Redacted for Public Version

US Army Corps
of Engineers®
Portland District

Appendix 1-H to Willamette Master Water Control Manual

Water Control Manual Foster Lake

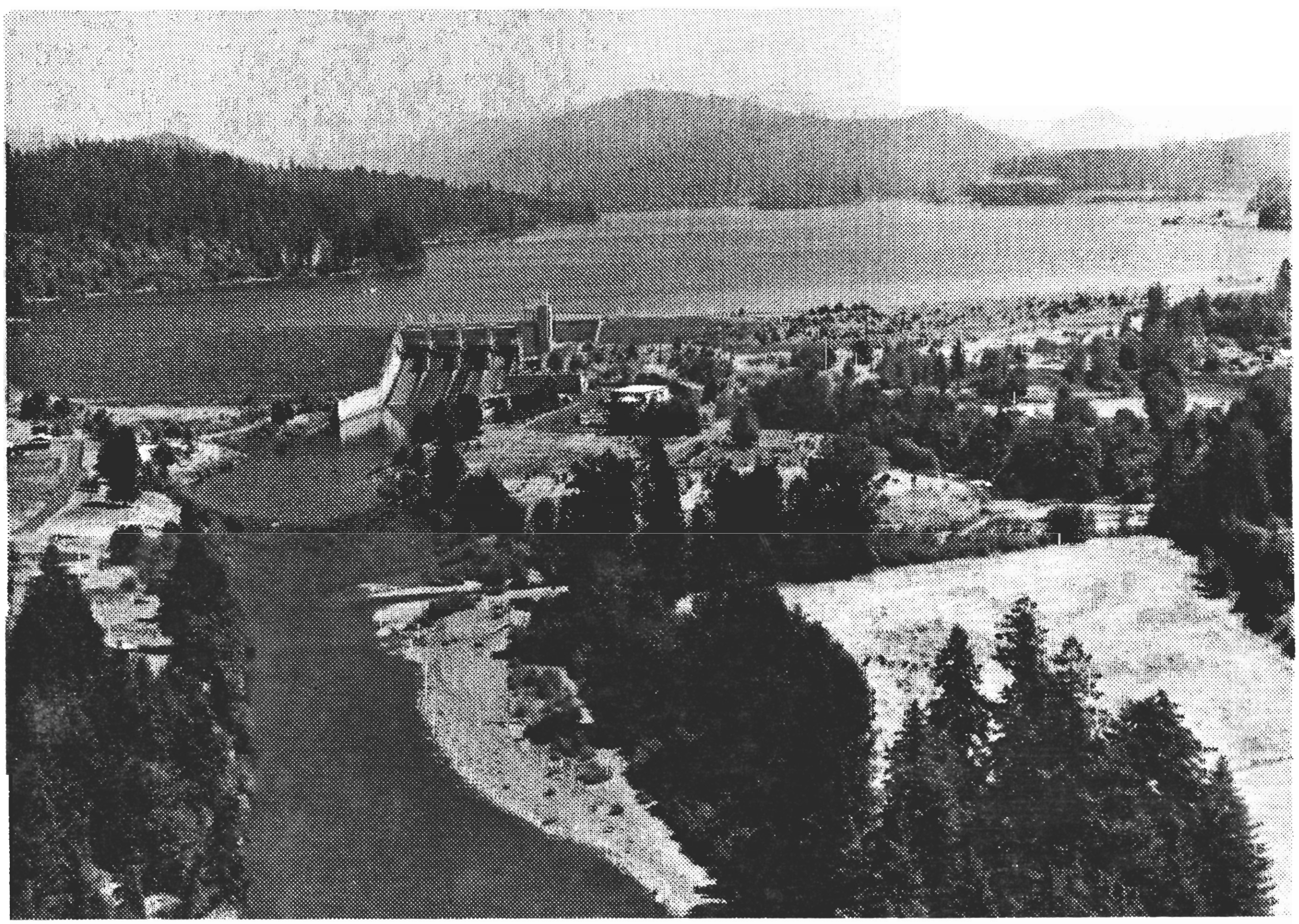
Oregon

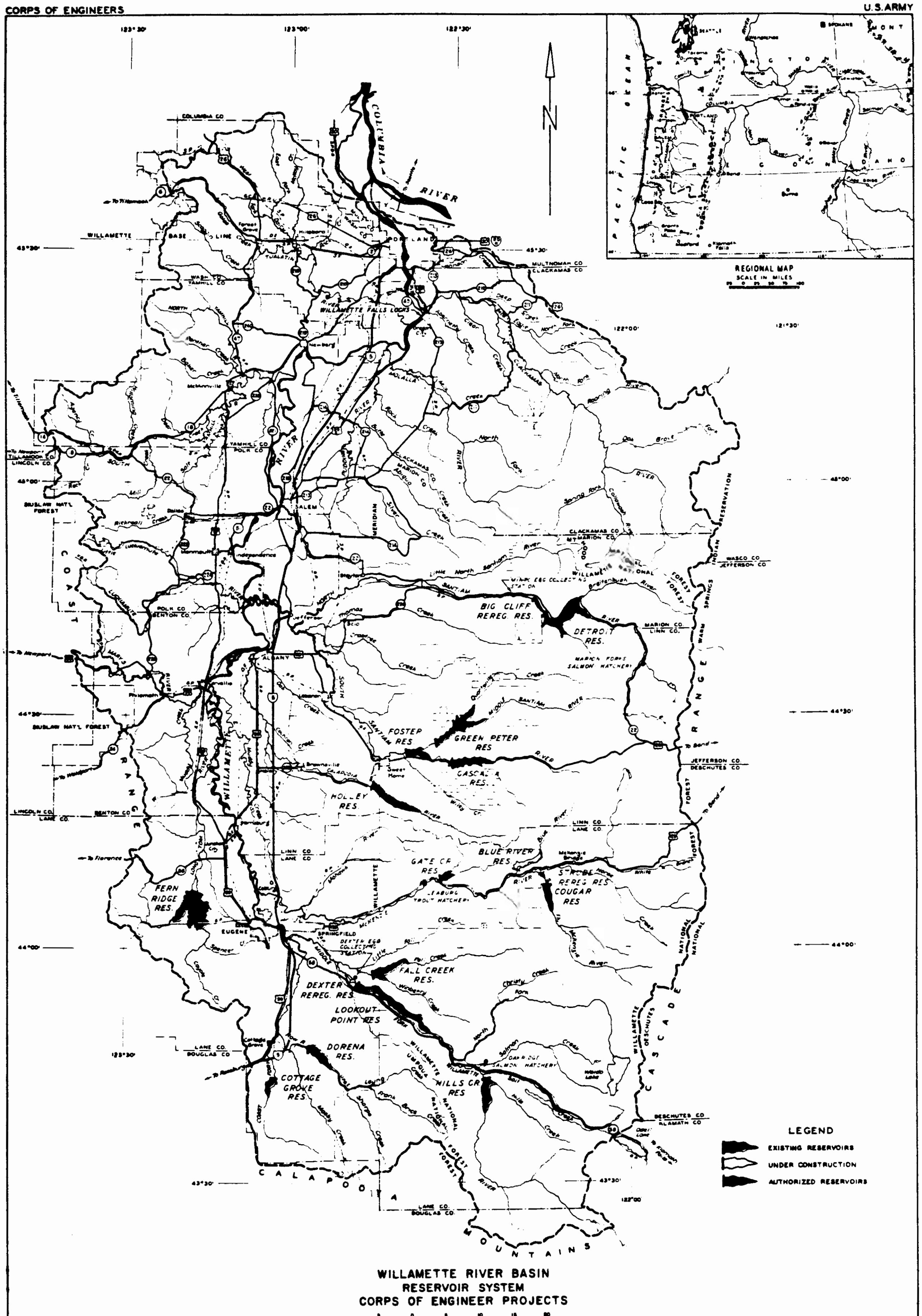
1968
Revision 2, July 28, 2017

US Army Corps
of Engineers
Portland District

Water Control Manual for Foster Lake

Oregon





WILLAMETTE RIVER BASIN
RESERVOIR SYSTEM
CORPS OF ENGINEER PROJECTS

U. S. ARMY ENGINEER DISTRICT, PORTLAND

NOTICE TO USERS OF THIS MANUAL

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

Change No.	Page / Paragraph / Section	Statement of Review or Change	Approval Date
Rev. 0		Initial Foster Water Control Manual	1968
Rev. 1	Chart 5	Revised Chart 5	1970
Rev. 2	Appendix Replaced	Update the Drought Contingency Plan, Exhibit A	July 28, 2017

EMERGENCY REGULATION ASSISTANCE PROCEDURES

In the event that unusual conditions arise during duty hours, contact between Willamette Valley Project staff and Reservoir Regulation and Water Quality staff (CENWP-EC-HR) can be made by calling the CENWP-EC-HR phone line at (503) 808-4896. If CENWP-EC-HR is unstaffed, further assistance can be achieved by contacting (in the order listed) one of the following persons assigned to be on call during non-duty hours:

1. Willamette Basin Regulator
   Work (503) 808-4960
   Cell (503) 819-9823

2. Backup Regulator
   Work (503) 808-4869
   Cell (503) 927-4642

3. Backup Regulator
   Work (503) 808-4891
   Cell (503) 475-2492

4. Backup Regulator
   Work (503) 808-4967
   Cell (503) 318-3524

5. Chief, Reservoir Regulation and Water Quality Section
   Work (503) 808-4887
   Cell (503) 819-4189

6. Willamette Valley Control Room, Lookout Point Dam
   (541) 937-9072
   (541) 937-2131x0
   Cell (541) 514-5623
   Satellite (480) 768-2500
   8816-2242-1180

In addition, the list of staff on call during non-duty hours is updated about once a week, and is provided in the after-hours call list provided through the Columbia Basin Telecommunications link at:

http://nwp-wmlocal2.nwp.usace.army.mil/nwp/schedules/www/Portland_District_Weekend_Duty_List

PRIOR DESIGN MEMORANDUMS

FOSTER RESERVOIR

No.	Subject	Date	
1.	Site Selection	May	1962
2.	Hydrology and Meteorology	August	1962
3.	Hydro-Power Capacity	August	1962
4.	General Design	October	1962
	General Design Supplement No. 1	March	1963
5A.	Preliminary Master Plan	October	1962
6.	Relocations	October	1962
7.	Real Estate	October	1962
9.	Spillway, Power, Intake and Fish Facilities	April	1963
10.	Clearing	December	1962
11.	Embankment Design	May	1963
12.	Powerhouse and Switchyard Preliminary Design Report	December	1963
12.1	Powerhouse - Architectural Design	September	1964
12.2	Powerhouse - Structural Design	March	1965
12.3	Powerhouse - Mechanical Design	April	1965
13.	Geology and Foundations	April	1964
14.	Master Plan	September	1967

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLES

CHARTS

CHARTS (Cont'd)

PLATES

FOSTER DAM AND RESERVOIR

August 1968

PERTINENT DATA

1. General:

Stream	South Santiam River
Drainage area	494 square miles
Location of dam	N 1/2, Section 27, T. 13 S., R. 1 E., W.M.
River miles above confluence of North and South Santiam Rivers	38.8
River miles above confluence of Santiam and Willamette Rivers	50.5
Airline miles south of Portland	80
Road distance to Salem, Oregon	53
Spillway design flood	214,000 c.f.s.
Standard project flood	~~100~~,000 c.f.s.
Maximum discharge (December 1964)	99,500 c.f.s.
Mean annual runoff (1926-1966)	1,846,~~370~~ acre-feet

2. Reservoir data:

Feature	Elevation (ft., m.s.l.)	Water surface area (acres)	Storage (acre-feet)	Length (miles)
Maximum and full pool	641	1,260	60,700	6.5
Maximum conservation pool	637	1,195	55,900	5.9
Minimum flood control pool	613	895	31,100	5.0
Spillway crest	596.8	--	17,950	--
Minimum invert	583.25	--	9,660	--
Lowest point	525	--	0	--
Storage space reserved for:				
Winter floods	613-641		29,600	
Summer floods	637-641		4,800	

3. Spillway:

Type	Concrete gravity, gated, ogee section
Crest length (net)	180 feet
Crest elevation	596.8 feet, m.s.l.
Design discharge	195,000 c.f.s.
Gates, type	Tainter
Number	4
Size	45' x 44.6'

4. Dam:

Type	Gravel and quarried rockfill
Elevation, top of dam	646 feet, m.s.l.
Freeboard above maximum pool (641)	5 feet
Length	4,800 feet
Maximum height, streambed to top of dam	126 feet

5. Outlet works: None

6. Powerplant:

Powerhouse	Indoor
Number of units	2
Type of turbines	Kaplan
Rating of each unit	10,000 kw.
Installed capacity	20,000 kw.
Maximum head - minimum tailwater to top of pondage pool (525-640)	115 feet
Minimum tailwater elevation (550 c.f.s.)	524.5 feet

7. Planned reservoir releases:

Minimum releases	
February - April	800 c.f.s.
May	750 c.f.s.
June	600 c.f.s.
July - November	400 c.f.s.
Flood periods (before Cascadia Reservoir)	
Normal release (not to exceed)	10,000 c.f.s.
Flood evacuation	
Maximum (at Waterloo gage)	18,000 c.f.s.

8. Limiting rates of increase in outflow:

Low-water season	
Normal per hour	300 c.f.s.
Maximum per half hour	300 c.f.s.
Flood periods	
Normal per hour	1,500 c.f.s.
Maximum per hour	2,500 c.f.s.

FOSTER RESERVOIR REGULATION MANUAL

SECTION I - INTRODUCTION

1-01. Authority. - Authority for preparing this manual is contained in paragraph 5 of ER 1110-2-240, dated 25 March 1963. Its preparation has been in accordance with instructions presented in EM 1110-2-3600, dated 25 May 1959.

1-02. Purpose and scope. - The function of this manual is to document the plan of reservoir regulation and to provide a reference source for higher authority and for personnel who will be responsible for the regulation and coordination of Foster Reservoir with other Willamette Valley reservoirs for flood control and conservation uses.

1-03. The manual contains a concise description of the river basin and project, the coordinated plan of basin development, information necessary for understanding the objectives of the project, and instructions for regulating the reservoir. Full coverage is given to method of regulating, operating rules and schedules, hydrologic network, forecasting procedures, organization of reservoir regulation personnel, communication facilities, and emergency instructions.

1-04. Revisions to manual. - Changes and revisions to the manual will be made by the Engineering Division of the Portland District as techniques of regulation and forecasting are developed which will improve the effectiveness of the project. Any change in the manual which affects the authorized functions of the reservoir or involves a significant deviation from the approved plan will be submitted through the North

Pacific Division Office to the Office, Chief of Engineers, for prior approval. All revisions will be dated and a master file will be kept by the Portland District.

SECTION II - BASIN DESCRIPTION

2-01. Location. - Foster Reservoir is located at river mile 38.8 on the South Santiam River, 80 airline miles south of Portland, Oregon, and 2 miles below the junction of the Middle Santiam and South Santiam Rivers. The South Santiam River Basin tributary to Foster Dam is located on the west slope of the Cascade Range about 30 miles east of Albany, Oregon. Plate 1 and the frontispiece show the location of the project and basin with respect to other major geographical features in western Oregon, including the system of storage projects that are existing, under construction, and authorized for the Willamette River Basin.

2-02. Drainage area. - The South Santiam River Basin tributary to Foster Reservoir is a fan-shaped area of 494 square miles. About one-half of the area above the damsite lies within the Willamette National Forest and the terrain is mountainous and heavily timbered. The mean elevation of the basin is 2,750 feet varying from 525 feet at the dam to 5,818 feet on the eastern boundary of the Middle Santiam watershed. An area-elevation curve of the basin tributary to Foster Dam is shown on chart 1.

2-03. Streams. - Plate 1 shows the stream system of the Santiam River Basin. There are two main watercourses that drain the area above the project, the Middle Santiam River and the South Santiam River. The South Santiam River rises in the southeastern portion of the watershed and flows about 25 miles in a westerly direction before joining Middle Santiam River 2 miles above Foster Dam. The watersheds are rugged, mountainous areas and the streams flow through deep canyons.

Low-water profiles for the Middle Santiam and the South Santiam Rivers are shown on plate 2.

2-04. Forest cover. - Above Sweet Home in the South Santiam Basin, the greater portion of tributary area is forested. Most of the lower basin and a considerable portion of the upper basin have been logged off. Vegetation in the recently logged-off areas varies from brush to small coniferous trees. Earlier logged areas have good stands of second growth timber. Near the project, a comparatively small amount of old growth timber remains with the second growth of Douglas fir ranging from 30 to 50 years old. The high-elevation areas in the eastern sector, comprising about 50 percent of the drainage basin, are in the Willamette National Forest. Forty percent of the remaining area, generally lower in elevation and located in the western part of the drainage basin, is administered by the Bureau of Land Management and 60 percent is held in private ownership. The forest cover retards soil erosion, improves permeability and the infiltration capacity of the soil, and shields the basin snow cover, which results in a more gradual snowmelt runoff.

2-05. Population. - The 1965 census shows the population within a 50-mile radius of the Foster Reservoir to be about 380,000, of which 240,000 is urban. In this 50-mile zone, nine cities have populations exceeding 3,000. The largest is Salem with a population of 62,860.

2-06. There is no extensive residential development above the reservoir. Below the reservoir the principal towns are Sweet Home and Lebanon in the South Santiam River Basin. Lebanon, the largest, had a 1965 population of 5,200 and Sweet Home, 4,050. Both towns have had significant population growths in the past 25 years as a result of increased activity in construction and logging, and because of the expansion of the lumber, plywood, and pulp and paper industries.

2-07. Industry and resources. - Processing of timber products is the major industry in the populated sectors of the South Santiam Basin. There are more than 60 forest-products manufacturing firms in or near the towns of Sweet Home and Lebanon, which are downstream from Foster Dam 18 and 5 miles, respectively.

2-08. Below Sweet Home, valley lands in the South Santiam and Santiam Basins are used principally for agriculture. The soil is light and very productive. Crops that are grown include string beans, hops, sweet corn, squash, mint, fruit, nuts, fall and spring grains, and alfalfa. String beans return the largest dollar income per acre. As of September 1966 there was no large-scale irrigation development in the South Santiam or Santiam flood plains, although a considerable area is sprinkler irrigated with water pumped from ground water or streams. The demand for irrigation water will undoubtedly increase, and stored water will be required to complement the present sources.

2-10. Transportation. - Foster Reservoir is served by county, Federal, and private roads. U.S. Highway 20 extends from Interstate 5 near Albany along the left bank of the South Santiam River and connects with U.S. Highway 99 near Bend, Oregon. From Foster, a county road extends from Highway 20 along the right bank of the Middle Santiam River, thence along the right shore of Foster and Green Peter Reservoirs to the headwaters of Quartzville Creek. Railroad service extends to the Willamette National Mill near the left abutment of Foster Dam.

2-11. Flood damages. - South Santiam River was unregulated in December 1964, when the basin experienced a very severe flood. At that time over 27,000 acres were inundated in South Santiam River Basin and over 69,000 acres in the flood plain of Santiam River and Willamette River below the mouth of the Santiam. Average annual damages in the flood plain below Foster Reservoir, at 1965 economic development and price levels and existing channel conditions, would be approximately $12,513,000 with no upstream flood regulation. Foster Reservoir would reduce these average annual damages by about $165,000. Based on data obtained from the December 1964 flood damage survey, the distribution of damages to the various categories of properties in the flood plain, below the Foster Reservoir, would be as follows:

Reach	Percent of damages				
	Agricultural	Residential	Commercial	Industrial	Other 1/
South Santiam and Santiam R.	41	8	4	3	44
Willamette R. below mouth of Santiam R.	21	11	19	30	19

1/ Includes damages to utilities, public facilities, transportation, channel improvements and control structures, and emergency relief.

Flood damages at 1965 prices and development that would result from the recurrence of the more recent, larger floods with no storage regulation are as follows:

Flood	South Santiam River 1/	Santiam River	Willamette R. below mouth of Santiam R.
December 1964	$3,950,000	$2,280,000	$446,700,000
February 1961	1,850,000	1,510,000	16,550,000
December 1955	1,420,000	1,020,000	19,110,000
December 1945	2,230,000	1,160,000	10,040,000
Dec 1942/Jan 1943	1,300,000	740,000	18,400,000

1/ Does not include damages above Foster Reservoir.

Foster's contribution to flood-damage reductions, with the presently authorized system of 14 reservoirs operating in the Willamette River Basin, would average about 5 percent in the South Santiam flood plain, 3 percent in the Santiam flood plain, and 1 percent along Willamette River below the mouth of Santiam River. However, bank erosion caused by extended periods of near-bankfull stages during reservoir evacuation would partially offset this reduction.

2-12. Average annual benefits of $597,000 are creditable to Foster for reduction of flood damages in the flood plain below Foster Reservoir, based on a 100-year project economic life and 1966 prices.

SECTION III - PROJECT DESCRIPTION

3-01. General. - Need for flood control was recognized early in the history of the Willamette Valley, but control by reservoirs was not then considered feasible. Even as late as 1932, the Corps of Engineers reported that no extensive flood control project was economically justified. After that date, population growth and industrial development were rapid. With the accelerated growth of the region, demands for flood protection and use of the water resource became increasingly urgent, leading to the development of a general comprehensive plan for the control of floods and utilization of the water resources of the basin.

3-02. Project authority. - Authorization for Foster Dam and Reservoir was by the Flood Control Act of 1960 (Public 645, 86th Congress, H.R. 7634) approved 14 July 1960. Survey report plans and description of the project were published in Senate Document 104, 86th Congress, 2d session.

3-03. Project purpose. - The principal functions of Foster Dam and Reservoir will be flood control, conservation of water for irrigation and navigation, power generation, and the reregulation of releases from Green Peter Reservoir. Flood control benefits will be greatest below Lebanon on South Santiam River and on Willamette River in the reach between mouth of Santiam River and Salem. Foster Reservoir will effect only minor flood control benefits until Cascadia Reservoir is constructed. After Cascadia Reservoir is completed, approximately 48 percent of the South Santiam Basin will be above reservoirs.

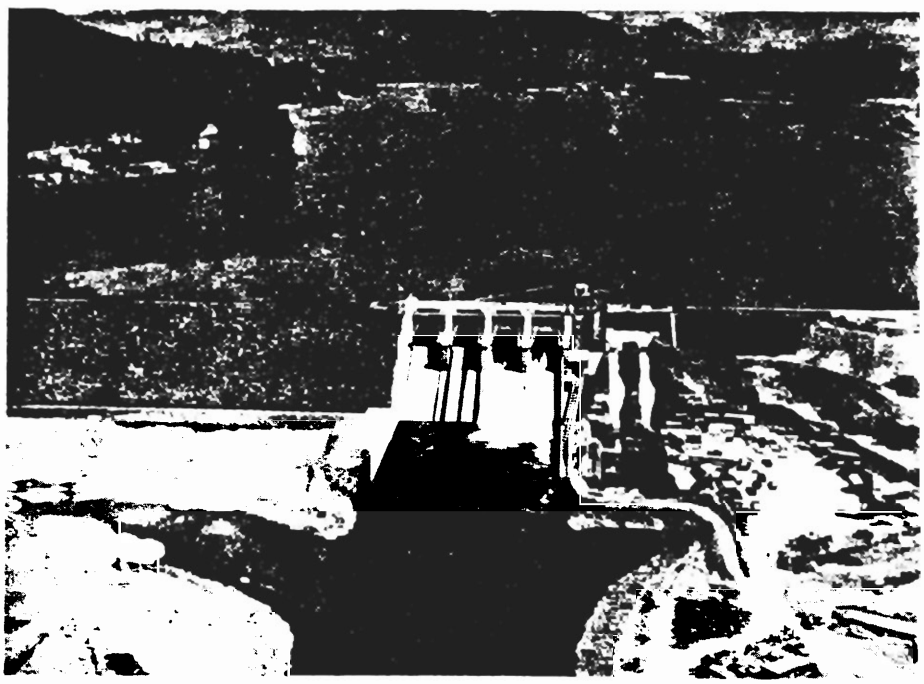
Secondary or incidental functions of the project include increased water supply for domestic use, fish life, and water quality control. Considerable public use of the reservoir and adjoining lands at Foster Reservoir for recreational purposes is anticipated.

3-04. Location of project. - The frontispiece shows the geographical location of Foster Dam and Reservoir. Foster Dam is located at river mile 38.8 on South Santiam River at Foster, Oregon, 2 miles downstream from junction of the Middle and South Santiam Rivers, and 8 miles downstream from Green Peter Dam.

3-05. Guide taking line. - Criteria followed in establishing the permanent boundary of the project were as follows. Fee title to all shoreward lands within 300 feet of the pool at elevation 640, m.s.l., was taken. Where road relocation right-of-way was within or close to the 300-foot taking, the shoreward boundary of the road right-of-way was the guide taking line. Where road relocations were not close to the 300-foot taking limit, the right-of-way was made a separate taking. Exceptions to the 300-foot guide taking limit were for construction material and public use sites, in which instances the taking was made sufficient to cover the needed areas. Plate 3 shows the boundaries of the property acquired by the Government for Foster Reservoir.

3-06. Foster Dam. - Foster Dam is a gravel and quarried rockfill structure. The embankment, 126 feet high from streambed to top of dam, is about 4,800 feet long at crest elevation 646. The spillway is a concrete gravity section with four spillway bays equipped with 45-foot by 44.6-foot tainter gates. The spillway section is 180 feet long and

UPSTREAM FACE



DAM AND RESERVOIR
(Powerhouse Under Construction, May 1967)

is located between the powerhouse and main embankment. It has a design capacity of 195,000 c.f.s. at maximum pool, elevation 641, and discharges into a stilling basin that is 210 feet wide and 169 feet long. The powerhouse is situated at the toe of the concrete nonoverflow section adjacent to the spillway and has an installed capacity of 20,000 kilowatts. Plate 4 shows the general plan of the embankment and the principal features of the project. Spillway discharge rating curves are shown on charts 2 and 3, and on table 1.

3-07. Foster Reservoir. - At full pool, elevation 641, Foster Dam backs water up the South Santiam and Middle Santiam Rivers a distance of 6.5 and 5.8 miles, respectively, forming a pool with a surface area of 1,260 acres. Foster Reservoir has a gross capacity of 60,700 acre-feet, of which 29,600 acre-feet will be usable. Of the usable storage, 24,800 acre-feet will be reserved for multiple use. ~~In addition, 3,600 acre-feet will be reserved for reregulation~~ of Green Peter power [redacted]. Chart 4 shows reservoir area and capacity curves with pertinent pool elevations noted on the curves.

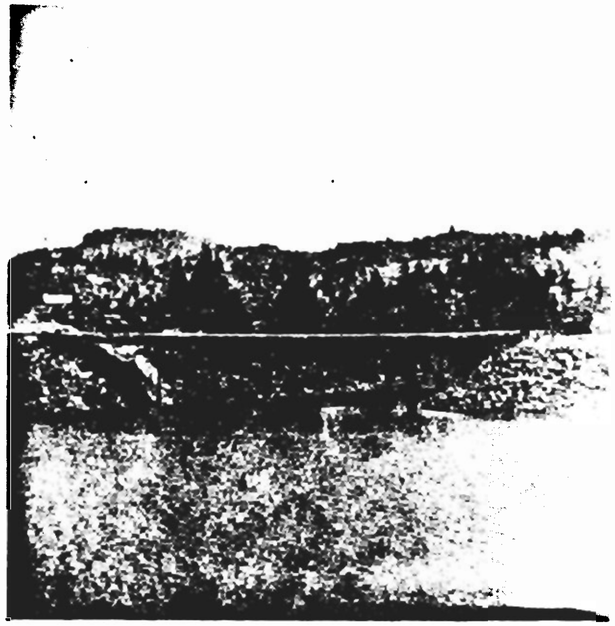
3-08. Backwater studies indicate that the reservoir will be practically level except during flood periods, and that the only significant backwater effect in the pool will be confined to the upper end where the reservoir pool intersects the streams flowing into the reservoir.

3-09. Regulating outlets. - No outlets are provided at Foster Dam. The crest of the spillway is 16.2 feet below minimum flood control pool. All releases other than those for power generation and fish facilities will be made through the spillway. One spillway bay will be especially equipped for making small adjustments in discharge.

3-10. <u>Power-generating facilities</u>. - The powerhouse is located on the left side of the spillway stilling basin and houses two 10,000-kilowatt generating units. Each unit is connected to a 13-foot 6-inch diameter steel penstock about 243 feet in length. Penstock intakes are located in the face of the concrete nonoverflow dam, and are provided with trashracks, bulkhead, and emergency slide gates.

3-11. Two Kaplan-type hydraulic turbines, each rated at 13,800 horsepower at a net rated head of 101 feet, are installed in the powerhouse. The two generators develop 10,000 kilowatts at 0.95 power factor and are capable of continuous operation at an overload of 15 percent. The powerplant normally will be operated at a daily load factor of not less than 80 percent. Prime power is 12,600 kilowatts and dependable capacity is 15,750 kilowatts. Gross heads will vary from a minimum of 81 feet between normal tailwater and minimum pool to a maximum of 115 feet between minimum tailwater and maximum pool. Turbine discharges will vary from a minimum of about 800 c.f.s. to a maximum of about 1,800 c.f.s. per unit. Power generation curves are shown on chart 5.

3-13. <u>Principal changes in the authorized project</u>. - The adopted plan for construction of Foster Dam incorporated several changes from the project document plan as authorized by the Flood Control Act of 1960.



BRIDGE, MIDDLE SANTIAM ARM

TRASH BOOM

Major changes were as follows: Location of the spillway and powerhouse was reversed. The fish facility was changed from a fish ladder crossing the dam to a fish transfer system crossing the dam. The spillway was changed from six to four bays with the crest elevation lowered from 601 to 596.79 feet, m.s.l. The powerplant was changed from three 10,000-kilowatt units to two 10,000-kilowatt units.

3-14. The General Design Memorandum dated October 1962 documents the studies and justification for the changes in the project document plan. The changes were approved by the Office, Chief of Engineers, with certain comments and recommendations that were incorporated into other design memorandums. Page i shows a list of design memorandums and the dates they were prepared.

3-15. <u>Resume of construction activities</u>. - Construction of Foster project began 10 June 1963 with relocation of a county road. During the next 52 months, major contracts were awarded including the main dam, bridges, powerhouse, clearing, and road construction. Construction of the main dam was started in October 1964 and all work on the dam was completed 22 August 1967. The stop logs were dropped on Dec 17, 1966. The reservoir was available for partial flood control and reregulating until Dec. 1967 when it became fully operative for flood control ~~in December~~ 1967. Construction of the powerhouse was started in March 1966 and as of May 1968 was 94 percent complete. Unit No. 1 was scheduled to go on the line in July 1968 and Unit No. 2 in September 1968. Only one major contract for recreational facilities remained to be let as of May 1968.

3-16. <u>Construction contracts and project costs.</u> - The following table lists (1) major contracts, (2) dates that contracts were awarded, and (3) total bid costs.

Contract item	Principal contractor	Contract	
		Award date	Bid cost
Quartzville Road and bridges	Carl Halverson, Inc.	06/10/63	$914,524
Two 13,800-hp. turbines	Baldwin-Lima Corp.	09/17/64	793,964
Dam contract	Paul Hardemen Co., Inc.	10/15/64	9,979,132
Right-bank road	Paul Zimmerly Road Const.	03/24/65	283,469
South Santiam (U.S. 20)	State of Oregon	06/01/65	150,000
Relocate Hwy No. 20	Erickson Paving Co.	08/11/65	1,412,941
Governors and spare parts	Baldwin-Lima Corp.	10/19/65	120,500
Two generators and spare parts	Allis-Chalmers	10/21/65	603,001
Installation of equipment	Chaney & James Const.	03/18/66	1,565,399
Clearing areas B, C-1, and C-2 (416 acres)	Beaver State Contrs.	05/24/66	136,000
Const. of residences hatchery building, rearing and holding ponds, and fishladder	Paul & Backer Co.	06/01/67	417,000

As of 1 January 1968, the estimated total cost of Foster project was $25,421,100.

3-17. Public use facilities. - Section 4 of the Flood Control Act of 1944, as amended, authorizes the development and management of recreation facilities at Corps of Engineer reservoirs. Such development may be by the Corps of Engineers, or by other agencies, groups, or individuals, under agreement with the Corps. The Act also authorizes the Corps of Engineers to administer all such agreements. Various other Federal statutes, including Public Law 85,624, the Revised Fish and Wildlife Coordination Act; Public Law 86-717, the Conservation Act; and Public Law 89-72, the Federal Water Project Recreation Act, provide for the development and management of Federal reservoirs for various purposes.

3-18. Initial public use development at Foster Reservoir will be constructed by the Corps of Engineers. Linn County has informally agreed to administer the initially developed areas. The Master Plan for Reservoir Management and Public Use Development for Foster Reservoir includes plans for future development of public use facilities.

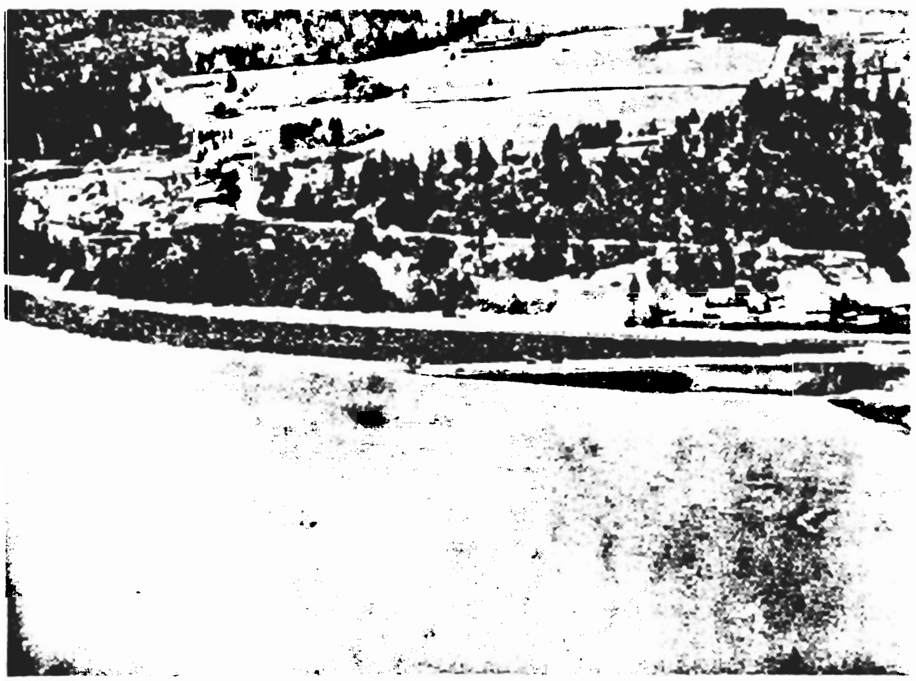
3-19. While recreation is not an authorized function of the project, the land and water areas afford considerable recreation potential for picnicking, camping, and water-associated activities such as boating, fishing, and swimming. The recreational value of the project is high and recreation will be extended as much consideration as practicable as long as this can be done without adversely affecting service to authorized project purposes. Normally, Foster Reservoir will remain full or nearly full until 1 October in the interest of recreation.

3-20. Debris control. - The watershed above Foster Reservoir is extensively timbered and logging operations in the area will be a constant source of debris which will accumulate on the pool. A floating log boom, which fluctuates with the pool levels, will keep floating debris away from the spillway gates, power intakes, and fish facilities. The debris will be collected, beached, and burned when the accumulation becomes a hazard to recreational activities and the operation of the project.

3-21. Fish facilities. - Fish facilities have been provided at Foster Dam for the upstream and downstream passage of anadromous fish. Pipes are provided on the right bank of the project to supply water for a salmon and steelhead hatchery to be operated by the Fish Commission of Oregon. Hatchery flow will vary from 45 to 100 c.f.s.

a. Upstream migrant facilities. - The upstream migrant facilities at Foster include a fish ladder with two entrances, one near the powerhouse draft tube exits and one in the spillway guide wall. Auxiliary water for the ladder entrances will be pumped from the powerhouse tailwater. The normal water supply for the fish ladder will be taken from the penstock intakes at two different elevations to provide some degree of water quality and temperature control. The ladder will require a water supply of approximately 37 c.f.s. whereas the water supply capability is much greater. Extra water will be used for attraction purposes at the spillway entrance when needed. Chart 6 illustrates these facilities.

b. Fish collected at the top of the ladder will be sorted and the desirable species will be placed in a hopper which will transport them to the top deck and across into the reservoir. Undesirable species



BOAT RAMP

FISH HOPPER

RESERVOIR WATER TEMPERATURE RECORDER

will be disposed of to prevent reinfestation of the upstream areas where those fish have been eradicated by the Oregon Game Commission. Services for separating the undesirable fish at the hopper will be provided by Fish Commission personnel assigned to the hatchery which is located on the right bank downstream from the project. The transfer facility is equipped to stop the hopper on the deck of the dam for loading fish-tank trucks with adults to be transferred to assigned areas.

c. Downstream migration facilities. - No separate facilities are provided for the downstream movement of migrating fish. However, the turbine design, penstock intake elevations, and draft tube characteristics were carefully planned to provide the most desirable conditions for safe passage of juvenile migrants, which are expected to be passed safely through the turbines or under the spillway gates, depending on the project releases at the time the fish are moving.

SECTION IV - CLIMATOLOGY

4-01. Climate. - The climate of the area above Foster Dam is characterized by mild, wet winters and warm, dry summers. With the exception of occasional short periods of continental air mass control, maritime air masses dominate the areas throughout the year. Principal climatic controls are topography, proximity to the Pacific Ocean, and the prevailing westerly winds. The areas are subject to frequent winter storms of varied intensities. Winter temperatures are generally below freezing at the higher levels, resulting in snow accumulating to great depths. Summer rainstorms occur occasionally and are generally of the convective type, characterized by short duration and small areal coverage.

4-02. Climatological records. - Past climatological records applicable to the watershed tributary to Foster damsite are available at two stations. One is a recording precipitation gage formerly located about 12 miles southwest of Quartzville in the Middle Santiam River Basin at a location now inundated by Green Peter Reservoir. Data at that station are confined to precipitation records from 1939 through 1961. The second station is located at Cascadia in the South Santiam River Basin about 10 miles east of Foster Dam. Both temperature and precipitation records have been maintained at the Cascadia station since 1908. Because of Cascadia's close proximity and similarity in elevation to the Foster project, its records are considered most representative of conditions at the dam. Other climatological stations in the general vicinity of Foster Dam are Waterloo, Lacomb, and Detroit. Plate 1 shows the location and length of record of climatological stations in the Santiam River watershed and surrounding area.

4-03. Precipitation. - Normal annual precipitation for the 494-square-mile watershed above Foster Dam is estimated to be 86 inches, varying from about 68 inches near the damsite to more than 108 inches near Quartzville. Normally, 68 percent of the annual precipitation falls in the 5-month period, November through March. July and August are normally the driest months of the year, with less than 2 percent of the annual precipitation occurring in those 2 months. Rainless periods of more than 30 days are not uncommon during the summer season. Monthly minimum, average, and maximum precipitation of record for selected stations in and near the basin are shown on plate 5.

4-04. The areal distribution of normal annual precipitation over the drainage area tributary to Foster damsite is shown on plate 6. The normal annual isohyetal pattern was developed as part of a comprehensive report for the Willamette River Basin. Available precipitation data, streamflow, snow-course data, and topography were taken into consideration in preparing the annual isohyetal map for the basin.

4-05. At Cascadia, where the weather and climatic conditions are considered to be representative of conditions at the damsite, the greatest recorded 1-day precipitation was 4.69 inches on 20 November 1921. The wettest month of record was November 1942, with 20.91 inches of precipitation, and the wettest year was 1950, with 82.02 inches of precipitation. On the average, 156 days per year experience 0.01 inch or more of precipitation. Tables 2, 3, and 4 summarize climatological data by months for Quartzville, Cascadia, and Salem, respectively. Table 5 compares climatological data for Quartzville and Cascadia with those of three other stations in the general area.

4-06. Snow. - Less than 5 percent of the precipitation at Foster damsite, the lowest elevation in the basin, occurs as snow, whereas about 60 percent of the precipitation at the highest elevation occurs as snow. Snow cover below 2,000 feet is generally transient and may accumulate and melt several times during a winter season. Above 4,000 feet, snow generally starts accumulating in December and continues to about mid-April.

4-07. No snow courses exist in the watershed above the damsite. Snow courses in the adjacent North Santiam River drainage area are considered representative of snow conditions in South Santiam Basin at comparable elevations. April 1 snow surveys at elevations above 2,500 feet generally indicate maximum water equivalent depths for the season. As indicated in table 6, average 1 April water contents range from 43.7 inches at Hogg Pass, elevation 4,755 feet, to 13.2 inches at Marion Forks, elevation 2,730 feet. Maximum seasonal depths at Breitenbush, elevation 2,325 feet, are generally recorded on 1 March; the average depth on that date is 4.8 inches. Plate 5 graphically illustrates the variations in depth and water equivalent of the snowpack by months for the period of record at Hogg Pass, Santiam Junction, and Marion Forks snow courses.

4-08. Temperature. - Because of the moderating effects of maritime air from the Pacific Ocean, seasonal variations of temperature are relatively small. Average monthly temperature at Cascadia, as shown in table 3, range from 37.1° F. in January to 65.1° F. in July. Average daily maximums and minimums are 44.6° and 29.8° F., respectively, in January, and 81.9° and 48.1° F., respectively, in July. The highest temperature recorded at Cascadia was 106° F. in July 1946, and the lowest was 1° F. in December 1932 and January 1950. Those temperatures are approximately representative of conditions at Foster Dam. Temperatures decrease with increase in elevation at a rate of about 3° F. per thousand feet. Temperature data for selected stations are shown in tables 3, 4, and 5 and on plate 5.

4-09. Storms. - Flood-producing storms occur chiefly during the winter season but are not uncommon in late fall and early spring. The seasonal storm pattern is largely a result of the southward displacement of the Aleutian Low during the winter season. With increased pressure gradient between the Aleutian Low and the Pacific High, a strong westerly-to-southwesterly flow of moist maritime air develops over the area. Lifting of the air over topographic barriers, augmented by convergence and frontal lifting, results in precipitation of varied intensities, often of flood-producing proportions. Frontal activity generally consists of a series of north-south-oriented occluded fronts moving eastward over the area. Frequently, however, a quasi-stationary front will develop over the area in an east-west direction. The strong westerly flow of moist air and minor waves associated with such fronts results in continuous precipitation, generally of high intensity, in the frontal area.

4-10. The sequence of meteorological events in December 1964 produced the largest flood of record in the Willamette Basin. The synoptic situation prior to the storm consisted of a high-pressure area dominating the Pacific Northwest. Beginning on the 18th, a weakening of the high and the passage of several fronts resulted in light-to-moderate precipitation through the 20th. Prior to the 21st, freezing levels were generally below 3,000 feet; thus a large percentage of the precipitation occurred as snow. A strong westerly flow of moist air accompanied by several storm fronts resulted in heavy rains on the 21st and 22nd, with lesser amounts occurring thereafter for a period of approximately 10 days. Freezing levels began rising on the 19th, reaching elevation 10,000 feet over Salem on the 22nd, resulting in high snowmelt, thus augmenting the runoff resulting from heavy rain. A sharp drop in temperatures and diminished precipitation on the 31st marked the end of a 13-day storm period.

4-11. On the basis of reports from adjacent stations, it is estimated that 20 inches of precipitation fell over the Foster watershed during the 13-day storm period, 0700 18 December to 0700 31 December. Maximum 24-hour and 96-hour basin precipitation depths are estimated to be 4.0 inches and 11 inches, respectively.

4-12. Winds. - No data are available on wind speed in the South Santiam River Basin. For study purposes, wind data observed at Eugene, Oregon, from 1941 to 1964 were used. On the average, the wind at Eugene is 3 miles per hour, or less, about 37 percent of the time. Sixty-one percent of the time the wind speed is between 4 and 15 miles per hour, and most of the remaining 2 percent of the time the wind speed is between 15 and 31 miles per hour. Occasionally, sustained wind speeds reach 45 miles per hour with gusts in excess of 80 miles per hour. The highest wind of record occurred on 12 October 1962 with a maximum 1-minute velocity of 63 miles per hour and a maximum gust of 86 miles per hour. Velocities ranging from 45 to 55 miles per hour were sustained for about 2 hours during the storm. The higher velocity winds have a westerly component and blow upstream, and therefore the higher wind-generated waves will move away from the dam.

4-13. Evaporation. - No evaporation records are available for Foster Reservoir. Records at Fern Ridge Reservoir, located about 40 miles southwest of Foster, show an annual land pan evaporation of 38.1 inches. Forty percent of that amount occurs during July and August. Evaporation is negligible during the winter months, increases progressively during the spring months, and decreases during the autumn months. Table 7 shows estimated average monthly evaporation amounts for Foster Reservoir. Those values are based on data observed at Fern Ridge Reservoir which have been adjusted on the basis of the findings in the publication: Water Loss Investigation, Lake Hefner Studies, U.S.G.S. Professional Paper No. 269. Using 0.71 as the yearly conversion factor, it is estimated that, on the average, 2,517 acre-feet will evaporate each year from Foster Reservoir.

4-14. Table 7 indicates that the monthly evaporation varies largely in accordance with the mean monthly air temperature which is primarily a function of solar and terrestrial radiation. Although wind is an important factor in the appraisal of daily evaporation amounts, it is not a significant factor when evaluating mean monthly values. Records for Willamette River Basin show that the average wind speed for each month of the year is nearly constant.

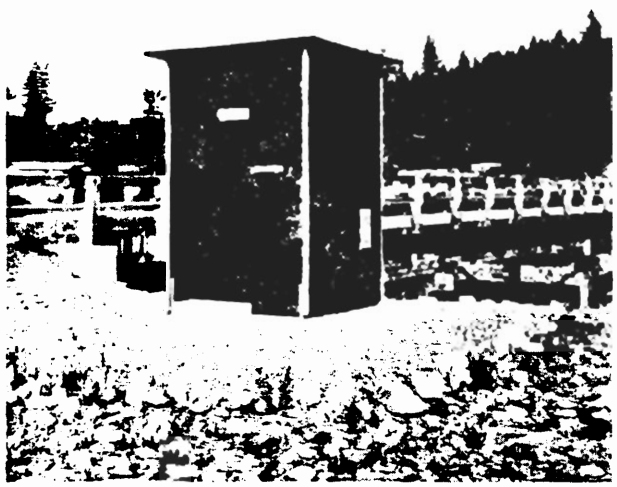
SECTION V - HYDROLOGY

5-01. Discharge records. - Discharge records for Middle and South Santiam Rivers in the vicinity of Foster Dam date back to 1910, but none of the gaging stations have a continuous discharge record for the period 1910 to date. The longest continuous record, 1923 to date, is for South Santiam River at Waterloo, drainage area 640 square miles. Discharge records for Middle Santiam River near Foster are available from 1931 through 1966 and for the South Santiam below Cascadia, from 1935 to date. Two new gaging stations were established in August 1963 at head of Green Peter Reservoir; one on Middle Santiam River, and one on Quartzville Creek. Another new gaging station was established in 1966 on South Santiam River below Foster Dam for gaging releases from the dam. Plate 1 shows the locations, periods of record, and other pertinent data for all stream-gaging stations in the Santiam River Basin.

5-02. The Waterloo station is one of the principal control points for flood regulation at Foster Reservoir. Santiam River at Jefferson and Willamette River at Salem are the other downstream control points.

5-03. Streamflow characteristics. - The streamflow regimen of the Santiam River and tributaries is similar to the seasonal precipitation pattern. Low flows normally prevail from June throughout October, the season of low precipitation. Higher flows, which may fluctuate widely, prevail during the remainder of the year, the season of high precipitation. Snowmelt at the high elevations maintains a moderate base flow until early summer. From July through September the streams recede to their minimum flows. Daily discharge hydrographs shown on plates 7

CASCADIA, INFLOW GAGING STATION



BELOW FOSTER DAM, OUTFLOW GAGING STATION through 16 illustrate the streamflow pattern, the frequency of high- and low-water periods, and the flashy character of the floods. Nearly 90 percent of the annual runoff occurs during the 8-month period, November through June.

5-04. Runoff. - A runoff summary of minimum, maximum, and mean monthly flows, including a flow-duration curve, for Foster Dam are shown on chart 7. Annual runoffs at Foster Dam, for the period 1926-1966, are shown in table 8 and are graphically illustrated on chart 7. The mean annual runoff at Foster Dam is 1,846,370 acre-feet, with extremes of 2,845,920 acre-feet in 1956 and 1,049,080 acre-feet in 1931.

5-05. Flood characteristics. - Floods on Santiam River and tributaries are usually produced by intense precipitation of 2- to 4-day duration, augmented to varying degrees by snowmelt runoff. The snowmelt contribution is largely from areas of low and intermediate elevations and generally has a greater influence on the flood volume than on the flood peak. An exception was the December 1964 flood when frozen ground and excessive snowmelt not only contributed to the flood volume, but also to the peak. The bulk of the high-level snowpack usually melts and runs off without damaging effects after the first of March. When periods of intense rainfall, which occur frequently during the rainy season, are preceded by an extended period of moderate precipitation that saturates the ground, a flood develops. Double-crested floods are not uncommon and may at times create reservoir regulation problems.

5-06. The area above Foster is heavily timbered and little flooding occurs along the upstream reaches. The duration of the average flood along the lower reaches below the project is usually from 2 to 4 days, but a series of storms have at times extended the periods of downstream flooding to a week or more. An example of this latter situation is the December 1964 flood. December and January are the months with the highest and most frequent floods. However, the maximum annual high water can occur in any month from October through April. Table 9 shows maximum annual instantaneous discharges for selected stations in the South Santiam River Basin.

5-07. Flood frequencies. - Recorded and computed maximum annual discharges through 1965 were used in the derivation of the maximum annual flood frequency curve for Foster Dam shown on chart 8. The following tabulation shows computed peak discharges for Foster Dam for selected recurrence intervals.

Average recurrence interval in years	Maximum discharge in c.f.s.
5	48,000
10	57,000
25	68,500
50	77,500
100	86,000

5-08. Past floods. - At Foster Dam, based on observed records at gaging stations upstream and downstream from the damsite, the December 1964 flood with a peak discharge of 99,500 c.f.s. and a volume of 540,000 acre-feet at Foster Dam exceeded all past floods of record, including the historical floods of December 1861 and February 1890, both from the standpoint of peak discharge and volume.

5-09. Channel velocities. - At the head of Foster Reservoir the Middle Santiam and South Santiam Rivers have gradients of approximately 70 feet per mile. This relatively steep gradient results in excessive stream velocities during high-water periods. The following tabulation shows average stream velocities observed at the Waterloo gaging station approximately 13 miles downstream. Slightly higher velocities can be expected below Foster Dam. Maximum velocities may be as much as 50 percent greater than average velocity.

Discharge in c.f.s.	Average velocity in feet per second
500	0.9
2,000	2.1
10,000	4.7
25,000	7.1
50,000	9.6
70,000	10.9

Normal maximum release at Foster during evacuation or flood regulation will be limited to a discharge that will not result in a flow greater than 18,000 c.f.s. at Waterloo.

5-10. Channel capacities. - The South Santiam River between Foster Dam and Lebanon has a reasonably adequate channel capacity and a narrow flood plain. The flood problems in this reach are not as critical as along the lower river. Below Lebanon, the South Santiam River Valley widens, and serious overbank flooding occurs even at moderate flood discharges. Flooding also occurs along the entire length of Santiam River below the junction of North and South Santiam Rivers.

5-11. Flood control regulation of Green Peter and Foster Reservoirs will be based primarily on protecting lands along South Santiam River, using the stage at the gaging station near Waterloo as an index. Existing bankfull capacity in this reach of the river is approximately 18,000 c.f.s., which can be expected to be exceeded quite frequently until Cascadia Reservoir is built. Bankfull capacities at downstream locations pertinent to the operation of Foster Reservoir are shown on the following tabulation:

Station	Stream	Drainage area, square miles	Bankfull data	
			C.f.s.	Stage
Waterloo	South Santiam	640	18,000	9.9
Jefferson	Santiam	1,790	35,000	13.2
Salem	Willamette	7,280	120,000	23.3

5-12. Outlet capacity. - Since the crest of the spillway is 16.2 feet below minimum flood control pool, no conduits were constructed through the dam to serve as outlets. Releases for flood regulation will be made through the spillway gates which have a capacity of 38,000 c.f.s. at minimum flood control pool. Normal release will not exceed the existing bankfull capacity at Waterloo of 18,000 c.f.s.

5-13. Reservoir capacity. - In determining the flood control storage requirements for Foster Reservoir, the principal criterion was that the reservoir, together with Green Peter and Cascadia Reservoirs, should be capable of retaining the flood runoff of either the 1861 flood or the December 1964 flood until such time that the discharge over the spillway would not result in a secondary flood crest at Waterloo in excess of that caused by the peak runoff from the uncontrolled area, 146 square miles, between Foster damsite and Waterloo.

5-14. Total capacity of Foster Reservoir at full pool, elevation 641, will be 60,700 acre-feet. Of that total, 31,000 acre-feet will be inactive and dead storage below minimum flood control pool, elevation 613. The 29,600 acre-feet of storage space between elevations 613 and 641 will be used primarily for flood regulation, with 24,800 acre-feet of space scheduled for multiple-purpose conservation use. Reservoir storage and area curves are shown on chart 4. Table 10 shows a tabulation of storage capacities. The storage allotment for various uses is shown on chart 9.

5-15. Studies show that the 29,600 acre-feet of usable storage space in Foster Reservoir will effectively control all floods of record from the 38-square-mile area between Foster and the upstream sites of Green Peter and Cascadia, including the historical floods of 1890 and 1861, and the largest observed flood of record, that of December 1964.

5-16. Until Cascadia Reservoir is constructed, there will be 217 square miles of area above Foster Reservoir from which runoff will be uncontrolled. Therefore, optimum flood regulation during the interim period requires that storage space at Foster be scheduled for regulating the large floods. Only inflows, as modified by Green Peter Reservoir, in excess of 10,000 c.f.s. will be regulated at Foster until Cascadia Reservoir is constructed.

5-17. Powerhouse tailwater. - The powerhouse tailwater rating curve is shown on chart 10. Tailwater elevations at the powerhouse will fluctuate about 1.5 feet for turbine discharges varying from 1,600 c.f.s. to 3,600 c.f.s., the normal operating range. The powerhouse tailwater gage should be used only to determine the gross head differential between pool and tailrace levels. Releases from Foster Dam will be recorded at the gaging station located just downstream from Foster Dam and upstream from the mouth of Wiley Creek.

5-18. Sedimentation. - The channel of South Santiam River in the vicinity of Foster Reservoir is typical of the tributaries which originate high in the Cascade Range. The riverbed is composed largely of bedrock and the side slopes are well-covered with a sustained growth of vegetation. Only during intense storms is there any appreciable erosion of topsoil. No significant bedload movement or reservoir silting are anticipated because of the nature of the streambed and the closeness of the upstream reservoirs of Green Peter, constructed, and Cascadia, authorized.

5-19. Sedimentation studies made in Willamette River Basin from 1949 to 1951 showed that suspended sediment concentrations in mountainous streams were not significant except during flood periods. In addition to the 1949-1951 suspended sediment studies, reservoir surveys have been made at Cottage Grove, Fern Ridge, and Dorena Reservoirs. Those surveys show that siltation has not materially affected the capacities of the existing reservoirs. The latest survey at Cottage Grove in 1966 showed that the annual silting rate was approximately 0.15 acre-foot per square mile.

5-20. No suspended sediment observations have been made in the vicinity of Foster Reservoir. Between 1949 and 1951, 321 samples of suspended sediment were taken at the gaging station on South Santiam

River at Waterloo. Analysis of those samples showed that, during low water, only a trace of sediment was evident. A maximum concentration of 370 parts per million was observed in a sample during a flood. Suspended sediment rates at Foster Reservoir will be approximately the same as those observed on South Santiam River at Waterloo. On the basis of suspended sediment data and prior reservoir surveys, it is estimated that the average annual silting in Foster Reservoir will not exceed 12 acre-feet after Green Peter and Cascadia Reservoirs are in operation. Loss of reservoir storage space will be small and will not materially affect the storage capacities during the 100-year economic life of the project. Three permanent index-type sedimentation ranges shown on plate 17 have been established in and downstream from Foster Reservoir to evaluate future silting in the reservoir and degradation of the river channel below the reservoir. Experience at existing reservoirs in Willamette River Basin indicates that silting will be so minor in Foster Reservoir that resurveys will be infrequent. For more information on the sedimentation ranges refer to the report, "Proposed Sedimentation Ranges, Green Peter and Foster Reservoirs," dated August 1963.

5-21. River temperatures. - Daily maximum and minimum water temperatures of Middle Santiam River at mouth near Foster are available from September 1953 to 1966. Temperature records are also available for South Santiam River at Waterloo since October 1963, and for South Santiam River below Cascadia since June 1962. At the Cascadia station, water temperature records show that, during the 4-month period December through March, mean daily water temperatures ranged from 34° F. in February 1956 to 40° F. in December 1958. The widest range in daily minimum and maximum temperatures was experienced in July, 46° F. in 1955 and 77° F. in 1958. The typical pattern of monthly maximum and minimum water temperatures is shown on charts 11 and 12.

5-22. Reservoir temperatures. - Foster Dam is equipped with seven recording thermometers, which are located in the upstream face of the dam at 10-foot intervals between elevation 575 and elevation 635. In addition, there is a floating thermometer on the pool surface near the dam; one in each of the upper and lower penstock taps; one in each of the upper and lower dissipators; and one in the tailrace. The following listed contract drawings show locations of thermometers and details pertaining to water temperature measurements at Foster Dam:

FSP - 1 - 6 - 1A 1/2
FSP - 1 - 6 - 1A 11/4
FSP - 4 - 0/16
FSD - 2 - 23
FSD - 4 - 18
FSD - 4 - 19
FSD - 4 - 21

5-23. Water quality control is not a project function and temperature selection is not a part of the operation of Foster Reservoir; however, some cooling of downstream flows may be effected as a result of releasing water through the turbines. Studies made at Lookout Point and Detroit Reservoirs indicate that the temperature of released water will probably vary from 50° F. in June to 65° F. in September. The higher temperatures will occur as the storage is depleted. Nevertheless, the maximum temperature of the released water should be about 10 degrees cooler than the inflow during July and August. Surface water in Foster Reservoir will generally be warmer than the air temperature. For a typical year the average monthly temperature of the surface water will range from 0.95 to 1.20 times that of the average monthly air temperature. The higher ratios apply during the fall, and the lower ratios in the spring. Outflow temperatures will reach a maximum of approximately 65° F. in August or September. Starting in October the reservoir temperatures start to fall and the pool will become isothermal at about 40° F. by January. From January to March the reservoir temperatures will remain isothermal for the full depth of the reservoir. Frequent filling and emptying of the reservoir and the absence of surface heating will keep the reservoir contents completely mixed.

SECTION VI - FLOOD CONTROL REGULATION

6-01. General criteria. - Flood control regulation at Foster Reservoir will be closely coordinated with the regulation of Green Peter Reservoir on Middle Santiam River and Detroit Reservoir on North Santiam River. In addition, there will be coordination with all other flood control reservoirs in Willamette River Basin during both regulation of a flood and the evacuation of stored water immediately following a flood.

6-02. ~~During the period before the authorized Cascadia Reservoir is constructed on South Santiam River,~~ Green Peter Reservoir on Middle Santiam River will provide the principal flood regulation in South Santiam River Basin. The 29,600 acre-feet of storage space available in Foster Reservoir are not adequate to effectively regulate the higher runoffs from the 217 square miles of area from which inflow to Foster project is unregulated. In order to make the best use of the 29,600 acre-feet of storage space in Foster Reservoir, it will be reserved to regulate the larger floods. Foster Reservoir will frequently fill, and when this occurs, the release from Green Peter plus the runoff from the area between Green Peter and Foster will be passed unregulated through Foster Reservoir. After Cascadia Reservoir is constructed, Foster Reservoir will be capable of effectively regulating the runoff from the 38-square-mile drainage area below the two upstream dams.

6-03. Flood control regulation schedules. - The normal flood control regulation schedule for Foster Reservoir is shown on chart 13. The basic criterion is to pass inflow ~~to~~ from Green Peter and Foster Reservoirs as long as it is possible to do so without exceeding bankfull stage at a downstream control station. Bankfull stages at Waterloo and Jefferson correspond to discharges of 18,000 c.f.s. and 35,000 c.f.s., respectively. Chart 13 shows the maximum combined release from Foster and Detroit if bankfull stage is not to be exceeded at Jefferson.

6-04. When natural flows would exceed bankfull stages at the downstream control stations, water is stored in Green Peter Reservoir. When the modified inflow into Foster exceeds 10,000 c.f.s. the flood control storage in Foster Reservoir will be utilized. During a flood, a release from Foster of 10,000 c.f.s. will be maintained until the end of the flood or until special curves indicate a greater release should be made.

6-05. Following a flood which fills Foster Reservoir, but does not tax the capacity of Green Peter Reservoir, Foster will be evacuated first, followed by evacuation of Green Peter. However, if the capacity of Green Peter should be taxed and the occurrence of another storm or series of storms should appear to be imminent, Green Peter Reservoir would be evacuated concurrently with Foster Reservoir. Green Peter Reservoir, with 270,000 acre-feet of usable storage space, is capable of regulating at the damsite a flood as large as the December 1964 flood which has a recurrence probability of only once in more than 100 years.

6-06. In scheduling the evacuation of Foster and Green Peter Reservoirs following a flood, downstream bankfull stages should not be exceeded except under very unusual circumstances such as full or near-full reservoirs concurrent with a forecast of an approaching storm with serious implications. Even then the evacuation rate should not result in a downstream stage greater than that caused by runoff from the uncontrolled area during the previous flood. Bankfull flows that will be taken into consideration when scheduling postflood evacuation are 18,000 c.f.s. at Waterloo, 35,000 c.f.s. at Jefferson, and 120,000 c.f.s. at Salem. The most critical downstream point would control the scheduled reservoir releases. When less than 50 percent of the allocated flood control space is filled during a flood, evacuation of floodwaters will not be scheduled to the limit of the indicated bankfull capacities unless there is a forecast of an impending second storm. Evacuation within a 7-day period is an acceptable guide for releasing at less than bankfull capacities. Extended periods of evacuation at bankfull stage produces excessive bank erosion. This should be avoided when it can be accomplished with a minimum of risk.

6-07. Special flood-regulation schedule. - During a moderate flood, or larger, Foster Reservoir will fill rapidly. Before Foster Reservoir fills, the special flood-regulation schedule shown on chart 14 will be used to determine releases. These special flood-regulation rule curves will be used when continued regulation by the normal flood control schedule would result in a premature filling of Foster Reservoir resulting in an excessive spill. The special regulation curves are so constructed that by entering chart 14 with the current pool elevation and the reservoir inflow, an outflow is indicated which will make the most effective use of the remaining flood control storage space without exceeding full pool elevation. Frequency of adjustment will vary depending upon the magnitude of the inflow; the larger the flood the more frequently checks should be made for determining the necessity of changing the reservoir outflow. During large floods the inflow should be checked and outflow adjustments made at 2-hour intervals.

6-08. Rate of change in reservoir releases. - Sudden large increases in the release from Foster Reservoir create a safety hazard and should not be made unless indicated by the special reservoir regulation curves shown on chart 14. During and following floods, increases in the controlled release should not exceed 2,500 c.f.s. in any 1-hour period. The increase can be made in one or more adjustments; however, it is cautioned that the maximum rate of increase should be used only when absolutely necessary. Under normal operating conditions, the increase in release should be held to a maximum rate of 1,500 c.f.s. per hour or less.

6-09. Examples of regulation. - Examples of flood regulation are illustrated on plates 18 and 19 for (1) the flood of December 1964, the largest observed flood of record in Willamette River Basin; (2) the flood of February 1961, a recent major flood with an unusually large runoff downstream from the storage reservoirs; and (3) the December 1945 flood, one of the larger floods for which observed streamflow records are available.

6-10. It was assumed in studying each flood that reservoirs at Hills Creek, Lookout Point, Fall Creek, Dorena, Cottage Grove, Fern Ridge, Cougar, Detroit, Green Peter, and Foster were operative and that all were at their minimum flood control pools at the beginning of the flood. Data shown for each example include precipitation, Green Peter and Foster Reservoir inflows, regulated outflows, pool elevations, and discharge of South Santiam River at Waterloo, both natural and as modified by Green Peter and Foster. Flows of Santiam River at Jefferson are shown for three conditions: (1) natural; (2) modified by Detroit regulation; and (3) modified by Detroit, Green Peter, and Foster regulation. Also three flow conditions are shown for Willamette River at Salem: (1) natural; (2) modified by Hills Creek, Lookout Point, Fall Creek, Cottage Grove, Dorena, Fern Ridge, Cougar, and Detroit regulation; and (3) modified by reservoirs listed in condition (2) plus Green Peter and Foster.

6-11. The December 1964 flood, the largest observed flood of record, had a peak discharge at Green Peter Dam of 66,000 c.f.s. and an 8-day volume of 346,000 acre-feet. The 1964 flood, based upon the maximum discharge, is estimated to be slightly larger than a 100-year flood. As shown on plate 18, the Green Peter Reservoir release was maintained at 100 c.f.s. until the special flood-regulation schedule prescribed a gradual increase in the outflow. The maximum release, which occurred near the end of the flood, was 18,100 c.f.s. Foster Reservoir filled, but not until after the time of peak inflow, as modified by Green Peter. The modified peak inflow of 42,000 c.f.s. was reduced to a maximum release of 26,800 c.f.s. by Foster regulation. At Waterloo, the natural peak discharge was reduced from 95,400 c.f.s. to 32,000 c.f.s. The natural discharge at Salem was reduced from 472,000 c.f.s. to 307,000 c.f.s. by existing reservoirs. Green Peter and Foster Reservoirs effected an additional reduction of 47,000 c.f.s., reducing the Salem regulated flow to 260,000 c.f.s.

6-12. The February 1961 flood, a recent major flood with an unusually large runoff below the storage reservoirs, had a total volume of 140,000 acre-feet at Green Peter Dam, and a peak discharge of 40,000 c.f.s. That flood, which had a 10-year recurrence probability, based on peak discharge, could have been completely controlled at Green Peter Dam using 50 percent of the storage space allocated to flood regulation. Foster Reservoir would have filled just after the modified peak inflow. The peak discharge at Waterloo would have been reduced from 69,000 c.f.s. to 19,300 c.f.s. The natural discharge at Salem would have been reduced by existing projects from 304,000 c.f.s. to 232,000 c.f.s. Green Peter and Foster effected an additional reduction of 32,000 c.f.s., and a regulated flow at Salem of 200,000 c.f.s. Plate 19 shows the natural and regulated hydrographs at key downstream stations.

6-13. Flood routings were made for the December 1945 flood, another significant flood for which observed streamflow data are available. That flood had a recurrence probability of once in a 15-year period, a total volume of 157,000 acre-feet, and a peak discharge of 44,000 c.f.s. at Green Peter Dam. As shown on plate 19, the minimum release of 100 c.f.s. from Green Peter would have been maintained for the duration of the flood. The maximum water surface at Green Peter reached elevation 972.7 feet, m.s.l., which is 42.3 feet below full pool elevation. Foster effected a 10,600-c.f.s. reduction in the modified inflow. The natural peak discharge at Waterloo was reduced from 74,200 c.f.s. to 31,000 c.f.s.

6-14. The natural discharge at Salem was reduced from 262,000 c.f.s. to 170,000 c.f.s. by reservoirs listed in paragraph 6-10. Green Peter and Foster regulation effected an additional reduction of 15,000 c.f.s., and a regulated flow at Salem of 155,000 c.f.s.

6-15. Regulation of the spillway design and standard project floods for Foster Reservoir, which are shown on charts 15 and 16, respectively, offers unusual examples of flood regulation as both floods had volumes that exceeded the flood control capacity of the project and special regulation had to be effected to make optimum use of the available storage. An empty reservoir at the start of the flood was assumed in both routings.

a. Spillway design flood. - Chart 15 shows it was necessary to use special reservoir regulation curves early in the flood, approximately 22 hours prior to the flood crest. The peak discharge from the reservoir, 180,000 c.f.s., occurred concurrently with the peak inflow and represented a reduction of 15,500 c.f.s. at the damsite. The unregulated peak inflow to Foster of 214,000 c.f.s. was reduced to 195,500 c.f.s. by Green Peter regulation.

b. Standard project flood. - The unregulated peak of the standard project flood, 141,000 c.f.s., was reduced by Green Peter to 84,500 c.f.s. which is shown on chart 16. Special reservoir regulation curves were used starting about 36 hours prior to the peak inflow. The maximum release of 81,800 c.f.s. occurred concurrently with the peak inflow and represents a reduction of 2,700 c.f.s. in the peak inflow of 84,500 c.f.s. as modified by Green Peter. The flood reduction would be greater downstream as the maximum releases at Green Peter and Foster were delayed long enough for the peak of the uncontrolled area below Foster to crest and recede to the extent that the increased releases would not produce a higher secondary crest. The special reservoir regulation curves increase the effectiveness of the projects to regulate the larger floods at downstream stations.

SECTION VII - STORING FOR CONSERVATION

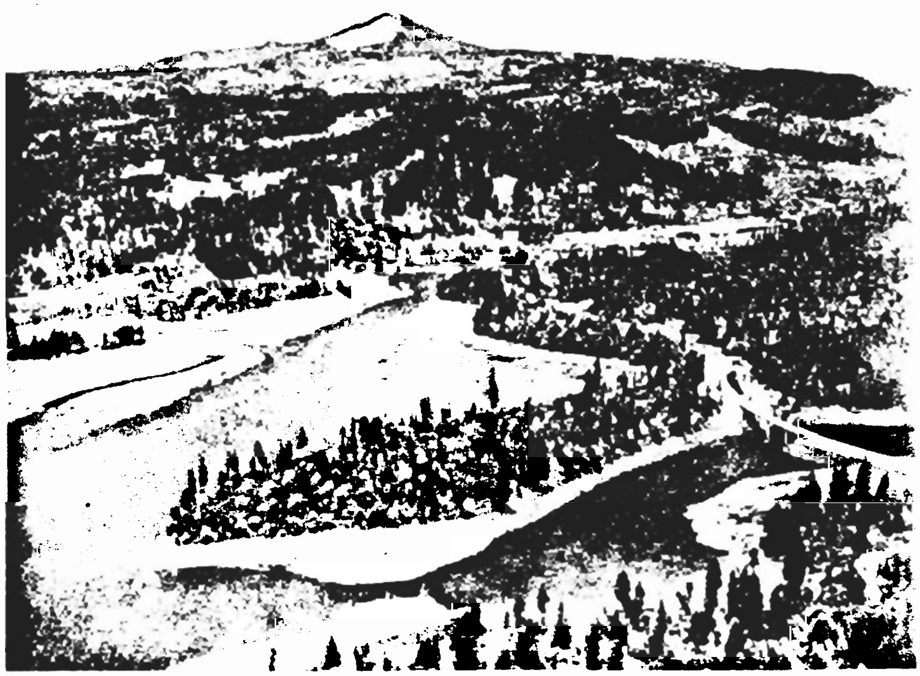
7-01. General. - Willamette River Basin is unique in that storage reservoirs in the basin can be scheduled for multiple-purpose use. Space reserved for flood control during the winter months can gradually be filled near the end of the flood season as the storm activity decreases, without jeopardizing the flood control effectiveness of the project. After 1 February, storms over South Santiam River Basin decrease in both intensity and frequency. By mid-May the probability of a significant flood has become small; therefore, during the period 1 February through 10 May, storage space in Foster Reservoir is gradually filled for conservation use.

7-02. Filling schedule. - The filling schedule for Foster Reservoir, shown on chart 9 and in table 11, permits storing at an average accumulated rate of 251 acre-feet per day during the period from 1 February through 10 May. Filling at that rate, maximum conservation pool, elevation 637, is reached on 11 May. Scheduled pool elevations, shown on chart 9 and in table 11, should not be exceeded except in case of a flood. Above maximum conservation pool, 4,800 acre-feet of storage space between elevations 637 and 641 is reserved for summer flood regulation. Thirty-six hundred acre-feet of the summer flood control storage space is used as pondage to level off Foster releases which otherwise would fluctuate too severely as the result of power peaking at Green Peter. Dual use of the 3,600 acre-feet between elevations 637 and 640 is considered practical as any water stored above elevation 637 can be evacuated readily when it is needed for flood regulation.

7-03. The basic regulation schedule shown by the solid line on chart 9 indicates the scheduled annual storage reservations for flood regulation. Filling above this storage level would occur only as the result of regulating a flood or from reregulating releases from Green Peter Reservoir. The latter activity is limited to the use of 3,600 acre-feet above maximum conservation pool and will be restricted whenever a flood is imminent after the reservoir has been filled to maximum conservation pool. Prior to the construction of Cascadia Reservoir, an upstream storage reservoir, conservation filling at Foster Reservoir will, under normal circumstances, be delayed. Filling will not be a problem because of the large contributing area, 217 square miles. Further, the reserving of additional storage space for flood regulation after 1 February will enhance the effectiveness of Green Peter and Foster Reservoirs to regulate late-season floods, particularly until Cascadia is constructed. Runoff forecasts after 1 February will serve as a guide for scheduling the conservation filling. Conservation filling will vary from year to year depending upon the weather and the water content of the snowpack above the reservoir. Chart 17 will be used to forecast the runoff above Foster Reservoir.

7-04. After Cascadia Reservoir is constructed, Foster Reservoir will be regulated differently than in the interim period. Foster Reservoir will then regulate the uncontrolled runoff from the 38 square miles of area below Green Peter and Cascadia, and conservation filling scheduled by chart 9 will be the normal operation. The storage space reserved above the solid line on chart 9 is capable of regulating the

SOUTH SANTIAM BRIDGE



RESERVOIR AT MINIMUM POOL

uncontrolled runoff from the area below Green Peter and Cascadia Reservoirs.

7-05. Departures from the filling schedule shown on chart 9 may occur as the result of: (1) a water supply more than adequate to fill the reservoir, (2) a critical power situation, (3) inadequate water supply, and (4) occurrence of a flood. Each of the above conditions is discussed in the following paragraphs.

7-06. Water supply more than adequate. - Should an excessive snow-pack exist above the reservoir, filling will be curtailed temporarily in the interest of providing greater storage space reservation for regulating a flood that might develop from rainfall and an existing snowpack. An excessive snowpack would exist when the forecasted runoff, based upon minimum precipitation for the remainder of the storing period, exceeds the storage space to be filled after downstream requirements have been satisfied. The use of runoff forecast curves to effect this particular storage regulation is discussed in paragraph 7-12.

7-07. Critical power situation. - During a year when the winter flow in Columbia River is critically low, supplementary power generation at Green Peter and Foster Dams may be desirable to meet firm power commitments in the Northwest Power Pool. Operation for the production of supplementary power could affect the normal filling of Green Peter Reservoir to the extent that the reservoir might be only partially filled at the end of the filling season, 10 May. During the interim period before Cascadia Dam is constructed, ample water will be available to fill the 24,800 acre-feet of storage space in Foster Reservoir between elevations 613 and 637, even in a low-water year. After Cascadia is constructed it is possible that, by generating supplementary power during the filling months to the detriment of filling, there may not be adequate amounts of water stored to meet irrigation and other high-priority requirements during the subsequent conservation release season, particularly after irrigation becomes more fully developed. Should there be a shortage of stored water for irrigation and water supply following a period of curtailed filling as a result of the above circumstances, exclusive power storage and possibly dead storage may be used for those purposes, in the amount that power generation curtailed the normal filling. Power interests would be apprised of this risk, by District Office, before any special regulation that might jeopardize filling of Green Peter Reservoir would be effected.

7-08. Inadequate water supply. - There may be times when the reservoir inflow is not adequate to maintain, simultaneously, the normal minimum releases and the desired filling rates. Minimum mean daily releases from Foster Reservoir which will have precedence are as follows:

Period	Release, c.f.s.
February - April	800
May	750
June	600
July - November	400

Any deficiency in filling, regardless of the reason, will be made up at a later date if there is an excess of streamflow after downstream minimum flow requirements have been satisfied.

7-09. Occurrence of a flood. - Although the flood potential of the basin normally decreases as the spring season advances, floods can occur during the conservation storing period. Regulation of a flood during that, or any other, period will be in accordance with Section VI of this manual, using the schedules shown on charts 13 and 14. Following a flood that occurs during the conservation storing period, excess floodwater stored in Foster Reservoir will be evacuated and the pool will be drawn down to the storage level indicated by the rule curve on chart 9.

7-10. Flexibility in seasonal filling schedule - Flexibility in the filling schedule for Foster Reservoir makes it possible to generate extra power during the filling period when there is a surplus of water. Experience at existing power reservoirs in the Willamette River Basin has established the desirability of flexibility in the conservation storing schedule so that power may be generated when it is needed in the Federal system so long as the filling of the conservation storage is not jeopardized. This phase of flow regulation at Willamette Valley reservoirs will be given continuous attention.

7-11. The scheduled pool elevations, shown on chart 9 and in table 11, should not be exceeded, except in case of a flood or when a forecasted shortage of seasonal runoff clearly indicates a limited storing above the scheduled pool level is desirable. Action of this latter type would require special authorization from higher authority and will not be a factor until Cascadia is constructed. The annual filling schedule provides sufficient storage space to regulate all but the most infrequent floods during the February-May storing period. Frequent forecasts of residual runoff tributary to the reservoir will be made during the filling period in order to establish the minimum storing rate which will provide reasonable assurances of filling the reservoir. Forecasts of seasonal runoff will be important in years when extra water during the filling period could be used to advantage for water-conservation purposes.

7-12. Residual runoff forecasts after February. - Any deviation in the rate of filling of Foster Reservoir will be made on the basis of residual runoff forecasts which will be made at 15-day intervals, starting on 1 February. The forecasted runoff determined from chart 17 will be for the period between the date of the forecast and the end of June. Enter chart 17 with the residual runoff forecast for Green Peter Reservoir to determine the expected runoff into Foster Reservoir during the corresponding forecast period. The correlation between corresponding runoffs at Green Peter and Foster is good. The procedure for forecasting the runoff of Middle Santiam River at Green Peter Reservoir is presented in a special report, "Procedure for Forecasting Inflow to Willamette Basin Power Reservoirs After 1 February," dated January 1968.

SECTION VIII - UTILIZATION OF STORED WATER

8-01. General. - At Foster, from 1 October through 15 November, stored water will be released in the interest of the authorized project purposes, as listed in Section III. Conservation benefits from operation of Foster project will be realized along lower South Santiam River, Santiam River, and Willamette River below the mouth of the Santiam.

8-02. Total conservation storage in Foster Reservoir between minimum flood control pool, elevation 613, and maximum conservation pool, elevation 637, is 24,800 acre-feet.

8-03. Conservation release schedule. - The storage reservation for flood regulation at Foster Reservoir, shown on chart 9, indicates the maximum pool elevations which should not be exceeded except in case of floods, to insure the availability of flood control space during all seasons of the year.

8-04. From 11 May through 30 September, 4,800 acre-feet of flood control storage space will be available for the control of minor freshets. Thirty-six hundred acre-feet of that storage space will be used to reregulate flows from Green Peter Reservoir. Whenever the hydrologic situation indicates the 3,600 acre-feet might be needed for flood regulation, it will be made available. After 1 October, additional storage space will gradually be made available for flood regulation, and by 16 November 29,600 acre-feet of flood control space between elevations 613 and 641 will be reserved for flood regulation. See table 12 for evacuation schedule.

8-05. Should a flood occur during the conservation release schedule, the reservoir will be regulated in accordance with Section VI of this manual, and floodwater will be stored to effect downstream flood regulation. Following a flood, excess water will be evacuated and the reservoir will be drawn down to, or below, the indicated pool elevations for that date as soon as the channel capacities at Waterloo and Jefferson will permit.

8-06. Demands for stored water during the conservation release season will vary from year to year. Because of variable demand and the variations in precipitation and streamflow, it is not practicable to establish a fixed schedule of reservoir releases during the low-water season. A provisional schedule, incorporating the basic principles outlined in the preceding paragraphs, will be prepared and submitted to higher authority for approval each year before the initiation of major conservation releases. The provisional schedule, which will be prepared on the basis of available stored water and anticipated hydrologic conditions, will be reviewed periodically during the season and changes will be made should conditions warrant.

8-07. Water-use priorities. - The priority of the use of stored water in Foster Reservoir is as follows:

a. Domestic and municipal water supply (under 1958 Water Supply Act).

b. Maintenance of minimum flows for fish life.

c. Power (authorized project purpose).

d. Navigation (authorized project purpose).

e. Water quality control (secondary project purpose).

f. Recreation (secondary project purpose).

The above priorities on stored water are consistent with authorized project functions, State water laws, and policy. A facility has been constructed in the dam, on the basis of assurances on file in the District Office, for serving the future requirements of municipal and industrial water supply. The project is committed to maintaining downstream passage of fingerlings, and maintaining minimum flows for fish life below the dam. Irrigation has a high priority on stored water and any water released at an upstream reservoir for that purpose will be passed at Foster. However, at the present time no contracts have been negotiated by the U.S. Bureau of Reclamation with irrigators for stored water from the reservoirs in South Santiam River Basin. Only a nominal draft on stored water at the power reservoirs will be accomplished prior to the first of September. Except for the flow necessary to pass downstream migrants, most of the stored water in Foster Reservoir will be released through the generators to produce hydroelectric energy. No specific amount of storage is reserved for navigation and incidental water quality control. Releases made for power and other nonconsumptive uses will benefit navigation. All releases of good quality water will benefit water quality control, at least downstream to the point of diversion and consumptive use. Recreation, although not an authorized project function, will be extended as much consideration as possible. Maximum conservation pool will be maintained until 1 October.

8-08. Prior water rights. - The water laws of the State of Oregon provide that all water within the State from all sources of supply belongs to the public. Subject to existing water rights, and in accordance with the statutory provisions governing such matters, all natural flow within the State may be appropriated for beneficial use. Prior to January 1956, the administration of the water laws of the State of Oregon was vested in the State Engineer, who issued permits for the use of water and was generally recognized as the authority on all matters concerning adjudication and appropriation of water rights. Since January 1956, however, such administration has been vested in a seven-man Water Resources Board, created by the 1955 session of the Oregon State Legislature.

8-09. Prior water rights granted in accordance with Oregon law will be honored to the extent of the natural inflow into Foster Reservoir. The proposed minimum release of 400 c.f.s. from Foster Reservoir during the July-November period is well in excess of all existing water rights in the reach of South Santiam River below Foster. No problems associated with appropriated flows are anticipated in the regulation of Foster project.

8-10. Minimum reservoir releases. - Normal minimum releases from Foster Reservoir, other than during a flood, were discussed in a series of conferences with the U.S. Fish and Wildlife Service, the Oregon State Game Commission, and the Fish Commission of Oregon in 1946. The principal concern in selecting minimum flows below Foster Reservoir was to insure an adequate flow of water for maintenance of the normal resident fish population and the anadromous fish runs.

8-11. From 1 February through June, the planned minimum mean daily release will vary as follows:

February through April	800 c.f.s.
May	750 c.f.s.
June	600 c.f.s.
July through November	400 c.f.s.

Between 1 July and 15 November, the minimum mean daily release will be 400 c.f.s. During the latter part of November, December, and January the reservoir normally will be maintained near minimum flood control pool, except in case of a flood. Minimum release during the mid-winter period will be the inflow to Foster Reservoir except as regulated during a flood period. On the average, natural flows during the mid-winter months are in excess of 900 c.f.s. During a flood, when the inflow to Foster is in excess of 10,000 c.f.s. the release will be maintained at 10,000 c.f.s. until higher releases are indicated by the special reservoir regulation curves.

8-12. Irrigation. - The natural flow of Willamette River and its tributaries is low during the months of July, August, and the first half of September, when irrigation demands are greatest. As the acreage under irrigation increases, so does the dependence on stored water increase. The Bureau of Reclamation has estimated that 52,000 acres of productive land in the lower South Santiam plains could ultimately be irrigated with South Santiam River storage. Green Peter Reservoir will supply water needed for irrigation during the interim period before Cascadia Reservoir is constructed on South Santiam River. Foster Reservoir will not provide stored water for irrigation under normal circumstances but will pass all stored water released for this purpose from upstream reservoirs. Foster pool is to be maintained full for recreational and power purposes until 1 October.

8-13. The Bureau of Reclamation, which is responsible for the sale of stored water for irrigation at Government projects, receives all payments for the United States Government. That agency has filed with the State Engineer on all multiple-purpose conservation storage in five of the eight existing Willamette River Basin reservoirs: Lookout Point, Dorena, Cottage Grove, Fern Ridge, and Detroit. As of 1 January 1968, no filing had been made on storage in Hills Creek, Cougar, Fall Creek, Green Peter, or Foster projects. Filings on these latter reservoirs have been held in abeyance pending submission of the Willamette Review Report scheduled for completion in 1969, but it is understood that a filing now is being prepared. The Bureau will keep the Portland District informed of irrigation demands on those projects for which they have contracts, so that long-range and day-to-day reservoir releases can include the irrigators' requirements. The Corps of Engineers will release stored water for irrigation at the request of the Bureau of Reclamation if a filing has been made, a valid contract is in force, and the necessary rights for diversion of stored water have been granted by the State.

8-14. Power. - Power generated at Foster Dam will be integrated into the Northwest power system. The streamflow regimen of Middle and South Santiam Rivers makes this arrangement highly beneficial to the system because Santiam flows normally are high when flows in Columbia River are low. The critical power production period in the Northwest is from approximately September through April. During the remainder of the year, power generation at Foster project normally will be incidental to releases for other conservation uses. For this reason the general plan of reservoir regulation during the conservation releases period is to keep Foster pool high until 1 October. After that date, any release made for a conservation use other than power will likewise benefit power. With the exception of Fern Ridge Reservoir, reservoirs in Willamette River Basin will be scheduled to augment nonpower low-water demands during July and August.

8-15. The power installation at Foster Dam consists of two 10,000-kilowatt units, which will operate between heads of 115 feet and 81 feet. Conservation storage above elevation 613, not allocated to a higher priority interest, would be available for power generation. However, the water must be evacuated by 16 November in the interest of flood regulation.

8-16. <u>Navigation</u>. - Natural flows during the summer and early fall, which are being progressively depleted by pumping for irrigation, are inadequate for navigation. Release of stored water from Foster Reservoir, in conjunction with releases from other reservoirs in Willamette River Basin, will materially increase low flows in Willamette River. Foster Reservoir will not benefit navigation or increase low-water flows until after 1 October.

8-17. In the interim period before all authorized multiple-purpose dams are operative, the objective will be to maintain as high a flow in the Willamette River during the low-water season as is possible with the volume of stored water available, consistent with the needs of other authorized conservation functions. Studies show that, when all of the presently authorized dams have been constructed, it will be possible to maintain minimum flows of approximately 5,000 c.f.s. at Albany and approximately 6,000 c.f.s. at Salem in 75 percent of the years. A simulated system operation study of the 14 existing and authorized reservoirs in Willamette River Basin showed that those minimum scheduled flows at Albany and Salem could have been maintained in all but 8 years during the period 1926-1955.

8-18. Water quality control. - Conservation releases from Foster Reservoir will benefit water quality along both Santiam River and Willamette River downstream from the mouth of Santiam River. In past years Willamette River has been seriously polluted with domestic and industrial waste, but there has been a considerable increase in the number of sewage and industrial waste treatment plants along Willamette River and its tributaries. The sewage, industrial wastes, and turbidity which still exist in the river are major problems for fish propagation, fish passage, recreation, and domestic and industrial water supplies. The dilution which takes place when stored water is released from Willamette River Basin reservoirs during the low-water season greatly improves the quality of the river water.

8-19. No special regulation of Foster Reservoir is planned for water quality control, but water released for other nonconsumptive conservation uses, such as navigation and power will also be effective in alleviating pollution conditions in Willamette River. Irrigation releases will be fully effective downstream to the point of diversion and may have some residual beneficial effect downstream from that point. The maximum water needs for water quality control and navigation tend to occur simultaneously. During the first years of operation, a program to monitor the quality of the water in Foster Reservoir will be in effect. This is a precautionary measure to insure that the water released from Foster Reservoir is not detrimental to downstream fish life and to determine what effect releases from the reservoir have on the quality of the water downstream from the dam.

8-20. Public use. - From a recreational standpoint it is desirable to maintain Foster Reservoir at maximum conservation pool throughout the summer and fall months, a policy which will be followed under normal circumstances. Any change from this operating procedure would require prior approval from higher authority. The proposed plan of operating Foster with a high, relatively stable pool during the summer months gives Foster Reservoir a high recreational potential.

8-21. Mosquito control. - There is no indication that Foster Reservoir will present a potential malaria hazard based on experience at other Willamette reservoirs. Several of those reservoirs have been in operation for more than 20 years. Establishment of special pool fluctuation schedules for mosquito control will be resorted to only if the mosquito problem should become serious and other control methods fail.

SECTION IX - HYDROMETEOROLOGICAL FACILITIES

9-01. General. - Effective regulation of Foster Reservoir requires reservoir regulation personnel to make use of short- and long-range weather forecasts and daily quantitative precipitation forecasts for all zones in western Oregon during the rainy season, October through March. These forecasts are prepared in the Seattle Office of the Weather Bureau and are relayed to the District Office through the Weather Bureau Office in Portland over the District teletype circuit.

9-02. In addition to the Weather Bureau forecasts, supplementary forecasts will be made by a District meteorologist as required. Weather maps are received in the District Office over the weather facsimile circuit, which provides service 24 hours a day, 7 days a week. Normally, one set of surface and upper air charts is received each morning, Monday through Friday. During critical flood situations, additional sets of weather charts are made available at 6-hour intervals and over the weekends. In addition, there is close coordination with the local Weather Bureau offices during flood periods, so that special reservoir, hydrologic, and weather information can be interchanged with a minimum of delay.

9-03. Project weather station. - Maintenance and operation of the weather station located at Foster Dam is the responsibility of the Project Engineer. The station consists of an instrument shelter house, maximum and minimum thermometer, aerovane, hydrothermograph, psychrometer, manual precipitation gage, recording precipitation gage, and an evaporation pan with anemometer. Weather stations are also operated at or in the immediate vicinity of the other flood control and multiple-purpose reservoirs in Willamette River Basin. The first-order Weather Bureau station nearest to Foster is located at Salem, about 40 miles northwest of Foster Dam.

9-04. Precipitation stations. - A limited number of stations, namely; Marion Forks, Detroit, and Detroit Dam, record both precipitation and snow data in Santiam River Basin. Eleven other stations in the basin record either rain, snow, or climatological data. These include the Jordan precipitation station in North Santiam River Basin, which automatically reports precipitation each hour by radio to the Portland District Office. These latter precipitation reports have been of considerable value in regulating Detroit Reservoir and will be equally important in the regulation of South Santiam reservoirs for flood control. In addition, special reports are received from several of the climatological stations, on a criteria basis. At the present time there are no reporting climatological stations located in the area tributary to Foster Reservoir. Precipitation records have been obtained at Quartzville, elevation 823, and are being obtained at Cascadia, elevation 796. At the present time it would be difficult to establish and maintain direct contact with climatological stations above Foster Reservoir because of the sparsity of population. Observers are not available in the more remote areas, particularly during the winter months or flood season. When observers and communication facilities become available, climatological stations deemed beneficial to the operation of the project will be established. Locations, elevations, and periods of record of pertinent precipitation stations are shown on plate 1.

9-05. Snow courses. - Snow depth and water content of the snowpack are measured at a number of snow courses in the general area of Foster Reservoir. None of the snow courses are located within the basin tributary to Foster Reservoir, but several are located in North Santiam River Basin, and in the adjoining areas. Snow conditions in the adjacent watersheds are considered representative of conditions at comparable elevations above Foster Reservoir. Locations, elevations, and periods of record of pertinent snow courses are shown on plate 1.

9-06. In addition to the standard snow courses, special snow measurements are made bimonthly, starting on 1 January and ending 1 May, at Santiam Junction and Hogg Pass which are near the summit of passes over the Cascade Range, east of Santiam River Basin. Data from those snow courses, together with snow-course data obtained at McKenzie Pass and at other auxiliary locations, will be utilized in estimating a profile of snow depth and water equivalent in South Santiam River Basin. Plate 1 shows the location of snow courses pertinent to the Foster project, with the exception of McKenzie Pass. Future plans include aerial reconnaissance flights to determine the areal distribution of the snowpack which will be used to supplement snow-course data in the preparation of seasonal runoff forecasts for the basin above the reservoir.

9-07. Communication facilities. - A radio communication system between the Portland District Office and several of the existing flood control and multiple-purpose dams in the Willamette Valley is now operative. This radio system supplements commercial telephone, the normal means of communicating with the dams. At the present time commercial

TAILWATER GAGING EQUIPMENT

telephone is the only means of voice communication with Foster Dam. However, it is planned to study the feasibility of extending the radio network to include the Foster project. Likewise it is planned to install a teletype drop at Foster Dam which will feed into the Columbia Basin teletype network. This is to expedite the process of getting project data to the various offices interested in receiving reports from the project.

9-08. Water-stage recorders essential to the operation of the project and in the immediate vicinity of the reservoir are connected electrically to a control panel in Foster powerhouse. Composite data from those gages will be continuously recorded on charts located in the

9-09. There are a number of stream-gaging stations in Willamette River Basin equipped with automatic telephone transmitting devices, Telemarks, which transmit the gage height as a series of audible tones when the station is interrogated by telephone. The majority of the stations equipped with Telemarks are operated by the Corps of Engineers, the remainder being operated by the U.S. Weather Bureau. Stations equipped with Telemarks which are most directly associated with the regulation of the Foster project are: Cascadia, located about 10 miles upstream from

Foster Dam on South Santiam River; Waterloo, located approximately 14 miles downstream on South Santiam River; and Jefferson, located at about mile 10 on Santiam River, below the confluence of North and South Santiam Rivers. No additional Telemarks are proposed for the operations of Foster project; however, should a need develop as a result of operating experience, the desired facilities will be provided.

9-10. Hydrologic reporting network. - Basic hydrologic data for forecasting floods and regulating reservoirs in Willamette River Basin for flood control originate from three categories of stations which make up the hydrologic reporting network. One group of stations is operated and financed by the Corps of Engineers as a project function. Those stations are located at the existing storage projects or are stations equipped with telemetering or Telemarks, and can be contacted without the services of an observer by project personnel. Reports from this group of stations are collected and forwarded by Corps of Engineers' personnel. Another group of stations, referred to as the FC-5 reporting network, is partially financed by the Corps of Engineers through a transfer of funds to the U.S. Weather Bureau which is responsible for operation and for the collection and dissemination of special reports during flood periods. Individual observers report by telephone on a criteria basis or on call. This information and that received from regular U.S. Weather Bureau stations, the third category, are disseminated by teletype or telephone to those interested, which includes the Corps of Engineers. Data and forecasts thus exchanged are utilized in the regulation of Foster Reservoir.

9-11. Plate 1 shows the location of all climatological and stream-gaging stations within a 25-50 mile radius of the Foster project. As a result of this coordinated network of reporting stations there is a free and continuous exchange of weather, reservoir, and streamflow information between the Weather Bureau and the Corps of Engineers.

9-12. The following tabulation lists the stations in the reporting network that are most pertinent to the regulation of Green Peter-Foster project. The stations are also shown on plate 1.

Station number	Station	Stream or watershed	Communication	Information reported
1859	Above Green Peter Reservoir	Quartzville Cr.	Telemetering[1/]	River (reservoir inflow)
1858	Above Green Peter Reservoir	Middle Santiam R.	Telemetering[1/]	River (reservoir inflow)
	Green Peter Dam	Middle Santiam R.	Telemetering[1/]	Pool elevation
	Green Peter Dam below dam	Middle Santiam R.	Telemetering[1/]	Tailwater elevation
1850	Cascadia	South Santiam R.	Telemark[1/]	River (reservoir inflow)
	Foster Dam	South Santiam R.	Telemetering[1/]	Pool elevation
	Foster Dam below dam	South Santiam R.	Telemetering[1/]	Tailwater elevation
	Foster Dam	South Santiam R.	Telephone[2/]	Precip., temp., weather
1867	At Foster below dam	South Santiam R.	Telemetering[1/]	River (reservoir releases)
1875	Waterloo	South Santiam R.	Telemark[1/]	River stage
1890	Jefferson	Santiam R.	Telemark[2/]	River stage
1815	Niagara	North Santiam R.	Telemetering[3/]	River (reservoir releases)
1830	Mehama	North Santiam R.	Telemetering[4/]	River stage
A	Jordan radio precipitation gage	North Santiam R.	Radio[5/]	Hourly precipitation
1910	Salem	Willamette R.	Telemark[4/]	River stage

1/ Recorded at Foster Dam and relayed to District Office by dam personnel.

2/ Collected and relayed to District Office by dam personnel.

3/ Collected at Detroit Dam and relayed to District Office by dam personnel.

4/ Collected by U.S. Weather Bureau and related to District Office.

5/ Recorded in District Office.

Tables 13 through 18 are rating tables for stations most pertinent to the regulation of Foster and Green Peter Reservoirs.

9-13. Data from the above stations are collected and forwarded to Portland on a daily basis, except during the summer low-water season when reports are not submitted over the weekends and holidays. Six-hour weather reports are received from Civil Aeronautics Administration teletype service from the first-order Weather Bureau stations at Roseburg, Eugene, and Salem. Stream-gaging stations equipped with Telemarks may be called at any hour, but for reasons of economy they are usually called by the Corps or Weather Bureau Office in the vicinity of the project and the data transmitted to Portland as a part of the interoffice report. Special reports are received when the streams approach or exceed bankfull capacities, or on request. FTS service provides a very convenient means of contacting the projects in an emergency or when the communication cannot be conveniently carried out over the teletype. Normally, the teletype will be used to communicate with the project.

9-14. <u>River forecast center</u>. - Arrangements have been made for the River Forecast Center of the U.S. Weather Bureau in Portland, Oregon, and the Corps of Engineers to cooperate in forecasting floods in Willamette and Columbia River Basins. The U.S. Weather Bureau has the responsibility of providing the public with flood-warning services, and the Corps of Engineers is responsible for regulating floods in both Willamette and Columbia River Basins. Therefore, there was a need for an interchange of information so that both agencies could carry out their responsibilities effectively. The U.S. Weather Bureau, in making its forecasts, utilizes the Corps of Engineers' electronic computer, data as to regulated discharges from Corps of Engineers' projects, and basic hydrologic data collected at the many Corps of Engineers' projects. The hydrologic and reservoir data obtained from the Corps of Engineers supplements hydrologic data collected through other channels. The only stage forecasts disseminated to the public are those made by the U.S. Weather Bureau.

SECTION X - RESPONSIBILITIES AND EMERGENCY INSTRUCTIONS

10-01. Organization for reservoir regulation. - Under authority contained in Sections 1 and 2 of the Flood Control Act of 22 June 1936, the Chief of Engineers is responsible for establishing overall policy for the regulation of reservoirs for flood control. In the Portland District, reservoir regulation plans and schedules for flood control projects are formulated in the Engineering Division in accordance with instructions contained in Engineering Manual 1110-2-3600, dated May 1959, and are submitted through the North Pacific Division to the Office, Chief of Engineers, for approval. Any future changes in the reservoir regulation plan that affect the authorized functions of the reservoirs, or constitute major changes in the approved regulation plan, will be submitted through the North Pacific Division to the Office, Chief of Engineers, for approval prior to field use.

10-02. Organization of the Portland District for the regulation of Foster project is shown on chart 18, which shows names and telephone numbers of personnel and the lines of communications by which instructions are transmitted, both administratively and functionally. Regulation for hydroelectric power production requires close coordination with Bonneville Power Administration, the marketing agency for power generated at all Federal projects in the Pacific Northwest. Coordination and liaison are maintained with the U.S. Weather Bureau and U.S. Geological Survey at all times for the purpose of obtaining basic meteorologic and hydrologic data essential to the regulation of Foster and other multiple-purpose reservoirs in the Willamette River Basin.

10-03. Engineering Division. - In accordance with the provisions of Chapter 2 of EM 1110-2-3600, "Reservoir Regulation," functional regulation of Foster Reservoir and other multiple-purpose reservoirs in the Portland District is the responsibility of the Engineering Division with the primary responsibility delegated to the Water Control Section of Planning Branch. Within the Water Control Section are personnel assigned to reservoir regulation and power scheduling. The Project Engineer at Foster Reservoir will be furnished with the names of District personnel authorized to issue reservoir regulation and power generation instructions to the project. This list will be revised as changes in personnel assigned to reservoir regulation are made. All significant reservoir regulation instructions issued by the Water Control Section will be confirmed in writing.

10-04. Duties of Engineering Division personnel assigned to regulation of Foster Reservoir are:

a. Develop a plan of regulation including schedules and rule curves which incorporate the concept of system regulation.

b. Maintain a continuing program of study to improve reservoir regulation technique and rule curves for more efficient operation of Foster Reservoir for flood regulation and conservation uses.

c. Prepare and distribute reservoir regulation manuals and make revisions when necessary.

d. Direct the functional regulation of the reservoir. During flood periods, Foster Reservoir will be subject to 24-hour surveillance, whereas water conservation is normally a day-to-day operation.

e. Develop schedules and coordinate the use of water impounded in Foster Reservoir. The Bureau of Reclamation is the Government agency responsible for the sale of stored water for irrigation. Stored water dispatched from Foster Reservoir for this purpose will be at the Bureau of Reclamation's request, when a valid contract is in effect. Bonneville Power Administration will be consulted in scheduling power releases from Foster as it is the Government agency responsible for the sale and distribution of power generated at Federal plants.

f. Develop a training program to improve technical proficiency and to enable the normal staff of reservoir regulation personnel to be supplemented during flood emergencies. Participate in mock-flood exercises to test the reservoir regulation training program, the flood emergency plan, reservoir regulation methods and schedules, and data reporting.

g. Prepare charts of Monthly Reservoir Regulation and provide applicable portions of special flood reports, survey reports, definite project reports, and design memorandums.

10-05. During the flood season, hydrologic reports are collected and analyzed on a continuous basis. Personnel assigned to reservoir regulation are responsible for keeping a constant surveillance of weather and streamflow conditions. Normally, a reduced staff is assigned to weekend and holiday duty with the off-duty personnel subject to call in an emergency. Personnel on duty have the authority to direct the operation of the reservoir in accordance with the schedules in the manual, but they are required to obtain approval of the Chief, Water Control

Section, or the Chief, Reservoir Regulation Subsection, before initiating significant deviations from the approved flood regulation schedules.

10-06. Project Operations Division. - Physical operation and maintenance of multiple-purpose projects in the Portland District is the responsibility of the Project Operations Division under the direct supervision of a Project Engineer. The Project Engineer is also responsible for carrying out reservoir regulation instructions received from the Engineering Division through dam tenders and powerhouse operators, who normally are the direct recipients of the instructions from the District Water Control Section. All instructions pertaining to the regulation of Foster Reservoir shall be logged by the dam attendant receiving the instructions. District instructions shall be recorded on Form NPP FL 54, August 1968. See chart 19. Date, time, and names of persons giving and receiving the instructions will be part of the logged data.

10-07. Forms and reports. - Several functional reports will be prepared by personnel at Foster. Those reports are to keep the many interested parties informed on project activities and to provide a permanent record of project activities. In general, the reports are made on standard forms and have a prescribed distribution. Some reports are for project use only; others are prescribed by regulations and require off-the-project distribution. This manual is primarily concerned with those reports pertaining to flood control that have an off-the-project distribution. The standard forms pertinent to this manual are shown in charts 19 through 23, and are listed in the following tabulation:

Forms for Reports	
Form number	Description and disposition
NPP FL 54 August 1968	Reservoir Regulation and Power Operation District Instructions to Project
Copies	1
Routing	1 - District Office File
Frequency	Following each significant instruction to project
NPP Form 34F September 1966	Foster Project Daily Hydrometeorological and Power Data
Copies	3
Routing	1 - Engineering Division 1 - Project Operations Division 1 - File at Foster Dam
Frequency	Daily
NPP 315 (Fos) January 1962	Monthly Reservoir Regulation
Copies	11
Routing	1 - Office, Chief of Engineers 1 - North Pacific Division 1 - Mail and Records 1 - Project Operations Division 1 - Engineering Division 2 - Foster Dam 4 - Outside Agencies (Distribution will be made by Reservoir Regulation Subsection)
Frequency	Monthly

Forms for Reports	
Form number	Description and disposition
NPP 252 (Rev) RCS-NPPVK-57	Power Production Report
Copies	5
Routing	1 - Office, Chief of Engineers 1 - Project Operations Division 1 - Engineering Division 2 - Bonneville Power Administration
Frequency	Monthly
F.P.C. No. 4 (FPC - 1001)	Monthly Power Plant Report
Copies	2
Routing	1 - Federal Power Commission 1 - Foster Project Office
Frequency	Monthly

10-08. Responsibilities for maintenance of hydrologic and meteorologic stations. - Maintenance and operation of the weather station at Foster project is the responsibility of the Project Engineer at Foster. Project personnel at Foster will receive instructions from the U.S. Weather Bureau and the Reservoir Regulation Subsection regarding the method of taking and recording observations. They will also collect and transmit river and reservoir stage data used in the regulation of Foster Reservoir to the District Reservoir Regulation Subsection. Project personnel will be responsible for making occasional inspection of the water-stage and weather stations and reporting to the Reservoir Regulation Subsection any equipment malfunction they are unable to repair.

In addition, the project personnel will take special observations as needed by the Reservoir Regulation Subsection for study purposes.

10-09. The Corps of Engineers contributes funds to the U.S. Weather Bureau and U.S. Geological Survey for installing, servicing, and maintaining, processing, and disseminating hydrologic and meteorologic data required for the regulation of Foster Reservoir. From time to time each agency inspects the condition of the equipment in which it has a direct interest and makes the repairs and replacements deemed necessary to minimize failures. They also are responsible for instructing the project personnel regarding the care and operation of those instruments in the immediate vicinity of the project and procedure in taking and recording observations. All supplies, such as parts, charts, forms, etc., necessary for recording and disseminating the hydrologic and meteorologic data are furnished by the appropriate agency. They also supply the Corps of Engineers with special reports and publications needed in the regulation of Foster project and the study of special problems.

10-10. Collection and transmission of data. - The following hydrologic and power generation data are collected at the project and transmitted to the Reservoir Regulation Subsection in the District Office.

a. Reservoir inflow, outflow, and pool elevations. These data are automatically recorded in the Foster powerhouse control room.

b. Gross and net hourly power generation delivered to Bonneville Power Administration.

c. Weather data at Foster including precipitation, current weather conditions, maximum and minimum air temperatures, and wind.

Normally, this information is furnished daily with the morning report; however, when required, weather information will be furnished on call.

d. Temperature of the released water.

10-11. During major storm periods, meteorological and hydrological reports may be required at 2-hour intervals, particularly if chart 14 is being used. Generally, 6-hourly reports are adequate for flood regulation. During nonflood periods, daily reports are adequate. Special river and weather reports are sent to the Reservoir Regulation Subsection on request.

10-12. For the immediate future, teletype and telephone will be the principal means of communicating between Foster Dam and the District Office. At a later date radio will probably be provided to back up the telephone and for use during emergency situations when the normal communications are not functioning.

10-13. Emergency instructions. - To anticipate every unusual flood, power emergency, or combination of events that will require special regulation is an impossibility. Therefore, general instructions are provided in the following paragraphs for such contingencies. Should an emergency develop or appear imminent, the Project Engineer at Foster, or a subordinate, will promptly contact the District Office, report existing project conditions, and request instructions. In the event of a communication failure, repeated efforts will be made to contact the District Office. If all efforts fail, the decision as to the action to be taken must be made in the field. Should such an event occur, all circumstances and emergency actions taken will be documented and reported in writing as soon as possible.

10-14. Should communications to Portland fail during a flood but remain operative to the stream-gaging stations at Waterloo and the inflow stations, the Project Engineer or an authorized representative will direct the regulation of Foster Reservoir, using the schedules shown on chart 13 or 14, whichever is applicable. Foster weather station will be used in computing the precipitation index.

10-15. In the event of complete failure of wire communications to the District Office and key stream-gaging stations above and below the dam, the outflow from Green Peter Dam will be reduced to 100 c.f.s. The inflow to Foster will be passed, up to a maximum of 10,000 c.f.s., unless greater releases are indicated by the special curves shown on chart 14. If inflow data are not available, compute the inflow by means of the storage equation using chart 24.

10-16. When the pool elevation and inflow indicate the special curves shown on chart 14 are applicable, the reservoir release will be increased to a discharge indicated on the horizontal scale, but the rate of increase should not exceed 2,500 c.f.s. in any 1-hour period. Rate of pool rise and outflow determinations will be made at 2-hour intervals. Should a release determination indicate a lower discharge, no change should be initiated until this trend is verified for the ensuing 2-hour period. This will avoid erratic adjustments in the releases. After the reservoir reaches maximum elevation, that elevation will be maintained by adjusting the reservoir release to equal the reservoir inflow, until normal postflood evacuation is initiated.

10-17. National emergency. - If all personnel are ordered to retire from the project during a national emergency, the spillway gates at Foster should be adjusted to discharge the following flows before leaving the project.

June - October	1,500 c.f.s.
November - May	5,000 c.f.s.

At the time the release at Foster is adjusted, the outlets at Green Peter Reservoir should be adjusted to discharge the following flows for the periods shown:

June - October	1,000 c.f.s.
November - May	3,500 c.f.s.

TABLE 1

FOSTER RESERVOIR

Spillway Gate Rating Table
(Single Gate)

Sheet 1 of 2

Gate Opening ft.	Elevation in Feet, M.S.L. 610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	Gate Opening ft.
0.1	81	83	86	[illegible]	91	94	96	98	101	103	105	107	109	111	113	115	0.1
0.2	161	167	172	177	182	187	192	196	201	205	210	214	218	222	226	230	0.2
0.3	242	250	[illegible]	266	273	281	288	295	302	308	315	321	327	333	339	345	0.3
0.4	322	333	344	354	364	374	384	393	402	411	420	428	436	444	452	460	0.4
0.5	403	417	430	443	456	468	480	491	503	514	525	535	545	555	566	576	0.5
0.6	484	500	516	532	547	561	575	589	603	616	630	641	654	666	679	691	0.6
0.7	564	583	[illegible]	620	638	655	671	687	704	719	734	748	763	777	792	806	0.7
0.8	645	666	688	709	730	749	767	786	804	822	839	855	872	888	905	921	0.8
0.9	725	750	774	797	820	842	863	884	905	924	944	962	981	999	1018	1036	0.9
1.0	806	833	860	886	911	935	959	982	1005	1027	1049	1069	1090	1110	1131	1151	1.0
1.1	890	920	950	979	1007	1034	1060	1086	1112	1136	1160	1183	1206	1228	1251	1274	1.1
1.2	974	1007	1040	1072	1103	1132	1161	1190	1220	1245	1271	1296	1322	1346	1372	1396	1.2
1.3	1058	1094	1130	1165	1198	1231	1263	1295	1327	1355	1383	1410	1438	1464	1492	1519	1.3
1.4	1142	1181	1220	1258	1294	1329	1364	1399	1435	1464	1494	1523	1553	1582	1613	1642	1.4
1.5	1226	1268	1311	1351	1390	1428	1465	1503	1542	1573	1605	1637	1669	1700	1733	1765	1.5
1.6	1309	1355	1401	1444	1486	1526	1566	1608	1649	1683	1716	1750	1785	1819	1853	1887	1.6
1.7	1393	1442	1491	1536	1582	1625	1667	1712	1757	1792	1827	1864	1901	1937	1974	2010	1.7
1.8	1477	1529	1581	1629	1677	1723	1769	1816	1864	1901	1939	1977	2016	2055	2094	2133	1.8
1.9	1561	1616	1671	1722	1773	1821	1870	1920	1972	2011	2050	2091	2132	2173	2215	2255	1.9
2.0	1645	1703	1761	1815	1869	1920	1971	2025	2079	2120	2161	2204	2248	2291	2335	2378	2.0
2.1	1725	1787	1848	1905	1962	2016	2069	2126	2183	2227	2270	2316	2361	2407	2453	2498	2.1
2.2	1805	1870	1934	1996	2054	2111	2167	2227	2286	2333	2378	2427	2474	2522	2570	2618	2.2
2.3	1886	1954	2021	2084	2147	2206	2265	2328	2390	2439	2487	2538	2587	2638	2688	2738	2.3
2.4	1966	2037	2107	2174	2239	2302	2363	2429	2494	2545	2595	2648	2700	2753	2806	2858	2.4
2.5	2046	2120	2194	2263	2332	2397	2462	2530	2598	2651	2704	2759	2813	2869	2923	2979	2.5
2.6	2126	2204	2281	2353	2424	2492	2560	2631	2701	2757	2812	2870	2927	2984	3041	3099	2.6
2.7	2206	2287	2367	2442	2517	2587	2658	2731	2805	2863	2921	2981	3040	3100	3159	3219	2.7
2.8	2287	2370	2454	2532	2609	2682	2756	2832	2909	2969	3029	3091	3153	3215	3277	3339	2.8
2.9	2367	2454	2540	2621	2702	2778	2854	2933	3012	3075	3138	3202	3266	3331	3394	3459	2.9
3.0	2447	2537	2627	2711	2794	2873	2952	3034	3116	3181	3246	3313	3379	3446	3512	3579	3.0
3.1	2519	2613	2706	2793	2879	2961	3042	3129	3215	3281	3346	3415	3484	3552	3621	3690	3.1
3.2	2592	2688	2784	2874	2963	3047	3132	3223	3314	3380	3446	3517	3588	3659	3730	3801	3.2
3.3	2664	2764	2863	2956	3048	3135	3222	3318	3413	3480	3545	3619	3692	3765	3839	3912	3.3
3.4	2737	2839	2941	3037	3132	3222	3312	3412	3512	3579	3645	3721	3797	3872	3947	4023	3.4
3.5	2809	2915	3020	3119	3217	3309	3402	3507	3611	3678	3745	3823	3901	3978	4056	4134	3.5
3.6	2881	2990	3098	3200	3301	3397	3491	3601	3710	3778	3845	3925	4005	4085	4165	4245	3.6
3.7	2954	3066	3177	3282	3386	3484	3581	3695	3809	3877	3945	4027	4109	4191	4274	4356	3.7
3.8	3026	3141	3255	3363	3470	3571	3671	3790	3908	3976	4044	4129	4214	4298	4382	4467	3.8
3.9	3099	3217	3334	3445	3555	3658	3761	3884	4007	4076	4144	4231	4318	4404	4491	4578	3.9
4.0	3171	3292	3412	3526	3639	3745	3851	3979	4106	4175	4244	4333	4422	4511	4600	4689	4.0
4.1	3244	3368	3492	3609	3725	3834	3943	4071	4198	4273	4347	4438	4530	4621	4713	4804	4.1
4.2	3317	3445	3572	3692	3811	3923	4035	4163	4291	4371	4450	4543	4638	4731	4826	4919	4.2
4.3	3390	3521	3652	3775	[illegible]	4012	4127	4255	4383	4468	4553	4649	4746	4842	4938	5034	4.3
4.4	3463	3598	3732	3858	[illegible]	4102	4219	[illegible]	4475	4566	4656	4754	4853	4952	5051	5149	4.4
4.5	3536	3674	3812	3941	[illegible]	4191	4312	4440	4568	4664	4759	4860	4961	5062	5164	5265	4.5
4.6	3609	3750	3891	4024	4156	4280	4404	4532	4660	4761	4862	4965	5069	5173	5276	5380	4.6
4.7	3682	3827	3971	4107	4242	4369	4496	4624	4752	4859	4965	5071	5177	5283	5389	5495	4.7
4.8	3755	3903	4051	4190	4327	4458	4588	4716	4844	4957	5068	5176	5284	5393	5502	5610	4.8
4.9	3828	3980	4131	4273	4415	4548	4680	4809	4938	5054	5171	5282	5392	5504	5614	5725	4.9
5.0	3901	4056	4211	4356	4501	4637	4772	4901	5029	5152	5274	5387	5500	5614	5727	5840	5.0
5.5	4247	4420	[illegible]	4754	4915	5067	5218	5361	5503	5639	5775	5901	6026	6152	6278	6403	5.5
6.0	4593	4784	[illegible]	5152	[illegible]	[illegible]	[illegible]	5820	5977	6127	6276	6414	6552	6690	6828	6966	6.0
6.5			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6264	6436	6599	6762	6913	7064	7215	7366	7517	6.5
7.0			[illegible]	5911	[illegible]	[illegible]	[illegible]	6707	6894	7071	7248	7412	7576	7739	7903	8067	7.0
7.5			6044	[illegible]	[illegible]	6717	[illegible]	7132	7335	7526	7717	7793	8070	8246	8422	8599	7.5
8.0			[illegible]	[illegible]	[illegible]	7112	7381	7558	7775	7980	8185	8374	8563	8752	8941	9130	8.0
8.5					7263	[illegible]	7736	7969	8202	8422	8641	8843	9046	9248	9450	9652	8.5
9.0					7603	7667	[illegible]	[illegible]	[illegible]	[illegible]	9097	9312	9528	9743	9959	10174	9.0
9.5							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						9.5
10.0							[illegible]	9173	[illegible]	9719	[illegible]						10.0

Source of Data: Spillway Discharge Rating Curves, dated July 1966.
Table is for single gate operation. For balanced operation using all four gates, multiply tabulated discharges by 4.

Minimum flood control pool, el. 613
Maximum flood control pool, el. 641

TABLE 1
FOSTER RESERVOIR

Spillway Gate Rating Table
(Single Gate)

Gate Opening ft.	Elevation in Feet, M.S.L.																Gate Opening ft.
	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	
0.1	117	119	121	123	125	126	128	130	132	133	135	137	138	140	142	143	0.1
0.2	234	238	241	245	249	253	256	260	263	267	270	273	276	280	283	286	0.2
0.3	351	357	362	368	374	379	384	389	395	400	405	410	415	420	425	429	0.3
0.4	468	476	483	490	498	505	512	519	526	533	540	546	553	560	566	572	0.4
0.5	585	595	604	613	623	632	640	649	658	667	675	683	691	700	708	716	0.5
0.6	702	713	724	736	747	758	768	779	789	800	809	820	829	839	849	859	0.6
0.7	819	832	845	858	872	884	896	909	921	933	944	956	967	979	991	1002	0.7
0.8	936	951	966	981	996	1010	1024	1038	1052	1066	1079	1093	1106	1119	1132	1145	0.8
0.9	1053	1070	1086	1103	1121	1137	1152	1168	1184	1200	1214	1229	1244	1259	1274	1288	0.9
1.0	1170	1189	1207	1226	1245	1263	1280	1298	1315	1333	1349	1366	1382	1399	1415	1431	1.0
1.1	1295	1316	1336	1357	1378	1398	1417	1437	1456	1476	1494	1512	1530	1549	1567	1585	1.1
1.2	1420	1443	1465	1488	1511	1533	1554	1576	1597	1618	1638	1659	1678	1699	1719	1738	1.2
1.3	1544	1569	1594	1619	1644	1668	1691	1714	1737	1761	1783	1805	1827	1849	1870	1892	1.3
1.4	1669	1696	1723	1750	1777	1803	1828	1853	1878	1904	1927	1951	1975	1999	2022	2045	1.4
1.5	1794	1823	1852	1881	1911	1938	1965	1992	2019	2047	2072	2098	2123	2149	2174	2199	1.5
1.6	1919	1950	1981	2012	2044	2073	2102	2131	2160	2189	2217	2244	2271	2298	2326	2352	1.6
1.7	2044	2077	2110	2143	2177	2208	2239	2270	2301	2332	2361	2390	2419	2448	2478	2506	1.7
1.8	2168	2203	2239	2274	2310	2343	2376	2408	2441	2475	2506	2536	2568	2598	2629	2659	1.8
1.9	2293	2330	2368	2405	2443	2478	2513	2547	2582	2617	2650	2683	2716	2748	2781	2813	1.9
2.0	2418	2457	2497	2536	2576	2613	2650	2686	2723	2760	2795	2829	2864	2898	2933	2966	2.0
2.1	2540	2581	2624	2665	2707	2746	2785	2823	2862	2901	2937	2973	3010	3046	3083	3118	2.1
2.2	2662	2706	2750	2793	2838	2878	2919	2959	3000	3041	3080	3118	3156	3194	3232	3269	2.2
2.3	2785	2830	2877	2922	2968	3011	3054	3096	3139	3182	3222	3262	3302	3342	3382	3421	2.3
2.4	2907	2955	3003	3051	3099	3144	3189	3233	3278	3322	3365	3406	3448	3490	3532	3572	2.4
2.5	3029	3079	3130	3180	3230	3277	3324	3370	3417	3463	3507	3551	3594	3638	3682	3724	2.5
2.6	3151	3203	3256	3308	3361	3409	3458	3506	3555	3604	3649	3695	3740	3785	3831	3875	2.6
2.7	3273	3328	3383	3437	3492	3542	3593	3643	3694	3744	3792	3839	3886	3933	3981	4027	2.7
2.8	3396	3452	3509	3566	3622	3675	3728	3780	3833	3885	3934	3983	4032	4081	4131	4178	2.8
2.9	3518	3577	3636	3694	3753	3807	3862	3916	3971	4025	4077	4128	4178	4229	4280	4330	2.9
3.0	3640	3701	3762	3823	3884	3940	3997	4053	4110	4166	4219	4272	4324	4377	4430	4481	3.0
3.1	3753	3816	3879	3942	4005	4063	4122	4180	4239	4297	4351	4406	4460	4515	4570	4622	3.1
3.2	3866	3931	3996	4061	4126	4186	4247	4307	4368	4427	4484	4540	4596	4653	4709	4763	3.2
3.3	3979	4046	4113	4181	4248	4309	4372	4434	4496	4558	4616	4675	4732	4790	4849	4905	3.3
3.4	4092	4161	4230	4300	4369	4432	4497	4561	4625	4689	4749	4809	4868	4928	4988	5046	3.4
3.5	4205	4277	4348	4419	4490	4556	4622	4688	4754	4820	4881	4943	5004	5066	5128	5187	3.5
3.6	4318	4392	4465	4538	4611	4679	4747	4814	4883	4950	5013	5077	5140	5204	5267	5328	3.6
3.7	4431	4507	4582	4657	4732	4802	4872	4941	5012	5081	5146	5211	5276	5342	5407	5469	3.7
3.8	4544	4622	4699	4777	4854	4925	4997	5068	5140	5212	5278	5346	5412	5479	5546	5611	3.8
3.9	4657	4737	4816	4896	4975	5048	5122	5195	5269	5342	5411	5480	5548	5617	5686	5752	3.9
4.0	4770	4852	4933	5015	5096	5171	5247	5322	5398	5473	5543	5614	5684	5755	5825	5893	4.0
4.1	4887	4971	5055	5139	5222	5299	5377	5454	5532	5609	5681	5754	5826	5899	5970	6040	4.1
4.2	5005	5091	5176	5263	5348	5427	5507	5586	5666	5745	5819	5893	5967	6042	6116	6188	4.2
4.3	5122	5210	5298	5386	5474	5555	5637	5718	5800	5881	5957	6033	6109	6186	6261	6335	4.3
4.4	5239	5330	5420	5510	5600	5683	5767	5850	5934	6017	6095	6173	6251	6329	6407	6482	4.4
4.5	5357	5449	5542	5634	5726	5811	5897	5982	6068	6153	6233	6313	6393	6473	6552	6630	4.5
4.6	5474	5568	5663	5758	5852	5939	6027	6114	6202	6289	6370	6452	6534	6616	6697	6777	4.6
4.7	5591	5688	5785	5882	5978	6067	6157	6246	6336	6425	6508	6592	6676	6760	6843	6924	4.7
4.8	5708	5807	5907	6005	6104	6195	6287	6378	6470	6561	6646	6732	6818	6903	6988	7071	4.8
4.9	5826	5927	6028	6129	6230	6323	6417	6510	6604	6697	6784	6871	6959	7047	7134	7219	4.9
5.0	5943	6046	6150	6253	6356	6451	6547	6642	6738	6833	6922	7011	7101	7190	7279	7366	5.0
5.5	6518	6632	6747	6861	6975	7081	7187	7292	7398	7504	7603	7701	7801	7899	7998	8094	5.5
6.0	7092	7217	7343	7468	7594	7710	7826	7942	8058	8174	8283	8391	8500	8608	8717	8821	6.0
6.5	7654	7791	7928	8065	8203	8329	8456	8582	8709	8835	8953	9071	9189	9307	9425		6.5
7.0	8216	8365	8513	8662	8811	8948	9085	9222	9359	9496	9623	9751	9878	10006	10133		7.0
7.5	8759	8919	9079	9239	9399	9547	9694	9842	9989	10137							7.5
8.0	9301	9473	9644	9816	9987	10145	10303	10461	10619	10777							8.0
8.5																	8.5
9.0																	9.0
9.5																	9.5
10.0																	10.0

Source of Data: Spillway Discharge Rating Curves, dated July 1966.
Table is for single gate operation. For balanced operation using all four gates, multiply tabulated discharges by 4.

Minimum flood control pool, el. 613
Maximum flood control pool, el. 641

TABLE 2

Station, Quartzville 13 SW County, Linn State, Oregon

Latitude, 44° 29' Longitude, 122° 30' Elevation, 823 feet

Data, Precipitation 1939-1961 = 23 years

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL
1939	--	15.74	8.14	1.91	3.15	4.14	1.06	2.18	0.31	10.65	3.18	16.32	---
40	7.06	23.69	11.62	5.98	2.76	.44	2.41	.17	6.50	8.43	15.67	8.77	93.50
41	12.02	3.99	3.14	2.91	10.55	3.66	.03	2.99	9.01	6.20	13.09	19.79	87.38
42	7.51	8.88	4.01	4.23	7.42	---	1.03	.03	.30	8.27	26.75	25.65	---
43	12.47	6.87	11.52	7.56	4.01	4.50	.68	2.66	4.01	8.49	6.64	4.32	73.71
44	6.49	8.45	5.88	8.14	3.41	2.41	.15	.05	4.70	1.75	8.98	4.59	55.00
45	11.17	11.88	10.89	9.28	7.92	--	--	.78	4.81	2.86	18.00	14.00	---
46	12.34	9.72	11.76	4.39	1.61	3.53	1.12	.17	2.68	11.51	12.16	18.31	89.30
47	9.12	2.37	10.00	7.83	.53	8.15	2.72	.88	--	15.33	12.27	9.38	---
48	11.37	16.48	9.41	7.86	--	--	1.63	2.40	5.78	5.36	13.81	22.36	---
49	3.99	23.53	6.71	3.35	7.07	2.01	.49	.20	2.41	7.98	10.57	13.06	81.37
1950	20.52	13.00	14.64	6.43	2.74	2.95	.40	1.69	2.16	20.48	15.82	15.71	116.54
51	20.97	10.04	10.57	2.24	4.68	T	.17	.90	2.49	16.98	12.22	15.80	97.06
52	9.85	10.84	10.25	2.52	2.12	5.80	0	.31	1.63	.91	2.38	13.82	60.43
53	27.39	15.73	11.01	5.80	8.41	4.18	.06	3.15	2.77	4.89	18.60	21.02	123.01
54	18.75	8.43	6.02	7.76	3.08	5.46	1.11	2.49	4.19	6.29	7.00	15.29	85.87
55	7.18	7.14	15.41	13.61	3.25	2.20	2.56	0	3.74	14.58	16.33	24.25	110.24
56	18.51	10.26	13.87	2.98	3.80	3.04	.05	1.14	1.21	13.63	3.64	17.07	89.20
57	5.85	12.14	15.41	4.84	4.81	2.61	.60	1.58	1.05	6.31	6.87	22.79	84.86
58	14.11	13.12	4.44	9.11	1.85	4.82	.11	.42	3.50	4.32	19.70	13.33	88.83
59	17.56	6.57	10.43	5.00	7.13	3.05	1.12	.25	8.69	9.58	7.53	5.43	82.34
1960	7.43	11.15	14.41	8.98	11.39	1.20	.05	2.84	1.40	8.31	18.73	6.74	92.63
61	8.26	20.65	14.18	4.54	5.29	.92	.50	.77	4.84	9.03	11.07	14.75	94.80
	(Discontinued)												
Ave.	12.27	11.77	10.16	5.97	4.86	3.25	.82	1.24	3.55	8.79	12.22	14.89	89.79
Max	27.39	23.69	15.41	13.61	11.39	8.15	2.72	3.15	9.01	20.48	26.75	25.65	123.01
Year	1953	1940	1957	1955	1960	1947	1947	1953	1941	1950	1942	1942	1953
Min	3.99	2.37	3.14	1.91	.53	T	0	0	.30	.91	2.38	4.32	55.00
Year	1949	1947	1941	1939	1947	1951	1952	1955	1942	1952	1952	1943	1944

TABLE 2

Table 3

Climatological Summary
Cascadia State Park
(Elevation, 850 feet)

Item and Description	Period of record	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
				Precipitation, Inches										
Average, inches	1908-1966	8.72	7.08	6.92	4.98	4.25	2.95	0.73	0.93	2.52	5.38	8.67	9.01	62.14
Percent of normal annual	1908-1966	14.0	11.4	11.1	8.0	6.8	4.7	1.2	1.5	4.1	8.7	14.0	14.5	
Maximum	1908-1966	15.82	15.83	13.00	10.38	9.97	7.09	4.06	5.46	9.78	15.58	20.91	20.65	82.02
Year of maximum	1908-1966	1965	1961	1916	1937	1915	1937	1916	1912	1920	1950	1942	1964	1950
Minimum	1908-1966	3.35	0.63	1.54	1.28	0.84	0.02	0.00	0.00	0.02	0.11	0.67	2.24	39.36
Year of minimum	1908-1966	1920	1920	1965	1951	1947	1951	1922[1]	1917[1]	1942	1917	1936	1914	1944
Greatest in 24 hours	1908-1966	4.00	3.46	3.10	2.19	1.92	1.92	1.51	1.89	2.87	3.11	4.69	3.90	4.69
Year of greatest 24 hours	1908-1966	1923	1961	1952	1914	1950	1952	1909	1912	1920	1947	1921	1929	1921
Ave. number days with 0.01 or more	1908-1966	19	18	19	16	13	10	3	4	7	12	16	19	156
Average snowfall	1908-1966	6.9	1.7	2.1	0.1	0	0	0	0	0	T	T	1.6	12.4
Maximum snowfall	1908-1966	56.7	31.0	29.2	2.3	T	T				1.0	4.0	12.0	65.0
Year of maximum snowfall	1908-1966	1950	1917	1951	1911	1909[1]	1950	0	0	0	1935	1961	1942	1916
				Temperature, °F										
Average	1909-1966	37.1	41.0	44.0	49.7	54.6	60.2	65.0	64.6	60.0	51.7	43.5	39.7	50.9
Average daily maximum	1909-1966	44.5	50.1	54.2	62.7	67.5	74.1	81.7	81.5	76.0	64.4	51.6	46.6	62.9
Average daily minimum	1909-1966	29.9	32.3	33.8	37.8	41.6	44.7	48.0	47.1	44.1	39.7	34.6	33.1	38.9
Absolute maximum	1909-1966	73	73	85	89	101	101	106	104	102	92	79	69	106
Year of absolute maximum	1909-1966	1961	1952	1923	1957	1955	1942[1]	1946	1944	1944	1932[1]	1923	1962	1946
Absolute minimum	1909-1966	1	4	19	24	25	30	33	34	26	20	10	1	1
Year of absolute minimum	1909-1966	1950	1950	1955	1941[1]	1954	1949[1]	1953	1965	1965	1938	1955	1932	1932[1]
				Miscellaneous Data										
Average number of days clear	1909-1948	8	7	9	10	12	12	20	21	16	12	9	9	135
Ave.number of days partly cloudy	1909-1948	5	6	6	6	6	6	6	4	5	6	5	6	67
Average number of days cloudy	1909-1948	18	15	16	14	13	12	5	6	9	13	16	16	153
Prevailing wind direction	1910-1929	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW	SW

1/ Prior to March 1964 records were maintained at Cascadia Ranger Station, latitude 44°23', longitude 122°30', elevation 796 feet

Table 4

Climatological Summary
Salem, Oregon
(Elevation, 196 Feet)

Item and Description	Period of record	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
					Precipitation, Inches									
Normal	1931-1960	6.70	5.31	4.68	2.23	2.11	1.45	0.35	0 45	1.38	3.91	5.71	7.37	41.75
Percent of normal annual		16	13	11	5	5	4	1	1	3	9	14	18	100
Maximum	1893-1965	15.40	12.31	10.13	7.68	6.23	4.61	2.72	2.91	4.84	11.17	16.99	17.54	17.54
Year of maximum		1953	1949	1894	1937	1895	1937	1916	1899	1914	1947	1896	1933	Dec. 1933
Minimum	1893-1965	0.57	0.34	0.59	0.39	0.18	0.00	0.00	0.00	0.01	0.00	0.48	1.95	0.00
Year of minimum		1949	1920	1911	1939	1947	1918	1952	1928+	1942+	1917+	1936	1903	Jul 1952+
Greatest in 24 hours	1893-1965	3.86	3.16	3.03	2.21	1.84	1.60	1.12	1.25	2.11	2.84	3.60	4.30	4.30
Year of greatest 24 hours		1911	1949	1943	1937	1963	1950	1909	1943	1911	1955	1896	1933	Dec. 1933
Avg. No. days with .01 or more	1893-1965	18	16	17	13	11	8	2	3	7	12	17	19	146
Average snowfall	1910-1965	3.3	1.2	0.6	T	T	0.0	0.0	0.0	0.0	0.1	0.1	1.5	6.8
Maximum snowfall	1893-1965	32.8	25.2	10.9	T	T	T	0.0	T	0.0	5.0	5.8	23.0	32.8
Year of maximum snowfall		1950	1937	1951	1963+	1964+	1952	—	1951	—	1935	1955	1919	Jan. 1950
Greatest 24 hour snowfall	1893-1965	11.0	25.0	8.5	T	T	T	0.0	T	0.0	5.0	4.0	17.5	25.0
Year of greatest 24 hour snowfall		1930	1937	1960	1963+	1964+	1952	—	1951	—	1935	1955	1919	1937
					Temperature, Degrees F.									
Normal	1931-1960	38.5	41.9	45.3	51.1	56.3	60.6	66.1	66.1	62.5	54.1	45.2	41.5	52.4
Normal daily maximum	1931-1960	45.5	50.3	55.1	62.5	68.3	73.4	81.7	80.8	76.8	65.7	53.8	48.6	63.5
Normal daily minimum	1931-1960	31.5	33.5	35.5	39.6	44.2	47.8	50.4	51.3	48.1	42.5	36.6	34.3	41.3
Absolute maximum	1893-1965	68	68	80	93	95	102	108	105	103	92	70	72	108
Year of absolute maximum		1899+	1932+	1947+	1926	1956	1942	1941+	1920	1944	1932	1927	1929	Jul 1941+
Absolute minimum	1893-1965	-10	-4	22	24	25	32	35	30	26	23	9	-6	-10
Year of absolute minimum		1950	1950	1965+	1935	1954	1899	1932+	1920	1934	1902+	1955	1919	Jan 1950
					Miscellaneous Data									
Average number of days clear	1893-1965	3	4	5	6	7	9	17	16	13	8	4	3	96
Average number of days partly cldy	1893-1965	6	5	7	8	8	7	7	8	8	8	5	4	82
Average number of days cloudy	1893-1965	22	19	19	16	16	14	6	7	9	15	20	24	188
Average hourly wind speed, MPH	1848-1965	8.8	8.1	8.4	7.4	6.6	6.5	6.6	6.4	6.2	6.5	7.7	8.1	7.3
Prevailing wind direction	1893-1965	S	S	S	S	S	S	N	NW	S	S	S	S	S

\+ Also on earlier dates.

Table 4

TABLE 5

Climatological Summary of Selected Stations
Santiam River Basin

Item	Station, Elevation, and Period of Record				
	Quartzville 823 ft. 1939-1961	Cascadia State Park 850 ft. 1908-1965	Waterloo 420 ft. 1924-1965	Lacomb 665 ft. 1940-1965	Detroit 1590 ft. 1902-1965
Precipitation					
Average annual precipitation, inches	89.79	61.26	44.08	48.87	73.61
Maximum annual precipitation, inches	123.01	82.02	64.20	60.62	109.13
Year of maximum annual precipitation	1953	1950	1937	1950	1950
Minimum annual precipitation, inches	55.00	39.86	28.51	38.48	43.55
Year of minimum annual precipitation	1944	1944	1930	1949	1918
Maximum monthly precipitation, inches	27.39	20.91	15.75	14.81	30.86
Month and year of maximum monthly precipitation	Jan. 1953	Nov. 1942	Dec. 1955	Dec. 1964	Dec. 1964
Maximum 1-day recorded precipitation inches	4.58	4.69	4.04	3.60	5.37
Month and year of maximum 1-day precipitation	Dec. 1945	Nov. 1921	Feb. 1949	Feb. 1949	Jan. 1965
Greatest seasonal snowfall, inches	25.0	68.0	12.3	19.3	195.0
Season of greatest snowfall	1955-56	1916	1950-51	1955-56	1915-16
Temperature					
Average annual temperature, °F.	No temp. data available	50.8	No temp. data available	51.6	49.0
Average annual maximum temperature, °F.		63.0		61.8	61.0
Average annual minimum temperature, °F.		38.9		40.9	36.8
Absolute maximum temperature, °F.		106		104	107
Month and year of maximum temperature		July 1946		July 1958	June 1961
Absolute minimum temperature, °F.		1		0	-10
Month and year of minimum temperature		Jan. 1950		Feb. 1950	Feb. 1950
January average temperature, °F.		37.1		38.3	34.2
July average temperature, °F.		65.1		65.1	64.4

July 1966
JDH

TABLE 6

SNOW SURVEY SUMMARY
(Record through 1966)

Snow Course	Hogg Pass	Marion Forks	McKenzie Pass	Santiam Junction
Elevation, feet, m.s.l.	4755	2730	4800	3990
February 1				
Length of record, years	29	25	23	26
Average snow depth, inches	78	29	73	47
Average water equivalent, inches	26.5	9.4	27.2	16.5
Highest water equivalent, inches	49.1	27.9	42.7	36.5
Year of highest	1952	1950	1956 1/	1952
Lowest water equivalent, inches	7.0	0.6	5.1	1.1
Year of lowest	1963	1945	1940	1963
March 1				
Length of record, years	26	25	18	26
Average snow depth, inches	94	31	102	53
Average water equivalent, inches	36.2	12.6	40.0	20.8
Highest water equivalent, inches	70.9	32.9	64.2	44.6
Year of highest	1949	1949	1949	1949
Lowest water equivalent, inches	7.5	0	8.0	0
Year of lowest	1963	1963	1963	1963
April 1				
Length of record, years	29	25	27	26
Average snow depth, inches	106	30	104	56
Average water equivalent, inches	43.7	13.2	44.6	24.2
Highest water equivalent, inches	73.5	32.8	70.5	45.7
Year of highest	1956	1950	1956	1956
Lowest water equivalent, inches	11.5	0	12.6	0
Year of lowest	1963	1963 1/	1963	1941

1/ Earlier years also.

July 1966 S.M.

TABLE 7

TABLE 7

Evaporation and Related Data

Item	Yrs Rec. 1/	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
FERN RIDGE RESERVOIR														
Average wind 2,3/ speed (m.p.h.)	23	2.31	2.03	2.62	2.49	2.26	2.16	2.34	2.24	2.18	1.85	1.71	2.17	2.19
Mean air temperature	22	38.5	42.3	44.5	49.8	55.2	60.5	63.0	65.7	62.1	53.6	45.1	41.0	51.8
Class A Pan evaporation(ins.)3/	23	0.36	0.73	1.69	2.86	4.84	5.81	8.13	6.79	4.60	1.80	0.55	0.37	38.53
FOSTER RESERVOIR														
Pan coefficient4/		0.76	0.13	0.51	0.39	0.52	0.65	0.67	0.77	0.93	0.90	1.32	1.06	
Evaporation5/ inches		0.27	0.09	0.86	1.12	2.52	3.78	5.45	5.23	4.28	1.62	0.73	0.39	26.34
Evaporation5/ acre-feet		21	7	72	103	252	378	545	523	392	135	58	31	2517

NOTES:

1. Record thru 1965.
2. Wind speed 6" above evaporation pan.
3. No record of evaporation and wind speed Oct thru March 1944 - 51 and 1956 - 63.
4. Pan coefficients are based on "Lake Heffner Study", U. S. Geological Survey Professional Paper No. 269.
5. Based on average scheduled pool elevations at Foster Reservoir.

July 1966
JDH

Gage Established ____________
Datum m.s.l.

Stream South Santiam River
Station Foster Dam Site
Drainage Area 494 sq.mi.

MONTHLY DISCHARGE DATA

Date 6/23/66
By HCL - BHB
CK. HCL.
Sheet 1 of 2

Water Year	Discharge in c.f.s. — Mean Monthly: Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Mean Ann.	Extremes of Discharge — Max. Inst.: Date	Stage Ft.	Q c.f.s.	Max. Daily: Date		Q c.f.s.	Minimun: Date		Q c.f.s.	Annual Run-off: Ac. Ft.	Inches
1926	125	900	3470	2180	7620	2100	940	1100	445	160	255	530	1652										1,196,048	45.40
1927	1610	4920	3650	4950	7730	3240	2760	3250	2670	480	210	850	3027										2,191,548	83.18
1928	2490	7170	3470	5070	1560	6030	4580	1790	480	290	150	155	2770										2,011,020	76.33
1929	385	1400	2200	2490	1590	4470	4500	3220	1960	410	210	140	1920										1,390,080	52.76
1930	140	100	3840	1320	6370	2200	1440	1910	1100	295	160	155	1586										1,148,264	43.58
1931	335	1420	1170	2260	1180	4400	4580	760	700	305	140	140	1449										1,049,076	39.82
1932	565	2580	3380	4260	2480	7470	4530	3500	1750	445	210	145	2776										2,015,376	76.50
1933	500	4400	4020	4020	2720	4320	4240	5120	5500	1030	275	635	3065										2,219,060	84.23
1934	675	1200	8100	6080	1250	3120	2120	1090	475	230	145	135	2052										1,485,648	56.39
1935	1520	5290	5260	3430	3680	7060	3580	2380	890	370	160	140	2480										1,795,520	68.15
1936	380	1080	1640	8400	3020	3230	3400	2890	1240	430	200	200	2175										1,579,050	59.94
1937	120	100	1500	720	3400	4700	6740	4660	3700	760	300	220	2257										1,634,068	62.02
1938	920	5530	5300	5340	3440	5130	5200	2940	870	280	165	150	2939										2,127,836	80.77
1939	240	2290	3600	2780	3860	4910	2930	1370	1180	430	195	175	2002										1,449,448	55.02
1940	500	320	3150	2300	6460	4180	2050	1230	350	195	120	190	1754										1,273,404	48.33
1941	460	2970	2740	3640	1410	1060	960	1900	1110	435	255	905	1487										1,076,588	40.86
1942	980	3130	5910	2980	3350	2160	1500	2170	1610	630	260	155	2070										1,498,680	56.89
1943	230	8550	9280	5400	5620	3100	4930	1960	2310	660	310	195	3537										2,560,788	97.20
1944	1390	2000	1750	1700	2430	2300	2920	1590	925	325	180	230	1478										1,073,028	40.73
1945	215	1100	920	3870	6130	3500	4490	4420	950	310	180	245	2193										1,587,732	60.27
1946	180	4800	6960	5580	3450	4460	2940	2280	1320	540	210	210	2747										1,988,828	75.49
1947	1480	5590	7530	3240	4000	3300	3810	830	1550	675	335	275	2745										1,987,380	75.43
1948	4420	5500	2850	6480	5110	3140	3950	2800	1660	500	280	400	3179										2,307,954	87.60
1949	1130	3250	6500	1300	6470	4170	3830	4700	1030	330	185	205	2758										1,996,792	75.79
1950	830	2180	3,110	4680	6920	6110	4290	2930	3020	840	300	175	3033										2,195,892	83.35
Total																								
Mean																								
Max.																								
Min.																								

Remarks: See note on sheet 2

sheet 1

MONTHLY DISCHARGE DATA

Gage Established ____________ Datum m.s.l.

Stream: South Santiam River
Station: Foster Dam Site
Drainage Area: 494 sq. mi.

Date: 5/23/68
By: HCL-BHB
CK.: HCL
Sheet 2 of 2

Discharge in ____ c.f.s. — Mean Monthly

Water Year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Mean Ann.
1951	3980	7100	5270	7300	5590	3090	3090	2460	605	280	180	175	3260
1952	3480	3400	5300	2360	5520	3570	4080	2760	1580	880	265	195	2783
1953	130	185	2020	10 980	7620	3430	3070	4045	2360	615	343	224	2919
1954	655	5120	8820	5900	5670	2520	3970	1345	2030	630	335	600	3136
1955	1110	1760	3350	3080	3140	3480	4740	4450	3420	1160	335	330	2530
1956	2540	7110	11,130	7410	2285	4465	5095	3870	2100	580	265	185	3920
1957	1390	2290	6280	1425	5390	6340	3385	1910	910	365	240	160	2507
1958	550	1610	8360	5995	6660	2060	4510	1425	1255	475	215	230	2779
1959	365	6045	4370	6540	3470	3535	3235	3145	1270	425	205	1070	2806
1960	2730	2390	1605	1855	4990	5690	4895	4900	1415	380	270	225	2612
1961	610	6870	3070	3015	10375	5895	2830	2935	830	300	165	320	3101
1962	1205	3710	6685	3015	2560	4240	5320	3180	1135	355	305	305	2668
1963	1910	4155	3865	1170	5610	2540	4365	4115	915	745	300	350	2503
1964	565	5340	2505	5795	3025	3445	3515	3250	2810	685	325	255	2626
1965	235	2870	13,100	8900	3220	1525	2250	1520	556	240	192	127	2895
1966	255	1660	1700	5780	2100	4710	3530	1760	628	340	160	156	1898
Total	43,530	139,385	188,730	174,980	178,465	158,825	149,010	111,820	62,914	19,770	9490	11,902	104,074
Mean	1062	3400	4603	4268	4353	3874	3634	2,727	1534	482	231	290	2538
Max.	3,980	8,550	13,100	10,980	10,375	9,470	6,740	5,120	5,500	1,160	343	1070	3,920
Min.	120	100	1,170	720	1,180	1,060	940	760	350	160	120	135	1,449

Extremes of Discharge / Annual Run-off

Water Year	Max. Inst. Date	Max. Inst. Stage Ft.	Max. Inst. Q ___ c.f.s.	Max. Daily Date		Max. Daily Q ___ c.f.s.	Minimum Date		Minimum Q ___ c.f.s.	Annual Run-off Ac. Ft.	Annual Run-off Inches
1951										2,360,240	89.59
1952										2,020,458	76.69
1953										2,113,356	80.22
1954										2,270,464	86.18
1955										1,831,720	69.53
1956										2,845,920	108.02
1957										1,815,068	68.89
1958										2,011,996	76.37
1959										2031,544	77.11
1960										1,896,[illegible]	71.98
1961										2,245,124	85.22
1962										1,931,632	73.32
1963										1,812,172	68.78
1964										1,906,476	72.36
1965										2,095,980	79.56
1966										1,374,152	52.16
										15,9[illegible]722	
Total										~~75,707,722~~	2862.01
Mean										~~1,846,030~~	69.81
Max.										2,845,920	108.02
Min.										1,049,076	39.82

Remarks: Mean monthly discharges estimated from observed record on the South Santiam River

sheet 2

TABLE 8

TABLE 9

MAXIMUM ANNUAL INSTANTANEOUS DISCHARGES

SOUTH SANTIAM RIVER BASIN

Water Year	Date	Discharge in C. F. S.: South Santiam River: At Waterloo Obs. (640)	South Santiam River: At Foster D.S. Est. (494)	South Santiam River: Below Cascadia Obs. (174)	Middle Santiam River: At Mouth Obs.[2] (271)[1] (287)	Middle Santiam River: At Green Peter D.S. Est. (277)	Wiley Creek near Foster Obs. (52)
1906	Jan. 24	14,000					
1907	Feb. 5	41,500					
1924	Dec. 6	36,000	31,500			22,200	
1925	Nov. 22	29,100	26,000			18,400	
1926	Feb. 6	33,800	29,800			21,800	
1927	Feb. 21	60,000	51,800			35,100	
1928	Nov. 25	38,400	33,800			23,900	
1929	Mar. 21	21,000	19,400			13,600	
1930	Dec. 18	38,800	34,000			23,800	
1931	Mar. 31	70,000	60,000			40,500	
1932	Mar. 18	47,800	41,500		29,500	30,000	
1933	June 9	23,800	21,500		19,300	19,600	
1934	Dec. 22	24,600	22,500		26,100	26,500	
1935	Dec. 20	29,900	27,500		21,700	22,100	
1936	Jan. 4	37,200	34,[illegible]	9,200	24,300	24,700	
1937	Apr. 15	34,300	30,[illegible]	9,200	19,400	19,730	
1938	Jan. 22	37,600	34,000	10,700	24,300	24,700	
1939	Feb. 15	23,800	22,000	5,720	15,400	15,700	
1940	Feb. 6	16,600	[illegible]	[illegible][3]	[illegible]	11,500	
1941	Nov. 29	19,500	18,000	4,800	13,200	13,400	
1942	Nov. 15	30,300	25,[illegible]	9,220	15,100[3]	15,400	
1943	Jan. 1	60,700	52,600	17,[illegible]	33,500	34,100	
1944	Nov. 4	24,600	21,800	5,850	14,800	15,100	
1945	Feb. 8	32,500	29,000	8,570	19,600	19,900	
1946	Dec. 28	74,200	[illegible]	23,400	41,300	42,500	
1947	Dec. 14	48,100	42,800	13,[illegible]	28,600	29,100	
1948	Jan. 7	58,800	51,300	17,600	35,800[2]	34,300	5,410
1949	Dec. 12	45,700	40,000	12,900	26,4[illegible][3]	27,500	4,300
1950	Feb. 25	41,200	37,000	1[illegible],000[3]	27,100[2]	26,100	[illegible],000
1951	Nov. 2	45,400	38,600	15,[illegible]	26,500[2]	28,800	3,630
1952	Oct. 23	27,900	24,400	7,7[illegible]	16,900	16,500	2,060
1953	Jan. 18	57,7[illegible]	52,[illegible]	17,[illegible]	[illegible]	35,400	4,7[illegible]
1954	Nov. 22	61,[illegible]	[illegible],700	18,900	[illegible]	37,[illegible]	[illegible]
1955	Dec. 31	36,900	33,[illegible]	11,[illegible]	[illegible]	23,900	2,[illegible]
1956	Dec. 21	62,800	[illegible]	20,900	32,[illegible]	31,700	6,290
1957	Dec. 11	69,3[illegible]	[illegible]	2[illegible]	41,[illegible]	39,900	3,1[illegible]
1958	Dec. 20	55,[illegible]	[illegible]	17,8[illegible]	33,700	29,900	4,820
1959	Nov. 19	32,[illegible]0	29,5[illegible]	[illegible]	21,400	20,500	2,770
1960	Feb. 8	20,7[illegible]	18,[illegible]	6,330	12,100	11,800	[illegible]
1961	Feb. 10	69,300	58,300	18,900	[illegible],400	34,500	6,860[3]
1962	Nov. 22	34,8[illegible]	33,3[illegible]	11,4[illegible]	[illegible]	27,[illegible]	2,660[3]
1963	Nov. 20	28,900	28,[illegible]	8,[illegible][3]	[illegible]	25,700	2,[illegible][3]
1964	Nov. 8	33,[illegible]	28,5[illegible]	[illegible]	19,[illegible]	18,500	3,48[illegible][3]
1965	Dec. 22	[illegible]	[illegible]	[illegible]	67,8[illegible]	66,000	5,370
1966	Jan. 6	34,400	30,000	11,800	19,700	19,400	4,460

Remarks

Note: Extremes of observed record are underlined.

1 For period 1932 to 1947 inclusive, station was located 6 miles upstream from mouth.

2 Peak flows on Middle Santiam River for period of no record were estimated from correlation curve.

3 Dates of maximum flows which differ from those in the table are:

Water Year	Date
1940	Feb. 28
1942	Dec. 2
1950	Jan. 22
1960	Nov. 23
1962	Nov. 2[illegible]
1963	(Feb. [illegible])
1963	(Mar. [illegible])
1964	Jan. 19

TABLE 10

FOSTER CAPACITY TABLE

ELEV FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
	CAPACITY IN ACRE FEET									
525.0	0	0	0	0	0	0	0	0	0	0
526.0	0	0	0	0	0	0	1	1	1	1
527.0	1	1	1	2	2	2	2	3	3	3
528.0	4	4	4	5	5	6	6	7	7	8
529.0	9	9	10	11	11	12	13	14	15	16
530.0	17	18	19	20	21	22	23	24	25	27
531.0	28	29	31	32	33	35	36	38	39	41
532.0	42	44	45	47	49	50	52	54	56	58
533.0	59	61	63	65	67	69	71	74	76	78
534.0	80	82	85	87	90	92	94	97	99	102
535.0	105	107	110	113	116	119	121	124	127	130
536.0	133	136	140	143	146	149	153	156	159	163
537.0	166	170	174	177	181	185	189	192	196	200
538.0	204	208	212	217	221	225	229	234	238	243
539.0	247	252	256	261	266	270	275	280	285	290
540.0	295	300	306	311	316	321	327	332	338	343
541.0	349	354	360	366	371	377	383	389	395	401
542.0	407	413	419	425	431	438	444	450	457	463
543.0	470	476	483	490	496	503	510	517	524	531
544.0	538	545	552	560	567	574	582	589	597	604
545.0	612	619	627	635	643	651	659	667	675	683
546.0	691	699	708	716	724	733	741	750	759	767
547.0	776	785	794	803	812	821	830	839	848	858
548.0	867	877	886	896	905	915	925	935	944	954
549.0	964	975	985	995	1005	1015	1026	1036	1047	1058
550.0	1068	1079	1090	1101	1111	1122	1133	1144	1156	1167
551.0	1178	1189	1201	1212	1223	1235	1247	1258	1270	1282
552.0	1293	1305	1317	1329	1341	1353	1366	1378	1390	1402
553.0	1415	1427	1440	1452	1465	1478	1491	1503	1516	1529
554.0	1542	1555	1569	1582	1595	1608	1622	1635	1649	1662

Minimum Flood Control Pool..El. 613

Maximum Conservation Pool...El. 637

Full and Maximum Pool.......El. 641

TABLE 10

FOSTER CAPACITY TABLE

ELEV FEET	CAPACITY IN ACRE FEET .0	.1	.2	.3	.4	.5	.6	.7	.8	.9
555.0	1676	1690	1703	1717	1731	1745	1759	1773	1787	1801
556.0	1816	1830	1844	1859	1873	1888	1903	1917	1932	1947
557.0	1962	1977	1992	2007	2022	2038	2053	2068	2084	2099
558.0	2115	2131	2146	2162	2178	2194	2210	2226	2242	2258
559.0	2275	2291	2307	2324	2340	2357	2374	2390	2407	2424
560.0	2441	2458	2475	2492	2510	2527	2545	2562	2580	2598
561.0	2616	2634	2652	2670	2689	2707	2725	2744	2763	2782
562.0	2801	2820	2839	2858	2877	2897	2916	2936	2955	2975
563.0	2995	3015	3035	3056	3076	3096	3117	3138	3159	3179
564.0	3200	3221	3243	3264	3285	3307	3329	3350	3372	3394
565.0	3416	3438	3461	3483	3505	3528	3551	3574	3597	3620
566.0	3643	3666	3689	3713	3737	3760	3784	3808	3832	3856
567.0	3881	3905	3930	3954	3979	4004	4029	4054	4079	4104
568.0	4130	4155	4181	4207	4233	4259	4285	4311	4338	4364
569.0	4391	4417	4444	4471	4498	4526	4553	4581	4608	4636
570.0	4664	4692	4720	4748	4776	4805	4833	4862	4891	4920
571.0	4949	4979	5008	5038	5067	5097	5127	5157	5188	5218
572.0	5249	5279	5310	5341	5372	5404	5435	5467	5498	5530
573.0	5562	5594	5626	5659	5691	5724	5757	5790	5823	5856
574.0	5890	5923	5957	5991	6025	6059	6093	6128	6162	6197
575.0	6232	6267	6302	6337	6373	6408	6444	6480	6516	6552
576.0	6589	6625	6662	6699	6736	6773	6810	6848	6885	6923
577.0	6961	6999	7037	7076	7114	7153	7192	7231	7270	7309
578.0	7349	7388	7428	7468	7508	7549	7589	7630	7670	7711
579.0	7752	7794	7835	7877	7918	7960	8002	8045	8087	8129
580.0	8172	8215	8258	8301	8345	8388	8432	8476	8520	8565
581.0	8609	8654	8699	8744	8789	8834	8880	8926	8972	9018
582.0	9064	9111	9157	9204	9251	9298	9346	9393	9441	9489
583.0	9537	9586	9634	9683	9732	9781	9830	9880	9929	9979
584.0	10029	10080	10130	10181	10232	10283	10334	10385	10437	10489

TABLE 10

FOSTER CAPACITY TABLE

ELEV FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
					CAPACITY IN ACRE FEET					
585.0	10541	10593	10645	10698	10751	10804	10857	10910	10964	11018
586.0	11071	11126	11180	11235	11289	11344	11399	11455	11510	11566
587.0	11622	11678	11735	11791	11848	11905	11962	12020	12077	12135
588.0	12193	12251	12310	12368	12427	12486	12545	12605	12664	12724
589.0	12784	12845	12905	12966	13027	13088	13149	13211	13273	13335
590.0	13397	13459	13522	13584	13647	13710	13773	13836	13899	13963
591.0	14026	14090	14154	14218	14282	14346	14410	14475	14540	14604
592.0	14669	14734	14799	14865	14930	14996	15061	15127	15193	15259
593.0	15325	15392	15458	15525	15592	15658	15726	15793	15860	15928
594.0	15995	16063	16131	16199	16267	16335	16403	16472	16541	16610
595.0	16678	16748	16817	16886	16956	17025	17095	17165	17235	17305
596.0	17376	17446	17517	17588	17659	17729	17801	17872	17943	18015
597.0	18087	18159	18231	18303	18375	18448	18520	18593	18666	18739
598.0	18812	18885	18959	19032	19106	19180	19254	19328	19402	19477
599.0	19551	19626	19701	19776	19851	19927	20002	20078	20153	20229
600.0	20305	20381	20458	20534	20611	20687	20764	20841	20917	20994
601.0	21071	21148	21226	21303	21381	21458	21536	21614	21691	21769
602.0	21847	21926	22004	22082	22161	22239	22318	22397	22476	22555
603.0	22634	22713	22792	22872	22951	23031	23111	23191	23270	23350
604.0	23430	23511	23591	23672	23752	23833	23913	23994	24075	24156
605.0	24237	24319	24400	24482	24563	24645	24727	24809	24891	24973
606.0	25055	25137	25220	25302	25385	25467	25550	25633	25716	25800
607.0	25883	25966	26050	26133	26217	26301	26384	26469	26553	26637
608.0	26721	26805	26890	26975	27059	27144	27229	27314	27399	27485
609.0	27570	27656	27741	27827	27913	27998	28085	28171	28257	28343
610.0	28430	28516	28603	28690	28777	28863	28951	29038	29125	29212
611.0	29300	29387	29475	29562	29650	29738	29826	29914	30002	30091
612.0	30179	30268	30356	30445	30534	30622	30711	30801	30890	30979
613.0	31068	31158	31247	31337	31427	31517	31607	31697	31787	31877
614.0	31967	32058	32148	32239	32330	32421	32512	32603	32694	32785

FOSTER CAPACITY TABLE

ELEV FEET	CAPACITY IN ACRE FEET .0	.1	.2	.3	.4	.5	.6	.7	.8	.9
615.0	32876	32968	33059	33151	33243	33334	33426	33519	33611	33703
616.0	33795	33888	33980	34073	34165	34258	34351	34444	34537	34631
617.0	34724	34817	34911	35004	35098	35192	35286	35380	35474	35568
618.0	35663	35757	35852	35946	36041	36136	36231	36326	36421	36516
619.0	36611	36707	36802	36898	36994	37090	37186	37282	37378	37474
620.0	37570	37667	37764	37860	37957	38054	38151	38248	38346	38443
621.0	38541	38638	38736	38834	38933	39031	39129	39228	39326	39425
622.0	39524	39623	39722	39821	39921	40020	40120	40220	40320	40420
623.0	40520	40620	40721	40821	40922	41023	41124	41225	41326	41427
624.0	41529	41630	41732	41834	41936	42038	42140	42243	42345	42448
625.0	42551	42654	42757	42860	42963	43066	43170	43274	43378	43482
626.0	43586	43690	43794	43899	44003	44108	44213	44318	44423	44529
627.0	44634	44739	44845	44951	45057	45163	45269	45376	45482	45589
628.0	45695	45802	45909	46016	46124	46231	46339	46446	46554	46662
629.0	46770	46878	46987	47095	47204	47313	47422	47531	47640	47749
630.0	47858	47968	48078	48188	48298	48408	48518	48629	48739	48850
631.0	48960	49072	49183	49294	49405	49517	49629	49741	49852	49965
632.0	50077	50189	50302	50414	50527	50640	50754	50867	50980	51094
633.0	51207	51321	51435	51549	51664	51778	51893	52008	52122	52237
634.0	52352	52468	52583	52699	52815	52930	53047	53163	53279	53396
635.0	53512	53629	53746	53863	53980	54097	54215	54333	54450	54568
636.0	54686	54805	54923	55041	55160	55279	55398	55517	55636	55756
637.0	55875	55995	56115	56235	56355	56475	56596	56716	56837	56958
638.0	57079	57200	57321	57443	57564	57686	57808	57930	58052	58175
639.0	58297	58420	58543	58666	58789	58912	59036	59159	59283	59407
640.0	59528	59653	59777	59902	60027	60152	60277	60703	60529	60655
641.0	60781	60907	61034	61161	61288	61415	61543	61671	61799	61927

Foster Reservoir

Seasonal Filling Schedule

Revised February 1970

Date	February		March		April		May	
	Elev.	Storage	Elev.	Storage	Elev.	Storage	Elev.	Storage
Jan 31	613.00	31,066 ✓						
1	613.28	31,317	620.79	38,333	628.38	46,101	635.09	53,618
2	613.56	31,567	621.05	38,583	628.61	46,351	635.31	53,869
3	613.84	31,818	621.30	38,834	628.85	46,602	635.52	54,119
4	614.11	32,068	621.56	39,085	629.08	46,853	635.73	54,370
5	614.39	32,319	621.81	39,335	629.31	47,103	635.94	54,621
6	614.67	32,569	622.06	39,586	629.54	47,354	636.16	54,871
7	614.94	32,820	622.32	39,836	629.77	47,604	636.37	55,122
8	615.22	33,071	622.57	40,087	630.00	47,855	636.58	55,372
9	615.49	33,321	622.82	40,337	630.23	48,105	636.79	55,623
10	615.76	33,572	623.07	40,588	630.46	48,356	637.00	55,873
11	616.03	33,822	623.32	40,839	630.68	48,607		
12	616.30	34,073	623.57	41,089	630.91	48,857		
13	616.57	34,324	623.82	41,340	631.13	49,108		
14	616.84	34,574	624.06	41,590	631.36	49,358		
15	617.11	34,825	624.31	41,841	631.58	49,609		
16	617.38	35,075	624.55	42,092	631.81	49,860		
17	617.64	35,326	624.80	42,342	632.03	50,110		
18	617.91	35,576	625.04	42,593	632.25	50,361		
19	618.18	35,827	625.29	42,843	632.48	50,611		
20	618.44	36,078	625.53	43,094	632.70	50,862		
21	618.70	36,328	625.77	43,344	632.92	51,112		
22	618.97	36,579	626.01	43,595	633.14	51,363		
23	619.23	36,829	626.25	43,846	633.36	51,614		
24	619.49	37,080	626.49	44,096	633.58	51,864		
25	619.75	37,330	626.73	44,347	633.80	52,115		
26	620.01	37,581	626.97	44,597	634.01	52,365		
27	620.27	37,832	627.20	44,848	634.23	52,616		
28	620.53	38,082	627.44	45,098	634.45	52,866		
29			627.68	45,349	634.66	53,117		
30			627.91	45,600	634.88	53,368		
31			628.15	45,850				

Notes:

1. Pool elevation and corresponding acre-feet applicable to the midnight observation.
2. In leap years reservoir will be one day ahead of above schedule after 28 February.
3. Filling rate = 251 acre-feet/day = 126 c.f.s./day /125

Δ/hr = 10.41667

Foster Reservoir

Evacuation Schedule

Revised February 1970

Date	September		October		November			
	Elev.	Storage	Elev.	Storage	Elev.	Storage	Elev.	Storage
1			636.55	55,334	621.08	38,616		
2			636.09	54,794	620.53	38,077		
3			635.64	54,255	619.97	37,537		
4			635.18	53,716	619.41	36,998		
5			634.71	53,177	618.84	36,459		
6			634.25	52,637	618.28	35,920		
7			633.78	52,098	617.70	35,380		
8			633.31	51,559	617.13	34,841		
9			632.84	51,019	616.55	34,302		
10			632.36	50,480	615.97	33,763		
11			631.89	49,941	615.38	33,223		
12			631.40	49,402	614.79	32,684		
13			630.91	48,862	614.20	32,145		
14			630.43	48,323	613.60	31,605		
15			629.93	47,784	613.00	31,066		
16			629.44	47,245				
17			628.94	46,705				
18			628.44	46,166				
19			627.94	45,627				
20			627.43	45,087				
21			626.92	44,548				
22			626.41	44,009				
23			625.89	43,470				
24			625.37	42,930				
25			624.85	42,391				
26			624.32	41,852				
27			623.79	41,312				
28			623.26	40,773				
29			622.72	40,234				
30	637.00	55,873	622.18	39,695				
31			621.63	39,155				

Notes:

1. Pool elevation above mean sea level and corresponding storage in acre-feet applicable to the midnight observation.
2. Evacuation rate = 539 acre-feet/day = ~~272~~ c.f.s./day. 270

TABLE 13

9-210 Rev. *Provisional*

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY (WATER RESOURCES DIVISION)

Sta. No. 14-1853.00

Rating table for Middle Santiam River near Cascadia, Oreg
, from Dec 22, 1964, to , 19 , from , 19 , to , 19

Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs
.00			2.00	183	27	4.00	1,060	60	6.00	2,780	110	8.00	5,400	160	10.00	8,800	200	12.00	13,000	240
.10			.10	210	30	.10	1,120	70	.10	2,890	110	.10	5,560		.10	9,000		.10	13,240	
.20			.20	240		.20	1,190		.20	3,000	120	.20	5,720		.20	9,200		.20	13,480	
.30			.30	270	30	.30	1,260		.30	3,120		.30	5,880		.30	9,400		.30	13,720	
.40			.40	300	35	.40	1,330	70	.40	3,240		.40	6,040		.40	9,600		.40	13,960	
.50			.50	335		.50	1,400	80	.50	3,360	120	.50	6,200		.50	9,800		.50	14,200	
.60			.60	370		.60	1,480		.60	3,480	130	.60	6,360		.60	10,000		.60	14,440	
.70			.70	405	35	.70	1,560		.70	3,610		.70	6,520		.70	10,200		.70	14,680	
.80			.80	440	40	.80	1,640		.80	3,740		.80	6,680		.80	10,400		.80	14,920	
.90			.90	480	40	.90	1,720	80	.90	3,870	130	.90	6,840	160	.90	10,600	200	.90	15,160	240
1.00			3.00	520	50	5.00	1,800	90	7.00	4,000	140	9.00	7,000	180	11.00	10,800	220	13.00	15,400	2600
.10	27	11	.10	570		.10	1,890		.10	4,140		.10	7,180		.10	11,020		14 .10	18,000	2800
.20	38	12	.20	620		.20	1,980		.20	4,280		.20	7,360		.20	11,240		15 .20	20,800	2800
.30	50	14	.30	670		.30	2,070	90	.30	4,420		.30	7,540		.30	11,460		16 .30	23,600	
.40	64	16	.40	720		.40	2,160	100	.40	4,560		.40	7,720		.40	11,680		.40		
.50	80	17	.50	770	50	.50	2,260		.50	4,700		.50	7,900		.50	11,900		.50		
.60	97	18	.60	820	60	.60	2,360		.60	4,840		.60	8,080		.60	12,120		.60		
.70	115	20	.70	880		.70	2,460	100	.70	4,980		.70	8,260		.70	12,340		.70		
.80	135	23	.80	940		.80	2,560	110	.80	5,120		.80	8,440		.80	12,560		.80		
.90	158	25	.90	1000	60	.90	2,670	110	.90	5,260	140	.90	8,620	180	.90	12,780	220	.90		

This table is applicable for open-channel conditions. It is based on discharge measurements ~~made during~~ 16 to 23 and is well defined between cfs and cfs. Comp by WAH date 11-3-

Ckd by date.

Table No. 4

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY (WATI ESOURCES DIVISION)

Sta. No. 14-1859

Rating table for Quartzville Creek near Cascadia, Oreg.

from Oct. 16, 1965, to , 19 , from , 19 , to , 19

Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs
.00			5.00			7.00	365	40	9.00	1650	100	11.00	4000	160	13.00	7600	240	.00		
.10			.10			.10	355	40	.10	1750		.10	4160		.10	7840		.10		
.20			.20			.20	395	45	.20	1850		.20	4320		.20	8080		.20		
.30			.30			.30	440	50	.30	1950		.30	4450		.30	8320		.30		
.40			.40			.40	490	50	.40	2050	100	.40	4640		.40	8560		.40		
.50			.50	12	7	.50	540	50	.50	2150	110	.50	4800		.50	8800		.50		
.60			.60	19	7	.60	590	60	.60	2260		.60	4960		.60	9040		.60		
.70			.70	26	10	.70	650		.70	2370		.70	5120		.70	9280		.70		
.80			.80	36	11	.80	710		.80	2480		.80	5280		.80	9520		.80		
.90			.90	47	14	.90	770	60	.90	2590	110	.90	5440	160	.90	9760	240	.90		
.00			6.00	61	15	8.00	830	75	10.00	2700	120	12.00	5600	200	14.00	10,000		.00		
.10			.10	76	18	.10	905		.10	2820		.10	5800		.10			.10		
.20			.20	94	20	.20	980		.20	2940		.20	6000		.20			.20		
.30			.30	114	21	.30	1055	75	.30	3060		.30	6200		.30			.30		
.40			.40	135	25	.40	1130	80	.40	3180	120	.40	6400		.40			.40		
.50			.50	160	25	.50	1210	80	.50	3300	140	.50	6600		.50			.50		
.60			.60	185	30	.60	1290	90	.60	3440		.60	6800		.60			.60		
.70			.70	215	30	.70	1380		.70	3580		.70	7000		.70			.70		
.80			.80	245	35	.80	1470		.80	3720		.80	7200		.80			.80		
.90			.90	280	35	.90	1560	90	.90	3860	140	.90	7400	200	.90			.90		

This table is applicable for open-channel conditions. It is based on discharge measurements ~~made during~~ 18-21

and is well defined between cfs and cfs. Comp by [illegible] date [illegible]

Ckd by [illegible] date 1-4-6[illegible]

NEW SITE Table No. 1A

TABLE 14

TABLE 15

UNITED STATES DEPART NT OF THE INTERIOR
GEOLOGICAL SURVEY (WATER RESOURCES DIVISION)

Sta. No. 14-1850.00

Rating table for South Santiam River below Cascadia, Oreg.

, from Aug. 22, 1967, to , 19 , from , 19 , to , 19

Gage height Feet	Discharge Cfs	Difference Cfs	Gage height Feet	Discharge Cfs	Difference Cfs	Gage height Feet	Discharge Cfs	Difference Cfs	Gage height Feet	Discharge Cfs	Difference Cfs	Gage height Feet	Discharge Cfs	Difference Cfs	Gage height Feet	Discharge Cfs	Difference Cfs	Gage height Feet	Discharge Cfs	Difference Cfs
.00			2.00	134	15	4.00	890	65	6.00	2,530	100	8.00	4,800	120	10.00	7,730	170	12.0	11,300	2,000
.10			.10	149	16	.10	955	65	.10	2,630	|	.10	4,920	120	.10	7,900	|	13.0	13,300	|
.20			.20	165	20	.20	1,020	70	.20	2,730	100	.20	5,040	130	.20	8,070	|	14.0	15,300	2,000
.30			.30	185	20	.30	1,090	|	.30	2,830	110	.30	5,170	|	.30	8,240	|	15.0	17,300	2,100
.40			.40	205	25	.40	1,160	|	.40	2,940	|	.40	5,300	|	.40	8,410	|	16.0	19,400	2,200
.50			.50	230	25	.50	1,230	|	.50	3050	|	.50	5,430	130	.50	8,580	|	17.0	21,600	|
.60			.60	255	25	.60	1,300	70	.60	3160	|	.60	5,560	140	.60	8,750	170	18.0	23,800	2,200
.70			.70	280	30	.70	1,370	80	.70	3,270	|	.70	5,700	|	.70	8,920	180	19.0	26,000	2,400
.80			.80	310	35	.80	1,450	|	.80	3,380	|	.80	5,840	|	.80	9,100	|	20.0	28,400	
.90			.90	345	40	.90	1,530	|	.90	3,490	110	.90	5,980	140	.90	9,280	|	.90		
1.00	44	5	3.00	385	40	5.00	1,610	|	7.00	3,600	120	9.00	6,120	150	11.00	9,460	|	.00		
.10	49	6	.10	425	45	.10	1,690	80	.10	3,720	|	.10	6,270	|	.10	9,640	|	.10		
.20	55	6	.20	470	|	.20	1,770	90	.20	3,840	|	.20	6420	150	.20	9,820	|	.20		
.30	61	7	.30	515	45	.30	1,860	|	.30	3,960	|	.30	6,570	160	.30	10,000	|	.30		
.40	68	8	.40	560	50	.40	1,950	|	.40	4,080	|	.40	6,730	|	.40	10,180	|	.40		
.50	76	10	.50	610	50	.50	2,040	90	.50	4,200	|	.50	6,890	160	.50	10,360	180	.50		
.60	86	10	.60	660	55	.60	2,130	100	.60	4,320	|	.60	7,050	170	.60	10,540	190	.60		
.70	96	11	.70	715	55	.70	2,230	|	.70	4,440	|	.70	7,220	|	.70	10,730	|	.70		
.80	107	13	.80	770	60	.80	2,330	|	.80	4,560	|	.80	7,390	|	.80	10,920	|	.80		
.90	120	14	.90	830	60	.90	2,430	100	.90	4,680	120	.90	7,560	170	.90	11,110	190	.90		

This table is applicable for open-channel conditions. It is based on —— discharge measurements ~~made during~~ 253-259 & previous rating above 9.5 ft. ~~and is~~ ~~well defined between~~ ~~cfs and~~ cfs.

Comp by DLG date

Ckd by WAH date 8-22-67

Table No. 11 A

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY (WATER RESOURCES DIVISION)

Sta. No. 14 18 - 200
Table No. 02
Begin 66 11 16 __ (YR. MO. D. HR.)

Rating table for South Santiam River at Foster, Oreg.
from Nov. 16, 1966 to ______, from ______ to ______, from ______ to ______

Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs
1.00	10	12	3.00	1,100	100	5.00	4,000	200	7.00	8,400	260	9.00	14,500	4000	.00			.00		
.10	22	16	.10	1,200	100	.10	4,200		.10	8,660		10.00	18,500	4,500	.10			.10		
.20	38	24	.20	1,300	110	.20	4,400		.20	8,920		11.00	23,000	5,000	.20			.20		
.30	62	30	.30	1,410	110	.30	4,600		.30	9,180		12.00	28,000		.30			.30		
.40	92	34	.40	1,520	120	.40	4,800	200	.40	9,440	260	.40			.40			.40		
.50	126	38	.50	1,640	120	.50	5,000	220	.50	9,700	280	.50			.50			.50		
.60	164	41	.60	1,760	140	.60	5,220		.60	9,980		.60			.60			.60		
.70	205	45	.70	1,900		.70	5,440		.70	10,260		.70			.70			.70		
.80	250	50	.80	2,040		.80	5,660		.80	10,540		.80			.80			.80		
.90	300	50	.90	2,180	140	.90	5,880		.90	10,820	280	.90			.90			.90		
2.00	350	60	4.00	2,320	160	6.00	6,100		8.00	11,100	300	1[illegible].00			.00			.00		
.10	410	60	.10	2,480		.10	6,320		.10	11,400		1[illegible].00			.10			.10		
.20	470	70	.20	2,640		.20	6,540		.20	11,700		1[illegible].00			.20			.20		
.30	540		.30	2,800		.30	6,760		.30	12,000	300	1[illegible].00			.30			.30		
.40	610	70	.40	2,960		.40	6,980	220	.40	12,300	350	1[illegible].00			.40			.40		
.50	680	80	.50	3,120	160	.50	7,200	240	.50	12,650		.50			.50			.50		
.60	760		.60	3,280	180	.60	7,440		.60	13,000		.60			.60			.60		
.70	840	80	.70	3,460		.70	7,680		.70	13,350	350	.70			.70			.70		
.80	920	90	.80	3,640		.80	7,920		.80	13,700	400	.80			.80			.80		
.90	1,010	90	.90	3,820	180	.90	8,160	240	.90	14,100	400	.90			.90			.90		

TABLE 16

This table is applicable for open-channel conditions. It is based on ______ discharge measurements ~~made during~~ ______
______ ~~and is ______ well defined between ______ cfs and ______ cfs.~~

Same as table 1 above 9.0 ft.

Comp. by J.F.C. date 2-12-68
Ckd. by E.H.S. date 2-14-68

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY (W R RESOURCES DIVISION)

Sta. No. 14-1875.00

Rating table for South Santiam River at Waterloo, Oreg.
, from Mar. 10, 1966, to , 19 , from , 19 , to , 19

Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs
1.00			3.00	900	110	5.00	3,900	200	7.00	8,600	300	9.00	15,000	350	11.00	22,100	370	13.0	29,700	4,100
.10			.10	1,010	110	.10	4,100		.10	8,900		.10	15,350		.10	22,470		14.0	33,800	4,300
.20			.20	1,120	120	.20	4,300		.20	9,200		.20	15,700		.20	22,840		15.0	38,100	4,600
.30			.30	1,240	120	.30	4,500	200	.30	9,500		.30	16,050		.30	23,210		16.0	42,700	4,900
.40			.40	1,360	120	.40	4,700	220	.40	9,800		.40	16,400		.40	23,580		17.0	47,600	5,200
.50			.50	1,480	130	.50	4,920		.50	10,100		.50	16,750		.50	23,950		18.0	52,800	5,500
.60			.60	1,610	130	.60	5,140		.60	10,400		.60	17,100		.60	24,320		19.0	58,300	5,800
.70	43	30	.70	1,740	130	.70	5,360		.70	10,700		.70	17,450		.70	24,690		20.0	64,100	6,100
.80	73	34	.80	1,870	140	.80	5,580	220	.80	11,000		.80	17,800		.80	25,060		21.0	70,200	6,500
.90	107	41	.90	2,010	140	.90	5,800	240	.90	11,300	300	.90	18,150	350	.90	25,430	370	22.0	76,700	7,000
2.00	148	47	4.00	2,150	150	6.00	6,040		8.00	11,600	340	10.00	18,500	360	12.00	25,800	390	23.0	83,700	7,500
.10	195	55	.10	2,300	160	.10	6,280		.10	11,940		.10	18,860		.10	26,190		24.0	91,200	8,000
.20	250	60	.20	2,460	170	.20	6,520		.20	12,280		.20	19,220		.20	26,580		25.0	99,200	
.30	310	65	.30	2,630	170	.30	6,760	240	.30	12,620		.30	19,580		.30	26,970		.30		
.40	375	75	.40	2,800	180	.40	7,000	260	.40	12,960		.40	19,940		.40	27,360		.40		
.50	450	80	.50	2,980		.50	7,260		.50	13,300		.50	20,300		.50	27,750		.50		
.60	530	85	.60	3,160		.60	7,520		.60	13,640		.60	20,660		.60	28,140		.60		
.70	615	90	.70	3,340		.70	7,780	260	.70	13,980		.70	21,020		.70	28,530		.70		
.80	705	95	.80	3,520	180	.80	8,040	280	.80	14,320		.80	21,380		.80	28,920		.80		
.90	800	100	.90	3,700	200	.90	8,320	280	.90	14,660	340	.90	21,740	360	.90	29,310	390	.90		

This table is applicable for open-channel conditions. It is based on —— discharge measurements ~~made during~~ 324–328 and
evious high-water ratings. ~~and is well defined between cfs and cfs.~~ Comp by WAH date 10/21/66
me as rating 8 above 4.0 ft. Ckd by E.N.L. date 11/7/66

Table No. 9

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY (WATER RESOURCES DIVISION)

Sta. No. 14-18' 00

Provisional

Rating table for Santiam River at Jefferson, Oreg.
from 1 Aug., 1966, to ......, 19...., from ......, 19...., to ......, 19....

Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs
0.00			2.00	1,460	80	4.00	3,970	160	6.00	8,000	240	8.00	13,500	350	10.00	20,500	400	12.00	29,000	500
.10			.10	1,540	90	.10	4,130	170	.10	8,240	|	.10	13,850	|	.10	20,900	|	.10	29,500	|
.20			.20	1,630	90	.20	4,300	|	.20	8,480	|	.20	14,200	|	.20	21,300	|	.20	30,000	|
.30			.30	1,720	100	.30	4,470	170	.30	8,720	|	.30	14,550	|	.30	21,700	|	.30	30,500	|
.40			.40	1,820	100	.40	4,640	180	.40	8,960	240	.40	14,900	|	.40	22,100	|	.40	31,000	|
.50	580	40	.50	1,920	110	.50	4,820	|	.50	9,200	260	.50	15,250	|	.50	22,500	|	.50	31,500	|
.60	620	|	.60	2,030	110	.60	5,000	180	.60	9,460	|	.60	15,600	|	.60	22,900	|	.60	32,000	|
.70	660	40	.70	2,140	120	.70	5,180	190	.70	9,720	|	.70	15,950	|	.70	23,300	|	.70	32,500	|
.80	700	50	.80	2,260	120	.80	5,370	190	.80	9,980	|	.80	16,300	|	.80	23,700	|	.80	33,000	|
.90	750	|	.90	2,380	130	.90	5,560	200	.90	10,240	260	.90	16,650	|	.90	24,100	400	.90	33,500	500
1.00	800	50	3.00	2,510	130	5.00	5,760	200	7.00	10,500	300	9.00	17,000	|	11.00	24,500	450	13.00	34,000	550
.10	850	60	.10	2,640	140	.10	5,960	210	.10	10,800	|	.10	17,350	|	.10	24,950	|	.10	34,550	|
.20	910	|	.20	2,780	|	.20	6,170	210	.20	11,100	|	.20	17,700	|	.20	25,400	|	.20	35,100	|
.30	970	|	.30	2,920	|	.30	6,380	220	.30	11,400	|	.30	18,050	|	.30	25,850	|	.30	35,650	|
.40	1,030	60	.40	3,060	140	.40	6,600	220	.40	11,700	|	.40	18,400	|	.40	26,300	|	.40	36,200	|
.50	1,090	70	.50	3,200	150	.50	6,820	230	.50	12,000	|	.50	18,750	|	.50	26,750	|	.50	36,750	|
.60	1,160	|	.60	3,350	|	.60	7,050	230	.60	12,300	|	.60	19,100	|	.60	27,200	|	.60	37,300	|
.70	1,230	70	.70	3,500	150	.70	7,280	240	.70	12,600	|	.70	19,450	|	.70	27,650	|	.70	37,850	|
.80	1,300	80	.80	3,650	160	.80	7,520	|	.80	12,900	|	.80	19,800	|	.80	28,100	|	.80	38,400	|
.90	1,380	80	.90	3,810	160	.90	7,760	240	.90	13,200	300	.90	20,150	350	.90	28,550	450	.90	38,950	550

This table is applicable for open-channel conditions. It is based on ...... discharge measurements made during 227 - 232 ...... and is ...... well defined between ...... cfs and ...... cfs.

Comp by WAH date 8-2-66
Ckd by JMA date 8-2-66
Table No. 9A

TABLE 18

Sheet 1

Sheet 1 of 2

TABLE 18

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY (WATER RESOURCES DIVISION)

Sta. No. 14-189 90

Provisional

Rating table for Santiam River at Jefferson, Oreg.
from 1 Aug., 1966, to ...., 19...., from ...., 19...., to ...., 19....

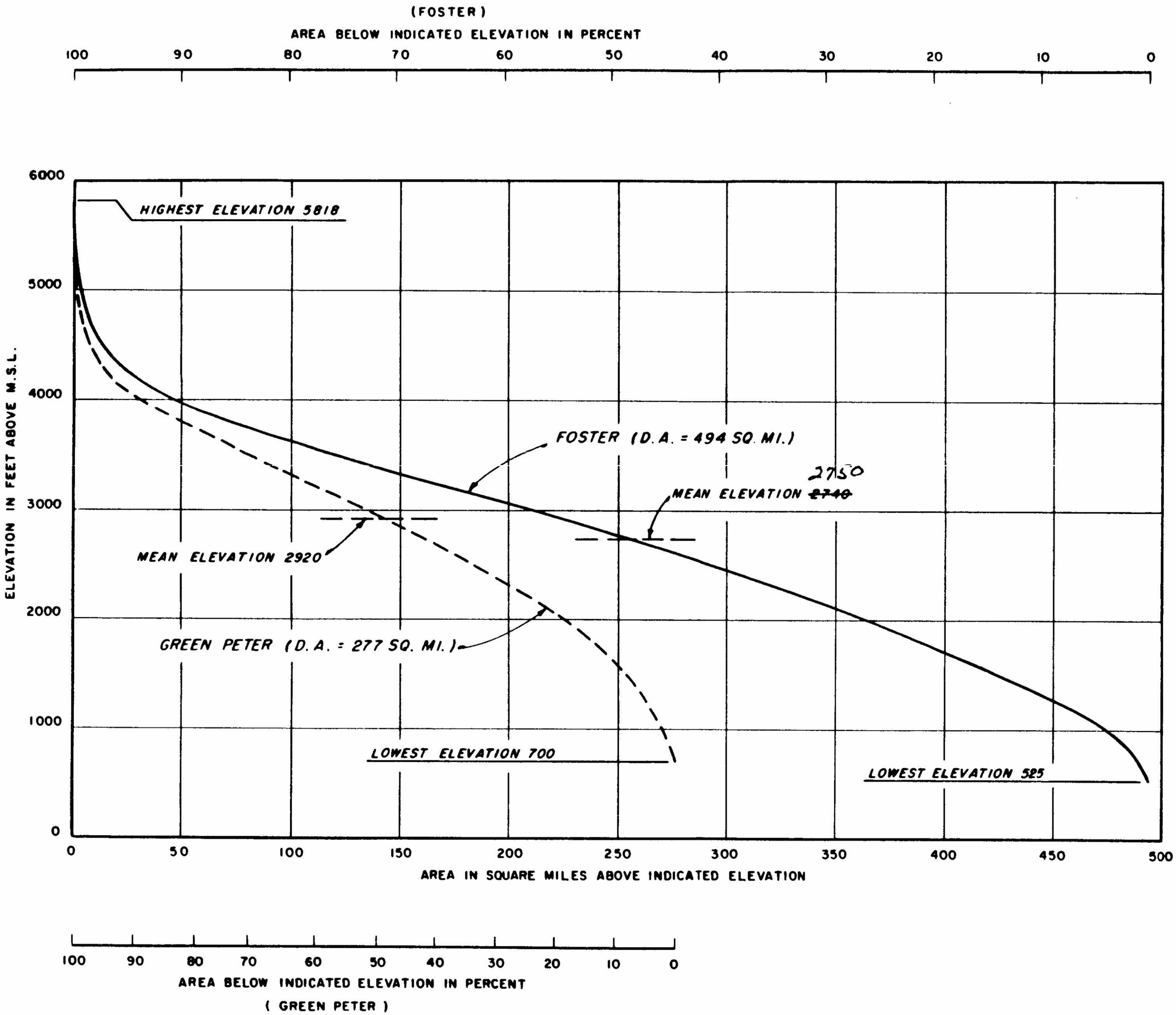
Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs
14.00	39,500	650	16.00	53,700	800	18.00	70,500	950	20.00	95,000	1,800	22.00	135,000	2,600	24.00	190,000	3,100	.00		
.10	40,150		.10	54,500		.10	71,450	950	.10	96,800		.10	137,600		.10	193,100		.10		
.20	40,800		.20	55,300		.20	72,400	1,000	.20	98,600		.20	140,200		.20	196,200		.20		
.30	41,450		.30	56,100		.30	73,400		.30	100,400		.30	142,800		.30	199,300	3100	.30		
.40	42,100		.40	56,900		.40	74,400	1,000	.40	102,200		.40	145,400		.40	202,400		.40		
.50	42,750		.50	57,700		.50	75,400	1,100	.50	104,000		.50	148,000		.50			.50		
.60	43,400		.60	58,500		.60	76,500		.60	105,800		.60	150,600		.60			.60		
.70	44,050		.70	59,300	800	.70	77,600	1,100	.70	107,600		.70	153,200		.70			.70		
.80	44,700		.80	60,100	850	.80	78,700	1,200	.80	109,400		.80	155,800		.80			.80		
.90	45,350	650	.90	60,950		.90	79,900		.90	111,200	1,800	.90	158,400	2,600	.90			.90		
15.00	46,000	750	17.00	61,800		19.00	81,100	1,200	21.00	113,000	2,200	23.00	161,000	2,900	.00			.00		
.10	46,750		.10	62,650		.10	82,300	1,300	.10	115,200		.10	163,900		.10			.10		
.20	47,500		.20	63,500		.20	83,600		.20	117,400		.20	166,800		.20			.20		
.30	48,250		.30	64,350		.30	84,900	1,300	.30	119,600		.30	169,700		.30			.30		
.40	49,000		.40	65,200		.40	86,200	1,400	.40	121,800		.40	172,600		.40			.40		
.50	49,750	750	.50	66,050	850	.50	87,600		.50	124,000		.50	175,500		.50			.50		
.60	50,500	800	.60	66,900	900	.60	89,000	1,400	.60	126,200		.60	178,400		.60			.60		
.70	51,300		.70	67,800		.70	90,400	1,500	.70	128,400		.70	181,300		.70			.70		
.80	52,100		.80	68,700		.80	91,900	1,500	.80	130,600		.80	184,200		.80			.80		
.90	52,900	800	.90	69,600	900	.90	93,400	1,600	.90	132,800	2,200	.90	187,100	2,900	.90			.90		

Sheet 2

This table is applicable for open-channel conditions. It is based on .... discharge measurements made during .... and is .... well defined between .... cfs and .... cfs.

Comp by WHH date 8-2-66
Ckd by JMA date 8-2-66
Table No. 9A

Sheet 2 of 2



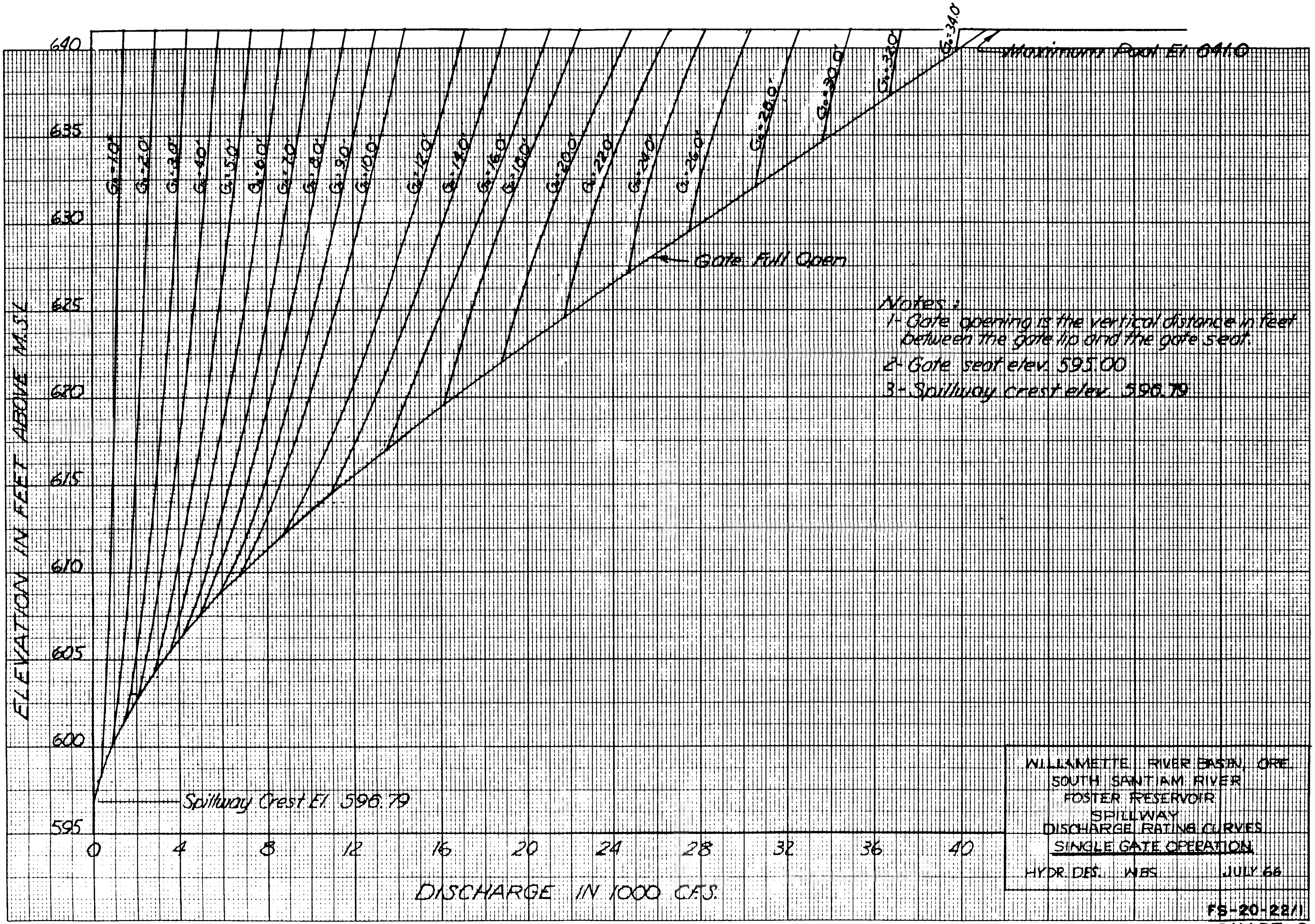
WILLAMETTE RIVER BASIN, OREGON
SOUTH SANTIAM BASIN

AREA-ELEVATION CURVES

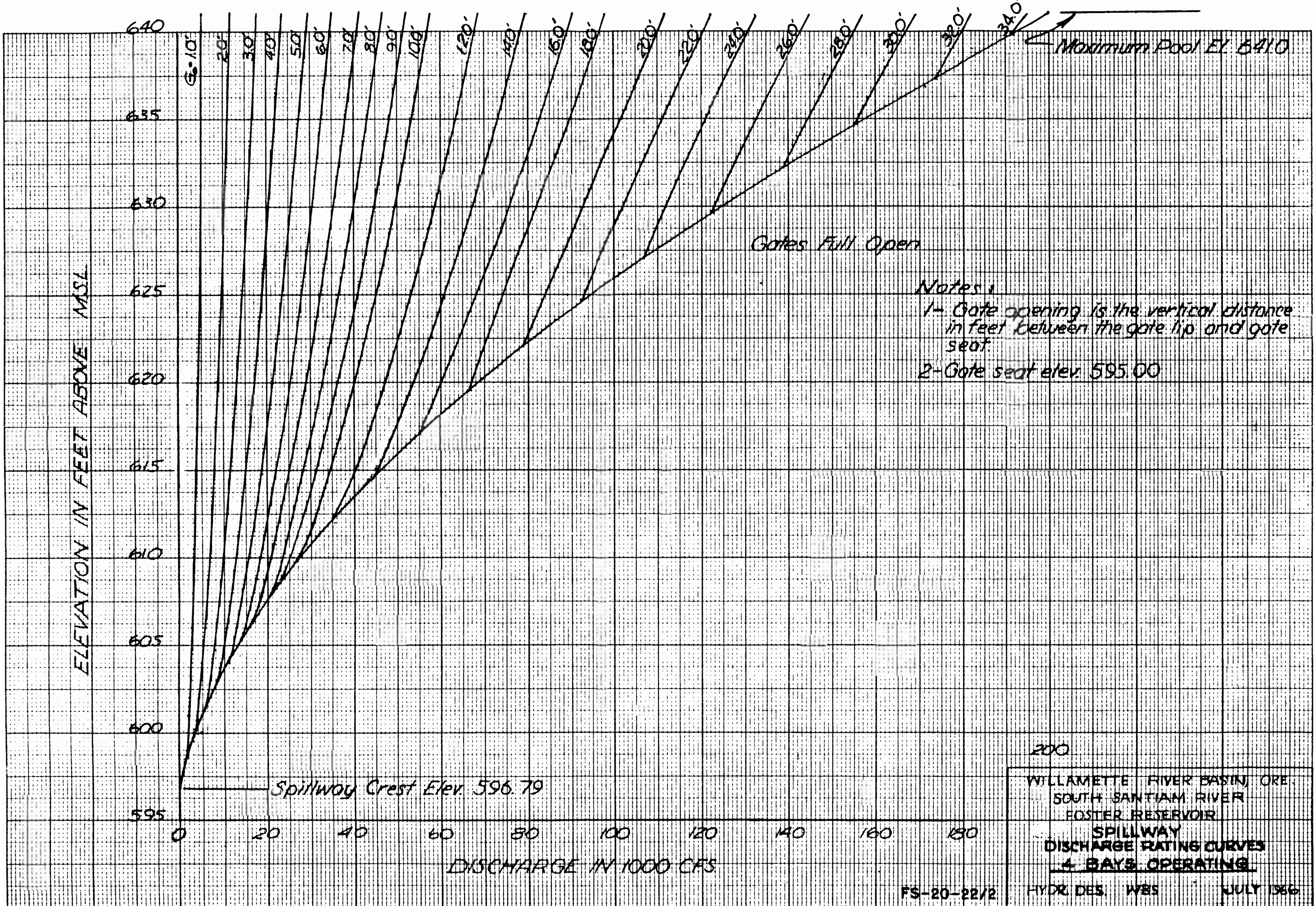
U.S. ARMY ENGINEER DISTRICT, PORTLAND
WATER CONTROL DISTRICT AUGUST 1966
PREPARED: CEJ, PBB CHECKED: GEG

REV. MAY 1968 GP-20-24/4

CHART 1

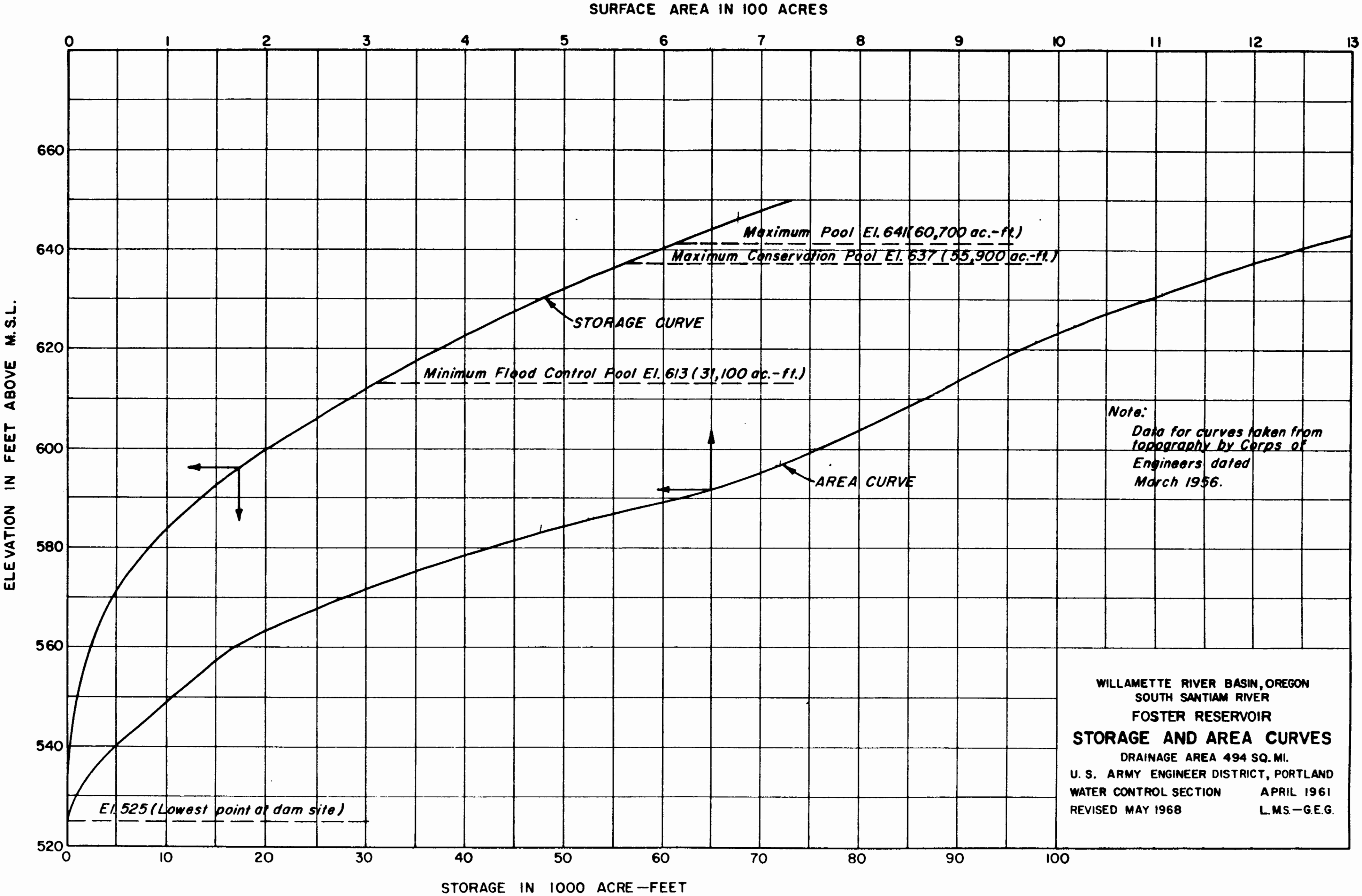


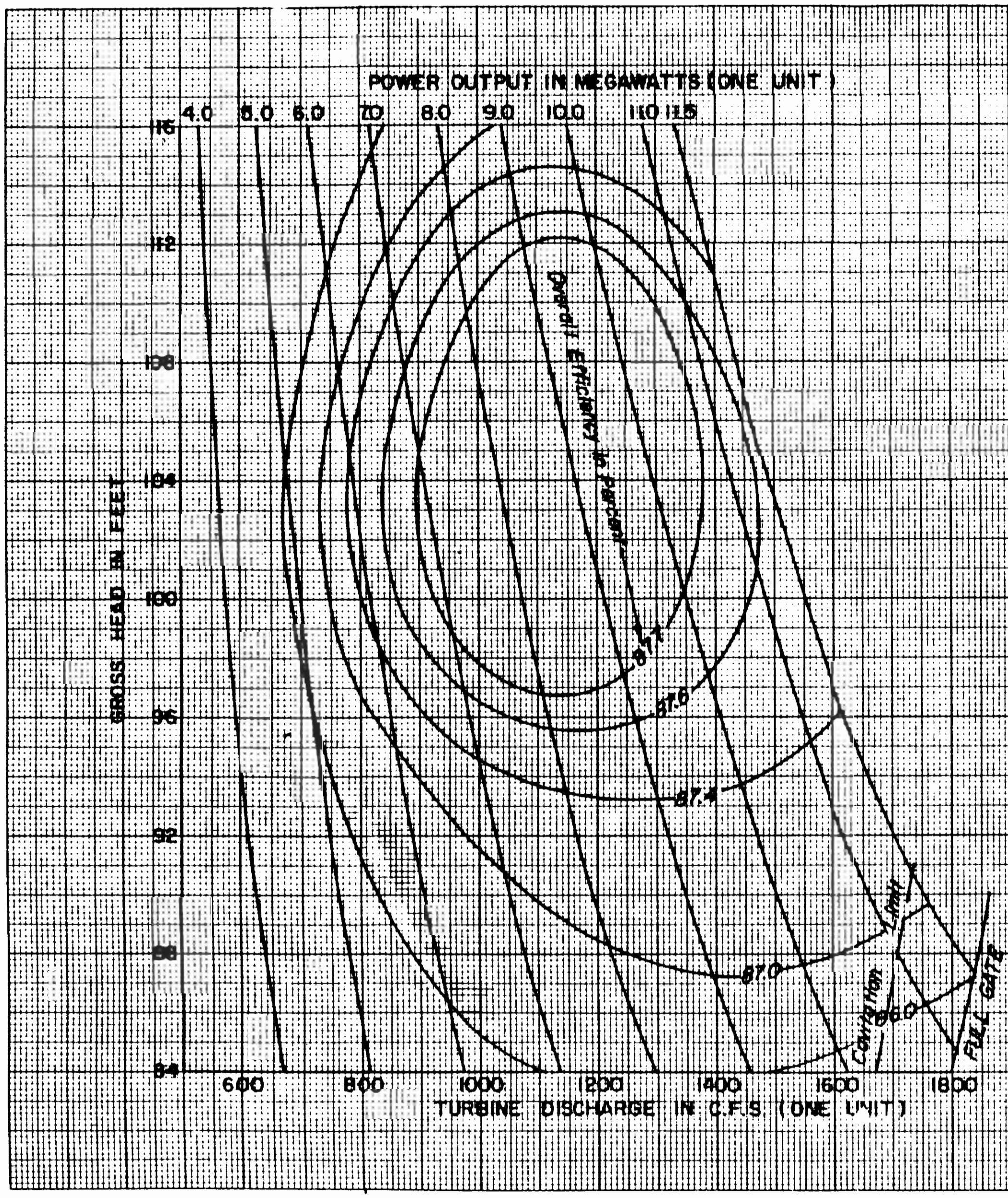
FS-20-22/1
CHART 2



ELEVATION IN FEET ABOVE MSL
DISCHARGE IN 1000 CFS
640
635
630
625
620
615
610
605
600
595
0
20
40
60
80
100
120
140
160
180
200
G.-1.0'
2.0'
3.0'
4.0'
5.0'
6.0'
7.0'
8.0'
9.0'
10.0'
12.0'
14.0'
16.0'
18.0'
20.0'
22.0'
24.0'
26.0'
28.0'
30.0'
32.0'
34.0'
Maximum Pool El. 641.0
Gates Full Open
Notes:
1- Gate opening is the vertical distance in feet between the gate lip and gate seat
2- Gate seat elev. 595.00
Spillway Crest Elev. 596.79
FS-20-22/2
WILLAMETTE RIVER BASIN, ORE.
SOUTH SANTIAM RIVER
FOSTER RESERVOIR
SPILLWAY
DISCHARGE RATING CURVES
4 BAYS OPERATING
HYDR. DES. WBS
JULY 1966

CHART 3


SURFACE AREA IN 100 ACRES
0
1
2
3
4
5
6
7
8
9
10
11
12
13
ELEVATION IN FEET ABOVE M.S.L.
660
640
620
600
580
560
540
520
Maximum Pool El. 641 (60,700 ac.-ft.)
Maximum Conservation Pool El. 637 (55,900 ac.-ft.)
STORAGE CURVE
Minimum Flood Control Pool El. 613 (31,100 ac.-ft.)
Note:
Data for curves taken from topography by Corps of Engineers dated March 1956.
AREA CURVE
El. 525 (Lowest point at dam site)
WILLAMETTE RIVER BASIN, OREGON
SOUTH SANTIAM RIVER
FOSTER RESERVOIR
STORAGE AND AREA CURVES
DRAINAGE AREA 494 SQ. MI.
U. S. ARMY ENGINEER DISTRICT, PORTLAND
WATER CONTROL SECTION APRIL 1961
REVISED MAY 1968 L.M.S.—G.E.G.
0
10
20
30
40
50
60
70
80
90
100
STORAGE IN 1000 ACRE—FEET



This chart supersedes FS-20-22/3, dated 24 August 1966.

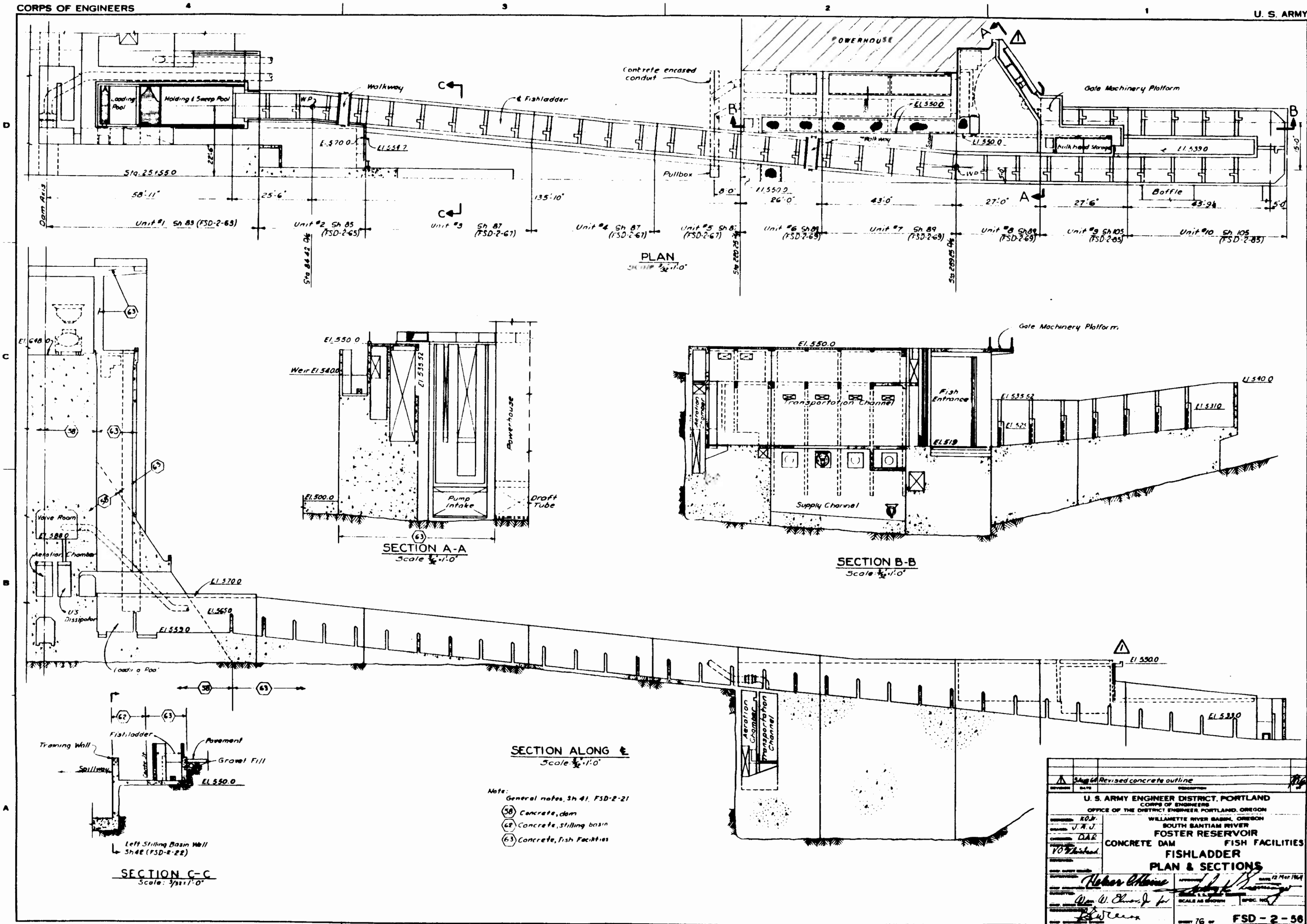
WILLAMETTE RIVER BASIN, OREGON
SOUTH SANTIAM RIVER
FOSTER RESERVOIR

OPERATION CURVES

U.S. ARMY ENGINEER DISTRICT, PORTLAND
DAM & FLOOD CONTROL PLANNING SEC. MAY 1970
PREPARED: B.M.B. CHECKED: K.H.K.

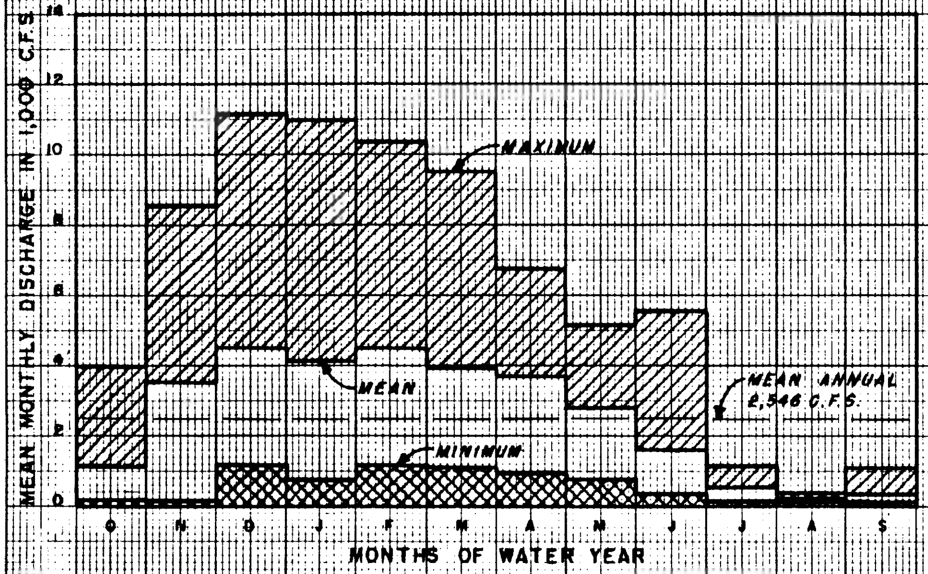
FS-20-22/13 CHART 5

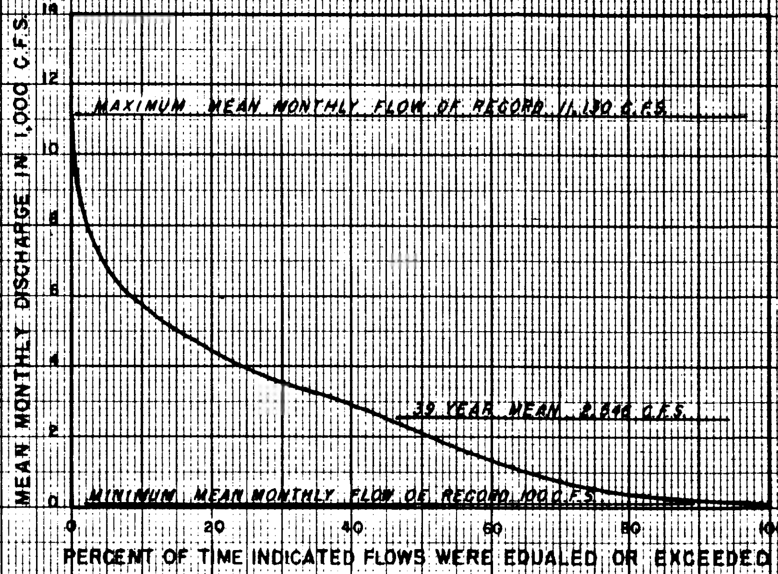
l.28-70

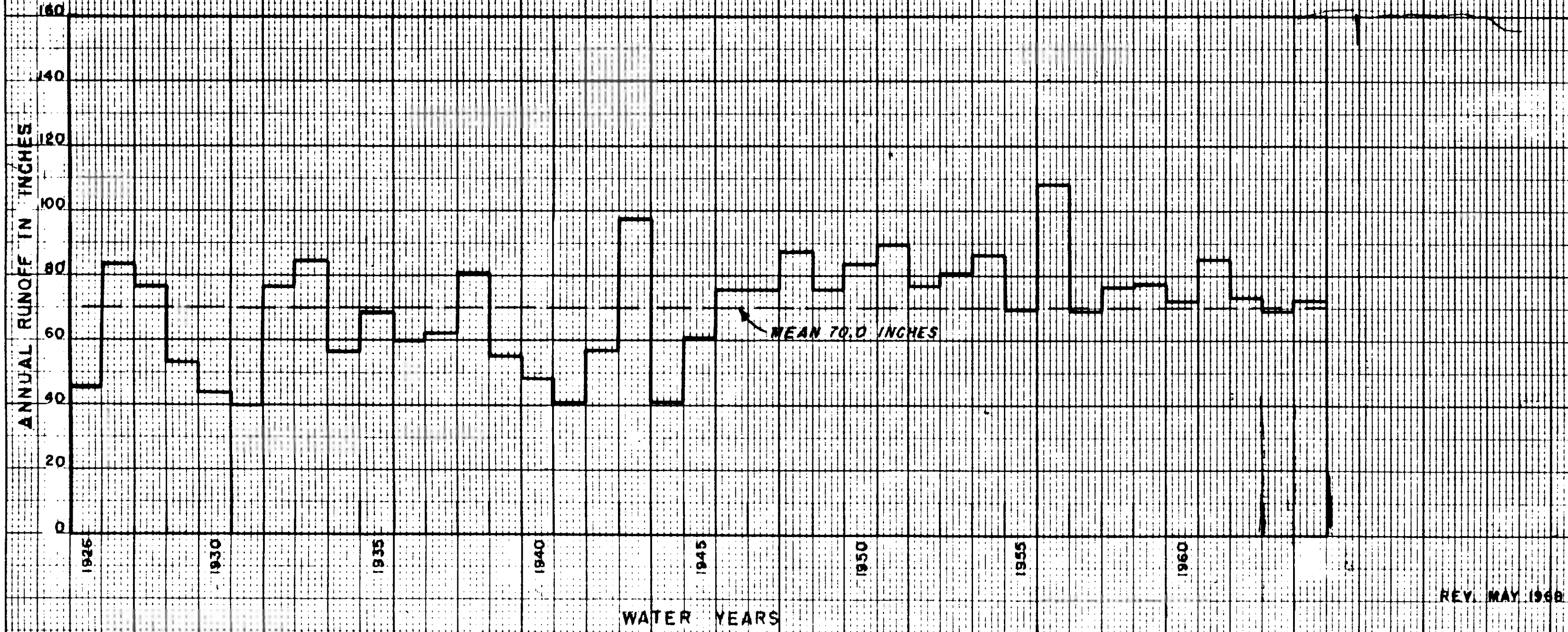


CORPS OF ENGINEERS
U. S. ARMY
POWERHOUSE
Concrete encased conduit
Walkway
℄ Fishladder
Gate Machinery Platform
Loading Pool
Holding & Sweep Pool
W.P.
El. 570.0
El. 559.7
El. 550.0
El. 553.0
El. 539.0
Bulkhead Storage
Pullbox
Baffle
Sta. 25+55.0
Dam Axis
58'-11"
25'-6"
22'-6"
135'-10"
8'-0"
26'-0"
43'-0"
27'-0"
27'-6"
43'-9½"
5'-0"
15'-0"
Unit #1 Sh 83 (FSD-2-65)
Unit #2 Sh 85 (FSD-2-65)
Unit #3 Sh 87 (FSD-2-67)
Unit #4 Sh 87 (FSD-2-67)
Unit #5 Sh 87 (FSD-2-67)
Unit #6 Sh 89 (FSD-2-69)
Unit #7 Sh 89 (FSD-2-69)
Unit #8 Sh 89 (FSD-2-69)
Unit #9 Sh 105 (FSD-2-85)
Unit #10 Sh 105 (FSD-2-85)
PLAN
Scale 3/32":1'-0"
El. 550.0
Weir El. 540.0
El. 539.52
Powerhouse
El. 500.0
Pump Intake
Draft Tube
SECTION A-A
Scale 1/8":1'-0"
Gate Machinery Platform
El. 550.0
El. 540.0
El. 535.52
El. 531.0
Aeration Chamber
Transportation Channel
Fish Entrance
El. 519
Supply Channel
SECTION B-B
Scale 1/8":1'-0"
El. 648.0
Valve Room
El. 588.0
Aeration Chamber
U/S Dissipator
El. 570.0
El. 565.0
El. 559.0
Loading Pool
El. 550.0
El. 533.0
Aeration Chamber
Transportation Channel
SECTION ALONG ℄
Scale 1/8":1'-0"
Note:
General notes, Sh 41, FSD-2-21
(58) Concrete, dam
(62) Concrete, stilling basin
(63) Concrete, fish facilities
Training Wall
Spillway
Fishladder
Pavement
Gravel Fill
El. 550.0
Left Stilling Basin Wall Sh 42 (FSD-2-22)
SECTION C-C
Scale: 3/32":1'-0"
3 Aug 64 Revised concrete outline
U. S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS
OFFICE OF THE DISTRICT ENGINEER, PORTLAND, OREGON
WILLAMETTE RIVER BASIN, OREGON
SOUTH SANTIAM RIVER
FOSTER RESERVOIR
CONCRETE DAM FISH FACILITIES
FISHLADDER
PLAN & SECTIONS
12 Mar 1964
SCALE AS SHOWN
SHEET 76
FSD-2-56

CHART 6







NOTE:

MEAN MONTHLY DISCHARGES WERE ESTIMATED FROM OBSERVED RECORD ON THE SOUTH SANTIAM RIVER.

REV. MAY 1968

FS-20-22/4

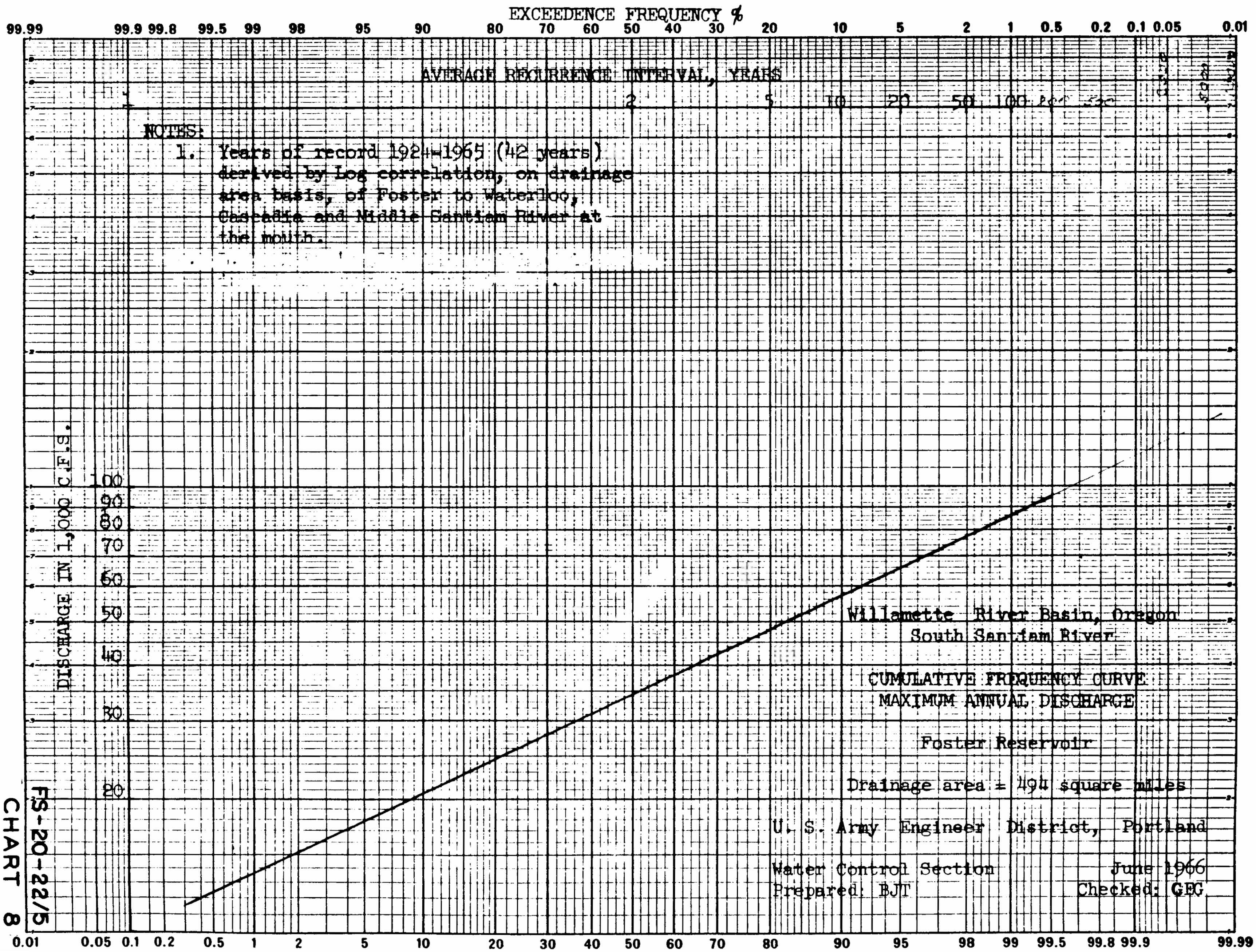
WILLAMETTE RIVER BASIN, OREGON
SOUTH SANTIAM RIVER
AT FOSTER DAMSITE

RUNOFF SUMMARY

DRAINAGE AREA 494 SQUARE MILES

U.S. ARMY ENGINEER DISTRICT, PORTLAND
WATER CONTROL SECTION JUNE 1966
PREPARED: R.L.W. CHECKED: B.H.B.

CHART



FS-20-22/5
CHART 8

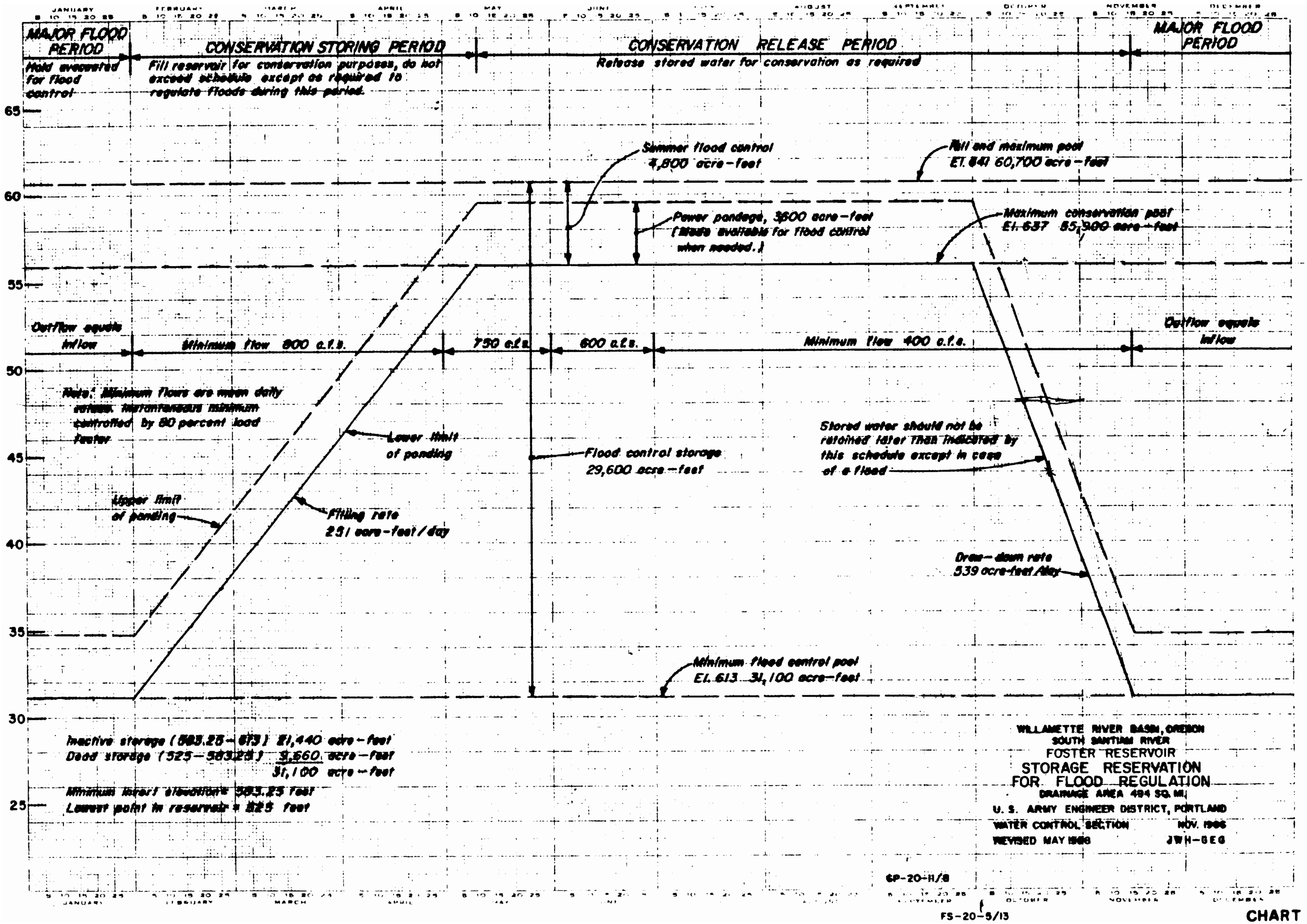
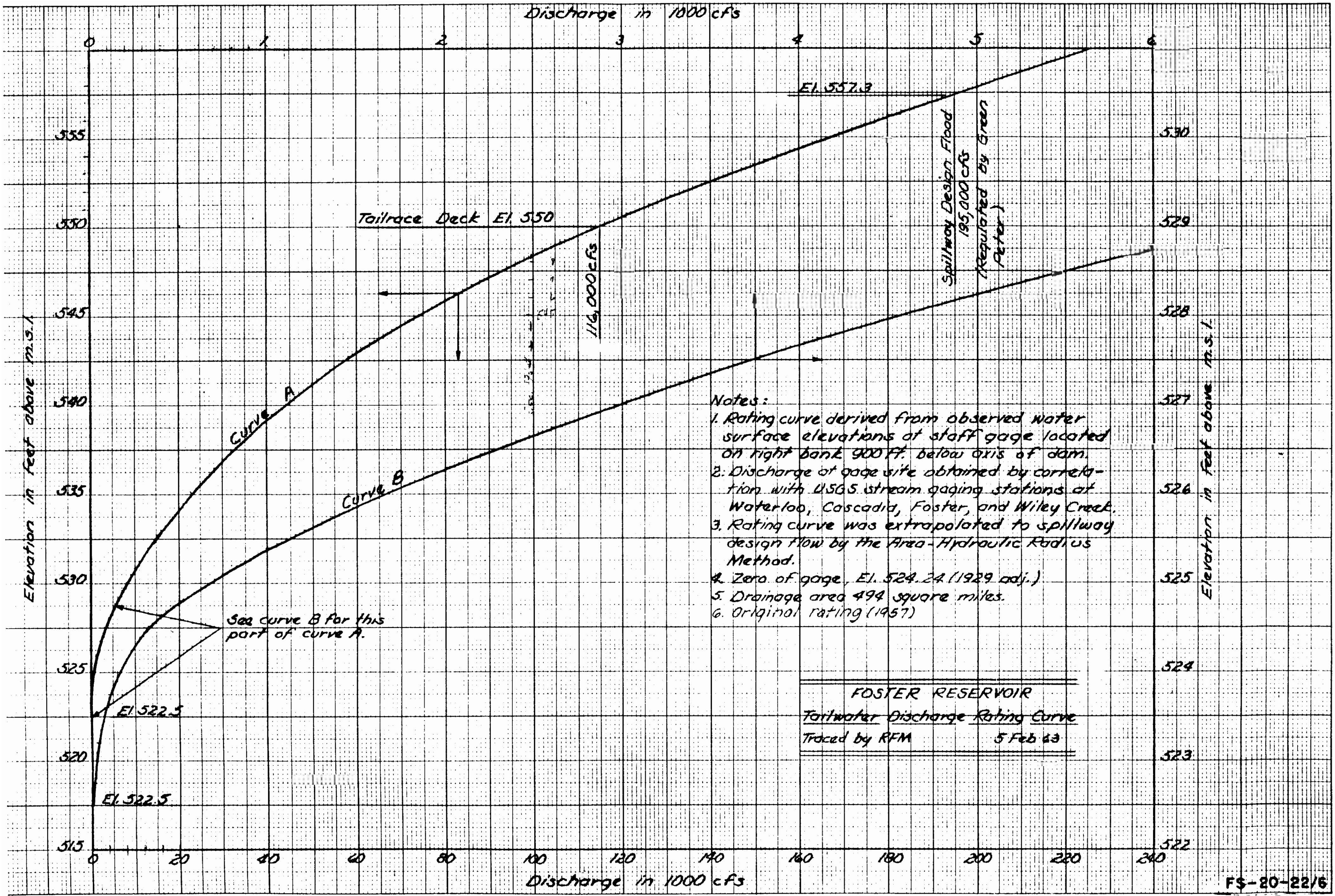
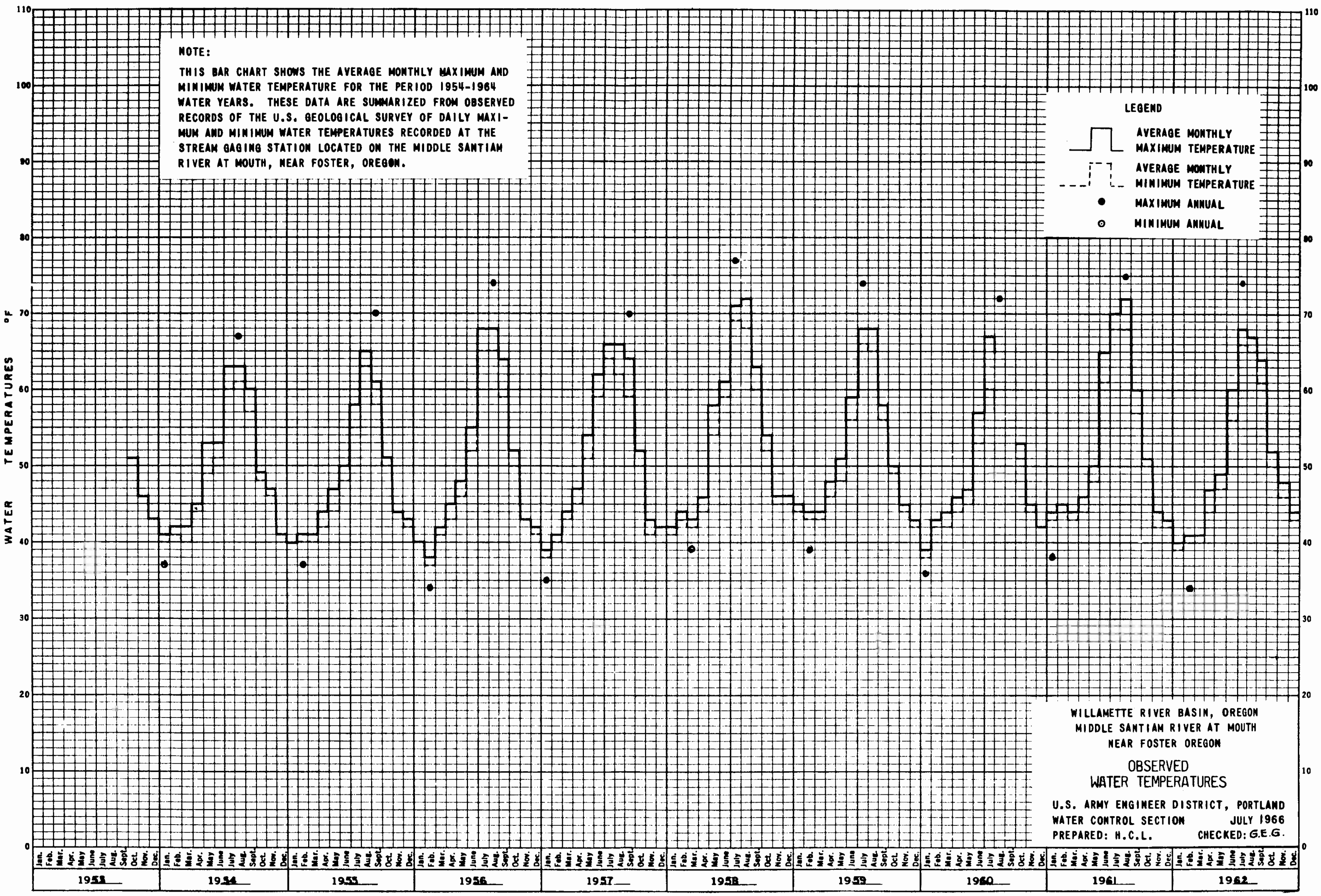

MAJOR FLOOD PERIOD
Hold evacuated for flood control
CONSERVATION STORING PERIOD
Fill reservoir for conservation purposes, do not exceed schedule except as required to regulate floods during this period.
CONSERVATION RELEASE PERIOD
Release stored water for conservation as required
MAJOR FLOOD PERIOD
Summer flood control 4,800 acre-feet
Full and maximum pool El. 641 60,700 acre-feet
Power pondage, 3,600 acre-feet (Made available for flood control when needed.)
Maximum conservation pool El. 637 55,900 acre-feet
Outflow equals inflow
Minimum flow 800 c.f.s.
750 c.f.s.
600 c.f.s.
Minimum flow 400 c.f.s.
Outflow equals inflow
Lower limit of ponding
Flood control storage 29,600 acre-feet
Stored water should not be retained later than indicated by this schedule except in case of a flood
Upper limit of ponding
Filling rate 231 acre-feet/day
Draw-down rate 539 acre-feet/day
Minimum flood control pool El. 613 31,100 acre-feet
Inactive storage (583.25-613) 21,440 acre-feet
Dead storage (525-583.25) 9,660 acre-feet
31,100 acre-feet
Minimum invert elevation= 583.25 feet
Lowest point in reservoir = 525 feet
WILLAMETTE RIVER BASIN, OREGON
SOUTH SANTIAM RIVER
FOSTER RESERVOIR
STORAGE RESERVATION FOR FLOOD REGULATION
DRAINAGE AREA 494 SQ. MI.
U. S. ARMY ENGINEER DISTRICT, PORTLAND
WATER CONTROL SECTION NOV. 1966
REVISED MAY 1968 JWH-BEG
GP-20-11/8
FS-20-5/13
JANUARY FEBRUARY MARCH APRIL MAY JUNE JULY AUGUST SEPTEMBER OCTOBER NOVEMBER DECEMBER
65
60
55
50
45
40
35
30
25

CHART 9

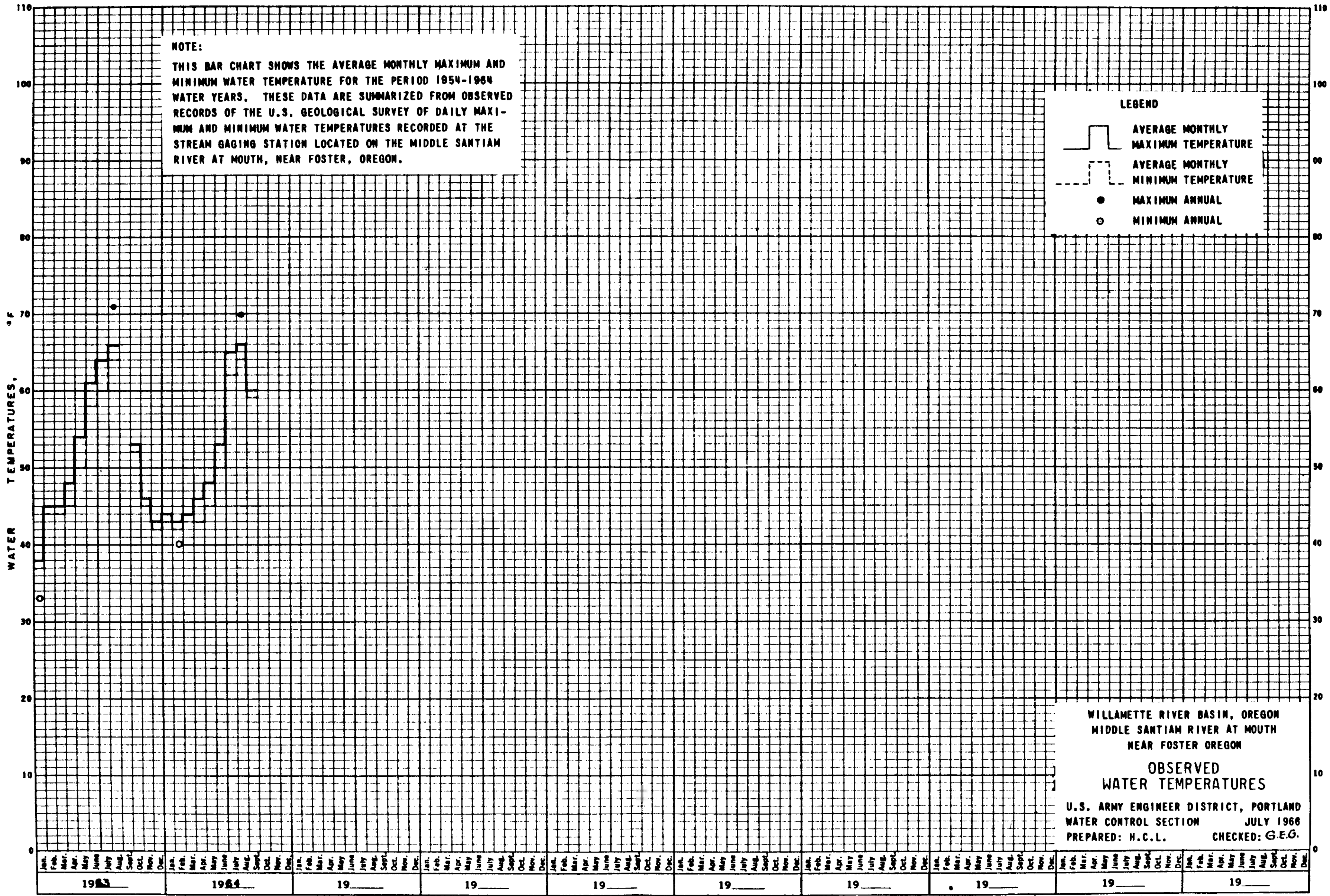


FS-20-22/6

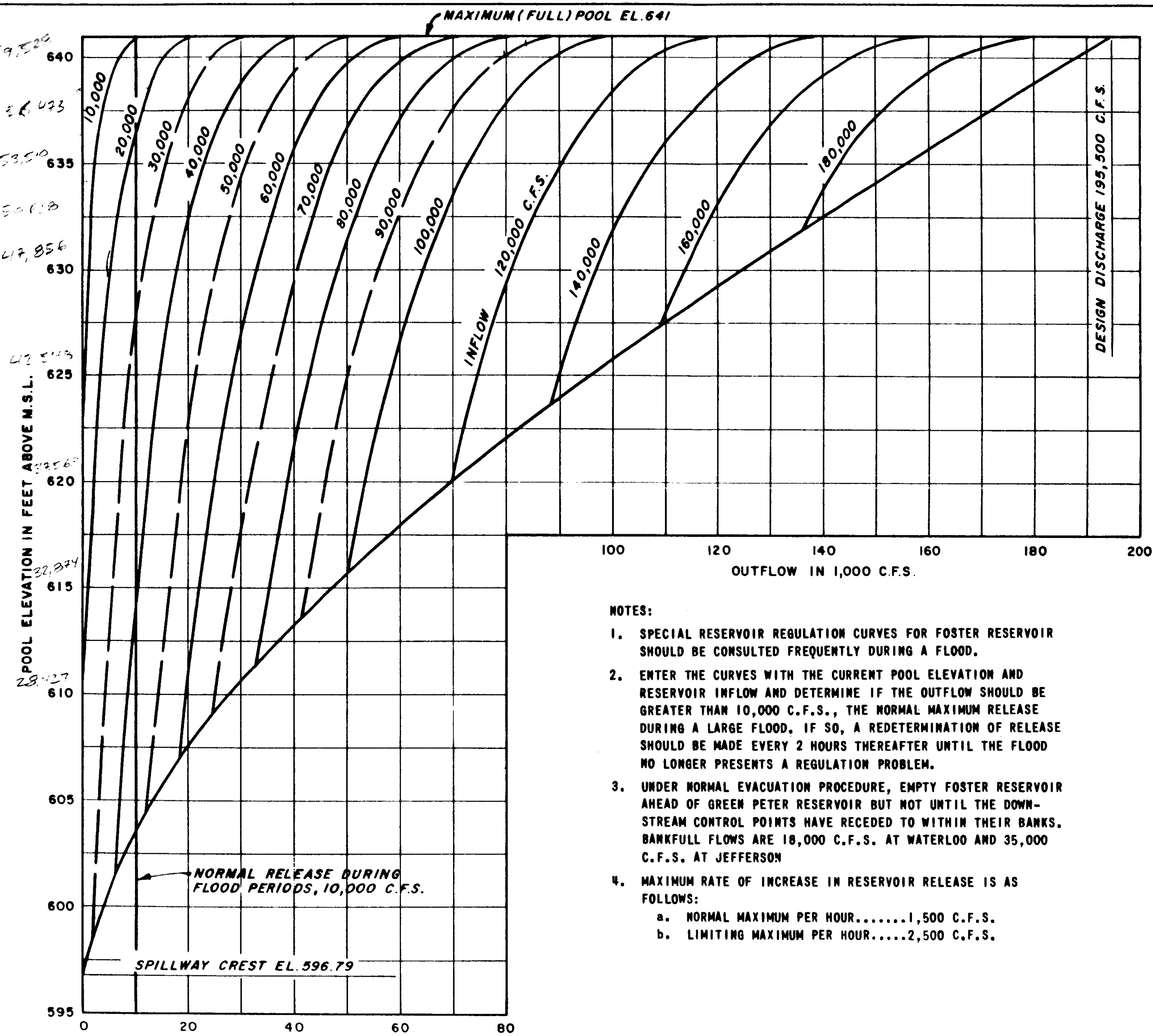
CHART 10



GP-20-24/16 CHART 11



GP-20-24/17 CHART 12



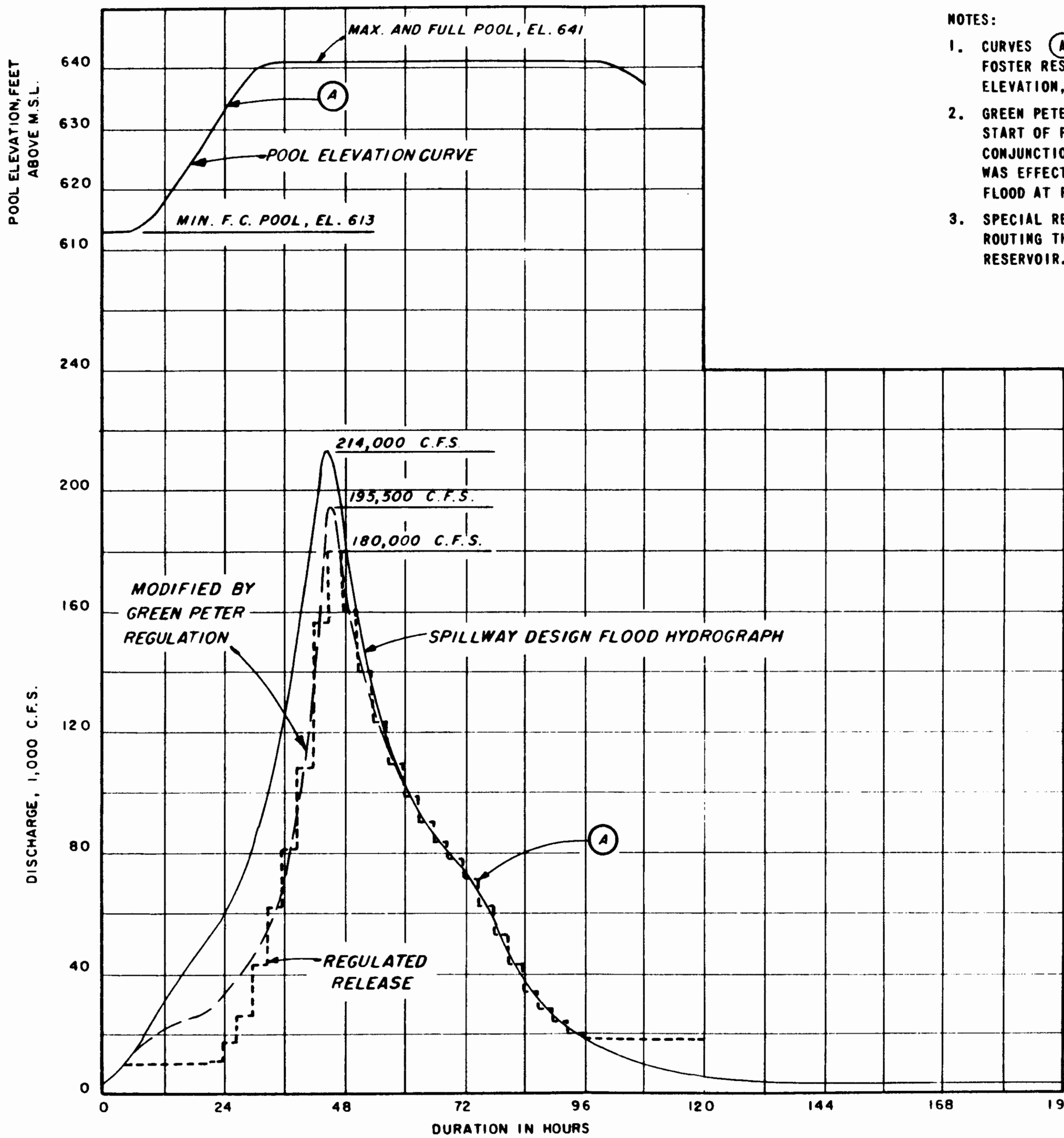
NOTES:

1. SPECIAL RESERVOIR REGULATION CURVES FOR FOSTER RESERVOIR SHOULD BE CONSULTED FREQUENTLY DURING A FLOOD.
2. ENTER THE CURVES WITH THE CURRENT POOL ELEVATION AND RESERVOIR INFLOW AND DETERMINE IF THE OUTFLOW SHOULD BE GREATER THAN 10,000 C.F.S., THE NORMAL MAXIMUM RELEASE DURING A LARGE FLOOD. IF SO, A REDETERMINATION OF RELEASE SHOULD BE MADE EVERY 2 HOURS THEREAFTER UNTIL THE FLOOD NO LONGER PRESENTS A REGULATION PROBLEM.
3. UNDER NORMAL EVACUATION PROCEDURE, EMPTY FOSTER RESERVOIR AHEAD OF GREEN PETER RESERVOIR BUT NOT UNTIL THE DOWN-STREAM CONTROL POINTS HAVE RECEDED TO WITHIN THEIR BANKS. BANKFULL FLOWS ARE 18,000 C.F.S. AT WATERLOO AND 35,000 C.F.S. AT JEFFERSON
4. MAXIMUM RATE OF INCREASE IN RESERVOIR RELEASE IS AS FOLLOWS:
   a. NORMAL MAXIMUM PER HOUR.......1,500 C.F.S.
   b. LIMITING MAXIMUM PER HOUR.....2,500 C.F.S.

WILLAMETTE RIVER BASIN, OREGON
SOUTH SANTIAM RIVER
FOSTER RESERVOIR

SPECIAL RESERVOIR REGULATION CURVES

U.S. ARMY ENGINEER DISTRICT, PORTLAND
WATER CONTROL SECTION AUGUST 1966
REV. MAY 1968 PREPARED: PBB CHECKED: GEG



NOTES:

1. CURVES (A) - SPILLWAY DESIGN FLOOD ROUTING WITH FOSTER RESERVOIR AT MINIMUM FLOOD CONTROL POOL ELEVATION, 613, AT BEGINNING OF FLOOD.
2. GREEN PETER RESERVOIR WAS AT SPILLWAY CREST AT START OF FLOOD. STORAGE ABOVE SPILLWAY IN CONJUNCTION WITH SPECIAL FLOOD REGULATION CURVES WAS EFFECTIVE IN REDUCING THE SPILLWAY DESIGN FLOOD AT FOSTER FROM 214,000 C.F.S. TO 195,500 C.F.S.
3. SPECIAL RESERVOIR REGULATION CURVES WERE USED IN ROUTING THE SPILLWAY DESIGN FLOOD THROUGH THE RESERVOIR.

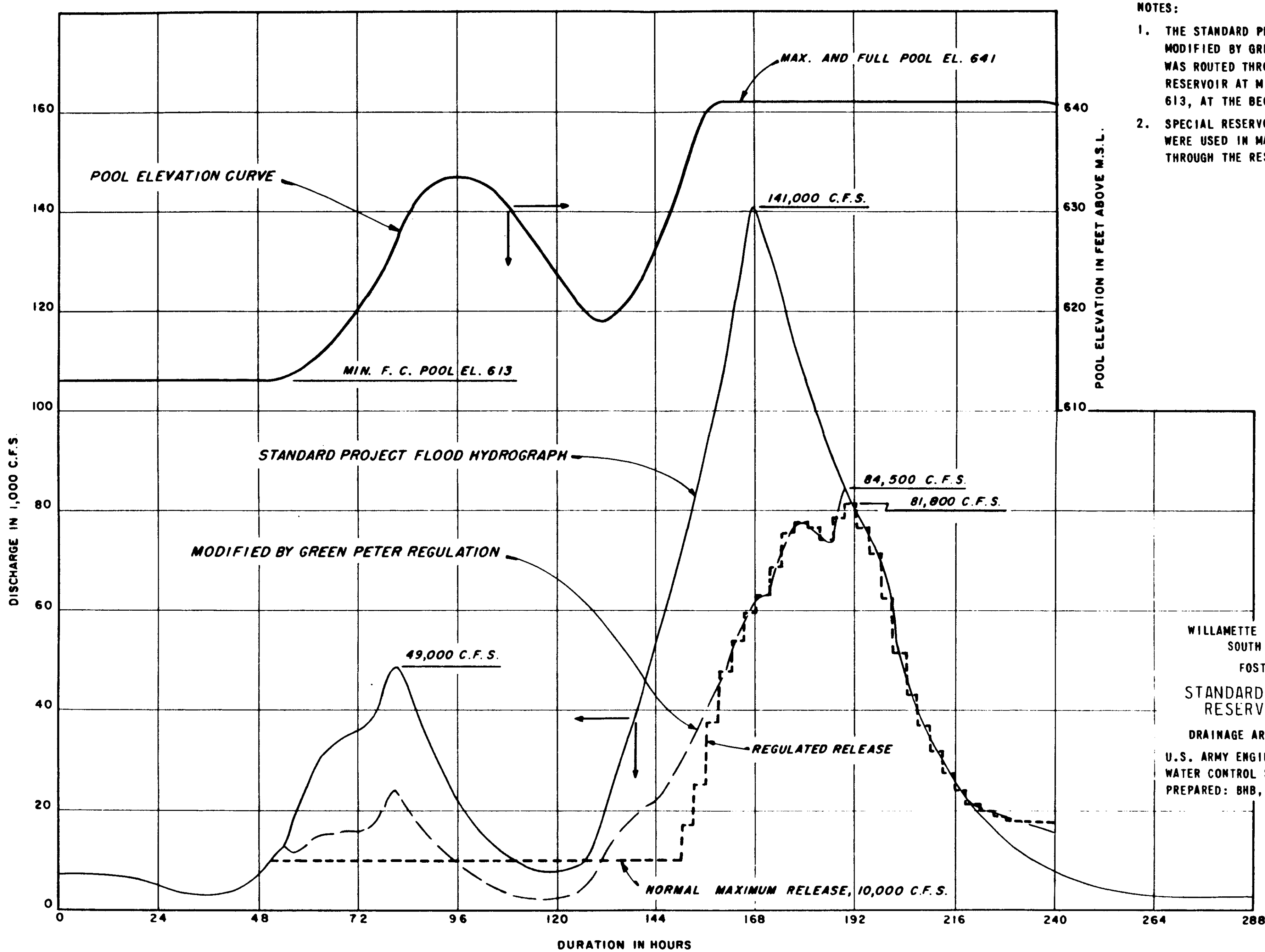
WILLAMETTE RIVER BASIN, OREGON
SOUTH SANTIAM RIVER
FOSTER RESERVOIR

SPILLWAY DESIGN FLOOD
RESERVOIR ROUTING

DRAINAGE AREA 494 SQUARE MILES

U.S. ARMY ENGINEER DISTRICT, PORTLAND
WATER CONTROL SECTION AUGUST 1966
PREPARED: G.E.G. CHECKED: G.E.G.

REV. MAY 1968



NOTES:

1. THE STANDARD PROJECT FLOOD AS MODIFIED BY GREEN PETER REGULATION WAS ROUTED THROUGH FOSTER ASSUMING RESERVOIR AT MINIMUM POOL ELEVATION 613, AT THE BEGINNING OF THE FLOOD.
2. SPECIAL RESERVOIR REGULATION CURVES WERE USED IN MAKING THE ROUTING THROUGH THE RESERVOIR.

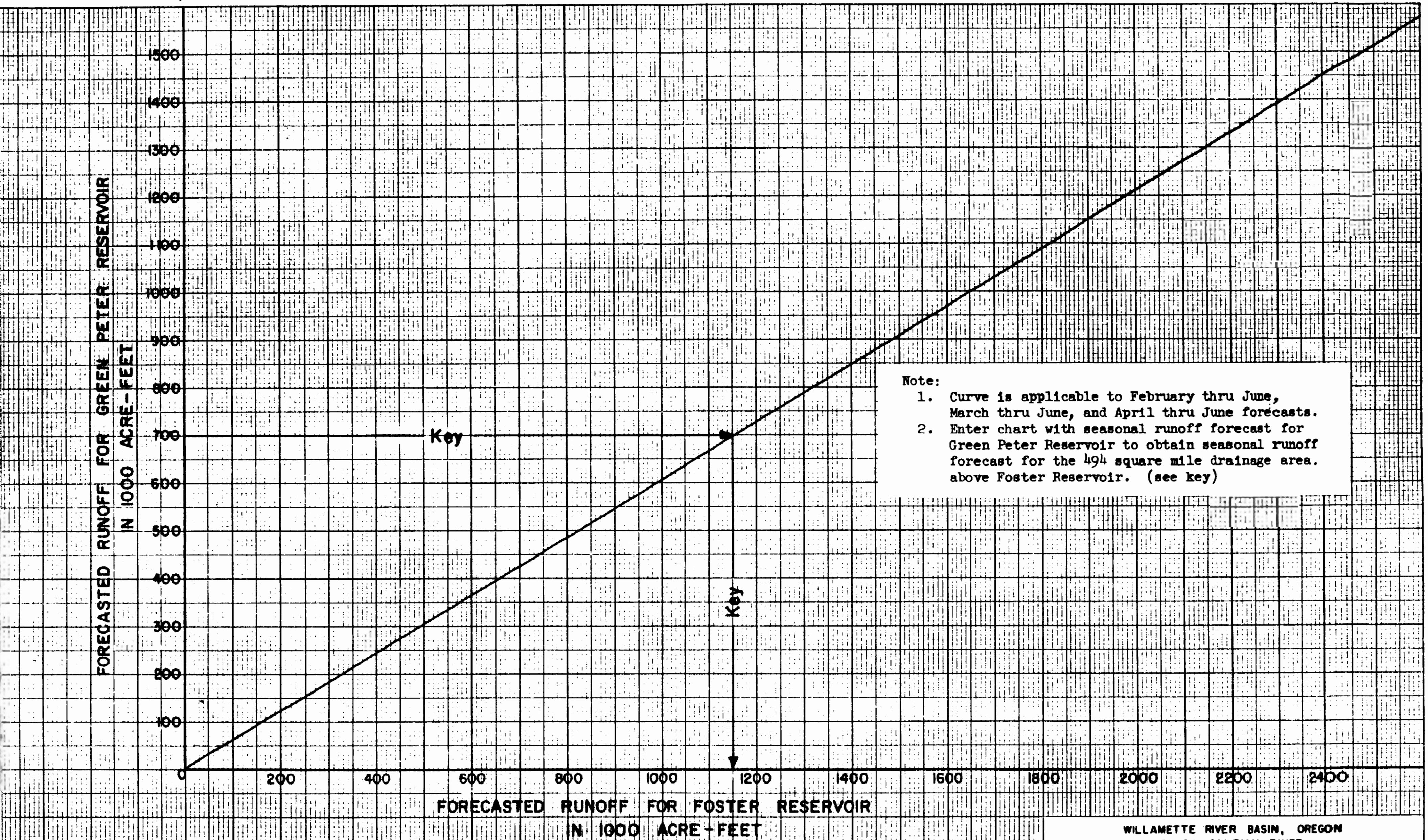
WILLAMETTE RIVER BASIN, OREGON
SOUTH SANTIAM RIVER
FOSTER RESERVOIR

STANDARD PROJECT FLOOD
RESERVOIR ROUTING

DRAINAGE AREA 494 SQUARE MILES

U.S. ARMY ENGINEER DISTRICT, PORTLAND
WATER CONTROL SECTION AUGUST 1966
PREPARED: BHB, BJT CHECKED: G.E.G.

REV. MAY 1968



Note:
1. Curve is applicable to February thru June, March thru June, and April thru June forecasts.
2. Enter chart with seasonal runoff forecast for Green Peter Reservoir to obtain seasonal runoff forecast for the 494 square mile drainage area. above Foster Reservoir. (see key)

Note: Curve is based on runoff records for the period 1926 through 1965 taken from U.S.G.S. Water Supply Papers.

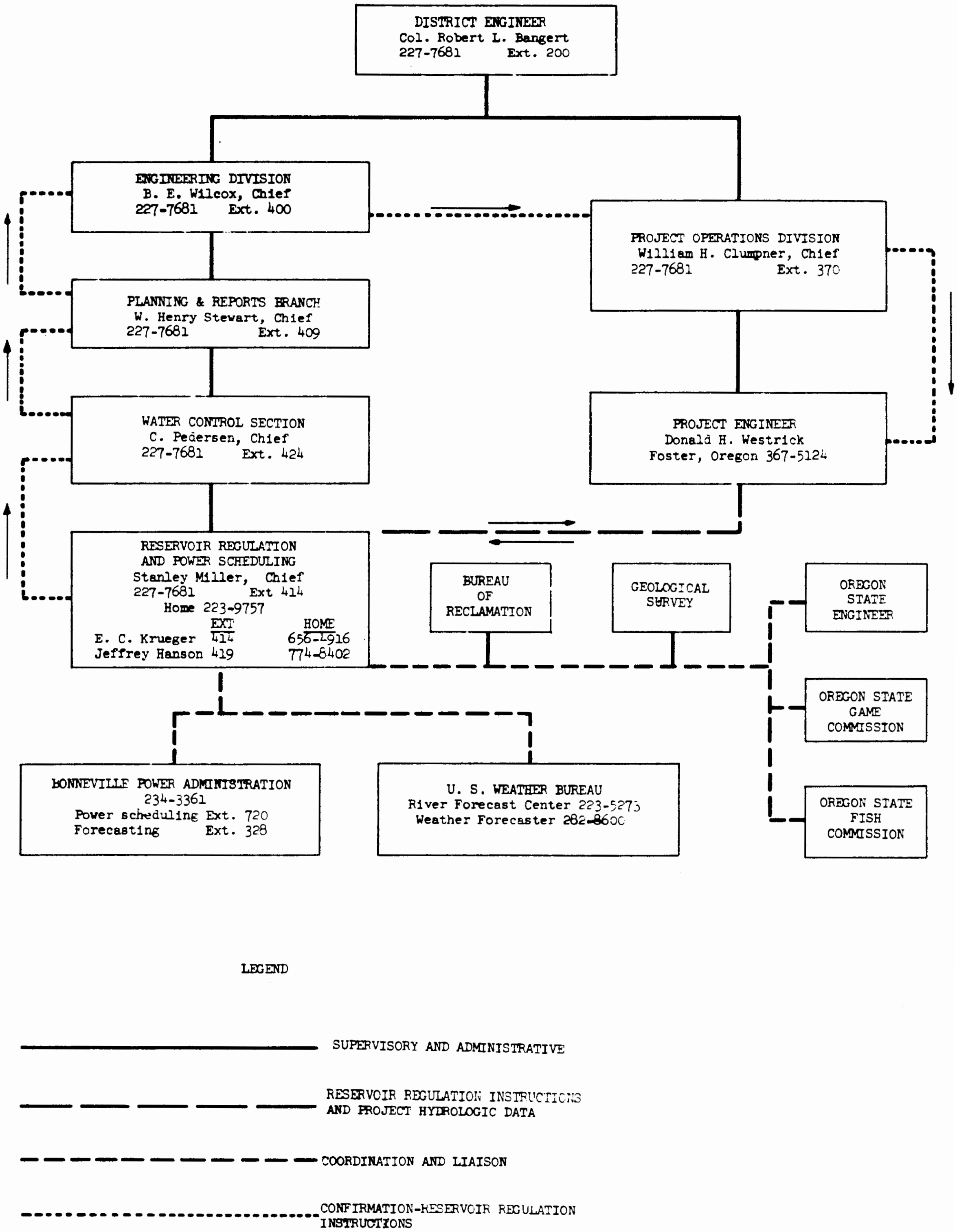
WILLAMETTE RIVER BASIN, OREGON
SOUTH SANTIAM RIVER
FOSTER RESERVOIR

SEASONAL RUNOFF FORECAST

DRAINAGE AREA, 494 SQUARE MILES
U. S. ARMY ENGINEER DISTRICT, PORTLAND
WATER CONTROL SECTION REV. MAY 1968
PREPARED: J. D. H. CHECKED: S. M.

GREEN PETER - FOSTER
PROJECT

Functional Organization Chart



Water Control Section Jan 1968
Prepared: S. M. Checked: CP

NPPEN-PP-6 No. ______________

District Instructions to Project

SUBJECT: Reservoir Regulation and Power Operation

Memo to the File

1. Oral instructions from ____

to ______________________; Foster Operator at ______________________PST

______________________, regarding operation of the reservoir(s)

indicated below:

( ) Green Peter ( ) Foster

2. The following instructions were issued: Generation schedule for

CHART 19

(Letter of transmittal unnecessary)

To: Reservoir Regulation Subsection
Project Operations Division

FOSTER PROJECT DAILY HYDROMETEOROLOGICAL & POWER DATA

RCS NPPEN-PR-42(R2)

Called in by: ______________ Received by: ______________ Time: __________ Date: ______________

TIME	FOSTER							STREAM & PRECIPITATION DATA								TIME
	GENERATION M.W.			DISCHARGE		ELEVATION		SOUTH SANTIAM NEAR CASCADIA		GREEN PETER OUTFLOW	SOUTH SANTIAM BELOW FOSTER		WATERLOO		POWER-HOUSE	
	UNIT 1	UNIT 2	TOTAL	TURBINES C.F.S.	GATES C.F.S.	POOL FT.	T.W. FT.	GAGE FT.	DISCHARGE C.F.S.	DISCHARGE C.F.S.	GAGE FT.	DISCHARGE C.F.S.	GAGE FT.	DISCHARGE C.F.S.	Precip. Inches	
01																01
02																02
03																03
04																04
05																05
06																06
07																07
08																08
09																09
10																10
11																11
12																12
13																13
14																14
15																15
16																16
17																17
18																18
19																19
20																20
21																21
22																22
23																23
24																24
Totals																Totals
Means																Means
Sta. Sw.																

OBSERVED STREAM DATA

STATION	Time	Tape	Chart	Staff	P. H.	Peak & Time
S. Santiam Nr. Cascadia						
S. Santiam below Foster						
Waterloo						

HYDROMETEOROLOGICAL DATA

TEMPERATURE			CURRENT WEATHER	CURR. WIND	HUM LOW	PRECIPITATION	
MAX.	MIN.	CURR.				STA.	P. H.

EVAP.		DIFF.		NET HEAD
ANEM.		DIFF.		

FOSTER GATE SETTINGS

Time	Gate	Feet	Time	Gate	Feet	Time	Gate	Feet

S - SPILLWAY

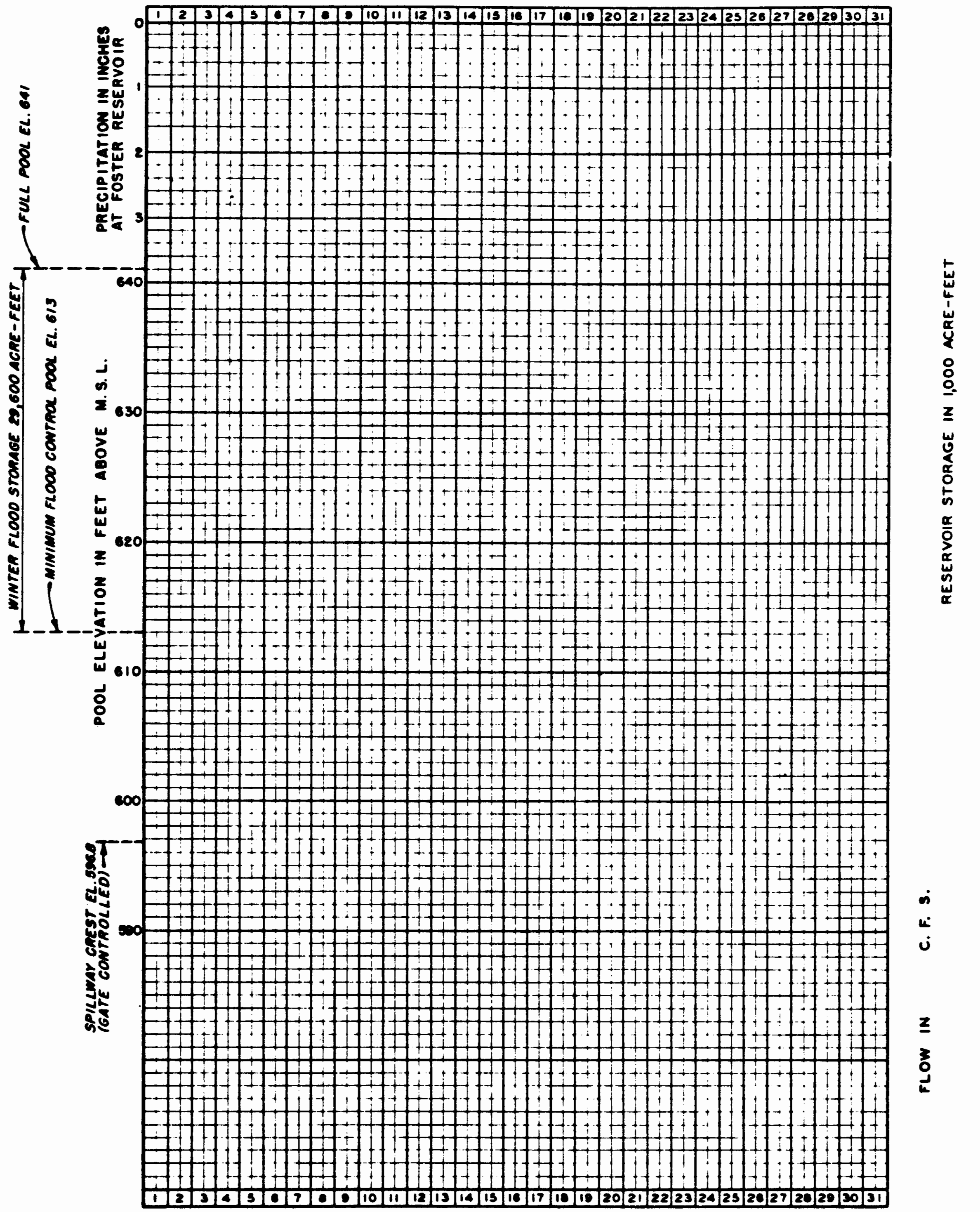
MID. TO MID. DATA

POOL FT.	STORAGE AC. FT.	INFLOW C. F. S.	WIND
1/2 Diff.			

DATE: ______________

CHART 20

Reports Control Symbol ENGCW-E-6



MONTH OF 19

Note:
% of outflow for the month was utilized for generation.

	EL. IN FEET ABOVE M. S. L.	GROSS STORAGE AC. FT.
MINIMUM FLOOD CONTROL POOL	613	31,100
MAXIMUM CONSERVATION POOL	637	55,900

MAXIMUM PLANNED RELEASE 18,000 C.F.S AT WATERLOO (D.A. 640 SQ. MI.)

MONTHLY RESERVOIR REGULATION

FOSTER RESERVOIR

WILLAMETTE RIVER BASIN

DRAINAGE AREA ABOVE FOSTER DAM 494 SQ. MI.

U.S. ARMY ENGINEER DISTRICT, PORTLAND

Total Evaporation Total Wind

CHART 21

TO: Multiple Purpose Projects Branch, Operations Division	POWER PRODUCTION REPORT	
	Month & Year	Reports Control Symbol NPPVK - 57
District: PORTLAND, OREGON	Project & Location:	

GENERATION				DISPOSITION		
GENERATOR NUMBER	MWH	GENERATOR NUMBER	MWH	LOCATION	LOCAL USE MWH	TO BPA MWH
1		12		STATION		
2		13		PROJECT		
3		14		NAVIGATION LOCK		
4		15		SPILLWAY		
5		16		FISHWAY		
6				BUILDINGS AND GROUNDS		
7				TO OTHERS		
8				UNACCOUNTED AND LOSSES		
9						
10						
11						
TOTAL GENERATION				TOTALS		

CONDENSER POWER		OTHER DATA			
UNIT	MWH	SUBJECT	MWH	TIME	DATE
1		5 Minute Peak		M.	
2		Clock Hour Peak		M.	
3		PLANT FACTOR: TOTAL GENERATION / (N.P. Rating X Total Hours in the Month) %			

TOTAL IN-SERVICE HOURS (All Units Except House Units)

NET GENERATION REPORTED ON FPC FORM 4 -

Remarks:

Distribution:	Project Engineer:

CHART 22

FEDERAL POWER COMMISSION
MONTHLY POWER PLANT REPORT

INSTALLED CAPACITY - The kilowatt capacity of each plant listed should represent total name-plate rating of generators exclusive of auxiliary or house units. Revise to include any additions, retirements, or re-ratings. State below or on reverse side, the kilowatt amount, nature and approximate date of each change. New plants should be added. If plant has been sold give name and address of purchaser.

GENERATION - Report net generation (gross less use by power plant for auxiliary equipment) by water power and by Each Kind of Fuel — anthracite, bituminous or lignite coal, coke, fuel oil, natural gas or other (Specify). Please give estimates if exact figures are not available.

FUEL CONSUMED - Report actual or estimated amount of fuel used in generating electric energy including fuel for maintenance of standby service. Report to nearest whole unit - short ton, 42 gal. bbl., or Mcf.

FUEL STOCKS - Enter coal and fuel oil held for electric energy generation including regular stocks at plant and in cars or barges at plant site. Amounts held in central storage yards should be included with appropriate note. Report to nearest whole unit.

UNITED STATES ARMY ENGINEERS
BONNEVILLE, OREGON
241
36-640

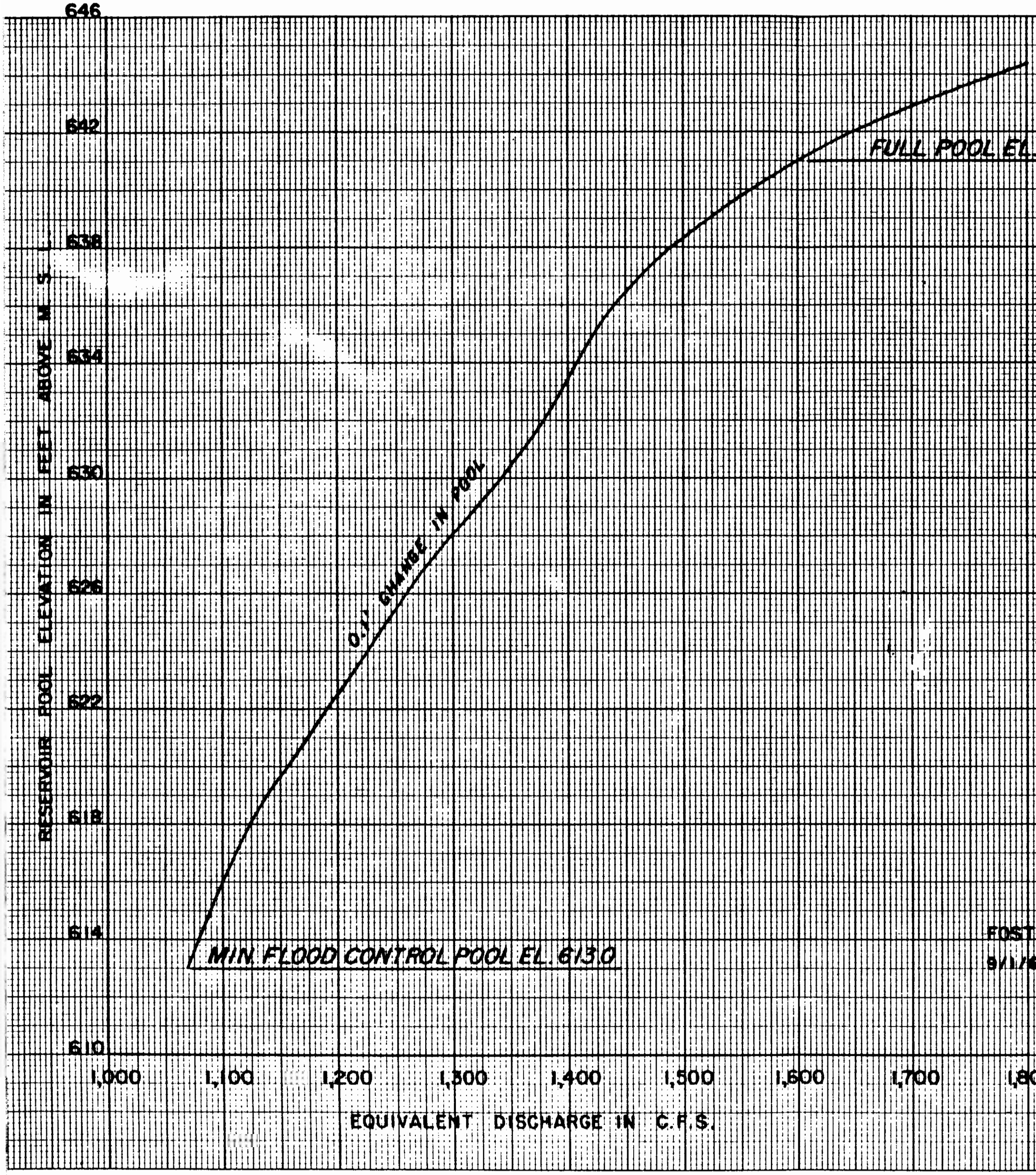
REPORT FOR
OCTOBER 1960

→ PLEASE RETURN ONE COPY BEFORE THE 10TH OF THE MONTH

PLANT NAME AND CODE NUMBERS	PRIME MOVER TYPE AND KIND OF FUEL	INSTALLED CAPACITY (Name-Plate Rating) KILOWATTS	NET GENERATION KILOWATT-HOURS	FUEL FOR GENERATION INCLUDING STANDBY SERVICE Nearest Short Ton; 42 Gal. Bbl.; Mcf.	
				Consumed During Month	Stocks End of Month
BONNEVILLE 92 36 7 1 640*001	WATER PWR	518,400	297,073,961		

→ PLEASE REPORT CAPACITY CHANGES - SEE INSTRUCTIONS

CHART 23



NOTES:

1) Reservoir inflow = outflow ± pool change.

2) To convert pool change to discharge, enter curve with current pool elevation and read discharge on horizontal scale for 0.1 pool change per hour. Multiply this discharge by hourly pool change in tenths to obtain the equivalent flow in c.f.s. in the last hour.

3) To compensate for small errors in reading the pool change it is advisable to average the hourly pool change over a 2 hour period.

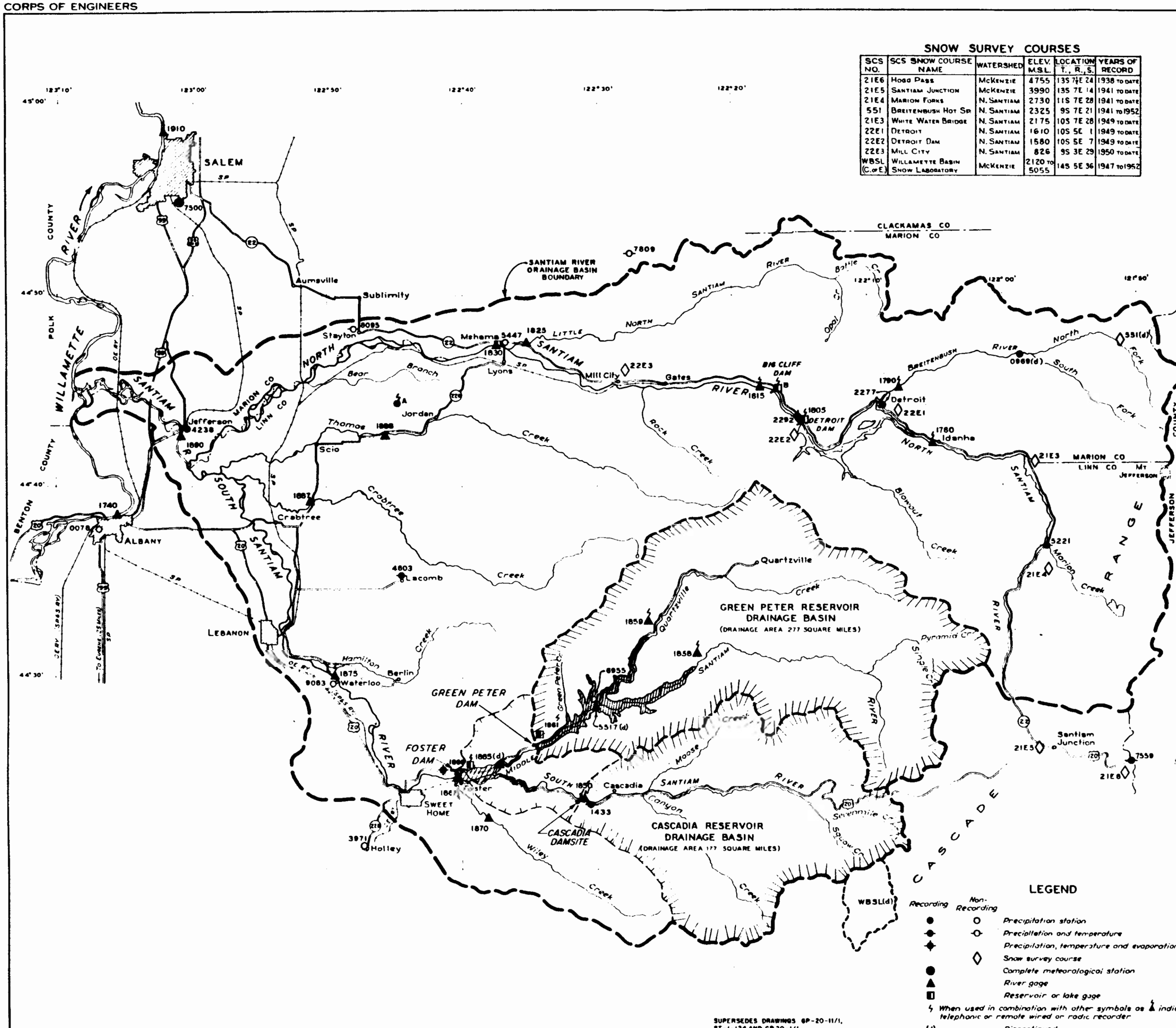
FS-20-22/12

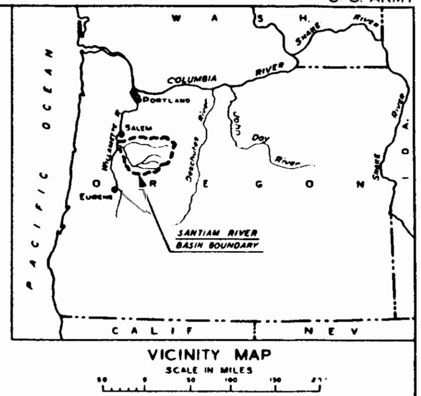
WILLAMETTE RIVER BASIN, OREGON
SOUTH SANTIAM RIVER
FOSTER RESERVOIR

COMPUTATION OF RESERVOIR INFLOW

DRAINAGE AREA 494 SQUARE MILES

U.S. ARMY ENGINEER DISTRICT, PORTLAND
WATER CONTROL SECTION SEP. 1966
PREPARED: E.C.K. CHECKED: J.D.H.





SNOW SURVEY COURSES

SCS NO.	SCS SNOW COURSE NAME	WATERSHED	ELEV. M.S.L.	LOCATION T., R., S.	YEARS OF RECORD
21E6	Hogg Pass	McKenzie	4755	13S 7½E 24	1938 to date
21E5	Santiam Junction	McKenzie	3990	13S 7E 14	1941 to date
21E4	Marion Forks	N. Santiam	2730	11S 7E 28	1941 to date
551	Breitenbush Hot Sp.	N. Santiam	2325	9S 7E 21	1941 to 1952
21E3	White Water Bridge	N. Santiam	2175	10S 7E 28	1949 to date
22E1	Detroit	N. Santiam	1610	10S 5E 1	1949 to date
22E2	Detroit Dam	N. Santiam	1580	10S 5E 7	1949 to date
22E3	Mill City	N. Santiam	826	9S 3E 29	1950 to date
WBSL (C. of E.)	Willamette Basin Snow Laboratory	McKenzie	2120 to 5055	14S 5E 36	1947 to 1952

CLIMATOLOGICAL STATIONS

USWB NO.	USWB STATION NAME	WATERSHED	ELEV. M.S.L.	LOCATION LAT.	LOCATION LONG.	YEARS OF RECORD
6955	Quartzville	Mid. Santiam	823	44°25'	122°30'	1939 to 1962
1433	Cascadia	S. Santiam	796	44°23'	122°30'	1908 to date
9083	Waterloo	S. Santiam	420	44°30'	122°49'	1924 to date
4603	Lacomb 1W NW	N. Santiam	665	44°35'	122°45'	1950 to date
5221	Marion Forks	N. Santiam	2475	44°36'	121°57'	1950 to date
0969	Breitenbush	N. Santiam	2220	44°47'	121°59'	1950 to 1954
2277	Detroit	N. Santiam	1586	44°44'	122°09'	1915 to date
2292	Detroit Dam	N. Santiam	1300	44°43'	122°15'	1953 to date
5447	Mehama	N. Santiam	620	44°47'	122°37'	1923 to date
8095	Stayton	N. Santiam	465	44°48'	122°46'	1951 to date
A (C of E)	Jordan G.S.	Santiam	1000	44°44'	122°44'	1952 to date
4238	Jefferson	Santiam	248	44°43'	123°01'	1908 to date
7559	Santiam Pass	McKenzie	4800	44°26'	121°51'	1950 to 1955
WBSL	Willamette Snow Lab	McKenzie	2-5000	44°20'	122°10'	1947 to 1952
7809	Silver Cr. Falls	Pudding	1350	44°52'	122°39'	1938 to date
0078	Albany	Willamette	212	44°39'	123°06'	1883 to date
7500	Salem	Willamette	196	44°55'	123°01'	1892 to date
2709	Eugene	Willamette	359	44°07'	123°13'	1890 to date
3971	Holley	Calapooia	540	44°21'	122°47'	1940 to date

RIVER AND RESERVOIR GAGING STATIONS

USGS FIELD NO.	USGS GAGE DESCRIPTION	NAME OF RIVER OR TRIBUTARY	D.A. IN SQUARE MILES	ZERO OF GAGE	LOCATION T., R., S.	YEARS OF RECORD
1790	above Canyon Cr.	Breitenbush	106	1573.95	9S 5E 36	1932 to date
1780	below Boulder Cr.	N. Santiam	216	1590.07	10S 6E 17	1928 to date
1805	at Detroit Dam	N. Santiam	438	0.00	10S 5E 7	1953 to date
B (C of E)	at Big Cliff Dam	N. Santiam	452	0.00	9S 4E 34	1954 to date
1815	at Niagara	N. Santiam	453	1093.78	9S 4E 34	1909 to date
1830	at Mehama	N. Santiam	655	602.49	9S 2E 18	1922 to date
1825	near Mehama	Little N. Santiam	112	655.41	9S 2E 16	1932 to date
1850	below Cascadia	S. Santiam	174	759.88	13S 2E 36	1936 to date
1870	near Foster	Wiley Cr.	52	716.08	14S 1E 12	1949 to date
5517	near Foster	Mid. Santiam	271	733.44	13S 2E 2	1931 to 1946
1865	near Foster	Mid. Santiam	287	562.14	13S 1E 24	1952 to 1966
1875	at Waterloo	S. Santiam	640	370.39	12S 1W 28	1924 to date
1890	at Jefferson	Santiam	1790	199.63	10S 3W 11	1940 to date
1740	at Albany	Willamette	4840	167.18	11S 3W 6	1892 to date
1910	at Salem	Willamette	7280	114.14	7S 3W 22	1928 to date
1858	near Cascadia	Mid. Santiam	104	1040*	12S 4E 19	1963 to date
1859	near Cascadia	Quartzville Cr.	99	1050*	12S 3E 10	1963 to date
1867	at Foster	S. Santiam	495	521.46	13S 1E 27	1966 to date
1887	near Crabtree	Crabtree Cr.	111	280*	10S 1W 31	1963 to date
1888	near Scio	Thomas Cr.	109	380.84	10S 1W 11	1962 to date
1861	at Green Peter	Mid Santiam	277	0.00	13S 2E 10	1967 to date
1866	at Foster Dam	S. Santiam	494	0.00	13S 1E 27	1967 to date

Note

Station descriptions are for present or most recent locations. See U.S. Geological Survey Water Supply Papers, and U.S. Weather Bureau "Substation History" for previous locations, detailed periods of record, datums of gages, and other information.

** From topographic map*

WILLAMETTE RIVER BASIN, OREGON
SANTIAM RIVER

BASIN MAP AND HYDROLOGIC STATIONS

SCALE IN MILES

U. S. ARMY ENGINEER DISTRICT, PORTLAND

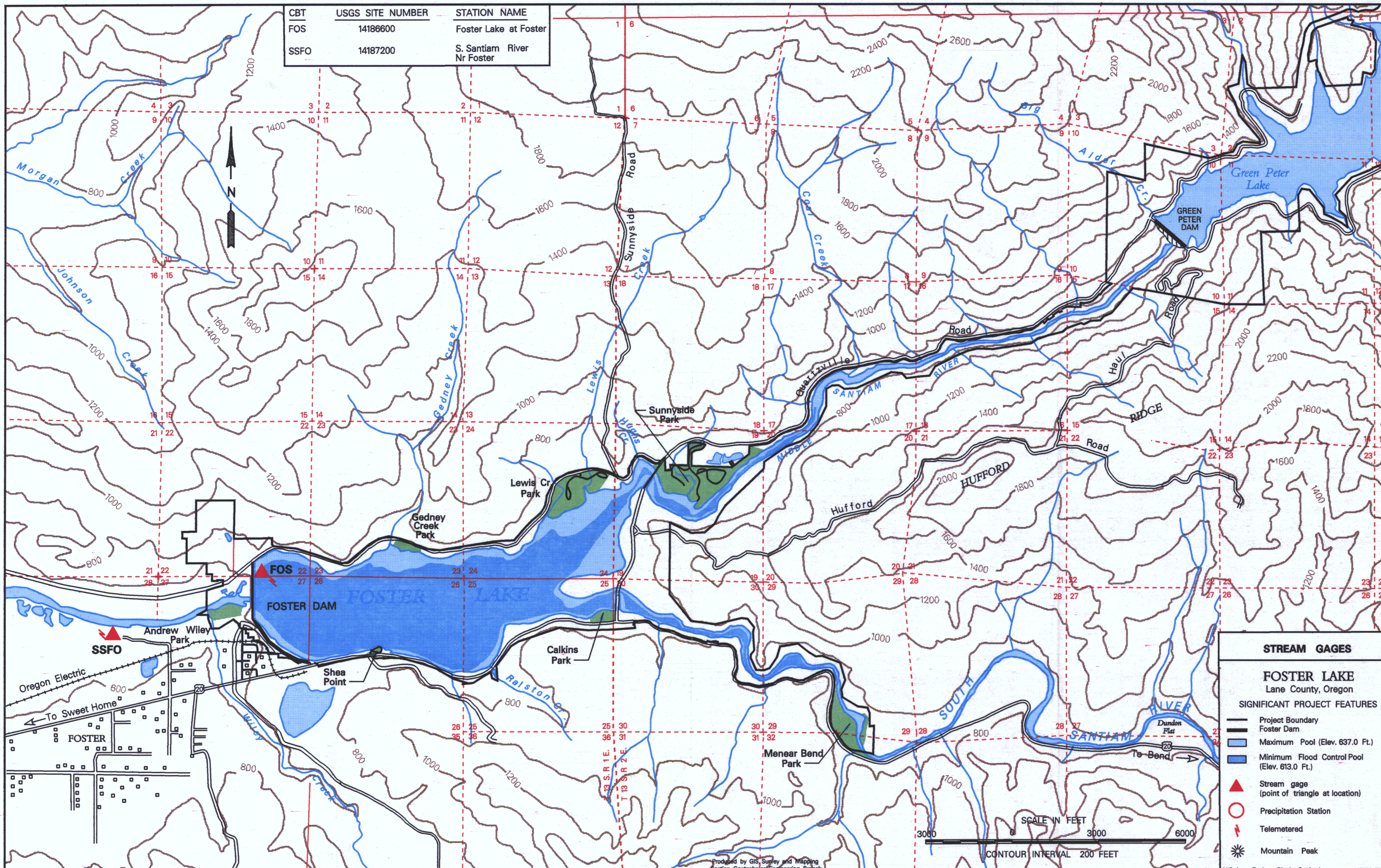
PREPARED: CHIEF, WATER CONTROL SECTION — RECOMMENDED: CHIEF, ENGINEERING DIVISION

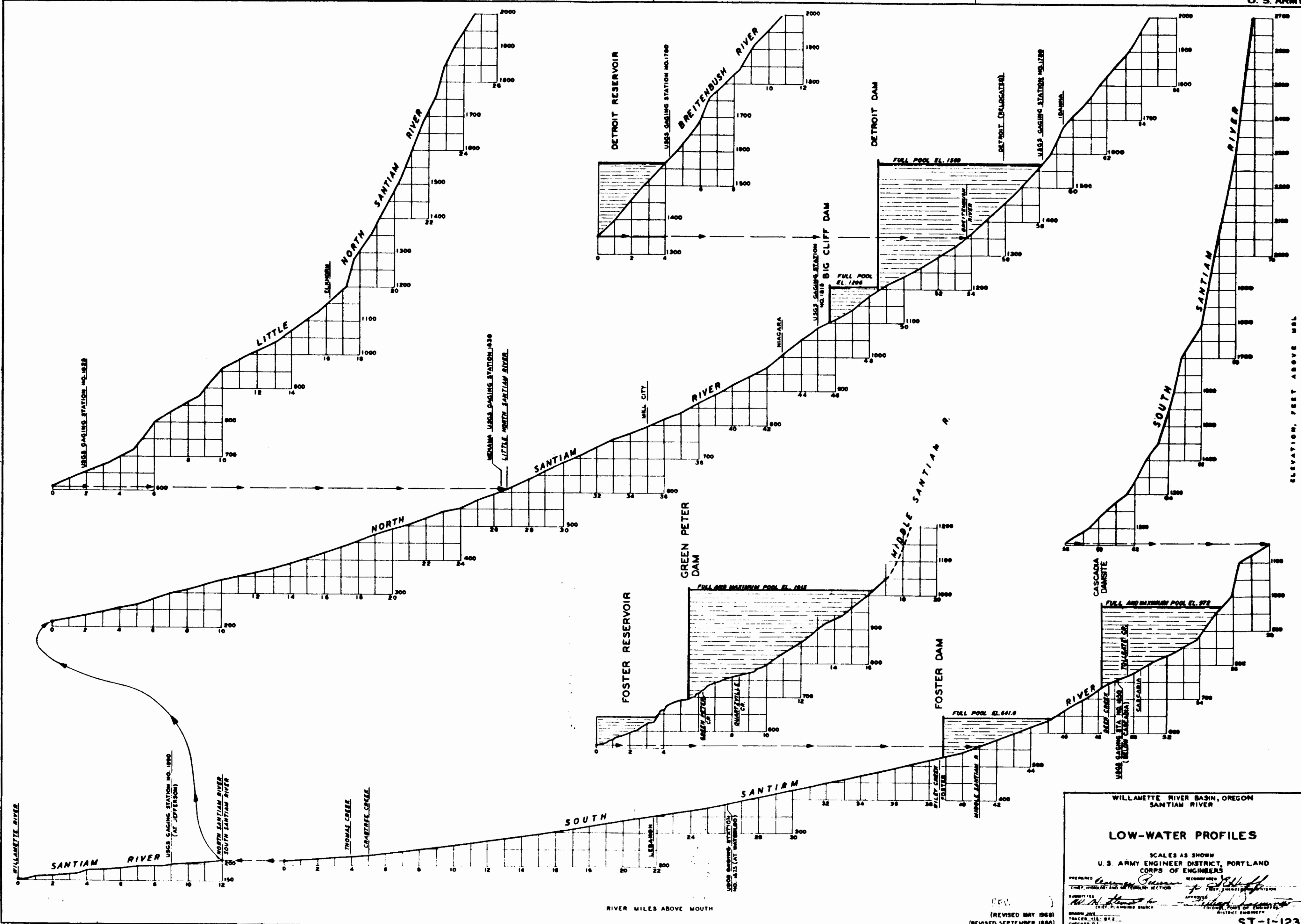
SUBMITTED: CHIEF, PLANNING BRANCH — APPROVED: COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

TRANSMITTED WITH REPORT DATED

GP-20-24/1

PLATE I


CBT
USGS SITE NUMBER
STATION NAME
FOS
14186600
Foster Lake at Foster
SSFO
14187200
S. Santiam River Nr Foster
STREAM GAGES
FOSTER LAKE
Lane County, Oregon
SIGNIFICANT PROJECT FEATURES
Project Boundary
Foster Dam
Maximum Pool (Elev. 637.0 Ft.)
Minimum Flood Control Pool (Elev. 613.0 Ft.)
Stream gage (point of triangle at location)
Precipitation Station
Telemetered
Mountain Peak
SCALE IN FEET
3000
0
3000
6000
CONTOUR INTERVAL 200 FEET
Produced by GIS, Survey and Mapping Section, Geotechnical Engineering Branch
U.S. Army Engineer District, Portland
CENPP-PE-HR
N
FOSTER LAKE
FOSTER DAM
FOS
SSFO
Green Peter Lake
GREEN PETER DAM
Andrew Wiley Park
Shea Point
Calkins Park
Gedney Creek Park
Lewis Cr. Park
Sunnyside Park
Menear Bend Park
FOSTER
To Sweet Home
Oregon Electric
To Bend
Dundon Flat
Morgan Creek
Johnson Creek
Gedney Creek
Lewis Creek
Sunnyside Road
Quartzville Road
Middle Santiam River
South Santiam River
Hufford Road
Hufford Ridge
Haul Road
Big Alder Cr.
Coal Creek
Ralston Cr.
Wiley Creek
T 13 S. R 1 E.
T 13 S. R 2 E.



(REVISED MAY 1969)
(REVISED SEPTEMBER 1966)

WILLAMETTE RIVER BASIN, OREGON
SANTIAM RIVER

LOW-WATER PROFILES

SCALES AS SHOWN
U. S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS

PREPARED — CHIEF, HYDROLOGY AND METEOROLOGY SECTION
RECOMMENDED — CHIEF, ENGINEERING DIVISION
SUBMITTED — CHIEF, PLANNING BRANCH
APPROVED — COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

ST-1-123

PLATE 2

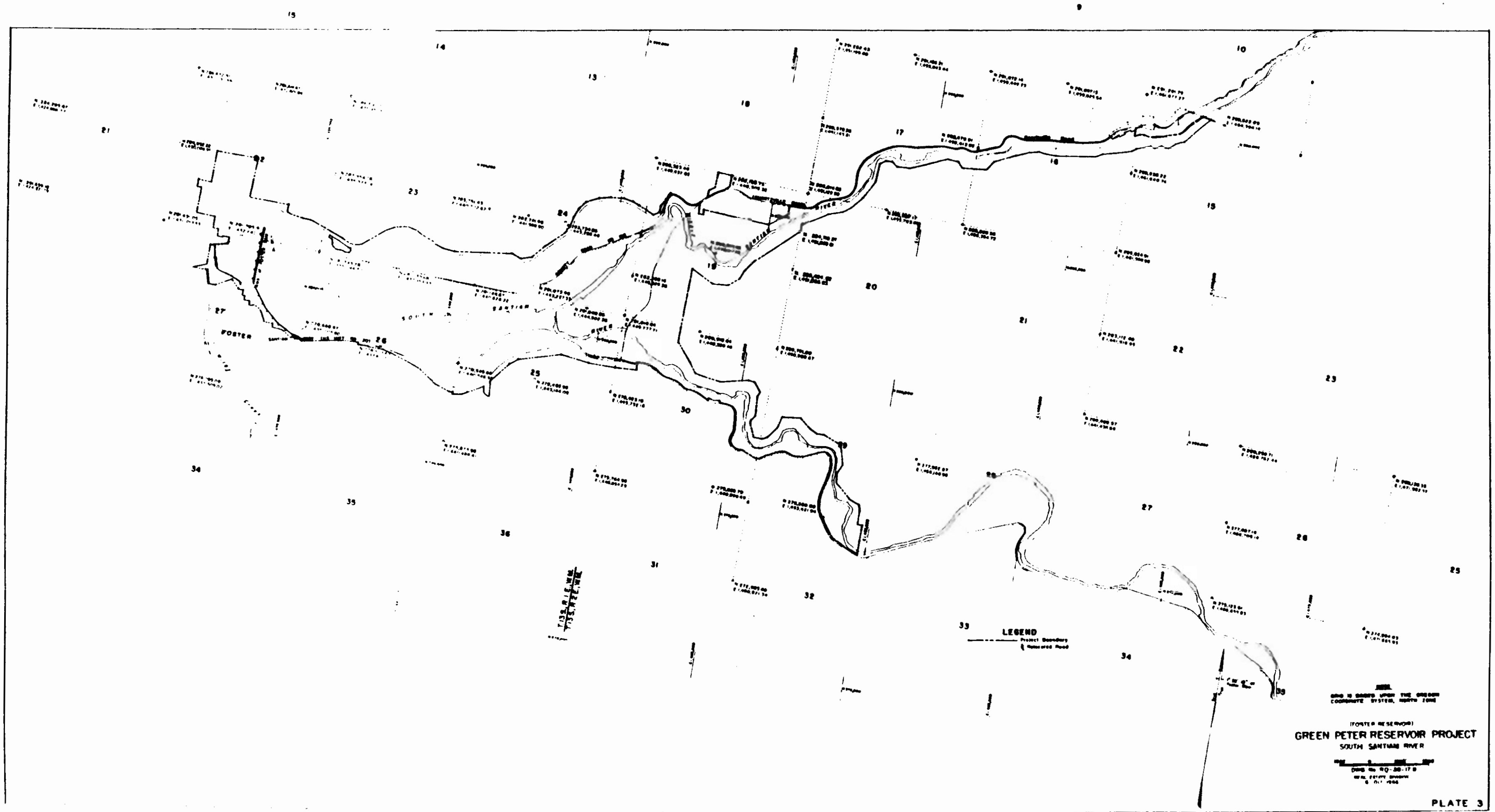
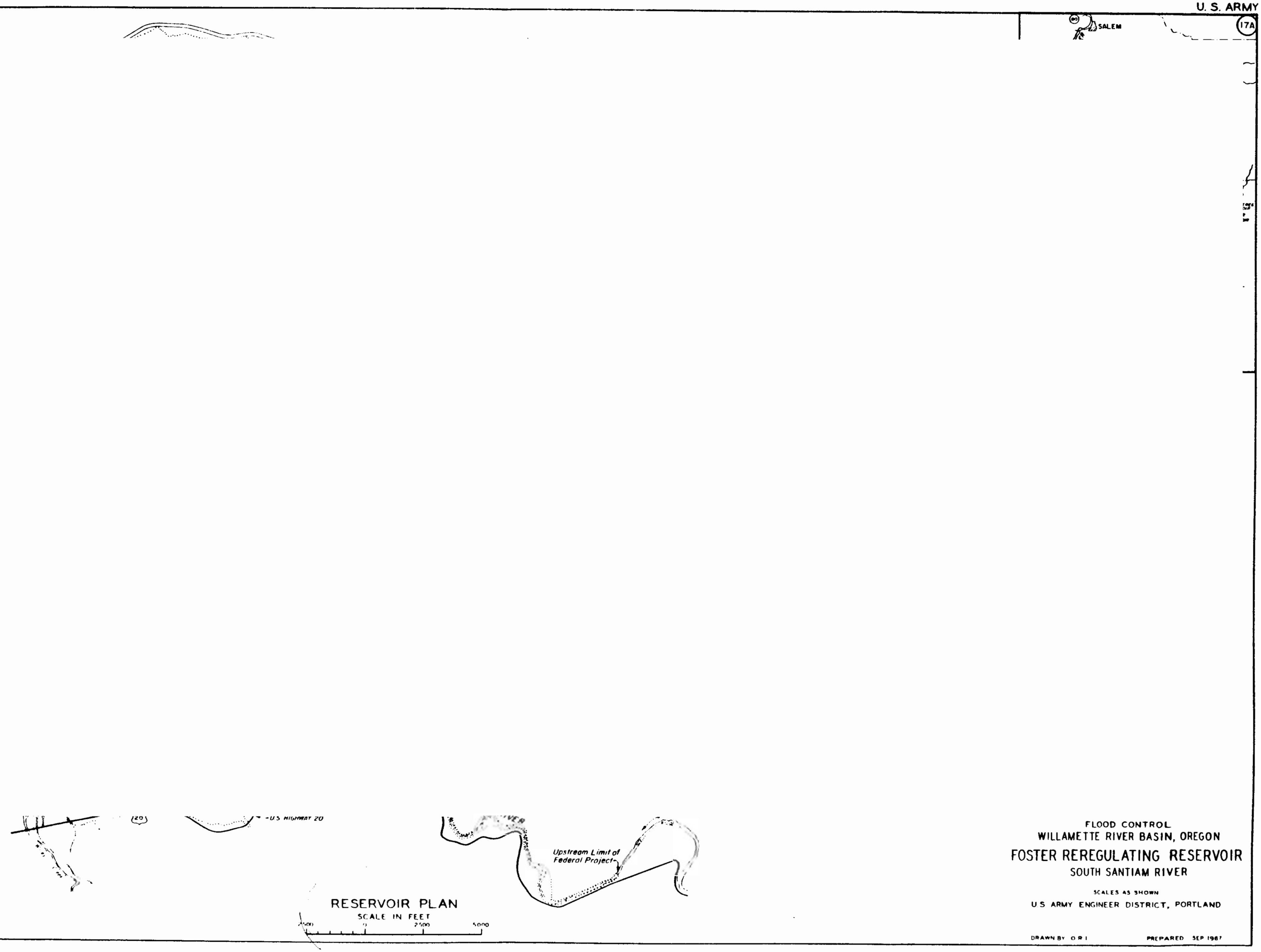

FOSTER
LEGEND
Project Boundary
Relocated Road
(FOSTER RESERVOIR)
GREEN PETER RESERVOIR PROJECT
SOUTH SANTIAM RIVER

PLATE 3



RESERVOIR PLAN

SCALE IN FEET

2500 0 2500 5000

FLOOD CONTROL
WILLAMETTE RIVER BASIN, OREGON

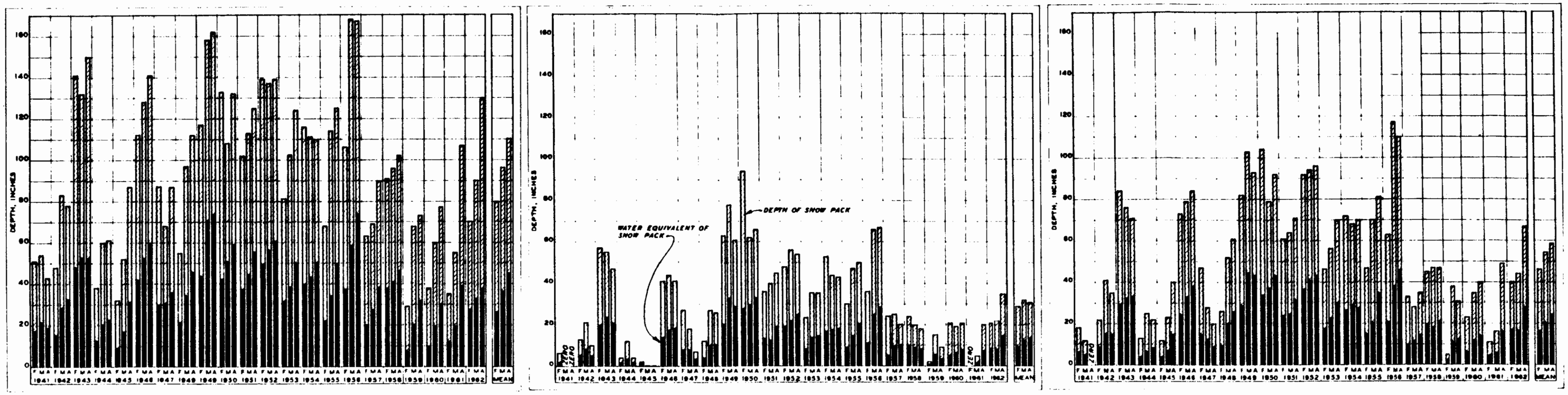
FOSTER REREGULATING RESERVOIR

SOUTH SANTIAM RIVER

SCALES AS SHOWN

U.S. ARMY ENGINEER DISTRICT, PORTLAND

DRAWN BY O.R.I. PREPARED SEP 1967

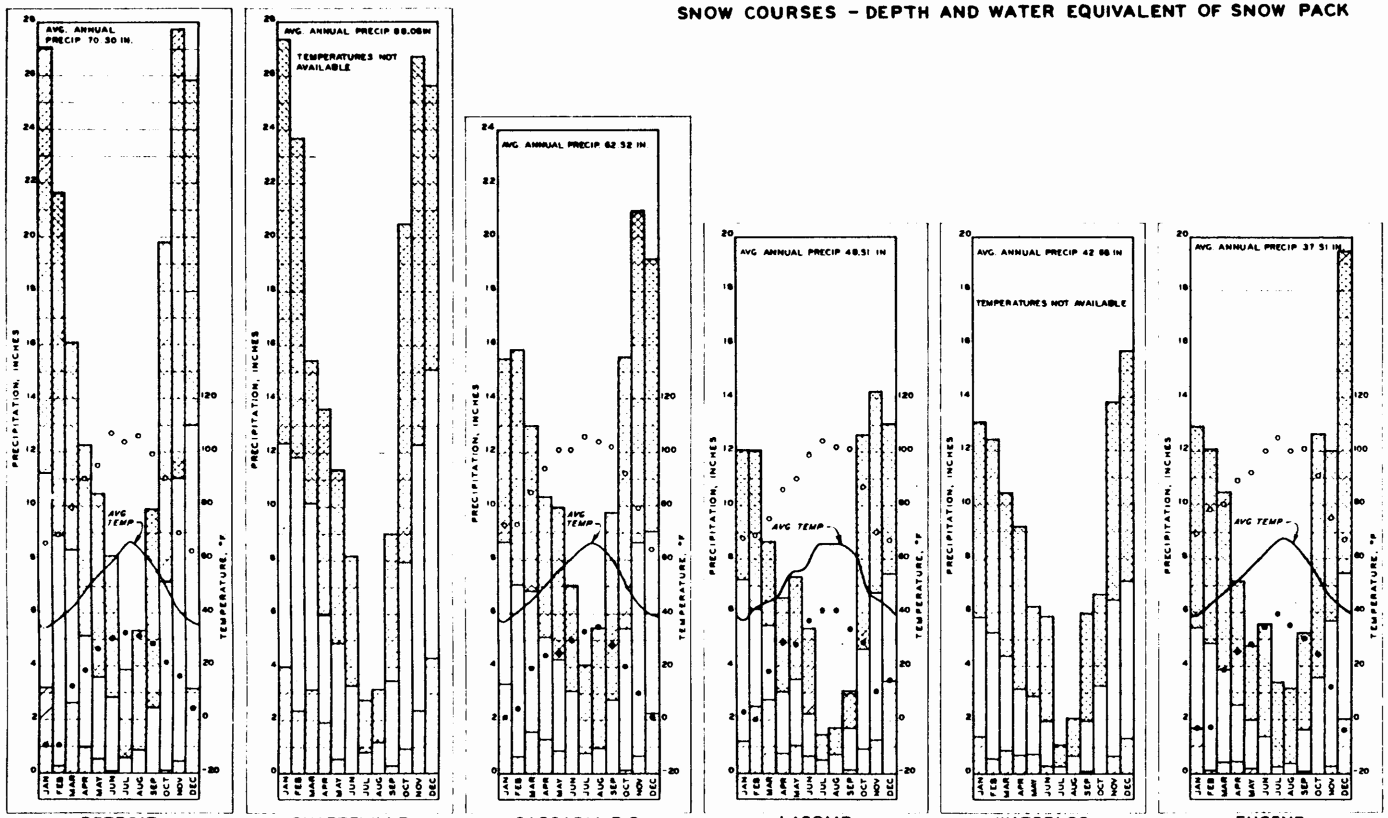


HOGG PASS
ELEVATION 4755

MARION FORKS
ELEVATION 2730

SANTIAM JUNCTION
ELEVATION 3880

SNOW COURSES – DEPTH AND WATER EQUIVALENT OF SNOW PACK



DETROIT
ELEVATION 1585
PERIOD OF RECORD 1864-1961

QUARTZVILLE
ELEVATION 881
PERIOD OF RECORD 1939-1961

CASCADIA R.S.
ELEVATION 796
PERIOD OF RECORD 1908-1961

LACOMB
ELEVATION 665
PERIOD OF RECORD 1842-1961

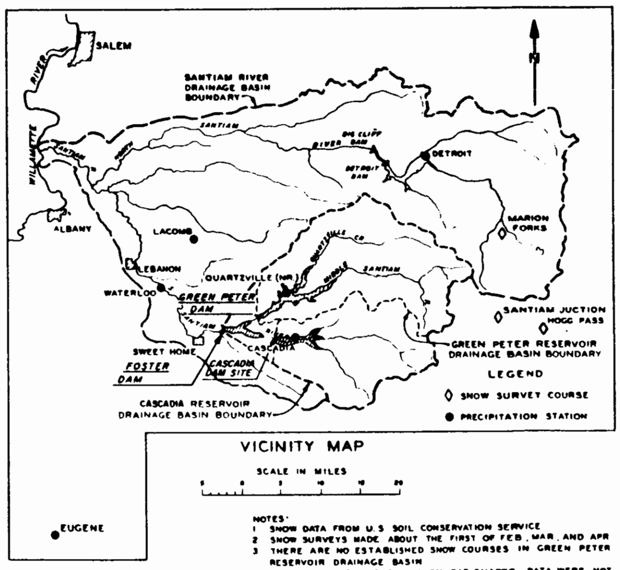
WATERLOO
ELEVATION 410
PERIOD OF RECORD 1924-1961

EUGENE
ELEVATION 364
PERIOD OF RECORD 1891-1961

MONTHLY PRECIPITATION AND TEMPERATURE

LEGEND

- MAXIMUM PRECIPITATION
- AVERAGE PRECIPITATION
- MINIMUM PRECIPITATION
- ○ ABSOLUTE MAXIMUM TEMPERATURE
- ● ABSOLUTE MINIMUM TEMPERATURE



VICINITY MAP

SCALE IN MILES

NOTES:
1. SNOW DATA FROM U.S SOIL CONSERVATION SERVICE
2. SNOW SURVEYS MADE ABOUT THE FIRST OF FEB., MAR., AND APR
3. THERE ARE NO ESTABLISHED SNOW COURSES IN GREEN PETER RESERVOIR DRAINAGE BASIN
4. WHERE NO ENTRY IS SHOWN ON BAR CHARTS, DATA WERE NOT AVAILABLE OR OBSERVATIONS WERE NOT MADE
5. PRECIPITATION AND TEMPERATURE DATA FROM RECORDS OF U S WEATHER BUREAU

WILLAMETTE RIVER BASIN, OREGON
SANTIAM RIVER

CLIMATIC CHARACTERISTICS

SCALES AS SHOWN
U. S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS

PREPARED: CHIEF, HYDROLOGY AND METEOROLOGY SECTION
RECOMMENDED: CHIEF, ENGINEERING DIVISION
SUBMITTED: CHIEF, PLANNING BRANCH
APPROVED: COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

ST-1-121

CORPS OF ENGINEERS

U. S. ARMY

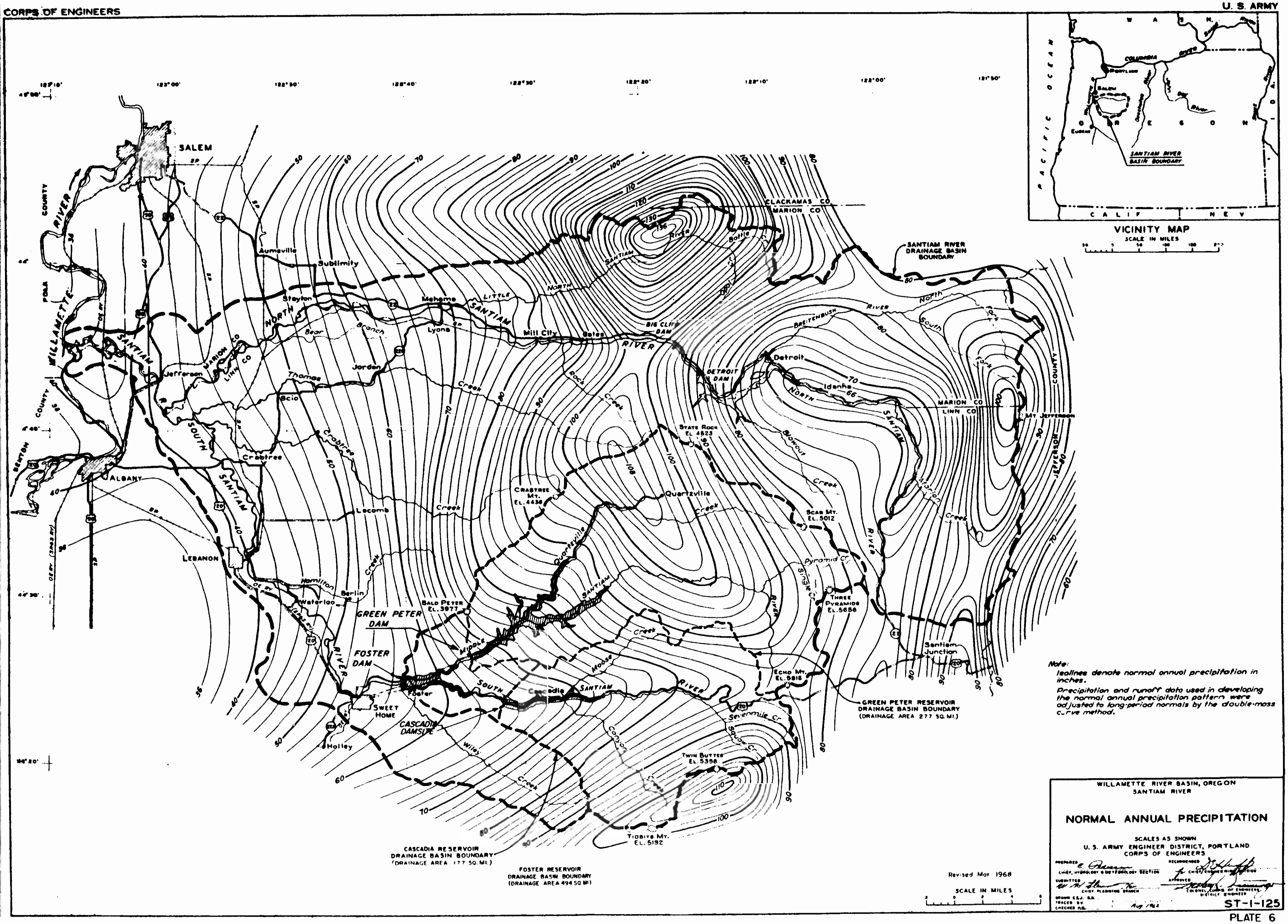
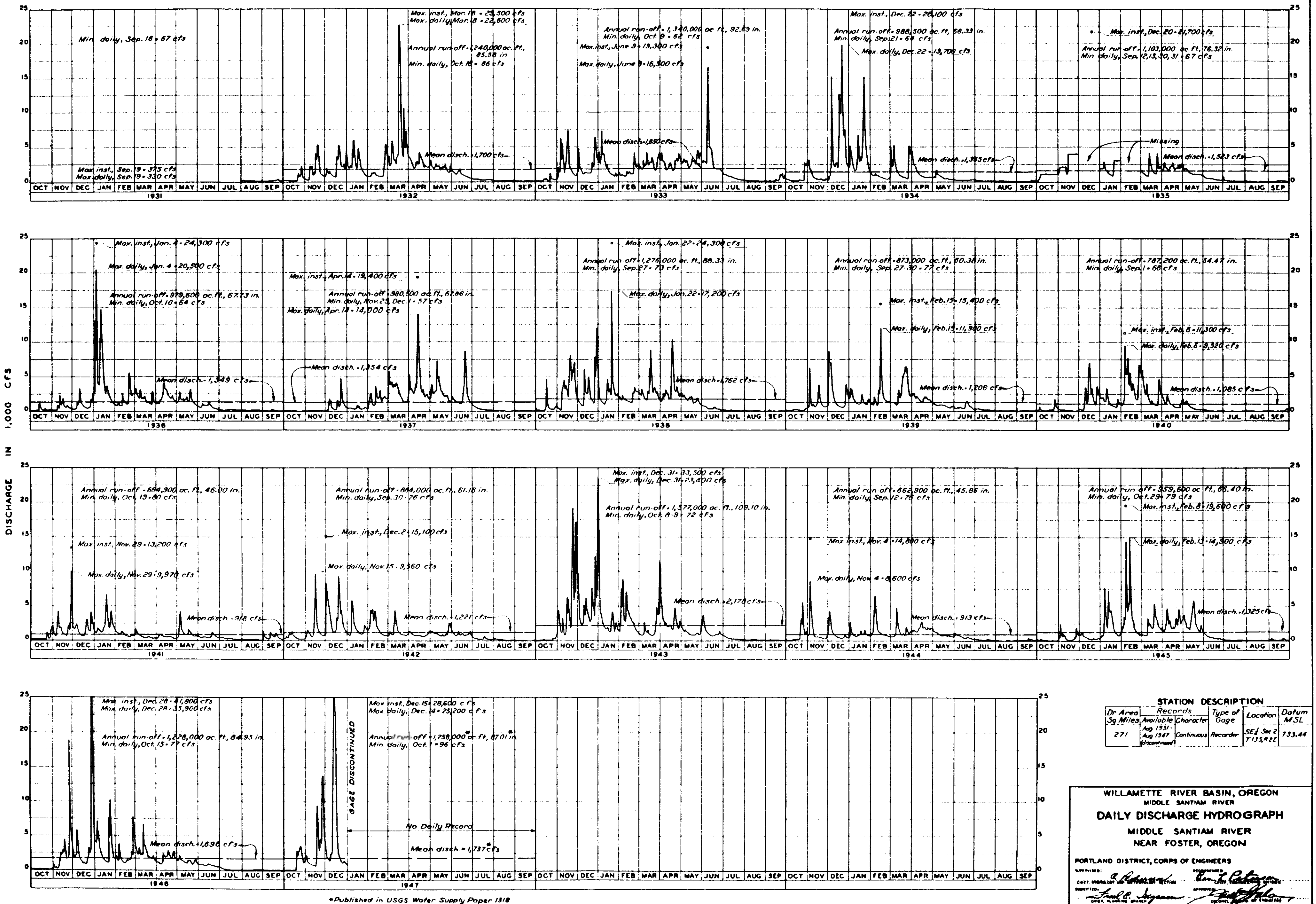


PLATE 6



*Published in USGS Water Supply Paper 1318

STATION DESCRIPTION

Dr Area Sq Miles	Records Available	Records Character	Type of Gage	Location	Datum MSL
271	Aug 1931 - Aug 1947 (discontinued)	Continuous	Recorder	SE¼ Sec 2 T13S R2E	733.44

WILLAMETTE RIVER BASIN, OREGON
MIDDLE SANTIAM RIVER

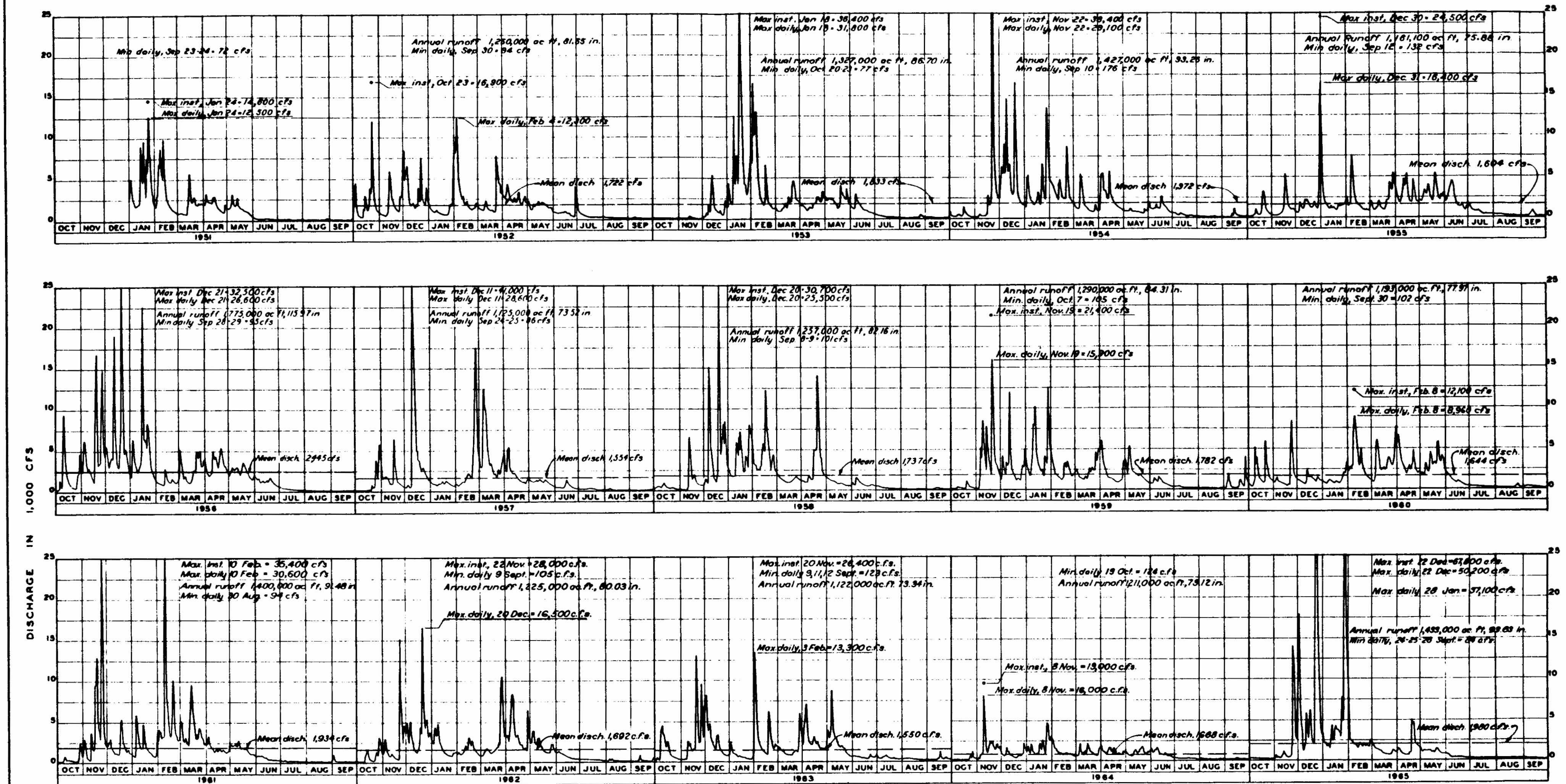
DAILY DISCHARGE HYDROGRAPH

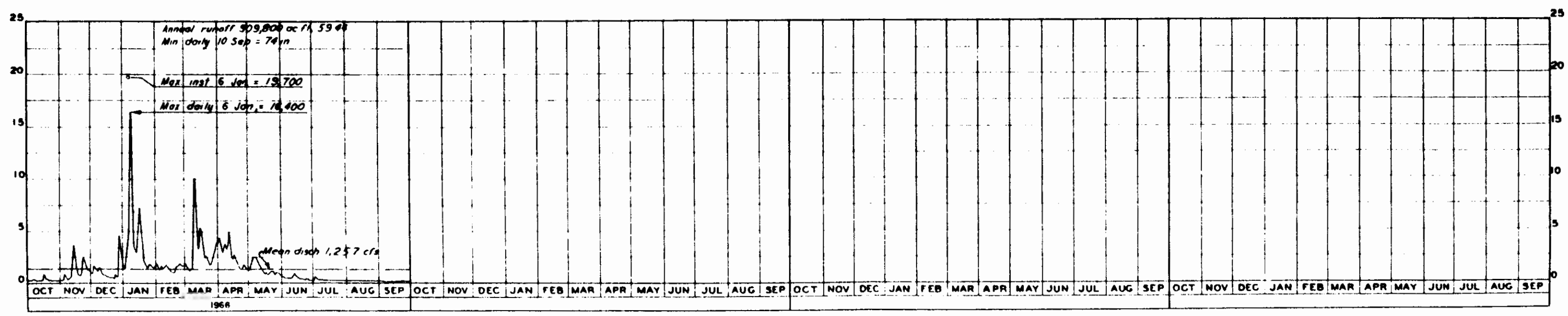
MIDDLE SANTIAM RIVER
NEAR FOSTER, OREGON

PORTLAND DISTRICT, CORPS OF ENGINEERS

PD-25-11/1

PLATE 7





STATION DESCRIPTION

Dr Area Sq Miles	Records Available	Records Character	Type of Gage	Location	Datum MSL
287	Jan 1951 to Sep 1966	Continuous	Staff (1951-1952) Recorder 1953-1966	NE¼ of SE¼ Sec 24 T13S, R1E	562.14

(Discontinued)

WILLAMETTE RIVER BASIN, OREGON
MIDDLE SANTIAM RIVER

DAILY DISCHARGE HYDROGRAPH

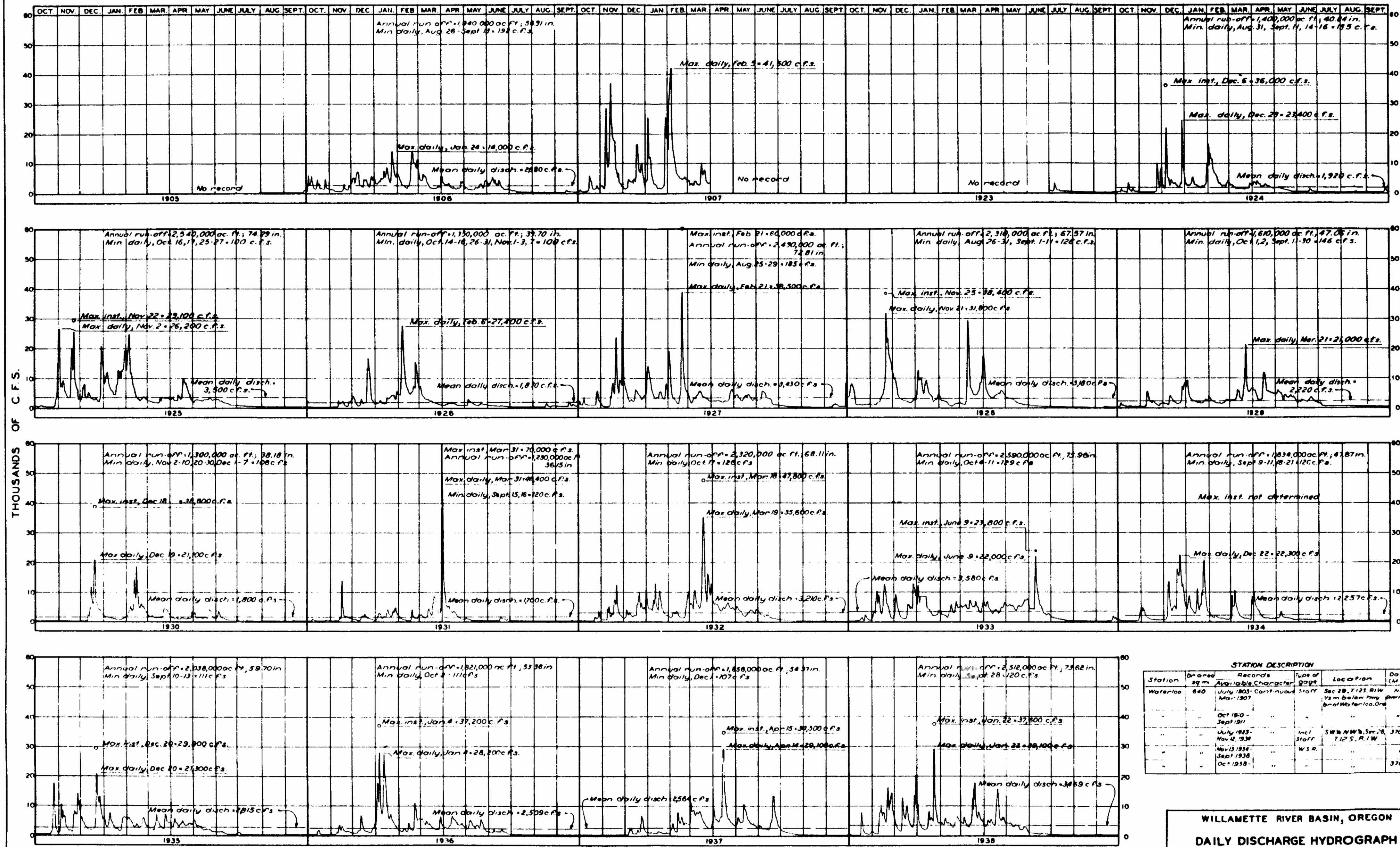
MIDDLE SANTIAM RIVER
AT MOUTH, NEAR FOSTER, OREGON

PORTLAND DISTRICT, CORPS OF ENGINEERS

SUPERVISED C. Pedersen — CHIEF, HYDROLOGY AND METEOROLOGY SECTION
RECOMMENDED Ben K. Peterson — CHIEF, ENGINEERING DIVISION
SUBMITTED Fred C. [illegible] — CHIEF, PLANNING BRANCH
APPROVED [illegible] — COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY JWH
TRACED BY MMB
CHECKED BY HEO

PD-25-11/2



STATION DESCRIPTION

Station	Drained sq mi	Records Available	Records Character	Type of gage	Location	Datum (M.S.L.)
Waterloo	640	July 1905 - Mar. 1907	Continuous	Staff	Sec 29, T 12 S, R 1 W ½ m below hwy brg at Waterloo, Ore	Not Determined
"	"	Oct 1910 - Sept 1911	"	"	"	"
"	"	July 1923 - Nov 12, 1934	"	Incl Staff	SW¼ NW¼, Sec 28, T 12 S, R 1 W	370.2
"	"	Nov 13, 1934 - Sept 1938	"	W.S.R.	"	"
"	"	Oct 1938 -	"	"	"	370.30

WILLAMETTE RIVER BASIN, OREGON

DAILY DISCHARGE HYDROGRAPH

SOUTH SANTIAM RIVER AT WATERLOO, OREGON

IN 3 SHEETS SHEET NO. 1

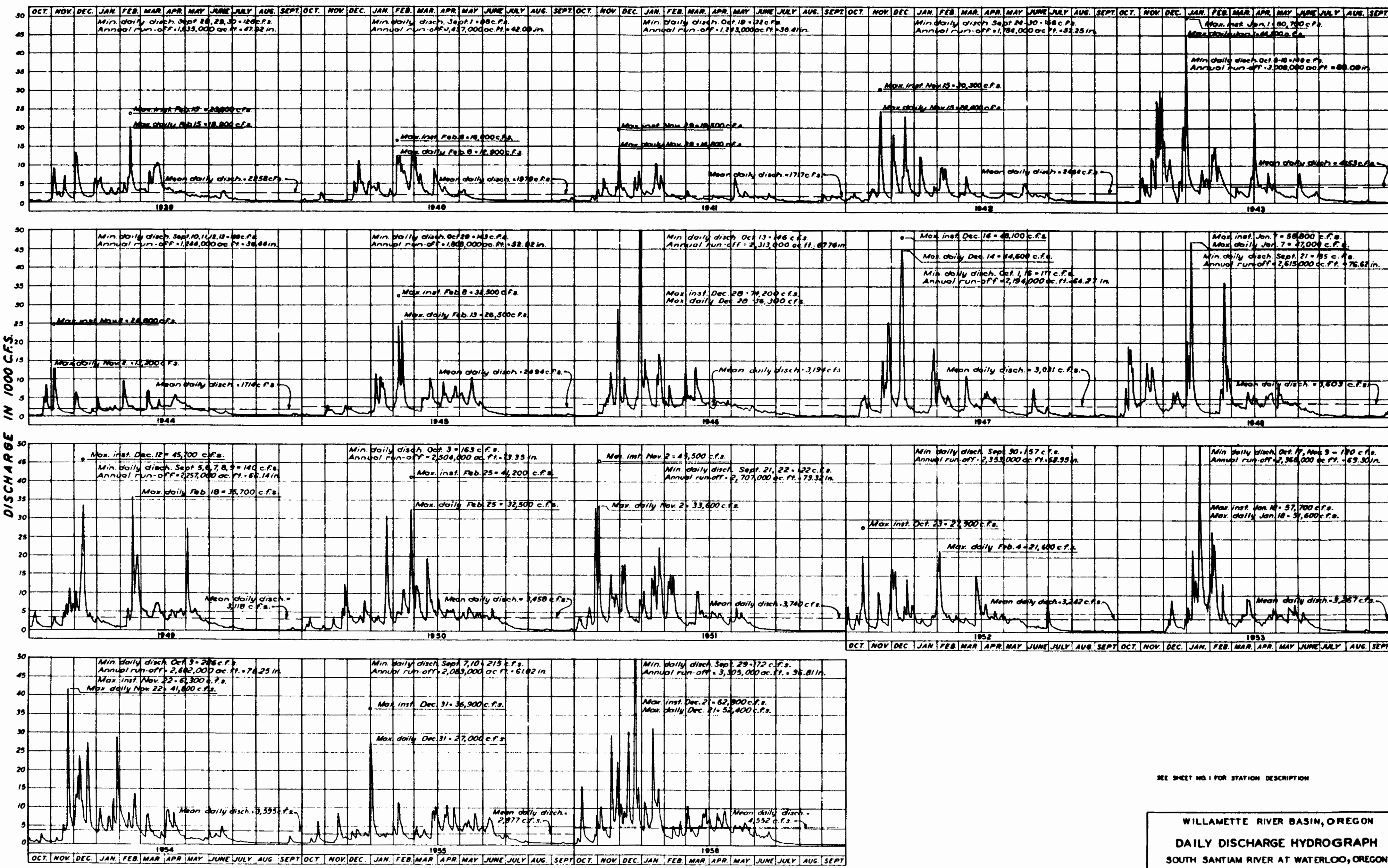
U. S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS

SUPERVISED: E. Peterson — CHIEF, HYDROLOGY AND METEOROLOGY SECTION
RECOMMENDED: [signature]
SUBMITTED: [signature]
APPROVED: [signature] — COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN: O.J.
TRACED: R.V.W.
CHECKED: O.J.

WB-05-3/29

PD-25-35/1



SEE SHEET NO. 1 FOR STATION DESCRIPTION

WILLAMETTE RIVER BASIN, OREGON

DAILY DISCHARGE HYDROGRAPH

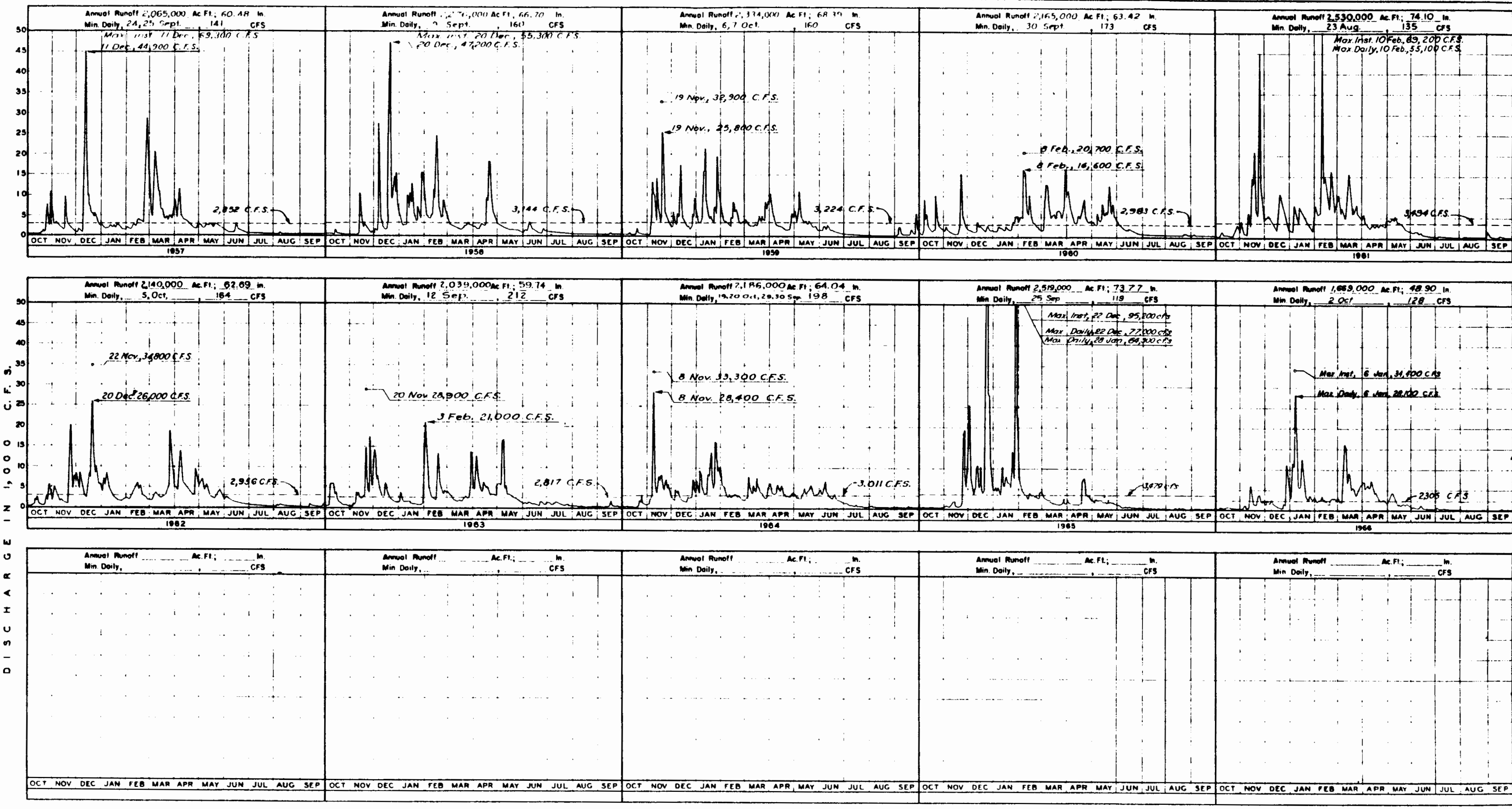
SOUTH SANTIAM RIVER AT WATERLOO, OREGON

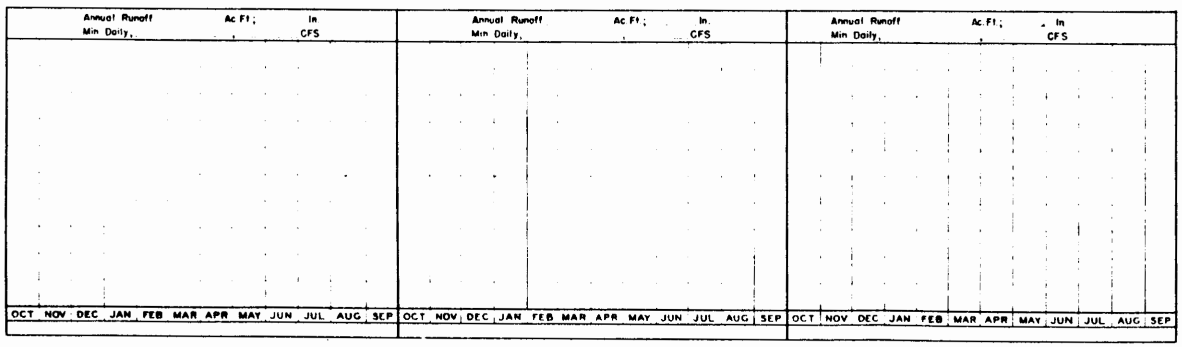
IN 3 SHEETS SHEET NO. 2

U. S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS

WB-05-3/30

PD-25-35/2





STATION DESCRIPTION

Station	Dr Area Sq Miles	Records Available	Records Character	Type of Gage	Location	Datum MSL

SEE SHEET NO. 1 FOR STATION DESCRIPTION

LEGEND

- · MAXIMUM INSTANTANEOUS DISCHARGE
- ← MAXIMUM DAILY DISCHARGE
- - - - MEAN DISCHARGE

WILLAMETTE RIVER BASIN, OREGON

DAILY DISCHARGE HYDROGRAPH

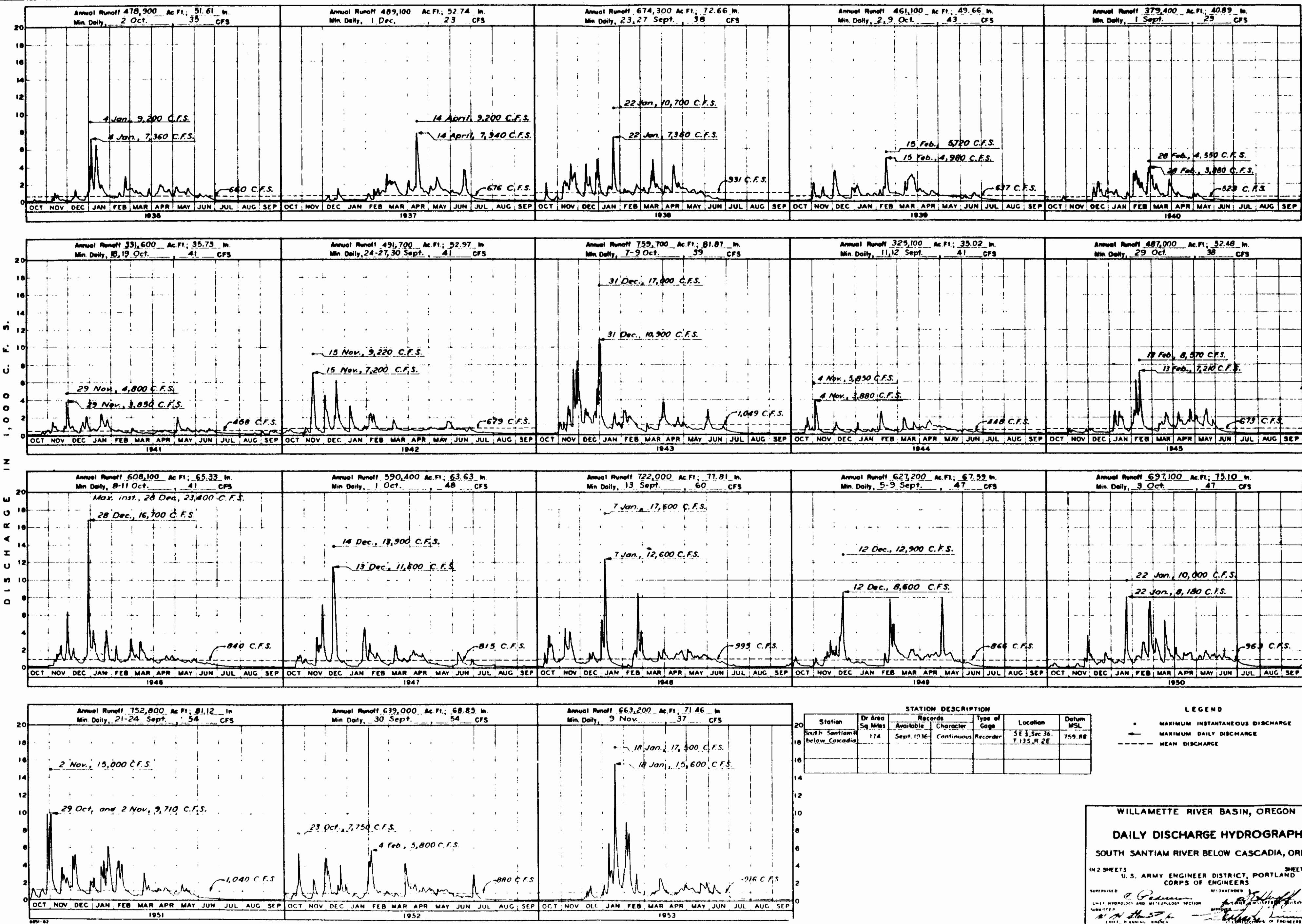
SOUTH SANTIAM RIVER AT WATERLOO, OREGON

IN 3 SHEETS SHEET NO. 3

U. S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS

SUPERVISED C. Pedersen — CHIEF, HYDROLOGY AND METEOROLOGY SECTION
RECOMMENDED — CHIEF, ENGINEERING DIVISION
SUBMITTED W. H. — CHIEF, PLANNING BRANCH
APPROVED — COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER
DRAWN O.J.
TRACED
CHECKED O.J.

P.D-25-35/3



STATION DESCRIPTION

Station	Dr Area Sq Miles	Records Available	Records Character	Type of Gage	Location	Datum MSL
South Santiam R below Cascadia	174	Sept. 1936-	Continuous	Recorder	SE ¼, Sec 36, T 13 S, R 2 E	759.88

LEGEND

- • MAXIMUM INSTANTANEOUS DISCHARGE
- ←— MAXIMUM DAILY DISCHARGE
- ----- MEAN DISCHARGE

WILLAMETTE RIVER BASIN, OREGON

DAILY DISCHARGE HYDROGRAPH

SOUTH SANTIAM RIVER BELOW CASCADIA, OREGON

IN 2 SHEETS SHEET NO 1

U. S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS

SUPERVISED [signature] CHIEF, HYDROLOGY AND METEOROLOGY SECTION
RECOMMENDED [signature] for CHIEF, ENGINEERING DIVISION
SUBMITTED [signature] CHIEF, PLANNING BRANCH
APPROVED [signature] LT. COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN O.J.
TRACED O.E.A.
CHECKED O.J.

PD-25-34/1

CORPS OF ENGINEERS　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　U. S. ARMY

STATION DESCRIPTION

Station	Dr Area Sq Miles	Records Available	Records Character	Type of Gage	Location	Datum MSL

See sheet No. 1 for station description

LEGEND

- • MAXIMUM INSTANTANEOUS DISCHARGE
- ← MAXIMUM DAILY DISCHARGE
- ----- MEAN DISCHARGE

WILLAMETTE RIVER BASIN, OREGON

DAILY DISCHARGE HYDROGRAPH

SOUTH SANTIAM RIVER BELOW CASCADIA, OREGON

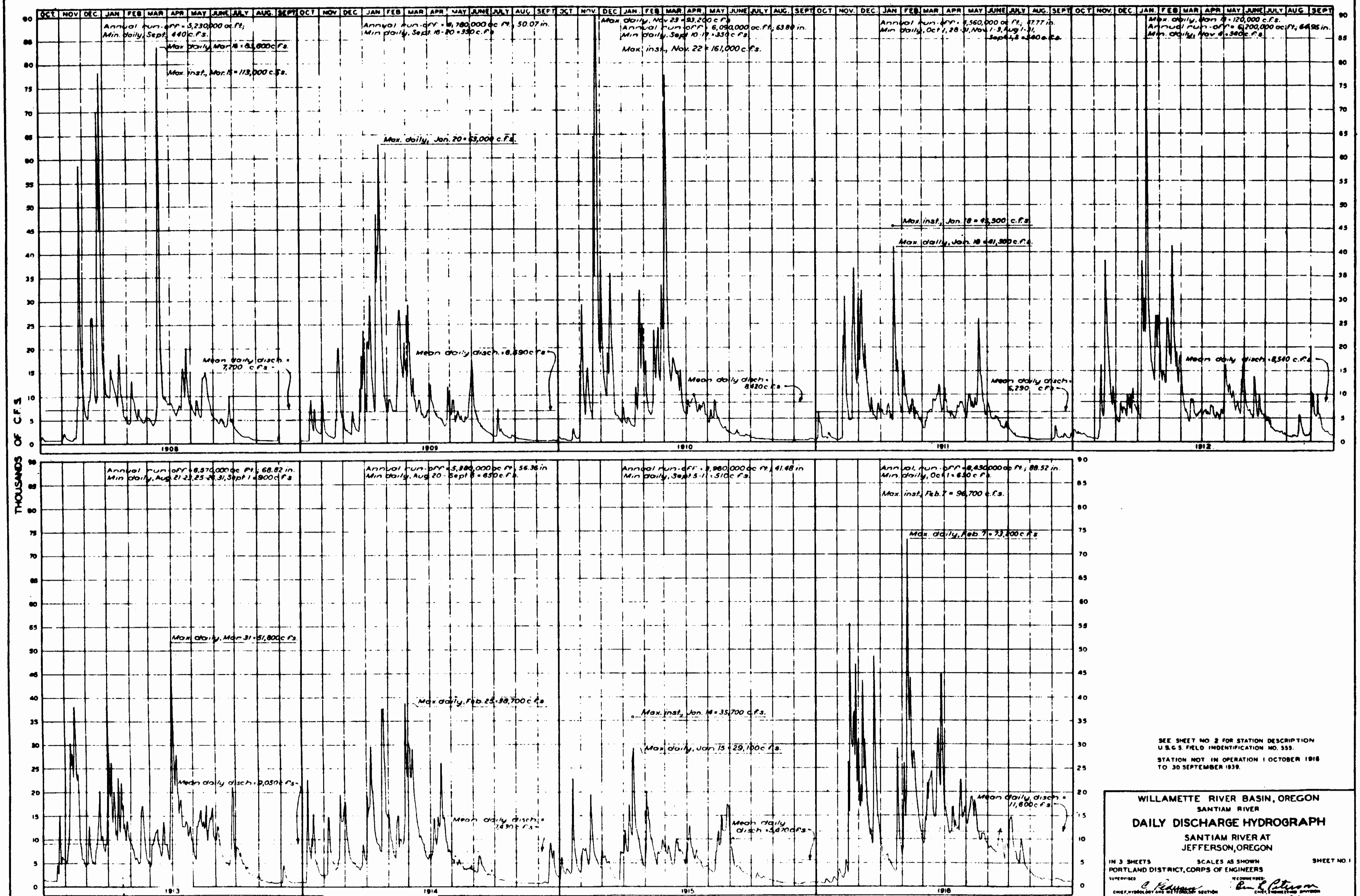
IN 2 SHEETS　　SHEET NO. 2

U. S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS

Aug 1966

RD-25-34/2

PLATE 13



SEE SHEET NO 2 FOR STATION DESCRIPTION
U.S.G.S. FIELD INDENTIFICATION NO. 555.

STATION NOT IN OPERATION 1 OCTOBER 1916 TO 30 SEPTEMBER 1939.

WILLAMETTE RIVER BASIN, OREGON

SANTIAM RIVER

DAILY DISCHARGE HYDROGRAPH

SANTIAM RIVER AT
JEFFERSON, OREGON

IN 3 SHEETS — SCALES AS SHOWN — SHEET NO. 1

PORTLAND DISTRICT, CORPS OF ENGINEERS

SUPERVISED: C. Kidman (signature) — CHIEF, HYDROLOGY AND METEOROLOGY SECTION

RECOMMENDED: Ben L. Peterson (signature) — CHIEF, ENGINEERING DIVISION

SUBMITTED: (signature) — CHIEF, PLANNING BRANCH

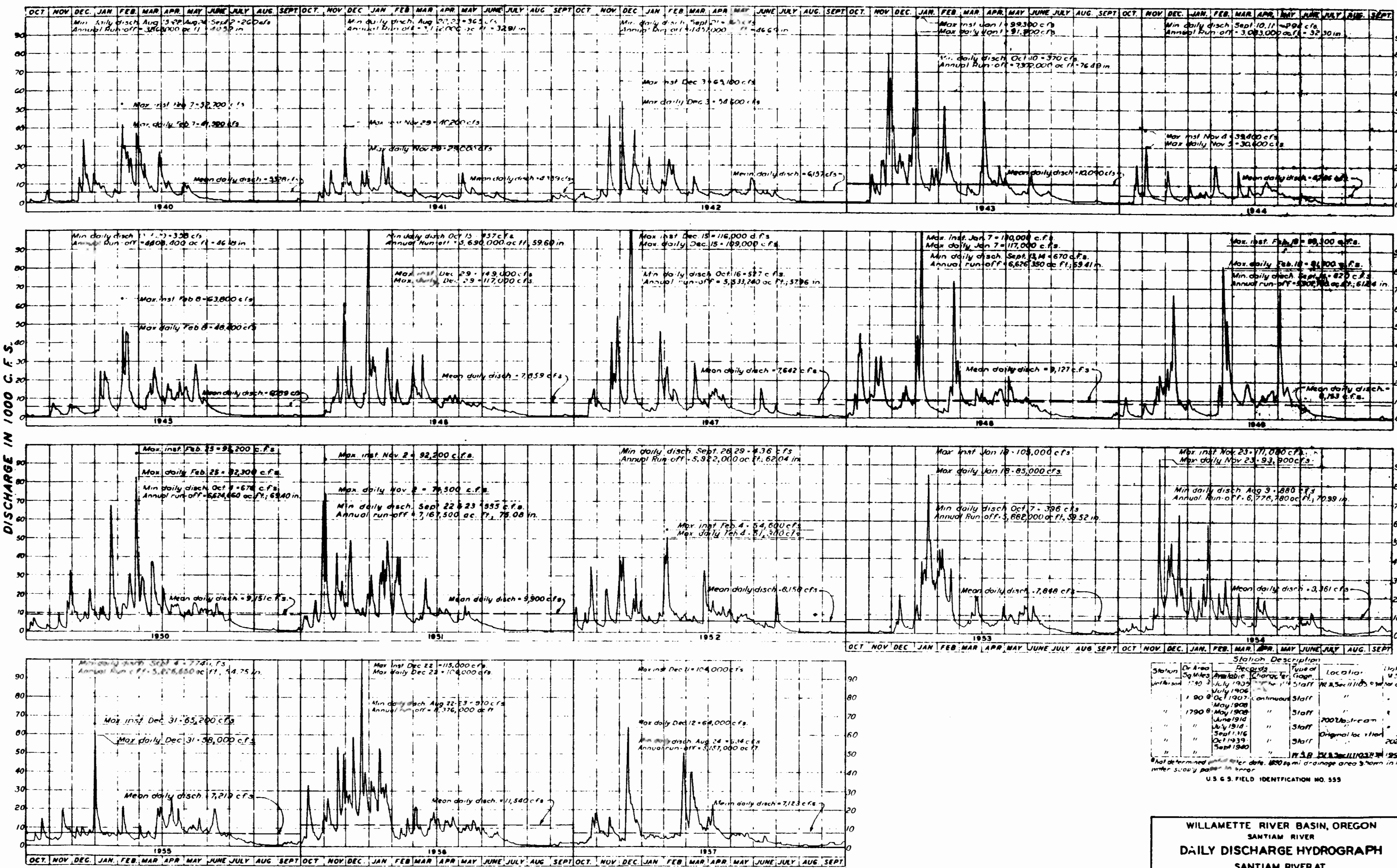
APPROVED: (signature) — COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY J.H.H.
TRACED BY W.W.G.
CHECKED BY R.T.D.

DE-20-45/10

PD-25-10/1

PLATE 14



Station Description

Station	Dr. Area Sq. Miles	Records Available	Records Character	Type of Gage	Location	Datum M.S.L.
Jefferson	1790 ®	July 1905 - July 1906	[illegible]	Staff	[illegible] Sec 11 T10S R3W	Not det.
	1790 ®	Oct 1907 - May 1908	Continuous	Staff	"	"
"	1790 ®	May 1908 - June 1910	"	Staff	"	"
"	"	July 1914 - Sept 1916	"	Staff	200' Upstream	"
"	"	Oct 1939 - Sept 1940	"	Staff	Original location	202.63
"	"		"	W.S.B.	[illegible] Sec 11 T10S R3W	199.63

® Not determined until later date. 1850 sq. mi drainage area shown in 1908 water supply paper in error

U.S.G.S. FIELD IDENTIFICATION NO. 555

WILLAMETTE RIVER BASIN, OREGON
SANTIAM RIVER

DAILY DISCHARGE HYDROGRAPH

SANTIAM RIVER AT
JEFFERSON, OREGON

IN 3 SHEETS — SCALES AS SHOWN — SHEET NO. 2
PORTLAND DISTRICT, CORPS OF ENGINEERS

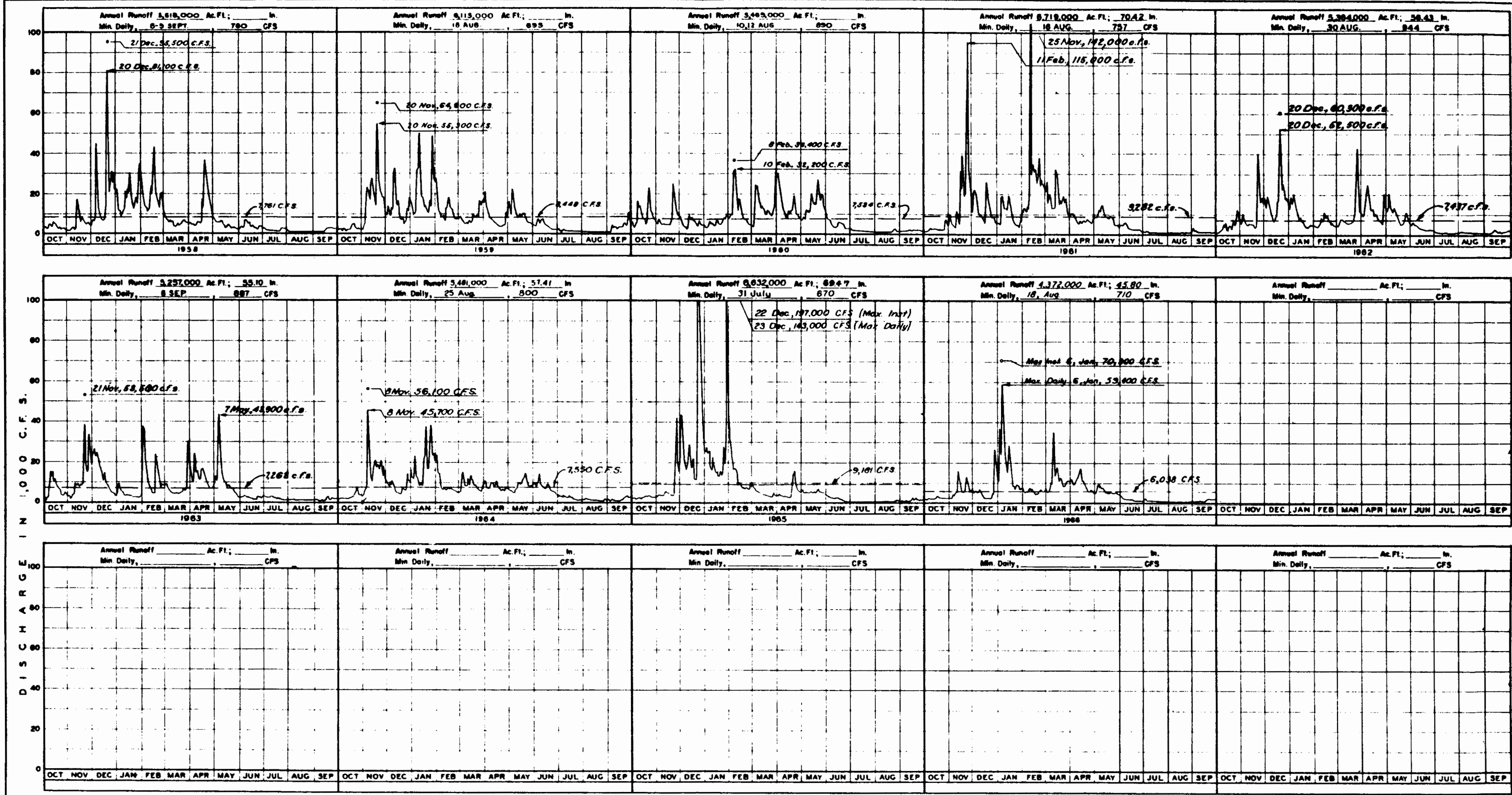
SUPERVISED: Chief, Hydrology and Meteorology Section
RECOMMENDED: Chief, Engineering Division
SUBMITTED: Chief, Planning Branch
APPROVED: Colonel, Corps of Engineers, District Engineer

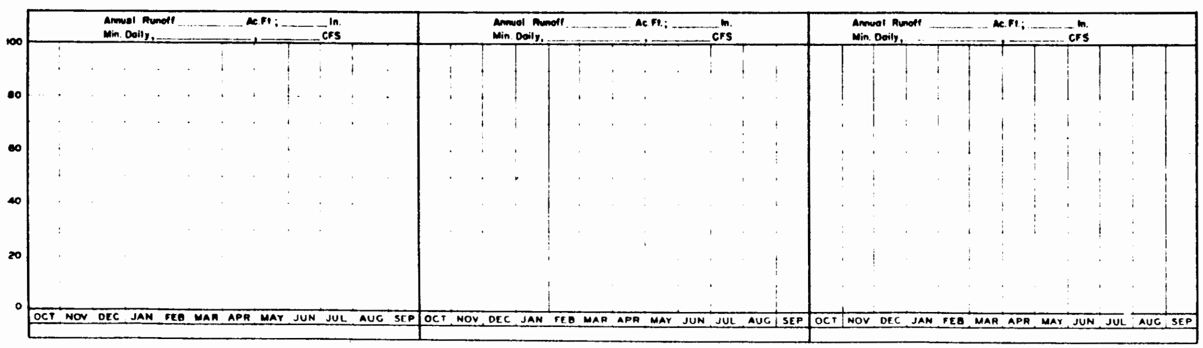
DRAWN BY JWH
TRACED BY HMB
CHECKED BY RTD

DE-20-46/17

PD-25-10/2

PLATE 15





STATION DESCRIPTION

Station	Dr Area Sq. Miles	Records Available	Records Character	Type of Gage	Location	Datum MSL

Note: See Sheet No. 2 for Station Description

LEGEND

- · MAXIMUM INSTANTANEOUS DISCHARGE
- ← MAXIMUM DAILY DISCHARGE
- - - - MEAN DISCHARGE

WILLAMETTE RIVER BASIN, OREGON

SANTIAM RIVER

DAILY DISCHARGE HYDROGRAPH

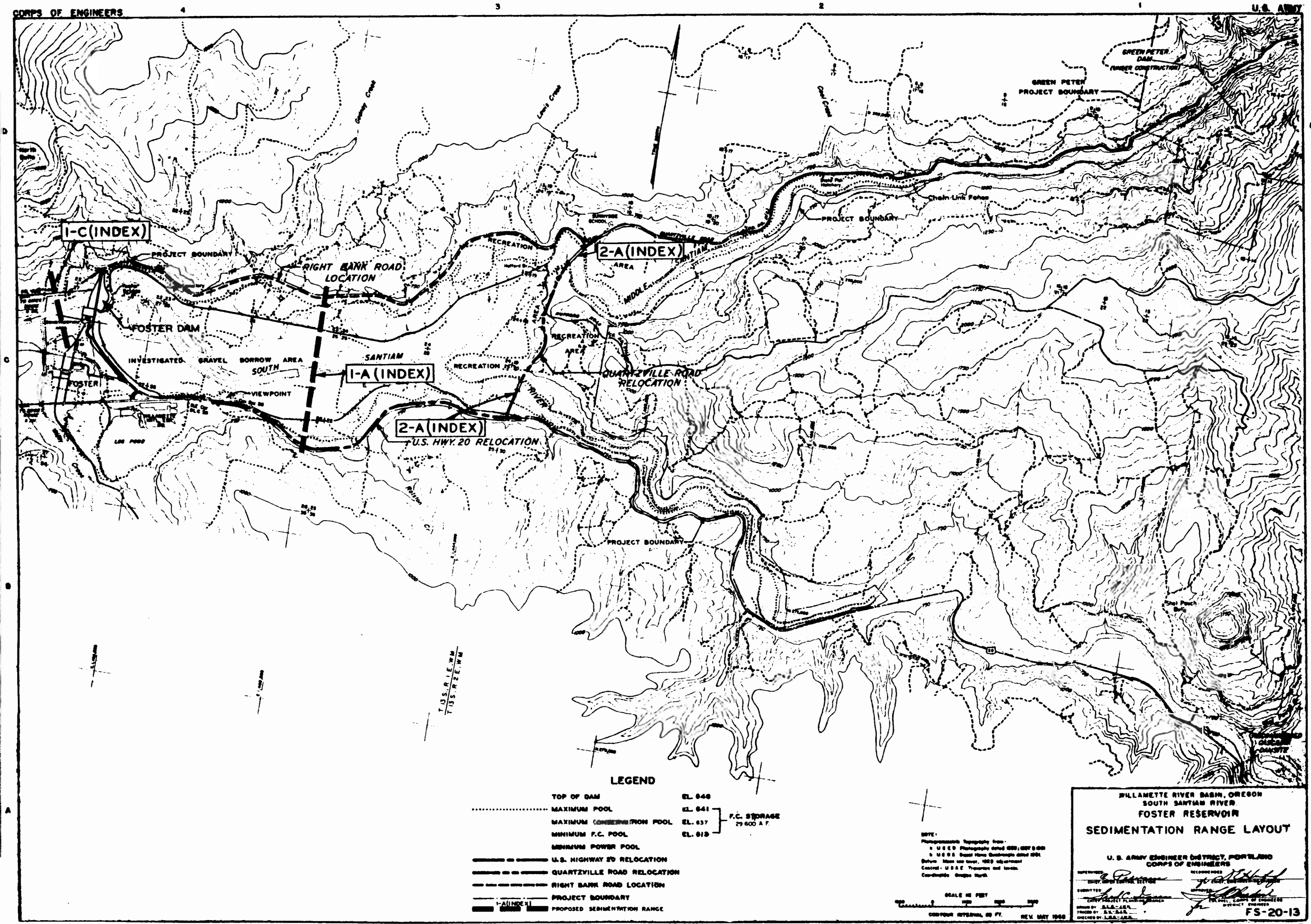
SANTIAM RIVER AT JEFFERSON, OREGON

IN 3 SHEETS — SHEET NO. 3

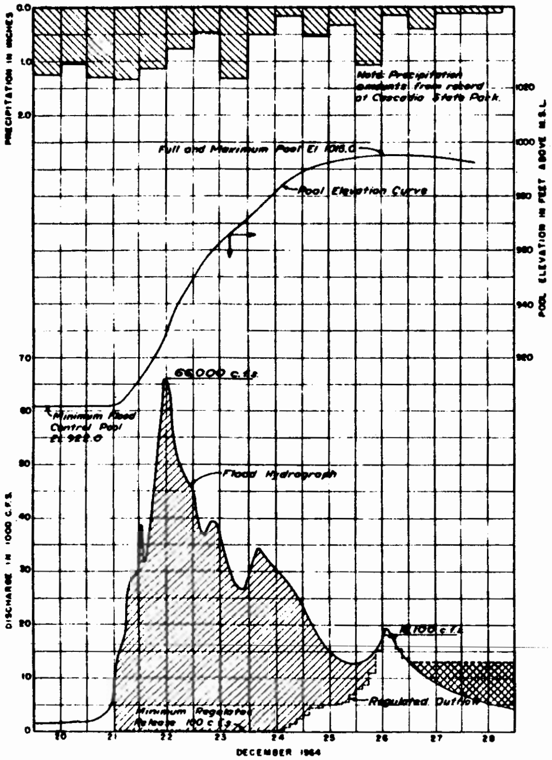
U. S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS

SUPERVISED: C. Pedersen — CHIEF, HYDROLOGY AND METEOROLOGY SECTION
RECOMMENDED: — CHIEF, ENGINEERING DIVISION
SUBMITTED: — CHIEF, PLANNING BRANCH
APPROVED: — COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER
DRAWN / TRACED / CHECKED

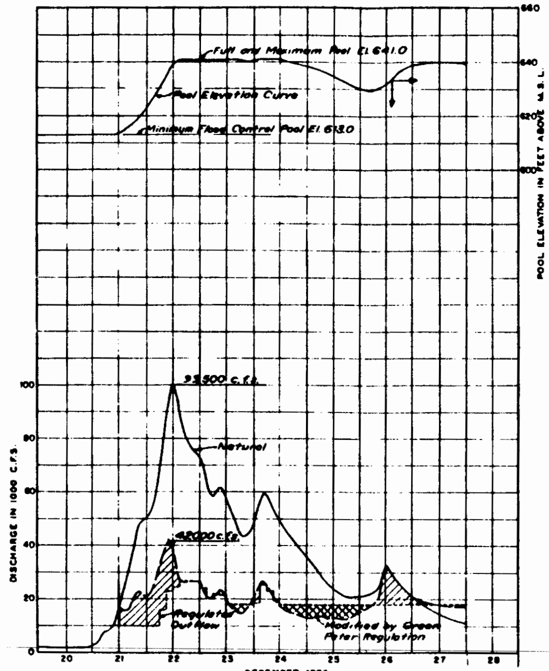
PD-25-10/3



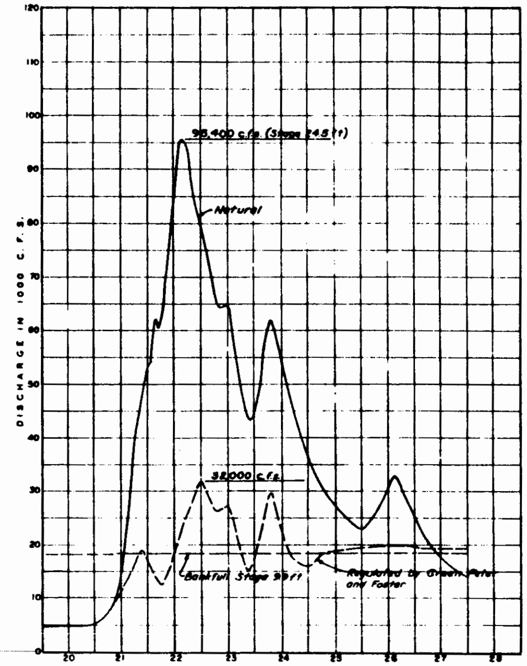
CORPS OF ENGINEERS
U.S. ARMY
GREEN PETER DAM (UNDER CONSTRUCTION)
GREEN PETER PROJECT BOUNDARY
Chain Link Fence
PROJECT BOUNDARY
1-C(INDEX)
PROJECT BOUNDARY
RIGHT BANK ROAD LOCATION
RECREATION
2-A(INDEX)
AREA
MIDDLE SANTIAM
FOSTER DAM
INVESTIGATED GRAVEL BORROW AREA
SOUTH
SANTIAM
1-A(INDEX)
RECREATION
RECREATION AREA
QUARTZVILLE ROAD RELOCATION
VIEWPOINT
FOSTER
RIVER
2-A(INDEX)
U.S. HWY. 20 RELOCATION
PROJECT BOUNDARY
LEGEND
TOP OF DAM EL. 646
MAXIMUM POOL EL. 641
MAXIMUM CONSERVATION POOL EL. 637
MINIMUM F.C. POOL EL. 613
F.C. STORAGE 29 600 A.F.
MINIMUM POWER POOL
U.S. HIGHWAY 20 RELOCATION
QUARTZVILLE ROAD RELOCATION
RIGHT BANK ROAD LOCATION
PROJECT BOUNDARY
1-A(INDEX) PROPOSED SEDIMENTATION RANGE
SCALE IN FEET
CONTOUR INTERVAL 20 FT.
REV. MAY 1968
WILLAMETTE RIVER BASIN, OREGON
SOUTH SANTIAM RIVER
FOSTER RESERVOIR
SEDIMENTATION RANGE LAYOUT
U. S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS
FS-20-13



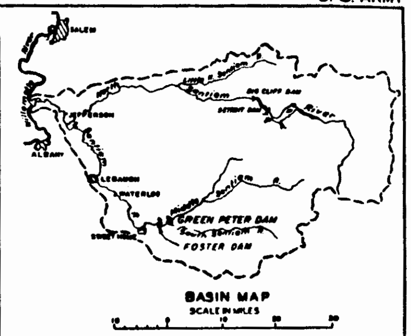
MIDDLE SANTIAM RIVER
AT GREEN PETER DAM
DRAINAGE AREA 277 SQ. MI.

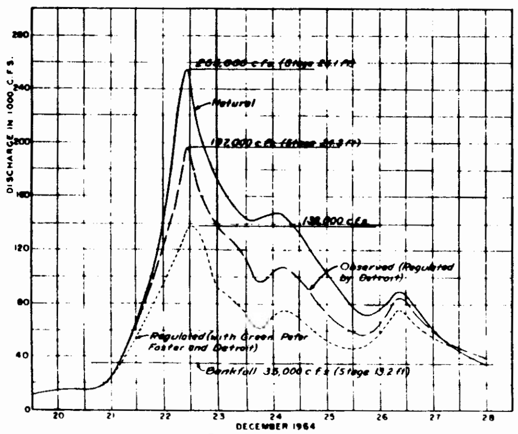


SOUTH SANTIAM RIVER
AT FOSTER DAM
DRAINAGE AREA 494 SQ. MI.

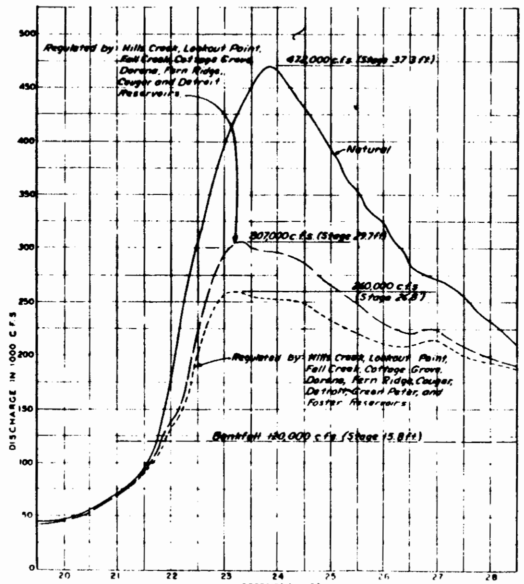


SOUTH SANTIAM RIVER
AT WATERLOO, OREGON
DRAINAGE AREA 640 SQ. MI.





SANTIAM RIVER
AT JEFFERSON, OREGON
DRAINAGE AREA 1,790 SQ. MI.

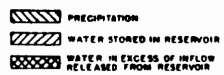


WILLAMETTE RIVER
AT SALEM, OREGON
DRAINAGE AREA 7,280 SQ. MI.

FLOOD CONTROL STORAGE
RESERVOIRS ABOVE SALEM

RESERVOIR	FLOOD CONTROL STORAGE ACRE-FEET	REMARKS
COTTAGE GROVE	30,000	EXISTING
DORENA	70,000	"
LOOKOUT POINT	337,000	"
FERN RIDGE	94,200	"
DETROIT	300,000	"
HILLS CREEK	200,000	"
COUGAR	155,000	"
GREEN PETER	270,000	"
FOSTER	30,000	"
FALL CREEK	115,000	"

LEGEND



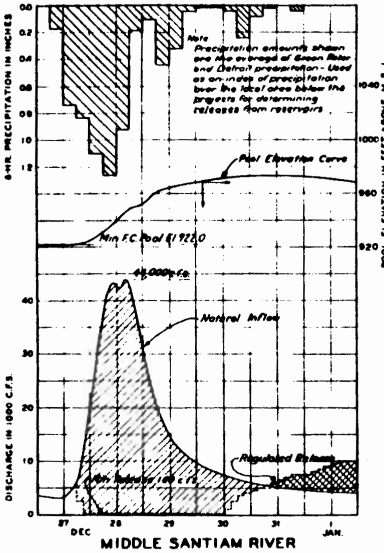
WILLAMETTE RIVER BASIN, OREGON
SANTIAM RIVER

NATURAL AND REGULATED HYDROGRAPHS
FLOOD OF DECEMBER 1964

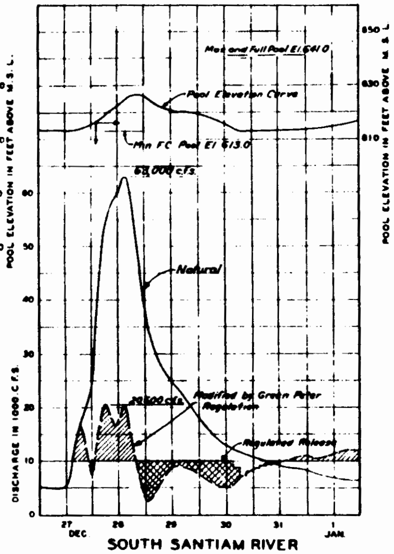
U. S. ARMY ENGINEER DISTRICT, PORTLAND

REV MAY 1968

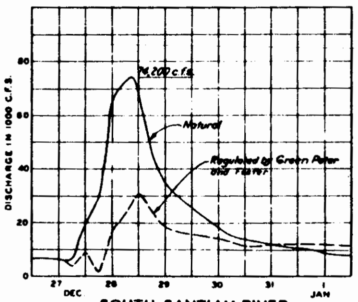
GP-20-24/2



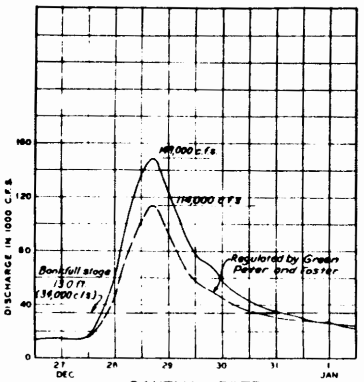
MIDDLE SANTIAM RIVER
AT GREEN PETER DAM
DRAINAGE AREA 277 SQ.MI.



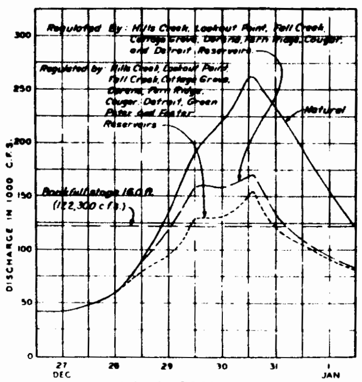
SOUTH SANTIAM RIVER
AT FOSTER DAM
DRAINAGE AREA 494 SQ.MI.



SOUTH SANTIAM RIVER
AT WATERLOO, OREGON
DRAINAGE AREA 640 SQ.MI.

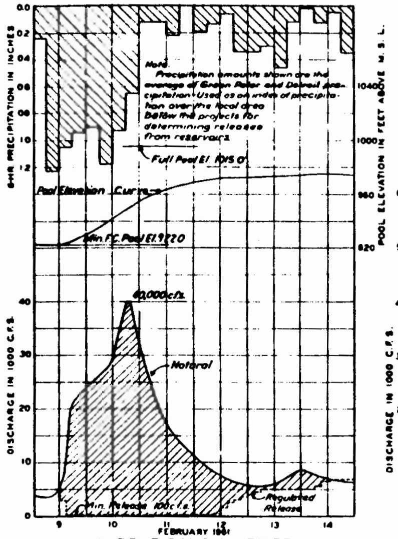


SANTIAM RIVER
AT JEFFERSON, OREGON
DRAINAGE AREA 1,790 SQ.MI.

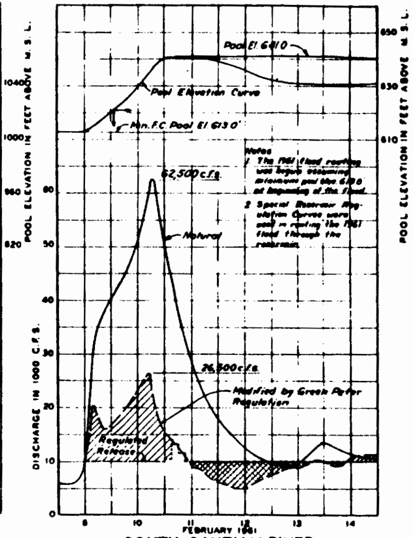


WILLAMETTE RIVER
AT SALEM, OREGON
DRAINAGE AREA 7,280 SQ.MI.

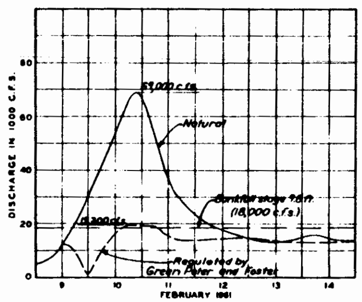
FLOOD OF DECEMBER 1945 - JANUARY 1946



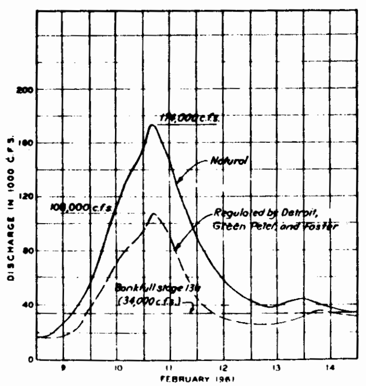
MIDDLE SANTIAM RIVER
AT GREEN PETER DAM
DRAINAGE AREA 277 SQ.MI.



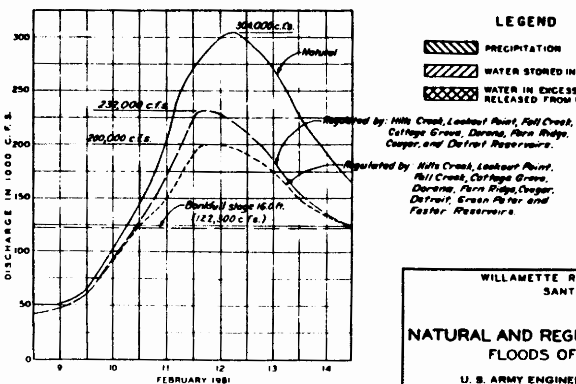
SOUTH SANTIAM RIVER
AT FOSTER DAM
DRAINAGE AREA 494 SQ.MI.



SOUTH SANTIAM RIVER
AT WATERLOO, OREGON
DRAINAGE AREA 640 SQ.MI.

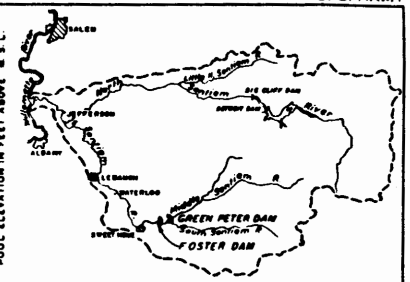


SANTIAM RIVER
AT JEFFERSON, OREGON
DRAINAGE AREA 1,790 SQ.MI.



WILLAMETTE RIVER
AT SALEM, OREGON
DRAINAGE AREA 7,280 SQ.MI.

FLOOD OF FEBRUARY 1961



BASIN MAP
SCALE IN MILES

FLOOD CONTROL STORAGE RESERVOIRS ABOVE SALEM

RESERVOIR	FLOOD CONTROL STORAGE ACRE-FEET	REMARKS
COTTAGE GROVE	30,000	EXISTING
DORENA	70,000	″
LOOKOUT POINT	337,000	″
FERN RIDGE	94,200	″
DETROIT	300,000	″
HILLS CREEK	200,000	″
COUGAR	155,000	″
GREEN PETER	270,000	″
FOSTER	30,000	″
FALL CREEK	115,000	″

LEGEND

- PRECIPITATION
- WATER STORED IN RESERVOIR
- WATER IN EXCESS OF INFLOW RELEASED FROM RESERVOIR

WILLAMETTE RIVER BASIN, OREGON
SANTIAM RIVER

NATURAL AND REGULATED HYDROGRAPHS
FLOODS OF 1945 AND 1961

U. S. ARMY ENGINEER DISTRICT, PORTLAND

PREPARED: CHIEF, WATER CONTROL SECTION
RECOMMENDED: CHIEF, ENGINEERING DIVISION
SUBMITTED: CHIEF, PLANNING BRANCH
APPROVED: COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

GP-20-24/3

US Army Corps
of Engineers®
Portland District

EXHIBIT A

DROUGHT CONTINGENCY PLAN FOR THE WILLAMETTE VALLEY PROJECT

Detroit reservoir at minimum power pool, after the 2015 Drought (Oct 17, 2015)

Drought Contingency Plan for the Willamette Valley Project

Table of Contents

Page

Page

Tables	Page

Figures	Page

BLANK PAGE

1.0 Introduction.

1-01. Purpose. The purpose of this document is to provide a drought contingency plan (DCP) for USACE reservoirs in the Willamette Valley Project.

1-02. Requirements. This DCP for the Willamette Valley Project meets the requirements of ER 1110-2-1941, *Development of Drought Contingency Plans*, dated 15 September, 1981. Engineering Regulation (ER) 1110-2-240, *Water Control Management*, dated 30 May 2016, Section 2-3.i, states that water control management policies and procedures, including project regulation, shall be evaluated for adaptation to climate change. A vulnerability assessment by the USACE, summarized in two reports, the 2011 and 2012 *USACE Climate Change Adaptation Plans and Report*, dated September 2011, and June 2012, respectively, identified drought as a source of continuing vulnerability in the future. Updated policy and guidance regarding DCP updates to account for climate change is planned as stated in the CWTS[1] Report 15-15, *USACE Drought Contingency Planning in the Context of Climate Change, U.S. Army Corps of Engineers: Washington DC*, dated September 2015 (Pinson et al., 2015).

1-03. Background. This 2017 DCP update provides a description of historical droughts, drought signals and indicators, drought trends in the context of climate change, water uses and availability, flow and drought management for the Willamette Valley Project, and addresses coordination and communications to take place during a drought situation. This DCP will be included as an exhibit to the Willamette Master Manual and the individual water control manuals upon approval. As of 2017, the Willamette Master Manual draft, dated March 2015, is awaiting the updated NEPA documentation on the operations and maintenance of the Willamette Valley Project.

1-04. Responsibilities. The Portland District Reservoir Regulation & Water Quality Section (CENWP-EC-HR) is responsible for preparation, revision, and implementation of the DCP. The Northwestern Division Water Management, Columbia Basin (CENWD-PDW) is responsible for oversight and approval of this DCP.

2.0 Authorities

The following list of authorities is pertinent to the preparation of drought contingency plans and drought related activities:

- Section 6 of the Flood Control Act of 1944, 33 U.S.C. § 708, provides authority for the Secretary of the Army to enter into agreements for surplus water with states, municipalities, private concerns, or individuals at such prices and on such terms as he may deem reasonable for domestic, municipal, and industrial uses (but not for crop irrigation), for surface water that may be available at any reservoir under the control of the Department of the Army, and provides adequate authority to permit temporary withdrawal of water from USACE projects to supplement normal supplies.

[1] "CWTS" is Civil Works Technical Series

- Flood Control Act of 1941, Pub. L. No. 84-99, 33 U.S.C. § 701n, as amended by Section 82 of the Water Resources Development Act of 1974, Pub. L. No. 93-251, grants the Chief of Engineers discretionary authority to provide emergency supplies of clean water. Work under this authority requires a request from the governor of the affected state. This law authorizes an emergency fund to be expended in preparation for emergency response to natural disasters, including drought, and authorizes the Chief of Engineers to perform emergency work and to provide emergency supplies of clean water on such terms as he determines to be advisable as a result of drought.
- Pub. L. No. 95-51, Disaster Relief Act of 1974 Appropriations Act, amended the Flood Control Act of 1941 to provide for disaster relief, and authorized the Secretary of the Army to construct wells and transport water to farmers, ranchers, and political subdivisions within areas determined to be drought distressed.
- The National Drought Policy Act of 1998, Pub. L. No. 105-199, established the National Drought Policy Commission to provide advice and recommendations on creation of an integrated coordinated Federal policy designed to prepare for and respond to serious drought emergencies.
- ER 1110-2-1941, *Development of Drought Contingency Plans*, dated 15 September 1981, provides policy and guidance for the preparation of drought contingency plans as part of the USACE over-all water management activities.
- ER 1110-2-240, *Water Control Management*, dated 30 May 2016, describes the policies and procedures to be followed in water management activities, including special regulations to be conducted during droughts. It also sets the responsibility and approval authority in development of water control plans.
- ER 500-1-1, *Emergency Employment of Army and Other Resources*, dated 30 September 2001, prescribes policies for the Civil Emergency Management Program of the USACE under the Flood Control Act of 1941. Section II of this ER describes the policy for the USACE to provide assistance during drought, the level of assistance authorized in providing emergency water, and funding procedures for emergency water activities.
- ER 405-1-12, *Real Estate Handbook*, dated 20 November 1985, provides guidance for issuing an appropriate real estate instrument for water withdrawal users who will be installing water lines or other facilities or equipment.
- EM 1110-2-3600, *Management of Water Control Systems*, 30 November 1987 requires that the drought management plan be incorporated into the project water control manuals and master water control manuals. It also provides guidance in formulating strategies for project regulation during droughts.

The USACE Institute for Water Resources, *Water Supply Handbook*, *Report 96-PS-4*, dated December 1998, Chapter 2, provides the authorities, policies and procedures for the different types of water during a drought. This includes storage costs, restrictions, disaster relief, emergency water supply planning and other water uses during a state of emergency, including drought conditions.

3.0 Droughts

3-01. Definition of Drought. The CWTS report 15-15 (referred to in Section 1-02), classifies three types of drought: meteorological, agricultural, and hydrologic. Socioeconomic and ecological droughts are other types described by the National Drought Mitigation Center. These types of droughts are described follows:

- **Meteorological** drought is a period of months to years in which precipitation is below normal. It can be accompanied by above-normal temperatures and other factors. It can precede and cause the other types of drought.
- **Agricultural or soil-moisture** drought is a period with dry soils which can reduce crop production and plant growth. Soil-moisture drought can result from below-normal precipitation, above-normal evaporation, or intense but less-frequent precipitation events. Susceptibility to soil-moisture drought can depend on crop or vegetation type.
- **Hydrologic** drought refers to a period when river streamflow and water storages in aquifers, lakes and reservoirs fall below long-term mean levels. It can develop slowly as stored water is used but not replenished.
- **Socioeconomic** droughts occur when the demand for an economic good exceeds supply as a result of a weather-related shortfall in water supply. The supply of economic goods, such as water, forage, food grains, fish and hydropower depends on weather. Because of the natural variability of climate, water supply is ample in some years, but not able to meet human and environmental needs in other years.
- **Ecological** drought is a prolonged and widespread deficit in naturally available water supplies, which include changes in natural and managed hydrology and create multiple stresses across ecosystems.

3-02. Historical Oregon Droughts. Droughts in Oregon occur in all parts of the state and in both winter and summer months. The region east of the Cascade Mountain Range is the most vulnerable to drought with localized risks statewide where climate is influenced by local topographical features. Water is often in short supply in much of Oregon during the low flow months of July through September. Figure 3-1 is reproduced from the draft Willamette Master Manual, dated March 2015, which shows the low precipitation during the summer months compared to the rest of the year. This condition has been described as Oregon's seasonal "drought". Droughts appear to be cyclic and can have an effect on the economy, particularly on the hydropower and agricultural sectors. Environmental consequences include insect infestations in forests and reduced water availability for endangered fish. Severe drought conditions have preceded major forest fires. Water allocation continues to be controversial.

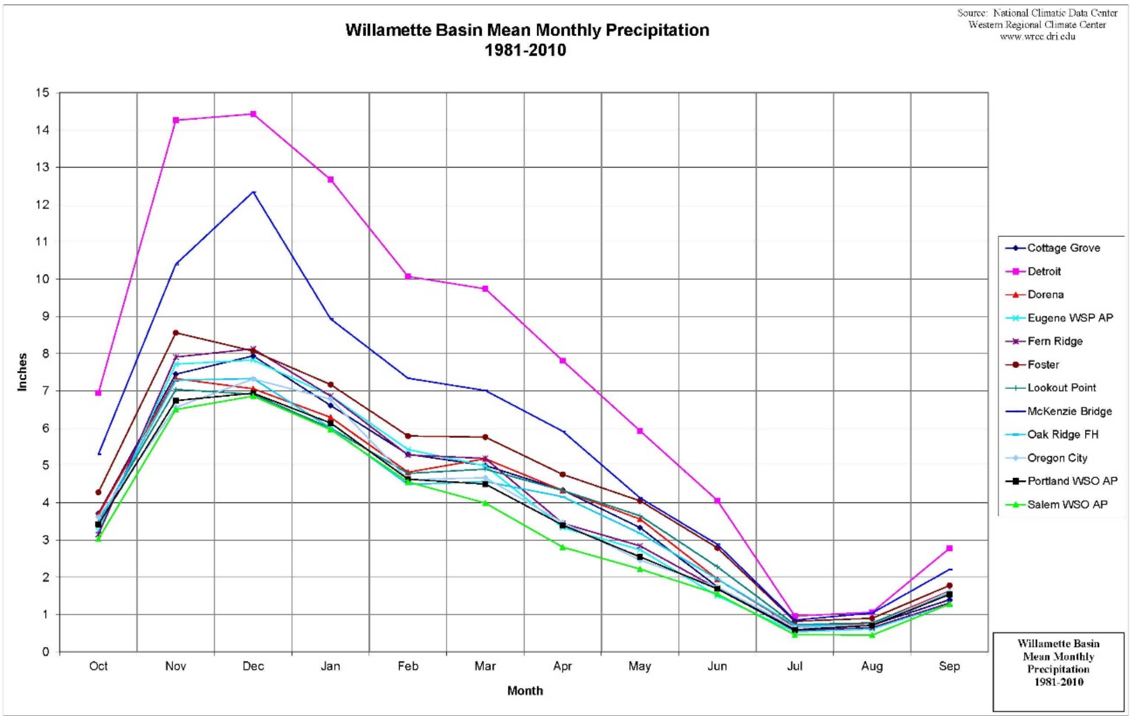


Figure 3-1. Willamette Basin Monthly Precipitation

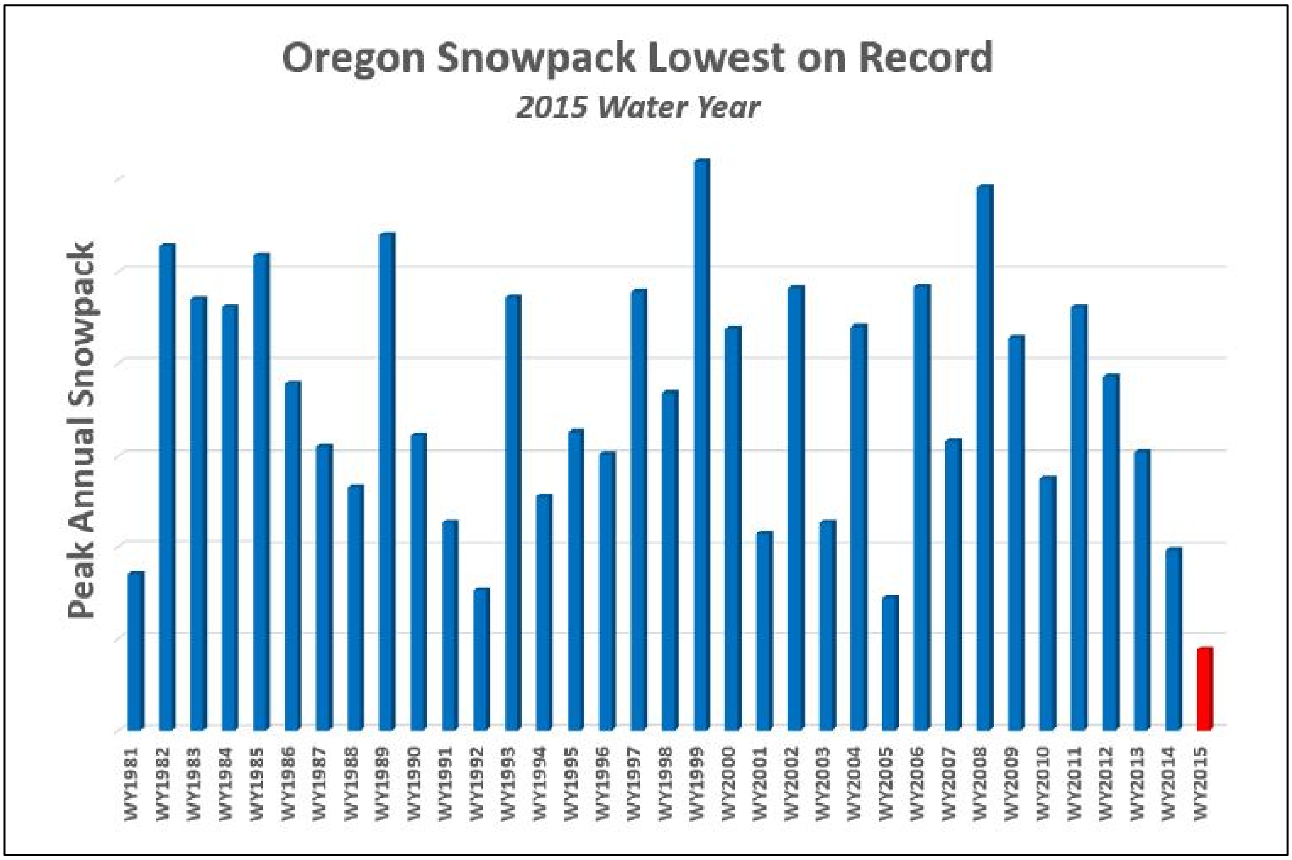
Eight significant hydrologic drought periods have occurred in Oregon since 1900 (*Oregon Emergency Management Plan*, *Natural Hazards Mitigation Plan*, *Drought Chapter*, February 2012, and the *2015 Drought After Action Report for Portland District Reservoir Operations*.).

1904-1905: Drought period of about 18 months
1917-1931: Very dry period punctuated by brief wet spells (1920-21, 1927)
1939-1941: Three year intense drought
1976-1977: Brief, but intense statewide drought
1985-1994: Generally dry period, with statewide droughts in 1992 and 1994
2001-2002: Second most intense drought in Oregon's history
2005: Drought affected at least eleven of Oregon's thirty-six counties
2015: El Niño brought dry and very warm conditions from February thru October

The most recent drought year occurred in water year 2015, and was a low water year for the history books with record low snowpack and streamflows along with record high temperatures that combined to create drought conditions across Oregon.

Based on the Oregon Surface Water Supply Index (SWSI) (see section 3-04.c), water year 2014 began quite dry, became normal in June and July, and then became dry again in September, resulting in an extremely dry start to water year 2015. The 2015 statewide snowpack set new record lows, replacing the previous low-snow years of 1977, 1981, 1992 and 2005. Many snow sites set records for the lowest peak snowpack and earliest melt-out date since measurements began. Figure 3-2 shows the relative, state-wide peak annual snowpack for each water year, 1981 through 2015, showing that 2015 was the lowest for this period.

For the period May 2015 through July 2015, Oregon recorded the warmest average temperatures since 1895 when record keeping began. By 1 September 2015, the SWSI for the entire state ranged from -1.65 to -3.78 (recalibrated as of September 2016), with the Willamette Basin at 3.78. By the end of September, the U.S. Drought Monitor showed the Willamette Basin to be in a D2 Severe Drought condition and 25 of Oregon's 36 counties had requested and received drought declarations from the Governor. Reservoirs fell to unprecedented levels, irrigators stopped irrigation early in the season, and some cities implemented water restrictions.



Source: Drought Annex, State of Oregon Emergency Operations Plan, January 2016

Figure 3-2. Peak Annual Oregon Snowpack 1981-2015

3-03. Drought Signals and Indicators. A key to understanding the impacts of a drought is to evaluate the specific components of the hydrologic cycle. Precipitation and snow can be considered the carrier of the drought signal, while hydrologic processes such as snowpack accumulation and melt, runoff, evaporation rates, soil moisture, streamflow magnitudes, and groundwater content and flow can be viewed as the indicators revealing the drought presence.

The El Niño Southern Oscillation Index (ENSO) refers to the cyclical conditions that occur across the equatorial Pacific Ocean due to natural interactions between the ocean and atmosphere. El Niño is the warm phase of the ENSO cycle and the La Niña, is the cool phase. A major El Niño event generally occurs every 3 to 7 years and tends to bring drier winters to the Pacific Northwest which could signal a potential drought. La Niña conditions in the Pacific Northwest are often, but not always, characterized by cold air temperatures starting in November and December, high snowpack conditions in the mountains and low elevation snowfall in the valleys, and reduced snowmelt in the mountains until late spring.

There does not appear to be a viable connection with ENSO for short term or sustained drought for Western Oregon. The overall warm signal for the Pacific Northwest during ENSO is marginal for Western Oregon at best. El Niño warmth may suggest higher snow levels, producing a less reliable snowmelt in the spring, which could be a factor for refill of the reservoirs. The La Niña (ENSO) phase, does lean wetter for the Willamette and might be considered to not produce a drought situation; however, caution should be used when considering the use of ENSO, as the resolution in climate models is low, there are lots of uncertainty, and the opposite of what might be expected in a La Niña or El Niño year does occur.

A discussion of the up-to-date ENSO status is issued monthly by NOAA's Climate Prediction Center and the International Research Institute for Climate and Society. The discussions and data can be accessed at the Climate Prediction Center's website provided in the Weblinks section of this document.

3-04. Drought Monitoring and Climate Forecasts. The United States Department of Agriculture (USDA) and the Natural Resources Conservation Service (NRCS) provide climate forecasts that include indicators of drought. Regulators monitor and use these to aid in making water management decisions.

a. USDA Drought Monitor. The USDA provide maps, data, and forecasts related to drought through the Drought Monitor website. The U.S. Drought Monitor is a weekly product that provides a general summary of current drought conditions. Various indices, outlooks, field reports, and news accounts are reviewed and synthesized. Policymakers and the media use the information in discussions of drought and in allocating drought relief. The Drought Monitor provides a color coded map of the U.S. that shows levels of drought intensities by region. The Drought Monitor Update Report for Oregon can be accessed at the weblink provided in the Weblinks section of this document.

b. Natural Resources Conservation Service Oregon. The NRCS Oregon provides snow and precipitation data for current water year, water supply outlook reports, climate, and soil moisture/temperature data for their SNOTEL sites. Snow survey products and water supply outlook reports for Oregon are provided through maps and graphs, and can be accessed at the weblink provided in the Weblinks section of this document.

The water supply outlook reports include the Oregon Basin Outlook Report, streamflow forecast tables and maps, daily water supply forecasts, reservoir reports, and the Surface Water Supply Index. The Oregon Basin Outlook Report provides a monthly update (January through June) of the water supply for select basins across Oregon and includes the current status of the snowpack and long term water supply forecasts.

c. Drought Severity. Drought is typically measured in terms of water availability in a defined geographical area. It is common to express drought with a numerical index that ranks severity. NOAA uses the Palmer Drought Severity Index that provides data back to 1900. Most federal agencies use the Palmer Method. This method uses precipitation, runoff, evaporation, and soil moisture as variables. Because the method does not use snowpack as a variable, the Palmer index does not provide an accurate indication of drought in the Pacific Northwest and Oregon; however, it can be useful because of its long term historical record of wet and dry conditions back to 1900.

The Oregon Water Resources Department uses the Surface Water Supply Index (SWSI) to help assess drought conditions. The SWSI is developed by the NRCS. The SWSI is calculated using mountain snowpack, precipitation, reservoir storage, and streamflow data to predict the anticipated water availability for the upcoming year. The SWSI scale measures anticipated water supply by drainage basin, ranging from a +4.1 representing extremely wet conditions to -4.1, representing extremely dry conditions. The SWSI calculations use different equations for each month, all available data, an objective method to determine coefficients, and a 5-month running average to smooth the effects between months. Figure 3-3 shows the 14 river basins within Oregon used to evaluate state-wide drought conditions. The up-to-date and historic SWSI values can be accessed at the weblink provided in the Weblinks section of this document.

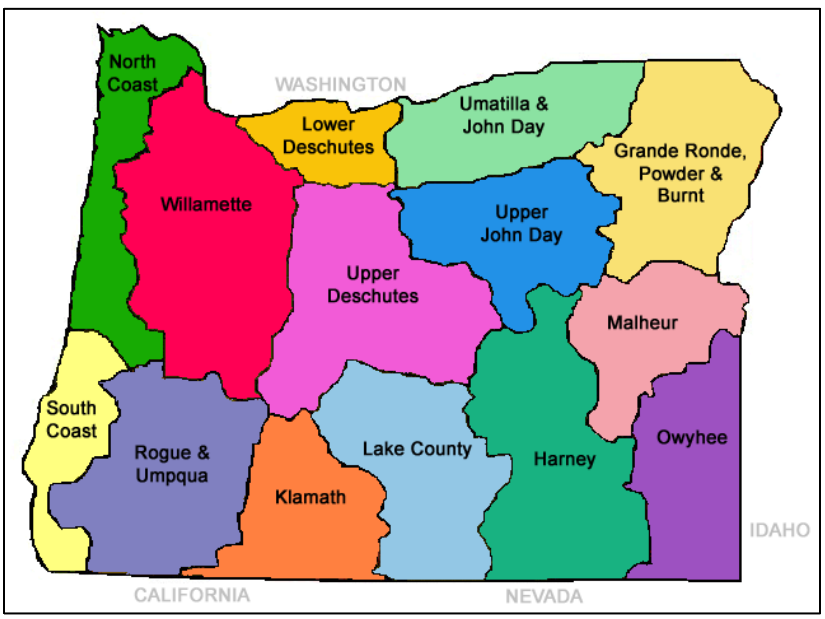


Figure 3-3. Oregon River Basins to Evaluate Drought Conditions

3-05. Drought in the Context of Climate Change. Drought contingency plans are a critical element of flexible water management when combined with water control manuals and the operation deviation process. The following describes efforts to include climate change in DCPs, climate and streamflow projections in Oregon, and implications to future operations of the Willamette Valley Project.

a. Drought Contingency Planning for Climate Change. The CTWS Report 15-15, contains an overview of climate change and drought in the U.S. to aid in planning for current and future droughts at USACE projects. As of 2017, the report may be accessed at the weblink provided in the Weblinks section of this document. Table 1 of the CTWS Report 15-15, shows that the prediction for the Northwest is for a possible increase in summer drought conditions, and increased hydrologic drought due to changes in mountain snowpack. Appendix B of the report provides a summary of the climate change impacts for six regions in the U.S., including the Northwest.

b. Climate and Streamflow Projections. The report prepared for the CENWP by the Oregon Climate Change Research Institute, *Historical Trends and Future Projections of Climate and Streamflow in the Willamette Valley and Rogue River Basins*, dated June 2015 and revised March 3, 2016, examines observed changes in temperature, precipitation, snowpack, and streamflow in the Willamette and Rogue River Basins, provides projections of the future changes of these variables based on global climate model (GCM) simulations, and addresses implications to water management. The following is a summary of the findings of this study. Refer to the report for details.

1) Temperature. The temperature trend analysis shows, that the minimum and maximum temperatures are projected to increase year-round with greater warming in June through August periods. There is a high degree of confidence in the temperature increases because all models agree with the trend.

2) Precipitation. Some model predictions show an increase and some show a decrease in precipitation. The average multi-model projection change is small in each season, with slightly more precipitation in the winter and less in the summer. While the average multi-model projection change is small, the range of plausible outcomes should be considered.

3) Snowpack. Snow water equivalent as a portion of cumulative precipitation is expected to decline across the region. The North Santiam sub-basins which historically receive the most snow, show a projected December through February decline. The Middle Willamette sub-basin generally receives less snow compared to the other basins and future trend is to receive even less snow. In addition, the small increases in total winter precipitation are projected to potentially equate to very little snow in the future due to the increase in winter temperatures.

4) Streamflow. Changes in streamflow are primarily driven by decreases in snow accumulation, and secondarily by seasonal variation in precipitation change. Models show that mean winter flows will increase and summer flows will decrease, with the magnitude of change mainly determined by the basin’s sensitivity to a decline in snow accumulation. The North Santiam is considered sensitive to the snowpack. In this basin, the mean flow is projected to increase significantly during the winter and decrease in the spring and summer, whereas, in the

Middle Fork, the winter flows are projected to increase slightly with small changes during the rest of the year.

Annual peak flows are projected to increase in the future with the peak flows with lower return periods to increase more than those with higher return periods. For rain driven basins, annual peak flows of are of short duration (1 to 5 days), and are projected to occur up to 5 days earlier in the water year. For basins with a larger snowmelt component such as in the North Santiam, peaks are expected to occur up to 2 weeks earlier.

c. Implications for Water Management. The probability of drought is projected to increase under future climate change if drought were defined as prolonged periods of demand exceeding supply. As of 2017, it is not clear if current operations provide enough flexibility to manage hydrological changes.

4.0 Basin Description

4-01. Willamette Basin Description. The Willamette Basin is an 11,200 square mile watershed that is a major tributary to the Columbia River and is located entirely within the state of Oregon. The basin has a maximum north-south length of about 150 miles, averages about 75 miles in width, and encompasses 12 percent of the state. The basin is bound by three mountain ranges: the Cascade Range to the east, the Coast Range to the west, and the Calapooya Mountains to the south. Maximum elevations exceed 10,000 feet in the Cascade Range, 4,000 feet in the Coast Range, and 6,000 feet in the Calapooya Mountains. Thirteen of Oregon's thirty-six counties intersect or lie within the boundary of the basin and nearly seventy percent of Oregon's population lives within the basin.

Principal tributaries of the Willamette River originate in the Cascade Range and have headwater elevations generally around 6,000 feet (see figure 4-1). In the upper reaches, these tributaries flow in narrow valleys with steep gradients. The major Cascade Range tributaries include the Santiam, McKenzie, Middle Fork of the Willamette, Molalla, and Clackamas Rivers. The Willamette River is also fed by major tributaries from the Coast Range, including the Long Tom, Marys, Luckiamute, Yamhill, and Tualatin rivers. At the south end of the basin, the Coast Fork of the Willamette River emerges from the Calapooya Mountains and joins the mainstem Willamette River near the City of Springfield (near Eugene).

Precipitation ranges from 40 to 200 inches in the Willamette Basin. Based on computations from USGS data, the average annual flow at Salem (river mile 84, drainage area of 7,280 square miles) for the water years 1910-2015 is 23,300 cfs, or about 16.9 million acre-feet per year. The minimum daily flow at Salem was 2,480 cfs on 27 August 1940. This flow occurred before the USACE dams were completed and operational. The minimum regulated flow for the period 1970-2016 after all of the USACE dams in the Willamette Basin became operational, was 4,140 cfs which occurred on February 20th, 1977.

4-02. Willamette Reservoir System. The USACE operates 13 dams in the Willamette Basin. The system of 13 dams is referred to as the Willamette Valley Project. Eleven of the USACE dams are operated as multiple purpose storage projects and two are strictly reregulating dams for hydropower production. The locations of the individual dams are shown on figure 4-1. The USACE' reservoirs in the Willamette Valley Project can store up to approximately 1.6 million acre-feet of usable water. This represents about 9 percent of the average annual runoff of the Willamette River at Salem. The 13 USACE dams manage about 27 percent of the entire drainage area above Portland and 42 percent of the drainage area above Salem.

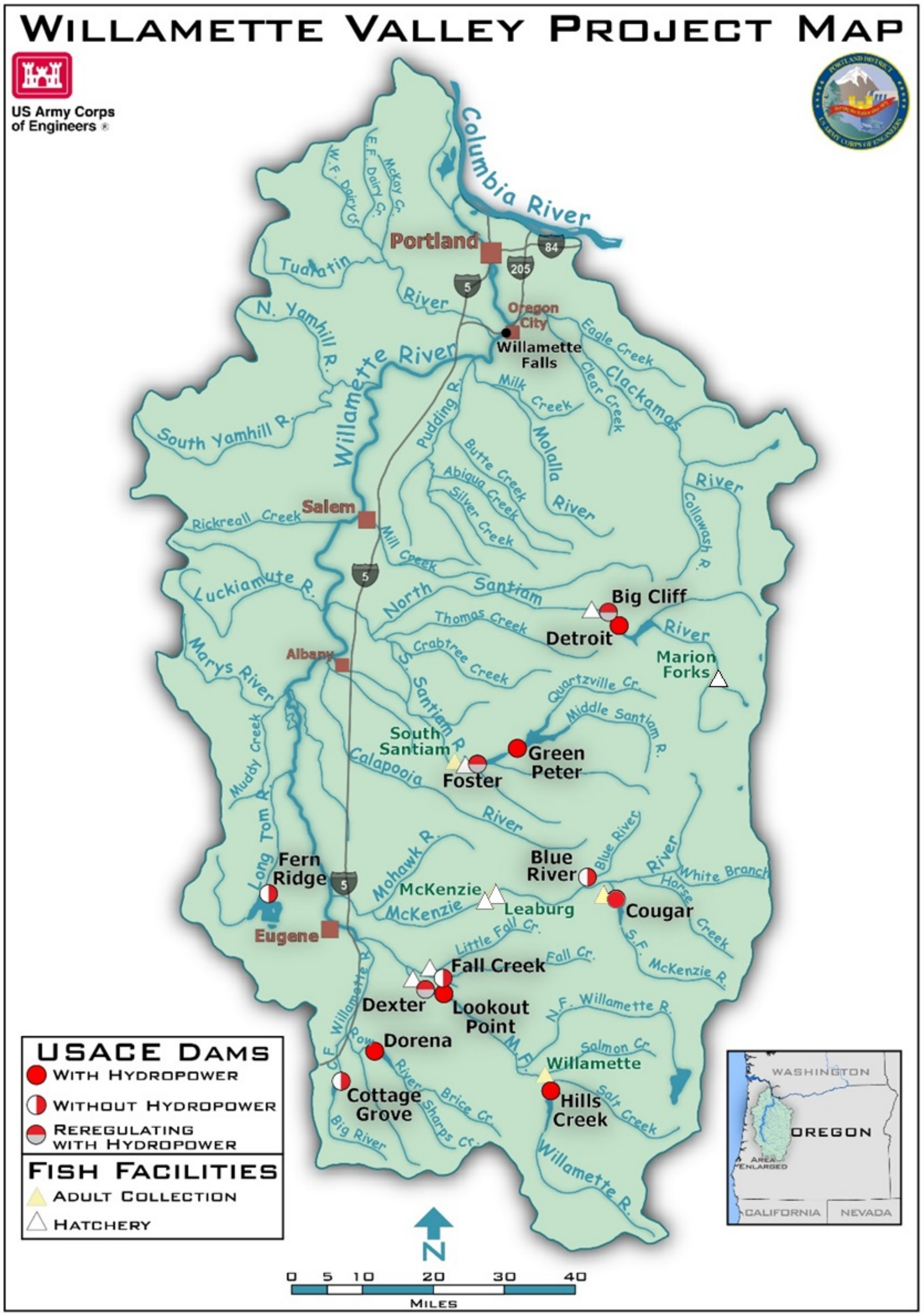


Figure 4-1. Willamette Valley Project Map

4-03. USACE Projects in the Willamette Valley Project. The list of 13 USACE projects in the Willamette Basin are shown on table 4-1. Each water control manual is an appendix to the draft

Willamette Master Manual. As of 2017, the Willamette Master Manual is in draft form while awaiting updated NEPA documentation on the operations and maintenance of the Willamette Valley Project, which is required for approval of the Master Manual. The location of each project is shown on Figure 4-1. A description of each project can be found in their respective water control manuals. Three projects have reregulation dams downstream of them; Big Cliff is the reregulation dam for Detroit; Dexter is the reregulation dam for Lookout Point; and Foster is the reregulation dam for Green Peter, but also has storage capability.

Table 4-1. List of Willamette Valley Project Water Control Manuals

Appendix	**Project**
--	Willamette Master Manual
1-A	Blue River Lake
1-B	Cottage Grove Lake
1-C	Cougar Lake
1-D	Detroit and Big Cliff Lakes
1-E	Dorena Lake
1-F	Fall Creek lake
1-G	Fern Ridge Lake
1-H	Foster Lake
1-I	Green Peter Lake
1-J	Hills Creek Lake
1-K	Lookout Point and Dexter Project

5.0 Water Uses and Availability

5-01. Water Uses. Water that is stored in the Willamette Valley Project is currently (2017) used for irrigation, fishery enhancement, recreation, hydropower, and environmental flows. Future water storage allocations may include municipal and industrial water supply. It is increasingly important to plan for providing adequate flows for multiple water uses. Informed decision making is accomplished through coordination of the Willamette Conservation Plan (see Section 7-02). The following is a brief description of water use in the Willamette Basin. In addition the effect on cultural resources as a result of low pool levels is provided.

a. Irrigation. According to House Document (HD) 531 that provides authorization for the Willamette Valley Project, irrigation was anticipated to be a significant use of water stored in the Project reservoirs. The U.S. Bureau of Reclamation (Reclamation) administers water service contracts for irrigators within 15 water service contract reaches. Irrigation use in the Willamette Basin has not occurred as initially projected and is not expected to occur in the future at levels near the scope and scale originally envisioned. As of February 2017, nearly 75,000 acre-feet of water (less than 5% of the conservation storage) is contracted for irrigation. Table 5-1 shows the number of contracts within each reach, volume of water contracted, and the acres served for each reach in the Willamette Basin. Figure 5-1 shows the reach locations.

Table 5-1. Willamette System Irrigation Contract Data

	Reach	Reservoirs Providing Water	Number of Contracts	Acre-Feet Contracted	Acres Served
1	Willamette River	All Reservoirs	45	22,825	11,289
2	Santiam River	All Reservoirs on North and South Santiam Rivers	3	242	323
3	North Santiam River	Big Cliff, Detroit	29	11,375	6,584
4	South Santiam River	Foster, Green Peter	13	914	492
5	Willamette River	All Reservoirs Except Santiam Reservoirs	28	15,603	11,015
6	Long Tom River	Fern Ridge	55	19,715	8,379
7	Willamette River	All Reservoirs Except Santiam and Fern Ridge	9	749	458
8	McKenzie River	Blue River, Cougar	31	1,772	911
10	Middle Fork Willamette River	Fall Creek, Dexter, Lookout Point, Hills Creek	2	911	472
11	Middle Fork Willamette River	Dexter, Lookout Point, Hills Creek	2	92	37
12	Fall Creek	Fall Creek	3	11	5
13	Coast Fork Willamette River and Row River	Dorena, Cottage Grove	6	581	233
14	Row River	Dorena	1	51	20
15	Coast Fork Willamette River	Cottage Grove	1	56	45
	Total		**228**	**74,899**	**40,262**

Source: Reclamation, as of February, 2017

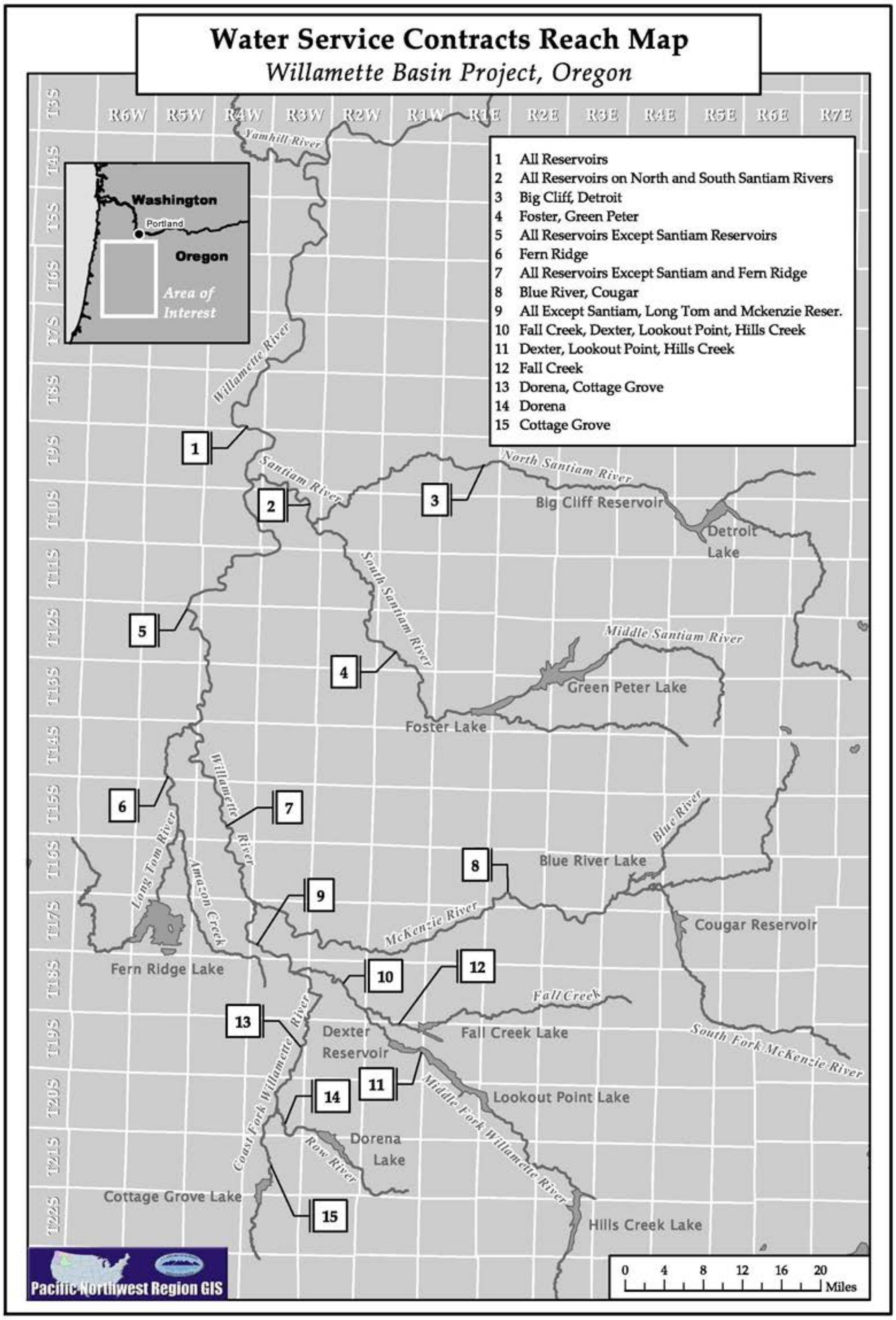


Figure 5-1. Water Service Contracts Reach Map

b. Fishery Enhancement. State and federal fishery resource agencies have identified a number of fish species in the Willamette Basin that are of regional or national significance. Upper Willamette River (UWR) winter steelhead, UWR Spring Chinook salmon, and bull trout are listed as "threatened" under the national Endangered Species Act. Oregon chub was listed as threatened but was delisted in 2015. As habitat degradation and water quality problems, including temperature, affect fish populations, it will be increasingly important to provide for adequate flows in the Willamette Basin.

c. Recreation. Reservoir recreation such as boating and water skiing are major revenue sources for many basin communities. Peak demand for these activities often coincides with the driest point of the summer season, when water for irrigation and in-stream needs is most critical. In some years as early as July, some reservoirs may be drawn down to levels too low to allow use of boat ramps; however, these same summer releases may provide flows for fishing, kayaking, and other recreation on rivers like the McKenzie and North Santiam. The reservoirs are not operated to meet recreation needs during a drought.

d. Hydropower. Eight of the Willamette Valley Project dams have a federal hydropower facility. These dams provide enough power to service 300,000 homes. Generation from the peaking projects are often based upon load throughout the day or week and are subject to frequent fluctuations. The reregulation reservoirs are used to absorb the fluctuations in flows from their upstream peaking projects and release flows at a more uniform level. The generation at the baseload projects provides uniform generation supply. Monthly generation can change drastically from year to year depending on the amount of runoff which occurs in the basin. A non-federal hydropower facility was added to Dorena Dam in 2014. The Dorena water control plan has not been altered due to installation of the hydropower facility. All flow releases from Dorena Dam are as determined by CENWP-EC-HR and reservoir regulations are documented in the Dorena Water Control Manual.

e. Environmental. A set of environmental flow recommendations (e-flows) were developed through the Sustainable Rivers Project, a USACE and The Nature Conservancy partnership. The purpose and benefits of the e-flows are to improve habitats on the flood plain margins, re-establish some river dynamism such as increasing river sediment transport, thereby encouraging re-formation of pools and riffles, re-establishing extant flood plain connection and smoothing the flow transitions after winter high flow events to facilitate lateral movement between refugia, seed dispersal, and birdnesting, etc. These operations are targeted for winter and spring months and use water that would need to be released to stay within the rule curve elevations. The e- flow operations provide ecological benefits while affecting minimal change to flood risk reduction, water quality, hydropower and meeting biological opinion flow objectives. E-flow targets are for the Middle Fork Willamette River at Jasper (outflows from Fall Creek and Dexter), South Fork McKenzie outflows from Cougar, and the North Santiam at Mehama (outflows from Big Cliff) and have been incorporated into the respective water control manuals.

f. Municipal and Industrial Water Supply. Some of the largest cities in the Willamette Basin rely on the Willamette River and its tributaries for drinking water. As population increases throughout the valley, and as environmental and financing issues reduce the likelihood that municipalities will build new reservoirs for drinking water, river flow and existing reservoirs will continue to be an important water source.

Throughout the basin, employers such as pulp and paper mills use river water directly without purchasing through a municipal provider. In addition, high-tech industries have grown and have a significant demand for water. Although most of the high-tech industries receive their water through a municipal system, it is important to include all industry needs when planning for dry season uses of reservoir water.

As of 2017, the Willamette River Basin Review Feasibility Study is assessing the feasibility of reallocating storage in the Willamette Valley Project reservoirs from general joint-use to specific originally authorized purposes, including municipal and industrial (M&I) water supply, irrigation, and fish and wildlife. Any reallocation plan will require approval from Congress as the volume of storage exceeds the limits for local approval. Once the storage is reallocated and state issued water rights are modified, storage will be available for M&I use. The amount of storage and water expected to be needed for M&I is higher than listed in HD 531, but still much less than irrigation.

g. Navigation. Navigation is an authorized purpose of the Willamette Valley Project, but the project flows are no longer regulated for navigation use above the Willamette Falls Lock at Oregon City. Project authorizing documents (HD 544, 75th Congress, third session, March 16, 1938) stipulated a minimum flow of 5,000 cfs between Albany and the Santiam River, and 6,500 cfs downstream to Salem to provide navigation depths of 6 feet and 5 feet, respectively, above Willamette Falls. These minimum flows have been adopted for water quality purposes (see section 5-01.h). Over the years, the ODEQ has issued wastewater discharge permits based on a 7Q10 flow (the EPA definition: the lowest 7-day regulated average flow that occurs on average once every 10 years), which is approximately 5,500 cfs near Salem. The USACE continues to attempt to meet these flows to aid in water quality and fisheries enhancement in compliance with the 2008 Biological Opinion.

h. Water Quality. The minimum congressional flows of 5,000 cfs at Albany and 6,500 cfs at Salem were established for the purposes of navigation, but have become base flows used to maintain water quality standards in the mainstem Willamette. Both water quantity and quality were of great concern, particularly in watersheds with salmon and other fish species listed as endangered or threatened under the Endangered Species Act. Many streams in Oregon do not meet water quality standards during the summer due to high water temperatures, but release of water from reservoirs provide some aid in reducing water temperatures downstream of the dams. Water quality standards are also limited due to inadequate riparian zones and increasing problems associated with agriculture and forestry chemicals.

i. Effects on Cultural Resources. The USACE Willamette Valley Projects Dams lies within the traditional lands for four federally recognized Native American Tribes, the Confederated Tribes of the Grand Ronde Community of Oregon, the Confederated Tribes of the Siletz Indians, the Cow Creek Tribes of Umpqua Indians, and the Confederated Tribes of the Warm Springs Reservation of Oregon. The tributaries that the dams block are used traditionally by these tribes (historically and today) for the gathering of plants for food and fiber, fish, and other wildlife associated with the watershed. The projects also have inundated hundreds of historic and Native American archaeological sites. Drought situations where water levels are altered, such as being lower for longer periods of time, might affect the archaeological resources due to exposure, wave action, recreational uses, and vandalism / looting. It also has the potential to have an additional negative effect on subsistence fishing utilized by the Tribes. The USACE has a responsibility to the protection of these resources, archaeological and historic under the National Historic Preservation Act. Tribal traditional cultural properties are included under the NHPA, as well as the consultation and coordination under the Executive Order 13175, Department of Defense (DoD) American Indian and Alaska Native Policy, 2004; Department of the Army American Indian and Alaska Native Policy, 24 Oct 2012; Tribal Consultation, Presidential Memorandum, 5 Nov 2009: USACE Memorandum, Sovereignty and Government-to-Government Relations with American Indian and Alaska Native Tribal Governments: USACE Tribal Policy Principles, 10 May 2010; and USACE Tribal Consultation Policy, 1 Nov 2012.

5-02. Available Storage. The storage of water in the Willamette Valley Project is based on seasonal regulation schedules established according to each project's rule curve. The Willamette Valley Project can store up to approximately 1.6 million acre-feet of water within the conservation pool. The ability to use water from inactive storage, power pool storage, and uncontracted stored water is described below.

a. Quantity of Inactive Storage. For projects with hydropower that have regulating outlets (Hills Creek, Lookout Point, Cougar, Green Peter, and Detroit), the inactive storage is the reservoir capacity between the minimum power pool and the lowest regulating outlet invert elevation. For projects without USACE operated hydropower (Fall Creek, Cottage Grove, Dorena, Fern Ridge, and Blue River), the inactive storage is the reservoir capacity between the minimum flood pool and lowest regulating outlet invert elevations. For reregulation projects (Dexter, Foster, and Big Cliff), the inactive storage is the reservoir capacity between the minimum power pool and the spillway crest. The total inactive storage for the Willamette Valley Project reservoirs is approximately 359,999 acre-feet. Table 5-2 shows the percent of inactive storage by project.

b. Ability to Use Inactive Storage. Under no circumstances should the inactive storage be used for power generation, as operating to the low heads could cause damage to the turbines. In 2015, most of the Willamette Valley Project reservoirs dipped into inactive storage to meet minimum flow with little impact. The impact of drafting into the inactive storage is an increased risk of not refilling the reservoir. Fall Creek Project uses 9,505 acre-feet of inactive storage in winter for a maximum of two weeks to pass predatory fish in order to reduce predation on salmonids in the reservoir.

Table 5-2. Inactive Storage Volume by Project[1]

Project	Inactive Storage Volume (Acre-Feet)	Inactive Storage (Percent)
Hills Creek	6,600	1.8%
Lookout Point	19,194	5.3%
Dexter	97,644	27.1%
Fall Creek	9,505	2.6%
Cottage Grove	3,139	0.9%
Dorena	7,355	2.0%
Fern Ridge	2,802	0.8%
Cougar	16,700	4.6%
Blue River	3,430	1.0%
Green Peter	71,220	19.8%
Foster	10,980	3.1%
Detroit	109,700	30.5%
Big Cliff	1,730	0.5%
Total	**359,999**	100.0%

[1]Volumes derived based on reservoir storage capacity tables located on the CENWP-EC-HR weblink, as of June 2017.

c. Ability to Use Power Pool Storage. The power pool is the reservoir capacity between the minimum flood pool and the minimum power pool. Table 5-3 shows the powerpool storage by project (Dexter and Big Cliff do not have flood pools, therefore they are not shown). Under project authorities, the power pool is reserved exclusively for power generation. Infrequent, limited (or modest) drafting into the power pool on a case-by-case basis may be accomplished pursuant to project authorities. This decision must be coordinated with the Bonneville Power Administration to ensure that any decision to use the power pool has taken into consideration power requirements. The decision should also consider how critical the need is to draft (e.g., biological need to provide minimum flows at the time).

If reservoirs draft to the minimum power pool level, generation will be stopped to avoid damage to the generating units. Station service will be supplied to the plants from the transmission grid. Regulating outlets will be used to maintain streamflow.

Table 5-3. Powerpool Storage Volume by Project[1]

Project	Powerpool Storage Volume (Acre-Feet)	Powerpool Storage (Percent)
Hills Creek	48,800	28.5%
Lookout Point	11,377	6.6%
Cougar	8,700	5.1%
Green Peter	62,600	36.5%
Foster	3,600	2.1%
Detroit	36,375	21.2%
Total	**171,452**	**100.0%**

[1]Volumes derived based on reservoir storage capacity tables located on the CENWP-EC-HR weblink, as of June 2017.

d. Quantity of Uncontracted Water Supply Storage. The Reclamation holds two water rights with the State of Oregon to store 1.64 million acre-ft (applications filed in 1954 and 1968) of water in the Willamette Valley Project reservoirs for irrigation use only. As of February 2017, there are only 74,899 acre-feet of water actually contracted, therefore the uncontracted storage is about 95% of the water rights storage. It is important to note that the entirety of the conservation storage volume remains is in the joint-use purpose. As of 2017, the conservation storage volume in the Willamette Valley Project is 1.6 million acre-ft. See section 6-03 for more information on irrigation contracts.

e. Ability to Use Uncontracted Water and Procedures to Obtain Water. The withdrawal of water from streams, lakes, and reservoirs, is regulated by the OWRD under the state water law. An applicant must file for a water right with the OWRD. Any withdrawal permit for stored water will be issued subject to a contract or agreement with the owner/operator of the facility (such as the USACE).

f. Use of Surplus Water. Section 6 of the Flood Control Act of 1944 (Public Law 78-534) authorized the Secretary of the Army to enter into agreements for use of surplus water for temporary drought relief, and for purposes other than crop irrigation. Surplus water will only be declared available when the use would not significantly affect other authorized purposes. When stored water is in excess of meeting the authorized project purposes it can be identified as surplus water available for use on a temporary (5 years, with the ability for one 5-year extension). Surplus water withdrawn from the streams below USACE projects will require a signed agreement accompanied by a brief letter report documenting how and why stored water is determined to be available as surplus. The level of detail will be commensurate with the amount of water to be used, time of use, and economic and environmental effects. Authority to sign these agreements by the District Commander requires approval from USACE Headquarters. As of December 2016, the price of the available water is based on the updated cost of storage (highest of four cost methods for the Willamette Valley Project), as required for reallocated storage, though draft rule making issued in December 2016 may change this methodology. A template for a surplus water agreement for use of water from USACE reservoirs is provided in Attachment 1.

6.0 Oregon Water Rights

6-01. Appropriation Doctrine. Water rights in Oregon are managed by the OWRD. Refer to the *Water Rights in Oregon, An Introduction to Oregon's Water Laws*, by the OWRD, dated November 2013. In Oregon, the prior appropriation doctrine has been law since February 24, 1909 when the first unified water code introduced state control over the right to use water. The principle of prior appropriation means the first person to obtain a water right on a stream is the last to be shut off in times of low streamflows. Before 1909, water users had to depend on themselves or local courts to defend their rights to water. The appropriation doctrine holds that a water right is limited to the quantity of water which is beneficially used, without waste. In 1935, an Oregon Revised Statute (ORS 537.1 0) concerning public ownership of water was established. The statute stated that "All water within the state from all sources belongs to the public." During times of low streamflows, the appropriator with the oldest date of priority can demand water specified in their water right permit obtained from the Department, regardless of the needs of other users. The date of priority, determined by the date of application for the permit, determines the seniority of the appropriators' right. The more senior the water right, the longer water is available during periods of low streamflow.

6-02. Instream Water Rights. An instream water right law was enacted in Oregon via Senate Bill 140 during 1987. The Oregon legislation recognized that public uses are beneficial uses, as defined by the appropriation doctrine. The act allows the Departments of Fish and Wildlife, Environmental Quality, and Parks and Recreation to request instream water rights from the Department. The law gives instream water rights the same status as other water rights, except that municipal uses may have priority over these rights. In a Governor declared drought, Oregon law allows the Department to give preference to human consumption and livestock watering over other uses. Unlike minimum perennial streamflows, the commission cannot waive the instream right in favor of later water rights during the periods of low streamflow. Instream water rights have a priority date, and are regulated in the same way as other water rights. An instream water right cannot affect a use of water with a senior priority date. In the Willamette Basin, the majority of the minimum perennial streamflows established in 1964 have not been converted to instream water rights. Once converted the instream water rights will have a priority date of 1964.

Instream water rights do not guarantee that a specified quantity of water will be maintained in a stream or is available for use. When the water level in a stream is below the instream water right level, holders of junior water rights are required to stop using the water. A holder of a water right to the natural flow of the stream has no right to stored water in a reservoir without an additional water right for use of stored water.

6-03. Irrigation Contracts. The Reclamation implements and manages the sale of irrigation water for the Federal government. The Reclamation filed applications for water rights in 1954 and 1968 on behalf of the federal government. Subsequent state water right certificates have been issued to the Reclamation authorizing all of the 1.64 million acre-feet of system conservation pool storage for irrigation uses (Certificates 72755 and 72756). Currently, irrigators have contracted for less than five percent of the 1.64 million acre-feet; however, agricultural needs may increase in the future. To use the stored water, a contract holder with the Reclamation must obtain a state permit to withdraw the water from an Oregon stream, referred to as a secondary water right.

The storage of water in the Willamette Valley Project is based on the seasonal regulation schedules established according to the rule curve for each dam. The USACE coordinates with the multiple federal and state agencies when releasing stored water at projects to meet secondary project purposes.

7.0 Flow Management

7-01. Reservoir Regulation Seasons. Reservoir regulation activities occur over three regulation seasons; major flood, conservation storage, and conservation release. The major flood season is from mid-November through January. During the major flood season, reservoirs are kept at their minimum flood pool to capture high inflows in order to reduce the risk of downstream flooding. The conservation storage season is from February through about mid-May. During this period, the reservoirs fill to their maximum conservation pool level to store water for the conservation release season. During the conservation release season from mid-May through mid-November, water stored within the conservation pool is released for multiple uses, including hydropower, fisheries enhancement, water quality, environmental purposes, recreation, and consumptive use for irrigation.

7-02. Willamette Conservation Plan. The Willamette Conservation Plan (WCP) is the annual water management plan for the Willamette Valley Project and identifies flow and storage needs for each tributary and reservoir in the Willamette Valley Project. Forecasts in April, of runoff volume and system-wide volume storage in the Willamette Valley Project by mid-May are used to set minimum flow objectives for April through October on the mainstem Willamette River, which is central to the WCP. The WCP includes estimates of mainstem flows and reservoir storage volumes likely to occur over the conservation season based on forecasts, system operational alternatives, and constraints through modeling. Reservoir modeling considers the likelihood of meeting the tributary flow objectives in table 7-1 and the mainstem flow objectives in table 7-3. Adaptive management (see section 7-07) may be used to adjust operations within authorized project purposes due to changing conditions and with new knowledge that is gained from ongoing operating experience or studies. Refer to the most recent WCP for the up-to-date minimum flow objectives, as they vary from year-to-year depending on water availability. The WCP may be obtained from the CENWP-EC-HR.

The WCP is coordinated to meet the ESA and all other purposes of the Willamette Valley Project. The Willamette Action Team for Ecosystem Restoration (WATER) is a forum of the Action Agencies (USACE, Reclamation, and BPA), Services (USFWS and NOAA Fisheries), state agencies, and tribes, responsible for planning and implementing flow management in the Willamette Basin. The Flow Management Committee is the technical committee under WATER to coordinate the development of and implement the WCP. The WCP is updated annually during the conservation storage season based on the April forecast made in early April, and anticipated total system storage in mid-May. The plan is fine-tuned in early June after spring refill.

7-03. Forecasts. Forecasts are required during the conservation storage period to assess the timing and capability of refilling to the desired maximum conservation storage elevation of individual projects. The benefits of an accurate forecast are twofold: (1) minimum flow requirements less than normal minimum releases can be requested through the OWRD if insufficient inflows are forecasted and (2) probability of lake refill and timing can be estimated in order to inform lake users. Projections of lake levels during the summer and fall periods are also useful for the same reasons. Adaptive management (see section 7-07) allows for adjustments in reservoir operations if unexpected hydrologic changes were to occur.

NOAA's Climate Prediction Center Seasonal Drought Outlook or the Department of Agriculture's drought indices can be used as an indicator of a short-term drought in consideration of planning for operations in meeting minimum flow objectives without much base-flow or rain. If rainfall and runoff forecasts show that the Willamette Valley Project reservoirs may not fill to the maximum conservation pool levels, a potential drought situation may be indicated. Drought forecasting in the Willamette Basin is most useful in preparing for and during the conservation release season.

Beginning in January, the USACE uses NRCS's April-September water supply volume forecasts issued monthly, and may use Ensemble Streamflow Prediction (ESP) forecasts issued by the Northwest River Forecast Center of the National Weather Service, as input in modeling of the reservoir system. The ESP forecasts use historical meteorological data to represent possible future conditions for probabilistic analyses. These forecasts help estimate how full the reservoirs may be in May and June and how much stored water may be available for release during the conservation season.

7-04. Methods and Tools. Methods and tools are discussed in individual project water control manuals or as described in the *Standard Procedures for Regulation of the Willamette Basin Projects* (contact CENWP-EC-HR for the most up-to-date version). The tools assist in developing estimates of reservoir refill during the conservation filling period.

For long-term planning (greater than 6 months) and for use in the Willamette Conservation Plan, the CENWP-EC-HR runs the USACE's Hydrologic Engineering Center (HEC), reservoir simulation model, HEC-ResSim, to evaluate the water supply forecasts. Water supply volumes are input to the ResSim model to estimate how full the reservoirs may be in May and how much stored water will be available for the release season.

For shorter-term planning, as of 2017, the USACE and Northwest River Forecast Center (NWRFC) use the Community Hydrologic Prediction System (CHPS) reservoir system simulation model, a product of the NWRFC. The USACE provides reservoir regulation information as input to the model while the NWRFC provides weather sequences of given probabilities, soil moisture and ground water conditions. Model runs are made with these parameters and assumptions, and the output are forecasts of lake inflows, streamflows, and lake elevations. The model is used to inform project operational decisions.

During the summer and during drought situations, the CHPS model is run twice a week to ensure the summer flow objectives are met. In addition, the water travel time during the summer is longer due to lower flows, and the CHPS forecast model runs help ensure the flow objectives are met with proper timing.

7-05. Project Minimum Flows. Throughout the year, water is passed through the dams to meet or exceed the congressionally authorized minimum flows. Due to developments in the basin to meet Endangered Species Act needs, a set of minimum flow objectives were recommended by the NOAA's National Marine Fisheries Service Biological Opinion, *Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation, Consultation on the "Willamette River Basin Flood Control Project,*" dated 11 July 2008. The Congressional minimum flows as stated in House Document 531, Volume V (Appendix J) and the biological opinion objective flows are provided in table 7-1.

The operational flow objectives and the associated flow management guidelines are intended to balance the risks to listed fish species under low water year conditions with the risks to other uses authorized by Congress for the Willamette Valley Project. Key among these authorized uses are those significant to human health and safety, including flood risk management, hydropower production, and summer and fall low flow augmentation for maintenance of water quality.

7-06. System Minimum Flow Objectives. In addition to the project minimum flows discussed in section 7-05, the 2008 Biological Opinion provides Willamette River mainstem minimum flow objectives at Salem and Albany. Because the water supply in the Willamette can vary significantly from year to year, the 2008 Biological Opinion allows for adaptive management (see section 7-07) of the reservoir system dependent upon predicted system water availability by mid-May. The 2008 Biological Opinion designates four levels of water availability, in terms of forecasted volume of storage in the Willamette Valley Project reservoirs by mid-May. The designation of a conservation season runoff forecast as “abundant”, “adequate”, “insufficient”, or “deficit” will lead to differing management approaches.

Table 7-2 summarizes the designation of Willamette Basin runoff observed over a 64-year period of record. Table 7-3 shows the minimum flow objectives for Salem in “deficit” years (column 6), and for “abundant” and “adequate” years (column 5). Minimum flow objectives for insufficient years are based on a sliding scale between columns 5 and 6. The minimum flow objective for Albany is the same for all years. The flow objectives for April through June are flow objectives for fish while the summer and fall flows at Albany help maintain water quality. For years designated as “abundant” or “adequate”, minimum flow objectives during spring, summer, and fall would be expected to be met or exceeded whenever possible (e.g., considering factors such as the accuracy of weather forecasts, constraints in the accuracy of operational adjustments at dams, and delayed system response time between the points of storage release and Salem), therefore these years would not be considered drought years. For years designated as “insufficient” or “deficit”, the minimum flow objectives are not expected to be met, and these would be considered drought years. The mainstem spring flow objectives may be temporary actions and are subject to review and revision in accordance with results of appropriate monitoring and evaluation.

Table 7-1. 2008 Biological Opinion and Congressional Minimum Reservoir Outflow

Location	2008 NMFS Biological Opinion			Water Control Manual		House Document No. 531 Volume V	
	Date	Minimum Flow (cfs)	Remarks	Date	Minimum Flow (cfs)	Date	Minimum Flow for Fish[1]
Detroit/Big Cliff	1 Feb - 15 Mar	1000	Rearing/adult migration	Feb-Jun	1,000	Feb-Jun	1,000
	16 Mar - 31 May	1500	steelhead spawning	Jul-Nov	750	Jul - Nov	750
	1 Jun - 15 Jul	1200	steelhead incubation				
	16 Jul - 31 Aug	1000	rearing				
	1 Sep - 15 Oct	1500	chinook spawning				
	16 Oct - 31 Jan	1200	chinook incubation				
Blue River	1 Feb - 31 Aug	50	rearing	Jul-Nov	50	Feb-Jun	30
	1 Sep - 15 Oct	50	chinook spawning			Jul - Nov	30
	16 Oct - 31 Jan	50	chinook incubation				
Cottage Grove	1 Feb - 30 Jun	75		Feb-Jun	75	Feb-Jun	75
	1 Jul - 31 Oct	50		Jul-Oct	50	Jul - Nov	50
	1 Nov - 31 Jan	inflow					
Cougar	1 Feb - 31 May	300	rearing	Feb-Jun	300	Feb-Jun	300
	1 Jun - 30 Jun	400	rearing adult migration			Jul - Nov	200
	1 Jul - 31 Aug	300	rearing				
	1 Sep - 15 Oct	300	chinook spawning				
	16 Oct - 31 Jan	300	chinook incubation				
Dorena	1 Feb - 30 Jun	190		Feb-Jun	190	Feb-Jun	190
	1 Jul - 31 Oct	100		Jul-Oct	100	Jul - Nov	100
	1 Nov - 31 Jan	inflow					
Fall Creek	1 Feb - 31 Mar	50	rearing	1 Feb - 15 Nov	30	Feb-Jun	30
	1 Apr - 31 Aug	80	rearing, adult migration (Jun)			Jul - Nov	30
	1 Sep - 15 Oct	200	chinook spawning				
	16 Oct - 31 Jan	50	chinook incubation				
Fern Ridge	1 Feb - 30 Jun	50		Dec-Jun	50	Feb-Jun	50
	1 Jul - 31 Oct	30		Jul-Nov	30	Jul - Nov	30
	1 Nov - 31 Jan	inflow					
Green Peter/Foster	1 Feb - 15 Mar	800	Rearing/adult migration	Feb-Arp	800	Feb-Apr	500
	16 Mar - 15 May	1500	steelhead spawning	May	750	May	450
	16 May - 30 Jun	1100	steelhead incubation	1 Jul - 15 Nov	400	Jun	300
	1 Jul - 31 Aug	800	rearing			Jul - Nov	300
	1 Sep - Oct 15	1500	chinook spawning				
	16 Oct - 31 Jan	1100	chinook incubation				
Hills Creek	1 Feb - 31 Aug	400	rearing	Feb-Nov	100	Feb-Jun	100
	1 Sep - 31 Jan	400	migration and rearing			Jul - Nov	100
Lookout Point/Dexter	1 Feb - 31 Aug	1200	rearing	Feb-Jun	1,200	Feb-Jun	1,200
	1 Sep - 15 Oct	1200	chinook spawning	1 Jul - 15 Nov	1,000	Jul - Nov	1,000
	16 Oct - 31 Jan	1200	chinook incubation				

[1] *House Document 531, Review Report on Columbia River and Tributaries, Appendix J, Willamette River Basin*, Table III-1. Minimum flows were adopted for the preservation of fish. At the power reservoirs (Hills Creek, Cougar, Green Peter, and Detroit) the releases during the power season (October - March, inclusive) are substantially greater than the minimum regulated flows shown.

Table 7-2. Evaluation of Spring Runoff and Conservation Operation

Volume in Storage by 10-20 May (MAF)	Designation	Occurrences (years)[1]	Percent of Years
< 0.9	Deficit	10	16
0.9 – 1.19	Insufficient	6	9
1.20 – 1.48	Adequate	11	17
> 1.48	Abundant	37	58
1.59	Maximum[2]	---	---

[1] Period of record 1936-1999 using flow objectives in columns 2, 4, and 5 in Table 7-3
[2] Maximum usable conservation storage.

Table 7-3. Minimum Mainstem Threshold Flows for Albany and Salem (cfs)

<table>
<tr><th></th><th colspan="2">Albany</th><th colspan="3">Salem</th><th></th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th></tr>
<tr><th>Period</th><th>Minimum Average Flow[1]</th><th>HD 531[2]</th><th>Minimum Instantaneous Flow[3]</th><th>Minimum Weekly Flow Threshold Abundant and Adequate[4]</th><th>Minimum Weekly Flow Threshold Deficit Years[4]</th><th>HD 531[2]</th></tr>
<tr><td>April</td><td>--</td><td rowspan="9">5,000</td><td>14,300</td><td>17,800[3]</td><td>15,000</td><td rowspan="9">6,500</td></tr>
<tr><td>May</td><td>--</td><td>12,000</td><td>15,000[3]</td><td>15,000</td></tr>
<tr><td>1 – 15 June</td><td>4,500</td><td>10,500</td><td>13,000[3]</td><td>11,000</td></tr>
<tr><td>16 – 30 June</td><td>4,500</td><td>7,000</td><td>8,700[3]</td><td>5,500</td></tr>
<tr><td>July</td><td>4,500</td><td>--</td><td>6,000[1]</td><td>5,000</td></tr>
<tr><td>1 – 15 August</td><td>5,000</td><td>--</td><td>6,000[1]</td><td>5,000</td></tr>
<tr><td>16 – 31 August</td><td>5,000</td><td>--</td><td>6,500[1]</td><td>5,000</td></tr>
<tr><td>September</td><td>5,000</td><td>--</td><td>7,000[1]</td><td>5,000</td></tr>
<tr><td>October</td><td>5,000</td><td>--</td><td>7,000[1]</td><td>5,000</td></tr>
</table>

[1] 2008 Biological Opinion Appendix D, Table D-2.
[2] Congressional minimum flows from House Document (HD) 531, Volume 5, paragraph 88.
[3] 2008 Biological Opinion Appendix D, Table D-1, biologically based minimum flow objectives.
[4] 2008 Biological Opinion Appendix D, Table D-4. Flows in Column 5 are for "Abundant", and "Adequate" years. Flows for "Insufficient" years are based on a sliding scale between Columns 5 and 6.

7-07. Adaptive Management. Adaptive management of flow objectives involve making adjustments to reservoir operations and flow releases based on changing conditions and changing forecasted hydrologic conditions. Current volume forecast methods do not differentiate between the significant contribution of snowmelt and the highly variable rainfall contribution which makes it difficult to forecast runoff volumes. It is not possible to foresee, describe, and model all of the possible management scenarios and contingencies. In a rain-driven system like the Willamette Basin the best available hydrologic modeling early in the season may result in forecasts that differ significantly from actual conditions later in the conservation season. Since the plan calls for setting operational flow objectives at Salem beginning on 1 April based on a storage forecast for mid-May, flow objectives may need to be adjusted throughout the conservation release season. The availability of water will be re-assessed monthly (or as necessary) and related changes in management strategy will be made.

Adaptive management allows for spreading the risk of insufficient water among all authorized project purposes. Adaptive management is especially important during low water years to balance needs for flows during spring that support spawning and incubation of ESA-listed winter steelhead, needs for storage that provide flows during summer for water quality, and for fall spawning and incubation of ESA-listed Spring Chinook salmon.

8.0 Drought Management

8-01. Reservoir Regulation in Drought Conditions. Drought-related water management work is integrated within the overall USACE water management responsibilities and associated activities, which play a major role in characterizing drought conditions in the Willamette Basin. The Willamette Conservation Plan, consistent with the 2008 Biological Opinion, is the vehicle that sets the operational flow objectives in all water year conditions, including drought years. As drought conditions and priorities may vary from year to year, reservoir operational agreements will be made dependent upon the WCP and agreements made under the WATER forum and Flow Management Committee coordination, therefore a prescriptive procedure is not provided in this document. Operations in past drought years may provide an indication for operational strategies for future drought years. Operations used in past years is provided in the following paragraphs.

8-02. Flow Objectives in Past Drought Years. In previous years of extreme drought, interagency agreements resulted in minimum flow objectives at Salem that were less than the Congressional minimum flows at Albany and Salem of 6,500 cfs and 5,000 cfs, respectively. Tables 8-1 and 8-2 show the minimum flow objectives for Albany and Salem, respectively, in various drought years.

Table 8-1. Past Drought Year Interagency Minimum Flow Objectives, Albany

Period	**Drought Years**				
	1977	**1987**	**1988-91**	**1992**	**2015**
June	4,000	4,000	4,500	4,000	3,500
July 1-15	4,000	4,000	4,500	4,000	3,500
July 16-31	4,000	4,500	4,500	4,000	3,500
August 1-15	4,000	4,500	5,000	4,500	3,500
August 16-31	5,000	4,500	5,000	4,500	3,500
September	5,000	4,800	5,000	4,500	3,500

Table 8-2. Past Drought Year Interagency Minimum Flow Objectives, Salem

Period	**Drought Years**					
	1977	**1987**	**1988-91**	**1992**	**2001**	**2015**
June 1-15	5,000	5,000	6,000	5,500	11,000	5,000
June 16-30	5,000	5,000	6,000	5,500	5,500	5,000
July 1-15	5,000	5,000	6,000	5,500	5,000	5,000
July 16-31	5,000	5,500	6,000	5,500	5,000	5,000
August 1-15	5,000	5,500	6,000	5,500	5,000	5,000
August 16-31	6,000	5,500	6,500	5,500	5,000	5,000
September	7,000	7,000	7,000	6,000	5,000	5,000

8-03. Reservoir Regulations in Past Drought Years. The following is a description of reservoir operations and coordination used in recent low water years in the Willamette Basin in drought years.

a. Reducing Minimum Winter Flow. Refill of the reservoirs begins on 1 February. When the observed elevation was below an individual project's rule curve and the forecast was for dry weather, the USACE requested a reduced minimum flow from NOAA Fisheries.

b. Winter Steelhead in the Santiam Basin. In the Santiam Basin, Big Cliff and Foster Dams released minimum flows of 1,500 cfs for winter steelhead spawning. The release periods are from 16 March through 15 May for Foster and from 16 March through 31 May for Big Cliff. During low water years (drought), discussions with NOAA Fisheries took place as modeling showed reservoir levels well below the rule curve. In past years, NOAA Fisheries has agreed to reduce spawning flows to about 1,200 cfs below Big Cliff and 1,100 cfs below Foster.

After steelhead spawning, the steelhead incubation period occurs. This incubation period occurs from 16 May through 30 June at Foster, and from 1 June through 15 July for Big Cliff. In the past, NOAA Fisheries had agreed to reduce incubation flows to be equal to the reduced spawning flows minus 200 cfs.

Rearing flows are maintained during the dry season. Past operations have met the minimum biological opinion rearing flows or released higher flows in order to meet mainstem flows. The ODFW and the NOAA Fisheries have supported steady tributary flows that draft the projects to minimum conservation pool by 1 October without maintaining the mainstem minimum flows.

c. Chinook Spawning in the Santiam Basin. Chinook spawning occurs from 1 September – 15 October. For Big Cliff and Foster Dams, even when pool levels were low, the fisheries agencies preferred to release spawning flows. Although the preference is to provide the spawning flow (1,500 cfs), flows have been reduced by 200-300 cfs, have begun later, or have been stepped-up from the summer flow to the spawning flow over a week.

By the end of spawning, in years of little precipitation and when projects were near or at minimum conservation pool, NOAA Fisheries had expressed a need to use power pool storage and inactive pool storage to provide water for fish. Under this condition, major impacts could occur. Any use of power pool water must be discussed and agreed upon by the BPA.

d. Mainstem Flows. Projects outside of the Santiam Basin have operated to minimum flows. Fisheries agencies have agreed to reduce mainstem flows slightly after April 1. When the observed elevation was below an individual project's rule curve and the forecast was for dry weather, the USACE requested a reduced mainstem flow from NOAA Fisheries. NOAA Fisheries has agreed to lower flows in April and May for the Willamette River at Salem as well as a fixed release from the projects and the elimination of minimum flows for the months of June thru September. The amount that NOAA Fisheries has reduced the mainstem flow requirement has varied from year-to-year based on the extent to which the reservoirs have drafted below rule curve.

8-04. Determination of Interim Draft Limits. Reservoir-specific interim draft limits will be used to avoid over-draft of stored water during the early part of the flow management season. The interim draft limits conserve water in order to meet minimum tributary and mainstem flows later in the summer and early fall. Beginning in May, regulators can use a spreadsheet to back calculate, from October to May, the required storage in the reservoirs at month-end throughout the spring and summer to meet the 2008 Biological Opinion flow objectives at Salem and Albany through 31 October. Modeling may include the use of 90% exceedance inflows from the Period of Record data; however, users can test different levels of inflow and outflow to see resulting reservoir levels within the spreadsheet for a risk assessment.

8-05. Priorities. In both "insufficient" and "deficit" year cases, recreational use would be considered a low priority. Hydropower generation, irrigation, and other authorized uses will be met to the fullest extent possible through both discharges of reservoir inflows during spring and release of storage during summer and fall to meet mainstem flow management objectives. Priority will be given to those flow needs directly related to human health and safety. Reservoir inflow in excess of that needed to meet the mainstem operational flow objectives during spring will be stored in a manner that maximizes the likelihood of being able to meet minimum discharge rates, mainstem Willamette River flow objectives at Albany and Salem during June through October, and Willamette Basin hydropower production needs.

As of 2017, due to low level of use for water service contracts, the USACE does not make special operational adjustments, such as increasing flow releases, to meet contract requirements at most projects with the exception of Fern Ridge and Detroit. However, in "deficit" water years, the National Marine Fisheries Service's (NOAA Fisheries) Reasonable and Prudent Alternative (RPA) requires the Reclamation to curtail water contract diversions. In other years, the RPA requires the USACE to release more than minimum flow to ensure the contract users do not take water intended for fish purposes from Fern Ridge and Detroit. In "deficit" water years, a partial water supply or no water supply may be available to satisfy irrigation contracts. Water deliveries may be ceased or curtailed under these conditions, per RPA 3.4.

9.0. USACE's Emergency Navigation

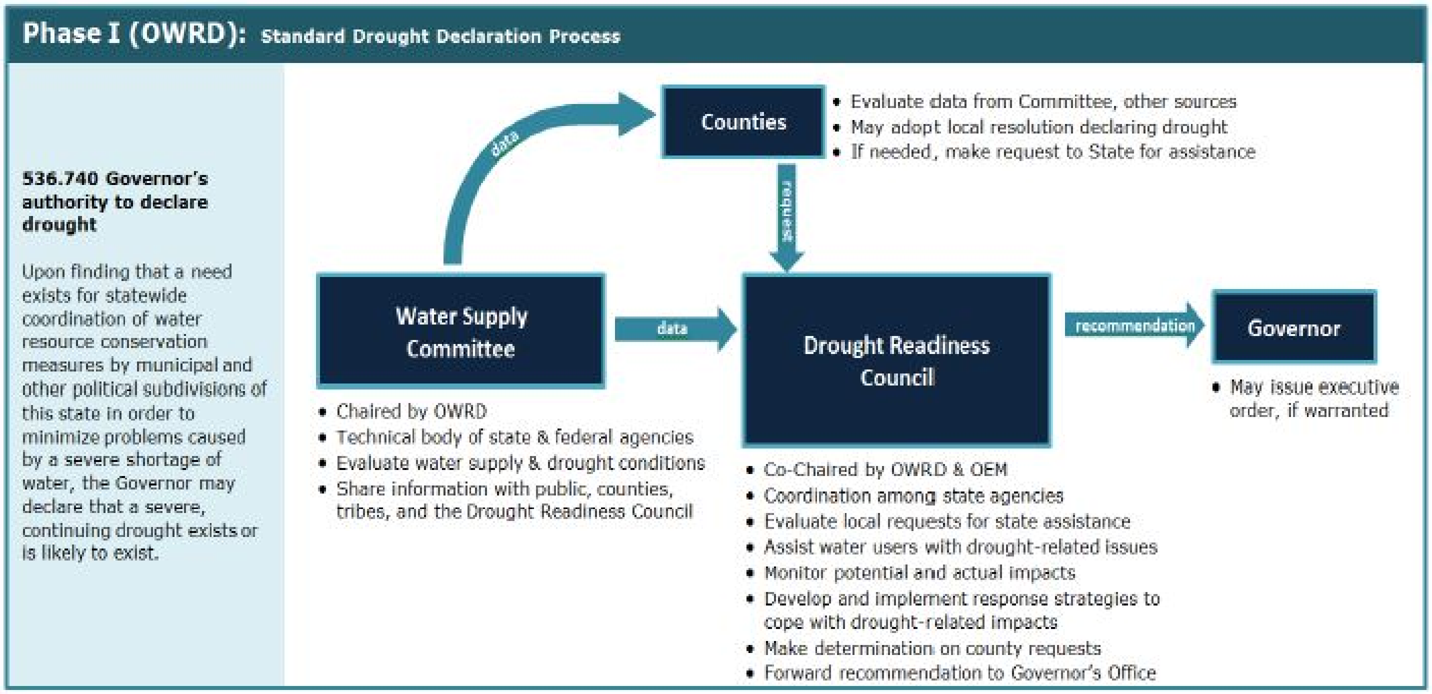
Although there is authorization for navigation in the mainstem Willamette River, there is currently little to no actual navigation for commercial purposes. There is no opportunity to move boats around the Willamette Falls at Oregon City except by trailer. Navigation did not seem to be an issue during the drought of 2001 or 2015. In December of 2011, the Willamette Falls Locks were placed in a non-operational status because of safety issues.

10.0 State of Oregon Drought Management

10-01. Authorities. The legal authorities for the State of Oregon's drought mitigation and response functions are found in ORS 536.700 - 536.780 and Oregon Administrative Rules (OAR) Chapter 690, Division 19. The Governor, through the request of a local jurisdiction, can declare an emergency under ORS 401.165. Under ORS 536.740, the Governor has authority to declare that a severe, continuing drought exists, or may exist, in any (or all) of the drainage basins in Oregon. Based on that declaration, the Governor or the Oregon Water Resources Commission can also direct state agencies and political subdivisions to implement a water conservation plan or water curtailment plan. Additionally, ORS 536.750 states that a drought declaration by the Governor allows the Water Resources Department to provide existing water right holders with access to temporary water management tools, described in OAR 690-019.

The Water Resources Commission is made up of seven members who represent different areas of the state. The commission is a citizen body that sets state water policy and oversees activities of the Water Resources Department. WRC meetings are held regularly at different locations around the state and is open to the public. The region areas in the Willamette Valley are the Northwest Region and the West Central Region.

10-02. Declaration of Drought. The declaration of drought in Oregon is performed by the Governor on a county-by-county or on a state-wide basis. The Governor's technical advisory group is the Oregon Drought Readiness Council (DRC) (see 10-02.a), and the interagency Water Supply Availability Committee (WSAC) (see 10-02.b) reports to the DRC. The two interagency groups evaluate water supply conditions and help assess and communicate potential drought related impacts. The State of Oregon's drought declaration process is shown on figure 10-1. A description of the DRC and WSAC and their activities are provided in the following sections, along with the State's drought strategy. The USACE does not make a declaration of drought conditions associated with its reservoirs in the Willamette Basin.



Source: Drought Annex, State of Oregon Emergency Operations Plan, January 2016.

Figure 10-1. Standard Drought Declaration Process

a. Drought Readiness Council. The DRC relies on information from the WSAC to assess how conditions may affect various sectors across the state, including instream and out-of-stream uses. The DRC reviews local requests for assistance and makes recommendations to the Governor regarding the need for state drought declarations. The DRC is responsible for ensuring coordination among state agencies and help water users access drought related information and assistance programs. The DRC consists of nine state agencies with natural resources management, public health, or emergency services expertise. Co-chairs of the Drought Readiness Council is the Administrator, Technical Services Division of the OWRD, and the Section Manager of the Office of Emergency Management.

b. Water Supply Availability Committee. The WSAC consists of ten state and federal science and emergency preparedness agencies that meet throughout the year to evaluate the potential for drought conditions. If drought is likely, monthly meetings occur shortly after release of the NRCS Water Supply Outlook reports to assess conditions. The WSAC communicates through the OWRD, the status of drought conditions to local, state, and tribal agencies. The WSAC is responsible for providing updates and reports on conditions to the Drought Readiness Council. As of 2016, the chair of the Water Supply Availability Committee is the Surface Water Hydrology Manager of the OWRD. The Chief of CENWP-EC-HR or designee represents the USACE on this committee.

10-03. Drought Strategies. Because of the 2015 drought, the Governor signed Executive Order 15-09, to direct state agencies to plan for resiliency to drought to meet the challenge that a changing climate brings. The document, *Report to the Governor Kate Brown, Implementation of Executive Order No. 15-09 Directing State Agencies to Plan for Resiliency to Drought*, dated 1 November 2015 (Report to the Governor) is in response to the Executive Order, and contains an overview of activities that Oregon's agencies, boards, and commissions are to do to prepare for and respond to drought now and in the future. The weblink for the Executive Order is provided in the Weblinks section of this document.

The Executive Order also directed the Office of Emergency Management and the Oregon Water Resources Department (OWRD) to update the *Drought Annex* to the State's *Emergency Operations Plan*. The *Drought Annex*, dated January 2016, was prepared by the Oregon Office of Emergency Management, OWRD. The purpose of the annex is to coordinate state and federal agency response to drought emergencies and to provide emergency water supplies for human consumption under conditions of inadequate supply. The annex outlines steps and lists responsibilities of various federal, state, and local jurisdictions. It also includes a description of federal drought assistance programs and guidelines for water curtailment planning and program development. The *Emergency Operations Plan* and the *Drought Annex* are provided in the Weblinks section of the document.

Two other state of Oregon strategies support the Drought Annex. The first, is the 2015 *Natural Hazards Mitigation Plan*, dated September 2015, which contains an up-to-date description of Oregon's natural hazards and their probability, the state's vulnerabilities, and its mitigation strategies and implementation capability. Cities and counties can use this information when preparing local natural hazard mitigation plans. The second, is the *Oregon's 2012 Integrated Water Resources Strategy*, dated August 2012. The purpose of the document is to describe the water needs of Oregon and to provide a strategy to meet those needs. The intent of the strategy is to provide a blueprint for future actions.

11.0 Coordination

11-01. USACE. The Chief, CENWP-EC-HR updates the Corporate Board (District Commander, Deputy District Engineer, and other CENWP Chiefs) of the drought situation, typically on a monthly basis. The reservoir regulation team, along with CENWD water management will meet at least weekly to discuss the drought situation, decisions to be made and the possible impacts of those decisions. Reports of the drought situation are prepared by the CENWP-EC-HR, and may be provided to USACE Headquarters (CECW-EC), through the CENWD. CENWP-EC-HR also reports to the Portland District Readiness Section (CENWP-OD-SE), who coordinates with the CENWD Regional Contingency Office (CENWD-RCO), for upward reporting to Head Quarters Emergency Management. The CENWP-EC-HR also coordinates with Portland District Public Affairs (CENWP-PA) to develop talking points for news releases and public inquiries (see section 12.0).

11-02. Regional. The USACE coordinates with the region on reservoir operations to meet the ESA and all other purposes of the Willamette Valley Project through the WATER forum. WATER works as a collaborative regional forum among the sovereign governments (federal/state/tribal) with responsibility for assisting the federal Action Agencies (USACE, BPA, and Reclamation) in the coordinated implementation of the ESA and related measures. WATER is also responsible for making recommendations to the Action Agencies in implementing the Willamette Biological Opinions' RPA.

11-03. State of Oregon. The WSAC meets nearly monthly and discuss the status of water supply conditions across the state. The members of the WSAC are: NOAA, NRCS, Oregon Climate Change Research Institute, Oregon Department of Agriculture, Oregon Department of Forestry, Oregon Office of Emergency Management, Oregon Water Resources Department, USACE (CENWP-EC-HR), Reclamation, and the U.S. Geological Survey. The CENWP-EC-HR provides the status of the reservoirs and an assurance that project outflow will not be zero cfs, that in fact the rivers below USACE dams will still contain water. The Chief, CENWP-EC-HR coordinates with the State Engineer for the OWRD.

11-04. County Emergency Managers. The WSAC provides data to the counties and other sources. The counties may adopt a local resolution declaring a drought. If needed, counties make a request to the Drought Readiness Council for assistance. The Drought Readiness Council evaluates the local requests for assistance, and makes recommendations to the Governor, who in turn may make a request to the USACE for assistance.

12.0 Internal and External Communication

12-01. Congressional Briefs and Public Officials. The Deputy District Engineer for Program and Project Management (DDEPPM) meets with congressional representatives when requested. The Chiefs of CENWP-EC-H and CENWP-HR support the DDEPPM by providing technical information on specific questions they may have. Senior Management will maintain open communication with local officials and staff as needed, including the city and county commissioners and selected officials from the governor's office.

12-02. Public Communication. The CENWP-EC-HR coordinates with the CENWP-PA to provide the news media and the general public with water resources information related to the Willamette Valley Project, using a positive approach to deal with drought distress situations. The Willamette Valley Project staff and CENWP-EC-HR staff should attend watershed council meetings, chambers of commerce, and City Council meetings and civic organizations to help reinforce understanding of competing demands of authorized purposes on reservoirs. The CENWP-PA may attend public meetings and provide support to the Willamette Valley Project staff and CENWP-EC-HR by disseminating information through social media and by printing flyers and other materials. As required, news releases containing updated water resources facts concerning the drought, as they relate to USACE reservoir conditions, will be prepared and distributed by the CENWP-PA.

12-03. Internet. Reservoir levels, recreation updates, current issues, and other information will be posted on the District internet site. The internet is one of the District's most comprehensive public resources for information on USACE activities. The weblink for this information is provided in the Weblinks section of this document. In a drought year, the CENWP will create a public web page to share drought related information. Drought information include forecasts and impacts, current reservoir data, information on emergency water assistance, and links to State of Oregon and other federal agency websites. Current conditions related to drought is provided in the weblink in the Weblinks section of this document.

13.0 Emergency Assistance for Drought

The USACE authority for Drought Assistance is contained in section 6-5, Policy – Emergency Water Assistance Due to Drought, of Engineering Regulation 500-1-1, *Emergency Employment of Army and Other Resources*, *Civil Emergency Management Program*, dated 30 September, 2001. The Portland District, Business Operations Branch, Readiness Section (CENWP-OD-SE), is the point of contact for drought assistance.

The USACE is authorized to transport emergency supplies of clean drinking water for human consumption to any locality designated as a drought distressed area, and to construct wells in such drought distressed areas. Assistance will only be to meet minimum public health and welfare requirements. Assistance may be in the form of emergency supply of clean drinking water for human consumption, and construction of wells (at state/local expense) if not commercially possible. Water normally provided by tank trucks or small diameter pipelines. Beneficiaries are any locality faced with a threat to public health and welfare from a drought situation affecting the water system.

Application for program assistance to the CENWP must be initiated by the Governor or his/her authorized representative, but assistance is subject to approval at a higher level. The impacted area must be designated as a "drought distressed" area by Assistant Secretary of the Army for Civil Works. For other details on obtaining assistance during a drought, contact CENWP-OD-SE.

REFERENCES

NOAA's National Marine Fisheries Service, *Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation, Consultation on the "Willamette River Basin Flood Control Project,"* 11 July 2008.

Oregon Office of Emergency Management, Oregon Water Resources Department, *Drought Annex, State of Oregon Emergency Operations Plan*, January 2016,

Oregon Partnership for Disaster Resilience for the State of Oregon, Oregon Emergency Management, *Natural Hazards Mitigation Plan, Drought Chapter*, February 2012,

Oregon Water Resources Department, *Water Rights in Oregon, An Introduction to Oregon's Water Laws*, November 2013.

Oregon Climate Change Research Institute, *Historical Trends and Future Projections of Climate and Streamflow in the Willamette Valley and Rogue River Basins*, June 2015 and revised March 3, 2016.

Pinson, A., A. Jordan, B. Baker, K. D. White, R. Vermeeren, and K. Fagot (2015), *USACE Drought Contingency Planning in the Context of Climate Change*, Civil Works Technical Report, CWTS 15-15, US Army Corps of Engineers: Washington, DC, September 2015.

U.S. Army Corps of Engineers, *2011 USACE Climate Change Adaptation Plans and Report*, dated September 2011.

U.S. Army Corps of Engineers, *2012 USACE Climate Change Adaptation Plans and Report*, dated June 2012.

U.S. Fish and Wildlife Service and Oregon Fish and Wildlife Office, *Final Biological Opinion on the Willamette River Basin Flood Control Project, Biological Opinion on the Continued Operation and Maintenance of the Willamette Basin River Project and Effects to Oregon Chub, Bull Trout and Bull Trout Critical Habitat Designated Under the Endangered Species Act*, 11 July 2008.

WEBLINKS (as of May 2017)

NOAA's Climate Prediction Center ENSO status:
http://www.cpc.ncep.noaa.gov/products/expert_assessment/ENSO_DD_archive.shtml

Drought Monitor Update Report for Oregon:
http://droughtmonitor.unl.edu/Home/StateDroughtMonitor.aspx?OR

NRCS Oregon Snow Survey Reports: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/or/snow/

Oregon Water Supply Outlook Reports:
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/or/snow/waterproducts/?cid=nrcs142p2_048083

Oregon Surface Water Supply Index (SWSI):
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/or/snow/waterproducts/?cid=stelprdb1244919

CWTS Report 15-15: http://www.corpsclimate.us/ccaupddr.cfm.

The State of Oregon's Governor Executive Order:
http://www.oregon.gov/owrd/pages/wr/drought.aspx#Implementing_the_Drought_Executive_Order.

State of Oregon's Emergency Operations Plan and the Drought Annex:
http://www.oregon.gov/OMD/OEM/Pages/plans_train/EOP.aspx.

Portland District internet site: http://www.nwp.usace.army.mil/

Portland District current conditions related to drought:
http://www.nwp.usace.army.mil/Missions/Water/Drought.

Reservoir storage capacity tables:
http://wmlocal.nwd.usace.army.mil/nwp/ratings/www/index.html

Attachment 1

USACE-City Agreement Template
Temporary Withdrawal of Water

AGREEMENT
BETWEEN
THE DEPARTMENT OF THE ARMY
AND
[CITY]
FOR
TEMPORARY WITHDRAWAL OF WATER
FROM
[RESERVOIR], [STATE]
PURSUANT TO
SECTION 6 OF THE FLOOD CONTROL ACT OF 1944

THIS AGREEMENT, entered into this ____ day of MONTH, YEAR, by and between the DEPARTMENT OF THE ARMY (hereinafter called the "Government") represented by the District Engineer executing this Agreement, and CITY, (hereinafter called the "User"*);

WITNESSETH THAT:

WHEREAS, pursuant to the Flood Control Acts of 1938 (Public Law 75-761) and 1950 (Public Law 81-516), the Government has constructed and is operating [Project] on the [waterway], (hereinafter called the "Project"); and

WHEREAS, Section 6 of the Flood Control Act of 1944 (Public Law 78-534), as amended (33 U.S.C. 708), provides that the Secretary of the Army is authorized to enter into agreements with states, municipalities, private concerns, or individuals, at such prices and on such terms as the Secretary may deem reasonable, for domestic and industrial uses for surplus water that may be available at any reservoir under the Secretary's control provided that no agreements for such water shall adversely affect the existing lawful uses of such water; and

WHEREAS, pursuant to Section 6 of the Flood Control Act of 1944, as amended, the Government has determined that up to [volume] acre-feet of storage, as described in the [supporting document] (hereinafter called the "Report"), approved [date], is available at the Project as surplus water for municipal and industrial use, as the withdrawal of such amount will not interfere with Project purposes, nor adversely affect the existing lawful uses of water from the Project; and

WHEREAS, the User desires to enter into an agreement with the Government for the withdrawal of up to [volume] acre-feet of surplus water downstream from the Project for municipal purposes; and

WHEREAS, the User, as shown in Exhibit "A", attached to and made a part of this Agreement, is empowered to enter into an agreement with the Government and is vested with all necessary powers of accomplishment of the purposes of this Agreement.

NOW, THEREFORE, the parties do mutually agree as follows:

ARTICLE 1 - Withdrawal of Surplus Water

a. The Government grants the User the right to withdraw water from the Project, or request releases to be made by the Government through the outlet works of the Project, for municipal use, subject to the User's compliance with its responsibility for water rights as set out in Article 3 of this Agreement.

The rate of such withdrawal shall not exceed [rate], and the volume shall not to exceed [volume] acre-feet per year, during the term of this Agreement as specified in Article 5 hereof.

b. The User's rights under this Agreement are subject to the Government's control and use of any or all storage in the Project to fulfill the authorized purposes of the Project. In the event that the Government determines that withdrawals of any or all of the surplus water identified in the Report are resulting in unexpected adverse impacts to other Project purposes or operations, the User shall immediately suspend withdrawals.

c. The Government further reserves the right to take such measures as it determines in its sole discretion to be necessary to inspect, operate, maintain, and repair the Project, including taking any and all measures necessary to protect life and property.

d. The water which may be available for withdrawal by the User pursuant to this Agreement is raw water only. The Government makes no representation with respect to the quality of water which may be available and assumes no responsibility therefore, or for treatment of the water.

e. The Government makes no guarantee with respect to the availability of water. The water level of the Project will be maintained at elevations which the Government deems will best serve the authorized purposes of the Project, and this Agreement shall not be construed as giving the User any rights to have the water level maintained at any elevation.

ARTICLE 2 – Metering and Recordkeeping

For the purpose of maintaining an accurate record of the water withdrawn from the Project, the User agrees to furnish and install, or cause to be installed, meters or measuring devices satisfactory to the District Engineer, without cost to the Government. Such devices shall be available for inspection by Government representatives at all reasonable times. The User agrees to furnish to the District Engineer: (i) advance estimates of need; and (ii) records of the quantity of water actually withdrawn as requested by the District Engineer, but in any event no less frequently than once a year.

ARTICLE 3 - Regulation of and Right to the Use of Water

The regulation of the use of water withdrawn or released from the storage space under this Agreement shall be the sole responsibility of the User. The User has the full responsibility to acquire in accordance with applicable law, and if necessary to establish or defend, any and all water rights needed for the water withdrawn or released from the Project under this Agreement. The Government shall not be responsible for the use of water by the User, nor will it become a party to any controversies involving the water use, except as such controversies may affect the operations of the Project.

ARTICLE 4 - Consideration and Payment

a. In consideration of the right to withdraw [volume] acre-feet between [timeframe] per year for a period not to exceed five (5) years from the Project for municipal and industrial water supply purposes, the User shall pay the Government $[capital cost] per year in capital costs, the first of which shall be due and payable within thirty (30) days of the effective date of the Agreement as set forth in Article 5 herein. In addition to the annual capital cost payment, the User shall be responsible for a share of the Operations and Maintenance (O&M) costs of the Project. The first payment will be for $[O&M cost] and is due within thirty (30) days of the effective date of the Agreement. Future capital and O&M payments thereafter will be due and payable on the anniversary date the first payment is due.

b. The repayment amount shown in Article 4(a) is based upon joint use and specific water supply construction costs updated to [month year] price levels using appropriate indices and the Fiscal Year [FY] water supply interest rate of [interest rate] percent as computed by the Secretary of the Treasury in accordance with Section 932 of the Water Resources Development Act of 1986 (Public Law 99-662).

c. If the User shall fail to make any payment under this Agreement within thirty (30) days of the date due, the delinquent payment shall be charged interest at the Current Value of Funds Rate, as determined by the Secretary of the Treasury that is applicable on the date that the payment became delinquent, with such penalty interest as may be required by Federal law or regulation. This provision shall not be construed as waiving any other rights the Government may have in the event of default by the User, including but not limited to the right to terminate this Agreement for default.

ARTICLE 5 - Duration of Agreement

This agreement shall become effective upon the date it is signed by the Government, and shall continue in full force and effect under the conditions set forth herein for a period of not to exceed five (5) years from the said date of approval. Upon expiration, this agreement may be extended by mutual agreement for additional periods of not to exceed five (5) years each. All such agreement extensions shall be subject to recalculation of reimbursement. Nothing in this agreement, nor in any extension thereto, shall imply a permanent right to utilize the storage space.

ARTICLE 6 - Termination of Agreement

a. The User may terminate the Agreement upon fourteen (14) days written notice.

b. The Government may terminate this Agreement upon thirty (30) days written notice in the event the Government determines that withdrawals of any or all of the surplus water identified in the Report are resulting in unexpected adverse impacts to other Project purposes or operations.

c. The Government may terminate this Agreement and the User's right to withdraw water upon thirty (30) days written notice if the User shall default in performance of any obligation of this Agreement. Upon such a termination, the User shall continue to be liable to the Government for any monies owed and for any costs incurred by the Government as a result of the default.

d. In the event of any termination pursuant to this Article or Article 5, User shall, upon request of the Government, promptly remove, at User's expense, any facilities constructed on Project land for water withdrawal and restore premises around the removed facilities to a condition satisfactory to the Government.

e. Not later than ten (10) calendar days from the date of the written notice to terminate, the Government shall commence a final accounting of the financial obligations of the User under Article 4.a. of this Agreement. The results of the final accounting will be furnished by written notice to the User.

(i) Should the final accounting show that the User owes the Government further payment under this Agreement, the User, not later than ninety (90) calendar days after receipt of the written notice from the Government, shall provide the Government with the full amount by delivering a check payable to "FAO. USAED, Portland" to the District Engineer, or by providing an Electronic Funds Transfer of the required funds in accordance with procedures established by the Government.

(ii) Should the final accounting show that the amount of funds provided by the User exceeds its financial obligations under this Agreement, the Government, subject to the availability of funds, shall refund the excess amount to the User within ninety (90) calendar days of the date of completion of the final accounting, or if funds are not available, shall seek such appropriations as are necessary to make the refund.

ARTICLE 7 - Rights-of-Way

Occupancy and use of Project lands shall be in accordance with any permits, rights-of-way, or easements granted to the User by the Government.

ARTICLE 8 - Release of Claims

The User shall hold and save the Government, including its officers, agents, and employees, harmless from liability of any nature or kind for or on account of any claim for damages which may be filed or asserted as a result of the withdrawal or release of water from the Project made pursuant to the terms of the Agreement, or as a result of the construction, operation or maintenance of any facilities or appurtenances owned and operated by the User except for damages due to the fault or negligence of the Government or its contractors.

ARTICLE 9 - Transfer or Assignment

The User shall not transfer or assign this Agreement nor any rights acquired thereunder, nor grant any interest, privilege or license whatsoever in connection with this Agreement, without the approval of the Secretary of the Army or his duly authorized representative, provided that this restriction shall not be construed to apply to any water withdrawn or obtained from the Project and furnished by the User to any third party or parties, or to the rates charged therefor.

ARTICLE 10 - Officials Not to Benefit

No member of or delegate to Congress, or Resident Commissioner, shall be admitted to any share or part of this Agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this Agreement if made with a corporation for its general benefit.

ARTICLE 11 - Covenant Against Contingent Fees

The User warrants that no person or selling agency has been employed or retained to solicit or secure this Agreement upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies by the User for the purpose of securing business. For breach or violation of this warranty, the Government shall have the right to annul this Agreement without liability, or in its discretion, to add to the Agreement price or consideration the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE 12 - Environmental Quality

During any construction, operation, and maintenance by the User of any facilities, specific actions will be taken to control environmental pollution which could result from such activity and to comply with applicable Federal, State and local laws and regulations concerning environmental pollution. Particular attention should be given to (1) reduction of air pollution by control of burning, minimization of dust, containment of chemical vapors, and control of engine exhaust gases, and of smoke from temporary heaters; (2) reduction of water pollution by control of sanitary facilities, storage of fuels and other contaminants, and control of turbidity and siltation from erosion; (3) minimization of noise levels; (4) onsite and offsite disposal of water and spoil; and (5) prevention of landscape defacement and damage.

ARTICLE 13 - Civil Rights Assurance and Certification Regarding Lobbying

a. The User furnishes, as part of the Agreement, an assurance (Exhibit C) that it will comply with Title VI of the Civil Rights Act of l964 (78 Stat. 252; 42 U.S.C. 2000d, et seq.) and Department of Defense Directive 5500.11 issued pursuant thereto and published in Part 195 of Title 32, Code of Federal Regulations.

b. The user furnishes, as part of this Agreement, a certification (Exhibit D) that no appropriated funds have been paid or will be paid to an officer or employee of a Federal agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the execution of this Agreement; and that any funds other than appropriated funds that have been paid or will be paid to such persons will be disclosed on the appropriate form.

ARTICLE 14 - Approval of Agreement

This Agreement shall be subject to the written approval of the Secretary of the Army or his duly authorized representative and shall not be binding until so approved.

IN WITNESS WHEREOF, the parties have executed this Agreement as of the day and year first above written.

FOR THE DEPARTMENT OF THE ARMY

By ______________________________
[Commander]
Colonel, U.S. Army
District Engineer
U.S. Army Engineer District
Portland, Oregon

DATE:____________________________

FOR THE [CITY]

By __________________________
[name of signatory]
[position or title]

DATE:_______________________

EXHIBIT A: CERTIFICATION

I ___________________________, Attorney for the [ENTITY], have reviewed the foregoing agreement executed by __________________________________ and, as principal legal officer for the [ENTITY], certify that the [ENTITY] is legally and financially capable of entering into the contractual obligations contained in the foregoing agreement and that, upon acceptance by the Department of the Army, it will be legally enforceable.

Given under my hand, this _______ day of _______________ [YEAR].

____

Attorney for [ENTITY]

EXHIBIT B

The cost charged to the user for [volume] acre-feet of storage for five years is $[total cost], plus an annual O&M fee. For a surplus water supply agreement, the user will pay the annual fees as listed in the table below.

TOTAL ANNUAL COST TO USER
FOR SURPLUS WATER SUPPLY STORAGE

Item	Type of Use	Computation	Cost
Interest and amortization	Annual cost of storage space	$[cost per acre-foot] x [acre-feet], (based on 30 year repayment plan) and 5 payments at interest rate of [interest rate]%.	$[total cost]
Operation and maintenance [1]	Joint-use actual for FY [previous FY]	[ ]% [2] x $[total joint-use O&M for previous FY]	$[share of O&M]
Repair, rehabilitation and replacement [3]	Joint-use actual for FY [previous FY]	[ ]% [2] x $[total joint-use O&M for previous FY]	$[share of RR&R]

Notes:

1 Payment due and payable on the date specified in Article 4(a).

2 Percent of Users share of the Usable storage space in the project.

3 Repair, rehabilitation and replacement costs are payable only when incurred as specified in Article 5(b).

EXHIBIT C: ASSURANCE OF COMPLIANCE

ASSURANCE OF COMPLIANCE WITH THE DEPARTMENT OF DEFENSE DIRECTIVE UNDER TITLE VI OF THE CIVIL RIGHTS ACT OF 1964, AS AMENDED; THE AGE DISCRIMINATION ACT OF 1975; AND THE REHABILITATION ACT OF 1973, AS AMENDED

The party executing this assurance, being the applicant recipient of Federal financial assistance under the instrument to which this assurance is attached hereby agrees that, as a part of its obligations under the aforesaid instrument, it will comply with Title VI of the Civil Rights Act of 1964 (P.L. 88-352), as amended (42 U.S.C. 2000d), and all requirements imposed by or pursuant to the Directive of the Department of Defense (32 CFR Part 195), issued as Department of Defense Directive 5500.11 pursuant to that title; The Age Discrimination Act of 1975 (42 U.S.C. 6102); the Rehabilitation Act of 1973, as amended (29 U.S.C. 794), to the end that in accordance with the aforementioned Title, Directive and Acts, no person in the United States shall on the ground of race, color, age, sex, religion, handicap or national origin be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity for which the Applicant-Recipient receives Federal financial assistance from the Department of the Army and gives assurances that it will immediately take any measures necessary to effectuate this agreement.

If any personal property or real property, or interest therein, or structure thereon is provided or improved with the aid of Federal financial assistance extended to the applicant-recipient by the Department of the Army, or if such assistance is in the form of personal property or real property, or interest therein or structure thereon, then this assurance shall obligate the applicant-recipient or in the case of any transfer of such property, any transferee, for the period during which the property is used for a purpose for which the Federal financial assistance is extended or for another purpose involving the provision of similar services or benefits, or for the period during which it retains ownership or possession of the property whichever is longer. In all other cases, this assurance shall obligate the applicant-recipient for the period during which the Federal financial assistance is extended to it by the Department of the Army. The Department of the Army representatives will be allowed to visit the recipient's facilities. They will inspect the facilities to ensure that there are no barriers to impede the handicap's accessibility in either programs or activities.

This assurance is given in consideration of and for the purpose of obtaining any and all Federal grants, loans, contracts, property, discounts or other Federal financial assistance extended after the date hereof to the applicant-recipient by the Department of the Army, including installment payments after such date on account of arrangements for Federal financial assistance which were approved before such date. The applicant-recipient recognizes and agrees that such Federal financial assistance will be extended in reliance on the representations and agreements made in this assurance, and that the United States shall have the right to seek judicial enforcement of this assurance. This assurance is binding on the applicant-recipient, its successors, transferees, and assignees, and the person or persons whose signatures appear below are authorized to sign this assurance on behalf of the applicant.

Date ____________________ By __________________________________

[position/title]
[entity]

Mailing Address:
[ ]

EXHIBIT D: CERTIFICATION REGARDING LOBBYING

The undersigned certifies, to the best of his or her knowledge and belief that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by Section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

____

[position/title]
[entity]

DATE: ____________________