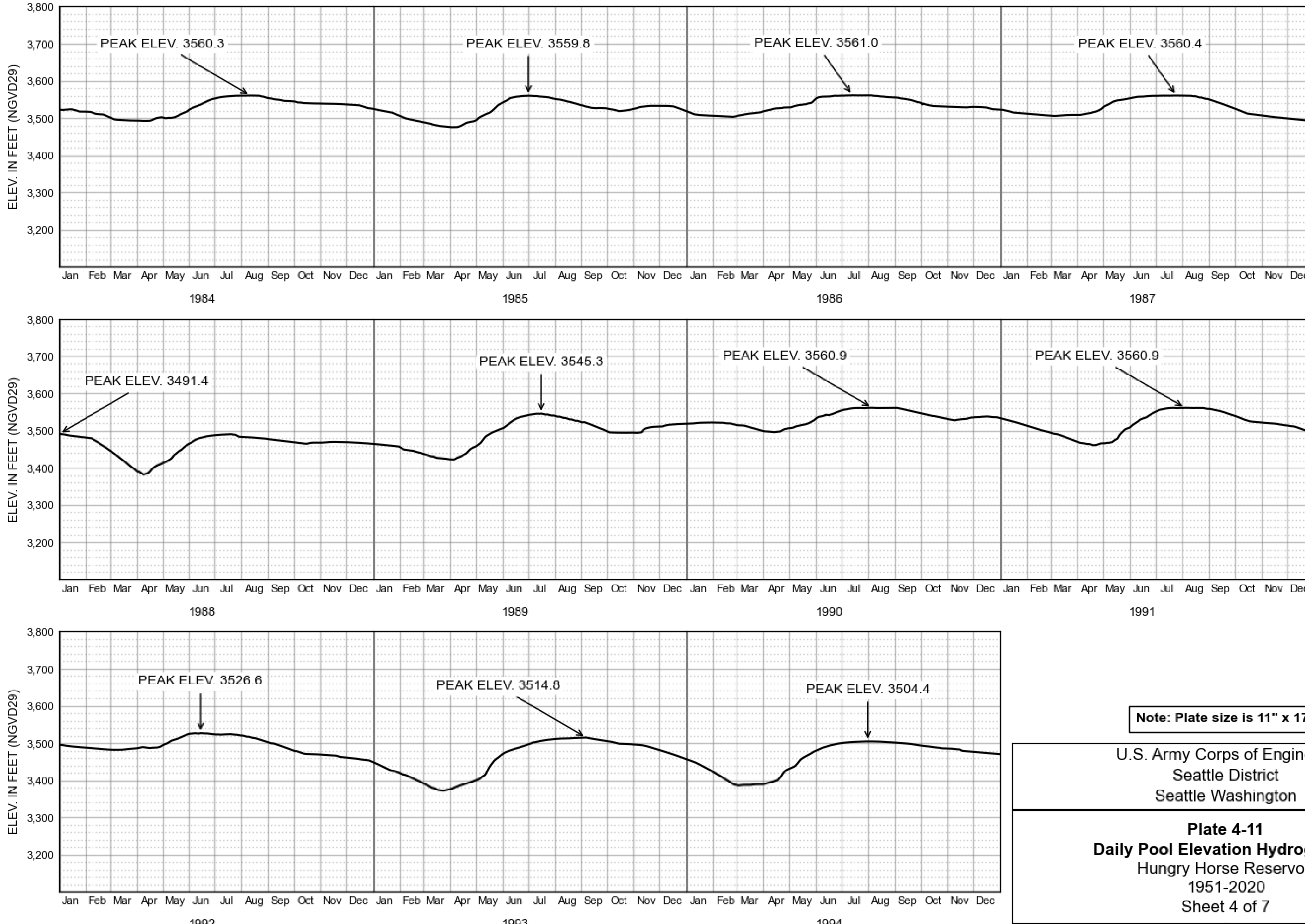


Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-11
Daily Pool Elevation Hydrographs
Hungry Horse Reservoir
1951-2020
Sheet 3 of 7

Completed by: WEST	March 2021

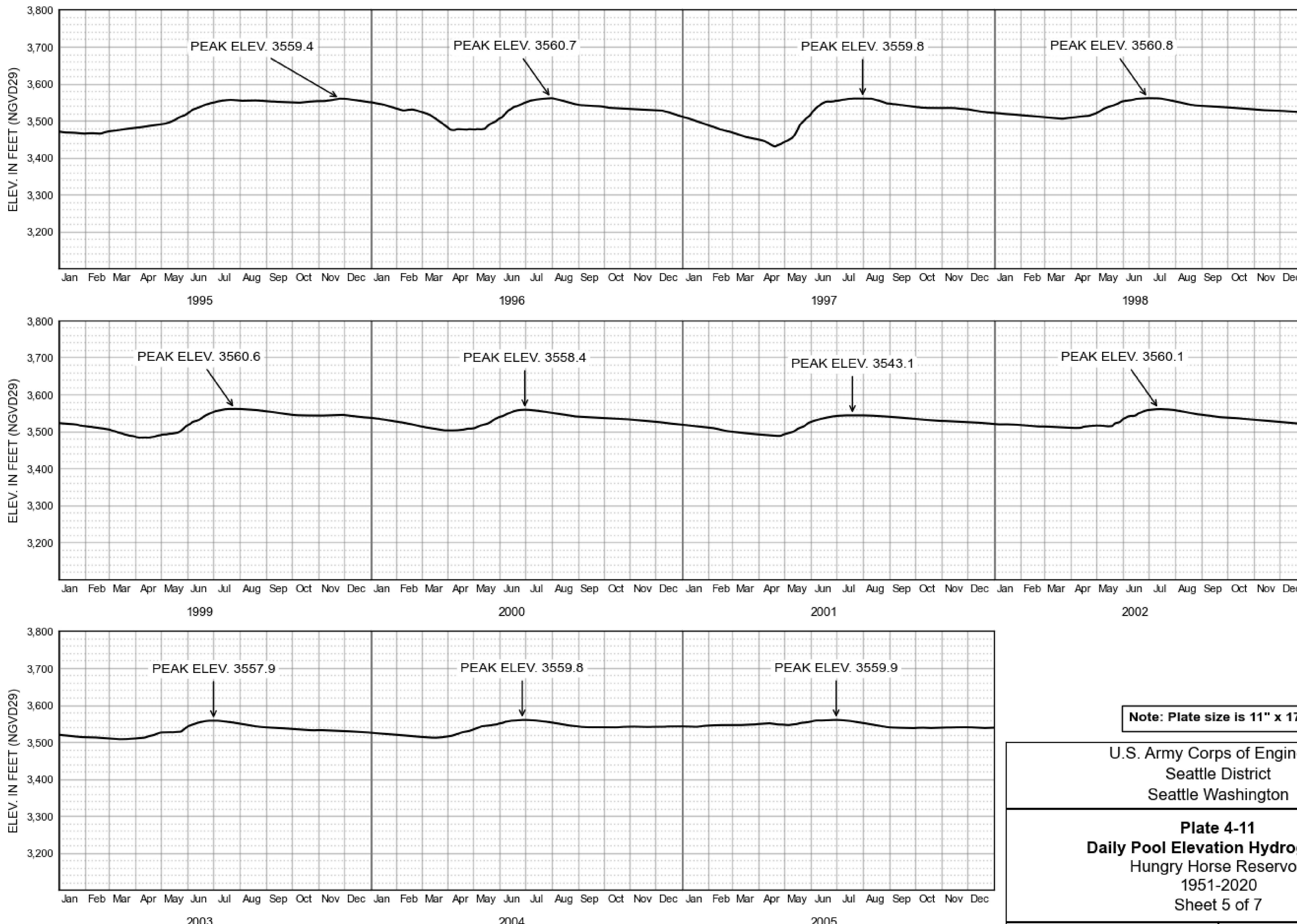


Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-11
Daily Pool Elevation Hydrographs
Hungry Horse Reservoir
1951-2020
Sheet 4 of 7

Completed by: WEST	March 2021



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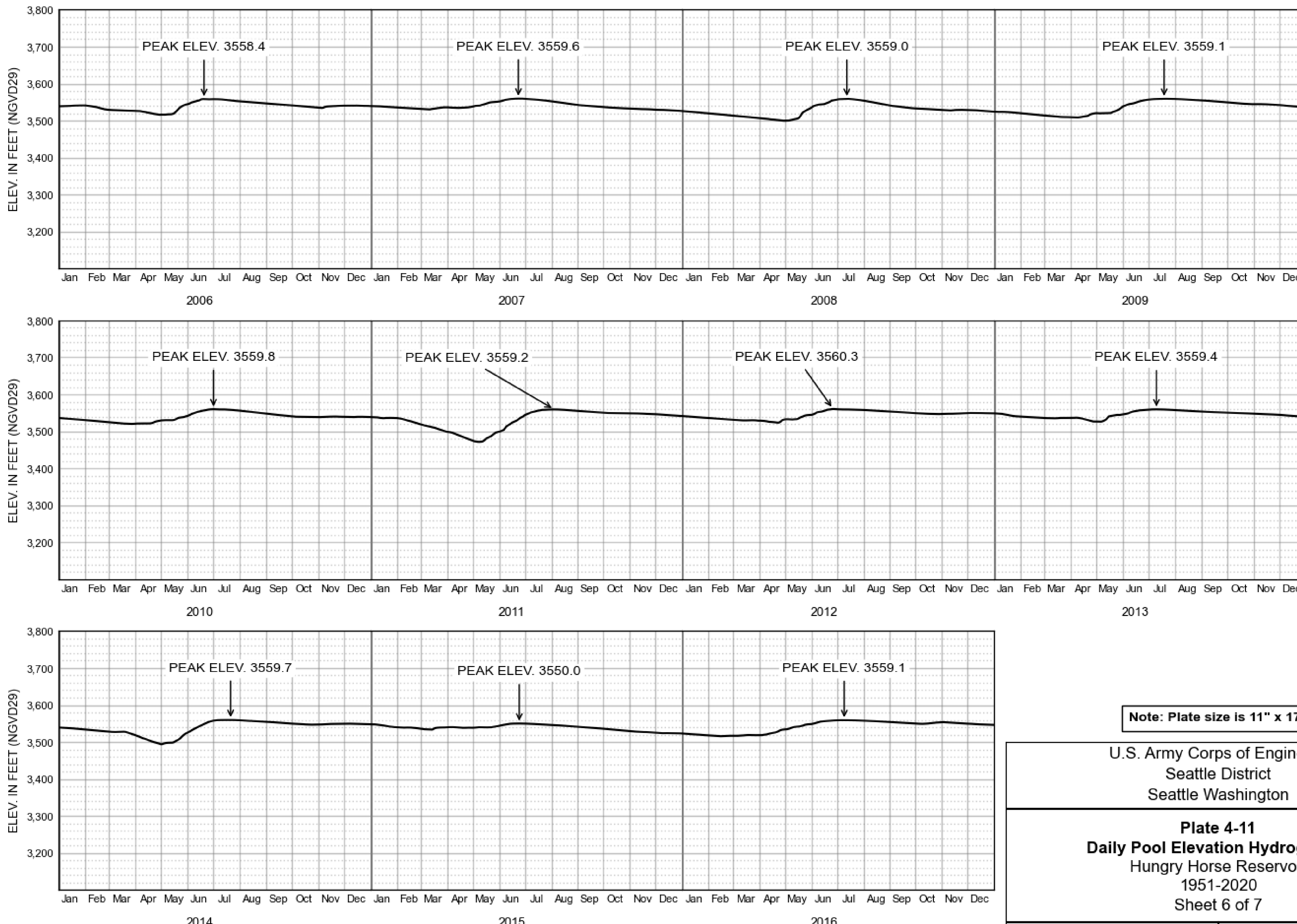
U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-11
Daily Pool Elevation Hydrographs
Hungry Horse Reservoir
1951-2020
Sheet 5 of 7

Completed by: WEST	March 2021

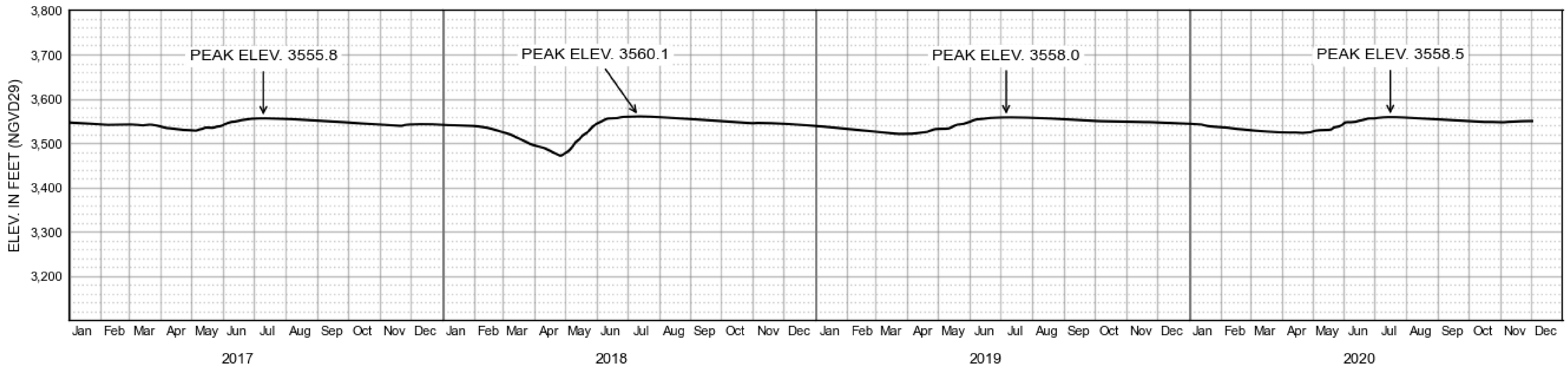


Note: Plate size is 11" x 17"

U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-11
Daily Pool Elevation Hydrographs
Hungry Horse Reservoir
1951-2020
Sheet 6 of 7

Completed by: WEST | March 2021

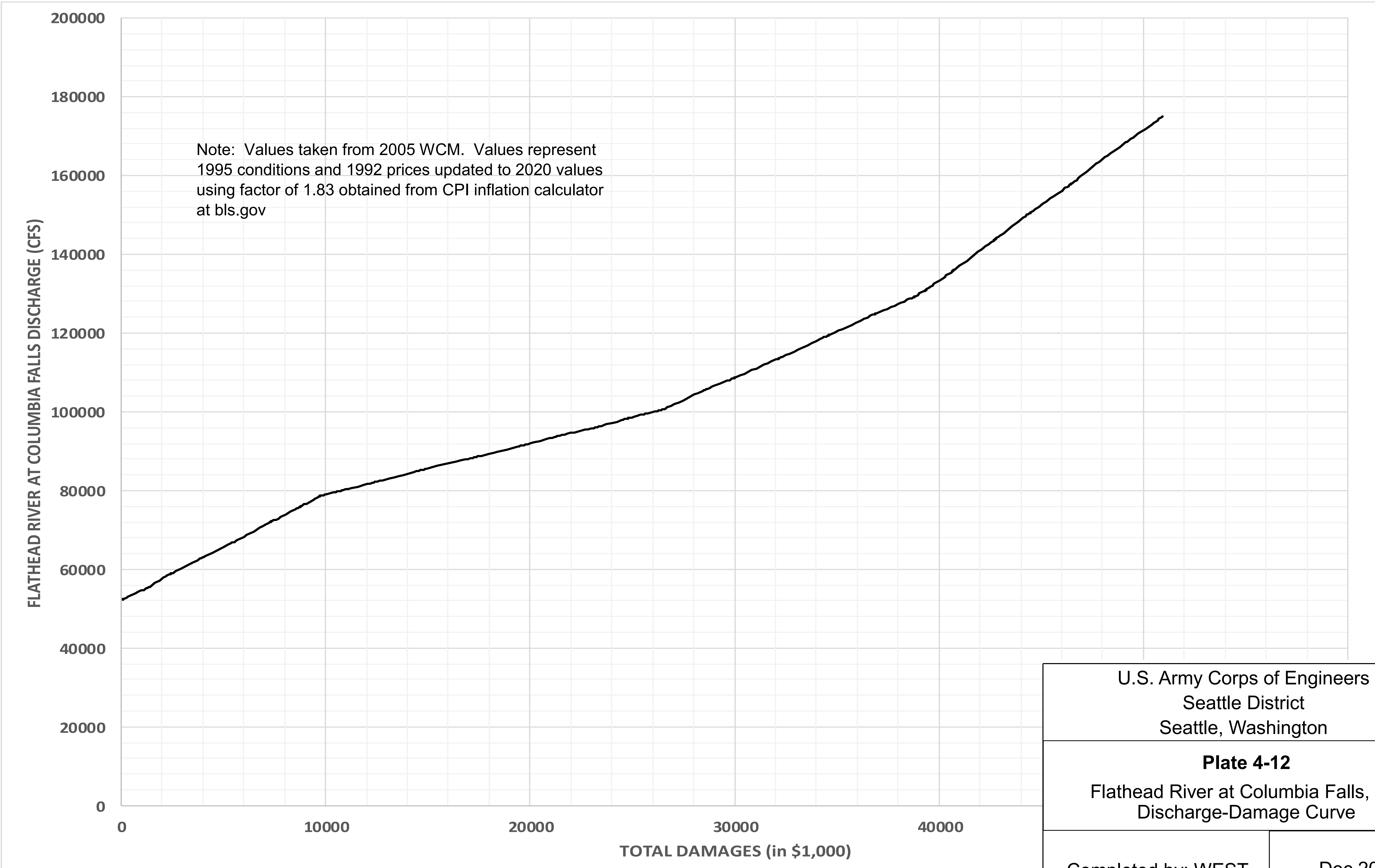


Note: Plate size is 11" x 17"

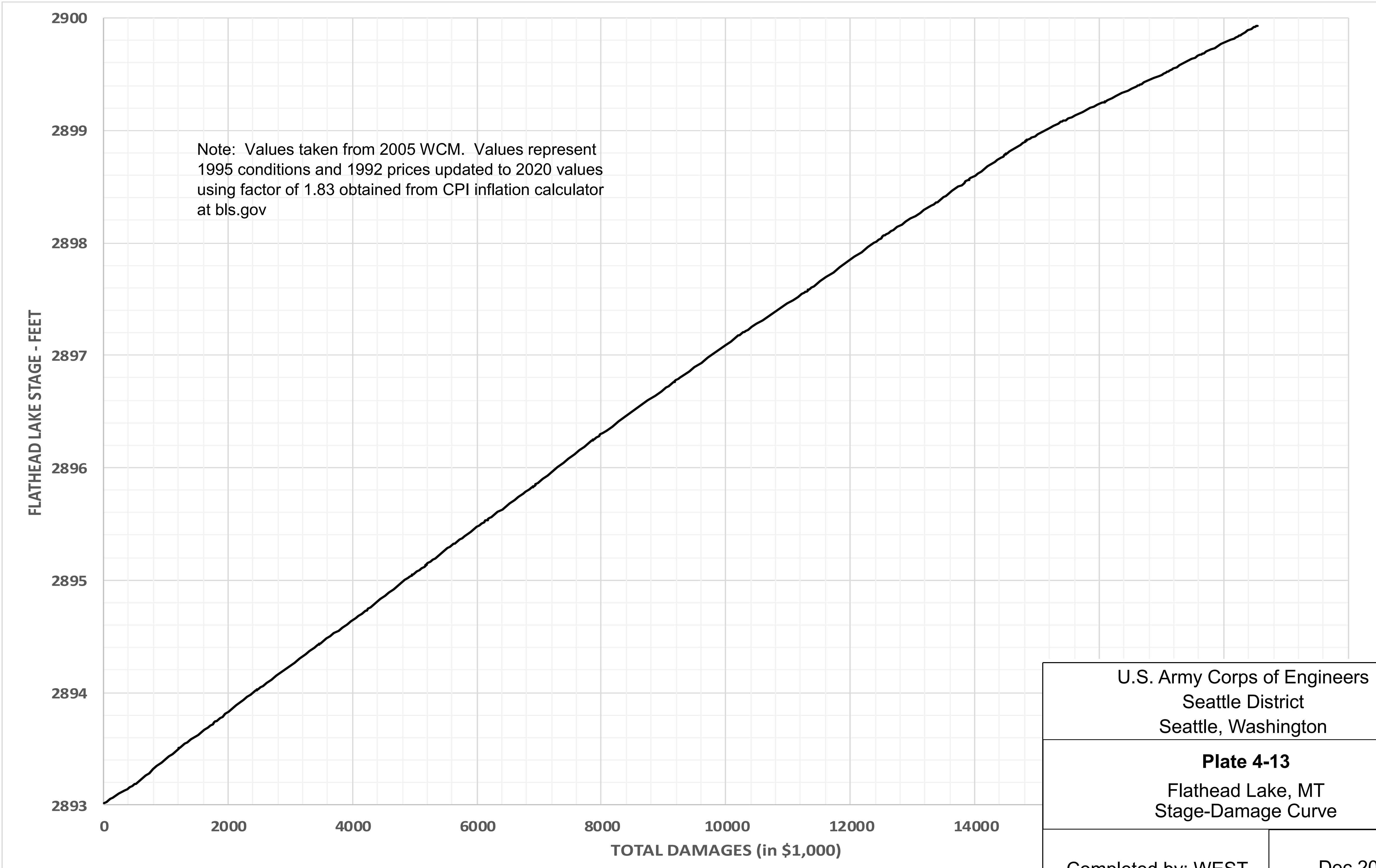
U.S. Army Corps of Engineers
Seattle District
Seattle Washington

Plate 4-11
Daily Pool Elevation Hydrographs
Hungry Horse Reservoir
1951-2020
Sheet 7 of 7

Completed by: WEST	March 2021



U.S. Army Corps of Engineers Seattle District Seattle, Washington	
Plate 4-12 Flathead River at Columbia Falls, MT Discharge-Damage Curve	
Completed by: WEST	Dec 2020

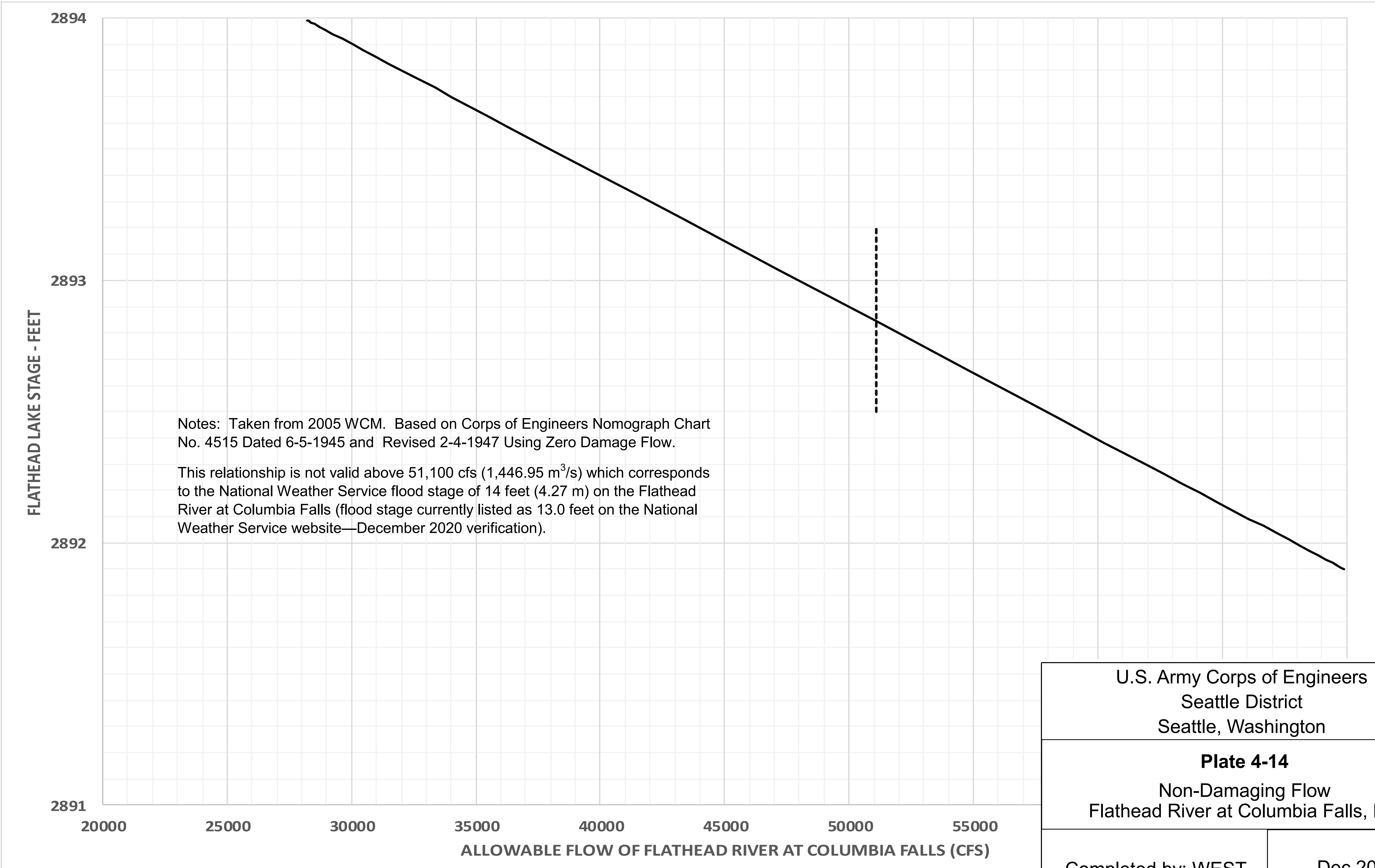


U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 4-13

Flathead Lake, MT
Stage-Damage Curve

Completed by: WEST	Dec 2020

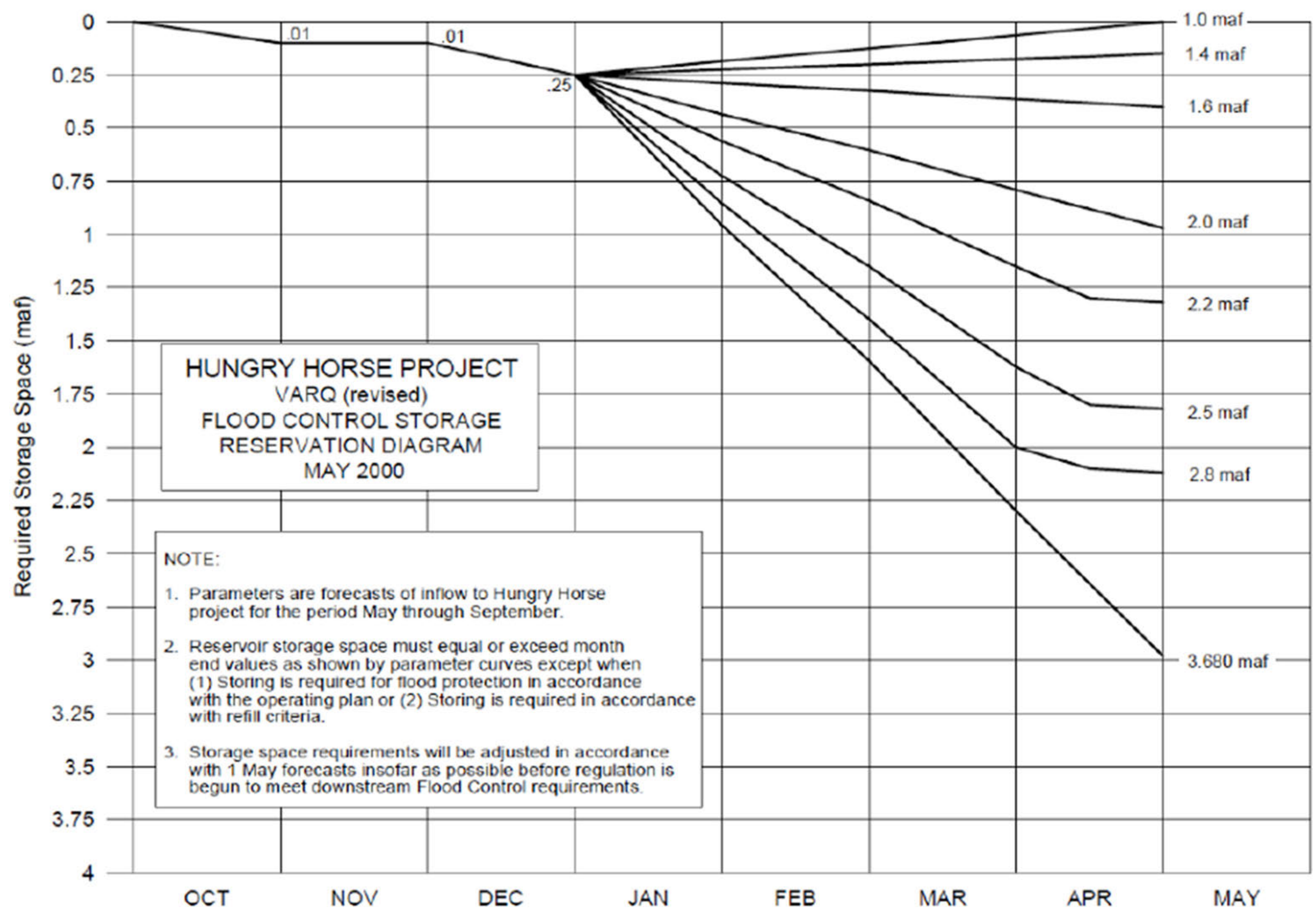


U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 4-14

Non-Damaging Flow
Flathead River at Columbia Falls, MT

Completed by: WEST	Dec 2020

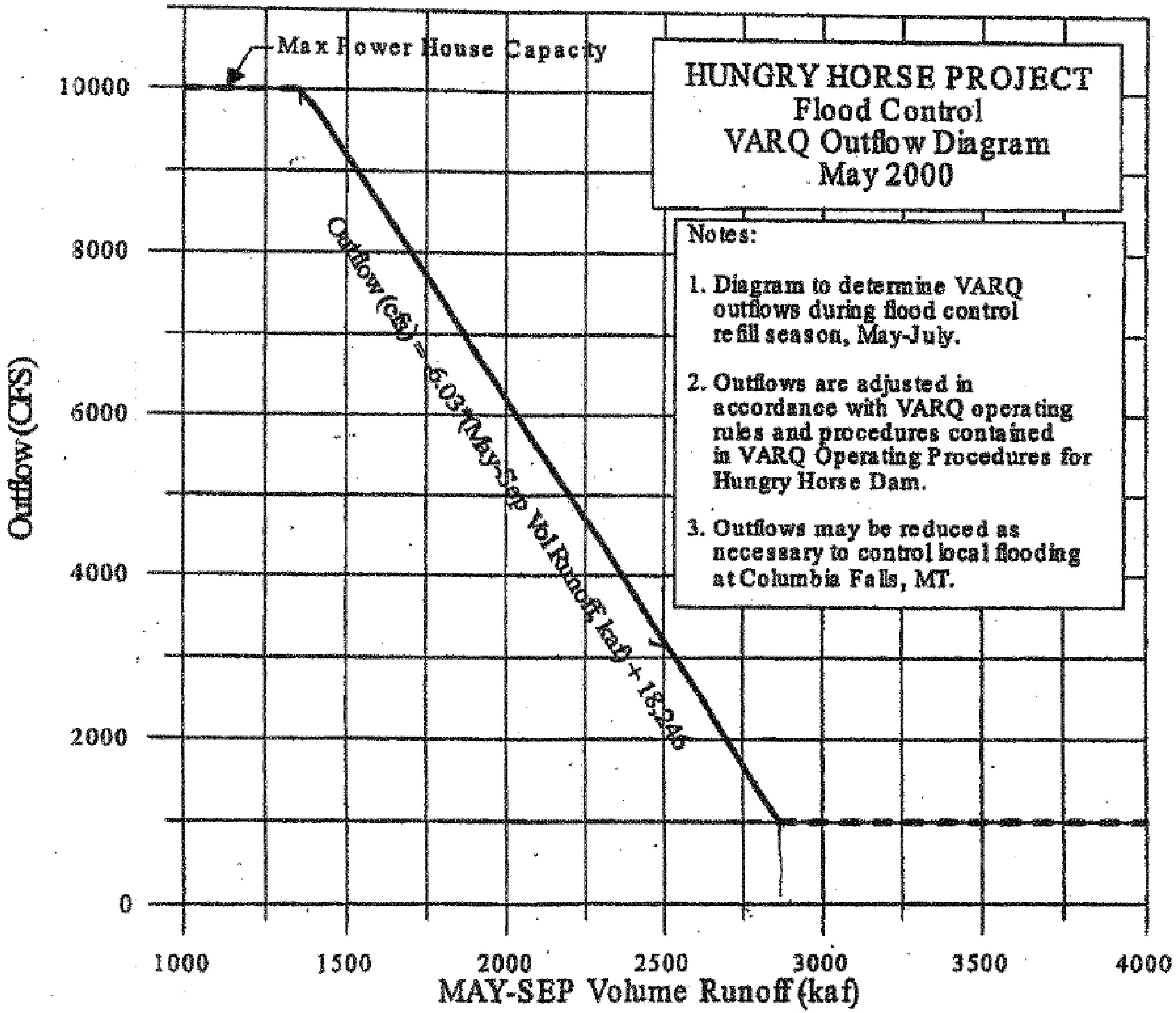


U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 7-1

Hungry Horse
VARQ FRM Storage Reservation Diagram

Notes: Source: 2020 CRSO EIS App. V , Figure 2.8	September 2022



U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 7-2

Hungry Horse
VARQ Flood Control Outflow Diagram

Notes:
Source: 2005 HGH WCM

September 2022

FLOOD CONTROL REFILL CURVE COMPUTATION

PROJECT________________ MAXIMUM CONTENTS________________

DATE________________ POWER DISCHARGE REQUIREMENT________________

MOST PROBABLE RUNOFF FORECAST, ________________

________________ THROUGH________________

95 % FORECAST ERROR________________

INFLOW FORECAST, 95 % ASSURANCE ________________

DATE	MEAN DAILY INFLOW	ACCUM. INFLOW	RESID. INFLOW VOL.	MIN. OUTFLOW THRU *July*	UPSTREAM SPACE AVAIL ABLE	AVAIL. FOR REFILL	ALLOWABLE STORAGE CONTENTS	F.C. R.C.	ACTUAL ELEV
	KSFD	KSFD	KSFD	KSFD	KSFD	KSFD	KSFD	FT	FT
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
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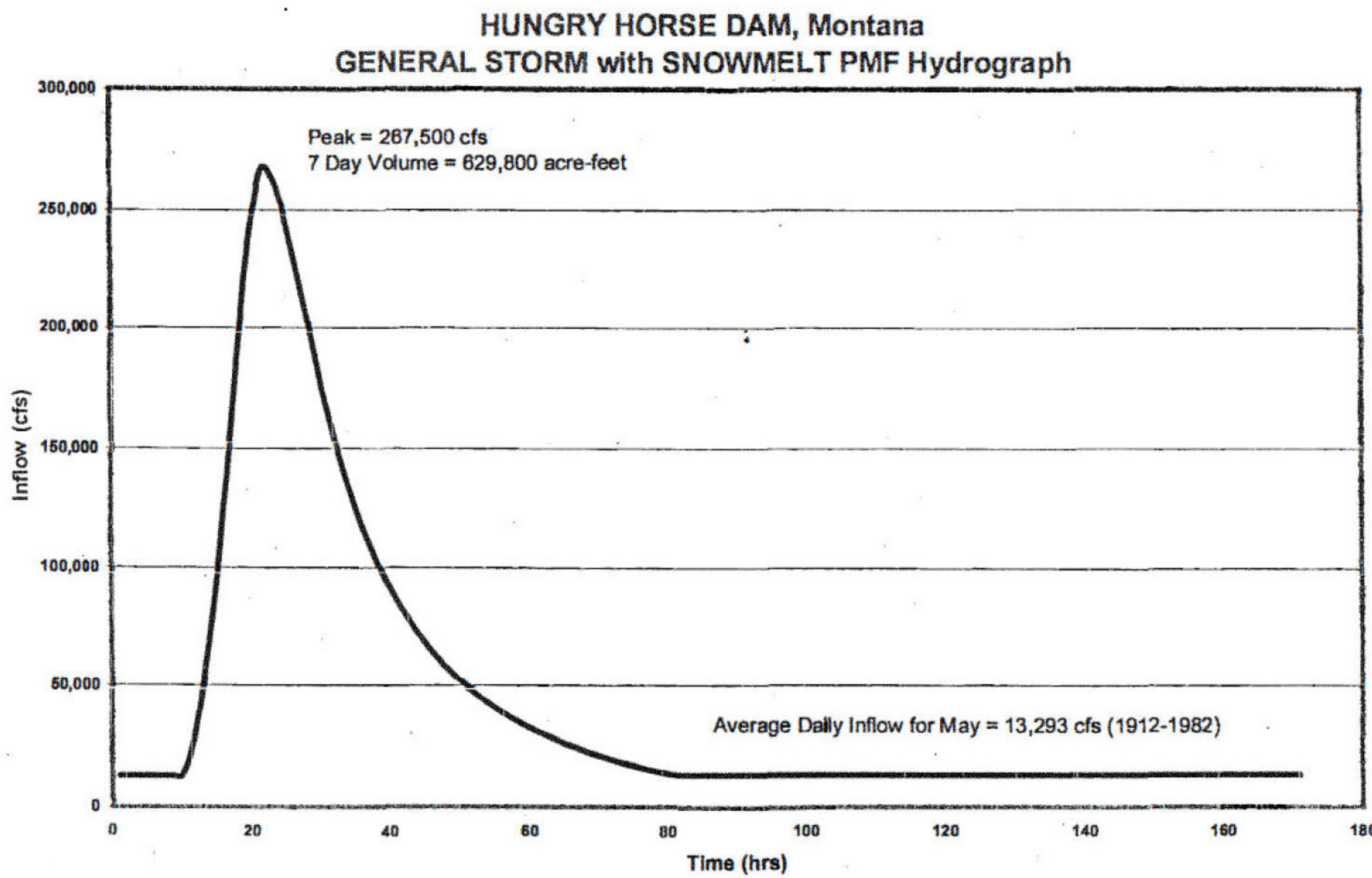


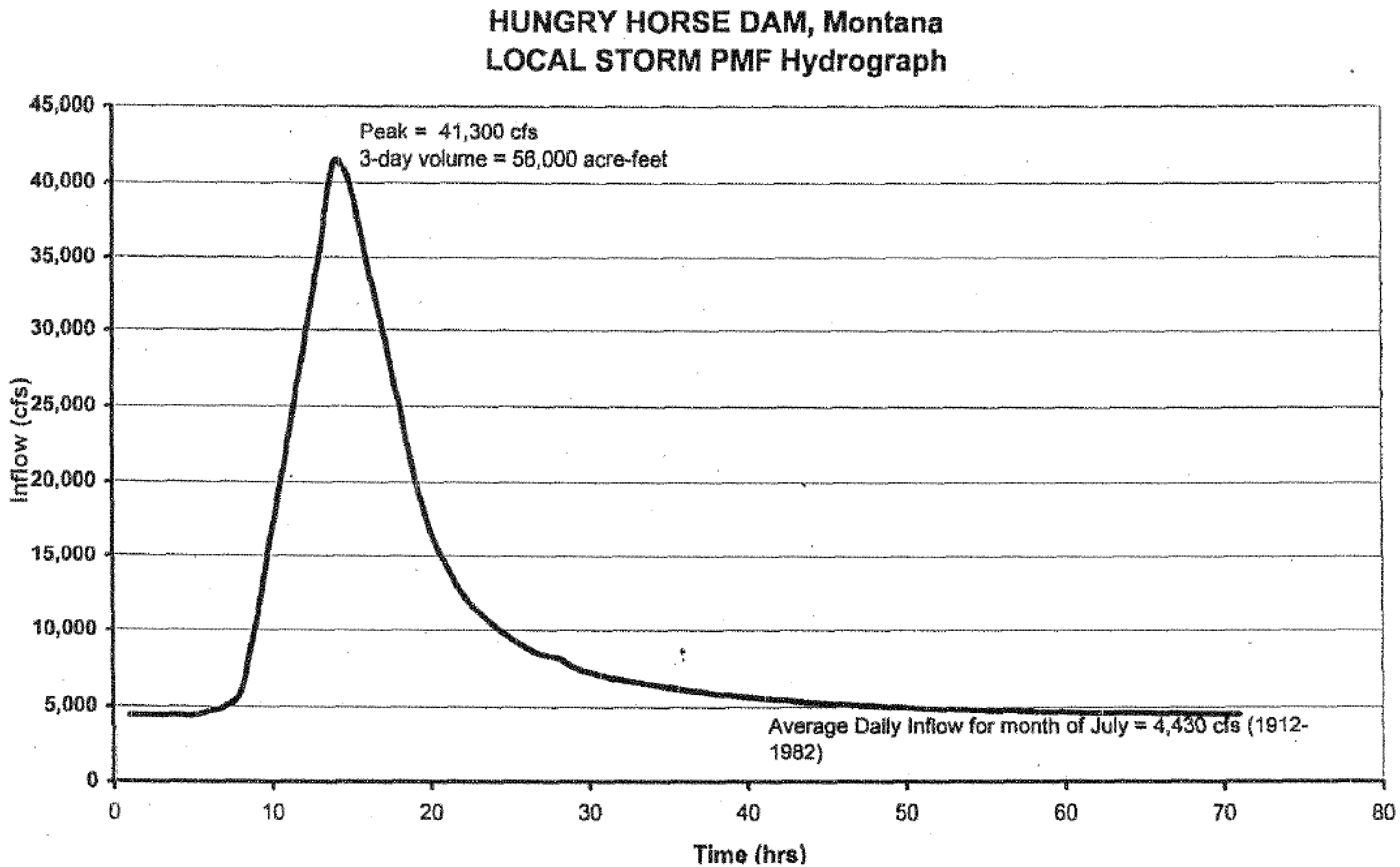
U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 8-1

Hungry Horse
General Storm with Snowmelt PMF

Notes:
Source: 2005 HGH WCM

September 2022



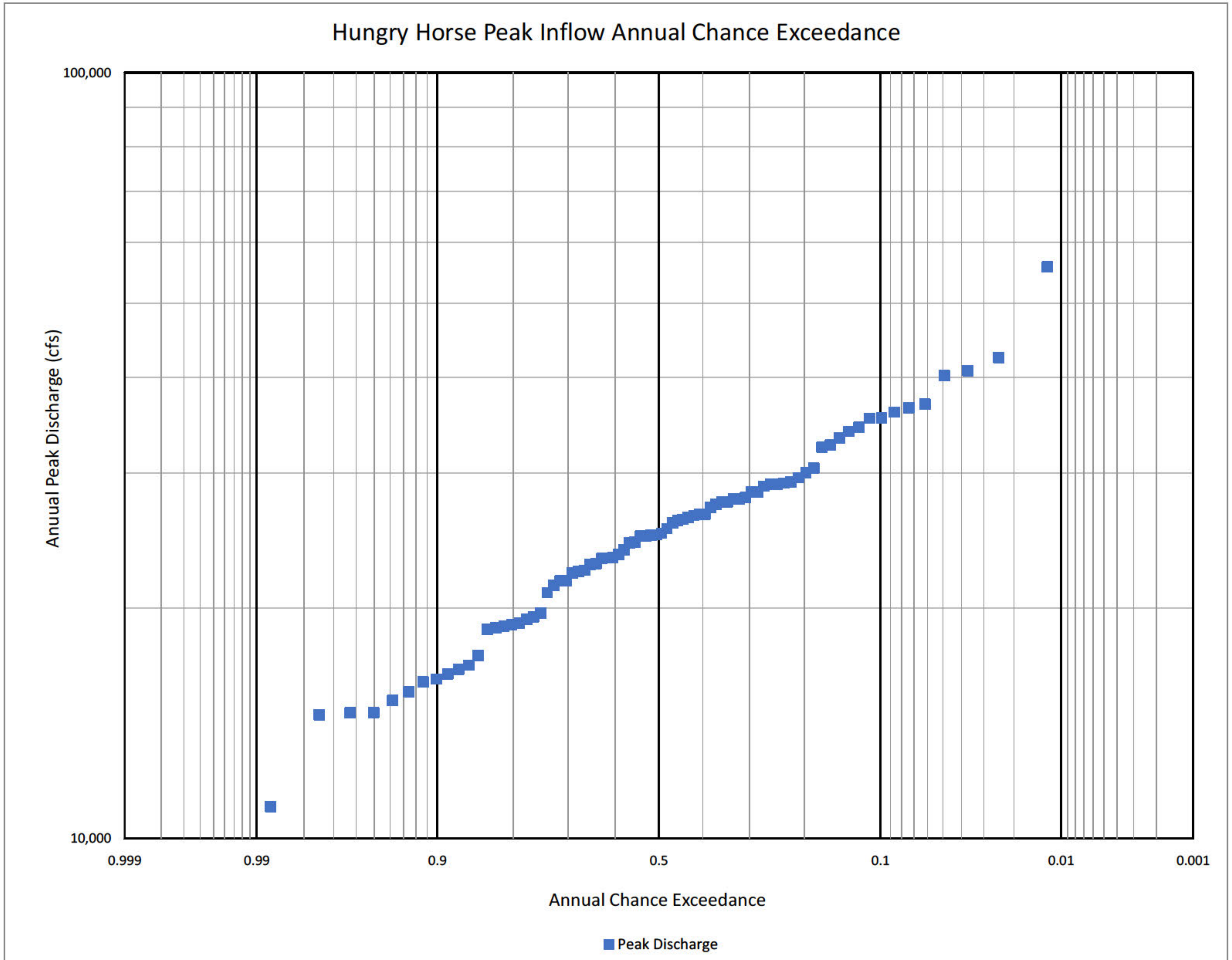
U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 8-2

Hungry Horse
Local Storm PMF Hydrograph

Notes:
Source: 2005 HGH WCM

September 2022



Annual Percent Chance Exceedance	Discharge (cfs)
1	46,952
25	29,921
Median	25,039
75	20,280
99	12,270

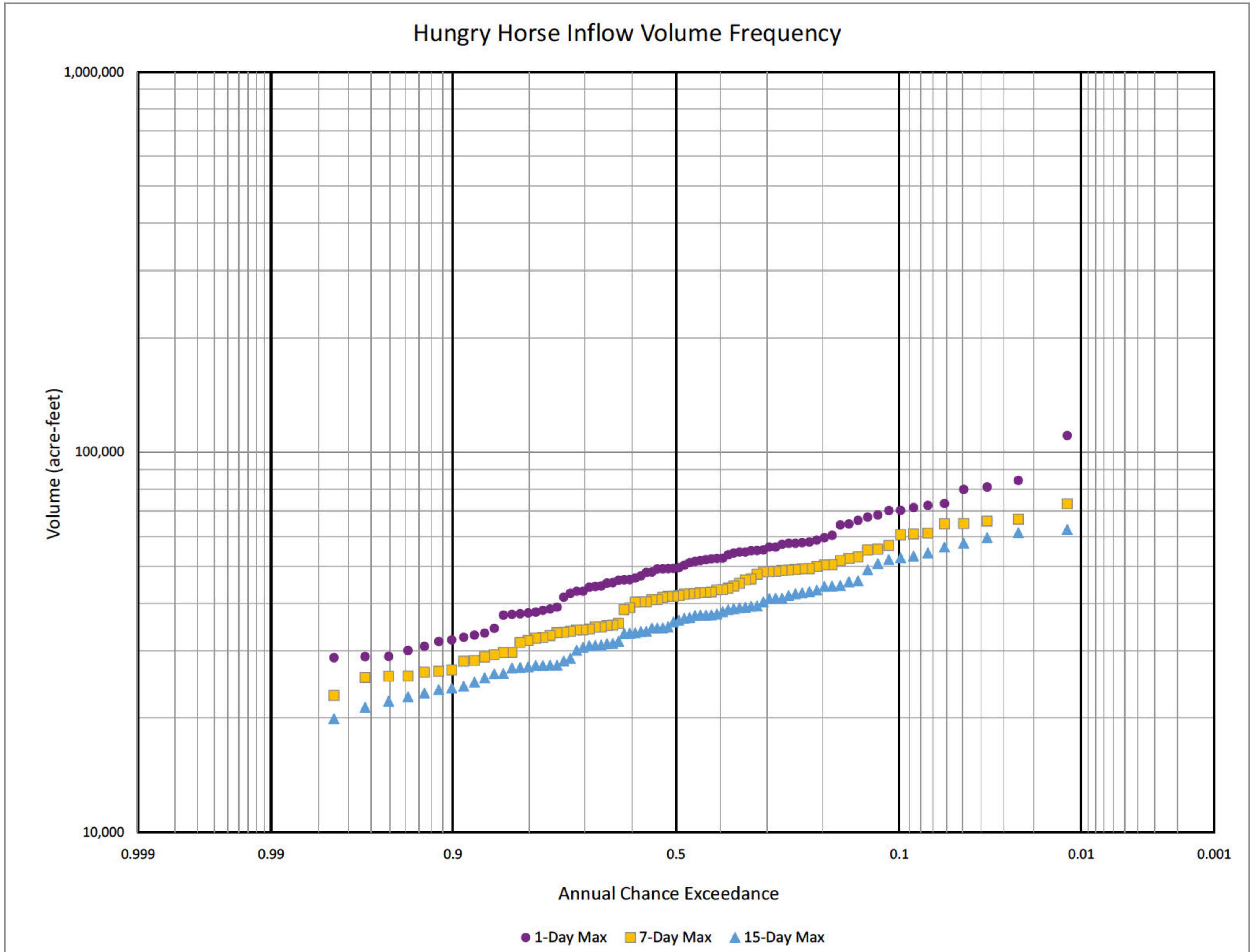
U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 8-3

Hungry Horse
Peak Inflow Annual Chance Exceedance

Notes
Data provided by USACE NWD from 2020 CRSO-EIS Study, Preferred Alternative, using 2010L modified streamflow (1928-2008).

September 2022



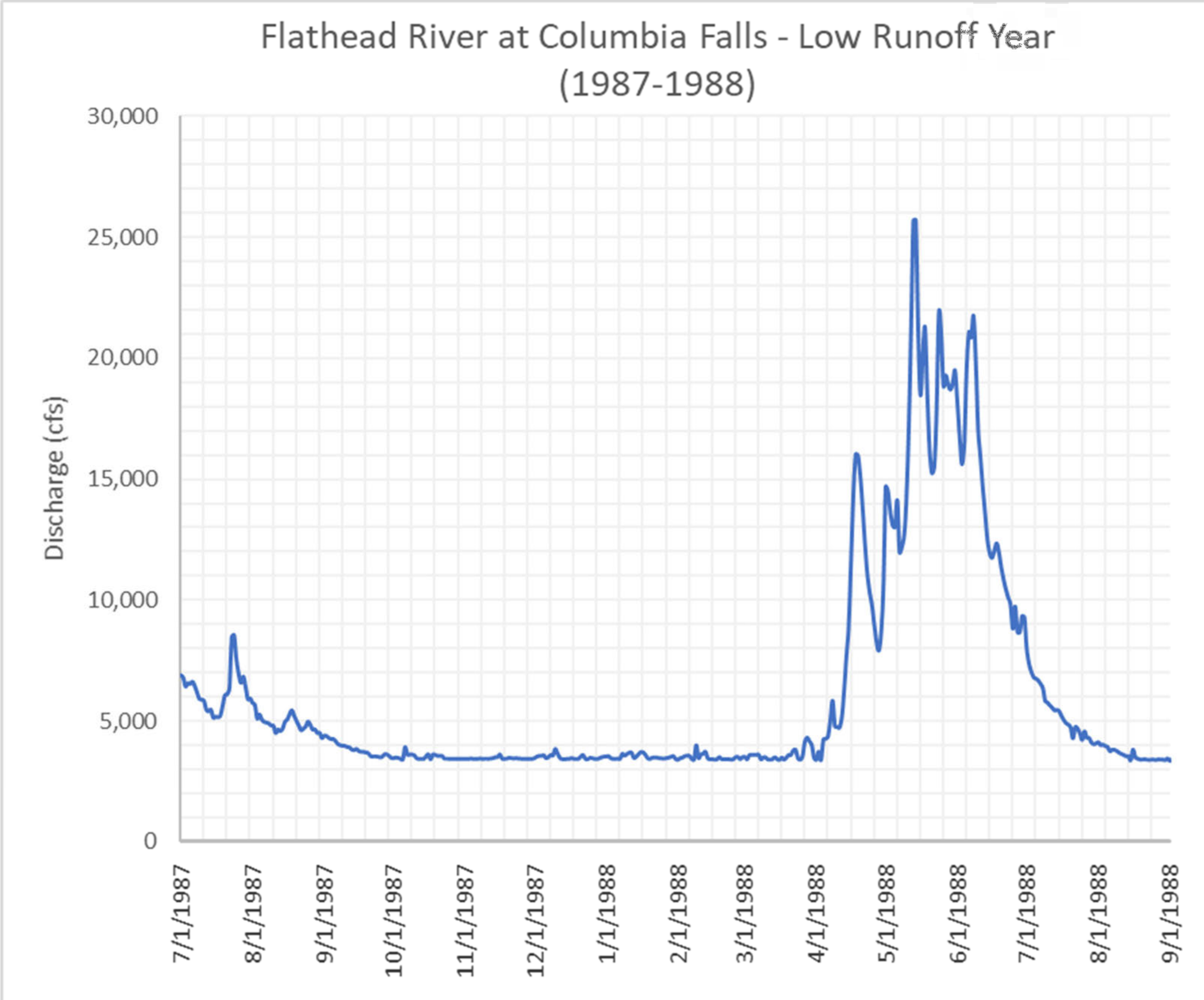
U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 8-4

Hungry Horse
Inflow Volume Frequency

Notes
Data provided by USACE NWD from 2020 CRSO-EIS Study, Preferred Alternative, using 2010L modified streamflow (1928-2008).

September 2022



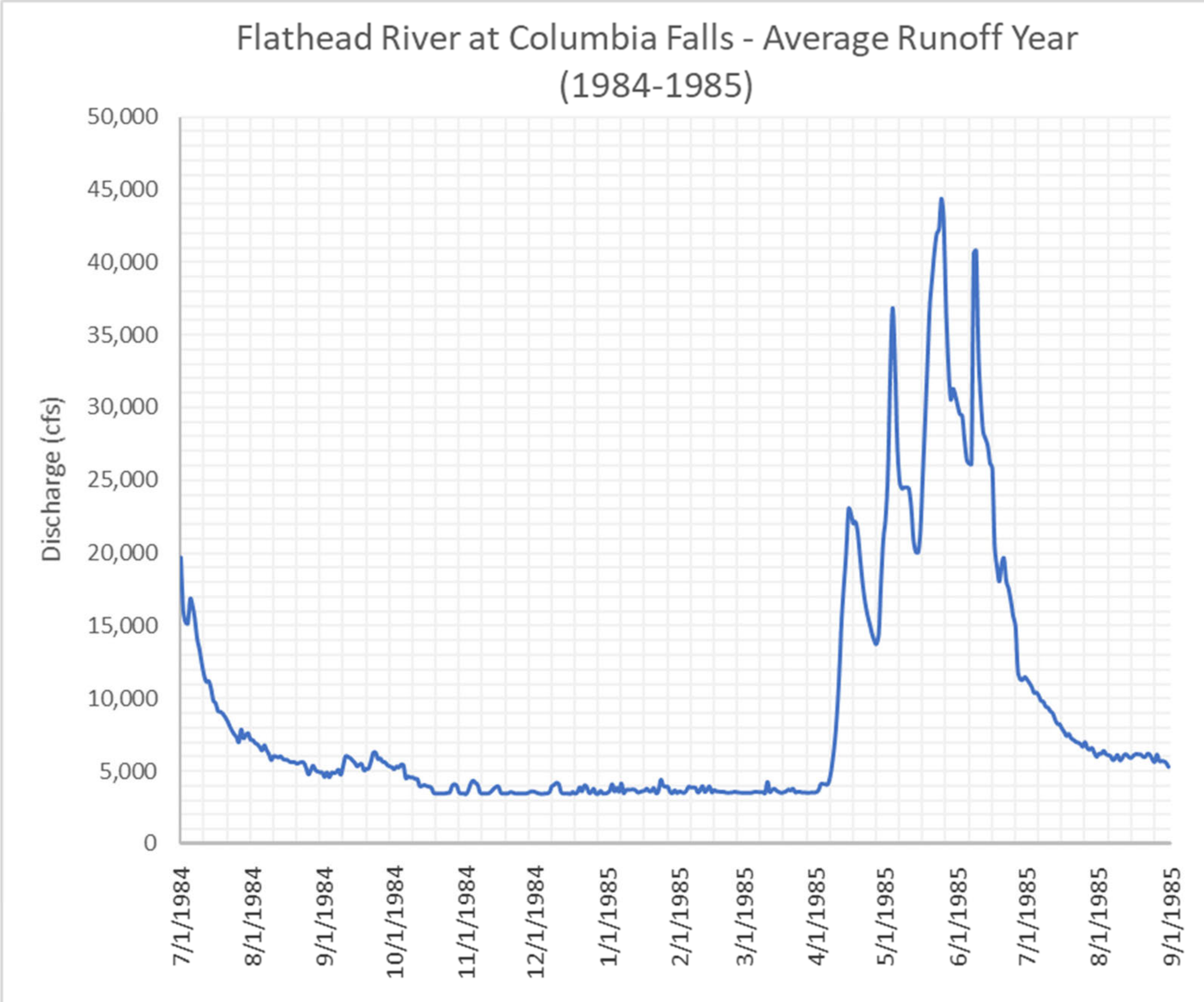
U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 8-5

Flathead River at Columbia Falls
Low Runoff Year Discharge Hydrograph (1987-1988)

Notes
Data provided by USACE NWD from 2020 CRSO-EIS Study, Preferred Alternative, using 2010L modified streamflow (1928-2008).

September 2022



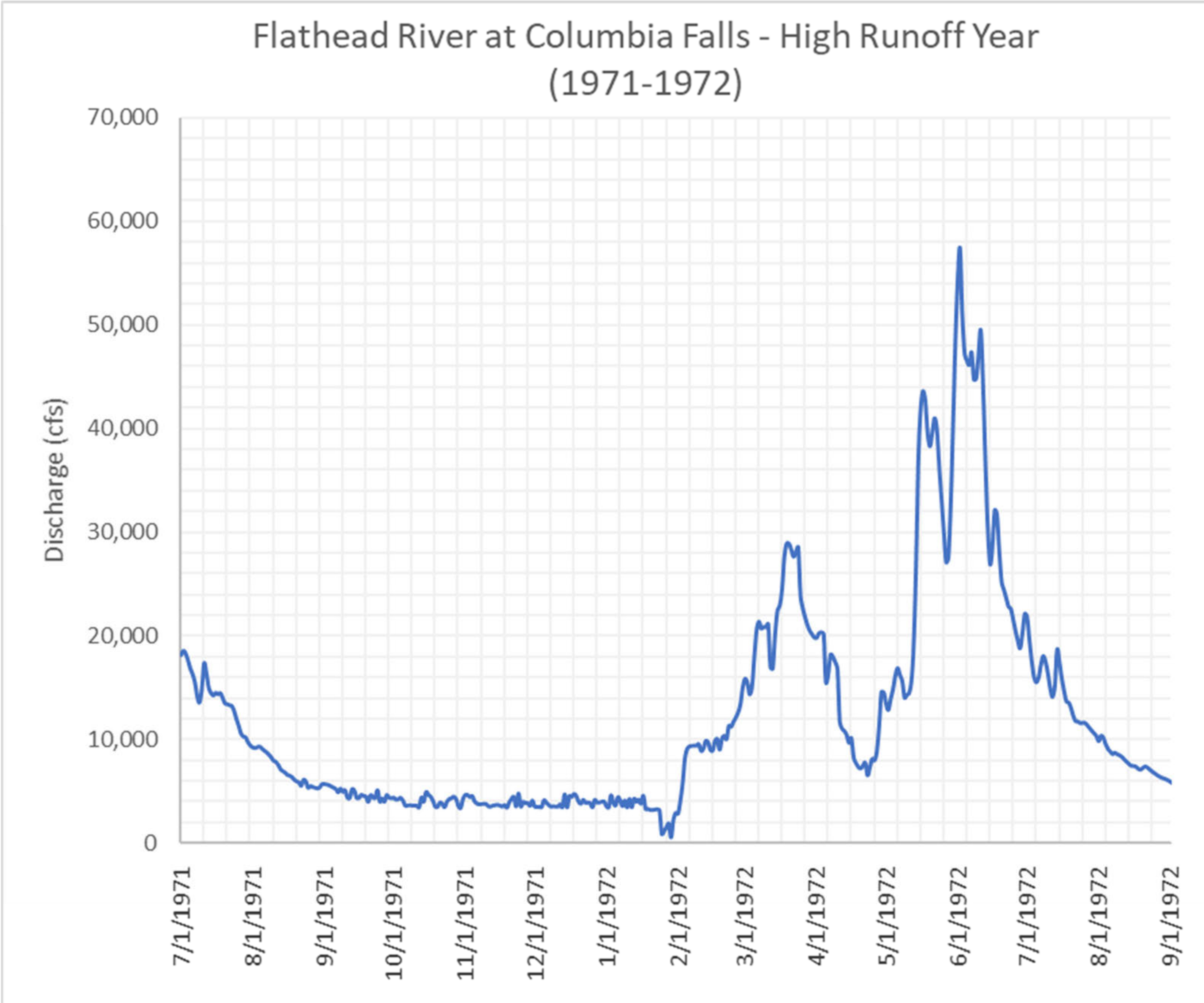
U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 8-6

Flathead River at Columbia Falls
Avg Runoff Year Discharge Hydrograph (1984-1985)

Notes
Data provided by USACE NWD from 2020 CRSO-EIS Study, Preferred Alternative, using 2010L modified streamflow (1928-2008).

September 2022

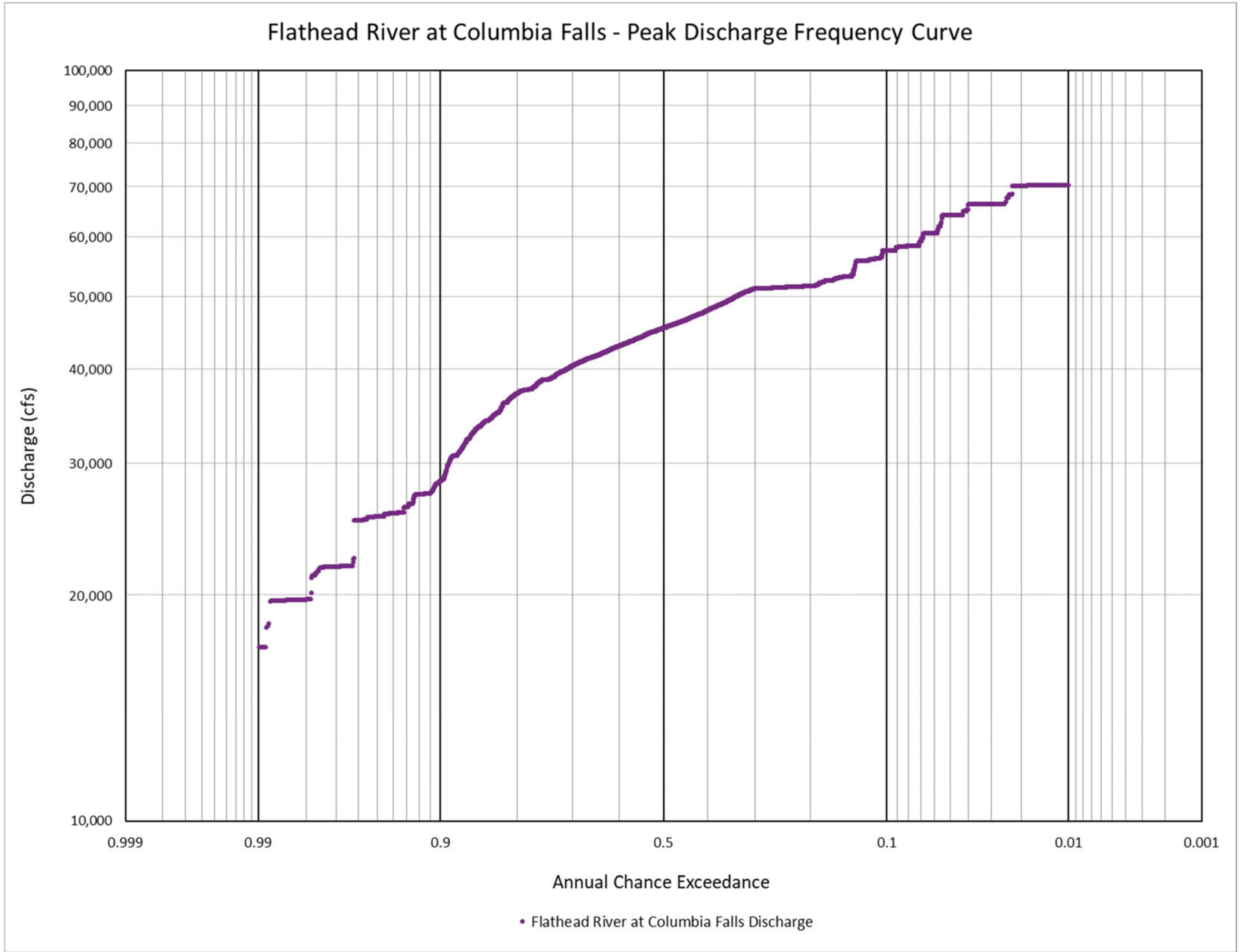


U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 8-7

Flathead River at Columbia Falls
High Runoff Year Discharge Hydrograph (1971-1972)

Notes Data provided by USACE NWD from 2020 CRSO-EIS Study, Preferred Alternative, using 2010L modified streamflow (1928-2008).	September 2022

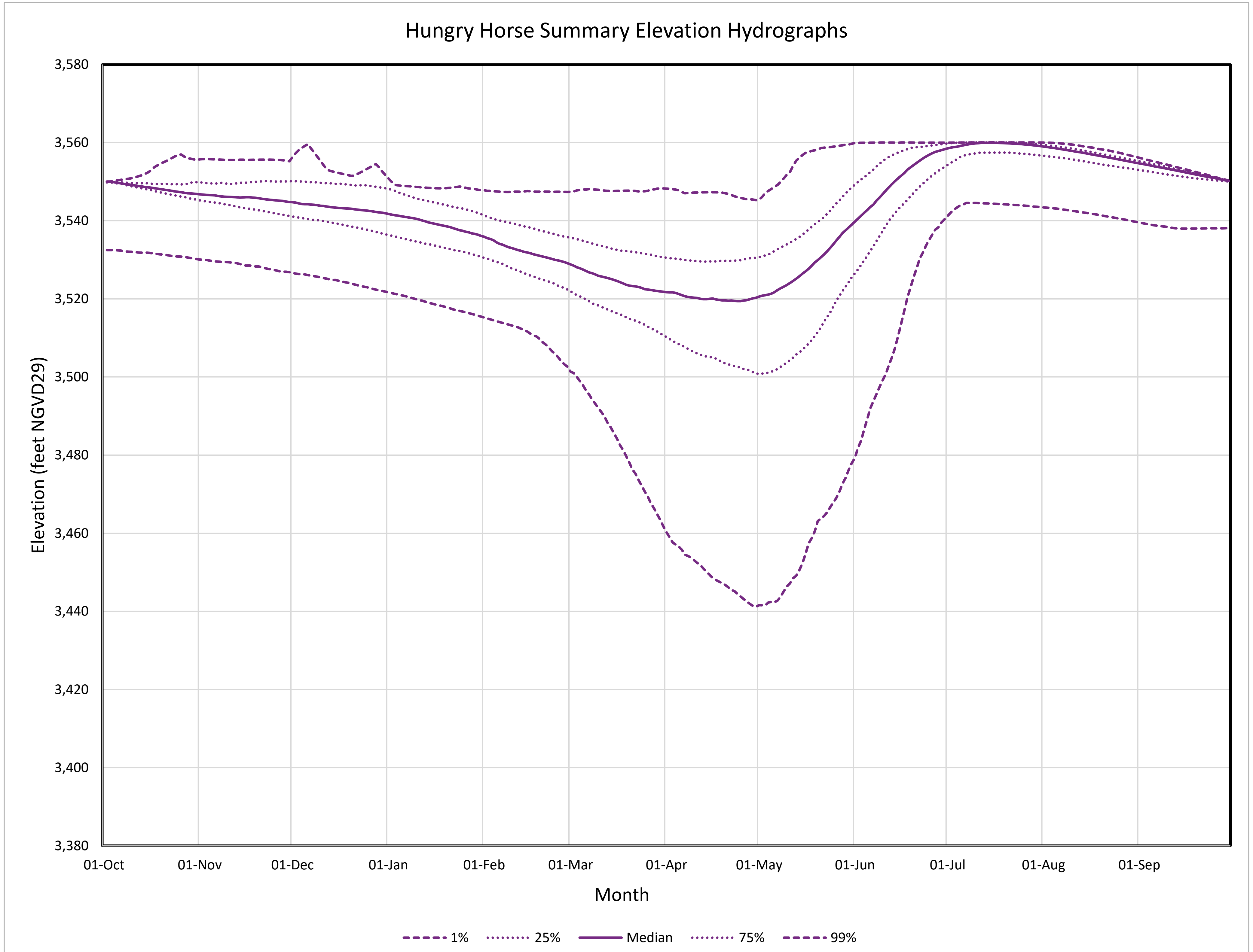


U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 8-8

Flathead River at Columbia Falls
Peak Discharge Frequency Curve

Notes Data provided by USACE NWD from 2020 CRSO-EIS Study, Preferred Alternative, using 2010L modified streamflow (1928-2008).	September 2022



U.S. Army Corps of Engineers
Seattle District
Seattle, Washington

Plate 8-9

Hungry Horse
Reservoir Summary Hydrographs - Elevation

Notes
Data provided by USACE NWD from 2020 CRSO-EIS Study, Preferred Alternative, using 2010L modified streamflow (1928-2008).

September 2022

Contract No. 14-06-100-6461

M E M O R A N D U M   O F   A G R E E M E N T

Between the

FOREST SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE

and the

BUREAU OF RECLAMATION
UNITED STATES DEPARTMENT OF THE INTERIOR

FOR ADMINISTRATION OF FOREST RESOURCES, RECREATION FACILITIES, LANDS, WATERS, AND RECLAMATION WORKS IN THE HUNGRY HORSE RESERVOIR AREA, HUNGRY HORSE PROJECT, FLATHEAD NATIONAL FOREST, MONTANA

THIS MEMORANDUM OF AGREEMENT, Made this 12th day of March, 1969, between the FOREST SERVICE, United States Department of Agriculture, hereinafter called the Service, represented by the Regional Forester, Region 1, Missoula, Montana, and the BUREAU OF RECLAMATION, United States Department of the Interior, hereinafter called the Bureau, represented by the Regional Director, Region 1, Boise, Idaho, acting pursuant to the Multiple-Use Sustained Yield Act of June 12, 1960 (74 Stat. 215); the Land and Water Conservation Fund Act of 1965 (78 Stat. 897); the Federal Water Project Recreation Act of July 9, 1965 (79 Stat. 213); and the Act of June 17, 1902 (32 Stat. 388), and all acts amendatory thereof or supplemental thereto; commonly referred to as the Federal Reclamation Laws, and such other legislation and regulations as may apply.

WITNESSETH, THAT:

2. WHEREAS, the area used for Hungry Horse Dam and Reservoir, Hungry Horse Project, Montana, hereinafter called the Reservoir Area,

located within or adjacent to the exterior boundaries of the Flathead National Forest, consists of National Forest lands reserved from the public domain which are also under reclamation withdrawal and lands acquired by the Bureau or all of which, upon transfer pursuant to the Federal Water Project Recreation Act, became National Forest lands with Weeks Law status; and

3. WHEREAS, the Order of Transfer of Administrative Jurisdiction (F.R. Vol. 30, No. 186, dated September 24, 1966, P. 12606) of the acquired lands pursuant to the Federal Water Project Recreation Act provided that all lands and waters within the Reservoir Area needed or used for the operation of the Hungry Horse Project and for other reclamation purposes shall continue to be administered by the Commissioner of Reclamation to the extent he determines necessary for such operation; and

4. WHEREAS, the parties hereto desire to terminate their existing agreement covering administration of Hungry Horse Reservoir and to make new arrangements for administration by the Service of the Reservoir Area for recreation and other National Forest System purposes consistent with reclamation requirements.

NOW, THEREFORE, the parties hereto agree as follows:

5. The Memorandum of Understanding between the parties hereto, for administration of reclamation facilities, lands and forest resources at Hungry Horse Reservoir, dated April 15, 1952, is terminated as of the date of this agreement.

6. The lands in the Reservoir Area covered by this agreement are all the lands heretofore withdrawn or acquired by the Bureau for the Hungry Horse Reservoir or in connection therewith, as shown bounded by

the line designated "Reservoir Area Boundary" on Exhibit A hereof. Exhibit A also shows those lands needed by the Bureau for operation of the dam and related facilities, which have been designated by the Bureau as the "Reclamation Zone." The Reclamation Zone is described as follows:

T. 30 N., R. 19 W., Principal Meridian, Montana
Sec. 8, Lots 1, 2, 5, S½NE¼, SE¼ and all the Reclamation acquired lands in the N½ except those tracts transferred to the Service pursuant to the Memorandum of Understanding between the parties hereto dated May 28, 1968, identified as Contract No. 14-06-100-6079.
Sec. 9, W½SW¼
Sec. 16, SW¼NE¼, W½SE¼, W½
Sec. 17, Lots 1, 2
Sec. 21, all land located southwest of the south fork of the Flathead River lying below elevation 3600 feet and all land located northeast of the river lying below elevation 3700 feet.
Sec. 22, NW¼SW¼, S½S½
Sec. 27, N½
Sec. 28, that portion of the N½ located along the south fork of the Flathead River and lying below elevation 3600 feet.

7. Development and administration of the Reservoir Area shall be carried out in accordance with a Reservoir Area Management Plan and any modifications thereof assembled by the Bureau and the Service to facilitate mutual understanding and coordinated administration of the reservoir and related areas. This Plan will encompass all lands and waters in the Reservoir Area. As a part of said Plan, the Service agrees to prepare in consultation with the Bureau, a Recreation and Related Resources Management section describing sites and proposed development sequence of recreation developments, together with a description of proposed management of the other resources. The Bureau agrees to prepare in cooperation

with the Service, a Reservoir Operation section which shall describe reservoir operational and other requirements so as to facilitate effective administration of the Reservoir Area. Significant deviations from the provisions or prescriptions of said Plan will be undertaken only with the concurrence of both agencies.

8. The Service recognizes the need of the Bureau to vary, as it deems necessary, the water surface of the reservoir as required for daily or other operations of or in connection with the operation and maintenance of its reservoir works as they are now constructed, and the Service agrees to reserve this right of the Bureau in all permits, agreements, and contracts granted or entered into by it.

9. The Bureau agrees that the Service may take free of charge from the Hungry Horse Reservoir such water as is necessary for normal campground and other general administrative needs of the Service and for the needs of its recreational concessionaires in the areas immediately adjacent thereto and such other water as is necessary for control of forest fires. The Service agrees that the taking or use of water from the Hungry Horse Reservoir for any other purpose shall be solely under the jurisdiction and authority of the Bureau.

10. The Bureau agrees to provide the Service, upon request and to the extent practicable, with an annual operation schedule for the Reservoir and as much advance notice of major planned deviations therefrom as possible.

11. The Service and the Bureau agree to include in all leases, licenses, permits, or contracts, issued by them pertaining to the Reservoir Area, provisions by which the lessee, licensee, permittee, or contractor undertakes to indemnify and hold harmless the Federal Government, its officers, agents, and employees, as to any liability for injury or damage to persons or property arising out of the acts or omissions, negligent or otherwise, of the lessee, licensee, permittee, or contractor.

12. The Service agrees in connection with its management activities in the Reservoir Area, except in the Reclamation Zone, to assume without reimbursement therefor, responsibility for disposal of floatable debris in the Reservoir and of hazardous, undermined, or fallen trees on National Forest land adjacent to the Reservoir in accordance with mutually agreed upon procedures.

13. Revenues collected by the Service for occupancy or use of the Reservoir Area and its resources in connection with its administration of the same for recreation and other National Forest System purposes, shall be distributed in accordance with law.

14. The Service and the Bureau shall cooperate with each other and with the State, county, and other Federal or local organizations in the performance of weed control measures on lands and waters covered by this agreement, including concurrence regarding species of plants proposed for establishment in the Reservoir Area.

15. The Service shall furnish the Bureau after December 31 each year data required for the Bureau's annual recreation and wildlife summary report on the Hungry Horse Reservoir.

16. This agreement shall not obligate the Bureau or the Service to make future payments or expenditures in excess of appropriations authorized by law.

17. This Memorandum of Agreement shall be effective from the day first above written and may be amended, supplemented, or superseded at any time by mutual consent of the Regional Forester and the Regional Director. Within 1 year of the signing of a new nationwide master agreement between the Bureau and the Service, this agreement will be jointly reviewed, and if necessary, modified to correspond with the terms of the new nationwide master agreement.

FOREST SERVICE
DEPARTMENT OF AGRICULTURE

By [signature]
Regional Forester, Region 1
Missoula, Montana

BUREAU OF RECLAMATION
DEPARTMENT OF THE INTERIOR

By Norman H. Moore
Acting Regional Director, Region 1
P. O. Box 8008, Boise, Idaho

EXHIBIT 3-1

[PUBLIC LAW 329–78TH CONGRESS]
[CHAPTER 234–2ND SESSION]
AN ACT

To provide for the partial construction of the Hungry Horse Dam on the South Fork of the Flathead River in the State of Montana, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That for the purpose of irrigation and reclamation of arid lands, for controlling floods, improving navigation, regulating the flow of the South Fork of the Flathead River, for the generation of electric energy, and for other beneficial uses primarily in the State of Montana but also in downstream areas, the Secretary of the Interior is authorized and directed to proceed as soon as practicable with the construction, operation, and maintenance of the proposed Hungry Horse Dam (including facilities for generating electric energy) on the South Fork of the Flathead River, Flathead County, Montana, to such a height as may be necessary to impound not less than one million acre-feet of water.

SEC. 2. The Secretary of the Interior is authorized to complete, as soon as the necessary additional material is available, the construction of the Hungry Horse Dam so as to provide a storage reservoir of the maximum usable and feasible capacity.

SEC. 3. The Secretary of the Interior is authorized to construct, operate, and maintain under the provisions of the Federal reclamation laws (Act of June 17,1902, 32 Stat. 388 and Acts amendatory thereof or supplementary thereto), such additional works as he may deem necessary for irrigation purposes. Such irrigation works may be undertaken only after a report and findings thereon have been made by the Secretary of the Interior as provided in such Federal reclamation laws; and, within the limits of the water user's repayment ability, such report may be predicated on allocation to irrigation of an appropriate portion of the cost of constructing said dam and reservoir. Said dam and reservoir and said irrigation works may be utilized for irrigation purposes only pursuant to the provisions of said Federal reclamation laws.

SEC. 4. There are authorized to be appropriated such sums as may be necessary to carry out the purposes of this Act.

Approved June 5, 1944.

VARQ Operating Procedures for Hungry Horse Dam

February 2001

Prepared by

U.S. Army Corps of Engineers
Northwestern Division
North Pacific Region
Portland, Oregon

Introduction. This report contains the information necessary to implement the VARQ flood control procedure at Hungry Horse Dam. The general rules that govern the VARQ flood control procedure are listed below.

Rule 1. Storage Reservation Diagrams. The Hungry Horse storage reservation diagram (Figure 1) guides the evacuation of space that is needed for controlling spring runoff in the Flathead Basin and in the lower Columbia River. Flood control space is a function of the May-September water supply forecast. Following evacuation (after May 1) the project are required to maintain this space until the initiation of refill. During evacuation and up until the initiation of refill, outflows should be limited to hydraulic capacity of the powerhouse to the best extent possible. However, situations such as the loss of hydraulic capacity or rapidly changing forecasts may require spill to meet flood control requirements.

Rule 2. Initiation of Refill. Initiation of refill is determined by the operating procedures for system flood control on the lower Columbia River. These procedures are described in Columbia River Treaty, Flood Control Operating Plan, October 1999. At Hungry Horse, refill is initiated approximately ten days prior to when streamflow forecasts of unregulated flow are projected to exceed the Initial Control Flow (ICF) at The Dalles, Oregon. This criteria applies most of the time: however, if the reservoir intersects with its flood control refill curve (FCRC) prior to ICF being reached, then refill is initiated at that time. The FCRC is a refill curve that fills the reservoir with 95 percent confidence at minimum outflow.

Rule 3. Initial VARQ Outflow. Use VARQ Outflow Diagram (Figure 2) to determine an initial VARQ outflow for Hungry Horse (VQ).

Rule 4. Adjusting VARQ Outflows for Delta Storage. Adjust the initial VARQ outflows, if necessary, to compensate for any storage difference between the actual May 1 reservoir level and the space required for flood control. This difference can reflect under or over-drafted conditions delta storage (DS). This is done in the following manner for the following forecast conditions:

a. May-Sep inflow forecast greater than 2,200 thousand acre-feet (kaf).

Estimate the duration of the system flood control operation (DUR) using Chart 13 (Figure 3) in Columbia River Treaty, Flood Control Operating Plan, October 1999. Select the appropriate curve based on the level of the latest projected control flow at The Dalles (ICF). From the selected curve determine the flood control duration using the April-August runoff forecast for The Dalles. Use this value to compute the VARQ storage adjustment (AS) in part c.

b. May-Sep inflow forecast less than or equal to 2,200 thousand acre-feet (kaf).

Hungry Horse is operated primarily for local flood control. For VARQ computations the duration of the flood control operation (DUR) is set to end at the end of June. Determine

DUR as the number of days from the initiation of refill (Rule 2) to June 30 and use this value to compute the VARQ storage adjustment (AS) in part c.

c. Compute the VARQ storage adjustment:

$$AS_{m,i} = [DS_{m,i} \times 0.5(ksfd/kaf)] / DUR_{m,i}$$

Where:

AS is the storage adjustment in ksfd for water supply forecast m and computation i

DS is the delta storage in kaf from the 1 May flood control requirement for water supply forecast m and computation i

DUR is the estimated flood control duration in days for water supply forecast m and computation i

Next, compute the new VARQ outflow:

$$VQ_{m,i+1} = VQ_{m,i} + AS_{m,i}$$

Where:

VQ is the VARQ seasonal outflow for water supply forecast m

d. If the runoff forecast at The Dalles is less than 85 million acre-feet, it is likely that system flood control of any significant duration will not be necessary for the lower Columbia River. Use streamflow forecasts to adjust VARQ outflows, if necessary, to compensate for any storage difference between the actual May 1 reservoir level and the space required for flood control. Reduce the VARQ outflows as necessary to provide protection against local flooding and to improve the likelihood of refill.

Rule 5. Adjusting VARQ Outflows for Prior VARQ Releases.

VARQ releases are seasonal in nature, generated using seasonal runoff forecasts. This rule accounts for the difference in outflows released since the initiation of refill and the new VARQ outflow developed using the updated runoff forecast:

$$AD_{m,i+1} = [VQ_{m,i+1} - VQ_{m,i}] \times [PR_{m,i} \ / [DUR_{m,i+1} - PR_{m,i}]]$$

Where:

AD is the adjustment for prior releases of VARQ outflows in ksfd for water supply forecast m and computation i

Compute final VARQ outflow:

$$VQ_{m,i+2} = VQ_{m,i+1} + AD_{m,i+1}$$

Rule 6. Inflows Less Than VARQ Outflows. At the initiation of refill, if inflows are less than the VARQ outflow, pass inflow until inflows rise to the VARQ level. Thereafter, if inflows drop below the VARQ outflow, pass inflow until they rise again to the VARQ level.

Rule 7. Updating VARQ Outflows During Refill Season. Update VARQ outflows throughout the refill season, May through June, as new runoff forecasts are developed. Use streamflow forecasts to evaluate the performance of the VARQ outflows in meeting system and local flood control objectives. Reduce VARQ outflows if necessary to provide protection from local flooding. Return to VARQ outflows once local flooding is over. When reducing Hungry Horse outflows, keep in mind that minimum project outflow when Columbia Falls stage is greater than 13.0 feet (52,000 cfs) is 145 cfs.

Rule 8. Final Stages of Refill. Adjust VARQ outflows during the final stages of refill to avoid overfilling and unwanted spill. Use streamflow forecasts and engineering judgement to select the appropriate outflows.

EXAMPLE

Water Year: 1997
Condition: High runoff year, 2932 kaf, 153% of the 1961-1990 normal.
Figure 4 shows the daily reservoir operation.

January 1 – April 30:

Ops: Evacuation of flood control space.

April May-Sep Runoff Forecast for Hungry Horse	2731 kaf
Rule 1. Flood Control Space Requirement	2049 kaf
Flood Control Elevation	3445.6 ft
Observed Space	2049 kaf
Observed Pool Elevation	3445.6 ft
April Apr-Aug Runoff Forecast for The Dalles	125 maf
Initial Control Flow at The Dalles	494 kcfs

May 1:

Ops: Maintain Pool at 3445.6 ft until initiation of refill.

May 2:

Ops: Refill begins (Rule 2). IFC is reached in unregulated streamflow forecast ten days out on May 11.

Rule 3. Initial VARQ Outflow	1.78 kcfs
Rule 4. Delta Storage (2049–2049=0)	0 kaf
Rule 4. Duration	63 days
Rule 4. VARQ Delta Storage Adjustment	0 kcfs
Rule 4. Final VARQ Outflow (1.78+0=1.78)	1.78 kcfs

May 9:

Ops: May runoff forecast issued. Determine lookback adjustment to flood control space requirement for May 1 and, if necessary, adjust VARQ outflows.

May May-Sep Runoff Forecast for Hungry Horse	2861 kaf
Rule 1. May 1 Flood Control Space Requirement	2179 kaf
May 1 Flood Control Elevation	3424.5 ft
Rule 3. Initial VARQ Outflow	0.99 kcfs
Rule 4. Delta Storage (2179–2049=130)	130 kaf
May Apr-Aug Runoff Forecast for The Dalles	130 maf
Initial Control Flow at The Dalles	518 kcfs
Rule 4. New Duration	67 days

Rule 4. VARQ Storage Adjustment (130*0.504)/67=0.98	0.98 kcfs
Rule 4. New VARQ Outflow (0.99+0.98=1.97)	1.97 kcfs
Rule 5. Prior Release Duration	7 days
Rule 5. Duration Adjustment (1.97-1.78)*(7/(67-7))=0.02	0.02 kcfs
Rule 5. Final VARQ Outflow (1.97+0.02=1.99)	1.99 kcfs

May 16 – 18:

Ops: Reduce outflows to minimum for local flood control at Columbia Falls (Rule 7).

May 19 – 31:

Ops: Resume VARQ outflows of 1.99 kcfs.

June 1 –2:

Ops: Reduce outflows to minimum for local flood control at Columbia Falls (Rule 7).

June 3 – 7:

Ops: Resume VARQ outflows of 1.99 kcfs.

June 8 – 14:

Ops: June runoff forecast issued. Use new runoff forecast and latest streamflow forecast to adjust VARQ outflow. Determine regulation that provides protection against flooding and limits unnecessary spill.

June May-Sep WSF for Hungry Horse	2901 kaf
Rule 1. May 1 Lookback Flood Control Space Requirement	2221 kaf
Rule 3. Initial VARQ Outflow	0.75 kcfs
Rule 4. Delta Storage (2221-2049=172)	172 kaf
June Apr-Aug WSF for The Dalles	136 maf
Initial Control Flow at The Dalles	530 kcfs
Rule 4. New Duration	68 days
Rule 4. VARQ Storage Adjustment (172 x 0.504)/68=1.28	1.28 kcfs
Rule 4. New VARQ Outflow (0.75+1.28=2.03)	2.03 kcfs
Rule 5. Prior Release Duration	37 days
Rule 5. VARQ Duration Adjustment	
(2.03-Average Previous VARQ Outflows)*(37/(68-37))=0.39	0.39 kcfs
Rule 5. Final VARQ Outflow (2.03+0.39=2.42)	2.42 kcfs

June 15 – 30:

Ops: VARQ outflows adjusted during the final stages of refill to avoid overfilling and unwanted spill (Rule 8). Outflows selected using streamflow forecasts and engineering judgement.

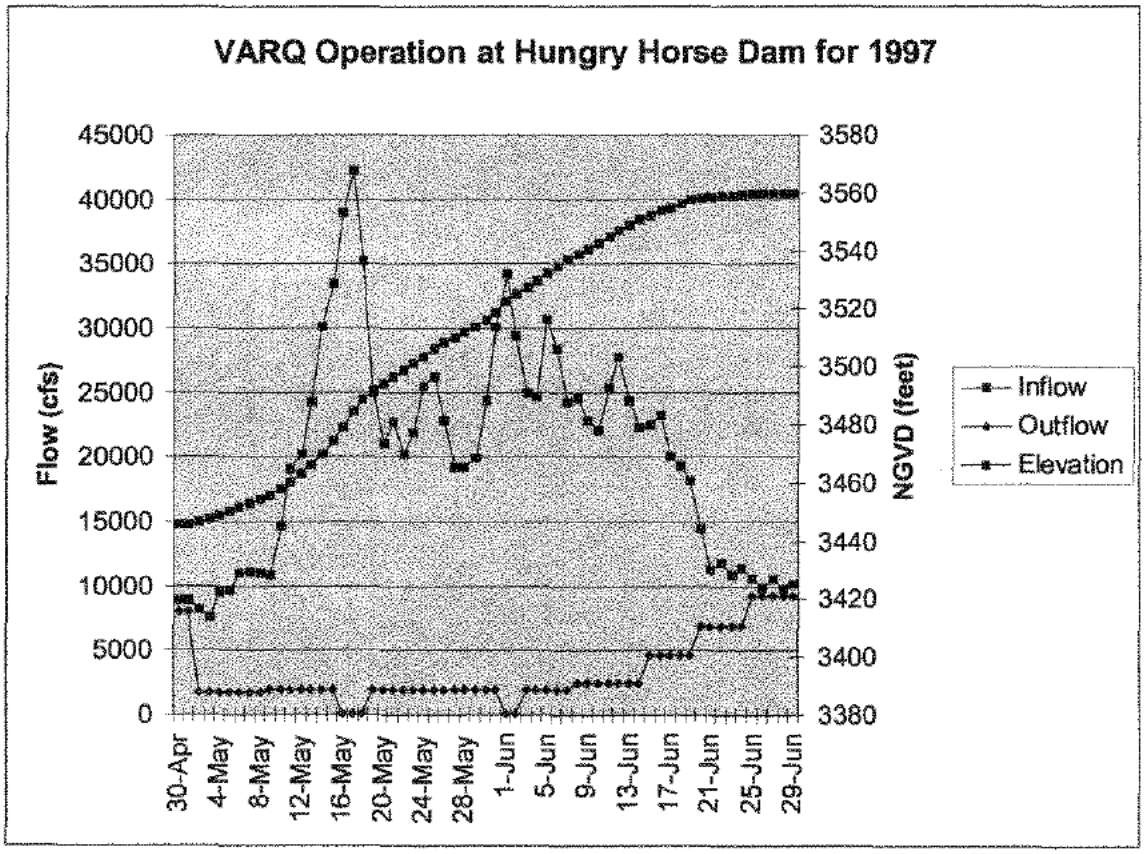


Figure 4. Example of VARQ Operation at Hungry Horse for the Spring 1997.