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Portland District

Appendix 1-D to Willamette Master Water Control Manual

Water Control Manual for Detroit and Big Cliff Lakes

Oregon

September 1953
Revision 2, July 28, 2017

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 Detroit and Big Cliff Reservoirs Water Control Manual	Sep 1953
Rev. 1	Exhibit 1 added Paragraph 6-11 added	Add MFR "Implementation of Environmental Flows in the Willamette Valley" as Exhibit 1. Add paragraph 6-11 to Section VII for discussion of the Environmental Flows."	Oct 1, 2015
Rev. 2	Appendix Replaced	Comprehensive Update of the Drought Contingency Plan, Renamed Exhibit A Renamed Exhibit 1 as Exhibit B	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

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, PORTLAND DISTRICT
PO BOX 2946
PORTLAND OR 97208-2946

REPLY TO
ATTENTION OF

CENWD-PDW 1 OCT 2015

MEMORANDUM THRU Laurie Nicholas, Chief, Reservoir Regulation and Water Quality Section (CENWP-EC-HR)

FOR Lance Helwig, Chief, Engineering and Construction Division (CENWP-EC)

SUBJECT: Response to Request for Review and Approval for Incorporation of the Environmental Flow Recommendations Memo into the Water Control Manuals for Willamette Valley Projects

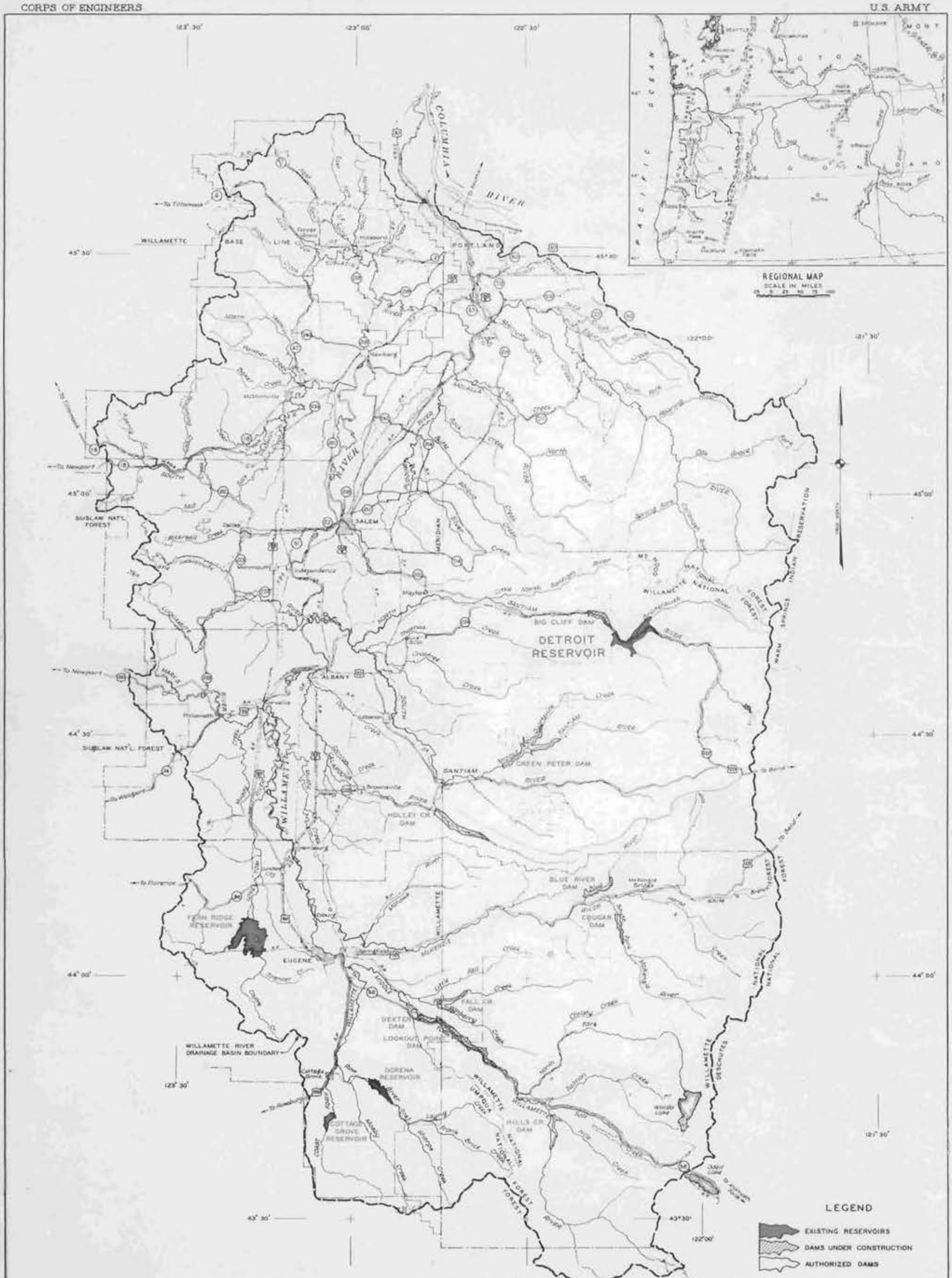
1. This memorandum is in response to the subject request, dated 14 September 2015, for review and approval of the permanent revisions to the Cougar, Detroit, and Lookout Point water control manuals to incorporate Environmental Flow Recommendations as part of the Sustainable Rivers Project.

2. In reviewing the changes, several of the Environmental Flow Targets note Operational Considerations of which regulators should be aware when considering releases to meet such targets. It is imperative that all Standard Operating Procedure (SOP) documents be updated to reflect the latest notification procedures for applicable thresholds identified in the Targets.

3. Subject to the items noted in paragraph 2, the Columbia Basin Water Management Division approves the revisions to the water control manuals for the projects listed in paragraph 1 to incorporate the Environmental Flow Recommendations.

STEVEN B. BARTON
Chief, Columbia Basin Water Management Division

CF:
CENWD-PDW-R (Ammann)
CENWD-PDW-H (Proctor)
CENWP-EC-HR (Nicholas)
CENWP-OD-V (Petersen, Bengtson, Bardy)
CENWP-PM-FP (Budai)



WILLAMETTE RIVER BASIN
RESERVOIR SYSTEM

SCALE IN MILES

REVISED JUNE 28, 1953

DE-20-45/22

RESERVOIR REGULATION MANUAL

DETROIT AND BIG CLIFF RESERVOIRS

NORTH SANTIAM RIVER

Prepared by
Portland District, Corps of Engineers
1 September 1953

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DETROIT DAM AND RESERVOIR

PERTINENT DATA

1. General:

Stream	North Santiam River
Location of dam:	
River mile:	
Above mouth of Santiam River	60.4
About mouth of North Santiam River	48.5
Airline mile:	
Distance from Portland	60
Distance from Salem	40
Public land survey	W$\frac{1}{4}$ Sec. 7, T. 10 S., R. 5 E., W.M.
Datum	Mean sea level, U. S. Coast & Geodetic Survey
Drainage area	438 square miles
Spillway design flood:	
Peak inflow	176,000 second-feet
Peak outflow	176,000 second-feet
Mean annual run-off (1922-46)	1,405,000 acre-feet
Discharge, maximum historical (1861) estimated	65,000 second-feet
Discharge, maximum of record (1945)	41,200 second-feet
Discharge, mean (1922-46)	1,940 second-feet
Discharge, minimum unregulated (1938-46)	410 second-feet

DETROIT DAM AND RESERVOIR

PERTINENT DATA (CONT'D)

2. Reservoir:

Pool elevations:

Minimum power pool	1,425 feet, m.s.l.
Minimum flood-control pool	1,450 feet, m.s.l.
Minimum conservation pool	1,425 feet, m.s.l.
Maximum conservation pool	1,563.5 feet, m.s.l.
Full pool	1,569 feet, m.s.l.
Maximum pool	1,574 feet, m.s.l.

Reservoir areas:

Minimum power pool	1,450 acres
Minimum flood-control pool	1,680 acres
Maximum conservation pool	3,460 acres
Full pool	3,580 acres
Maximum pool	3,700 acres

Reservoir storage:

Flood-control storage	300,000 acre-feet
Power storage	40,000 acre-feet
Total usable storage	340,000 acre-feet
Usable storage over drainage area	14.5 inches
Dead storage	115,000 acre-feet
Total storage below spillway crest	362,600 acre-feet
Total storage, full pool	455,000 acre-feet
Surcharge storage	17,800 acre-feet
Total storage, maximum pool	472,800 acre-feet

3. Spillway:

Type	Concrete-gravity gate-controlled
Crest length:	
Gross	294.5 feet
Net	252.0 feet
Crest elevation	1,541 feet, m.s.l.
Maximum head on crest	33 feet
Design discharge	176,000 second-feet
Type of stilling basin	Hydraulic jump - baffled horizontal apron
Elevation stilling basin floor	1,170 feet, m.s.l.
Design discharge stilling basin	157,600 second-feet
Tailwater elevations:	
Discharge, 176,000 second-feet	1,231.5 feet, m.s.l.
Spillway gates:	
Type	Radial
Number	6
Size (clear opening below full pool)	42 feet by 31 feet high
Operation	Electrically operated hoists

4. Outlet works:

Capacity at minimum flood-control pool, elevation 1,450 feet, m.s.l.	19,780 second-feet

4. Outlet works: (cont'd)

Capacity at minimum power pool elevation 1,425 feet, m.s.l.	17,530 second-feet
Capacity at spillway crest elevation 1,541 feet, m.s.l.	26,110 second-feet
Type	Conduit through dam
Number	2 conduits at centerline elevation 1,340 and 2 conduits at centerline elevation 1,265.33
Operating control	Four 5' 8" by 10' 0" fixed-wheel gates
Emergency control	Four 5' 8" by 10' 0" fixed-wheel gates

5. Dam:

Type	Straight concrete gravity
Elevation, roadway deck	1,579 feet, m.s.l.
Maximum height, foundation to roadway deck	450 feet
Freeboard above maximum pool	5 feet
Length:	
Left abutment nonoverflow section	696.0 feet
Spillway section	294.5 feet
Right abutment nonoverflow section	533.0 feet
Total	1,523.5 feet

5. Dam: (cont'd)

Width of roadway between curbs	20 feet
Total excavation, dam, powerhouse, and appurtenances	1,060,000 cubic yards
Total concrete, dam, powerhouse, and appurtenances	1,530,000 cubic yards
Total concreted rock fill	28,000 cubic yards

6. Power facilities:

Penstock:

Type	Steel
Number	2
Diameter	15 feet
Intake centerline elevation	1,403 feet, m.s.l.
Operating control	Tractor gates
Emergency control	Bulkhead gates

Powerhouse:

Location	Right abutment
Length over-all	175.9 feet
Width over-all	136.5 feet
Spacing of units	54.0 feet
Length of assembly bay	70.0 feet
Number of units	2
Elevation draft tube invert	1,170 feet, m.s.l.
Elevation centerline turbine runners	1,203 feet, m.s.l.

6. Power facilities: (cont'd)

Elevation operating deck	1,230 feet, m.s.l.
Turbines:	
Type	Francis
Diameter of turbine runner	130 inches
Revolutions per minute	163.6
Rated horsepower	70,000
Rated head	285 feet
Generators:	
Installed capacity (nameplate rating)	(2) 50,000 kilowatts
Power factor	0.9
General:	
Maximum head	371 feet
Minimum head	219 feet
Average head	285 feet
Average tailwater elevation	1,198 feet, m.s.l.
Nominal continuous power	35,000 kilowatts
Nominal firm power	87,500 kilowatts
Power draft regulated at Big Cliff Dam, 2.8 miles downstream from Detroit Dam	

BIG CLIFF DAM AND RESERVOIR

PERTINENT DATA

1. General:

Stream	North Santiam River
Location of dam:	
River mile:	
Above mouth of Santiam River	57.6
Above mouth of North Santiam R.	45.8
Below Detroit Dam, miles	2.8
Airline mile:	
Distance from Portland	57
Distance from Salem	37
Public land survey	NE$\frac{1}{4}$ Sec. 35, T. 9 S., R. 4 E., W.M.
Datum	Mean sea level, U. S. Coast & Geodetic Survey
Drainage area	452 square miles
Spillway design flood:	
Peak inflow	179,000 second-feet
Peak outflow	179,000 second-feet
Mean annual run-off (1922-46)	1,450,000 acre-feet
Discharge, maximum historical (1861) estimated	67,000 second-feet
Discharge, maximum of record (1945)	42,400 second-feet
Discharge, mean (1922-46)	2,000 second-feet
Discharge, minimum unregulated (1938-46)	410 second-feet

BIG CLIFF DAM AND RESERVOIR

PERTINENT DATA (CONT'D)

1. General: (cont'd)

Discharge, minimum regulated for fish life:	
Filling season (February-June)	1,000 second-feet
Low-water season (July-November)	750 second-feet
Flood season (December-January)	Reservoir inflow

2. Reservoir:

Pool elevations:	
Minimum power pool	~~1,193~~ 1,182 feet, m.s.l.
Full pool	1,206 feet, m.s.l.
Maximum pool	1,210 feet, m.s.l.
Reservoir areas:	
Minimum power pool	120 acres
Full pool	141 acres
Maximum pool	120 ~~146~~ acres
Reservoir storage:	
Power storage	~~1,800~~ acre-feet
Dead storage	4,650 acre-feet
Total storage, full pool	6,450 acre-feet
Total storage, maximum pool	7,020 acre-feet

3. Spillway:

Type	Concrete-gravity gate-controlled
Crest length:	
Gross	156 feet

3. Spillway: (cont'd)

Crest length: (cont'd)	
Net	138 feet
Crest elevation	1,161.5 feet, m.s.l.
Maximum head on crest	48.5 feet
Design discharge	179,000 second-feet
Type of stilling basin	Hydraulic jump - baffled horizontal apron
Elevation stilling basin floor	1,078 feet, m.s.l.
Design discharge stilling basin	179,000 second-feet
Tailwater elevations:	
Discharge, 179,000 second-feet	1,143 feet, m.s.l.
Spillway gates:	
Type	Radial
Number	3
Size (clear opening below full pool)	46 feet by 44.5 feet high
Operation	Electrically operated hoists

4. Dam:

Type	Straight concrete-gravity
Elevation, roadway deck	1,212 feet, m.s.l.
Maximum height, foundation to roadway deck	172 feet
Freeboard above maximum pool	2 feet

4. Dam: (cont'd)

Length:

Left abutment nonoverflow section	16 feet
Spillway section	156 feet
Right abutment nonoverflow section	123 feet
Total	295 feet
Width of roadway between curbs	15 feet

5. Power facilities:

Penstock:

Type	Steel
Number	1
Diameter	20 feet
Intake centerline elevation	1,140 feet, m.s.l.
Operating control	Tractor gates
Emergency control	Bulkhead gates

Powerhouse:

Location	Right abutment
Length over-all	80 feet
Width over-all	62 feet
Number of units	1
Elevation draft tube invert	1,072 feet, m.s.l.
Elevation centerline turbine distributor	1,106 feet, m.s.l.
Elevation operating deck	1,140 feet, m.s.l.

BIG CLIFF DAM AND RESERVOIR

PERTINENT DATA (CONT'D)

5. Power facilities (cont'd)

Turbine:

Type	Kaplan
Diameter of turbine runner	148 inches
Revolutions per minute	163.6
Rated horsepower	26,500
Rated head	91 feet

Generators:

Installed capacity (nameplate rating)	18,000 kilowatts
Power factor	0.9

General:

Maximum head	98 feet
Minimum head	73 feet
Average head	91 feet.
Average tailwater elevation	1,109 feet, m.s.l.
Nominal continuous power	10,900 kilowatts
Nominal firm power	13,700 kilowatts

Min flood release 100 c.f.s.

DETROIT AND BIG CLIFF RESERVOIR REGULATION MANUAL

SECTION I - INTRODUCTION

1-01. Authority. - Authority for this manual is contained in Section 20, Part II, Chapter IV, Orders and Regulations. Instructions for the preparation of this manual are contained in Part CXXXVI, Reservoir Regulation, Engineering Manual, Civil Works Construction.

1-02. Purpose and scope of manual. - Purpose of this manual is to present detailed information pertinent to the regulation of Detroit and Big Cliff Reservoirs for flood control, power, irrigation, and other conservation uses. The manual contains historical, descriptive, organizational, and other pertinent data, as well as an explanation of the plan of operation.

1-03. Revisions to manual. - As changes and revisions to this manual are required, they will be made by the Engineering Division of the Portland District. Changes will be made for the purpose of improving reservoir regulation technique, or when developments occur which require revision of the information and data presented in this manual. Any changes in the reservoir regulation plan that affect the authorized functions of the reservoirs, or otherwise constitute major changes in the approved regulation plan, will be submitted through the North Pacific Division to the Office, Chief of Engineers, for prior approval. Whenever revisions are made, new pages containing the revised material will be printed and issued to each person or office having a copy of this manual. Revised pages will show the date of revision. All copies of this manual which are issued will be numbered and recorded so that complete distribution of revisions can be made.

SECTION II - PROJECT HISTORY

2-01. Project authority. - Detroit project was authorized by the Flood Control Act approved 28 June 1938; Public Law 761, Seventy-fifth Congress, third session, on the basis of the report published as House Document 544, Seventy-fifth Congress, third session. Authorization for power at Detroit Dam, including Big Cliff Reregulating Reservoir, was contained in the Flood Control Act approved 30 June 1948 (Public Law 858, 80th Congress, 2nd Session), on the basis of the report published as House Document 531, Eighty-first Congress, second session. Authorization for recreational facilities was contained in the Flood Control Act approved 22 December 1944, Public Law 534, Seventy-eighth Congress, second session. The Flood Control Act approved 24 July 1946; Public Law 526, Seventy-ninth Congress, second session, authorized construction of a new school at Detroit, Oreg.

2-02. Project purpose. - Detroit project is a major unit of the comprehensive plan for the coordinated development and utilization of the water resources in Willamette River Basin. The principal functions of the project will be to provide flood control, navigation, irrigation, power, domestic water supply, pollution abatement, and related benefits.

2-03. Principal changes in design. - As provided for in the project document (House Document No. 544), Detroit Dam was to have been a variable-radius concrete arch with a gate-controlled spillway on the right abutment, outlet conduits in the river section, and a powerhouse on the left bank. Detroit Dam as now constructed is a concrete-gravity structure with a gate-controlled spillway located in the river section and the power plant located on the right bank. Six 42-foot by 28-foot radial spillway gates have been substituted for the four 64-foot by 28-foot spillway gates originally proposed. Stop logs for the spillway gates were eliminated, and a floating log boom added. Original plans provided for a single tier of three 72-inch flood-control outlets, supplemented by two 108-inch regulatory conduits through the left abutment. As a result of further planning, however, Detroit Dam was constructed with four conduits passing in tiers of two through the spillway section. Regulation is effected by means of four fixed-wheel gates 5 feet 8 inches in width by 10 feet in height.

2-04. Early plans called for installation of three 30,000-kilowatt capacity generating units, but those plans were modified to provide two 45,000-kilowatt units. A later modification increased the power installation to two 50,000-kilowatt units. A horizontal stilling basin with two rows of baffles and an end sill was adopted in lieu of a sloping basin. Also, the spillway capacity has been increased to provide for a design flood of 176,000 second-feet.

2-05. The project document plan for Big Cliff Dam has been modified as follows: the spillway crest was raised to elevation 1,162.5, one-half foot above the original design; the spillway section length was increased 5 feet; the three radial gates were increased in size from 45 feet by 35 feet to 46 feet by 43.5 feet; the deck elevation of the operating roadway was decreased from 1,218 to 1,212, and the over-all width was decreased from 30 feet to 26 feet; and the installed power-generating capacity was increased from 16,000 kilowatts to 18,000 kilowatts.

2-06. Resume of construction activities. - Construction at Detroit Dam was initiated by contract 30 March 1949. Prior to that date, all temporary housing, dormitories, mess hall, and shops were completed. The school building, play shed, and water supply system at the town of Detroit were complete. Relocation of North Santiam Highway was initiated in 1947 and completed in 1950. The river diversion tunnel was completed in 1949 and excavation to foundation grade in the spillway, stilling basin, and powerhouse was completed during 1950.

2-07. Concrete placing was started on 5 August 1950. Also, the fabrication of much of the powerhouse and spillway equipment was started by supply contractors during 1950. Placing of concrete in the spillway was virtually complete at the end of 1952. The dam was completed on 31 May 1953, with the exception of the spillway gates which were installed during the summer of 1953.

2-08. The powerhouse substructure was constructed between 5 August 1950 and April 1951. Draft tube liners were installed during the summer of 1951 and work on the superstructure was started in August 1952. The two generators were installed during 1953 and initial power from the first generator was delivered to Bonneville Power Administration the first part of July 1953.

2-09. Clearing and construction of the diversion tunnel at Big Cliff was started 15 December 1950. Construction of Big Cliff reregulating dam and powerhouse was started in August 1951. Construction of the dam and powerhouse was 94 percent complete at the end of the 1953 fiscal year. Both are scheduled for completion in March 1954. Use of Big Cliff Dam for reregulation of the daily fluctuations in the Detroit turbine releases will be initiated in the latter part of 1953, and power at Big Cliff is scheduled to go on the line in April 1954.

2-10. Construction of a salmon hatchery at Marion Forks is complete and the facility is in operation. A permanent salmon egg collecting station at Minto pool below Big Cliff Dam is essentially complete and in operation. Both the hatchery and the egg collection station are adjuncts to Detroit project and were constructed with Detroit funds. Minor uncompleted road grading surfacing and oiling will be accomplished during the 1954 construction season.

2-11. Costs, Detroit Project. - The total costs for the Detroit project have been $59,271,679.47 as of 1 July 1953. The estimated total cost of the project is $63,711,200.

SECTION III - BASIN DESCRIPTION

3-01. Willamette River Basin. - Willamette River and tributaries drain an area in northwest Oregon approximately 11,200 square miles in extent. The basin, roughly rectangular in shape, with a maximum north to south length of about 150 miles and an average width of 75 miles, is part of the lower Columbia River watershed. Two parallel mountain barriers, the Coast and Cascade Ranges, form the western and eastern boundaries, respectively. Maximum elevations exceed 10,000 feet in the Cascade Range and 4,000 feet in the Coast Range. The Calapooya Mountains, which join the Coast and Cascade Ranges to form the southern boundary, have maximum elevations of about 6,000 feet.

3-02. The major tributaries of Willamette River rise in the Cascade Range, and have headwater elevations generally around 6,000 feet. In the upper reaches, these tributaries flow in narrow valleys with steep gradients. The principal tributaries, in downstream order, are: Middle Fork Willamette, McKenzie, Calapooya, Santiam, Molalla, and Clackamas Rivers from the Cascades; Coast Fork Willamette River from the Calapooya Mountains; and Long Tom, Marys, Luckiamute, Yamhill, and Tualatin Rivers from the Coast Range. Santiam River is formed by the confluence of North and South Santiam Rivers at a point about 11 miles upstream from the confluence of Santiam and Willamette Rivers. The frontispiece illustrates the stream system of Willamette Basin.

3-03. North Santiam River Basin. - North Santiam River Basin tributary to Detroit Dam is a fan-shaped area of 438 square miles, located on the west slope of the Cascade Range about 60 miles southeast of Portland, Oreg. Plate 1 illustrates this area and its relation to the Cascade

NORTH SANTIAM WATERSHED ABOVE BIG CLIFF AND DETROIT DAMS

Range. The basin terrain is mountainous and is covered with a heavy stand of coniferous trees. Extremes in elevation within the basin are 1,200 feet at the dam and 10,495 feet on the summit of Mount Jefferson. The average elevation of that part of the basin tributary to the dam is 3,765 feet. Figures 1 and 2 on plate 5 illustrate the area-elevation characteristics of the basin. In general, this area is underlain with basalt and many outcrops penetrate the thin organic soil cover. Principal tributaries to North Santiam River above Detroit Dam, in downstream order, are Marion, Pamelia, and Whitewater Creeks; Breitenbush River; and Blowout and Kinney Creeks.

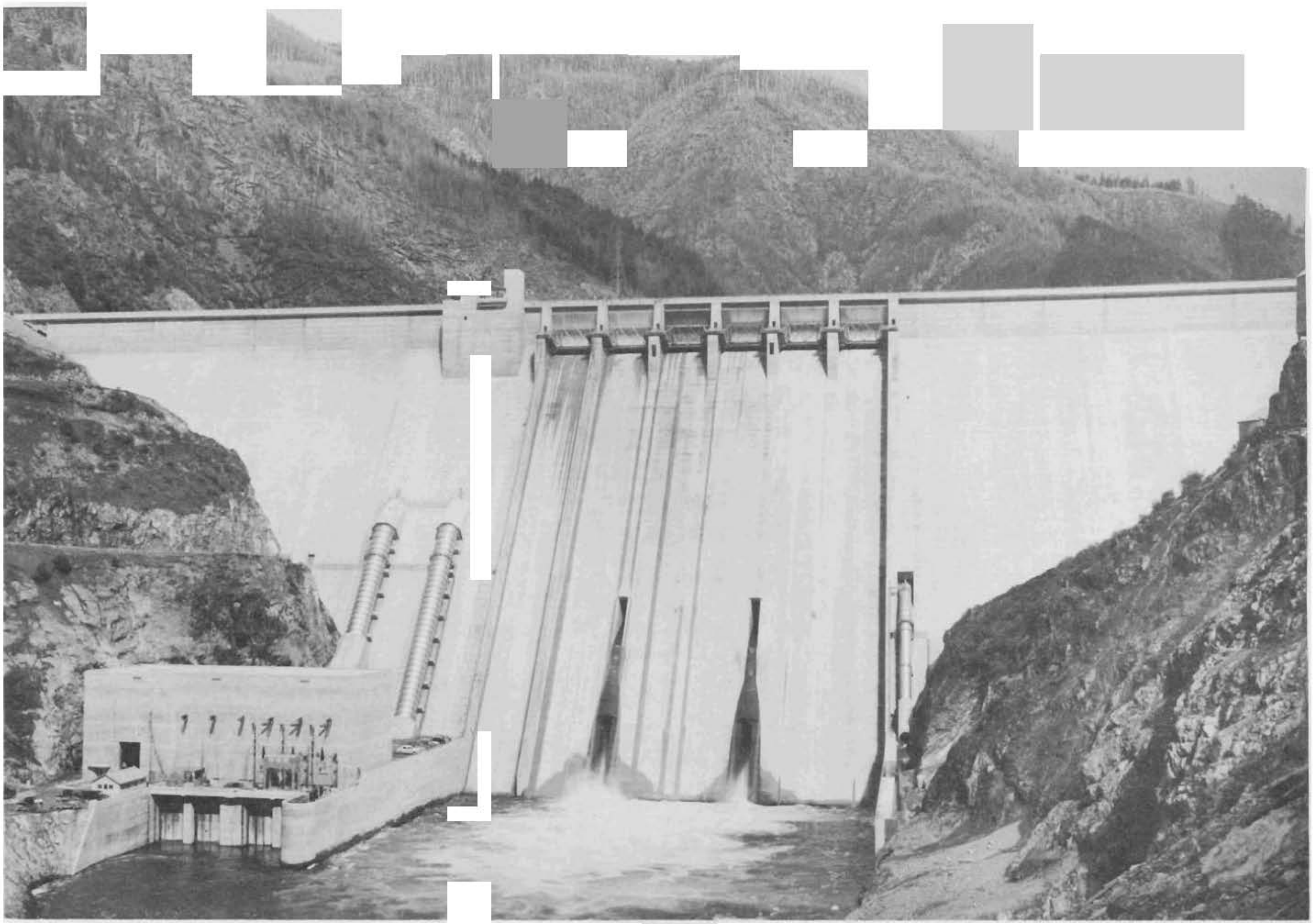
3-04. Big Cliff Dam is located in a narrow gorge on the North Santiam River about 2.8 miles downstream from Detroit Dam. In the vicinity of Detroit and Big Cliff Dams, the canyon walls are very precipitous and the river has an average fall of about 40 feet to the mile. Downstream from Big Cliff Dam the valley opens out, the slopes flatten, and the river has an average fall of 25 feet per mile. Below Stayton, about 17 miles above the confluence with South Santiam River, the North Santiam River enters the flood plain and the average slope drops to 15 feet per mile.

3-05. South Santiam Basin. - South Santiam River, a major tributary of Santiam River, has a drainage area of 1,040 square miles as compared to 750 square miles in the North Santiam River Basin. South Santiam River Basin is quite similar to North Santiam Basin in topography and vegetative cover. The range in elevation is from 5,820 feet to 200 feet, and the average elevation is 2,040 feet. The principal tributaries to South Santiam River above the confluence, in downstream order, are: Middle Santiam River and Wiley, Beaver, Crabtree, and Thomas Creeks. Middle

Santiam River is the most significant of the tributaries as it comprises about one-third of the area in the South Santiam watershed. A major storage project is authorized on the Middle Santiam River at the Green Peter site.

3-06. Santiam River Basin. - Below the confluence of North and South Santiam Rivers, the main Santiam River flows in a meandering course through a broad flood plain. The major contributor to floods in this area is the South Santiam River, as it drains a mountainous area of 1,040 square miles as compared with 750 square miles drained by North Santiam River. Until the authorized multiple-purpose storage project at Green Peter, and possibly the recommended Cascadia and Wiley Creek projects, are completed in the South Santiam Basin, the South Santiam River will be unregulated. Detroit Reservoir alone will be unable to control adequately the larger floods on Santiam River.

3-07. Population. - On the basis of the 1950 census, the urban population within a 50-mile radius of the Detroit project is about 100,000. In this zone 7 cities have populations over 2,500. The residential development above the project is limited to the towns of Detroit and Idanha and their immediate environs. Detroit and Idanha had post-war booms in population and building construction as a result of the increased activities in logging, milling, and wood processing brought about by the continuing favorable market for timber products. Below the project and within the North Santiam River Basin are Mill City, Mehama, and Stayton. Stayton, the largest town, had a 1950 population of 1,510. Jefferson, one and one-half miles below the confluence of the North and South Santiam Rivers, with a 1950 population of 640, is the largest town in the lower basin.



DETROIT DAM

3-08. Industry and resources. - The greater portion of lands within the North Santiam Basin are forest lands. Comparatively little old-growth timber remains near the project area, and the existing stand of Douglas fir is only 20 to 40 years old. Major logging operations, however, are being carried on in areas beyond the project limits by means of private logging roads.

3-09. Lumber production within the North Santiam Basin, both above and below Detroit Reservoir project, based on "Forest Products Industry Directory," published by the "Timberman" in 1950, is estimated to be approximately 116,000,000 board feet annually. There are an estimated 22 mills in the area.

3-10. Agriculture within the lower valley around Jefferson, by area, consists of mint, 10 percent; string beans, 10 percent; sweet corn, 5 percent; alfalfa, 10 percent; fall and spring grains, 15 percent; flax, 5 percent; pasture, 40 percent; and hops, orchards, and miscellaneous crops, 5 percent. Mint returns the largest dollar value per acre.

3-11. Power transmission. - The central Willamette Basin has been deficient in adequately developed power resources. The Bonneville Power Administration's 230-kilovolt transmission line, McNary-Detroit-Goshen, and the Detroit hydro-electric plant have increased the reliability of electric services in that region. Location of the transmission line is shown on plate 1. The Detroit power plant, located near the load end of this long, heavy transmission line, is most valuable in furnishing peak power.

3-12. Transportation. - Public transportation facilities are confined to the north bank of the river and consists of the North Santiam

Highway (State Highway No. 22), which connects the Willamette Valley with the road system east of the Cascade Range. The highway, as relocated in connection with the project, follows the northerly side of the Detroit Reservoir. The Mill City branch of the Southern Pacific Company's railroad system, which formerly terminated at Idanha above the reservoir, was purchased by the Government and removed from the project area in accordance with Interstate Commerce Commission approval. Access to the southerly side of the river is confined to a Forest Service road around a portion of the reservoir and privately owned bridges and logging roads.

3-13. Flood damages. - Floods on North Santiam River cause inundation of up to 12,800 acres in the North Santiam River Basin and contribute to the inundation of up to 81,300 acres along lower Santiam and Willamette Rivers. Properties within those flood plains are valued at approximately 3.7 million dollars along North Santiam River and 160 million dollars along the lower streams, and are steadily increasing in value. Along North Santiam River, the properties are predominantly agricultural, including considerable areas of pasture and waste land which will be made more productive when floods are regulated. The lands along Willamette River below the mouth of Santiam River are highly developed and include parts of the cities of Salem, Oregon City, and Portland, as well as smaller towns and suburban areas.

3-14. Average annual flood damages have been estimated to be $181,800 along North Santiam River and $2,792,000 along the Santiam River and Willamette River below the confluence with Santiam River, based on 1951 prices and a stage of development as of 1948. Based upon 1951 prices and 1951 developments in the flood plain area, the damages that would result from the recurrence of the 1861, 1927, 1943, and 1945 floods would be as follows:

Flood	Damages: Along North Santiam River	Damages: Below North Santiam River
1861	$1,473,000	$24,465,000
1927	124,000	4,248,000
1943	239,400	7,944,000
1945	241,600	4,823,000

Numerous floods of smaller magnitude cause damage, often several times during one year, particularly near the mouth of North Santiam River and along Santiam River. Operation of Detroit Reservoir is expected to reduce damages along North Santiam River by about 81 percent and along Willamette River and the lower reaches of Santiam River by about 21 percent.

SECTION IV - PROJECT DESCRIPTION

4-01. Location. - Detroit Reservoir and Dam and Big Cliff Reregulating Dam are located in the narrow valley of the upper reaches of North Santiam River about 60 miles southeast of Portland, Oreg. The project lies east of Willamette River about two-thirds the distance between Willamette River and the eastern boundary of the basin, and is entirely within the state of Oregon. The frontispiece shows the location of the project area. Detroit Dam is 48.5 miles above the mouth of North Santiam River and Big Cliff Reregulating Dam, 2.8 miles downstream, is 45.7 miles above the mouth. The project area is about 40 miles east of Salem, Oreg. Minto egg collecting station, 4 miles below Big Cliff Reregulating Dam, and Marion Forks Salmon Hatchery, 22 miles above Detroit Dam, were constructed as part of the Detroit project.

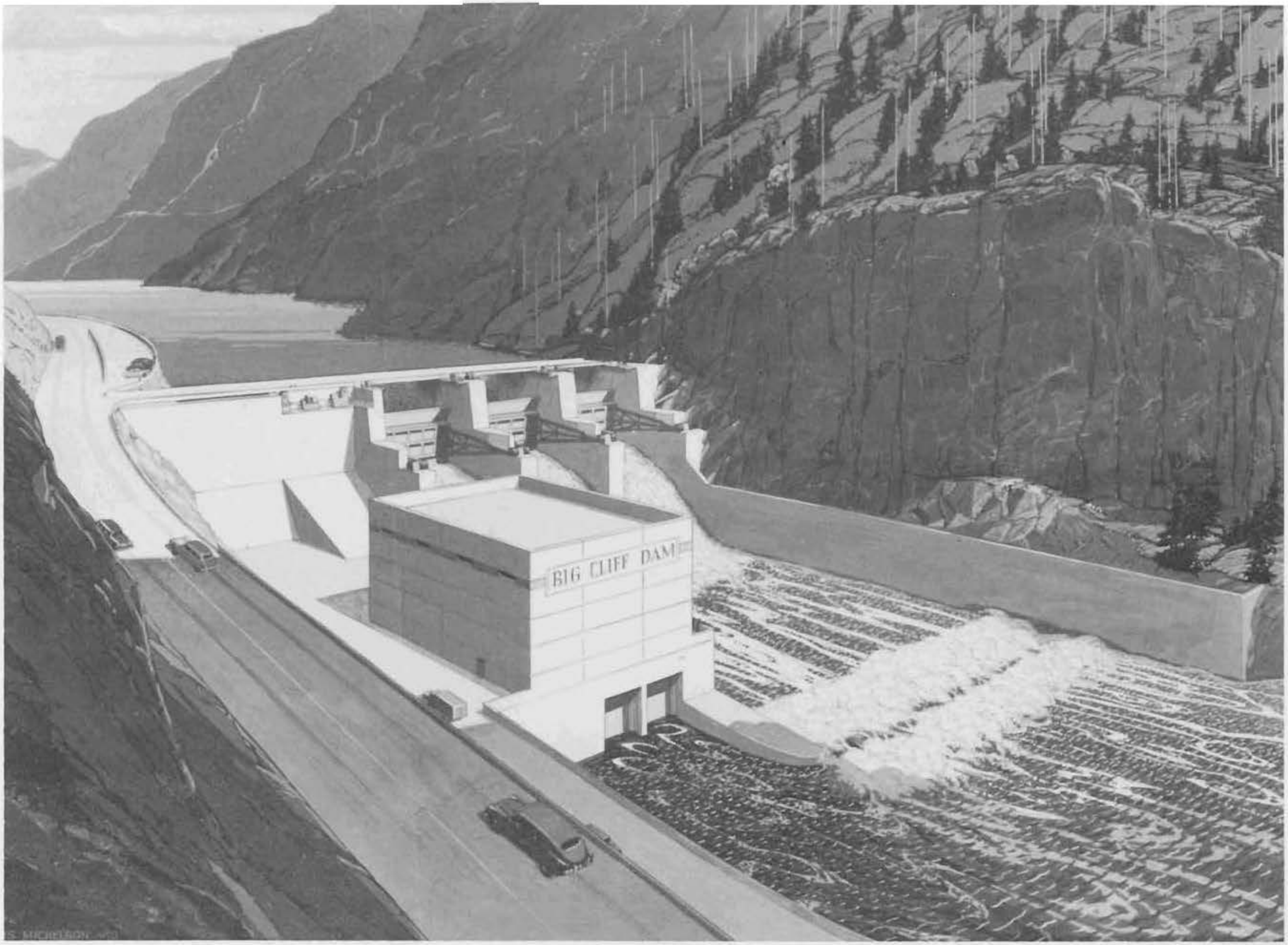
4-02. Detroit Dam. - Detroit Dam is a straight concrete-gravity structure 386 feet high between controlled minimum tailwater, elevation 1,193, and top of dam, elevation 1,579. A 20-foot service road, 1,524 feet long, is located across the top of the dam at elevation 1,579, which is 10 feet above full pool and 5 feet above maximum pool. A 294.5-foot spillway section, equipped with six 42- by 32-foot 7-inch radial gates, is located near the center of the dam. The crest of the spillway is at elevation 1,541, which is 371 feet above the floor of the stilling basin. Two tiers of two outlets each pass through the spillway section, at the third points in length. The centerline of the lower tier is at elevation 1,265.33, and the upper tier is at elevation 1,340.0. The outlets are controlled by hydraulically operated 5-foot 8-inch by 10-foot fixed-wheel gates.

4-03. Flows over the spillway and through the outlets discharge into a horizontal stilling basin 250 feet long and 294.5 feet wide. The stilling basin contains 48 baffles, 6 feet high and 8 feet long, set in two rows, and a three-step end sill 10 feet high. The stilling basin is flanked by training walls 65 feet high. The control tower, which houses the controls for the gates that regulate the flow through the penstocks, is located at elevation 1,579.75 on the downstream side of the service road to the right of the spillway section. Galleries through the dam, used in connection with grouting, drainage, operation, inspection, and escape, are served by a stairway and an elevator in the gravity section under the control tower. The right spillway bay has been made into a test chute by addition of a training wall and observation facilities, and an 8-foot diameter conduit has been constructed in the nonoverflow section to the left of the spillway to facilitate certain hydraulic tests.

4-04. The powerhouse is located along the right side of the spillway stilling basin. The generator floor in the powerhouse is at elevation 1,230.0. The right stilling basin training wall separates the powerhouse from the stilling basin. Two 15-foot steel penstocks serve the powerhouse. Emergency closure of the penstocks can be accomplished by use of tractor gates. Additional protection is afforded by bulkhead gates. Two Francis-type hydraulic turbines, each rated at 70,000 horsepower at a net head of 285 feet, are installed in the powerhouse. The two generators develop 100,000 kilowatts at 0.9 power factor and, at the same power factor, are capable of continuous operation at an overload of 15 percent. The Detroit power plant normally will be operated at a relatively low load factor to meet peak demands on the integrated northwest power system. Plate 2 illustrates the general plan, the spillway and outlet works, and the powerhouse sections for Detroit Dam and Big Cliff Reregulating Dam.

4-05. Detroit Reservoir. - Detroit Reservoir at full pool has a length of about 10 miles and a maximum width of about 1.4 miles. At full pool, elevation 1,569, the gross storage is 454,900 acre-feet. The surcharge storage between full pool and maximum pool, elevation 1,574, is 17,900 acre-feet. Plate 3 shows the reservoir areas and area and capacity curves for both Detroit and Big Cliff Reservoirs.

4-06. Big Cliff Reregulating Dam. - Big Cliff Reregulating Dam, which also is a concrete-gravity structure, is 104 feet high between minimum tailwater, elevation 1,108, and top of dam, elevation 1,212. Total length of the dam at the crest is 295 feet, including the 156-foot spillway. Discharge over the spillway crest, elevation 1,161.5, is regulated by means of three 46- by 45.5-foot radial gates. Dissipation of energy in high-velocity flows below the spillway is accomplished in a paved stilling basin 190 feet long and 156 feet wide. The deck of the 20-foot service road over the dam, at elevation 1,212.0, is 2 feet above maximum pool. The machinery that operates the spillway gates is located on the piers on the downstream side of the roadway. A 20-foot diameter penstock serves the powerhouse. The penstock is provided with an expansion joint and an accelerating elbow 20 feet long. The powerhouse is located on the right bank behind the stilling basin training wall and the generator floor in the powerhouse is at elevation 1,140, which is 3 feet lower than the maximum tailwater. One Kaplan-type turbine, capable of developing 25,800 horsepower under an 82-foot head, which is 1,000 horsepower greater than



BIG CLIFF DAM

the generator nameplate rating, will be installed. The turbine will be capable of developing 28,600 horsepower at normal pool under a 95-foot head. The generator will have a rating of 18,000 kilowatts at 0.9 power factor and will be capable of continuous operation at an overload of 15 percent.

4-07. Energy generated at Big Cliff power plant will be transmitted at generator voltage, 13,800 volts, to the Detroit generator bus. From there, it will be raised to 230,000 volts through the main Detroit transformer for transfer to the Bonneville Power Administration switchyard on the McNary-Detroit-Goshen transmission line.

4-08. Big Cliff Reservoir. - Big Cliff Reservoir is 2.8 miles long and very narrow, extending upstream to the tailwater of Detroit Dam. Maximum pool is at elevation 1,210. Full pool elevation is 1,206. Pool elevation will fluctuate several feet each day in the course of reregulating flows from the Detroit power plant.

4-09. Fish facilities. - The Minto Egg Collecting Station, located at about elevation 960 and 4 miles below Big Cliff Dam, has facilities for trapping and holding adult salmon and steelhead until they attain sexual maturity and also facilities for collecting and eyeing the eggs. The eggs taken at Minto are trucked to the Marion Forks Salmon Hatchery, located 22 miles above Detroit Dam within the Willamette National Forest, at the confluence of Horn and Marion Creeks, both tributaries to North Santiam River. That hatchery has a capacity of 18,000,000 salmon eggs and 6,000,000 steelhead eggs, and the ponds have a rearing capacity of 1,152,000 16-month old fish.

4-10. Public-use facilities. - Detroit Reservoir has considerable appeal as a recreational center for sportsmen and campers from the Salem area and three areas have been designated for recreational development. Two of the areas, Mongold Boat Ramp and Lakeshore Forest Camp, are located on the north shore of the reservoir about half way between the dam and Idanha, which is just above the head of the reservoir. The third location, Sauers Creek Forest Camp, is located on the south shore of the reservoir directly across from the Lakeshore Forest Camp. The forest camps are operated by the U. S. Forest Service. Parking and sanitary facilities for the public have been provided at the dam. Location of the above public-use areas is shown on plate 3. Other than limited facilities at the Lakeshore Forest Camp, little development work has been undertaken at the recreational camps. Plans for those recreational areas have been completed, but the lack of funds may curtail their development for some time.

4-11. Developed recreational facilities at Big Cliff Reregulating Dam are limited to the scenic overlook adjoining the highway above the right abutment, a small observation room, and sanitary facilities in the control house.

4-12. Minto Egg Collecting Station and Marion Forks Salmon Hatchery have sufficient parking areas for a limited number of sight-seers. The U. S. Forest Service maintains a camping area adjacent to Marion Forks Hatchery.

SECTION V - METEOROLOGY AND HYDROLOGY

5-01. Climate. - North Santiam River Basin is located on the west slope of the Cascade Range and is dominated by maritime air-mass influences during the entire year, except during short periods of continental air-mass control. The climate is characterized by wet, rather cool winters and relatively dry, warm summers. The average winter temperatures in the higher elevations of the basin are generally near freezing; and snow accumulates to great depths during the cold, wet winter months. The area is subject to frequent winter storms of varied precipitation intensities. During the summer months, thunder storms occasionally occur in the mountains. These storms are of a local nature and result in no significant increase in discharges at Detroit.

5-02. Climatological stations. - In the immediate area of the North Santiam River Basin above Detroit Dam there are six climatological stations all with automatic precipitation recorders. Those stations are located at Santiam Junction, Santiam Pass, Marion Forks, Breitenbush, Detroit, and Detroit Dam. In the North Santiam River Basin below Detroit Dam there are two stations, neither of which have automatic precipitation recorders. Those stations are located at Mehama and Stayton. Silver Creek Falls, a nearby station, is slightly north of North Santiam River Basin in the headwaters of Silver Creek, a tributary of Pudding River. Plate 1 shows the location of all climatological stations within and adjacent to the Santiam River Basin.

5-03. In the South Santiam River Basin there are five active climatological stations, namely: Cascadia, Quartzville, Foster, Waterloo, and Lacomb. Only Cascadia and Lacomb are equipped with precipitation recorders.

In the lower Santiam Rivervalley, below the confluence of North and South Santiam Rivers, Jefferson is the only climatological station. It is equipped with a recorder type precipitation gage.

5-04. Climatological stations at Albany and Salem, which are not in the immediate lower Santiam valley but in the Willamette River Basin proper, are used in the determination of "down-river" flows as related to North Santiam regulation by Detroit Dam. Basic data and periods of record for all climatological stations are presented as bar graphs on plate 5 and the locations of the stations are shown on plate 1.

5-05. Precipitation. - Normal annual precipitation over the portion of North Santiam River Basin above Detroit Dam is 82 inches. Within that part of the basin, the normal annual precipitation ranges from 65 inches in the vicinity of Detroit to about 100 inches at the higher elevations on the west slope of Mount Jefferson. That portion of the basin below Detroit Dam, which includes the high precipitation area of the Little North Santiam River Basin, has a normal annual precipitation of 88 inches. South Santiam River Basin, which contributes run-off to the lower Santiam River, has a normal annual precipitation of 73 inches; and the area tributary to Santiam River below the confluence of North and South Santiam Rivers has a normal annual precipitation of 40 inches.

5-06. Climatological records for the station at Detroit show that about 60 percent of the average annual precipitation occurs during the winter months, November through February. The average November precipitation slightly exceeds that of each of the other three months. During the summer months, June through September, only 10 percent of the average annual precipitation occurs. The maximum monthly precipitation recorded at Detroit was 27.76 inches in November 1942. Complete absence of precipitation has occasionally been recorded during the months of July, August, and September. The highest 24-hour precipitation of record, 4.81 inches, occurred in November 1909. Precipitation data for Detroit and Detroit Dam are summarized in tables 1 and 2. Normal annual precipitation over the Santiam River Basin is illustrated by the normal annual isohyetal map shown on plate 4. Plate 6 shows bar graphs of monthly and annual precipitation for the period of record for Detroit and Cascadia.

5-07. Winter precipitation over that portion of the basin above Detroit Dam frequently occurs in the form of snow, which accumulates to great depths at the higher elevations. About 10 percent of the mean annual precipitation is estimated to occur as snow at 2,000-foot elevation, 50 percent at 5,000-foot elevation, and 75 percent at 7,000-foot elevation. The snow at the lower elevations usually melts off several times each winter, whereas at the higher elevations it accumulates continuously throughout the winter. On rare occasions, as in the winter of 1948-49, snow accumulates to great depths at the lower elevations. At Detroit, the average observed annual snowfall has been 56 inches. Extremes in recorded snowfall at Detroit are 195 inches during the winter of 1915-16, and 29 inches in a 24-hour period in January 1895. Bar graphs of the annual snowfall at Detroit and Cascadia are shown on plate 6.

5-08. Snow surveys. - At the higher elevations, snow surveys are made on the 1st and 15th of January, February, March, and April at four regular snow courses within or adjacent to North Santiam River Basin. Hogg Pass, located just outside North Santiam Basin, has experienced the greatest snow depths of any of the courses within or adjacent to the basin. On 1 April, the approximate date at which the snow pack normally has its greatest water content, the snow pack at Hogg Pass has had an average water content of 40.2 inches. The greatest snow depth recorded at Hogg Pass was 162 inches on 1 April 1949, at which time the water equivalent was 73.4 inches. In addition to the regular snow courses, snow measurements now are being made at four auxiliary courses within the basin. From those measurements, a snow profile from the dam to the highest regular snow course is prepared. Plate 5 lists the regular and auxiliary snow courses, and the geographical locations are shown on plate 1.

5-09. Temperature. - The modifying effect of maritime air results in a comparatively small variation of temperature throughout the entire Santiam River Basin, particularly over the upper portion. Average monthly temperatures at Salem, which are indicative of temperatures at Jefferson, range from 39.5° F. in January to 67.0° F. in July. For the year, the average monthly temperature range at Detroit is from 33.2° to 64.2° F. Detroit is an index station for the upper portion of Santiam River Basin. Temperature extremes of -10° and 108° F. have been recorded at Salem, and -10° and 106° F. have been recorded at Detroit. Histographs of monthly temperatures for Detroit and Cascadia are shown on plate 6.

5-10. Evaporation. - During the winter months, when temperatures are low and humidity is generally high, evaporation is negligible. Maximum evaporation rates occur during July and August when the air is warm and dry. Evaporation records at Cottage Grove on Coast Fork Willamette River indicate that the annual evaporation at Detroit Reservoir will be about 36 inches, and will occur during the 7-month period April-October. On the basis of 36 inches, it is estimated that the gross annual evaporation loss from Detroit Reservoir, after the project is in normal operation, will be 7,000 acre-feet. Of that amount, rainfall during the conservation season will restore approximately 2,500 acre-feet. The net evaporation loss, 4,500 acre-feet, represents about 2 percent of the usable storage. In programming the release of stored water, the net evaporation loss will be considered as a consumptive use distributed throughout the year as follows: April, 310 acre-feet; May, 570 acre-feet; June, 750 acre-feet; July, 1,100 acre-feet; August, 970 acre-feet; September, 480 acre-feet; and October, 320 acre-feet.

5-11. Storms. - Except for occasional summer thunderstorms in the mountains, maximum precipitation in the basin occurs during the winter months when the area is subject to frequent cyclonic storms moving in from the Pacific Ocean. In the summer the paths followed by those storms lie far to the north, whereas in the winter the storm path moves southward to permit storms of varying intensities to cross the Pacific Northwest. A strong pressure gradient, resulting from a well-developed, southerly displaced Aleutian low, produces a rapid flow of moist air which, upon being forced upward by the Cascade Range, produces heavy precipitation, supplementing that produced by frontal activity. Little North Santiam River Basin receives a greater amount of precipitation than the adjacent areas to the north and south. This condition is caused by the orientation and elevation of the basin and by the relatively low portion of the Coast Range to the west of the basin. This permits a stronger flow of moist air over the basin than over the adjoining watersheds, increasing both storm intensities and annual precipitation depths.

5-12. The larger storms of record which have occurred over Willamette Basin were investigated to determine which had produced the greatest depths of precipitation over the area above Detroit Dam. The study indicated that for all durations up to 72 hours, the storm of 21-25 November 1909 exceeded all other storms of record. Complete records for this storm, however, are not available. The storm of 18-22 November 1921 had similar characteristics and the depth-duration curve for that storm is shown on plate 6.

5-13. Stream gaging stations. - Ten active stream gaging stations are located within the Santiam River watershed. Five of the stations are in the North Santiam River Basin, three on Santiam River, and two on principal tributaries. The stations on North Santiam River are located at Mehama, near Niagara below Big Cliff Dam; and near Detroit at the head of Detroit Reservoir. The tributary stations are at Detroit, at the head of Detroit Reservoir on Breitenbush River; and at Mehama on Little North Santiam River. Four stations are operated in South Santiam River Basin, two on South Santiam River, and two on tributaries. The main stream stations are at Waterloo and Cascadia. The two tributary stations are located near Foster on Middle Santiam River and near Foster on Wiley Creek. Below the confluence of North and South Santiam Rivers, a station is operated at Jefferson on Santiam River. Plate 1 shows the locations of the ten stream gaging stations. Plate 5 shows pertinent information about each individual station.

5-14. The regulated flow of Willamette River above the mouth of Santiam River is measured at the hydrologic station at Albany. The regulated flow of Willamette downstream from Santiam River is measured at Salem. To determine the amount of "down-river" regulation obtained by the Detroit project, the daily effect is determined at Salem by comparison of the Salem and Albany discharges. The location of Salem and Albany in relation to the Santiam River Basin is shown on plate 1 and bar graphs of record on plate 5.

5-15. Tailwater station. - The water-stage recorder station near Niagara, 0.9 mile below Big Cliff Dam on the left bank of North Santiam River, serves as a tailwater gage. Table 12 shows stage-discharge data for the tailwater station. Releases from Detroit project will be recorded as the discharge gaged at the Niagara tailwater station. Telemetering equipment will transmit over telephone wires the Niagara gage height continuously to the Detroit powerhouse. The station, exclusive of telemetering equipment, is maintained and operated by the U. S. Geological Survey but financed by the Corps of Engineers.

5-16. Water temperatures. - Water temperatures of North Santiam River have been observed at Detroit and below Big Cliff Dam over a period of several years. An analysis of the data shows that during the 4-month period, December through March, water temperatures are generally below 42° F. A minimum water temperature of approximately 35° F. was observed at a time when ice was floating in the river. The highest observed water temperature was 61.5° F. in the month of July 1945. Generally, water temperatures in July and August are above 56° F. and remain constant during those 2 months. May, June, September, and October are transition months and the greatest range in water temperature takes place in those months.

5-17. Hydrothermographs have been installed as part of the equipment in the concrete water-stage recorder houses located immediately above Detroit Reservoir on North Santiam and Breitenbush Rivers and below Big Cliff Dam on North Santiam River. In addition, thermohms have been installed in Detroit Dam for measuring the temperature of the water in the reservoir at various levels. This information has been and is being collected in the interest of future reservoir regulation for fish life below Detroit Dam.

5-18. Stream-flow characteristics. - The stream-flow pattern of Santiam River at Jefferson or of North Santiam River at Detroit Dam is similar to the annual rainfall pattern for western Oregon in that low flows prevail from June through October, the season of low precipitation, and high flows occur during the remainder of the year. Daily discharge hydrographs, plates 9 through 17, illustrate the stream-flow characteristics of the streams above and below Detroit Reservoir. After the ground becomes partially saturated in the fall, the streams respond readily to any rain in excess of the infiltration capacity of the top soil, which may vary from 0.1 to 0.03 inch per hour, depending upon the degree of saturation. The maximum annual high water usually occurs during November, December, or January. Numerous secondary freshets occur each year during the rainy season. Snowmelt from the higher elevations assists in maintaining a fairly high base flow until midsummer.

5-19. Run-off. - The average annual run-off at Detroit Dam is 1,940 second-feet, 1,405,000 acre-feet, or 60.2 inches. The normal annual precipitation is 82 inches, which indicates that the average annual basin loss is about 22 inches. At Detroit Dam, the average mean monthly flow of North

Santiam River for each month from December through May is in excess of 2,500 second-feet. Seventy-two percent of the annual run-off occurs in that 6-month period. The run-off summaries for Santiam River Basin are presented on plate 8.

5-20. Stream velocities. - The gradient of North Santiam River in the vicinity of Detroit Dam is about 60 feet per mile. Velocity data obtained at the gaging station located 850 feet below the axis of the dam indicate that the average velocity for low water is about one foot per second; for 10,000 second-feet, 6 feet per second; for 50,000 second-feet, 11 feet per second; and for the spillway design flood, 176,000 second-feet, 17 feet per second. The latter velocity is an estimated value based upon an extrapolated rating curve. Those velocities, which are averages for the entire cross-section of the river, will be appreciably exceeded in the more constricted sections of the river and in the main channel. During high-water periods, velocities are high enough to cause a bedload movement of everything but the larger boulders and to cause erosion of any soil exposed to the river currents.

5-21. Floods. - Floods on North Santiam River are usually the result of intense rain storms of 2- to 4-day duration, augmented quite frequently with snowmelt. The snowmelt effect is more pronounced in the early winter months before the basin snow cover becomes too deep and too packed. The rugged terrain of the basin, which is situated in the path of warm maritime air masses moving in from the Pacific Ocean, intercepts much of the moisture in the air. This condition results in frequent intense rainfall over the basin and a high unit run-off. The flashy characteristics of North Santiam River is illustrated by the daily hydrographs shown on plates 9 through 15.

5-22. Reliable information regarding the magnitude of North Santiam River floods prior to 1905 is meager. Special studies have been made to determine the volume and magnitude of the 1861 and 1890 floods, the two largest known historical floods. Maximum discharges computed for the river at Detroit dam site for the 1861 and 1890 floods were 65,000 and 55,000 second-feet, respectively. Fragmentary reports on high-water marks for floods in November 1896 and November 1909 indicate those floods to have been equal in magnitude and to have had peak discharges at Detroit Dam of 50,000 second-feet each. The largest observed flood was 41,200 second-feet in December 1945. The following tabulation lists the 10 largest historical and observed floods at the site of Detroit Dam:

Relative magnitude	Date	Max. discharge, second-feet	Remarks
1	Dec. 1861	65,000	Historical, special investigation
2	Feb. 1890	55,000	do
3	Nov. 1896	50,000	Historical, high-water marks
4	Nov. 1909	50,000	do
5	Dec. 1945	41,200	Observed
6	Jan. 1948	34,500	do
7	Nov. 1921	34,000	Est. based on observed record
8	Jan. 1923	34,000	do
9	Feb. 1907	31,800	do
10	Dec. 1946	31,100	Observed

5-23. A flood frequency study based on all historical and observed floods and shown on figure 2 of plate 7 indicates the following maximum discharges at Detroit Dam:

Frequency in years	Maximum discharge, second-feet
2	19,800
5	27,900
10	33,400
25	40,300
50	46,500
100	52,500

5-24. Flood volumes. - From the standpoint of flood regulation with storage reservoirs, the volume of a flood is of major importance. Studies indicate that the 300,000 acre-feet of usable flood-control storage in Detroit Reservoir will completely regulate at the site of the dam all floods of record on North Santiam River. The historical 1861 flood, however, would not have been completely regulated. The following tabulation shows required storages to regulate the larger historical floods and floods of record at Detroit Dam:

Flood	Maximum inflow in second-feet	Required storage, acre-feet
1861	65,000	305,200
1890	55,000	223,700
1927	27,700	69,600
1943	24,900	122,000
1945	40,900	125,800
1948	34,600	91,400

5-25. <u>Reduction of flood stage on Willamette River</u>. - Although the immediate areas which will benefit from Detroit Dam are along the lower reach of North Santiam River and along the entire length of Santiam River, areas along Willamette River below the mouth of Santiam River also will benefit from the reduction of flood stages. Appreciable reduction in peak stages will be effected at Salem. A number of smaller towns and agricultural areas downstream from Salem also will benefit. To a lesser extent, the stage reduction effects will extend downstream as far as Portland, Oreg., and vicinity.

5-26. Regulation for reduction of stages on Santiam River normally will result in effective regulation on Willamette River. Discharge from Detroit Dam usually will reach Willamette River ahead of the crest moving down Willamette River from the upper end of the valley. It will be necessary, however, before making sustained evacuation releases from Detroit Reservoir, to determine when and in what amount such releases can be made without adding an excessive increment to the flow moving down Willamette River. Under adverse circumstances following an over-all basin storm, it may be necessary to delay the initiation of evacuation of Detroit Reservoir as much as 2 days.

5-27. <u>Bankfull stages</u>. - Considerable significance is attached to bankfull capacities downstream from flood-control storage projects, as those capacities are the basis for deriving reservoir regulation schedules for the control of floods. Below Detroit Dam, the more critical reaches of the river, from the standpoint of overbank flooding, are near the mouth of North Santiam River, along the entire length of Santiam River, and on Willamette River below the mouth of Santiam River.

Bankfull data for index stations along the above reaches are shown in the following tabulation:

Station	Stream	Drainage area, sq. mi.	Normal bankfull data		
			Discharge, c.f.s.	Stage, feet	Index reach
Mehama	N. Santiam R.	665	26,000	9.3	Lower N. Santiam
Jefferson	Santiam R.	1,790	40,000	14.2	Jefferson & vic.
Salem	Willamette R.	7,280	120,000	16.0	Salem & vic.

Bankfull stages at Jefferson and Salem are most significant and have been the controlling factors in formulating the present reservoir regulation schedule for Detroit Reservoir. It should be noted that the nominal bankfull stages shown are not intended to indicate that no overflow will take place at those stages. House Document 531 contained a recommendation for authorization of overflow channel closures to confine evacuation releases to the channel. To date, however, Congress has not authorized such facilities.

5-28. Until flood-control storage is provided on South Santiam River, flooding will occur frequently below the confluence of North and South Santiam Rivers in vicinity of Jefferson, even with the flow at Detroit Dam reduced to a minimum. Detroit Dam controls run-off from only 25 percent of the drainage area above Jefferson. The remaining 75 percent, which amounts to 1,350 square miles, contributes a run-off which, on many occasions, will exceed the bankfull stage at Jefferson and add to the flood flows on Willamette River.

5-29. Determination of reservoir inflow. - Average or total reservoir inflow over a period of time may best be estimated by algebraically adding the change in storage during the period to the reservoir release. Although this method generally yields the most reliable estimates of average daily inflows, it cannot be used with accuracy to determine the inflow over very short periods of time. Also, this method must be used with caution when the surface wind is sufficiently strong to affect the level of the water surface at the reservoir gaging station. The storage equation actually gives inflow less losses, but during much of the year the losses are minor as compared to the inflow.

5-30. Instantaneous reservoir inflow may be estimated by applying a factor to the instantaneous discharges at the two upstream gaging stations located at the head of the reservoir, one near Idanha on North Santiam River and the other near the new town of Detroit on Breitenbush River. The two inflow stream gaging stations are equipped with automatic telemetering equipment which records the river stages at the control station in Detroit Dam powerhouse. Run-off from approximately 75 percent of the area tributary to Detroit Dam is gaged at those two stations. A correlation of the combined discharge at those two stations with that observed at Detroit Dam indicated a variable ratio which varies from near unity for low flows to a maximum of 1.70 for intermediate flows. The factor that should be applied to the combined discharges for any particular time should be based upon the storage equation derived for the immediate run-off conditions. The ratio of the total area above Detroit Dam to the combined drainage area above the two inflow stations is approximately 1.3. During prolonged dry periods, the factor decreases and may approach unity as the run-off contribution of the ungaged area becomes very small. The factor is of least reliability during the winter months when snow and below-freezing temperatures are experienced in the basin.

5-31. Hydrologic reporting network. - For effective reservoir regulation, it is essential that operating personnel receive periodic information concerning meteorologic and hydrologic conditions for both the area above and below a reservoir. Such information can best be obtained through a hydrologic reporting network. Such a network was initiated for Willamette Valley in 1939 by cooperative agreement between the Corps of Engineers and the U. S. Weather Bureau. Stations in the network report precipitation, temperature, river stages, etc. to a central office in accordance with prescribed instructions. In some instances, reports are sent in only when the precipitation has been more than one inch in preceding 24 hours, or when streams are flooding. Other stations report at least once a day, or as often as directed during critical storm periods. All stations are subject to call from the office operating the station. Communication between the network stations and collection points is primarily by telephone. Radio communication between inaccessible areas and collection centers and between the Willamette dams and the District Office is being considered.

5-32. At the present time, the Willamette River Basin network consists of approximately 70 stations strategically dispersed. The greater station density is in areas where reservoirs are in operation. Twenty of the network stations report directly to the Corps of Engineers. Those stations are situated in the immediate vicinity of existing reservoirs operated by this agency. Twenty-five stations are operated by cooperative agreement between the Corps of Engineers and the Weather Bureau; the Weather Bureau does the actual operating and the Corps of Engineers finances the operation. The remaining 25 stations are operated exclusively by the Weather Bureau. A free and continuous exchange of information obtained from stations in the hydrologic reporting network exists between the Corps of Engineers and Weather Bureau at all times.

5-33. All the stream gaging and weather stations that are intimately related to Detroit Dam and Reservoir are listed on plate 5. Those stations in the list that are a part of the hydrologic reporting network are noted with the subscript 1. Seven stream gaging stations and 8 weather stations are denoted as being stations in the hydrologic reporting network. Five of those stream gaging stations and one of the weather stations report to the District Office through the operating personnel at Detroit Dam. Reports from the other network stations are received through other channels. Stations reported by personnel at Detroit Dam are as follows:

Station number	Station	Stream or watershed	Information reported
5537	Above Canyon Creek	Breitenbush R.	River stage
5536	Below Boulder Creek	N. Santiam R.	do
5539	At Detroit Dam	do	Reservoir elevation
553	Above Niagara	do	River stage
555	At Jefferson	Santiam R.	do
2290	Detroit Dam	N. Santiam R.	Weather

The geographical locations of the stations listed in the above tabulation are shown on plate 1.

5-34. Telemetering equipment transmits continuously to the Detroit powerhouse the river stage on Breitenbush River above Canyon Creek, North

Santiam River below Boulder Creek, and North Santiam River above Niagara. River stages at Jefferson on Santiam River and at Salem on Willamette River can be obtained by telephone as those stations are equipped with Telemarks. Telephone numbers are Jefferson 211 and Salem 4-5283, respectively. Other hydrologic reporting stations in the immediate vicinity of Detroit Dam report on a person to person basis.

5-35. Snow courses. - A large portion of the area tributary to North Santiam River above Detroit Dam is high enough in elevation that snow is an important hydrologic factor. For that reason, means have been provided to obtain information on snow conditions above Detroit Dam. Four standard snow courses are located within or adjacent to North Santiam River Basin, namely: Breitenbush, elevation 2,325; Marion Forks, elevation 2,730; Santiam Junction, elevation 3,990; and Hogg Pass, elevation 4,755. Four auxiliary courses are now being measured within the basin, namely: Whitewater Bridge, elevation 2,175; Detroit, Oreg., elevation 1,750, Detroit Dam, elevation 1,580; and Mill City, Oreg., elevation 826. These courses are measured on the 1st and 15th of the month starting on 1 January and continuing through 1 April. The geographical locations of the snow courses are shown on plate 1. See plate 5 for map identification numbers.

5-36. Sedimentation. - Because of the vegetal cover and geology of the watershed, North Santiam River does not carry a heavy sediment load. Suspended sedimentation studies, conducted in the basin over a 2-year period, indicate that during floods North Santiam River at Mehama contains between 75 and 200 parts per million of suspended material. During low flows, the amount of suspended material drops to less than 15 parts per million.

5-37. Studies of suspended sediment indicate a higher sediment concentration in North Santiam River than in Coast Fork Willamette River above Cottage Grove Reservoir. On the basis of a reservoir survey made at Cottage Grove in 1947, and assuming that the relationship of suspended material applies to the reservoir catchment rate, it is estimated that Detroit Reservoir will fill with sediment at the rate of 175 acre-feet per year.

5-38. In order to facilitate the keeping of a permanent record of the rate of siltation taking place in Detroit and Big Cliff Reservoirs, a permanent set of sedimentation range lines were established in the spring of 1953. In the future those range lines will be resurveyed whenever a survey is considered advisable and the loss of reservoir storage space will be computed. The results of the survey will be furnished the Office, Chief of Engineers, on Standard Form 1787.

5-39. Since Detroit and Big Cliff Reservoirs will act as desilting reservoirs, there is a possibility of degradation taking place below Detroit and Big Cliff Dams. Should critical scouring of the downstream channel occur, action will be taken to correct the situation.

SECTION VI - SEASONAL REGULATION SCHEDULE

6-01. General. - The primary function of Detroit Reservoir is flood control, and the primary function of Big Cliff Reservoir is the regulation of daily discharges from Detroit Reservoir. Together, the two reservoirs are regulated so as to provide maximum over-all benefits and utilization of water resources of North Santiam River. Other interests which benefit directly by the seasonal regulation of Detroit Reservoir include power, irrigation, fish life, navigation, pollution abatement, and recreation. Economic and physical limitations preclude the provision of separate storage capacity for all the above functions. The seasonal stream flow regimen, however, is such that those functions can be served quite satisfactorily by following the seasonal regulation schedule shown on plate 20. Thus, it is possible to make multiple use of the same storage space for flood control, power, and other conservation purposes, at a considerable saving in cost.

6-02. The scheduled regulation of Detroit Reservoir is divided into three seasons: (1) major flood season, 1 December-21 January; (2) conservation storing season, 1 February-5 May; and (3) conservation release season, 6 May-30 November. Those three functional divisions of the seasonal schedule are illustrated graphically in figure 1 of plate 20, and discussed in the following paragraphs.

6-03. Major flood season (1 December-31 January). - A maximum of flood-control space must be provided yearly at Detroit from 1 December to 31 January, inclusive, as that is the period of maximum flood potential. During that season, the reservoir is held evacuated to minimum flood-control pool, elevation 1,450, except as the control and regulation of floods may require use of storage space or as water stored in secondary flood-control storage space is required for power generation. See paragraph 8-15 for details in regard to the use of water stored in secondary flood-control storage space for power generation. Section VII, Flood-Control Regulation, describes in detail the flood-control regulation schedules for Detroit Reservoir. Rate of evacuation of stored floodwater will be governed by the available flood-control storage space and the Santiam River stage at Jefferson, and will vary in accordance with the date. Evacuation discharges will be increased or decreased in accordance with criteria shown in figure 6, plate 7. Normally, before floodwaters are evacuated from Detroit Reservoir, the flows in both the Santiam and Willamette Rivers will have receded so that the releases will not add to the duration of overbank stages.

6-04. Conservation storing season (1 February-5 May). - After 1 February, the flood potential of North Santiam River gradually decreases, which permits storing of water for conservation uses. In accordance with the rates shown on figure 1 of plate 20 and given in table 9, Detroit Reservoir is to be filled during the 94-day period, 1 February-5 May, to elevation 1,563.5 feet, which is the level of the maximum conservation pool. Between minimum and maximum conservation pools, there is space for storing 321,000 acre-feet of water.

6-05. Departures from the filling schedule given in table 9 may be caused either by the regulation of a flood or by an inadequate water supply. Regulation of a flood during the conservation storing season will be in accordance with Section VII of this manual and evacuation of the excess floodwater stored in the reservoir will be in accordance with the downstream criterion shown in figure 6 on plate 7 until the pool is drawn down to the scheduled reservoir elevation for that date. When the water supply is inadequate to maintain minimum downstream flows and the scheduled rate of filling, then filling falls behind schedule as minimum flows must be maintained. However, any deficiency in storing may be made up when the water supply is adequate or filling may be carried beyond the 5 May date if there is a surplus of stream flow.

6-06. Filling schedule. - During February, Detroit Reservoir will be filled at an average accumulative rate of 4,620 acre-feet per day, which will account for 46 percent of the water to be stored for conservation use. The remaining 54 percent will be accumulated gradually between 1 March and 5 May at an average rate of 2,296 acre-feet per day. If this schedule is maintained, maximum conservation pool, elevation 1,563.5, will be reached on 5 May and there will be 280,900 acre-feet of water stored for conservation use, exclusive of the 40,000 acre-feet reserved for power below minimum flood-control pool, elevation 1,450. Figure 1 on plate 20 and table 9 show graphically and in tabular form the conservation storing schedule for Detroit Reservoir.

6-07. During the filling period, the pool level should not exceed that which is scheduled, except when regulating a flood. In such instances, the excess stored water will be evacuated immediately following the flood. Should filling of the reservoir fall behind schedule because of an inadequate reservoir inflow or critical power requirements, it may be made up at a later date when stream flow is available. Storing may be continued after 5 May, if the reservoir is unfilled and there is more stream flow than is required to meet other scheduled commitments.

6-08. Should power generation at Detroit to meet system firm commitments curtail the scheduled filling of Detroit Reservoir and result in a partially filled reservoir to the extent that there is not sufficient water to meet irrigation and other high-priority requirements, then exclusive power storage and possibly dead storage in the amount that power generation curtailed the scheduled filling would be used for irrigation and other high-priority uses. This is a risk that power would assume if regulation for power jeopardized the normal filling of Detroit Reservoir.

6-09. Although the prescribed minimum release from Detroit Reservoir after 1 July is 750 second-feet, storing in Detroit Reservoir will be undertaken only when the inflow is in excess of 1,000 second-feet, and will apply only to that portion in excess of 1,000 second-feet. When the flow in North Santiam River at Detroit Dam is less than 1,000 second-feet, there is barely enough to maintain an acceptable flow in the lower river and storing would not be in the best over-all interest of fish life or the downstream water users. The 750-second-foot minimum release after 1 July should not be construed to imply that all flows in excess of 750 second-feet can be stored. The intention of the minimum release during that period is to insure a minimum flow even if storage has to be used to maintain that flow.

6-10. Conservation releases season (6 May-30 November). - Functional regulation of Detroit Reservoir during the season, 6 May-30 November, provides for the release of stored water for the most effective over-all conservation benefits. Since the actual amount of water stored for conservation use, the demands for stored water, and the required coordination with other storage projects may vary widely from year to year, it is not practicable to establish definite schedules for conservation releases. Instead, a provisional schedule predicated on available stored water, forecasted stream flow, and current water demands will be prepared each year at the conclusion of the filling season. During the conservation releases season, the provisional schedule will be checked periodically for possible revisions that would be required to meet changing water demands. Section VIII of this manual discusses in detail the various conservation uses and their interrelationships in regard to the use of stored water.

6-11 ENVIRONMENTAL FLOW IMPLEMENTATION

1. Background. The Sustainable Rivers Program (SRP) began in 2002 as a partnership between TNC and the Corps with the objective of developing, implementing and refining a framework for beneficial flows downstream of dams. TNC and the Corps have signed memorandums of agreements (MOAs) at the national level as well as the district level to study current hydro regulation operations. SRP efforts in the Willamette River Basin focus on identifying opportunities to improve overall downstream ecosystem health and resiliency by modifying dam releases within the existing operational constraints. The releases that benefit downstream ecosystem health are termed environmental flows (e-flows). The e-flows targets were developed through a process of collecting and synthesizing relevant hydrologic and ecological information and expert knowledge into a set of e-flow recommendations.

2. Purpose of E-flows. Flow recommendations focused on fall flows (October-November), winter high flows (November-February) and smaller spring bankfull flows (flows at Action Stage, as identified by the National Weather Service) (March-June). Each seasonal flow is important to some aspect of ecosystem health. Fall flows enhance channel habitat and provide flows for outmigration. Winter high flows provide benefits to habitat by modifying channel features and recruiting large woody debris. Spring time flows are important for providing out-migration flows as well as scouring and flushing during bank full events.

3. Implementation. The general intent is to maximize opportunities for achieving e-flows at the Willamette Valley projects considering operational constraints and forecast uncertainty. Exhibit 1 provides the discussion and procedure for their implementation.

SECTION VII - FLOOD-CONTROL REGULATION

7-01. Basic methods of flood regulation. - The three basic methods of reservoir regulation for flood control are: (1) regulation based on maximum beneficial use of the available storage during each flood event, (2) regulation based on control of a design flood or series of floods, or (3) a combination of the first and second methods. The flood-control regulation applicable to Detroit Reservoir is a compromise procedure based on the third method, which gives the most beneficial use of the authorized storage for flood control, consistent with the ability to forecast floods on North Santiam River. For small floods which do not threaten to fill the reservoir, regulation will be effected by the first method as long as ample storage space is available. By the use of this method, damaging stages at downstream locations are avoided as long as possible by controlled regulation with the storage space available.

7-02. If the forecast of volume and peak inflow for a large flood or series of small floods indicates that the reservoir capacity will be exceeded, the regulation schedule, as prepared for operation under method (1), will be superseded by a special set of reservoir regulation curves which effect a gradual increase in reservoir release in lieu of a sudden large spill such as would occur if the pool were filled before the spillway gates were opened. The release rates, which are variable and dependent upon reservoir pool elevation and rate of rise, are established so that a maximum use is made of the remaining storage at any particular time without exceeding the reservoir capacity before the end of the flood.

7-03. Normal flood-regulation schedule. - Regulation of Detroit Reservoir for flood control is based upon maintaining flows in Santiam

River at Jefferson at bankfull or less as long as it is physically possible. This is the immediate objective of the project and its accomplishment usually provides satisfactory flood control effect at other related points downstream, particularly during the main part of the flood. Evacuation of floodwaters following a flood requires that, in addition to the Santiam flows, the flows in middle and lower Willamette Rivers be taken into consideration in scheduling reservoir releases. The procedure derived for scheduling normal flood-control releases from Detroit Reservoir so that overbank stages are not exceeded unnecessarily at Jefferson involves a run-off forecast for the uncontrolled area between Detroit Dam and Jefferson for a period of 9 hours in advance of the observation time. Nine hours is the approximate travel time between Detroit Dam and Jefferson for flows of a magnitude which require flood regulation. Therefore, when the forecasted flow from the uncontrolled area is known 9 hours in advance, the release at Detroit that will result in a bankfull (40,000-second-foot) flow at Jefferson can be determined. The release at Detroit is normally not reduced lower than 2,000 second-feet in the interest of power generation. However, if the downstream flood situation is such that curtailment of power generation will make a critical contribution to alleviating flood damages, releases at Detroit may be reduced to 100 second-feet. This action would only be taken under the most extraordinary circumstances. If there is no significant need for power from Detroit during a flood crest, the release from Detroit Reservoir would be cut back temporarily to 100 second-feet.

7-04. Such a run-off forecast is incorporated in the normal flood-regulation schedule shown in figure 2 on plate 20. In deriving the parameter curves, it was found that the basin precipitation, if properly weighted, could be correlated satisfactorily with the run-off from the uncontrolled area 9 hours in advance, if the flow from the uncontrolled area at the beginning of the period were a parameter. The weighted basin precipitation is referred to as the precipitation index, and is derived by taking twice the basin precipitation during the last 6 hours, plus the basin precipitation for the 6 hours preceding the last 6 hours. If the temperature is such that part of the precipitation over the basin falls as snow, then it is necessary to adjust the precipitation index to correct for the ineffective precipitation. Paragraph 7-08 discusses the effect of low temperatures and gives factors for adjusting the precipitation index.

7-05. Basin precipitation will be ascertained from reports received from the following stations in and adjacent to the Santiam River Basin: Detroit Dam, Detroit, Mehama, Lacomb, Cascadia, Waterloo, and Salem. In addition, an experimental automatic radio reporting precipitation gage at Jordan Guard Station is being tested and may provide additional precipitation information. The Salem station is a first-order weather station and transmits complete weather reports every 6 hours over teletype Service "C" which is available in the District Office. Since precipitation reports will not be available from all those stations at any particular time, it will be a matter of using the available data to estimate a value for basin precipitation. Personnel in the Reservoir Regulation Subsection will make this determination.

7-06. During the major flood season, 1 December-31 January, minimum flood pool, elevation 1,450, will not be exceeded by more than 3 feet as long as releases prescribed by figure 2 on plate 20 are greater than the reservoir inflow. When the prescribed release is less than the inflow, water will be stored in the space reserved for flood control until the flood passes and then the stored water will be evacuated.

7-07. During the conservation storing season, 1 February-5 May, scheduled pool elevations, as illustrated by figure 1 on plate 20 and table 9, will not be exceeded unless it is necessary in the act of regulating floods. Control of floods during that period will be attained by storing the excess water beyond that required to maintain the filling schedule. After each flood, any excess storage will be evacuated. The same procedure will be followed should a flood occur during the conservation release season.

7-08. Effect of low temperatures on run-off. - Precipitation that falls during periods of low temperature may not contribute to the immediate surface run-off; therefore, a correction must be made in the precipitation index to adjust for the effect of low temperatures before consulting the reservoir regulation schedule shown in figure 2 on plate 20. Mean daily temperatures at Salem have been selected for making this adjustment as those temperatures are affected less by topography and are available every 6 hours on teletype Service "C." The following tabulation shows the significant range in temperature at Salem and the corresponding factor to be applied to the precipitation index:

Average of maximum and minimum temperature at Salem, Oreg., for past 24 hours	Factor to apply to precipitation index
44° F. and above	1.00
41° F. through 43° F.	0.75
38° F. through 40° F.	0.50
35° F. through 37° F.	0.25
Below 35° F.	0.10

7-09. Outlets. - Four outlets are provided through the spillway section of Detroit Dam for regulating releases from Detroit Reservoir. Those outlets are in two tiers, with invert elevations at 1,260.33 and 1,335.0, respectively. Control of the outlets is effected with hydraulically operated 5-foot 8-inch by 10-foot fixed wheel gates. The outlet gates are designed to operate at partial gate openings under heads up to approximately 200 feet. This design criterion will be adhered to for all pool elevations below 1,540. Above pool elevation 1,540 the upper tier of outlets will be operated at partial gate openings at heads in excess of 200 feet. Actual use of the outlet gates when the pool is above 1,540 will not be excessive as normally the release from the reservoir when the pool is above 1,540 will be through the turbines. It is important that, when the gates are operated at partial gate opening at heads in excess of 200 feet, special attention be given to any unusual gate vibration or conduit erosion. Discharge rating tables for the two tiers of outlets are shown on tables 4 and 5 and figures 1 and 2 on plate 19. At minimum flood-control pool, elevation 1,450, the combined discharge of all four outlets is 19,800 second-feet and at full pool, elevation 1,569, the maximum combined discharge is 27,700 second-feet. The capacity of the outlets even at minimum flood-control pool is ample for any foreseeable plan of flood-control regulation at Detroit. As shown by figure 2 of plate 20, the normal maximum controlled release which will be effected only during post flood evacuation is 17,000 second-feet. The outlets at Detroit will be used primarily for flood regulation. Normal releases will be made through the turbines for power generation.

7-10. At Big Cliff, releases in excess of power requirements will be made through one of the spillway gates which is specially equipped for making fine adjustments in releases. No outlet gates are provided through Big Cliff Dam. The one special spillway gate, in addition to being equipped for making fine adjustments, is connected with the turbine at Big Cliff so that when the turbine closes or opens the spillway gate adjusts itself automatically maintaining approximately a constant flow downstream from Big Cliff. A discharge rating table for Big Cliff spillway is shown in table 8.

7-11. Changes in reservoir releases. - Safety considerations preclude sudden large increases in the release from Big Cliff Dam. During and following floods, increases in the controlled release should not exceed 2,000 second-feet in any one-hour period. The increase can be made in one or more adjustments. It is cautioned that the maximum rate of increase in the controlled reservoir release should be used only when the situation is most critical. Under normal conditions, the increase in release should be held to a rate of 1,500 second-feet per hour or less. Since there is only a limited amount of storage available in Big Cliff Reservoir, limitations placed on the rate that increases from Big Cliff can be made would be equally applicable to Detroit. No limitations are placed on how fast the flows may be cut back at either Detroit or Big Cliff during a flood as long as they are coordinated with each other.

7-12. Frequent gate adjustments may be necessary when the reservoir inflow is high or changing rapidly. Figure 2 on plate 20 shows the maximum time allowable between determinations of prescribed reservoir releases. However, when a prescribed change in reservoir release is less than 500 second-feet during or shortly after a flood, no gate adjustment need be made. During nonflood periods, frequent and smaller gate adjustments will be made in connection with power generation. Paragraph 8-21 discusses the limitations on the rate that flows can be changed during nonflood periods.

7-13. Evacuation of floodwaters. - The criterion for the release of stored water from Detroit Reservoir following a flood is to evacuate the stored floodwater as rapidly as possible without causing or unduly prolonging damaging stages along Santiam and Willamette Rivers. During the conservation release and conservation storing seasons the evacuation following each flood will be to the scheduled elevation for that particular date, whereas during the major flood season the reservoir will be drawn down to minimum flood-control pool, elevation 1,450.

7-14. The critical stage at Jefferson, which is the key control point for the Santiam River, varies with the season of the year, particularly with regard to periods of prolonged evacuation. Figure 6 on plate 7 shows a seasonal schedule of discharges for Santiam River at Jefferson that should be considered before evacuating stored water from Detroit Reservoir. These scheduled discharges are conservative and generally less than bankfull discharge, which is the basis for the reservoir regulation during a flood. Bankfull discharge can be maintained for a short period of time without creating a seriously saturated subsoil and a drainage problem for areas adjacent to the river. The seriousness of a saturated subsoil increases as the growing season progresses. For this reason, flood evacuation from Detroit Reservoir following a late spring flood should be scheduled so as not to exceed the critical discharges shown in figure 6 on plate 7. Furthermore, releases from Detroit Reservoir will be coordinated with releases from other Willamette Valley reservoirs to insure an effective evacuation plan that will not increase or unduly prolong overbank stages along lower Willamette River. A number of forecasting aids that would be utilized in scheduling the evacuation from Detroit are shown on plate 7.

7-15. Coordination of flood regulation with flows in Willamette River. - Because of the fact that the Santiam River normally crests ahead of Willamette River at its confluence with Santiam River, special attention must be given to flood regulation effected on North Santiam River at Detroit near the end of the flood. This requires that increases in the release from Detroit Dam be delayed until the flood on main Willamette River has receded to bankfull stage. The maximum delay may amount to a day or two, which could present a storage problem. If such an occasion does occur, special action should be taken based upon the circumstances at that time.

7-16. Travel times and flood recession curves shown on plate 7 will be used in coordinating the Detroit flood regulation with the flows on Willamette River. No regulation problem is involved during the early stages of a flood, as any flood regulation required for Santiam River will be equally effective on main Willamette River. Past reservoir regulation studies show that regulation of North Santiam River floods results in appreciable stage reductions on lower Willamette River.

7-17. Special flood regulation. - A special set of flood regulation curves involving a deviation from the normal reservoir regulation is shown in figures 3 and 4 on plate 20. These special curves will be used only in instances when continued regulation by the normal flood regulation schedule would result in the reservoirs filling before the end of the flood. The special curves are so constructed that by entering the curves with the current pool elevation and the average pool rise in the last 3 hours, a discharge is indicated which, if effected, will keep the reservoir from exceeding its capacity. The increase in discharge in any one-hour period is limited to a maximum increase of 2,000 second-feet. Normally, this increase can be held to 1,500 second-feet, if adjustments are made hourly. By adjusting the outflow to the indicated value at hourly intervals, the increase in reservoir release is gradual and a sudden large increase in reservoir release can be avoided. In case of a very large flood, the required outflow could exceed the capacity of the outlets and the spillway gates would then be used. Table 6 shows discharges for one spillway gate at Detroit for various gate openings and pool elevations. The use of the spillway for flood regulations will be a very infrequent occurrence.

7-18. Whenever Detroit pool rises above the spillway crest and the rate of pool rise is still quite pronounced, these special curves will be referred to often so that they can be put into effect as soon as flood conditions indicate there is a need for special reservoir regulation. If the special curves are used and the pool exceeds elevation 1,569, evacuation will be accomplished as follows: outlets will be maintained at gate opening at which maximum pool was attained until pool recedes to elevation 1,569. After pool elevation 1,569 is reached, the discharge from the reservoir will be adjusted so that a constant pool is maintained until downstream channel conditions will permit an increased release from the reservoir. If the maximum pool attained is less than elevation 1,569, release of stored water will be consistent with that for normal reservoir regulation. Exact instructions in regard to releases following a flood of such magnitude will come from the Reservoir Regulation Subsection.

7-19. Since usable storage in Big Cliff Reservoir is insignificant with respect to the volume of a flood, all flood releases through Detroit Dam will be passed unchanged through the Big Cliff spillway. Table 8 shows, for one Big Cliff spillway gate, the discharge for various gate openings and pool elevations.

7-20. Examples of flood regulation. - Results from applying the reservoir regulation schedules derived for Detroit Reservoir to three of the larger floods that have occurred on North Santiam River are shown graphically on plate 21. The three floods included in this study are: December 1945, January 1943, and December 1861. The 1945 and 1943 floods are observed floods and represent the largest from the standpoint of peak discharge and volume, respectively. The 1861 flood, the largest flood of record, is an historical flood and has been derived from precipitation data. Data shown for each flood are: basin precipitation by 3-hour periods, reservoir inflow, regulated outflow, natural and regulated flow of North Santiam River at Jefferson, uncontrolled local inflow above Jefferson, and Detroit Reservoir pool elevation. Detroit Reservoir was assumed to be at minimum flood-control pool at the start of each flood regulation study.

7-21. Regulation of the December 1945 and the January 1943 floods could be accomplished with the normal reservoir regulation schedule. Even though maximum-possible regulation was effected at the dam, the regulated flow at Jefferson would have exceeded overbank stage in both floods. Too small a portion of the Santiam River Basin run-off is controlled to effect complete flood protection in the vicinity of Jefferson. The peak discharge at Jefferson in both the December 1945 and January 1943 floods would have been reduced about 1.5 feet. Evacuation of floodwater from Detroit Reservoir after each flood would not have been initiated until the natural flow at Jefferson had receded to 40,000 second-feet and the maximum release would have been limited to 17,000 second-feet. Under actual conditions, the flow in Willamette River would be considered and initial evacuation might be delayed a short time to permit the Willamette River above the mouth of Santiam River to recede. Normally, a maximum release of 17,000 second-feet will permit the evacuation of Detroit Reservoir at a rate that will empty the reservoir in less than 10 days. Such releases would not result in flows in excess of the existing bankfull stage at Jefferson. The Reservoir Regulation Subsection will study each particular flood event and prescribe the reservoir releases during the evacuation period to meet the situation that exists at that particular time.

7-22. Regulation of the 1861 flood would have required the use of the special flood regulation curves, because of the magnitude of the flood. The normal flood regulation schedule would have been followed until the pool elevation and rate of pool rise indicated that the flood would require special regulation to prevent a sudden large discharge over the spillway when the reservoir reached full pool. This situation would have become evident at the mid-point of the flood and the reservoir releases starting at that time would have been increased gradually in accordance with the special flood regulation curves. This special regulation would have reduced the flood at Detroit dam site from 65,000 second-feet to 45,200 second-feet. If the normal flood regulation schedule had been followed indiscriminately, the pool would have filled near the crest of the flood and the sudden spill would have been approximately the same as the reservoir inflow, a very undesirable condition. At Jefferson, a reduction of a little more than one foot in the flood stage would have been effected. Evacuation would have been predicated upon stream flow conditions on the Santiam River at Jefferson and the maximum release would have been held to 17,000 second-feet.

7-23. It is quite evident that effective flood regulation on lower Santiam River is contingent upon getting flood-control reservoirs constructed that will regulate flows on the South Santiam River. Until run-off from more area above Jefferson is controlled, overbank stages will be experienced frequently in spite of the regulation effected at Detroit. Detroit will provide good flood protection for the entire reach between the dam and 5 miles above the mouth of North Santiam River.

SECTION VIII - CONSERVATION RELEASE REGULATION

8-01. Water-use priorities. - During the conservation release season 6 May - 30 November, prior water rights granted in accordance with Oregon law will be honored to the extent of the natural inflow to Detroit Reservoir. Likewise stored water in Detroit Reservoir will be made available for distribution to satisfy the various conservation needs. Order of use priority on impounded water will be in accord with Section 8, Flood Control Act of 1944. Normally, reservoir releases made for conservation uses willbe adequate to maintain minimum planned flows from Big Cliff Reregulating Reservoir.

8-02. First priority on stored water is that for domestic and municipal use which in the case of Detroit will be minor. Of the major potential users of stored water from Detroit Reservoir, irrigation has the highest priority. Hydroelectric power will benefit from the stored water released for irrigation. Release of stored water solely for hydroelectric power production, navigation, and pollution abatement, which are basically non-consumptive, will be made after irrigation needs are provided for. Although these latter three non-consumptive uses are benefitted by the same water, releases for optimum power production may not necessarily provide regulation entirely satisfactory for navigation and pollution abatement. However, special efforts will be made to regulate in a manner satisfactory to both groups and not to accord either group preferential treatment to the exclusion of the needs of the others. Recreation has a low priority on stored water but it is extended as much consideration as is practicable without adversely affecting interests having a higher priority. The basic policy is to provide the most beneficial over-all regulation, consistent with the above water-use priorities.

8-03. Reservoir release schedules. - During the conservation release season, the schedule for reservoir regulation provides for a balanced distribution of water in accordance with the water-use priorities during the low-water period. Demands for water will vary widely, both from year to year and during any one single season. Because of this variable demand and the fact that precipitation and stream flow also vary within wide limits, it is not practicable to establish definite schedules for regulated releases during the low-water season. In order to secure as effective regulation as possible, a provisional schedule will be prepared by the Reservoir Regulation Subsection each year before the initiation of major conservation releases. This provisional schedule, which will be based on forecasted stream flow and estimated demands for stored water, will be revised periodically as required by changing weather and stream flow conditions.

8-04. For the years when Detroit Reservoir does not fill, the conservation demands will be adjusted to provide water during the entire low-water season, rather than satisfying all demands during the early part of the season and having an inadequate supply of water during the critical portion of the low-water season, late summer and early fall. In this provisional schedule, there is provided a safety factor in the form of a small reserve of stored water for release during any unpredicted deficiency which might occur during the latter part of the low-water season.

8-05. Since the primary function of Detroit Reservoir is the control of floods, under no circumstances will regulation for conservation uses be permitted to jeopardize regulation for flood control. After 1 September, the flood potential of the Willamette Basin begins to increase and, between that date and 1 December, the reservoir pool will not exceed the elevations shown on figure 1 of plate 20, except in case of a flood. Detroit Reservoir is to be drawn down to minimum conservation pool, elevation 1,450, by 1 December if the power situation in the Columbia Basin is not critical.

8-06. Prior water rights. - The present water laws of Oregon provide that all water within the state from all sources of water supply belong to the public. Subject to existing rights, all waters within the state may be appropriated for beneficial use. Such appropriation must be made in strict accordance with the statutory provisions governing such matters. The administration of the water laws of the State of Oregon is vested in the State Engineer, who issues permits for the use of water and is generally recognized as the authority on all matters concerning the adjudication and appropriation of water rights in the State of Oregon.

8-07. Ultimately, water may be at a premium in North Santiam River Basin. At that time, the State of Oregon may find it necessary to reduce all downstream diversion to absolute necessities. A large quantity of water is diverted from North Santiam River below Detroit Dam through the Salem and Gardiner Canals for power, municipal, and commercial use in addition to irrigation. Water rights for those two canals total 1,065 second-feet, 253 second-feet for the Salem Canal and 812 second-feet for the Gardiner Canal. A review of the Salem Canal water rights indicates that if power were exchanged for water, the absolute minimum diversion could be reduced to 53 second-feet for the Kay Woolen Mills and 20 second-feet for Mill Creek. In the past, about 170 second-feet have been diverted through the Salem Canal during the low-water season. Of that amount, about 50 second-feet have been by-passed through Mill Creek. The Gardiner Canal diverts from North Santiam River a short distance below the Salem Canal. Water rights for the Gardiner Canal total 812 second-feet, of which 762 second-feet are for power generation and 50 second-feet are for fish life. Below the power plant on the Gardiner Waterway Canal, the Willamette Valley Water Company and the Sidney Irrigation Company divert water from the canal for irrigation. The two companies have water rights for 340 second-feet of water. Another significant water right that must be considered is the 100 second-feet for the City of Salem. Water rights held by the City of Salem are to supplement their present domestic and industrial water supply. The Mill City water rights for 395 second-feet of water for power generation presents no immediate problem as the diversion dam has been recently removed.

8-08. Minimum reservoir releases. - Minimum releases from Big Cliff of 1000 second-feet during the period 1 February through 30 June, and 750 second-feet during the period 1 July through 30 November, were mutually agreed upon by this office, the U.S. Fish and Wildlife Service and the Oregon State Fish and Game Commissions, following a series of conferences in 1946 and 1947. It is the intent of this office to provide these minimum flows from Big Cliff Re-regulating Reservoir whenever possible. However, this office has no legal right to release stored water from Detroit Reservoir to maintain minimum flows in North Santiam

River in excess of 500 second-feet if an interest with authorized water rights on stored water in Detroit Reservoir objects on the grounds that they will be shorted stored water by this action. House Document No. 544, 75th Congress, 3rd session, did authorize the Corps of Engineers to maintain a minimum flow of 500 second-feet from Detroit Dam. The Oregon State Fish and Game Commissions have a water right for 50 second-feet on Gardiner Canal for a fish ladder at the Mountain States power plant. During December and January there are no planned minimum releases from Big Cliff, the reservoir schedule for Detroit Reservoir generally requires that all inflows to be passed except during periods of flood regulation. On the basis of past stream flow records and reservoir operational studies, there should be little concern about being unable to provide at least 1000 second-feet.

8-09. Irrigation. - Existing irrigation rights and estimates of irrigation needs within the next 10 years involve an amount of water sufficient for 60,000 acres. Irrigating these 60,000 acres will require an annual diversion from the river of an estimated 120,000 acre-feet during the months of May through September. None of the water rights for the Salem Canal are for irrigation, and only part of the waste water from Gardiner Canal is used for irrigating areas in the vicinity of Stayton. Of the estimated 120,000 acre-feet required annually for irrigation, 70 percent will come from storage. Maximum diversions by months within the next 10 years are estimated to be: May, 6,000 acre-feet; June, 26,400 acre-feet; July, 36,000 acre-feet; August, 37,200 acre-feet; and September, 14,400 acre-feet. Based on the demands anticipated within the next 10 years, an adequate supply of water for irrigation will be available, even during a critical low-water year. During the average year, a large surplus of water will be available for power, navigation, and pollution abatement.

8-10. Arrangements have been made for the sale and distribution of irrigation water released from storage at Detroit Reservoir. Plans are that the Bureau of Reclamation will administer the distribution of stored water to the irrigator or his representative, with the Corps of Engineers furnishing the water to the Bureau of Reclamation. All field agrenments would be made with the Bureau of Reclamation and that agency would receive payments to the United States Government for water releases from the reservoir for irrigation.

8-11. Power. - Releases made for the generation of power will conform to the requirements established in the preceding paragraphs, but within those limits the power releases will be scheduled by the Power Section in coordination with the Reservoir Regulation Subsection and Bonneville Power Administration to meet the requirements of the Federal power system with the least possible adverse affect on other water uses. Insofar as practicable, conflicting requirements of the various uses will be governed by established rules and limits, but optimum use of the water does not permit all conflicting requirements to be governed by fixed rules. For this reason, the scheduling of power releases may often require consideration of the relative importance of the power to be generated by a proposed schedule and the effect of that schedule on other water uses. The rules and limits which have been established to govern regulation for power are summarized on page 61.

8-12. The nonpower regulation of Detroit project is concerned primarily with the storage in Detroit Reservoir above elevation 1,450 and the flow downstream from Big Cliff. Detroit Reservoir storage between elevations 1,425 and 1,450, Big Cliff storage, and Detroit Reservoir releases are, therefore, a purely power function as long as they are regulated within the discharge capacity of the Detroit power units, the downstream flow requirement, and the reregulating capacity of Big Cliff Reservoir. The Detroit units are capable of generating 100,000 kilowatts and they may be operated at any output limited only by the mechanical characteristics of the units. Charts 1 and 2 indicate the output guarantee limits of the Detroit turbines, as well as the total power output and the power output per second-foot for any head and discharge.

8-13. Forty thousand acre-feet of power storage is provided in Detroit Reservoir below elevation 1,450 exclusively for power use. The filling schedule requires that any of this 40,000 acre-feet withdrawn from storage will have to be replaced from reservoir inflows by 1 February in all but critical water years so that there is no advantage to its use in normal water years, except as its use is necessary to regulate the variable December and January flows. During critical water years, when other reservoirs in the Northwest Power Pool are at or below their rule curve elevations and filling Detroit Reservoir would result in curtailment of firm power loads, the 40,000 acre-feet of power storage may be used and the filling delayed until the end of the critical power period which may be as late as April, subject to the requirements of paragraph 6-08.

8-14. Big Cliff Reservoir provides 3,000 acre-feet of effective storage for the daily regulation of the fluctuating Detroit power drafts. This storage is adequate for daily regulation of the most severe peaking requirements at Detroit power plant and will permit considerable weekend regulation, but it is not enough to permit the Detroit units to be shut down completely from the Friday to the Monday peak loads. Except in emergencies, all releases from Big Cliff Reservoir, up to approximately 3,000 second-feet, will be made through the Big Cliff turbine. To prevent a sudden change of this release, as a result of an unscheduled change in load, one spillway gate at Big Cliff is provided with a control which will automatically open or close the gate to compensate for the change in turbine release. In case of a turbine shut down, the gate will automatically open to an elevation which will release approximately the same amount that was being discharged through the turbine prior to shut down. Upon reestablishment of the turbine load and discharge, the gate will automatically close. There are no outlets in Big Cliff Dam so the regulation must be accomplished by the turbines, the spillway gates, or a combination of the two. The minimum output specified in the cavitation guarantee and the power output for any head and discharge may be obtained from chart 2. The Big Cliff Reservoir storage elevation curve is on plate 3, and table 7 is a tabulation of reservoir capacities.

8-15. The normal operation of Detroit project will hold the pool as high as possible until the first of September while meeting the downstream requirements of minimum flow (see paragraph 8-08) and irrigation. From 1 September to 15 November the remaining primary flood-control storage will be released to meet the requirements of power and other conservation uses, including navigation. Prior to 1 September the navigation flows are supplied as far as possible from nonpower reservoirs. Good power regulation may indicate that only the minimum drafts required for downstream conservation uses should be made during this period, if mandatory releases have drawn the reservoir below the flood-control rule curve. Following 15 November and prior to 1 December the secondary flood-control storage space is evacuated as best suits the requirements of power and other conservation uses, except when the 30-day forecast of Columbia River flows, as determined from the curve on chart 3, indicates a natural flow of less than 70,000 second-feet at Bonneville. The curve is an envelope curve with all the experienced flows lying above the curve so that it assures, as well as an historical record can, that the 30-day flows following the indicated 10-day inflow will never be greater than 70,000 and may be expected to be less. This rule for the use of secondary flood-control storage in the interest of power has been adopted because of the unreliability of long-range flood forecasting procedures in Willamette Basin. Historically, this rule would have permitted the use of secondary flood-control storage for power in the critical power years of the Northwest power system and, historically, no major floods have occurred in Willamette Basin when Columbia River flows at Bonneville were less than 70,000 second-feet. Two alternate rule curves are shown in figure 1 of plate 20. Rule curve (a) will establish the upper limit of pool elevation from 15 November to 1 December and would apply when the 30-day Columbia River forecast as determined from chart 3 indicates a flow greater than 70,000 second-feet. When the forecasted flow is less than 70,000 second-feet, rule curve (b) will control. Whenever the pool level is above rule curve (a) the 30-day Columbia River forecast and Willamette Basin hydrologic conditions will be subject to a continuous review to determine whether changing conditions require lowering the pool to rule curve (a).

8-16. Secondary flood-control storage may be used for short-period pondage for power at the discretion of the Portland District, but not to exceed 3 feet above the appropriate rule curve when climatological and hydrologic conditions are such as to assure that no major flood is imminent. In the event of conditions in Willamette Basin which indicate the possibility of a major flood during a period when rule curve (b) controls, the remainder of the secondary flood-control storage will be evacuated to minimum flood-control pool, elevation 1,450. Power operations may be curtailed temporarily at any time such curtailment is required by flood conditions, but the normal operation permits a minimum release of 2,000 second-feet during flood regulation.

Rules Governing Power Releases

Normal minimum downstream releases:

1 July to 30 November	750 second-feet
1 December to 1 February	Reservoir inflow except during periods of flood regulation
1 February to 1 July	1,000 second-feet

Maximum pool elevations:

Rule curves A and B, page 60

Curve to determine whether A or B is applicable, page 60

Limiting fluctuations of Big Cliff releases:

Maximum daily change (figure 1, plate 7)

Normal	Minimum 750 to maximum 1,120
Normal	Minimum 2,000 to maximum 2,680
Special operation	Minimum 750 to maximum 1,600
Special operation	Minimum 2,000 to maximum 3,400

Maximum rate of change

Normal at 750	200 second-feet per hour
Normal at 3,000	400 second-feet per hour
Special at 750	200 second-feet per half hour
Special at 3,000	400 second-feet per half hour

8-17. Navigation. - Commercial navigation is nonexistent on Santiam River but is of importance on middle and lower Willamette River. Because of normal low water during the summer and extensive pumping for irrigation, flows of Willamette River are frequently inadequate for navigation during the late summer and early fall months. Judicious release of water from Detroit Reservoir and other Willamette Basin reservoirs will be beneficial to navigation. In the average year, and particularly during the period before irrigation demands are fully developed, water will be available from Detroit Reservoir to increase and maintain low-water flows after 1 September. When all reservoirs now authorized for Willamette Basin are completed, it is proposed to maintain a minimum flow at Albany of 5,000 second-feet and 6,000 second-feet at Salem. These minimum flows can be maintained during all but the most critical low-water years. With the existing system of reservoirs, such flows are not always possible. The present objective is to maintain as high a flow in Willamette River as possible during the low-water season, consistent with other conservation requirements. A system analysis of all Willamette Basin reservoirs will be made by the Reservoir Regulation Subsection at the beginning of each conservation season for the purpose of establishing a tentative schedule for releasing stored waters during the conservation season. This schedule will be submitted to higher authority for their information and comment.

8-18. Pollution abatement. - The only pollution problem on North Santiam River is in the vicinity of Mill City, and this is not serious. This is in contrast with South Santiam River which is seriously polluted by industrial waste and raw domestic sewage discharged into the river at

Lebanon. Below the confluence of the North and South Santiam Rivers, no significant pollution problem exists, and the Oregon State Sanitary Authority has made no recommendations for abatement. At the present time the Willamette River is polluted with raw and domestic sewage and industrial waste. The State Sanitary Authority is enforcing requirements for treatment of sewage and numerous treatment plants are being constructed. Conservation releases from Detroit Reservoir, in the interest of navigation, will aid in abating this problem and regulation of Detroit Reservoir will consider requirements for navigation and pollution abatement simultaneously.

8-19. Recreation. - From a recreational viewpoint, it would be desirable to maintain a full reservoir at Detroit during the entire summer. Since this is not practical because there are other higher priority uses for the stored water, the pool will be partially drawn down each year during the recreation season. Irrigation will be the primary user of stored water during the summer months. Water reserved for power, navigation, and pollution abatement will not be used until after 1 September, a desirable schedule from a recreational viewpoint. In the immediate future, Detroit Reservoir will be drawn down about 10 feet during the recreation season. This draw-down will continue to increase as more and more lands are irrigated with water released from Detroit Reservoir. In a short water year, Detroit Reservoir may not fill, creating an undesirable situation for recreation.

8-20. Mosquito control. - A survey made by the U.S. Public Health Service in November 1945 indicated that Detroit Reservoir area would not create a malaria hazard. Therefore, no special reservoir regulation is proposed for mosquito control. Precautionary measures, such as drainage of low areas and removal of obnoxious plants, should be accomplished yearly at the time logs and debris are cleaned up along the reservoir shores.

8-21. Limitations on change in flows. - In addition to the minimum flow requirements, limitations have been placed upon the rate that releases from Big Cliff Dam can be fluctuated in the course of operating the Detroit project for power during nonflood periods. A limitation has been placed as to the maximum rate at which a change in release can be made and the range over which flows can be fluctuated in a 24-hour period. These are safety measures to protect human life downstream from the dam and to insure relatively uniform flows that will be in the best interest of fish life and the general public. Figure 1 on plate 7 illustrates graphically these limitations. The limitations vary with the magnitude of flow and with the urgency of making changes in the power releases. Even the rates of changes adopted for special occasions are not considered too hazardous. Normally, the changes in releases from Big Cliff Dam will not cause change in stage to exceed 0.3 foot in any one-hour period, or will the range in stage vary more than 0.5 foot in a 24-hour period. These stage ranges are in the immediate vicinity of Big Cliff Dam and will become decreasingly less as the flows move downstream. On special occasions of an urgent nature, these rates may be doubled. The following tabulation shows the limiting rates of changes in flows when the releases from Big Cliff are 750 and 3,000 second-feet, respectively. Rates of change for intermediate flows are on a prorated basis.

Big Cliff release in c.f.s.	Max. rate of change in Big Cliff release		Max. range in release in 24-hr. period		
			Minimum	Maximum, c.f.s.	
	Normal	Special	c.f.s.	Normal	Special
750	200 c.f.s./hr.	200 c.f.s./30 min.	750	1,120	1,600
3,000	400 c.f.s./hr.	400 c.f.s./30 min.	2,000	2,680	3,400

SECTION IX - RESPONSIBILITIES AND INSTRUCTIONS

9-01. 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 establishes over-all policies for the regulation of flood-control and multiple-purpose reservoir projects in which flood control is a major objective. Reservoir regulation plans and schedules for Detroit project and other multiple-purpose projects in Portland District are formulated by the District in accordance with Part CXXXVI of the Engineering Manual, Civil Works Construction, and are submitted through the North Pacific Division to the Office, Chief of Engineers, for approval. In the event of a major change in the regulation schedules, prior approval of the Office, Chief of Engineers, is obtained.

9-02. Organization of the Portland District for the regulation of Detroit project is shown on chart 4. Regulation for hydro-electric power production requires close coordination with the Bonneville Power Administration, the marketing agency for power generated by Detroit project, and other Federal power-producing 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 hydrologic data essential to the functional regulation of Detroit and other multiple-purpose reservoirs in Willamette River Basin.

9-03. Engineering Division. - In accordance with the provisions of Chapter 2 of Part CXXXVI, Reservoir Regulation, of the Engineering Manual for Civil Works Construction, functional regulation of Detroit and other multiple-purpose projects in the District is the responsibility of the Engineering Division. Within the Portland District Engineering Division the Hydrology and Meteorology Section, of which Reservoir Regulation is a Subsection, and the Power Section will have primary responsibility for the functional regulation of Detroit project. Names and telephone numbers of key personnel directly concerned with the regulation of Detroit and Big Cliff Reservoirs are shown on chart 4. The project engineer and powerhouse superintendent will be furnished with a list of District personnel authorized to issue reservoir regulation and power generation instructions for Detroit and Big Cliff projects. This list will be revised as changes in personnel assigned to reservoir regulation are made. All instructions given by Engineering Division personnel shall be confirmed in writing.

9-04. Duties of the Engineering Division personnel assigned to the functional regulation of Detroit and Big Cliff include the following:

a. Develop plan of operation for multiple-purpose reservoirs within Portland District, including detailed reservoir regulation schedules and system regulation procedures for coordinated regulation of all Willamette Basin reservoirs so as to secure maximum over-all benefits.

b. Maintain a continuing program of study to improve reservoir rggulation technique. Re-examine regulation schedules for adequacy and effectiveness following each flood experience.

c. Prepare and distribute reservoir regulation manuals for multiple-purpose reservoirs, including a master regulation manual for coordinating the regulation of all Corps of Engineers reservoirs in the Willamette River Basin. Keep manuals up to date and revise when necessary.

d. Direct the functional regulation of all Corps of Engineers reservoirs in the Willamette Basin during non-flood periods on a day-to-day basis. During flood periods, direct the functional regulation on an hour-to-hour basis, or as required. Coordinate the day-to-day and hour-to-hour regulation of the several reservoirs in the Willamette Basin so as to secure the most effective system regulation.

e. Collaborate and develop, in cooperation with irrigation, power, navigation, pollution abatement, recreation, and other conservation interests, schedules for using water impounded in Detroit Reservoir. Coordinate with Bureau of Reclamation with regard to reservoir releases for irrigation. Dispatch water for conservation uses. Coordinate with Bonneville Power Administration with regard to power generation at Detroit and Big Cliff. Coordinate the regulation for power with regulation for other conservation interests.

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

g. Prepare charts of Monthly Reservoir Regulation and Power Generation, applicable portions of flood reports, preliminary, interim, project planning, survey, and other planning reports, and design memoranda.

9-05. During the flood season and at other times when floods are threatening or occurring, current hydrologic reports are collected and analyzed over the weekends and holidays. Definite assignments are made well in advance so that at least two employees are familiar with current weather and stream flow conditions. One of these employees is assigned to weekend duty and the other employee acts as an alternate. The assigned employee has authority to direct operation of the reservoirs in accordance with the schedules in the manuals during non-work hours, but is required to obtain approval of the Chief, Hydrology and Meteorology Section, or Chief, Reservoir Regulation Subsection, before making significant modifications of the approved flood-regulation schedules. Major deviations from the last approved power-generation schedule will be cleared through the Chief of the Power Section, or his representative before initiating the action.

9-06. Reservoir regulation personnel will obtain and utilize short- and long-range weather forecasts and quantitative precipitation forecasts, as required for efficient regulation. Quantitative precipitation forecasts for all zones in western Oregon and southwestern Washington are received daily, except during the summer months when there is no general flood potential. The forecasts are prepared in the Seattle office of the Weather Bureau and relayed through the Weather Bureau office at Portland to the Reservoir Regulation Subsection.

9-07. In addition to the Weather Bureau forecasts, supplementary forecasts are made by the Reservoir Regulation Subsection when required. A copy of the 1230Z synoptic surface map, as received by the Weather Bureau by facsimile circuit, is obtained each week-day morning. Auxiliary weather charts, including plottings of the Air Weather Service rawinsonde at Portland, are prepared as needed. Upper air and surface atmospheric conditions are checked frequently by means of Service "C" weather teletype reports, which are received in the District Office. Close coordination is maintained with the Weather Bureau during flood periods and, when necessary to expedite receipt of reports and forecasts, a Portland District employee is assigned to the Weather Bureau office during critical periods.

9-08. Operations Division. - Physical operation and maintenance of all multiple-purpose projects in the Portland District are the responsibility of the Operations Division. Resident responsibility for Detroit project is assigned to the Project Engineer, who reports to the Chief, Operations Division through an assistant for multiple-purpose project operations. The Project Engineer is responsible for the operation and maintenance of Detroit and Big Cliff Dams and Reservoirs, the hydroelectric generating plants, and appurtenant facilities.

9-09. Damtenders and powerhouse operators are under the supervision of the Powerhouse Superintendent, who is responsible to the Project Engineer. The Powerhouse Superintendent directly supervises the operation of the dam, reservoir, powerhouse, and related equipment. Reservoir regulation instructions are normally issued to one of the powerhouse operators, but may be transmitted to the Powerhouse Superintendent, or on occasion the Project Engineer. All instructions pertaining to the regulation of Detroit project shall be logged by the dam attendant receiving the instructions and will be confirmed in writing by the party issuing the instruction. Date, time and names of persons involved shall be included in the confirmation.

9-10. Weather station. - Maintenance and operation of the weather station at Detroit Reservoir are the responsibility of the Project Engineer. Equipment and instruments at the station will include an instrument shelter house, maximum and minimum thermometers, hygrothermograph, psychrometer, evaporation pan, anemometer, manual precipitation gage, and recording precipitation gage. The evaporation pan will be the standard Weather Bureau pan of galvanized iron, 48 inches in diameter, and the anemometer will be the rotating cup type, mounted above the support for the evaporation pan. The recording precipitation gage will have a 12-inch capacity.

9-11. The U.S. Weather Bureau issues the instructions regarding the method of taking the observations, entering the data on the proper forms, and mailing the forms to their office. At intervals, usually monthly, the station will be checked by a field inspector of the Weather Bureau, and any difficulties such as damaged or malfunctioning equipment, are to be reported to that inspector. All supplies, including recorder charts, will be furnished by the Weather Bureau. The temperature, precipitation, and evaporation data will be published in monthly and annual bulletins of climatological data for Oregon. Plate 5, Inventory of Hydroclimatic Data, shows the period of time for which weather records are available at Detroit Dam.

9-12. Water-stage recorders. - Data of primary importance to the regulation of Detroit Reservoir are obtained from five water level recording stations. One of these stations is located at the dam and records the elevation of the water surface in Detroit Reservoir. There are two upstream gages at the head of the reservoir, one on the Breitenbush River and one on the North Santiam River, which record the inflow from 75 percent of the area tributary to the dam, and one downstream gage near Niagara, which records the total outflow. All data obtained at these four stations are transmitted automatically to the control room in the

Detroit powerhouse. The fifth water level station is at Jefferson on Santiam River and serves as an index station for downstream flood stages. Location, elevation, and tributary area for these five stations are shown on plate 5.

9-13. The operation and maintenance of the above water-stage recorders is accomplished by the U. S. Geological Survey, with financial support received from this office. Personnel of that agency will service and repair the instruments, change the charts, meter the streams, and perform other related duties. Operating personnel at Detroit Dam, in addition to collecting and transmitting water-stage data to the Reservoir Regulation Subsection, will be responsible for making occasional inspections of the five river gaging stations, particularly if there is any question as to whether an instrument is operating properly.

9-14. Collection and transmission of data. - The following hydrologic and power generation data are to be compiled and forwarded to reservoir regulation personnel in the Engineering Division at least once a day by operating personnel at Detroit Dam.

a. Stage and discharge for North Santiam River below Boulder Creek near Detroit, U.S.G.S. 5536. Stage readings from that station are received by wire and recorded automatically in control room of Detroit powerhouse. Table 10 is a discharge rating table for the North Santiam station above Boulder Creek.

b. Stage and discharge for Breitenbush River above Canyon Creek near Detroit, U.S.G.S. 5537. Stage readings from that station, which is located at head of reservoir, are received by wire and recorded automatically in control room of Detroit powerhouse. Table 11 is a discharge rating table for the Breitenbush station.

c. Stage and discharge for North Santiam River near Niagara, U.S.G.S. 553. Stage readings from that station, which is located 0.9 miles below Big Cliff Dam, are received by wire and recorded automatically in the control room of Detroit powerhouse. The station is the rated tailwater station for the Detroit project. Table 12 is a discharge rating table for the Niagara station.

d. Stage and discharge for Santiam River at Jefferson, U.S.G.S. 555. River stages at that station, which is the principal downstream control station, are received by Telemark. Telephone number for the Jefferson Telemark is Jefferson 211. Table 14 is a discharge rating table for the Jefferson station.

e. Stage and discharge for Willamette River at Salem, U.S.G.S. 516. This station represents flow conditions on the Willamette River below mouth of Santiam River and is equipped with a Telemark. Telephone number for the Salem gaging station is Salem 4-5283.

f. Pool elevation and storage for Detroit Reservoir, U.S.G.S. 5539. Pool elevation data are brought into the control room of Detroit powerhouse by wire and are recorded automatically on a chart mounted on the instrument panel. Table 3 is an elevation-capacity table for Detroit Reservoir.

g. Pool elevation and powerhouse tailwater at Big Cliff Reservoir are brought into the control room of Detroit powerhouse by remote indicators. Table 7 is an elevation-capacity table for Big Cliff Reservoir.

h. Hourly power generation, both gross and the amount delivered over to Bonneville Power Administration for distribution.

i. In addition to compiling and transmitting the data listed in items a through g, inclusive, there will be weather reports, including precipitation, snow, air temperatures, wind, humidity, and water temperature, to be compiled and transmitted.

9-15. During storm periods, meteorological and hydrological reports may be required every hour, particularly if the use of the special reservoir regulation curves is required. Normally, reports at 4- to 6-hour intervals will be adequate for flood regulation. During non-flood periods, hydrologic reports will normally be required but once a day. Power generation may require contacting the powerhouse superintendent or operators several times during a day. Normally, however, one contact a day will be adequate. Special river and weather reports will be sent to the Reservoir Regulation Subsection on request. Reservoir regulation instructions pertaining to functional regulation of the project will emanate from personnel in the Engineering Division responsible for reservoir regulation.

9-16. Charts and reports. - Form NPPRF 87a, Detroit Hydrometeorological Data, shown on chart 5, will be used by both the operating personnel at the dam and the Reservoir Regulation Subsections to record pertinent current hydrologic and reservoir data related to the regulation of Detroit and Big Cliff Reservoirs. During high-water periods, several of these reports may be reported to the Reservoir Regulation Subsection during the course of day. For confirmation purposes, a copy of each report should be mailed daily to the Reservoir Regulation Subsection by the powerhouse superintendent.

9-17. Chart 6 is a daily operation report form. Hourly power generation at Detroit and at Big Cliff and pertinent hydrologic data compiled at the project headquarters are recorded on the form. The form is completed daily by the Detroit powerhouse superintendent and copies are furnished chiefs of the Operations and Engineering Divisions.

9-18. Chart 7 is a daily power schedule form. Hourly power generation and corresponding reservoir releases at Detroit and Big Cliff that are scheduled for the subsequent day are recorded on this form. In addition, there are shown on this form comparative figures on power generation and reservoir releases for the day just past. The form is prepared by the Power Section in coordination with the Reservoir Regulation Subsection and Bonneville Power Administration. The scheduled power generation is given to the powerhouse superintendent for his observance. Copies of the daily power schedule, which are prepared daily, are furnished the District Engineer and Chiefs of the Operations and Engineering Divisions.

9-19. A permanent reservoir regulation record will be maintained on NPP Form 133C, Monthly Log of Reservoir Regulation, Detroit Dam and Reservoir. See chart 8. Operating personnel at the dam will maintain the required records of reservoir inflow, outflow, pool elevation, gate openings, and other pertinent data required for this log. All significant gate adjustments should be recorded. At least one entry should be made each day. The remarks column may be utilized for permanent information relating to reservoir regulation which would not otherwise be recorded. Unusual deviations from the regulation schedules will be explained briefly in the remarks column, and the authority for the action indicated. Other data required will consist of unusual weather or snow conditions, difficulties in obtaining necessary data, and malfunctioning of gages or equipment. Inasmuch as the log will become a permanent record of Detroit

Reservoir regulation, it should be as complete as possible.

9-20. Chart 9 shows a monthly reservoir regulation chart for Detroit Reservoir. Each completed chart will be a graphical record of daily reservoir pool elevation, stored water in acre-feet, reservoir inflow, outflow, basin precipitation, and water released for power generation. Discharge of Santiam River at Jefferson also will be shown on this chart. This chart will be prepared by the Reservoir Regulation Subsection. Copies of this chart are transmitted to the Office, Chief of Engineers, at the end of each month. Copies are also furnished the powerhouse superintendent and the Project Engineer.

9-21. Chart 10 is a monthly form for reporting daily power generation at Detroit and Big Cliff to Office, Chief of Engineers. Shown on the form will be the daily pool elevations and the average and the daily peak power generation at both Detroit and Big Cliff. Total generation for the month will be summarized at the foot of the form. The form will be prepared by the Power Section and copies will be forwarded to the North Pacific Division for transmittal to Office, Chief of Engineers. In addition, copies will be furnished the District Engineer, Chief of Operations Division, and the Project Engineer.

9-22. Continued reservoir regulation studies. - In the interest of obtaining maximum benefits by efficient operation of Detroit Reservoir, the Reservoir Regulation Subsection will conduct an intensive study of each flood for possible improvements in the regulation schedules and rule curves. Such studies will include not only flood regulation but also the conservation aspects of the project. As additional multiple-purpose reservoirs in Willamette Basin become operative, a greater significance will be attached to coordinating the regulation of Detroit Reservoir with the new projects. Changes in regulation procedure will be made on the basis of actual operating experience. Improvements in forecasting technique and new developments in reservoir regulation will be analyzed for possible application to regulation of Detroit Reservoir.

9-23. Emergency instructions. - It is not possible to anticipate every flood, power emergency, or combination of events, in a reservoir regulation manual. Should an emergency occur or appear to be developing, the Project Engineer, or subordinates, should promptly contact the District Office, report existing field conditions, and request instructions. In event of communications failure, repeated efforts should be made to contact the District Office; but if such efforts fail, the decision as to the action to be taken must be made in the field. Should such an eventuality occur, all circumstances should be reported as soon as possible.

9-24. Should communications to Portland fail during a flood, but remain operative to the stream gaging station at Jefferson, the Project Engineer or powerhouse superintendent will direct the regulation of Detroit Reservoir, using the schedules shown on plate 20. Precipitation observed at the Detroit Dam weather station will be used in computing the precipitation index. This procedure will also be followed if for any reason the receipt of reservoir regulation instructions from the Reservoir Regulation Subsection are unduly delayed during a flood.

9-25. In the event of a complete failure of communication facilities during a flood, the releases from Detroit and Big Cliff Reservoirs will be maintained at 2,000 second-feet if power is being produced, or 100 second-feet if hydro-electric power from the project is not needed at the time. The reduced outflows will be maintained until communications are re-established and downstream stages have receded sufficiently to permit greater releases, or until greater releases are required by figure 3 or 4 of plate 20. As long as the pool elevation and rate of rise over the preceding 3 hours indicate a point to the left of the curves, shown on figures 3 or 4, the regular schedule, figure 2, will continue to be used. When the pool elevation and rate of rise indicate a point within the special curves, the reservoir release will be increased to the rate indicated on the abscissa scale but not to exceed 2,000 second-feet in any one-hour period.

9-26. After the special regulation curves become applicable, the releases will be adjusted each hour on the basis of the average hourly rate of rise for the preceding 3 hours and the current reservoir elevation. Each hourly adjustment, however, will not increase the outflow by more than 2,000 second-feet. Adjustments will be made each subsequent hour as long as they are indicated by the special curves.

9-27. After the reservoir starts to fall, current gate openings will be maintained until the pool recedes to elevation 1,569. The reservoir will then be maintained at elevation 1,569, or at peak elevation attained if below 1,569, until normal post-flood evacuation as discussed in paragraph 7-13 of this manual can be initiated.

TABLE 1

Sheet No. 1

Corps of Engineers, U.S. Army
Portland, Oregon District

Station, Detroit Dam County, Marion State, Oregon

Latitude, 44° 44' Longitude, 122° 14' Elevation, 1585 feet

Data, Precipitation

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1949							0.36	0.15	2.81	6.42	12.11	12.15	
1950		13.05	14.64	7.84	2.96	6.31	.70	1.26	2.60	20.99	17.68	13.59	
1951	21.14	11.83	12.09	2.52	4.71	.35	.07	.63	1.96	16.13	13.28	18.27	102.98
1952	12.01	8.68	10.31	2.94	4.67	6.08	.00	.25	.82	.51	2.71	15.40	64.38
1953	28.32	13.07	9.90	5.33	7.39	3.51	.18	3.25	.97				
MEANS	Because of the short record no means were computed.												

REMARKS

TABLE 2

Corps of Engineers, U.S. Army
Portland, Oregon District

Station, Detroit County, Marion State, Oregon

Latitude, 44° 42' Longitude, 122° 04' Elevation, 1475 feet

Data, Precipitation

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1894					2.73	5.41	0.39	0.00	5.77	11.34	6.11	8.12	
1895	14.10	3.25	6.47	5.49	8.59	.63	1.00	.20	3.46	.10	8.01	18.67	69.97
1896	14.86	9.52	8.92	7.85	10.48	1.18	.00	1.80	1.08	4.97	22.95	13.35	96.96
1902	6.97	13.41	8.71	6.82	6.61	1.05	3.87	.47	2.25	3.00	11.91	15.85	80.92
1903							.13	.09	2.20	2.33	14.67	3.32	
1904		16.83	16.10	4.40	1.95	1.31	1.70	.52					
1909											23.23	9.70	
1910	9.89	15.69	5.10	3.24	3.58	1.47	.00	.24	1.13	6.02	18.85	9.28	74.49
1911	12.18	4.96	2.91	4.47	6.43	1.16	.04	.03	6.05	2.41	12.71	9.38	62.73
1912	18.79	11.99	5.68	5.43	5.60	4.08	.65	5.33	2.60	7.90	12.29	12.61	92.95
1913	14.08	3.16	11.91	4.66	3.99	4.96	1.58	.93	4.15	7.79	10.84	4.74	72.79
1914	16.65	7.67	6.95	6.15	2.50	3.37	.67	.10	7.74	8.10	7.09	3.14	70.13
1915	9.57	6.87	4.50	3.65	7.91	1.41	1.09	T	1.90	5.10	19.47	14.23	75.70
1916	10.99	9.72	13.64	5.76	6.18	4.04	2.73	.98	2.68	2.59	12.64	9.35	81.30
1917	5.61	7.23	8.14	8.05	3.76	2.88	.04	T	2.08	.65	9.45	25.84	73.73
1918	15.18	7.17	2.76	1.40	1.41	.07	.77	.45	.00	4.28	5.84	4.22	43.55
1919	14.23	10.61	6.88	3.31	2.88	1.17	.01	.01	3.43	6.88	14.51	9.70	73.62
1920	7.21	.26	8.79	7.96	.56	1.16	.84	1.27	5.97	3.33	6.20	14.23	57.78
1921	9.75	7.83	8.79	5.95	3.52	1.80	T	.35	4.80	5.85	18.82	5.60	73.06
1922	8.87	6.11	9.74	4.73	1.11	.90	.00	.88	1.99	3.85	3.74	16.58	58.50
1923	21.47	3.89	4.70	3.66	3.95	2.58	3.02	1.50	1.22	4.06	7.55	13.11	70.71
1924 ~~Means~~	7.85	7.87	4.53	1.96	.95	2.85	T	.67	4.32	9.68	17.14	10.00	67.81

REMARKS

TABLE 2

Corps of Engineers, U.S. Army
Portland, Oregon District

Station, Detroit County, Marion State, Oregon

Latitude, 44° 42' Longitude, 122° 04' Elevation, 1475 feet

Precipitation

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1925	16.69	11.53	4.42	5.42	4.70	1.68	.04	.53	1.20	.83	8.20	5.63	60.92
1926	6.20	12.79	1.09	3.37	4.31	.45	.00	3.41	3.42	6.58	17.58	7.41	66.61
1927	17.59	15.18	6.45	3.74	3.86	3.25	.08	.86	8.49	6.00	18.11	7.40	91.01
1928	9.99	2.74	9.84	5.62	1.65	.96	.02	.00	1.50	4.33	8.69	10.30	55.64
1929	8.75	3.07	6.14	7.70	2.24	3.88	.00	.00	1.04	1.70	.56	20.11	55.19
1930	5.70	11.30	4.25	4.03	4.83	1.21	.00	.00	2.08	4.96	7.23	4.42	50.01
1931	6.73	5.06	13.55	4.71	2.13	3.67	.00	.01	2.00	7.26	11.43	9.50	66.05
1932	10.95	4.62	9.18	5.79	2.80	.39	.69	.87	.20	6.96	11.94	6.13	60.52
1933	9.32	5.81	7.92	2.62	5.68	4.36	T	.47	6.07	4.98	3.04	24.70	74.97
1934	13.15	2.57	9.31	4.23	2.75	1.07	.33	.20	1.60	8.77	15.21	11.69	70.88
1936						3.45	.62	.00	2.20	.38	.42	13.17	
1937	7.66	11.91	4.39	12.28	3.13	6.52	.99	1.38	2.02	7.17	15.94	15.52	88.91
1938	10.64	8.83	13.42	5.20	1.88	1.29	.26	.37	2.00	4.00	10.81	10.68	69.38
1939	8.62	12.60	7.88	.98	1.62	2.37	.57	.90	1.34	5.68	1.50	13.74	57.80
1940	5.50	16.26	8.24	4.27	2.22	1.04	1.30	.06	5.13	6.28	11.65	6.58	68.53
1941	8.59	2.88	2.60	3.76	7.99	2.64	1.03	2.15	5.60	4.32	9.77	15.13	66.46
1942	6.20	8.18	4.17	4.22	5.72	3.63	.94	.21	.04	3.25	27.76	19.76	84.04
1943	12.40	9.10	9.79	8.35	2.95	4.69	.53	3.02	.15	12.40	5.76	3.50	72.64
1944	6.78	6.81	5.50	5.85	4.14	1.90	.06	.55	4.56	1.68	8.70	4.18	50.71
1945	10.09	13.85	11.91	9.24	8.08	.76	.22	1.20	4.06	2.83	21.49	15.26	98.99
1946	13.74	9.75	9.87	3.77	1.77	3.40	.41	.49	2.18	11.50	15.72	13.79	86.39
1947	10.46	4.70	8.51	5.39	.92	8.13	2.08	.96	1.72	16.00	11.83	7.99	78.69

REMARKS

TABLE 2

Corps of Engineers, U.S. Army
Portland, Oregon District

Station, Detroit County, Marion State, Oregon

Latitude, 44° 42' Longitude, 122° 04' Elevation, 1475 feet

Data, Precipitation

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1948	14.42	14.20	7.41	6.87	6.59	1.95	1.19	.92	4.36	4.65	14.06	18.29	94.91
1949	3.19	19.60	5.49	2.63	6.51	1.53	.25	.14	2.82	6.89	11.16	11.93	72.14
1950	21.75	11.03	13.17	4.70	2.14	3.46	.64	.98	2.25	19.80	15.87	13.34	109.13
1951	18.55	10.70	8.78	2.17	2.81	.06	.14	.78	1.84	14.32	12.18	15.30	87.63
1952	9.65	8.49	8.01			4.16	.00	.37	1.26	.41	2.26	13.31	
1953	27.09	12.64	8.60	4.34	5.87	2.55	.07	3.16	.70				
MEANS	11.53	8.92	7.72	5.03	4.00	2.46	.63	.76	2.89	5.83	11.73	11.45	72.95

REMARKS

...SON DIST

SECTI...

ENGINEERING DIV...

PROJECT Detroit Reservoir

SUBJECT Capacity in Ac. Ft. ...

BY ... DATE Jun. 18, 1962 CHECKED PART PAGE OF

Elevation	AF Capacity	Diff.	Elev.	Cap. AF	Diff.	Elev	Cap.	Diff.
1280	6000	200	1320	18,000	400	1360		
81	6200		21	18,400	400	61		
	6400		22	18,800	400	62		
	6600		23	19,200	400	63		
	6800		24	19,600	500	64		
						1365		
						66		
							49,700	
28	7600		38	21,600			50,500	
89	7800	200	39	22,100			51,300	800
1290	8000	300	1330	22,600			52,100	900
							53,000	
							53,900	
							54,800	
							55,700	900
							56,600	
26	12,800		46	32,700				
27	13,100		47	33,700				
1310	14,000	400	1350	36,100				
11	14,400		51	36,900				
12	14,800		52	37,700				920
17	16,8[illegible]			[illegible]1,700				
18	17,2[illegible]			[illegible]2,500				
19	17,600	400	5[illegible]	43,300	800			
1320	18,000		1360	44,100				

Form ... 118

TABLE NO. 3
CAPACITY OF DETROIT RESERVOIR
IN ACRE-FEET

El. in ft.	Capacity	Diff.
1375.0	56,600	90
.1	56,690	
.2	56,780	
.3	56,870	
.4	56,960	
.5	57,050	
.6	57,140	
.7	57,230	
.8	57,320	
.9	57,410	
1376.0	57,500	
.1	57,590	
.2	57,680	
.3	57,770	
.4	57,860	
.5	57,950	
.6	58,040	
.7	58,130	
.8	58,220	
.9	58,310	90
1377.0	58,400	100
.1	58,500	
.2	58,600	
.3	58,700	
.4	58,800	
.5	58,900	
.6	59,000	
.7	59,100	
.8	59,200	
.9	59,300	
1378.0	59,400	
.1	59,500	
.2	59,600	
.3	59,700	
.4	59,800	
.5	59,900	
.6	60,000	
.7	60,100	
.8	60,200	
.9	60,300	
1379.0	60,400	
.1	60,500	
.2	60,600	
.3	60,700	
.4	60,800	
.5	60,900	
.6	61,000	
.7	61,100	
.8	61,200	
.9	61,300	
1380.0	61,400	100

El. in ft.	Capacity	Diff.
1380.0	61,400	100
.1	61,500	
.2	61,600	
.3	61,700	
.4	61,800	
.5	61,900	
.6	62,000	
.7	62,100	
.8	62,200	
.9	62,300	
1381.0	62,400	
.1	62,500	
.2	62,600	
.3	62,700	
.4	62,800	
.5	62,900	
.6	63,000	
.7	63,100	
.8	63,200	
.9	63,300	
1382.0	63,400	
.1	63,500	
.2	63,600	
.3	63,700	
.4	63,800	
.5	63,900	
.6	64,000	
.7	64,100	
.8	64,200	
.9	64,300	
1383.0	64,400	
.1	64,500	
.2	64,600	
.3	64,700	
.4	64,800	
.5	64,900	
.6	65,000	
.7	65,100	
.8	65,200	
.9	65,300	
1384.0	65,400	
.1	65,500	
.2	65,600	
.3	65,700	
.4	65,800	
.5	65,900	
.6	66,000	
.7	66,100	
.8	66,200	
.9	66,300	
1385.0	66,400	100

El. in ft.	Capacity	Diff.
1385.0	66,400	100
.1	66,500	
.2	66,600	
.3	66,700	
.4	66,800	
.5	66,900	
.6	67,000	
.7	67,100	
.8	67,200	
.9	67,300	
1386.0	67,400	
.1	67,500	
.2	67,600	
.3	67,700	
.4	67,800	
.5	67,900	
.6	68,000	
.7	68,100	
.8	68,200	
.9	68,300	100
1387.0	68,400	110
.1	68,510	
.2	68,620	
.3	68,730	
.4	68,840	
.5	68,950	
.6	69,060	
.7	69,170	
.8	69,280	
.9	69,390	
1388.0	69,500	
.1	69,610	
.2	69,720	
.3	69,830	
.4	69,940	
.5	70,050	
.6	70,160	
.7	70,270	
.8	70,380	
.9	70,490	
1389.0	70,600	
.1	70,710	
.2	70,820	
.3	70,930	
.4	71,040	
.5	71,150	
.6	71,260	
.7	71,370	
.8	71,480	
.9	71,590	
1390.0	71,700	110

El. in ft.	Capacity	Diff.
1390.0	71,700	110
.1	71,810	
.2	71,920	
.3	72,030	
.4	72,140	
.5	72,250	
.6	72,360	
.7	72,470	
.8	72,580	
.9	72,690	
1391.0	72,800	
.1	72,910	
.2	73,020	
.3	73,130	
.4	73,240	
.5	73,350	
.6	73,460	
.7	73,570	
.8	73,680	
.9	73,790	
1392.0	73,900	
.1	74,010	
.2	74,120	
.3	74,230	
.4	74,340	
.5	74,450	
.6	74,560	
.7	74,670	
.8	74,780	
.9	74,890	
1393.0	75,000	
.1	75,110	
.2	75,220	
.3	75,330	
.4	75,440	
.5	75,550	
.6	75,660	
.7	75,770	
.8	75,880	
.9	75,990	
1394.0	76,100	
.1	76,210	
.2	76,320	
.3	76,430	
.4	76,540	
.5	76,650	
.6	76,760	
.7	76,870	
.8	76,980	
.9	77,090	
1395.0	77,200	110

El. in ft.	Capacity	Diff.
1395.0	77,200	110
.1	77,310	
.2	77,420	
.3	77,530	
.4	77,640	
.5	77,750	
.6	77,860	
.7	77,970	
.8	78,080	
.9	78,190	
1396.0	78,300	
.1	78,410	
.2	78,520	
.3	78,630	
.4	78,740	
.5	78,850	
.6	78,960	
.7	79,070	
.8	79,180	
.9	79,290	
1397.0	79,400	
.1	79,510	
.2	79,620	
.3	79,730	
.4	79,840	
.5	79,950	
.6	80,060	
.7	80,170	
.8	80,280	
.9	80,390	
1398.0	80,500	
.1	80,610	
.2	80,720	
.3	80,830	
.4	80,940	
.5	81,050	
.6	81,160	
.7	81,270	
.8	81,380	
.9	81,490	
1399.0	81,600	
.1	81,710	
.2	81,820	
.3	81,930	
.4	82,040	
.5	82,150	
.6	82,260	
.7	82,370	
.8	82,480	
.9	82,590	
1400.0	82,700	110

El. in ft.	Capacity	Diff.
1400.0	82,700	110
.1	82,810	
.2	82,920	
.3	83,030	
.4	83,140	
.5	83,250	
.6	83,360	
.7	83,470	
.8	83,580	
.9	83,690	110
1401.0	83,800	120
.1	83,920	
.2	84,040	
.3	84,160	
.4	84,280	
.5	84,400	
.6	84,520	
.7	84,640	
.8	84,760	
.9	84,880	
1402.0	85,000	
.1	85,120	
.2	85,240	
.3	85,360	
.4	85,480	
.5	85,600	
.6	85,720	
.7	85,840	
.8	85,960	
.9	86,080	
1403.0	86,200	
.1	86,320	
.2	86,440	
.3	86,560	
.4	86,680	
.5	86,800	
.6	86,920	
.7	87,040	
.8	87,160	
.9	87,280	
1404.0	87,400	
.1	87,520	
.2	87,640	
.3	87,760	
.4	87,880	
.5	88,000	
.6	88,120	
.7	88,240	
.8	88,360	
.9	88,480	
1405.0	88,600	120

El. in ft.	Capacity	Diff.
1405.0	88,600	120
.1	88,720	
.2	88,840	
.3	88,960	
.4	89,080	
.5	89,200	
.6	89,320	
.7	89,440	
.8	89,560	
.9	89,680	
1406.0	89,800	
.1	89,920	
.2	90,040	
.3	90,160	
.4	90,280	
.5	90,400	
.6	90,520	
.7	90,640	
.8	90,760	
.9	90,880	
1407.0	91,000	
.1	91,120	
.2	91,240	
.3	91,360	
.4	91,480	
.5	91,600	
.6	91,720	
.7	91,840	
.8	91,960	
.9	92,080	
1408.0	92,200	
.1	92,320	
.2	92,440	
.3	92,560	
.4	92,680	
.5	92,800	
.6	92,920	
.7	93,040	
.8	93,160	
.9	93,280	120
1409.0	93,400	130
.1	93,530	
.2	93,660	
.3	93,790	
.4	93,920	
.5	94,050	
.6	94,180	
.7	94,310	
.8	94,440	
.9	94,570	
1410.0	94,700	130

El. in ft.	Capacity	Diff.
1410.0	94,700	130
.1	94,830	
.2	94,960	
.3	95,090	
.4	95,220	
.5	95,350	
.6	95,480	
.7	95,610	
.8	95,740	
.9	95,870	
1411.0	96,000	
.1	96,130	
.2	96,260	
.3	96,390	
.4	96,520	
.5	96,650	
.6	96,780	
.7	96,910	
.8	97,040	
.9	97,170	
1412.0	97,300	
.1	97,430	
.2	97,560	
.3	97,690	
.4	97,820	
.5	97,950	
.6	98,080	
.7	98,210	
.8	98,340	
.9	98,470	
1413.0	98,600	
.1	98,730	
.2	98,860	
.3	98,990	
.4	99,120	
.5	99,250	
.6	99,380	
.7	99,510	
.8	99,640	
.9	99,770	
1414.0	99,900	
.1	100,030	
.2	100,160	
.3	100,290	
.4	100,420	
.5	100,550	
.6	100,680	
.7	100,810	
.8	100,940	
.9	101,070	
1415.0	101,200	130

El. in ft.	Capacity	Diff.
1415.0	101,200	130
.1	101,330	
.2	101,460	
.3	101,590	
.4	101,720	
.5	101,850	
.6	101,980	
.7	102,110	
.8	102,240	
.9	102,370	
1416.0	102,500	
.1	102,630	
.2	102,760	
.3	102,890	
.4	103,020	
.5	103,150	
.6	103,280	
.7	103,410	
.8	103,540	
.9	103,670	
1417.0	103,800	
.1	103,930	
.2	104,060	
.3	104,190	
.4	104,320	
.5	104,450	
.6	104,580	
.7	104,710	
.8	104,840	
.9	104,970	
1418.0	105,100	
.1	105,230	
.2	105,360	
.3	105,490	
.4	105,620	
.5	105,750	
.6	105,880	
.7	106,010	
.8	106,140	
.9	106,270	
1419.0	106,400	
.1	106,530	
.2	106,660	
.3	106,790	
.4	106,920	
.5	107,050	
.6	107,180	
.7	107,310	
.8	107,440	
.9	107,570	
1420.0	107,700	130

El. in ft.	Capacity	Diff.
1420.0	107,700	140
.1	107,840	
.2	107,980	
.3	108,120	
.4	108,260	
.5	108,400	
.6	108,540	
.7	108,680	
.8	108,820	
.9	108,960	
1421.0	109,100	
.1	109,240	
.2	109,380	
.3	109,520	
.4	109,660	
.5	109,800	
.6	109,940	
.7	110,080	
.8	110,220	
.9	110,360	
1422.0	110,500	
.1	110,640	
.2	110,780	
.3	110,920	
.4	111,060	
.5	111,200	
.6	111,340	
.7	111,480	
.8	111,620	
.9	111,760	
1423.0	111,900	
.1	112,040	
.2	112,180	
.3	112,320	
.4	112,460	
.5	112,600	
.6	112,740	
.7	112,880	
.8	113,020	
.9	113,160	
1424.0	113,300	
.1	113,440	
.2	113,580	
.3	113,720	
.4	113,860	
.5	114,000	
.6	114,140	
.7	114,280	
.8	114,420	
.9	114,560	
1425.0	114,700	140

Remarks: Elevations are above mean sea level, 1929 adjustment.

Minimum Power Pool 1425.0 feet
Minimum Flood Control Pool 1450.0 feet
Spillway Crest 1541.0 feet

Maximum Conservation Pool 1563.5 feet
Normal Flood Control Pool 1569.0 feet
Maximum Pool 1574.0 feet

Compiled by C.R.M.
Checked by M.L.
Date 28 Feb. 1952

TABLE NO. 3
CAPACITY OF DETROIT RESERVOIR
IN ACRE-FEET

El. in ft.	Capacity	Diff.
1425.0	114,700	140
.1	114,840	
.2	114,980	
.3	115,120	
.4	115,260	
.5	115,400	
.6	115,540	
.7	115,680	
.8	115,820	
.9	115,960	
1426.0	116,100	
.1	116,240	
.2	116,380	
.3	116,520	
.4	116,660	
.5	116,800	
.6	116,940	
.7	117,080	
.8	117,220	
.9	117,360	140
1427.0	117,500	150
.1	117,650	
.2	117,800	
.3	117,950	
.4	118,100	
.5	118,250	
.6	118,400	
.7	118,550	
.8	118,700	
.9	118,850	
1428.0	119,000	
.1	119,150	
.2	119,300	
.3	119,450	
.4	119,600	
.5	119,750	
.6	119,900	
.7	120,050	
.8	120,200	
.9	120,350	
1429.0	120,500	
.1	120,650	
.2	120,800	
.3	120,950	
.4	121,100	
.5	121,250	
.6	121,400	
.7	121,550	
.8	121,700	
.9	121,850	
1430.0	122,000	150

El. in ft.	Capacity	Diff.
1430.0	122,000	150
.1	122,150	
.2	122,300	
.3	122,450	
.4	122,600	
.5	122,750	
.6	122,900	
.7	123,050	
.8	123,200	
.9	123,350	
1431.0	123,500	
.1	123,650	
.2	123,800	
.3	123,950	
.4	124,100	
.5	124,250	
.6	124,400	
.7	124,550	
.8	124,700	
.9	124,850	150
1432.0	125,000	160
.1	125,160	
.2	125,320	
.3	125,480	
.4	125,640	
.5	125,800	
.6	125,960	
.7	126,120	
.8	126,280	
.9	126,440	
1433.0	126,600	
.1	126,760	
.2	126,920	
.3	127,080	
.4	127,240	
.5	127,400	
.6	127,560	
.7	127,720	
.8	127,880	
.9	128,040	
1434.0	128,200	
.1	128,360	
.2	128,520	
.3	128,680	
.4	128,840	
.5	129,000	
.6	129,160	
.7	129,320	
.8	129,480	
.9	129,640	
1435.0	129,800	160

El. in ft.	Capacity	Diff.
1435.0	129,800	160
.1	129,960	
.2	130,120	
.3	130,280	
.4	130,440	
.5	130,600	
.6	130,760	
.7	130,920	
.8	131,080	
.9	131,240	
1436.0	131,400	
.1	131,560	
.2	131,720	
.3	131,880	
.4	132,040	
.5	132,200	
.6	132,360	
.7	132,520	
.8	132,680	
.9	132,840	
1437.0	133,000	
.1	133,160	
.2	133,320	
.3	133,480	
.4	133,640	
.5	133,800	
.6	133,960	
.7	134,120	
.8	134,280	
.9	134,440	160
1438.0	134,600	170
.1	134,770	
.2	134,940	
.3	135,110	
.4	135,280	
.5	135,450	
.6	135,620	
.7	135,790	
.8	135,960	
.9	136,130	
1439.0	136,300	
.1	136,470	
.2	136,640	
.3	136,810	
.4	136,980	
.5	137,150	
.6	137,320	
.7	137,490	
.8	137,660	
.9	137,830	
1440.0	138,000	170

El. in ft.	Capacity	Diff.
1440.0	138,000	170
.1	138,170	
.2	138,340	
.3	138,510	
.4	138,680	
.5	138,850	
.6	139,020	
.7	139,190	
.8	139,360	
.9	139,530	
1441.0	139,700	
.1	139,870	
.2	140,040	
.3	140,210	
.4	140,380	
.5	140,550	
.6	140,720	
.7	140,890	
.8	141,060	
.9	141,230	
1442.0	141,400	
.1	141,570	
.2	141,740	
.3	141,910	
.4	142,080	
.5	142,250	
.6	142,420	
.7	142,590	
.8	142,760	
.9	142,930	
1443.0	143,100	
.1	143,270	
.2	143,440	
.3	143,610	
.4	143,780	
.5	143,950	
.6	144,120	
.7	144,290	
.8	144,460	
.9	144,630	
1444.0	144,800	
.1	144,970	
.2	145,140	
.3	145,310	
.4	145,480	
.5	145,650	
.6	145,820	
.7	145,990	
.8	146,160	
.9	146,330	
1445.0	146,500	170

El. in ft.	Capacity	Diff.
1445.0	146,500	170
.1	146,670	
.2	146,840	
.3	147,010	
.4	147,180	
.5	147,350	
.6	147,520	
.7	147,690	
.8	147,860	
.9	148,030	
1446.0	148,200	
.1	148,370	
.2	148,540	
.3	148,710	
.4	148,880	
.5	149,050	
.6	149,220	
.7	149,390	
.8	149,560	
.9	149,730	
1447.0	149,900	
.1	150,070	
.2	150,240	
.3	150,410	
.4	150,580	
.5	150,750	
.6	150,920	
.7	151,090	
.8	151,260	
.9	151,430	
1448.0	151,600	
.1	151,770	
.2	151,940	
.3	152,110	
.4	152,280	
.5	152,450	
.6	152,620	
.7	152,790	
.8	152,960	
.9	153,130	
1449.0	153,300	
.1	153,470	
.2	153,640	
.3	153,810	
.4	153,980	
.5	154,150	
.6	154,320	
.7	154,490	
.8	154,660	
.9	154,830	
1450.0	155,000	170

El. in ft.	Capacity	Diff.
1450.0	155,000	170
.1	155,170	
.2	155,340	
.3	155,510	
.4	155,680	
.5	155,850	
.6	156,020	
.7	156,190	
.8	156,360	
.9	156,530	
1451.0	156,700	
.1	156,870	
.2	157,040	
.3	157,210	
.4	157,380	
.5	157,550	
.6	157,720	
.7	157,890	
.8	158,060	
.9	158,230	
1452.0	158,400	
.1	158,570	
.2	158,740	
.3	158,910	
.4	159,080	
.5	159,250	
.6	159,420	
.7	159,590	
.8	159,760	
.9	159,930	
1453.0	160,100	
.1	160,270	
.2	160,440	
.3	160,610	
.4	160,780	
.5	160,950	
.6	161,120	
.7	161,290	
.8	161,460	
.9	161,630	170
1454.0	161,800	180
.1	161,980	
.2	162,160	
.3	162,340	
.4	162,520	
.5	162,700	
.6	162,880	
.7	163,060	
.8	163,240	
.9	163,420	
1455.0	163,600	180

El. in ft.	Capacity	Diff.
1455.0	163,600	180
.1	163,780	
.2	163,960	
.3	164,140	
.4	164,320	
.5	164,500	
.6	164,680	
.7	164,860	
.8	165,040	
.9	165,220	
1456.0	165,400	
.1	165,580	
.2	165,760	
.3	165,940	
.4	166,120	
.5	166,300	
.6	166,480	
.7	166,660	
.8	166,840	
.9	167,020	
1457.0	167,200	
.1	167,380	
.2	167,560	
.3	167,740	
.4	167,920	
.5	168,100	
.6	168,280	
.7	168,460	
.8	168,640	
.9	168,820	
1458.0	169,000	
.1	169,180	
.2	169,360	
.3	169,540	
.4	169,720	
.5	169,900	
.6	170,080	
.7	170,260	
.8	170,440	
.9	170,620	
1459.0	170,800	
.1	170,980	
.2	171,160	
.3	171,340	
.4	171,520	
.5	171,700	
.6	171,880	
.7	172,060	
.8	172,240	
.9	172,420	
1460.0	172,600	180

El. in ft.	Capacity	Diff.
1460.0	172,600	180
.1	172,780	
.2	172,960	
.3	173,140	
.4	173,320	
.5	173,500	
.6	173,680	
.7	173,860	
.8	174,040	
.9	174,220	
1461.0	174,400	
.1	174,580	
.2	174,760	
.3	174,940	
.4	175,120	
.5	175,300	
.6	175,480	
.7	175,660	
.8	175,840	
.9	176,020	
1462.0	176,200	
.1	176,380	
.2	176,560	
.3	176,740	
.4	176,920	
.5	177,100	
.6	177,280	
.7	177,460	
.8	177,640	
.9	177,820	
1463.0	178,000	
.1	178,180	
.2	178,360	
.3	178,540	
.4	178,720	
.5	178,900	
.6	179,080	
.7	179,260	
.8	179,440	
.9	179,620	
1464.0	179,800	
.1	179,980	
.2	180,160	
.3	180,340	
.4	180,520	
.5	180,700	
.6	180,880	
.7	181,060	
.8	181,240	
.9	181,420	
1465.0	181,600	180

El. in ft.	Capacity	Diff.
1465.0	181,600	180
.1	181,780	
.2	181,960	
.3	182,140	
.4	182,320	
.5	182,500	
.6	182,680	
.7	182,860	
.8	183,040	
.9	183,220	180
1466.0	183,400	190
.1	183,590	
.2	183,780	
.3	183,970	
.4	184,160	
.5	184,350	
.6	184,540	
.7	184,730	
.8	184,920	
.9	185,110	
1467.0	185,300	
.1	185,490	
.2	185,680	
.3	185,870	
.4	186,060	
.5	186,250	
.6	186,440	
.7	186,630	
.8	186,820	
.9	187,010	
1468.0	187,200	
.1	187,390	
.2	187,580	
.3	187,770	
.4	187,960	
.5	188,150	
.6	188,340	
.7	188,530	
.8	188,720	
.9	188,910	
1469.0	189,100	
.1	189,290	
.2	189,480	
.3	189,670	
.4	189,860	
.5	190,050	
.6	190,240	
.7	190,430	
.8	190,620	
.9	190,810	
1470.0	191,000	190

El. in ft.	Capacity	Diff.
1470.0	191,000	190
.1	191,190	
.2	191,380	
.3	191,570	
.4	191,760	
.5	191,950	
.6	192,140	
.7	192,330	
.8	192,520	
.9	192,710	
1471.0	192,900	
.1	193,090	
.2	193,280	
.3	193,470	
.4	193,660	
.5	193,850	
.6	194,040	
.7	194,230	
.8	194,420	
.9	194,610	
1472.0	194,800	
.1	194,990	
.2	195,180	
.3	195,370	
.4	195,560	
.5	195,750	
.6	195,940	
.7	196,130	
.8	196,320	
.9	196,510	
1473.0	196,700	
.1	196,890	
.2	197,080	
.3	197,270	
.4	197,460	
.5	197,650	
.6	197,840	
.7	198,030	
.8	198,220	
.9	198,410	190
1474.0	198,600	200
.1	198,800	
.2	199,000	
.3	199,200	
.4	199,400	
.5	199,600	
.6	199,800	
.7	200,000	
.8	200,200	
.9	200,400	
1475.0	200,600	200

Remarks:

Minimum Power Pool 1425.0 feet
Minimum Flood Control Pool 1450.0 feet
Spillway Crest 1541.0 feet

Maximum Conservation Pool 1563.5 feet
Normal Flood Control Pool 1569.0 feet
Maximum Pool 1574.0 feet

Compiled by C.R.M.
Checked by M.L.
Date 28 Feb 1952

TABLE NO. 3
CAPACITY OF DETROIT RESERVOIR IN ACRE-FEET

El. in ft.	Capacity	Diff.
1475.0	200,600	200
.1	200,800	
.2	201,000	
.3	201,200	
.4	201,400	
.5	201,600	
.6	201,800	
.7	202,000	
.8	202,200	
.9	202,400	
1476.0	202,600	
.1	202,800	
.2	203,000	
.3	203,200	
.4	203,400	
.5	203,600	
.6	203,800	
.7	204,000	
.8	204,200	
.9	204,400	
1477.0	204,600	
.1	204,800	
.2	205,000	
.3	205,200	
.4	205,400	
.5	205,600	
.6	205,800	
.7	206,000	
.8	206,200	
.9	206,400	
1478.0	206,600	
.1	206,800	
.2	207,000	
.3	207,200	
.4	207,400	
.5	207,600	
.6	207,800	
.7	208,000	
.8	208,200	
.9	208,400	
1479.0	208,600	
.1	208,800	
.2	209,000	
.3	209,200	
.4	209,400	
.5	209,600	
.6	209,800	
.7	210,000	
.8	210,200	
.9	210,400	
1480.0	210,600	200

El. in ft.	Capacity	Diff.
1480.0	210,600	200
.1	210,800	
.2	211,000	
.3	211,200	
.4	211,400	
.5	211,600	
.6	211,800	
.7	212,000	
.8	212,200	
.9	212,400	200
1481.0	212,600	210
.1	212,810	
.2	213,020	
.3	213,230	
.4	213,440	
.5	213,650	
.6	213,860	
.7	214,070	
.8	214,280	
.9	214,490	
1482.0	214,700	
.1	214,910	
.2	215,120	
.3	215,330	
.4	215,540	
.5	215,750	
.6	215,960	
.7	216,170	
.8	216,380	
.9	216,590	
1483.0	216,800	
.1	217,010	
.2	217,220	
.3	217,430	
.4	217,640	
.5	217,850	
.6	218,060	
.7	218,270	
.8	218,480	
.9	218,690	
1484.0	218,900	
.1	219,110	
.2	219,320	
.3	219,530	
.4	219,740	
.5	219,950	
.6	220,160	
.7	220,370	
.8	220,580	
.9	220,790	
1485.0	221,000	210

El. in ft.	Capacity	Diff.
1485.0	221,000	210
.1	221,210	
.2	221,420	
.3	221,630	
.4	221,840	
.5	222,050	
.6	222,260	
.7	222,470	
.8	222,680	
.9	222,890	
1486.0	223,100	
.1	223,310	
.2	223,520	
.3	223,730	
.4	223,940	
.5	224,150	
.6	224,360	
.7	224,570	
.8	224,780	
.9	224,990	210
1487.0	225,200	220
.1	225,420	
.2	225,640	
.3	225,860	
.4	226,080	
.5	226,300	
.6	226,520	
.7	226,740	
.8	226,960	
.9	227,180	
1488.0	227,400	
.1	227,620	
.2	227,840	
.3	228,060	
.4	228,280	
.5	228,500	
.6	228,720	
.7	228,940	
.8	229,160	
.9	229,380	
1489.0	229,600	
.1	229,820	
.2	230,040	
.3	230,260	
.4	230,480	
.5	230,700	
.6	230,920	
.7	231,140	
.8	231,360	
.9	231,580	
1490.0	231,800	220

El. in ft.	Capacity	Diff.
1490.0	231,800	220
.1	232,020	
.2	232,240	
.3	232,460	
.4	232,680	
.5	232,900	
.6	233,120	
.7	233,340	
.8	233,560	
.9	233,780	
1491.0	234,000	
.1	234,220	
.2	234,440	
.3	234,660	
.4	234,880	
.5	235,100	
.6	235,320	
.7	235,540	
.8	235,760	
.9	235,980	
1492.0	236,200	
.1	236,420	
.2	236,640	
.3	236,860	
.4	237,080	
.5	237,300	
.6	237,520	
.7	237,740	
.8	237,960	
.9	238,180	220
1493.0	238,400	230
.1	238,630	
.2	238,860	
.3	239,090	
.4	239,320	
.5	239,550	
.6	239,780	
.7	240,010	
.8	240,240	
.9	240,470	
1494.0	240,700	
.1	240,930	
.2	241,160	
.3	241,390	
.4	241,620	
.5	241,850	
.6	242,080	
.7	242,310	
.8	242,540	
.9	242,770	
1495.0	243,000	230

El. in ft.	Capacity	Diff.
1495.0	243,000	230
.1	243,230	
.2	243,460	
.3	243,690	
.4	243,920	
.5	244,150	
.6	244,380	
.7	244,610	
.8	244,840	
.9	245,070	
1496.0	245,300	
.1	245,530	
.2	245,760	
.3	245,990	
.4	246,220	
.5	246,450	
.6	246,680	
.7	246,910	
.8	247,140	
.9	247,370	
1497.0	247,600	
.1	247,830	
.2	248,060	
.3	248,290	
.4	248,520	
.5	248,750	
.6	248,980	
.7	249,210	
.8	249,440	
.9	249,670	
1498.0	249,900	
.1	250,130	
.2	250,360	
.3	250,590	
.4	250,820	
.5	251,050	
.6	251,280	
.7	251,510	
.8	251,740	
.9	251,970	
1499.0	252,200	
.1	252,430	
.2	252,660	
.3	252,890	
.4	253,120	
.5	253,350	
.6	253,580	
.7	253,810	
.8	254,040	
.9	254,270	
1500.0	254,500	230

El. in ft.	Capacity	Diff.
1500.0	254,500	240
.1	254,740	
.2	254,980	
.3	255,220	
.4	255,460	
.5	255,700	
.6	255,940	
.7	256,180	
.8	256,420	
.9	256,660	
1501.0	256,900	
.1	257,140	
.2	257,380	
.3	257,620	
.4	257,860	
.5	258,100	
.6	258,340	
.7	258,580	
.8	258,820	
.9	259,060	
1502.0	259,300	
.1	259,540	
.2	259,780	
.3	260,020	
.4	260,260	
.5	260,500	
.6	260,740	
.7	260,980	
.8	261,220	
.9	261,460	
1503.0	261,700	
.1	261,940	
.2	262,180	
.3	262,420	
.4	262,660	
.5	262,900	
.6	263,140	
.7	263,380	
.8	263,620	
.9	263,860	
1504.0	264,100	
.1	264,340	
.2	264,580	
.3	264,820	
.4	265,060	
.5	265,300	
.6	265,540	
.7	265,780	
.8	266,020	
.9	266,260	
1505.0	266,500	240

El. in ft.	Capacity	Diff.
1505.0	266,500	240
.1	266,740	
.2	266,980	
.3	267,220	
.4	267,460	
.5	267,700	
.6	267,940	
.7	268,180	
.8	268,420	
.9	268,660	
1506.0	268,900	
.1	269,140	
.2	269,380	
.3	269,620	
.4	269,860	
.5	270,100	
.6	270,340	
.7	270,580	
.8	270,820	
.9	271,060	240
1507.0	271,300	250
.1	271,550	
.2	271,800	
.3	272,050	
.4	272,300	
.5	272,550	
.6	272,800	
.7	273,050	
.8	273,300	
.9	273,550	
1508.0	273,800	
.1	274,050	
.2	274,300	
.3	274,550	
.4	274,800	
.5	275,050	
.6	275,300	
.7	275,550	
.8	275,800	
.9	276,050	
1509.0	276,300	
.1	276,550	
.2	276,800	
.3	277,050	
.4	277,300	
.5	277,550	
.6	277,800	
.7	278,050	
.8	278,300	
.9	278,550	
1510.0	278,800	250

El. in ft.	Capacity	Diff.
1510.0	278,800	250
.1	279,050	
.2	279,300	
.3	279,550	
.4	279,800	
.5	280,050	
.6	280,300	
.7	280,550	
.8	280,800	
.9	281,050	
1511.0	281,300	
.1	281,550	
.2	281,800	
.3	282,050	
.4	282,300	
.5	282,550	
.6	282,800	
.7	283,050	
.8	283,300	
.9	283,550	
1512.0	283,800	
.1	284,050	
.2	284,300	
.3	284,550	
.4	284,800	
.5	285,050	
.6	285,300	
.7	285,550	
.8	285,800	
.9	286,050	
1513.0	286,300	
.1	286,550	
.2	286,800	
.3	287,050	
.4	287,300	
.5	287,550	
.6	287,800	
.7	288,050	
.8	288,300	
.9	288,550	
1514.0	288,800	
.1	289,050	
.2	289,300	
.3	289,550	
.4	289,800	
.5	290,050	
.6	290,300	
.7	290,550	
.8	290,800	
.9	291,050	
1515.0	291,300	250

El. in ft.	Capacity	Diff.
1515.0	291,300	250
.1	291,550	
.2	291,800	
.3	292,050	
.4	292,300	
.5	292,550	
.6	292,800	
.7	293,050	
.8	293,300	
.9	293,550	250
1516.0	293,800	260
.1	294,060	
.2	294,320	
.3	294,580	
.4	294,840	
.5	295,100	
.6	295,360	
.7	295,620	
.8	295,880	
.9	296,140	
1517.0	296,400	
.1	296,660	
.2	296,920	
.3	297,180	
.4	297,440	
.5	297,700	
.6	297,960	
.7	298,220	
.8	298,480	
.9	298,740	
1518.0	299,000	
.1	299,260	
.2	299,520	
.3	299,780	
.4	300,040	
.5	300,300	
.6	300,560	
.7	300,820	
.8	301,080	
.9	301,340	
1519.0	301,600	
.1	301,860	
.2	302,120	
.3	302,380	
.4	302,640	
.5	302,900	
.6	303,160	
.7	303,420	
.8	303,680	
.9	303,940	
1520.0	304,200	260

El. in ft.	Capacity	Diff.
1520.0	304,200	260
.1	304,460	
.2	304,720	
.3	304,980	
.4	305,240	
.5	305,500	
.6	305,760	
.7	306,020	
.8	306,280	
.9	306,540	
1521.0	306,800	
.1	307,060	
.2	307,320	
.3	307,580	
.4	307,840	
.5	308,100	
.6	308,360	
.7	308,620	
.8	308,880	
.9	309,140	
1522.0	309,400	
.1	309,660	
.2	309,920	
.3	310,180	
.4	310,440	
.5	310,700	
.6	310,960	
.7	311,220	
.8	311,480	
.9	311,740	
1523.0	312,000	
.1	312,260	
.2	312,520	
.3	312,780	
.4	313,040	
.5	313,300	
.6	313,560	
.7	313,820	
.8	314,080	
.9	314,340	
1524.0	314,600	
.1	314,860	
.2	315,120	
.3	315,380	
.4	315,640	
.5	315,900	
.6	316,160	
.7	316,420	
.8	316,680	
.9	316,940	
1525.0	317,200	260

Remarks:

Minimum Power Pool 1425.0 feet
Minimum Flood Control Pool 1450.0 feet
Spillway Crest 1541.0 feet

Maximum Conservation Pool 1563.5 feet
Normal Flood Control Pool 1569.0 feet
Maximum Pool 1574.0 feet

Compiled by C.R.M.
Checked by M.L.
Date 28 Feb. 1952

Sheet 4 of 4

TABLE NO. 3
CAPACITY OF DETROIT RESERVOIR
IN ACRE-FEET

El. in ft.	Capacity	Diff.
1525.0	317,200	270
.1	317,470	
.2	317,740	
.3	318,010	
.4	318,280	
.5	318,550	
.6	318,820	
.7	319,090	
.8	319,360	
.9	319,630	
1526.0	319,900	
.1	320,170	
.2	320,440	
.3	320,710	
.4	320,980	
.5	321,250	
.6	321,520	
.7	321,790	
.8	322,060	
.9	322,330	
1527.0	322,600	
.1	322,870	
.2	323,140	
.3	323,410	
.4	323,680	
.5	323,950	
.6	324,220	
.7	324,490	
.8	324,760	
.9	325,030	
1528.0	325,300	
.1	325,570	
.2	325,840	
.3	326,110	
.4	326,380	
.5	326,650	
.6	326,920	
.7	327,190	
.8	327,460	
.9	327,730	270
1529.0	328,000	280
.1	328,280	
.2	328,560	
.3	328,840	
.4	329,120	
.5	329,400	
.6	329,680	
.7	329,960	
.8	330,240	
.9	330,520	280
1530.0	330,800	

El. in ft.	Capacity	Diff.
1530.0	330,800	280
.1	331,080	
.2	331,360	
.3	331,640	
.4	331,920	
.5	332,200	
.6	332,480	
.7	332,760	
.8	333,040	
.9	333,320	
1531.0	333,600	
.1	333,880	
.2	334,160	
.3	334,440	
.4	334,720	
.5	335,000	
.6	335,280	
.7	335,560	
.8	335,840	
.9	336,120	
1532.0	336,400	
.1	336,680	
.2	336,960	
.3	337,240	
.4	337,520	
.5	337,800	
.6	338,080	
.7	338,360	
.8	338,640	
.9	338,920	280
1533.0	339,200	290
.1	339,490	
.2	339,780	
.3	340,070	
.4	340,360	
.5	340,650	
.6	340,940	
.7	341,230	
.8	341,520	
.9	341,810	
1534.0	342,100	
.1	342,390	
.2	342,680	
.3	342,970	
.4	343,260	
.5	343,550	
.6	343,840	
.7	344,130	
.8	344,420	
.9	344,710	290
1535.0	345,000	

El. in ft.	Capacity	Diff.
1535.0	345,000	290
.1	345,290	
.2	345,580	
.3	345,870	
.4	346,160	
.5	346,450	
.6	346,740	
.7	347,030	
.8	347,320	
.9	347,610	
1536.0	347,900	
.1	348,190	
.2	348,480	
.3	348,770	
.4	349,060	
.5	349,350	
.6	349,640	
.7	349,930	
.8	350,220	
.9	350,510	
1537.0	350,800	
.1	351,090	
.2	351,380	
.3	351,670	
.4	351,960	
.5	352,250	
.6	352,540	
.7	352,830	
.8	353,120	
.9	353,410	
1538.0	353,700	
.1	353,990	
.2	354,280	
.3	354,570	
.4	354,860	
.5	355,150	
.6	355,440	
.7	355,730	
.8	356,020	
.9	356,310	290
1539.0	356,600	300
.1	356,900	
.2	357,200	
.3	357,500	
.4	357,800	
.5	358,100	
.6	358,400	
.7	358,700	
.8	359,000	
.9	359,300	300
1540.0	359,600	

El. in ft.	Capacity	Diff.
1540.0	359,600	300
.1	359,900	
.2	360,200	
.3	360,500	
.4	360,800	
.5	361,100	
.6	361,400	
.7	361,700	
.8	362,000	
.9	362,300	300
1541.0	362,600	310
.1	362,910	
.2	363,220	
.3	363,530	
.4	363,840	
.5	364,150	
.6	364,460	
.7	364,770	
.8	365,080	
.9	365,390	
1542.0	365,700	
.1	366,010	
.2	366,320	
.3	366,630	
.4	366,940	
.5	367,250	
.6	367,560	
.7	367,870	
.8	368,180	
.9	368,490	
1543.0	368,800	
.1	369,110	
.2	369,420	
.3	369,730	
.4	370,040	
.5	370,350	
.6	370,660	
.7	370,970	
.8	371,280	
.9	371,590	
1544.0	371,900	
.1	372,210	
.2	372,520	
.3	372,830	
.4	373,140	
.5	373,450	
.6	373,760	
.7	374,070	
.8	374,380	
.9	374,690	310
1545.0	375,000	

El. in ft.	Capacity	Diff.
1545.0	375,000	320
.1	375,320	
.2	375,640	
.3	375,960	
.4	376,280	
.5	376,600	
.6	376,920	
.7	377,240	
.8	377,560	
.9	377,880	
1546.0	378,200	
.1	378,520	
.2	378,840	
.3	379,160	
.4	379,480	
.5	379,800	
.6	380,120	
.7	380,440	
.8	380,760	
.9	381,080	
1547.0	381,400	
.1	381,720	
.2	382,040	
.3	382,360	
.4	382,680	
.5	383,000	
.6	383,320	
.7	383,640	
.8	383,960	
.9	384,280	
1548.0	384,600	
.1	384,920	
.2	385,240	
.3	385,560	
.4	385,880	
.5	386,200	
.6	386,520	
.7	386,840	
.8	387,160	
.9	387,480	
1549.0	387,800	
.1	388,120	
.2	388,440	
.3	388,760	
.4	389,080	
.5	389,400	
.6	389,720	
.7	390,040	
.8	390,360	
.9	390,680	320
1550.0	391,000	

El. in ft.	Capacity	Diff.
1550.0	391,000	320
.1	391,320	
.2	391,640	
.3	391,960	
.4	392,280	
.5	392,600	
.6	392,920	
.7	393,240	
.8	393,560	
.9	393,880	320
1551.0	394,200	330
.1	394,530	
.2	394,860	
.3	395,190	
.4	395,520	
.5	395,850	
.6	396,180	
.7	396,510	
.8	396,840	
.9	397,170	
1552.0	397,500	
.1	397,830	
.2	398,160	
.3	398,490	
.4	398,820	
.5	399,150	
.6	399,480	
.7	399,810	
.8	400,140	
.9	400,470	
1553.0	400,800	
.1	401,130	
.2	401,460	
.3	401,790	
.4	402,120	
.5	402,450	
.6	402,780	
.7	403,110	
.8	403,440	
.9	403,770	
1554.0	404,100	
.1	404,430	
.2	404,760	
.3	405,090	
.4	405,420	
.5	405,750	
.6	406,080	
.7	406,410	
.8	406,740	
.9	407,070	330
1555.0	407,400	

El. in ft.	Capacity	Diff.
1555.0	407,400	330
.1	407,730	
.2	408,060	
.3	408,390	
.4	408,720	
.5	409,050	
.6	409,380	
.7	409,710	
.8	410,040	
.9	410,370	
1556.0	410,700	
.1	411,030	
.2	411,360	
.3	411,690	
.4	412,020	
.5	412,350	
.6	412,680	
.7	413,010	
.8	413,340	
.9	413,670	
1557.0	414,000	
.1	414,330	
.2	414,660	
.3	414,990	
.4	415,320	
.5	415,650	
.6	415,980	
.7	416,310	
.8	416,640	
.9	416,970	
1558.0	417,300	
.1	417,630	
.2	417,960	
.3	418,290	
.4	418,620	
.5	418,950	
.6	419,280	
.7	419,610	
.8	419,940	
.9	420,270	330
1559.0	420,600	340
.1	420,940	
.2	421,280	
.3	421,620	
.4	421,960	
.5	422,300	
.6	422,640	
.7	422,980	
.8	423,320	
.9	423,660	340
1560.0	424,000	

El. in ft.	Capacity	Diff.
1560.0	424,000	340
.1	424,340	
.2	424,680	
.3	425,020	
.4	425,360	
.5	425,700	
.6	426,040	
.7	426,380	
.8	426,720	
.9	427,060	
1561.0	427,400	
.1	427,740	
.2	428,080	
.3	428,420	
.4	428,760	
.5	429,100	
.6	429,440	
.7	429,780	
.8	430,120	
.9	430,460	
1562.0	430,800	
.1	431,140	
.2	431,480	
.3	431,820	
.4	432,160	
.5	432,500	
.6	432,840	
.7	433,180	
.8	433,520	
.9	433,860	
1563.0	434,200	
.1	434,540	
.2	434,880	
.3	435,220	
.4	435,560	
.5	435,900	
.6	436,240	
.7	436,580	
.8	436,920	
.9	437,260	
1564.0	437,600	
.1	437,940	
.2	438,280	
.3	438,620	
.4	438,960	
.5	439,300	
.6	439,640	
.7	439,980	
.8	440,320	
.9	440,660	340
1565.0	441,000	

El. in ft.	Capacity	Diff.
1565.0	441,000	340
.1	441,340	
.2	441,680	
.3	442,020	
.4	442,360	
.5	442,700	
.6	443,040	
.7	443,380	
.8	443,720	
.9	444,060	340
1566.0	444,400	350
.1	444,750	
.2	445,100	
.3	445,450	
.4	445,800	
.5	446,150	
.6	446,500	
.7	446,850	
.8	447,200	
.9	447,550	
1567.0	447,900	
.1	448,250	
.2	448,600	
.3	448,950	
.4	449,300	
.5	449,650	
.6	450,000	
.7	450,350	
.8	450,700	
.9	451,050	
1568.0	451,400	
.1	451,750	
.2	452,100	
.3	452,450	
.4	452,800	
.5	453,150	
.6	453,500	
.7	453,850	
.8	454,200	
.9	454,550	
1569.0	454,900	
.1	455,250	
.2	455,600	
.3	455,950	
.4	456,300	
.5	456,650	
.6	457,000	
.7	457,350	
.8	457,700	
.9	458,050	350
1570.0	458,400	

El. in ft.	Capacity	Diff.
1570.0	458,400	360
.1	458,760	
.2	459,120	
.3	459,480	
.4	459,840	
.5	460,200	
.6	460,560	
.7	460,920	
.8	461,280	
.9	461,640	
1571.0	462,000	
.1	462,360	
.2	462,720	
.3	463,080	
.4	463,440	
.5	463,800	
.6	464,160	
.7	464,520	
.8	464,880	
.9	465,240	
1572.0	465,600	
.1	465,960	
.2	466,320	
.3	466,680	
.4	467,040	
.5	467,400	
.6	467,760	
.7	468,120	
.8	468,480	
.9	468,840	
1573.0	469,200	
.1	469,560	
.2	469,920	
.3	470,280	
.4	470,640	
.5	471,000	
.6	471,360	
.7	471,720	
.8	472,080	
.9	472,440	
1574.0	472,800	
.1	473,160	
.2	473,520	
.3	473,880	
.4	474,240	
.5	474,600	
.6	474,960	
.7	475,320	
.8	475,680	
.9	476,040	360
1575.0	476,400	

Remarks:

Minimum Power Pool 1425.0 feet
Minimum Flood Control Pool 1450.0 feet
Spillway Crest 1541.0 feet

Maximum Conservation Pool 1563.5 feet
Normal Flood Control Pool 1569.0 feet
Maximum Pool 1574.0 feet

Compiled by C.R.M.
Checked by M.L.
Date 28 Feb. 1952

TABLE 3

Upper tier service gate rating (one outlet)
Detroit Dam
Discharge in second-feet

Gate opening in feet

Pool elev. ft. m.s.l.	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5
1420	43	86	129	172	215	258	301	344	387	430	470	507	541	572	600	626	653	681	710	740	768	796	824	852	880
1422	43	86	129	173	216	260	303	346	389	433	472	511	544	577	606	633	661	689	718	748	776	804	832	861	889
1424	43	87	130	174	218	262	305	348	391	436	475	515	548	582	612	640	668	697	726	756	784	813	841	870	898
1426	43	87	131	175	219	264	307	351	394	439	479	519	552	587	618	647	675	704	734	764	792	821	850	879	907
1428	44	88	132	177	221	266	309	353	397	442	483	523	557	592	624	653	682	712	742	772	800	829	858	888	916
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1572	65	130	194	259	324	389	453	518	583	647	708	769	829	890	951	1011	1072	1133	1193	1254	1292	1330	1367	1405	1443
1574	65	130	195	260	325	390	455	520	586	650	711	772	833	894	955	1016	1077	1138	1199	1260	1298	1336	1374	1412	1450

2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	Pool elev. ft. m.s.l.
908	936	964	992	1020	1048	1076	1104	1132	1160	1188	1216	1248	1279	1310	1470	1630	1790	1960	2130	2300	2478	2650	2830	3018	3200	3380	1420
915	944	974	1001	1030	1058	1086	1115	1142	1177	1204	1231	1262	1291	1323	1485	1647	1811	1984	2157	2330	2510	2685	2868	3059	3245	3428	1422
924	953	984	1010	1040	1068	1096	1126	1158	1191	1218	1245	1276	1305	1336	1500	1664	1832	2008	2184	2360	2542	2720	2906	3100	3290	3476	1424
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970	1000	1032	1060	1090	1118	1150	1182	1214	1250	1278	1306	1339	1370	1401	1575	1749	1937	2128	2319	2510	2703	2895	3096	3306	3515	3716	1434
980	1010	1041	1070	1100	1128	1161	1193	1226	1260	1289	1319	1350	1381	1414	1590	1766	1958	2152	2346	2540	2736	2930	3134	3348	3560	3764	1436
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1016	1047	1078	1108	1138	1168	1200	1233	1266	1300	1332	1364	1397	1430	1464	1648	1832	2034	2238	2444	2650	2858	3066	3282	3508	3736	3964	1444
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1227	1262	1298	1335	1372	1411	1451	1492	1531	1570	1610	1651	1695	1741	1788	2026	2264	2503	2760	3038	3325	3631	3938	4245	4563	4897	5235	1498
1234	1269	1305	1342	1380	1419	1459	1500	1540	1580	1620	1662	1706	1752	1800	2040	2280	2520	2780	3060	3350	3660	3970	4280	4600	4940	5280	1500
1241	1276	1312	1350	1388	1427	1468	1509	1550	1590	1630	1673	1717	1764	1812	2054	2295	2538	2794	3078	3375	3685	3996	4312	4636	4980	5324	1502
1248	1284	1320	1358	1396	1436	1477	1518	1559	1600	1641	1684	1728	1775	1824	2067	2311	2557	2807	3099	3400	3711	4022	4343	4672	5020	5368	1504
1255	1291	1328	1365	1404	1444	1485	1528	1569	1610	1651	1695	1740	1787	1836	2080	2326	2575	2820	3119	3425	3736	4048	4374	4708	5060	5412	1506
1262	1298	1335	1373	1412	1453	1494	1537	1578	1620	1662	1706	1751	1798	1848	2094	2342	2594	2834	3139	3450	3762	4074	4406	4744	5100	5456	1508
1269	1306	1343	1381	1420	1461	1503	1546	1588	1630	1672	1716	1762	1810	1859	2108	2357	2612	2848	3158	3475	3788	4100	4438	4780	5140	5500	1510
1276	1313	1350	1389	1428	1469	1512	1555	1598	1640	1683	1728	1774	1822	1871	2121	2372	2630	2861	3178	3500	3813	4126	4469	4816	5178	5540	1512
1283	1320	1358	1396	1436	1478	1521	1564	1607	1650	1693	1738	1785	1833	1883	2134	2388	2649	2874	3198	3525	3838	4152	4500	4852	5216	5580	1514
1290	1328	1366	1404	1444	1486	1529	1574	1617	1660	1704	1749	1796	1845	1895	2148	2403	2667	2888	3218	3550	3864	4178	4532	4888	5254	5620	1516
1297	1335	1373	1412	1452	1495	1538	1583	1626	1670	1714	1760	1808	1856	1907	2162	2419	2685	2902	3237	3575	3890	4204	4564	4924	5292	5660	1518
1305	1342	1381	1420	1460	1503	1547	1592	1636	1680	1725	1771	1819	1868	1919	2175	2434	2704	2915	3257	3600	3915	4230	4595	4960	5330	5700	1520
1312	1350	1388	1428	1468	1511	1556	1601	1646	1690	1735	1782	1830	1880	1931	2189	2449	2722	2928	3275	3623	3942	4260	4626	4993	5365	5738	1522
1319	1357	1396	1435	1476	1520	1565	1610	1655	1700	1746	1793	1842	1891	1943	2202	2465	2740	2942	3294	3646	3968	4290	4656	5026	5401	5776	1524
1326	1364	1403	1443	1484	1528	1574	1619	1665	1710	1756	1804	1853	1903	1954	2216	2480	2759	2956	3312	3669	3994	4320	4687	5059	5436	5814	1526
1332	1372	1411	1451	1492	1537	1582	1629	1674	1720	1767	1815	1864	1915	1966	2229	2496	2777	2969	3330	3692	4021	4350	4718	5092	5472	5852	1528
1340	1379	1418	1459	1500	1545	1591	1638	1684	1730	1777	1826	1875	1926	1978	2243	2511	2796	2982	3348	3715	4048	4380	4748	5125	5507	5890	1530
1347	1386	1426	1466	1508	1553	1600	1647	1694	1740	1788	1837	1887	1938	1990	2256	2526	2814	2996	3368	3738	4074	4410	4779	5155	5537	5920	1532
1354	1394	1434	1474	1516	1562	1609	1656	1703	1750	1798	1848	1898	1950	2002	2270	2542	2832	3010	3385	3761	4100	4440	4810	5185	5567	5950	1534
1361	1401	1441	1482	1524	1570	1618	1665	1713	1760	1809	1858	1909	1961	2014	2283	2557	2851	3023	3403	3784	4127	4470	4841	5215	5597	5980	1536
1368	1408	1449	1490	1531	1579	1626	1674	1722	1770	1819	1869	1921	1973	2026	2297	2573	2869	3036	3422	3807	4154	4500	4871	5245	5627	6010	1538
1375	1415	1456	1498	1539	1587	1635	1684	1732	1780	1830	1880	1932	1984	2038	2310	2588	2888	3050	3440	3830	4180	4530	4902	5275	5657	6040	1540
1382	1423	1464	1505	1547	1596	1644	1693	1741	1790	1840	1891	1943	1996	2050	2324	2604	2906	3079	3466	3852	4204	4557	4929	5302	5685	6070	1542
1389	1430	1471	1513	1555	1604	1653	1702	1751	1800	1851	1902	1954	2008	2062	2337	2619	2924	3109	3491	3874	4229	4584	4956	5328	5714	6100	1544
1396	1437	1479	1521	1563	1612	1662	1711	1761	1810	1861	1913	1966	2019	2074	2351	2634	2943	3138	3517	3895	4253	4611	4982	5354	5742	6130	1546
1403	1445	1487	1529	1571	1621	1670	1720	1770	1820	1872	1924	1977	2031	2085	2364	2650	2961	3168	3542	3917	4278	4638	5009	5381	5770	6160	1548
1410	1452	1494	1537	1579	1629	1679	1730	1780	1830	1882	1935	1988	2042	2097	2378	2665	2979	3197	3568	3939	4302	4665	5036	5408	5798	6190	1550
1417	1459	1502	1544	1587	1638	1688	1739	1789	1840	1893	1946	2000	2054	2109	2391	2680	2998	3226	3594	3960	4326	4692	5063	5434	5827	6220	1552
1424	1467	1509	1552	1595	1646	1697	1748	1799	1850	1903	1957	2011	2066	2121	2405	2696	3016	3256	3619	3982	4351	4719	5090	5460	5855	6250	1554
1431	1474	1517	1560	1603	1654	1706	1757	1809	1860	1914	1968	2022	2077	2133	2418	2711	3034	3285	3645	4004	4375	4746	5116	5487	5883	6280	1556
1438	1481	1524	1568	1611	1662	1714	1766	1818	1870	1924	1979	2034	2089	2145	2432	2727	3053	3315	3670	4026	4400	4773	5143	5514	5912	6310	1558
1446	1489	1532	1576	1619	1671	1723	1776	1828	1880	1934	1990	2045	2101	2157	2445	2742	3071	3344	3696	4048	4424	4800	5170	5540	5940	6340	1560
1453	1496	1540	1583	1627	1680	1732	1785	1837	1890	1945	2000	2056	2112	2169	2459	2758	3090	3374	3721	4069	4447	4824	5194	5564	5965	6366	1562
1460	1503	1547	1591	1635	1688	1741	1794	1847	1900	1956	2011	2068	2124	2180	2472	2773	3108	3403	3747	4091	4469	4847	5218	5588	5991	6393	1564
1467	1511	1555	1599	1643	1696	1750	1803	1857	1910	1966	2022	2079	2136	2192	2486	2788	3126	3432	3773	4113	4492	4871	5242	5613	6016	6419	1566
1474	1518	1562	1607	1651	1705	1758	1812	1866	1920	1976	2033	2090	2147	2204	2499	2804	3145	3462	3798	4135	4515	4894	5266	5637	6042	6446	1568
1481	1525	1570	1614	1659	1713	1767	1822	1876	1930	1987	2044	2101	2159	2216	2513	2819	3163	3491	3824	4156	4538	4918	5290	5661	6067	6472	1570
1488	1533	1577	1622	1667	1722	1776	1831	1885	1940	1997	2055	2113	2170	2228	2526	2834	3182	3520	3849	4178	4560	4941	5314	5686	6092	6498	1572
1495	1540	1585	1630	1675	1730	1785	1840	1895	1950	2008	2066	2124	2182	2240	2540	2850	3200	3550	3875	4200	4583	4965	5338	5710	6118	6525	1574

Lower [illegible] service gate rating (one outlet)
Detroit Dam
Discharge in second-feet

Gate opening in feet

Pool elev. ft. m.s.l.	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0
1420	53	106	159	212	265	318	371	424	477	530	578	625	673	720	768	815	863	910	958	1005
1422	53	107	160	213	267	320	373	426	480	533	581	629	676	724	772	820	868	915	963	1011
1424	54	107	161	214	268	322	375	429	482	536	584	632	680	728	777	825	873	921	969	1017
1426	54	108	161	215	269	323	377	430	484	538	587	635	684	732	781	829	878	926	975	1023
1428	54	108	162	216	270	325	379	433	487	541	590	639	688	737	786	834	883	932	981	1030
1430	54	109	163	218	272	326	381	435	490	544	593	642	692	741	790	839	888	938	987	1036
1432	55	109	164	219	274	328	383	438	492	547	597	646	696	745	795	844	894	943	993	1042
1434	55	110	165	220	275	329	384	439	494	549	599	649	699	749	799	848	898	948	998	1048
1436	55	110	166	221	276	331	386	442	497	552	602	652	703	753	803	853	903	954	1004	1054
1438	56	111	167	222	278	333	389	444	500	555	606	656	707	757	808	858	909	959	1010	1060
1440	56	112	167	223	279	335	391	446	502	558	609	660	710	761	812	863	914	964	1015	1066
1442	56	112	168	224	280	336	392	448	504	560	611	662	714	765	816	867	918	970	1021	1072
1444	56	113	169	225	282	338	394	450	507	563	615	666	718	769	821	873	924	976	1027	1079
1446	57	113	170	226	283	340	396	453	509	566	618	670	722	774	826	877	929	981	1033	1085
1448	57	114	171	227	285	341	398	455	512	569	621	673	726	778	830	882	934	987	1039	1091
1450	57	114	171	228	286	343	400	457	514	571	624	676	729	781	834	887	939	992	1044	1097
1452	57	115	172	230	287	344	402	459	517	574	627	680	733	786	839	891	944	997	1050	1103
1454	58	115	173	231	289	346	404	462	519	577	630	683	737	790	843	896	949	1003	1056	1109
1456	58	116	174	232	290	347	405	463	521	579	633	686	740	793	847	901	954	1008	1061	1115
1458	58	116	175	233	291	349	407	466	524	582	636	690	744	798	852	905	959	1013	1067	1121
1460	59	117	176	234	293	351	410	468	527	585	639	694	748	802	857	911	965	1019	1074	1128
1462	59	118	176	235	294	353	412	470	529	588	643	697	752	806	861	916	970	1025	1079	1134
1464	59	118	177	236	295	354	413	472	531	590	645	700	755	810	865	920	975	1030	1085	1140
1466	59	119	178	237	297	356	415	474	534	593	648	704	759	814	870	925	980	1035	1091	1146
1468	60	119	179	238	298	358	417	477	536	596	652	707	763	818	874	930	985	1041	1096	1152
1470	60	120	180	240	300	359	419	479	539	599	655	711	767	823	879	934	990	1046	1102	1158
1472	60	120	181	241	301	361	421	482	542	602	658	714	771	827	883	939	995	1052	1108	1164
1474	60	121	181	242	302	362	423	483	544	604	661	717	774	830	887	944	1000	1057	1113	1170
1476	61	121	182	243	304	364	425	486	546	607	664	721	778	835	892	949	1006	1063	1120	1177
1478	61	122	183	244	305	366	427	488	549	610	667	725	782	839	897	954	1011	1068	1126	1183
1480	61	123	184	245	307	368	429	490	552	613	671	728	786	843	901	959	1016	1074	1131	1189
1482	62	123	185	246	308	369	431	492	554	615	673	731	789	847	905	963	1021	1079	1137	1195
1484	62	124	185	247	309	371	433	494	556	618	676	735	793	851	910	968	1026	1084	1143	1201
1486	62	124	186	248	311	373	435	497	559	621	680	738	797	855	914	973	1031	1090	1148	1207
1488	62	125	187	249	312	374	437	499	562	624	683	742	801	860	919	977	1036	1095	1154	1213
1490	63	125	188	250	313	376	438	501	563	626	685	745	804	863	923	982	1041	1100	1160	1219
1492	63	126	189	252	315	377	440	503	566	629	689	748	808	868	928	987	1047	1107	1166	1226
1494	63	126	190	253	316	379	442	506	569	632	692	752	812	872	932	992	1052	1112	1172	1232
1496	64	127	191	254	318	381	445	508	572	635	695	756	816	876	937	997	1057	1117	1178	1238
1498	64	127	191	255	319	382	446	510	573	637	698	758	819	880	941	1001	1062	1123	1183	1244
1500	64	128	192	256	320	384	448	512	576	640	701	762	823	884	945	1006	1067	1128	1189	1250
1502	64	129	193	257	322	386	450	514	579	643	704	766	827	888	950	1011	1072	1133	1105	1256
1504	65	129	194	258	323	388	452	517	581	646	708	769	831	892	954	1016	1077	1139	1200	1262
1506	65	130	195	260	325	389	454	519	584	649	711	773	835	897	959	1021	1083	1145	1207	1269
1508	65	130	196	261	326	391	456	522	587	652	714	777	839	901	964	1026	1088	1150	1213	1275
1510	66	131	197	262	328	393	459	524	590	655	718	780	843	905	968	1031	1093	1156	1218	1281
1512	66	132	197	263	329	395	461	526	592	658	721	784	847	910	973	1035	1098	1161	1224	1287
1514	66	132	198	264	331	397	463	529	595	661	724	788	851	914	978	1041	1104	1167	1231	1294
1516	66	133	199	266	332	398	465	531	598	664	728	791	855	918	982	1046	1109	1173	1236	1300
1518	67	133	200	267	334	400	467	534	600	667	731	795	859	923	987	1050	1114	1178	1242	1306
1520	67	134	201	268	335	402	469	536	603	670	734	798	863	927	991	1055	1119	1184	1248	1312
1522	67	135	202	269	337	404	471	538	606	673	738	802	867	931	996	1060	1125	1189	1254	1318
1524	68	135	203	270	338	406	473	541	608	676	741	806	871	936	1001	1065	1130	1195	1260	1325
1526	68	136	204	272	340	407	475	543	611	679	744	809	875	940	1005	1070	1135	1201	1266	1331
1528	68	136	205	273	341	409	477	546	614	682	748	813	879	944	1010	1075	1141	1206	1272	1337
1530	69	137	206	274	343	411	480	548	617	685	751	817	882	948	1014	1080	1146	1211	1277	1343
1532	69	138	206	275	344	413	482	550	619	688	754	820	886	952	1019	1085	1151	1217	1283	1349
1534	69	138	207	276	345	414	483	552	621	690	757	823	890	956	1023	1090	1156	1223	1289	1356
1536	69	139	208	277	347	416	485	554	624	693	760	827	894	961	1028	1094	1161	1228	1295	1362
1538	70	139	209	278	348	418	487	557	626	696	763	830	898	965	1032	1099	1166	1234	1301	1368
1540	70	140	210	280	350	419	489	559	629	699	767	834	902	969	1037	1104	1172	1239	1307	1374
1542	70	140	211	281	351	421	491	562	632	702	770	838	906	974	1042	1109	1177	1245	1313	1381
1544	71	141	212	282	352	423	494	564	635	705	773	841	910	978	1046	1114	1182	1251	1319	1387
1546	71	142	212	283	354	425	496	566	637	708	777	845	914	982	1051	1119	1188	1256	1325	1393
1548	71	142	213	284	356	427	498	569	640	711	780	849	917	986	1055	1124	1193	1261	1330	1399
1550	71	143	214	286	357	428	500	571	643	714	783	852	921	990	1060	1129	1198	1267	1336	1405
1552	72	143	215	287	359	430	502	574	645	717	787	856	926	995	1065	1134	1204	1273	1343	1412
1554	72	144	216	288	360	432	504	576	648	720	790	860	929	999	1069	1139	1209	1278	1348	1418
1556	72	145	217	289	362	434	506	578	651	723	793	863	933	1003	1074	1144	1214	1284	1354	1424
1558	73	145	218	290	363	436	508	581	653	726	796	867	937	1008	1078	1148	1219	1289	1360	1430
1560	73	146	219	292	365	437	510	583	656	729	800	870	941	1012	1083	1153	1224	1295	1365	1436
1562	73	146	220	293	366	439	512	586	659	732	803	874	945	1016	1088	1159	1230	1301	1372	1443
1564	74	147	221	294	368	441	515	588	662	735	806	878	949	1021	1092	1163	1235	1306	1378	1449
1566	74	148	221	295	369	443	517	590	664	738	810	881	953	1025	1097	1168	1240	1312	1383	1455
1568	74	148	222	296	371	445	519	593	667	741	813	885	957	1029	1101	1173	1245	1317	1389	1461
1570	74	149	223	298	372	446	521	595	670	744	816	889	961	1034	1106	1178	1251	1323	1396	1468
1572	75	149	224	299	374	448	523	598	672	747	820	892	965	1038	1111	1183	1256	1329	1401	1474
1574	75	150	225	300	375	450	525	600	675	750	823	896	969	1042	1115	1188	1261	1334	1407	1480

Pool elev. ft. m.s.l.	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9
1420	1037	1069	1101	1133	1165	1202	1239	1276	1313	1350	1393	1436	1479	1522	1565	1607	1649	1691	1733
1422	1043	1076	1108	1140	1173	1210	1247	1284	1321	1358	1402	1445	1489	1532	1575	1617	1660	1702	1744
1424	1050	1082	1115	1148	1180	1218	1255	1292	1330	1367	1411	1454	1498	1542	1585	1628	1671	1713	1756
1426	1056	1089	1122	1155	1188	1225	1263	1301	1338	1378	1420	1464	1508	1551	1595	1638	1681	1724	1767
1428	1063	1096	1129	1162	1195	1233	1271	1309	1346	1384	1428	1473	1517	1561	1605	1649	1692	1735	1778
1430	1069	1102	1136	1170	1203	1241	1279	1317	1355	1393	1437	1482	1527	1571	1616	1659	1703	1746	1790
1432	1076	1109	1143	1177	1211	1249	1287	1325	1363	1401	1446	1491	1536	1581	1626	1670	1714	1757	1801
1434	1082	1116	1150	1184	1218	1257	1295	1333	1372	1410	1455	1500	1546	1591	1636	1680	1724	1768	1813
1436	1088	1123	1157	1192	1226	1265	1303	1342	1380	1418	1464	1510	1555	1601	1646	1691	1735	1779	1824
1438	1095	1129	1164	1199	1234	1272	1311	1350	1388	1427	1473	1519	1565	1610	1656	1701	1746	1790	1835
1440	1101	1136	1171	1206	1241	1280	1319	1358	1397	1436	1482	1528	1574	1620	1666	1712	1757	1802	1847
1442	1108	1143	1178	1214	1249	1288	1327	1366	1405	1444	1491	1537	1584	1630	1676	1722	1767	1813	1858
1444	1114	1150	1185	1221	1256	1296	1335	1374	1413	1453	1500	1546	1593	1640	1687	1732	1778	1824	1869
1446	1120	1156	1192	1228	1264	1304	1343	1383	1422	1461	1508	1556	1603	1650	1697	1743	1789	1835	1881
1448	1127	1163	1199	1235	1272	1312	1351	1391	1430	1470	1517	1565	1612	1659	1707	1753	1800	1846	1892
1450	1133	1170	1206	1243	1279	1319	1359	1399	1438	1478	1526	1574	1622	1669	1717	1764	1811	1857	1904
1452	1140	1177	1213	1250	1287	1327	1367	1407	1447	1487	1535	1583	1631	1679	1727	1774	1821	1868	1915
1454	1146	1183	1220	1257	1295	1335	1375	1415	1455	1496	1544	1592	1641	1689	1737	1785	1832	1879	1926
1456	1153	1190	1227	1265	1302	1343	1383	1424	1464	1504	1553	1602	1650	1699	1748	1795	1843	1890	1938
1458	1159	1197	1234	1272	1310	1351	1391	1432	1472	1513	1562	1611	1660	1709	1758	1806	1854	1901	1949
1460	1165	1203	1241	1279	1317	1359	1399	1440	1480	1521	1571	1620	1669	1718	1768	1816	1864	1912	1960
1462	1172	1210	1248	1287	1325	1366	1407	1448	1489	1530	1580	1629	1678	1728	1778	1826	1875	1923	1972
1464	1178	1217	1255	1294	1332	1374	1415	1456	1497	1538	1588	1638	1688	1738	1788	1837	1886	1934	1983
1466	1185	1224	1262	1301	1340	1382	1423	1465	1506	1547	1597	1648	1698	1748	1798	1847	1897	1945	1995
1468	1191	1230	1269	1309	1348	1390	1431	1473	1514	1556	1606	1657	1707	1758	1808	1858	1907	1956	2006
1470	1198	1237	1277	1316	1356	1398	1439	1481	1522	1564	1615	1666	1717	1768	1819	1868	1918	1968	2017
1472	1204	1244	1284	1323	1363	1406	1447	1489	1531	1573	1624	1675	1726	1777	1829	1879	1929	1979	2029
1474	1211	1250	1291	1331	1370	1413	1455	1497	1539	1581	1633	1684	1736	1787	1839	1889	1940	1990	2040
1476	1217	1257	1296	1338	1378	1421	1463	1506	1547	1590	1642	1694	1745	1797	1849	1900	1951	2001	2051
1478	1223	1264	1305	1345	1386	1429	1471	1514	1556	1598	1651	1703	1755	1807	1859	1910	1961	2012	2063
1480	1230	1271	1312	1353	1394	1437	1479	1522	1564	1607	1660	1712	1764	1817	1869	1921	1972	2023	2074
1482	1236	1277	1319	1360	1401	1445	1487	1530	1572	1616	1668	1721	1	1826	1879	1931	1983	2034	2085
1484	1242	1284	1326	1367	1409	1453	1495	1538	1581	1624	1677	1730	1	1836	1889	1941	1994	2045	2097
1486	1249	1291	1333	1375	1416	1460	1503	1547	1589	1633	1686	1740	1	1846	1900	1952	2004	2056	2108
1488	1255	1297	1340	1382	1424	1468	1511	1555	1598	1641	1695	1749	1	1856	1910	1962	2015	2067	2120
1490	1262	1304	1347	1389	1432	1476	1519	1563	1606	1650	1704	1758	1	1866	1920	1973	2026	2078	2131
1492	1268	1311	1354	1397	1439	1483	1526	1570	1613	1657	1712	1766	181	1874	1928	1982	2035	2087	2140
1494	1275	1318	1361	1403	1447	1490	1533	1577	1621	1665	1719	1774	182	1882	1937	1991	2044	2097	2150
1496	1281	1324	1368	1411	1455	1497	1540	1585	1628	1672	1727	1781	183	1891	1945	2000	2053	2106	2160
1498	1287	1331	1375	1418	1462	1503	1547	1592	1635	1679	1734	1789	184	1899	1954	2009	2062	2115	2169
1500	1294	1338	1382	1426	1470	1511	1554	1599	1642	1687	1742	1797	185	1907	1962	2017	2071	2125	2178
1502	1300	1344	1389	1433	1477	1518	1561	1606	1650	1694	1750	1805	1860	1915	1971	2026	2080	2134	2188
1504	1306	1351	1395	1440	1484	1525	1568	1613	1657	1702	1757	1813	1868	1924	1979	2035	2089	2143	2198
1506	1313	1357	1402	1446	1490	1532	1576	1620	1664	1709	1765	1820	1876	1932	1988	2044	2098	2153	2207
1508	1319	1364	1408	1453	1497	1539	1583	1628	1672	1716	1772	1828	1884	1940	1996	2052	2107	2162	2217
1510	1326	1370	1415	1459	1504	1546	1590	1635	1679	1724	1780	1836	1892	1948	2005	2061	2116	2171	2226
1512	1332	1377	1421	1466	1511	1553	1597	1642	1686	1731	1788	1844	1900	1957	2013	2070	2125	2181	2236
1514	1339	1383	1428	1472	1517	1560	1604	1649	1693	1739	1795	1852	1908	1965	2021	2079	2134	2190	2245
1516	1345	1390	1434	1479	1524	1567	1611	1656	1701	1746	1803	1860	1916	1973	2030	2088	2143	2199	2255
1518	1351	1396	1441	1486	1531	1574	1618	1663	1708	1753	1810	1867	1924	1981	2038	2097	2153	2209	2265
1520	1357	1402	1448	1493	1538	1581	1625	1671	1715	1761	1818	1875	1932	1990	2047	2105	2162	2218	2274
1522	1363	1408	1454	1499	1544	1587	1632	1678	1723	1768	1826	1883	1940	1998	2055	2114	2171	2227	2283
1524	1370	1415	1461	1506	1551	1594	1639	1685	1730	1775	1833	1891	1948	2006	2064	2123	2180	2237	2293
1526	1376	1422	1467	1513	1558	1601	1646	1692	1737	1783	1841	1899	1956	2014	2072	2132	2189	2246	2303
1528	1383	1428	1474	1519	1565	1608	1653	1699	1745	1790	1848	1906	1964	2023	2081	2141	2198	2255	2312
1530	1389	1434	1480	1525	1571	1615	1660	1706	1752	1798	1856	1914	1972	2031	2089	2150	2207	2265	2322
1532	1395	1441	1486	1532	1578	1622	1667	1714	1759	1805	1864	1922	1980	2039	2097	2158	2216	2274	2332
1534	1402	1448	1493	1539	1585	1629	1675	1721	1766	1812	1871	1930	1988	2047	2106	2167	2225	2283	2341
1536	1408	1454	1500	1546	1592	1636	1682	1728	1774	1820	1879	1938	1996	2056	2114	2176	2234	2293	2351
1538	1414	1460	1506	1552	1598	1643	1689	1735	1781	1827	1886	1945	2004	2064	2123	2185	2243	2302	2360
1540	1420	1466	1513	1559	1605	1650	1696	1742	1788	1835	1894	1953	2013	2072	2031	2194	2252	2311	2370
1542	1427	1473	1520	1566	1612	1657	1703	1749	1796	1842	1902	1961	2021	2080	2040	2202	2261	2321	2379
1544	1433	1480	1526	1573	1619	1664	1710	1757	1803	1849	1909	1969	2029	2088	2148	2211	2270	2330	2389
1546	1439	1486	1532	1579	1625	1671	1717	1764	1810	1857	1917	1977	2037	2097	2157	2220	2280	2339	2399
1548	1446	1492	1539	1585	1632	1678	1724	1771	1817	1864	1924	1984	2045	2105	2165	2229	2289	2349	2408
1550	1452	1499	1545	1592	1639	1685	1731	1778	1825	1871	1932	1992	2053	2113	2174	2238	2298	2358	2418
1552	1459	1506	1552	1599	1646	1692	1738	1785	1832	1879	1940	2000	2061	2121	2182	2247	2307	2367	2427
1554	1465	1512	1559	1606	1653	1699	1745	1792	1839	1886	1947	2008	2069	2130	2190	2256	2316	2377	2437
1556	1471	1518	1565	1612	1659	1706	1752	1800	1847	1894	1955	2016	2077	2138	2199	2264	2325	2386	2446
1558	1477	1524	1572	1619	1666	1713	1759	1807	1854	1901	1962	2024	2085	2146	2207	2273	2334	2395	2456
1560	1483	1531	1578	1626	1673	1720	1766	1814	1861	1908	1970	2031	2093	2154	2216	2282	2343	2405	2466
1562	1490	1538	1585	1633	1680	1726	1774	1821	1868	1916	1978	2039	2101	2163	2224	2291	2352	2414	2475
1564	1496	1544	1591	1639	1686	1733	1781	1828	1876	1923	1985	2047	2109	2170	2233	2300	2361	2423	2485
1566	1503	1550	1598	1645	1693	1740	1788	1835	1883	1930	1993	2055	2117	2179	2241	2309	2370	2433	2494
1568	1509	1557	1604	1652	1700	1747	1795	1843	1890	1938	2000	2063	2125	2187	2250	2317	2379	2442	2504
1570	1516	1564	1611	1659	1707	1754	1802	1850	1898	1945	2008	2070	2133	2196	2258	2326	2388	2451	2513
1572	1522	570	1617	1665	1713	1761	1809	1857	1905	1953	2016	2078	2141	2204	2266	2335	2397	2461	2523
1574	1528	576	1624	1672	1720	1768	1816	1864	1912	1960	2023	2086	2149	2212	2275	2344	2407	2470	2533

Pool elev. ft. m.s.l.	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	Pool elev. ft. m.s.l.
1420	1775	2000	2230	2475	2720	2995	3270	3555	3840	4160	4480	4820	5160	1420
1422	1787	2014	2246	2492	2739	3017	3295	3583	3871	4192	4517	4860	5202	1422
1424	1799	2027	2262	2509	2757	3039	3321	3611	3901	4225	4554	4899	5244	1424
1426	1811	2041	2277	2527	2776	3061	3346	3639	3932	4257	4591	4939	5286	1426
1428	1823	2054	2293	2544	2795	3083	3371	3667	3963	4290	4628	4978	5328	1428
1430	1835	2068	2309	2561	2813	3105	3396	3695	3993	4322	4665	5018	5370	1430
1432	1847	2082	2325	2578	2832	3127	3422	3723	4024	4355	4702	5057	5412	1432
1434	1859	2095	2341	2595	2851	3149	3447	3751	4055	4387	4739	5097	5454	1434
1436	1871	2109	2356	2613	2869	3171	3472	3778	4085	4420	4776	5136	5496	1436
1438	1883	2122	2372	2630	2888	3193	3497	3806	4116	4452	4813	5176	5538	1438
1440	1895	2136	2388	2647	2907	3215	3523	3834	4147	4485	4850	5215	5580	1440
1442	1907	2150	2404	2664	2925	3237	3548	3862	4177	4517	4881	5250	5620	1442
1444	1919	2163	2420	2681	2944	3259	3573	3890	4208	4550	4912	5285	5659	1444
1446	1931	2177	2435	2699	2963	3281	3598	3918	4239	4582	4943	5321	5698	1446
1448	1943	2190	2451	2716	2981	3303	3624	3946	4269	4615	4974	5356	5738	1448
1450	1955	2204	2467	2733	3000	3325	3649	3974	4300	4647	5005	5391	5778	1450
1452	1967	18	2483	2749	3018	3345	3674	4002	4329	4677	5036	5426	5817	1452
1454	1979	31	2499	2765	3035	3365	3699	4029	4358	4706	5067	5461	5856	1454
1456	1991	45	2514	2781	3053	3385	3725	4056	4387	4736	5098	5497	5896	1456
1458	2003	58	2530	2796	3070	3405	3750	4083	4416	4765	5129	5532	5936	1458
1460	2015	72	2546	2812	3088	3425	3775	4110	4445	4795	5160	5567	5975	1460
1462	2027	2286	2562	2828	3105	3445	3800	4137	4474	4824	5190	5599	6008	1462
1464	2039	2299	2578	2844	3123	3465	3825	4164	4503	4854	5221	5630	6040	1464
1466	2051	2313	2593	2860	3140	3485	3850	4191	4532	4883	5252	5662	6072	1466
1468	2063	2326	2609	2876	3158	3505	3875	4218	4561	4913	5282	5693	6105	1468
1470	2075	2340	2625	2891	3175	3525	3900	4245	4590	4942	5312	5725	6138	1470
1472	2086	2353	2639	2907	3193	3545	3920	4268	4615	4972	5343	5756	6170	1472
1474	2097	2366	2653	2923	3210	3565	3940	4290	4640	5001	5374	5788	6202	1474
1476	2108	2379	2666	2939	3228	3585	3960	4313	4665	5031	5404	5819	6235	1476
1478	2119	2392	2680	2955	3245	3605	3980	4335	4690	5060	5434	5851	6268	1478
1480	2130	2405	2694	2971	3263	3625	4000	4358	4715	5090	5465	5882	6300	1480
1482	2140	2418	2708	2986	3280	3645	4020	43	4740	5115	5494	5911	6329	1482
1484	2151	2431	2722	3002	3298	3665	4040	44	4765	5140	5522	5940	6358	1484
1486	2162	2444	2735	3018	3315	3685	4060	44	4790	5165	5550	5969	6387	1486
1488	2173	2457	2749	3034	3333	3705	4080	44	4815	5190	5579	5997	6416	1488
1490	2184	2470	2763	3050	3350	3725	4100	44	4840	5216	5608	6026	6445	1490
1492	2195	2483	2777	3066	3366	3742	4119	4490	4863	5241	5636	6055	6474	1492
1494	2206	2496	2791	3081	3381	3760	4138	4510	4886	5266	5664	6084	6503	1494
1496	2217	2509	2804	3097	3397	3778	4157	4530	4909	5291	5693	6112	6532	1496
1498	2228	2522	2818	3113	3413	3795	4176	4550	4932	5316	5722	6141	6561	1498
1500	2239	2535	2832	3129	3428	3812	4195	4570	4955	5341	5750	6170	6590	1500
1502	2249	2548	2853	3144	3444	3829	4214	4590	4978	5366	5773	6194	6616	1502
1504	2260	2561	2866	3159	3460	3846	4233	4610	5001	5392	5796	6218	6641	1504
1506	2271	2574	2880	3174	3475	3863	4252	4630	5024	5417	5819	6243	6667	1506
1508	2282	2587	2893	3188	3491	3881	4271	4650	5047	5442	5842	6267	6693	1508
1510	2293	2600	2907	3203	3507	3898	4290	4670	5070	5467	5865	6291	6718	1510
1512	2304	2612	2920	3218	3522	3914	4307	4689	5090	5489	5888	6315	6744	1512
1514	2315	2625	2934	3233	3538	3931	4324	4708	5111	5511	5911	6339	6770	1514
1516	2326	2637	2947	3248	3554	3947	4340	4727	5131	5532	5934	6364	6795	1516
1518	2337	2649	2961	3263	3569	3963	4357	4746	5151	5554	5957	6388	6821	1518
1520	2348	2661	2975	3278	3585	3979	4374	4765	5171	5576	5980	6412	6847	1520
1522	2358	2674	2988	3292	3601	3996	4390	4784	5192	5597	6002	6436	6872	1522
1524	2369	2686	3002	3307	3616	4012	4407	4803	5212	5618	6024	6460	6898	1524
1526	2380	2698	3015	3322	3632	4028	4424	4822	5232	5639	6046	6485	6924	1526
1528	2391	2710	3029	3337	3648	4044	4441	4841	5252	5660	6068	6509	6949	1528
1530	2402	2723	3042	3352	3663	4061	4458	4860	5273	5682	6090	6533	6975	1530
1532	2413	2735	3056	3367	3679	4077	4474	4879	5293	5703	6112	6555	6998	1532
1534	2424	2747	3069	3381	3695	4093	4491	4898	5313	5724	6134	6576	7021	1534
1536	2435	2760	3083	3396	3710	4109	4508	4917	5333	5745	6156	6598	7044	1536
1538	2446	2772	3096	3411	3726	4126	4525	4936	5354	5765	6178	6620	7067	1538
1540	2457	2784	3110	3426	3742	4142	4541	4955	5374	5787	6200	6641	7090	1540
1542	2467	2794	3121	3439	3757	4158	4558	4974	5394	5806	6220	6663	7113	1542
1544	2480	2804	3132	3452	3773	4174	4575	4993	5414	5826	6240	6685	7136	1544
1546	2489	2813	3144	3466	3788	4191	4592	5012	5435	5845	6260	6706	7159	1546
1548	2499	2823	3155	3479	3804	4207	4608	5031	5455	5864	6280	6728	7182	1548
1550	2508	2833	3166	3492	3820	4223	4625	5050	5475	5883	6300	6750	7205	1550
1552	2517	2843	3177	3505	3835	4238	4640	5067	5493	5903	6320	6771	7227	1552
1554	2527	2852	3188	3518	3850	4253	4656	5083	5511	5922	6340	6793	7250	1554
1556	2536	2862	3199	3531	3865	4269	4671	5100	5529	5941	6360	6815	7273	1556
1558	2545	2872	3211	3545	3880	4284	4687	5117	5547	5961	6380	6837	7296	1558
1560	2554	2882	3222	3558	3895	4299	4702	5133	5565	5980	6400	6858	7319	1560
1562	2564	289	3233	3571	3910	4314	4718	5150	5582	5999	6420	6880	7342	1562
1564	2573	290	3244	3584	3925	4329	4733	5167	5600	6018	6440	6902	7365	1564
1566	2582	291	3255	3597	3940	4344	4748	5183	5618	6038	6460	6923	7388	1566
1568	2592	292	3267	3611	3955	4360	4764	5200	5636	6057	6480	6945	7411	1568
1570	2601	293	3278	3624	3970	4375	4779	5217	5654	6076	6500	6967	7434	1570
1572	2610	2940	3289	3637	3985	4390	4795	5233	5672	6096	6520	6988	7457	1572
1574	2620	2950	3300	3650	4000	4405	4810	5250	5690	6115	6540	7010	7480	1574

TABLE 6

Spillway Gate Rating
Detroit Dam

Elev., feet	Discharge in second-feet for one radial gate - gate openings in feet															Free overflow	
	(1)	(2)	(3)	(4)	(6)	(8)	(10)	(12)	(14)	(16)	(18)	(20)	(22)	(24)	(25)	1 bay	6 bays
1,542	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	1,080
1,543	290	420	420	420	420	420	420	420	420	420	420	420	420	420	420	420	2,520
1,544	340	630	720	720	720	720	720	720	720	720	720	720	720	720	720	720	4,320
1,545	390	730	1,070	1,080	1,080	1,080	1,080	1,080	1,080	1,080	1,080	1,080	1,080	1,080	1,080	1,080	6,480
1,546	440	820	1,180	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	9,000
1,547	480	910	1,290	1,720	1,980	1,980	1,980	1,980	1,980	1,980	1,980	1,980	1,980	1,980	1,980	1,980	11,880
1,548	520	990	1,400	1,880	2,520	2,520	2,520	2,520	2,520	2,520	2,520	2,520	2,520	2,520	2,520	2,520	15,120
1,549	560	1,060	1,510	2,030	2,970	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	3,120	18,720
1,550	590	1,120	1,610	2,170	3,190	3,780	3,780	3,780	3,780	3,780	3,780	3,780	3,780	3,780	3,780	3,780	22,680
1,551	620	1,170	1,710	2,300	3,410	4,520	4,520	4,520	4,520	4,520	4,520	4,520	4,520	4,520	4,520	4,520	27,120
1,552	650	1,220	1,810	2,420	3,620	4,800	5,320	5,320	5,320	5,320	5,320	5,320	5,320	5,320	5,320	5,320	31,920
1,553	680	1,270	1,900	2,540	3,820	5,010	6,170	6,170	6,170	6,170	6,170	6,170	6,170	6,170	6,170	6,170	37,020
1,554	700	1,320	1,990	2,650	4,010	5,220	6,680	7,070	7,070	7,070	7,070	7,070	7,070	7,070	7,070	7,070	42,420
1,555	720	1,370	2,070	2,760	4,190	5,440	6,880	8,010	8,010	8,010	8,010	8,010	8,010	8,010	8,010	8,010	48,060
1,556	740	1,420	2,150	2,860	4,360	5,660	7,090	8,980	8,980	8,980	8,980	8,980	8,980	8,980	8,980	8,980	53,880
1,557	760	1,470	2,220	2,960	4,520	5,880	7,300	9,130	9,970	9,970	9,970	9,970	9,970	9,970	9,970	9,970	59,820
1,558	780	1,520	2,290	3,060	4,670	6,100	7,520	9,320	10,970	10,970	10,970	10,970	10,970	10,970	10,970	10,970	65,820
1,559	800	1,560	2,360	3,160	4.810	6,310	7,740	9,520	11,600	11,990	11,990	11,990	11,990	11,990	11,990	11,990	71,940
1,560	820	1,600	2,430	3,250	4,950	6,510	7,970	9,730	11,730	13,040	13,040	13,040	13,040	13,040	13,040	13,040	78,240
1,561	840	1,640	2,500	3,340	5,090	6,710	8,210	9,950	11,880	14,130	14,130	14,130	14,130	14,130	14,130	14,130	84,780
1,562	860	1,680	2,570	3,430	5,220	6,910	8,450	10,180	12,050	14,280	15,260	15,260	15,260	15,260	15,260	15,260	91,560
1,563	880	1,720	2,630	3,520	5,350	7,100	8,690	10,420	12,240	14,450	16,430	16,430	16,430	16,430	16,430	16,430	98,580
1,564	900	1,760	2,690	3,610	5,480	7,280	8,920	10,670	12,450	14,630	17,070	17,640	17,640	17,640	17,640	17,640	105,840
1,565	910	1,800	2,740	3,690	5,610	7,460	9,140	10,930	12,680	14,820	17,230	18,890	18,890	18,890	18,890	18,890	113,340
1,566	920	1,840	2,790	3,770	5,730	7,630	9,360	11,190	12,930	15,020	17,410	20,180	20,180	20,180	20,180	20,180	121,080
1,567	930	1,880	2,840	3,840	5,840	7,800	9,570	11,450	13,200	15,230	17,610	20,230	21,510	21,510	21,510	21,510	129,060
1,568	940	1,920	2,890	3,910	5,950	7,960	9,780	11,700	13,480	15,460	17,830	20,380	22,880	22,880	22,880	22,880	137,280
1,569	950	1,950	2,940	3,980	6,050	8,120	9,980	11,940	13,760	15,710	18,070	20,540	23,650	24,290	24,290	24,290	145,740
1,570	960	1,980	2,990	4,050	6,150	8,270	10,180	12,180	14,040	15,980	18,320	20,720	23,740	25,740	25,740	25,740	154,440
1,571	970	2,010	3,040	4,120	6,250	8,420	10,380	12,420	14,330	16,270	18,580	20,920	23,850	27,230	27,230	27,230	163,380
1,572	980	2,040	3,090	4,190	6,350	8,570	10,580	12,660	14,620	16,580	18,850	21,150	23,990	27,320	28,760	28,760	172,560
1,573	990	2,070	3,140	4,260	6,450	8,720	10,780	12,900	14,910	16,910	19,130	21,410	24,170	27,430	29,180	30,330	181,980
1,574	1,000	2,100	3,190	4,330	6,550	8,870	10,980	13,140	15,200	17,260	19,420	21,700	24,400	27,550	29,320	31,940	191,640

FREE OVERFLOW

CONTROLLED FLOW

Notes
1. Spillway crest = 1541.0 feet.
2. Maximum conservation pool = 1563.5 feet.
3. Full pool = 1569.0 feet.
4. Maximum pool = 1574.0 feet.

Compiled by: C.R.M. & O.L.W.
Checked by: W.A.M.
Date: 3 August 1953

TABLE 8

Spillway Gate Rating
Big Cliff Reregulating Dam

Elev., feet	Dischar e in second-feet for one radial gate above crest - gate opening in feet																	Free overflow	
	(1)	(2)	(3)	(4)	(6)	(8)	(10)	(12)	(14)	(16)	(18)	(20)	(22)	(24)	(26)	(28)	(30)	1 bay	3 bays
1,165.0	400	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700	2,100
1,167.5	510	1,050	1,600	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	5,400
1,170	600	1,220	1,870	2,430	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	3,100	9,300
1,172	680	1,380	2,110	2,770	3,830	4,580	4,580	4,580	4,580	4,580	4,580	4,580	4,580	4,580	4,580	4,580	4,580	4,580	13,740
1,174	760	1,530	2,320	3,070	4,280	5,310	6,220	6,220	6,220	6,220	6,220	6,220	6,220	6,220	6,220	6,220	6,220	6,220	18,660
1,176	830	1,670	2,510	3,330	4,680	6,010	7,100	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	24,000
1,178	900	1,800	2,690	3,570	5,060	6,610	7,900	9,100	9,920	9,920	9,920	9,920	9,920	9,920	9,920	9,920	9,920	9,920	29,760
1,180	960	1,920	2,860	3,790	5,420	7,110	8,600	9,900	11,300	11,980	11,980	11,980	11,980	11,980	11,980	11,980	11,980	11,980	35,940
1,182	1,020	2,030	3,020	3,990	5,760	7,560	9,200	10,650	12,200	13,700	14,180	14,180	14,180	14,180	14,180	14,180	14,180	14,180	42,540
1,184	1,070	2,130	3,170	4,180	6,080	7,960	9,760	11,350	13,000	14,600	16,520	16,520	16,520	16,520	16,520	16,520	16,520	16,520	49,560
1,186	1,120	2,220	3,310	4,360	6,380	8,340	10,280	12,000	13,800	15,500	17,200	19,000	19,000	19,000	19,000	19,000	19,000	19,000	57,000
1,188	1,160	2,310	3,440	4,530	6,670	8,700	10,770	12,600	14,500	16,300	18,000	20,000	21,620	21,620	21,620	21,620	21,620	21,620	64,860
1,190	1,200	2,390	3,560	4,690	6,950	9,050	11,230	13,180	15,200	17,100	18,900	20,800	23,200	24,380	24,380	24,380	24,380	24,380	73,140
1,192	1,240	2,470	3,680	4,850	7,210	9,390	11,670	13,740	15,900	17,900	19,800	21,600	23,900	26,700	27,280	27,280	27,280	27,280	81,840
1,194	1,280	2,550	3,790	5,000	7,450	9,720	12,090	14,280	16,500	18,600	20,600	22,500	24,700	27,400	30,320	30,320	30,320	30,320	90,960
1,196	1,320	2,620	3,900	5,150	7,680	10,040	12,500	14,800	17,100	19,300	21,400	23,400	25,500	28,100	30,800	33,500	33,500	33,500	100,500
1,198	1,360	2,690	4,000	5,300	7,900	10,350	12,900	15,300	17,700	20,000	22,200	24,300	26,400	28,900	31,500	34,700	36,820	36,820	110,460
1,200	1,390	2,760	4,100	5,440	8,110	10,650	13,290	15,780	18,300	20,700	23,000	25,200	27,400	29,800	32,300	35,300	38,600	40,280	120,840
1,202	1,420	2,830	4,200	5,580	8,310	10,940	13,670	16,240	18,900	21,300	23,700	26,000	28,300	30,700	33,100	36,000	39,100	43,880	131,640
1,204	1,450	2,900	4,300	5,710	8,510	11,220	14,040	16,680	19,400	21,900	24,400	26,800	29,200	31,600	34,000	36,700	39,700	47,620	142,860
1,206	1,480	2,970	4,400	5,840	8,700	11,490	14,400	17,110	19,900	22,500	25,100	27,600	30,100	32,500	34,900	37,500	40,400	51,500	154,500
1,208	1,510	3,030	4,490	5,970	8,890	11,750	14,750	17,540	20,400	23,100	25,800	28,400	30,900	33,400	35,900	38,400	41,100	55,520	166,560
1,210	1,540	3,090	4,580	6,100	9,070	12,000	15,090	17,960	20,900	23,700	26,400	29,100	31,600	34,200	36,800	39,400	41,900	59,670	179,000

FREE OVERFLOW (elev. 1,165.0–1,184) / CONTROLLED FLOW (elev. 1,186–1,210)

Notes:
1. Spillway crest = 1161.5 feet.
2. Full pool = 1206.0 feet.
3. Maximum pool = 1210.0 feet.

Compiled by: C.R.M. & O.L.W.
Checked by: W.A.M.
Date: 3 August 1953

TABLE 9

Seasonal Filling Schedule
Detroit Reservoir

Date	February Elevation ft. m.s.l.	February Storage acre-feet	March Elevation ft. m.s.l.	March Storage acre-feet	April Elevation ft. m.s.l.	April Storage acre-feet	May Elevation ft. m.s.l.	May Storage acre-feet
1	1452.72	159,620	1513.12	286,600	1539.40	357,810	1560.80	426,720
2	1455.36	164,240	1514.04	288,900	1540.17	360,100	1561.48	429,020
3	1457.92	168,850	1514.96	291,200	1540.93	362,400	1562.15	431,310
4	1460.48	173,470	1515.88	293,490	1541.68	364,700	1562.83	433,610
5	1463.05	178,090	1516.77	295,790	1542.42	367,000	1563.50	435,900
6	1465.62	182,710	1517.65	298,090	1543.16	369,290		
7	1468.07	187,330	1518.53	300,380	1543.90	371,590		
8	1470.49	191,940	1519.42	302,680	1544.64	373,890		
9	1472.93	196,560	1520.30	304,980	1545.37	376,180		
10	1475.29	201,180	1521.18	307,270	1546.09	378,480		
11	1477.60	205,800	1522.07	309,570	1546.81	380,780		
12	1479.91	210,420	1522.95	311,870	1547.52	383,080		
13	1482.16	215,030	1523.83	314,160	1548.24	385,370		
14	1484.36	219,650	1524.72	316,460	1548.96	387,670		
15	1486.56	224,270	1525.58	318,760	1549.68	389,970		
16	1488.68	228,890	1526.43	321,060	1550.39	392,260		
17	1490.78	233,510	1527.28	323,350	1551.11	394,560		
18	1492.87	238,120	1528.13	325,650	1551.81	396,860		
19	1494.89	242,740	1528.98	327,950	1552.50	399,150		
20	1496.90	247,360	1529.80	330,240	1553.20	401,450		
21	1498.90	251,980	1530.62	332,540	1553.89	403,750		
22	1500.88	256,600	1531.44	334,840	1554.59	406,040		
23	1502.80	261,210	1532.26	337,140	1555.28	408,340		
24	1504.72	265,830	1533.08	339,430	1555.98	410,640		
25	1506.65	270,450	1533.87	341,730	1556.68	412,940		
26	1508.51	275,070	1534.67	344,030	1557.37	415,230		
27	1510.36	279,690	1535.46	346,320	1558.07	417,530		
28	1512.20	284,300	1536.25	348,620	1558.77	419,830		
29			1537.04	350,920	1559.45	422,120		
30			1537.83	353,210	1560.12	424,420		
31			1538.62	355,510				

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. Maximum conservation pool is elevation 1563.5.
4. Exclusive power storage is between elevation 1425, minimum power pool, and elevation 1450, minimum flood-control pool. Maintain pool at 1450 or above, except as required for generation of power.

TABLE 10

9-210

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File No. Washington .... Field 5536

Rating table for North Santiam River below Boulder Creek near Detroit, Oreg., from Aug 24, 1950, to ...., 19......

Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.
.00			3.00	820	80	5.00	3250	170	7.00	7,900	300	9.00	15,300	
.10			.10	900	80	.10	3420	180	.10	8200		.10		
.20			.20	980	90	.20	3600		.20	8,500		.20		
.30			.30	1,070		.30	3780	180	.30	8,800	300	.30		
.40			.40	1,160	90	.40	3960	190	.40	9,100	350	.40		
.50			.50	1,250	100	.50	4,150	200	.50	9,450		.50		
.60			.60	1,350	100	.60	4,350	210	.60	9800		.60		
.70			.70	1,450	110	.70	4,560	220	.70	10,150		.70		
.80			.80	1,560	110	.80	4,780	230	.80	10,500		.80		
.90			.90	1,670	120	.90	5,010	240	.90	10,850		.90		
2.00	270	40	4.00	1,790	120	6.00	5,250	250	8.00	11,200		.00		
.10	310		.10	1,910	130	.10	5,500		.10	11,550	350	.10		
.20	350	40	.20	2,040	130	.20	5,750		.20	11,900	400	.20		
.30	390	50	.30	2,170	140	.30	6,000		.30	12,300		.30		
.40	440	50	.40	2,310	140	.40	6,250		.40	12,700		.40		
.50	490	60	.50	2,450	150	.50	6,500		.50	13,100		.50		
.60	550	60	.60	2,600	150	.60	6,750	250	.60	13,500		.60		
.70	610	70	.70	2,750	160	.70	7,000	300	.70	13,900	400	.70		
.80	680		.80	2,910	170	.80	7,300		.80	14,300	500	.80		
.90	750	70	.90	3,080	170	.90	7,600	300	.90	14,800	500	.90		

The above table is not applicable for ice or obstructed channel conditions. It is based on 27 discharge measurements made during 1950-51 (1,3-10), 1951-52 (11-23), 1952-53 (24-26, 28, 29)

and is .... well defined between 400 second-feet and 13,000 second-feet.

Computed by J.A.H.
Checked by BBE
Date 2-3-53

March, 1915

U. S. GOVERNMENT PRINTING OFFICE 16—63817-1

9-210

TABLE 11

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File No. Washington .... Field 5537

Rating table for Breitenbush River above Canyon Creek near Detroit, Oreg., from Aug. 29, 1950, to ...., 19....

Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.
2.00			4.00	600	55	6.00	2,300	100	8.00	4,690	140	10.00	7,850	170
.10			.10	655	60	.10	2,400	100	.10	4,830		.10	8,020	
.20			.20	715	60	.20	2,500	110	.20	4,970		.20	8,190	
.30			.30	775	65	.30	2,610		.30	5,110	140	.30	8,360	
.40			.40	840	70	.40	2,720		.40	5,250	150	.40	8,530	
.50	115	15	.50	910	75	.50	2,830		.50	5,400		.50	8,700	
.60	130	17	.60	985	80	.60	2,940		.60	5,550	150	.60	8,870	170
.70	147	18	.70	1,065	85	.70	3,050	110	.70	5,700	160	.70	9,040	180
.80	165	20	.80	1,150	90	.80	3,160	120	.80	5,860		.80	9,220	
.90	185	23	.90	1,240		.90	3,280		.90	6,020		.90	9,400	180
3.00	208	25	5.00	1,330		7.00	3,400		9.00	6,180		.00	9,580	
.10	233	28	.10	1,420		.10	3,520		.10	6,340		.10		
.20	261	30	.20	1,510	90	.20	3,640		.20	6,500	160	.20		
.30	291	33	.30	1,600	100	.30	3,760	120	.30			.30		
.40	324	36	.40	1,700		.40	3,880	130	.40	6,830		.40		
.50	360	40	.50	1,800		.50	4,010		.50	7,000		.50		
.60	400	45	.60	1,900		.60	4,140	130		7,170		.60		
.70	445	50	.70	2,000		.70	4,270	140	.70	7,340		.70		
.80	495	50	.80	2,100		.80	4,410		.80	7,510		.80		
.90	545	5.	.90	2,200	100	.90	4,550	140	.90	7,680	170	.90		

The above table is not applicable for ice or obstructed channel conditions. It is based on 27 discharge measurements made during 1951 (3, 4, 6-10) 1952 (11-18, 20-23) 1953 (24-31)

and is .... well defined between 130 second-feet and 10,000 second-feet.

Computed by DRM
Checked by J.A.H.
Date 1-28-53

March, 1915

U. S. GOVERNMENT PRINTING OFFICE 16—63817-1

9-210

Provisional

TABLE 12

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File No. Washington ....
Field 553

Rating table for North Santiam River at Niagara, Oregon

.............................., from Oct. 1, 19 52, to ...., 19.....

Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.
1.00			3.00	1,260	90	5.00	3,940	180	7.00	8,600	300	9.00	15,600	
.10			.10	1,350	100	.10	4,120	190	.10	8,900	|	.10		
.20			.20	1,450	100	.20	4,310	190	.20	9,200	|	.20		
.30			.30	1,550	110	.30	4,500	200	.30	9,500	|	.30		
.40			.40	1,660	|	.40	4,700	200	.40	9,800	|	.40		
.50			.50	1,770	110	.50	4,900	210	.50	10,100	300	.50		
.60			.60	1,880	120	.60	5,110	210	.60	10,400	350	.60		
.70	345	55	.70	2,000	|	.70	5,320	220	.70	10,750	|	.70		
.80	400	60	.80	2,120	120	.80	5,540	220	.80	11,100	|	.80		
.90	460	|	.90	2,240	130	.90	5,760	230	.90	11,450	|	.90		
2.00	520	60	4.00	2,370	130	6.00	5,990	240	8.00	11,800	|	.00		
.10	580	65	.10	2,500	140	.10	6,230	240	.10	12,150	|	.10		
.20	645	70	.20	2,640	150	.20	6,470	250	.20	12,500	|	.20		
.30	715	70	.30	2,790	150	.30	6,720	250	.30	12,850	350	.30		
.40	785	75	.40	2,940	160	.40	6,970	260	.40	13,200	400	.40		
.50	860	|	.50	3,100	|	.50	7,230	260	.50	13,600	|	.50		
.60	935	75	.60	3,260	160	.60	7,490	270	.60	14,000	|	.60		
.70	1,010	80	.70	3,420	170	.70	7,760	270	.70	14,400	|	.70		
.80	1,090	80	.80	3,590	170	.80	8,030	280	.80	14,800	|	.80		
.90	1,170	90	.90	3,760	180	.90	8,310	290	.90	15,200	400	.90		

The above table is not applicable for ice or obstructed channel conditions. It is based on 8 discharge measurements, nos. 1, 2, 4-9, made ~~during~~ Sept. 16, 1952 to Feb. 25, 1953

and is .... well defined between 3.5 second-feet and 15,000 second-feet.

Computed by D.L.W.

Checked by B.B.E.

Date 3-5-53

March 1915

U. S. GOVERNMENT PRINTING OFFICE 16—63817-1

9-210

TABLE 13

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File No. Washington .... Field 554

Rating table for North Santiam River at Mehama, Oreg.

, from Oct. 1, 1951, to , 19

Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.
1.00			3.00	2,070	140	5.00	6,200	260	7.00	13,200	450	9.00	24,000	650
.10			.10	2,210	140	.10	6,460	280	.10	13,650	|	.10	24,650	650
.20			.20	2,350	150	.20	6,740	300	.20	14,100	450	.20	25,300	700
.30			.30	2,500	160	.30	7,040	320	.30	14,550	500	.30	26,000	|
.40	430	70	.40	2,660	170	.40	7,360	320	.40	15,050	|	.40	26,700	|
.50	500	70	.50	2,830	180	.50	7,680	340	.50	15,550	|	.50	27,400	|
.60	570	80	.60	3,010	190	.60	8,020	340	.60	16,050	500	.60	28,100	|
.70	650	|	.70	3,200	190	.70	8,360	340	.70	16,550	550	.70	28,800	700
.80	730	80	.80	3,390	200	.80	8,700	350	.80	17,100	|	.80	29,500	750
.90	810	90	.90	3,590	210	.90	9,050	|	.90	17,650	|	.90	30,250	750
2.00	900	90	4.00	3,800	220	6.00	9,400	|	8.00	18,200	|	10.0	31,000	8000
.10	990	100	.10	4,020	220	.10	9,750	|	.10	18,750	|	11	39,000	8,300
.20	1,090	110	.20	4,240	230	.20	10,100	|	.20	19,300	|	12	47,300	8,500
.30	1,200	110	.30	4,470	240	.30	10,450	350	.30	19,850	550	13	55,800	8,700
.40	1,310	120	.40	4,710	240	.40	10,800	400	.40	20,400	600	14	64,500	8,800
.50	1,430	|	.50	4950	240	.50	11,200	|	.50	21,000	|	15	73,300	8,900
.60	1,550	120	.60	5,190	250	.60	11,600	|	.60	21,600	|	16	82,200	
.70	1,670	130	.70	5,440	|	.70	12,000	|	.70	22,200	|	.70		
.80	1,800	130	.80	5,690	250	.80	12,400	|	.80	22,800	|	.80		
.90	1,930	140	.90	5,940	260	.90	12,800	400	.90	23,400	600	.90		

The above table is not applicable for ice or obstructed channel conditions. It is based on 20 discharge measurements ~~made during~~ (214-233) made Apr. 23, 1951, to July 1, 1953, and is same as rating 10-15-51 below 1.7 ft and above 12 ft.

and is well defined between 430 second-feet and 20,000 second-feet.
and is fairly well defined above 20,000 second-feet.

Computed by D. L. M.
Checked by A. M. M.
Date 8-20-53

March, 1915

U. S. GOVERNMENT PRINTING OFFICE 16—63817-1

TABLE 14

9-210

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

File No. Washington ______ Field 555

Rating table for Santiam River at Jefferson, Oreg.

______, from Dec. 7, 1950, to ______, 19__

Gauge height	Discharge	Difference	Gauge height	Discharge	Difference	Gauge height	Discharge	Difference	Gauge height	Discharge	Difference	Gauge height	Discharge	Difference
Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.
2.00			4.00	2420	160	6.00	6260	240	8.00	11,600	300	10.00	18,600	400
.10	530	50	.10	2580	170	.10	6500	240	.10	11,900		.10	19,000	
.20	580	60	.20	2750	170	.20	6740	250	.20	12,200		.20	19,400	
.30	640	80	.30	2920	180	.30	6990	250	.30	12,500		.30	19,800	
.40	720	80	.40	3100		.40	7240	250	.40	12,800	300	.40	20,200	
.50	800	80	.50	3280		.50	7490	260	.50	13,100	350	.50	20,600	
.60	880	85	.60	3460		.60	7750	260	.60	13,450		.60	21,000	
.70	965	85	.70	3640	180	.70	8010	260	.70	13,800		.70	21,400	
.80	1050	90	.80	3820	190	.80	8270	270	.80	14,150		.80	21,800	
.90	1140	90	.90	4010		.90	8540		.90	14,500		.90	22,200	400
3.00	1230	100	5.00	4200		7.00	8810		9.00	14,850		11.00	22,600	450
.10	1330	100	.10	4390		.10	9080		.10	15,200		.10	23,050	
.20	1430	110	.20	4580	190	.20	9350		.20	15,550		.20	23,500	
.30	1540	110	.30	4770	200	.30	9620		.30	15,900		.30	23,950	
.40	1650	110	.40	4970	200	.40	9890	270	.40	16,250	350	.40	24,400	
.50	1760	120	.50	5170	210	.50	10,160	280	.50	16,600	400	.50	24,850	
.60	1880	120	.60	5380	210	.60	10,440	280	.60	17,000		.60	25,300	
.70	2000	130	.70	5590	220	.70	10,720	280	.70	17,400		.70	25,750	
.80	2130	140	.80	5810	220	.80	11,000	300	.80	17,800		.80	26,200	
.90	2270	150	.90	6030	230	.90	11,300	300	.90	18,200	400	.90	26,650	450
												12.0	27,100	

The above table is not applicable for ice or obstructed channel conditions. It is based on 8 discharge measurements ~~made during~~ Nos. 96-103 made Jan. 9 1951 to Nov. 9, 1951

and is ______ well defined between 580 second-feet and 140,000 second-feet.
and is same as rating 11-23-51 above 12.0 feet

Computed by DLM
Checked by B.B.E.
Date 11-24-51

March, 1915

U. S. GOVERNMENT PRINTING OFFICE 6—7347

TABLE 14

9-210

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES BRANCH

File No. Washington ____ Field 555

Rating table for Santiam River at Jefferson, Oreg.

, from Nov. 24, 1949, to ____, 19__

Gauge height	Discharge	Difference	Gauge height	Discharge	Difference	Gauge height	Discharge	Difference	Gauge height	Discharge	Difference	Gauge height	Discharge	Difference
Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.
12.00	27,100	500	14.00	38,700	700	16.00	53,500	800	18.00	70,000	900	20.00	94,100	1,600
.10	27,600		.10	39,400		.10	54,300		.10	70,900	900	.10	95,700	1,700
.20	28,100		.20	40,100		.20	55,100		.20	71,800	1,000	.20	97,400	1,800
.30	28,600		.30	40,800		.30	55,900		.30	72,800	[illegible]	.30	99,200	1,800
.40	29,100	500	.40	41,500		.40	56,700		.40	73,800	[illegible]	.40	101,000	2,000
.50	29,600	550	.50	42,200		.50	57,500		.50	74,800	1,100	.50	103,000	
.60	30,150		.60	42,900		.60	58,300		.60	75,900		.60	105,000	
.70	30,700		.70	43,600	700	.70	59,100		.70	77,000		.70	107,000	
.80	31,250		.80	44,300	750	.80	59,900		.80	78,100	1,100	.80	109,000	
.90	31,800	550	.90	45,050		.90	60,700		.90	79,200	1,200	.90	111,000	2,000
13.00	32,350	600	15.00	45,800		17.00	61,500		19.00	80,400	1,200	21.00	113,000	22,000
.10	32,950		.10	46,550		.10	62,300	800	.10	81,600	1,200	22.0	135,000	26,000
.20	33,550		.20	47,300		.20	63,100	850	.20	82,800	1,300	23.0	161,000	29,000
.30	34,150		.30	48,050		.30	63,950		.30	84,100	1,300	24.0	190,000	31,000
.40	34,750	600	.40	48,800		.40	64,800		.40	85,400	1,300	24.4	202,400	
.50	35,350	650	.50	49,550	750	.50	66,650		.50	86,700	1,400	.50		
.60	36,000	650	.60	50,300	800	.60	66,500		.60	88,100	1,400	.60		
.70	36,650	650	.70	51,100		.70	67,350	850	.70	89,500	1,500	.70		
.80	37,300	700	.80	51,900		.80	68,200	900	.80	91,000	1,500	.80		
.90	38,000	700	.90	52,700	800	.90	69,100	900	.90	92,500	1,600	.90		

The above table is not applicable for ice or obstructed channel conditions. It is based on ____ discharge measurements made during ____

and is ____ well defined between ____ second-feet and ____ second-feet.

Computed by DLM

Checked by B.B.E.

Date 11-23-51
11-24-51

Sheet 2 of 2

March, 1915

U. S. GOVERNMENT PRINTING OFFICE 6—7347

9-210

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File No. Washington ....
Field 516

Rating table for Willamette River at Salem, Oreg.

.........., from Nov. 12, 1951, to ...., 19......

Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.
0.00	16,100	400	-2.00	9,000	300	0.00	16,100	400	2.00	25,000	450	4.00	34500	500
.10	15,700		.10	8,700		.10	16,500	400	.10	25,450		.10	35,000	
.20	15,300		.20	8,400		.20	16,900	450	.20	25,900		.20	35,500	
.30	14,900		.30	8,100		.30	17,350		.30	26,350		.30	36,000	
.40	14,500		.40	7,800		.40	17,800		.40	26,800		.40	36,500	
.50	14,100	400	.50	7,500	300	.50	18,250		.50	27,250		.50	37,000	
.60	13,700	350	.60	7,200	250	.60	18,700		.60	27,700		.60	37,500	
.70	13,350		.70	6,950		.70	19,150		.70	28,150		.70	38,000	
.80	13,000		.80	6,700		.80	19,600		.80	28,600		.80	38,500	
.90	12,650		.90	6,450		.90	20,050		.90	29,050	450	.90	39,000	500
1.00	12,300		-3.00	6,200		1.00	20,500		3.00	29,500	500	5.00	39,500	550
.10	11,950		.10	5,950		.10	20,950		.10	30,000		.10	40,050	
.20	11,600		.20	5,700		.20	21,400		.20	30,500		.20	40,600	
.30	11,250		.30	5,450	250	.30	21,850		.30	31,000		.30	41,150	
.40	10,900		.40	5,200	200	.40	22,300		.40	31,500		.40	41,700	
.50	10,550	350	.50	5,000		.50	22,750		.50	32,000		.50	42,250	
.60	10,200	300	.60	4,800		.60	23,200		.60	32,500		.60	42,800	
.70	9,900		.70	4,600		.70	23,650		.70	33,000		.70	43,350	
.80	9,600		.80	4,400		.80	24,100		.80	33,500		.80	43,900	
.90	9,300	300	.90	4,200	200	.90	24,550	450	.90	34,000	500	.90	44,450	550

-4.00 4,000
-4.10 3,800
-4.20 3,600

The above table is not applicable for ice or obstructed channel conditions. It is based on 10 discharge measurements (191-200) made during Dec. 6, 1951 to Nov. 12, 1952 and shape of previous curve.

and is .... well defined between 4,000 second-feet and 130,000 second-feet.

Computed by BBE
Checked by J.A.H.
Date 9-26-52

March, 1915

1 of 2

9-210

TABLE 15

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File No. Washington .... Field 516

Rating table for Willamette River at Salem, Oreg.

........, from Nov. 12, 1951, to ...., 19....

Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.	Feet	Sec.-ft.	Sec.-ft.
6.00	45,000	550	8.00	56,500	650	10.00	70,000	700	12.00	85,000	800	14.00	101,000	9,000
.10	45,550		.10	57,150		.10	70,700		.10	85,800		15.00	110,000	10,000
.20	46,100		.20	57,800		.20	71,400		.20	86,600		16.00	120,000	
.30	46,650		.30	58,450		.30	72,100		.30	87,400		17.00	130,000	
.40	47,200		.40	59,100		.40	72,800		.40	88,200		18.00	140,000	10,000
.50	47,750		.50	59,750		.50	73,500		.50	89,000		19.00	150,000	11,000
.60	48,300		.60	60,400		.60	74,200		.60	89,800		20.00	161,000	12,000
.70	48,850		.70	61,050		.70	74,900		.70	90,600		21.00	173,000	12,000
.80	49,400		.80	61,700		.80	75,600		.80	91,400		22.00	185,000	13,000
.90	49,950	550	.90	62,350	650	.90	76,300	700	.90	92,200		23.00	198,000	13,000
7.00	50,500	600	9.00	63,000	700	11.00	77,000	800	13.00	93,000		24.00	211,000	14,000
.10	51,100		.10	63,700		.10	77,800		.10	93,800		25.00	225,000	14,000
.20	51,700		.20	64,400		.20	78,600		.20	94,600		26.00	239,000	14,000
.30	52,300		.30	65,100		.30	79,400		.30	95,400		27.00	253,000	15,000
.40	52,900		.40	65,800		.40	80,200		.40	96,200		28.00	268,000	16,000
.50	53,500		.50	66,500		.50	81,000		.50	97,000		29.00	284,000	16,000
.60	54,100		.60	67,200		.60	81,800		.60	97,800		30.00	300,000	17,000
.70	54,700		.70	67,900		.70	82,600		.70	98,600		31.00	317,000	
.80	55,300		.80	68,600		.80	83,400		.80	99,400		32.00	334,000	
.90	55,900	600	.90	69,300	700	.90	84,200	800	.90	100,200	800	33.00	351,000	17,000

The above table is not applicable for ice or obstructed channel conditions. It is based on 10 discharge measurements (191-200) made during Dec. 6, 1951 to Nov. 17, 1952 and shape of previous curve.

and is .... well defined between 9,000 second-feet and 130,000 second-feet.

Computed by BBE

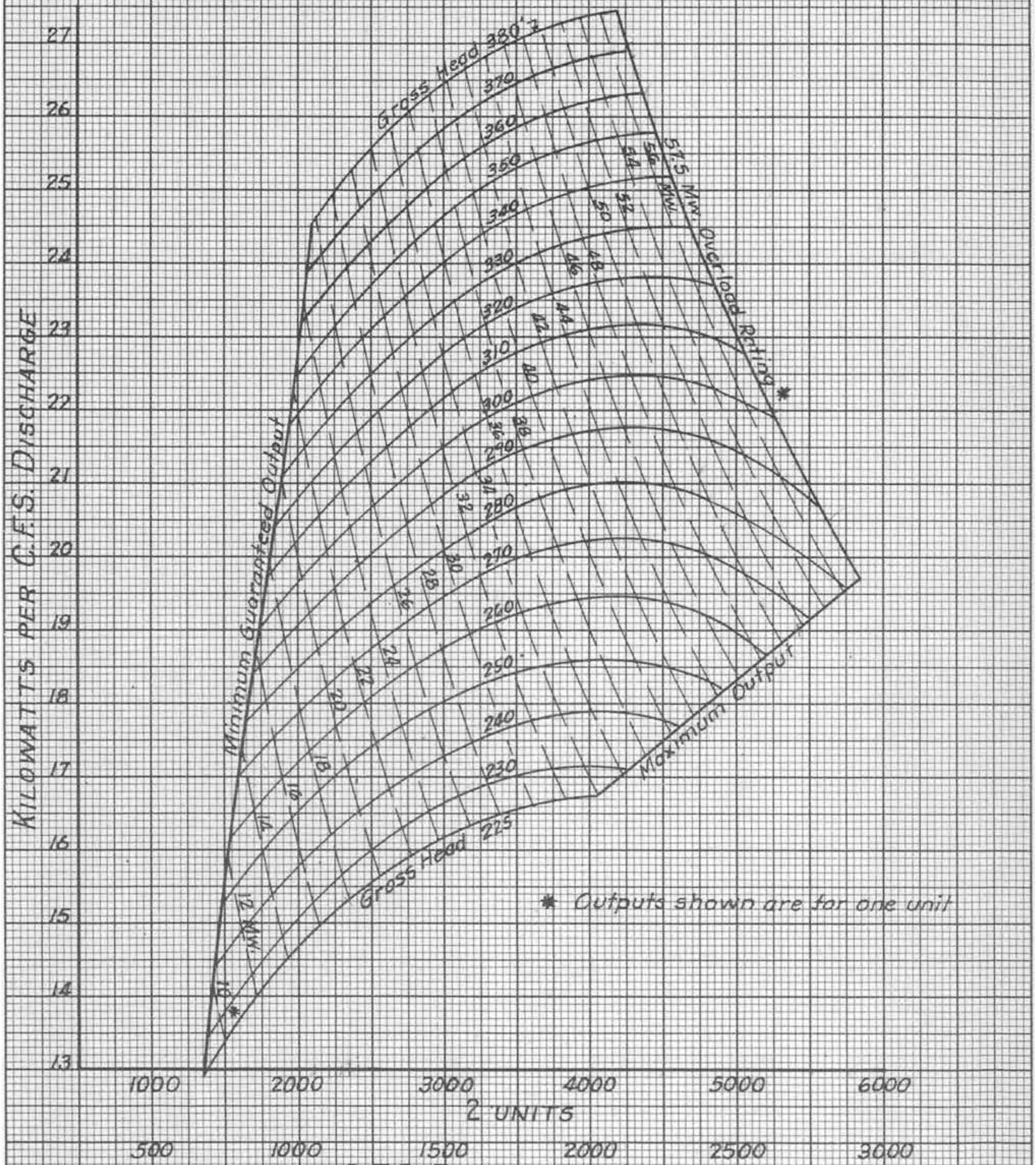
Checked by ....

Date 9-26-52

March, 1915

2 of 2

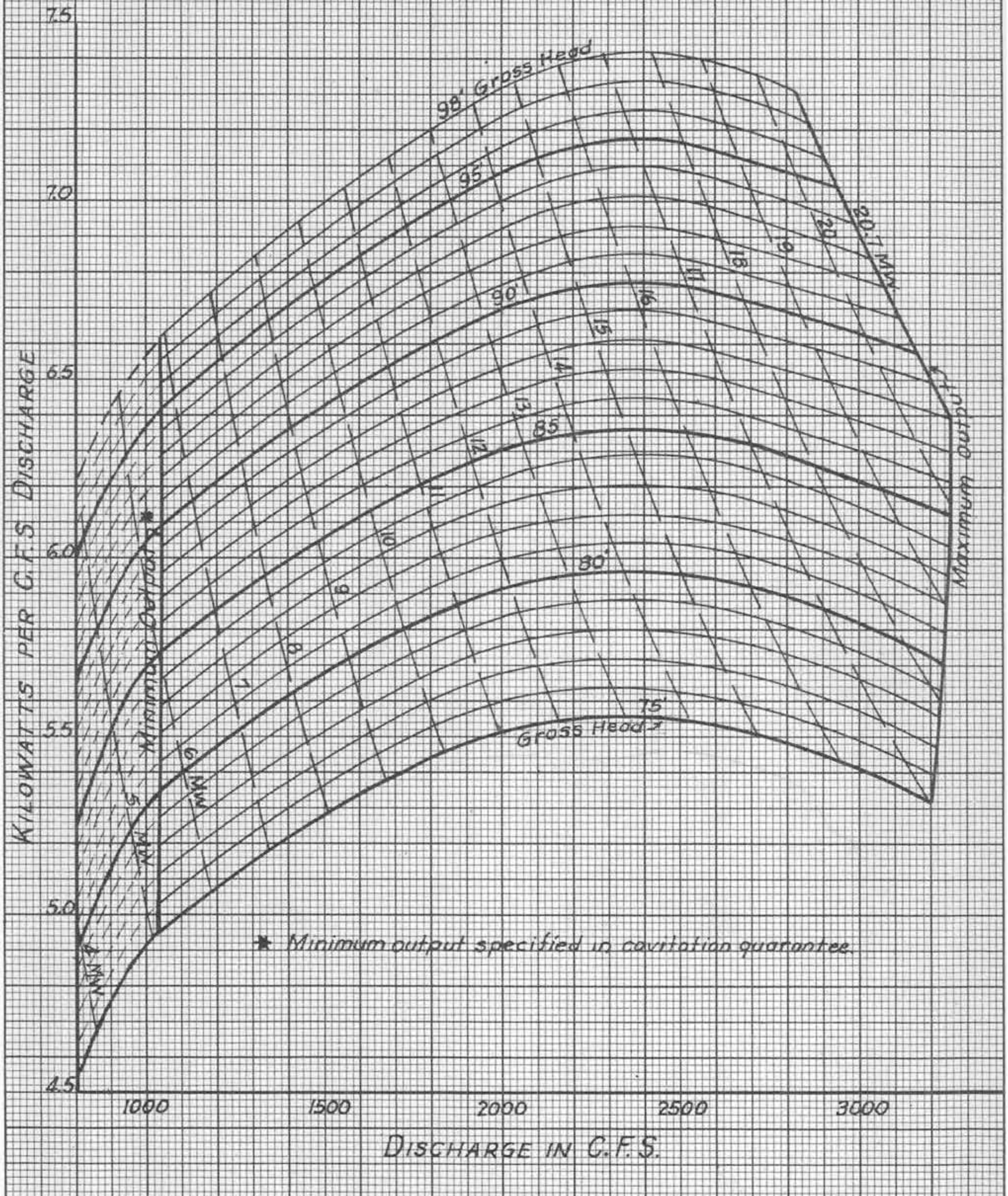
U. S. GOVERNMENT PRINTING OFFICE 16—63817-1



Detroit Power Plant

Power Output Curves

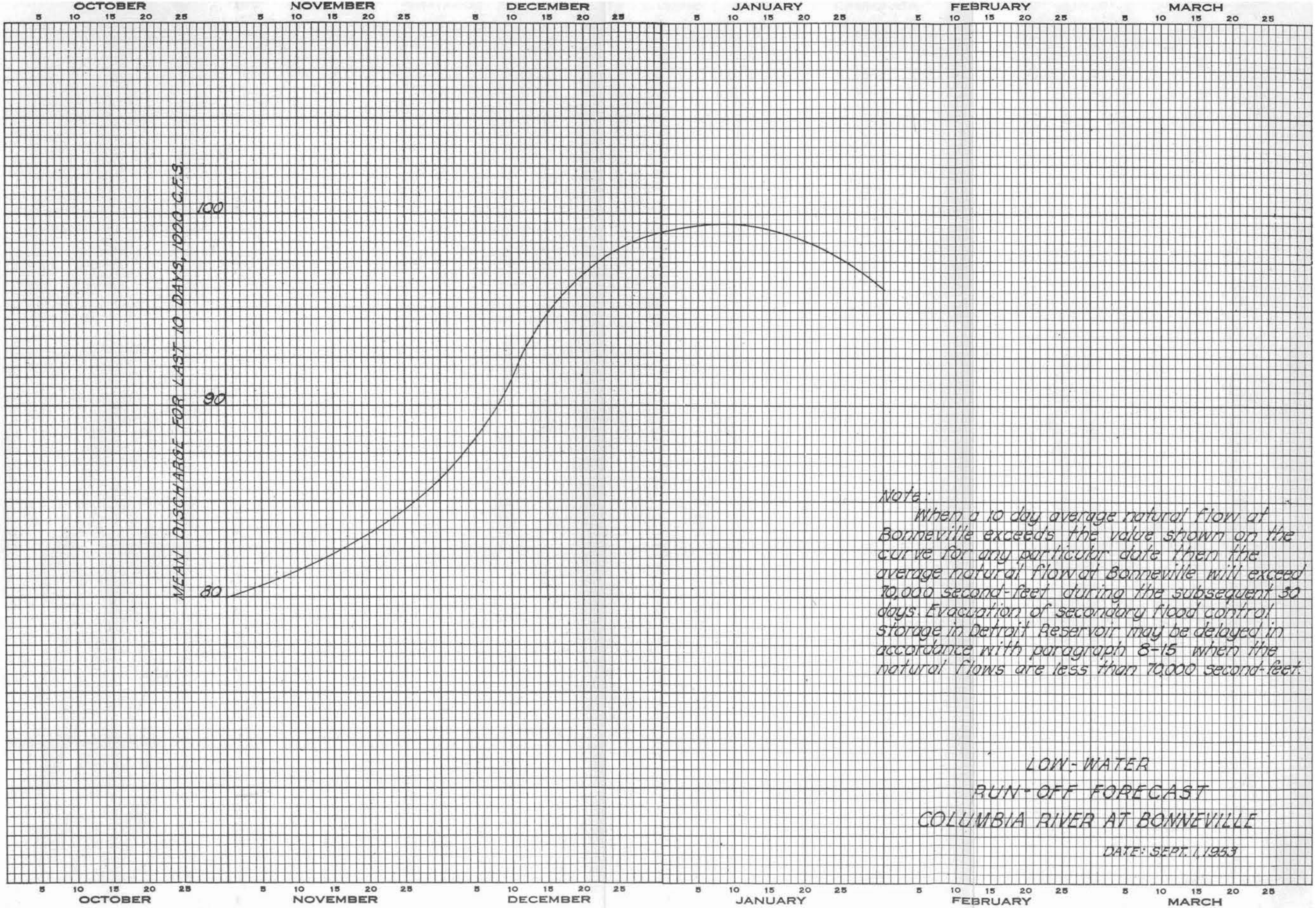
CHART I



Big Cliff Power Plant

Power Output Curves

CHART 2

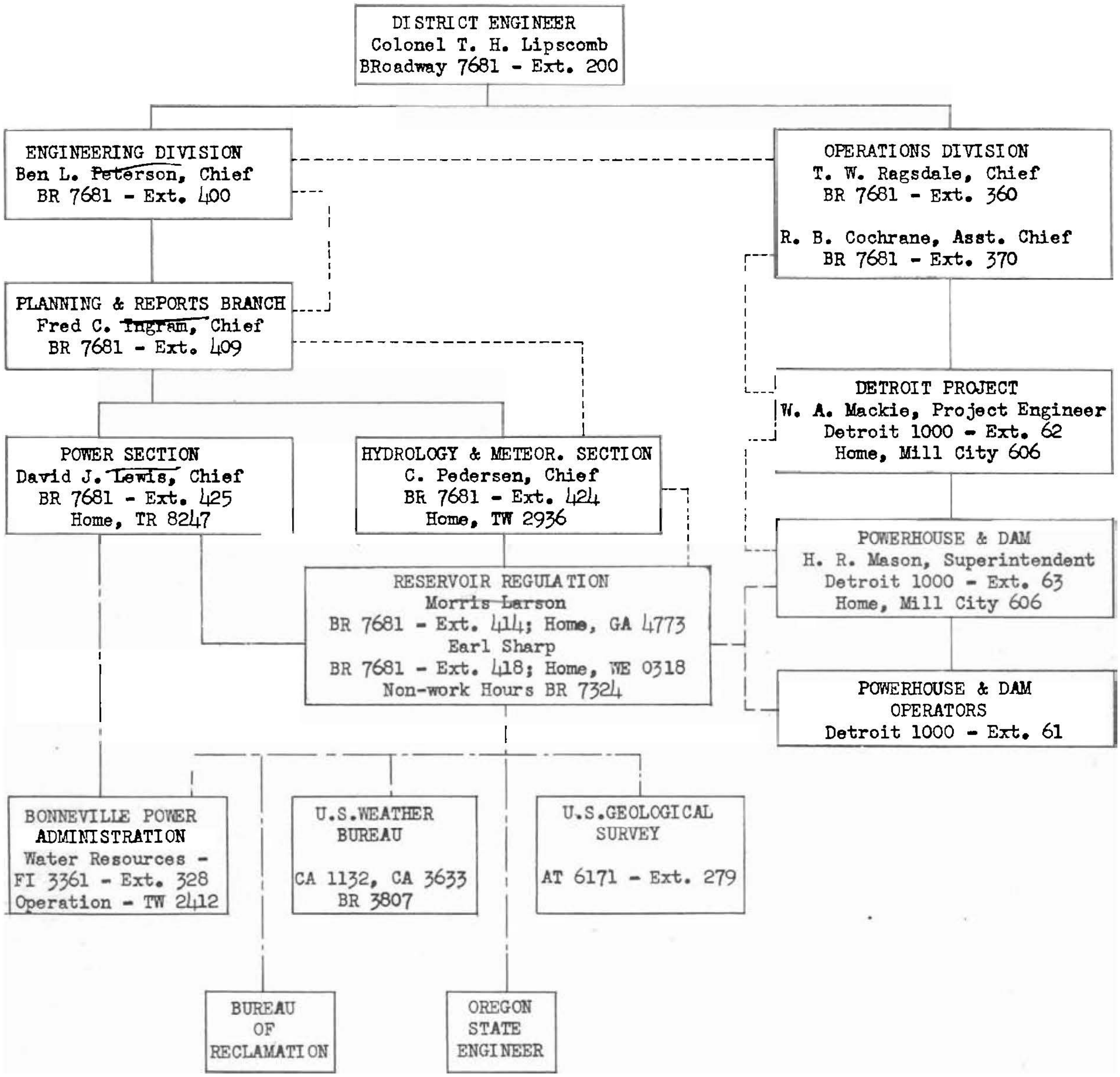


OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
5 10 15 20 25
MEAN DISCHARGE FOR LAST 10 DAYS, 1000 C.F.S.
100
90
80
Note:
When a 10 day average natural flow at Bonneville exceeds the value shown on the curve for any particular date then the average natural flow at Bonneville will exceed 70,000 second-feet during the subsequent 30 days. Evacuation of secondary flood control storage in Detroit Reservoir may be delayed in accordance with paragraph 8-15 when the natural flows are less than 70,000 second-feet.
LOW-WATER
RUN-OFF FORECAST
COLUMBIA RIVER AT BONNEVILLE
DATE: SEPT. 1, 1953

CHART 3

D E T R O I T   P R O J E C T

Organization for Functional Regulation



LEGEND

———————— SUPERVISORY AND ADMINISTRATIVE
— — — — — FUNCTIONAL RESERVOIR REGULATION INSTRUCTIONS
- - - - - - - - REGULATION CONFIRMATION
—— - —— - —— COORDINATION & LIAISON

DETROIT PROJECT
North Santiam River

ORGANIZATION
for
Reservoir and Power
Regulation
Portland District   Dec. 1, 1953

Chart 4

DETROIT HYDROMETEOROLOGICAL DATA

TIME 8:00 A.M. DATE 15 August 1953

Time	Breitenbush Gage feet	Breitenbush Discharge c.f.s.	N. Santiam Gage feet	N. Santiam Discharge c.f.s.	Total Flows c.f.s.	Service Gates Gate No.	Service Gates Set. ft.	Service Gates Discharge c.f.s.	Power House Gen. m.w.	Power House Discharge c.f.s.	Total Discharge c.f.s.	Pool Elev. feet	Pool Storage ac-ft.	Prec. in.
1 A						U/S	1.2	756			756	1524.44	315,744	
2												.44		
3												.46		
4												.48		
5												.48		
6														
7	2.89	183	2.74	638	821			756			756			
8						"	1.35					.49	315,946	
9						"	0		0					
10									20	1076	1076			
11	2.92	191	2.73	631	822				20	"				
Noon									20	"		.42		
1 P									20	"				
2						"	1.35	850	20	"				
3	2.90	185	2.72	624	809	"	1.2	756	0					
4														
5														
6														
7												.46		
8														
9														
10														
11														
Mid.												.47	315,822	
Totals									100				+ 78	0
Means	2.90	185	2.73	631	816			629		480	1109			

REMARKS:

METEOROLOGICAL DATA

Station	Temperature Max	Temperature Min	Temperature Curr	Current	Wind Curr.	Wind Max.	Hum. Low	Damsite Prec. 24 hr	Jordan Prec. 24 hr.
Damsite	90	57	58	Cloudy ceiling 1000'	NW-5	NW-25 4:00 P	25%	0	0

FORECAST: Mostly cloudy today and Sunday. Cooler today and Sunday. Variable light winds, mostly southerly. Higher humidity with a low humidity today of 35% and 40% on Sunday. High temperature today and Sunday 70°; low tonight 55°.

NPP RF SEP 53 87a

CHART 5

DAILY OPERATION REPORT -- DETROIT & BIG CLIFF

NPP RF 34
Aug 53

Date 9 Sept. 1953 (12:01 a.m. to 11:59 p.m.)

Time	DETROIT								BIG CLIFF					
	Power Generation			Turbine Discharge			Tailwater Elev. Ft., msl	Head ft.	Power Gen. mw	Turbine Disch. c.f.s.	Tailwater Elev. Ft., msl	Pool Elev. Ft., msl	Head ft.	Spillway Disch. c.f.s.
	Unit No. 1 mw	Unit No. 2 mw	Total mw	Unit No. 1 c.f.s.	Unit No. 2 c.f.s.	Total c.f.s.								
12:01 am	0													
1	0													
2	0													
3	0													
4	0													
5	0													
6	0													
7	1													
8	17													
9	20													
10	20													
11	20													
12 Noon	20													
1	20													
2	20													
3	20													
4	20													
5	20													
6	20													
7	20													
8	20													
9	20													
10	20													
11	18													
11:59 pm	0													

SUMMARY

Detroit & Big Cliff

Total Power Generated	316,000	kwh
Station Use	4,000	kwh
Delivered to B.P.A.	312,000	kwh
~~Unaccounted for~~ Condenser	13,000	kwh
Total Reactive	230	mvh
Max. Load	20,000	kw
Min. Load		kw
Avg. Load	13,166	kw

Detroit Only

Inflow	1532	ac. ft.
Releases		ac. ft.
Power	1410	ac. ft.
Outlets	512	ac. ft.
Spillway		ac. ft.
Change in Storage	-390	ac. ft.
Initial Pool	1524.27	ft., msl
Final Pool	1524.12	ft., msl

Wind Direction	E	
Wind Velocity	10	m.p.h.
Weather	High scattered clouds	
Precipitation	0	Inches
Snow Depth	0	Inches
Temperatures (degrees F.)		
Max.	75	
Min.	51	
Water	54	

CHART 6

NPPGP-5

Date 10 Sept. 1953

DETROIT PROJECT - DAILY POWER OPERATION

Scheduled Generation for 11 Sept. 1953

	A.M. 12	1	2	3	4	5	6	7	8	9	10	11	P.M. 12	1	2	3	4	5	6	7	8	9	10	11 (–12)
Sched-MW	0						0	17	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Sched-CFS	750						750	950	1080															1080

Est. inflow 740 CFS Est. outflow 978 CFS

Instructions to operators:

1. Operator can vary the output as the load dispatcher desires, provided he operate within the following limits:
   (a) Hourly fluctuations in discharge shall not exceed those shown on chart.
   (b) Minimum permissible discharge to be 750 CFS.
   (c) Maximum permissible discharge to be 1120 CFS for normal operation and 1600 CFS for special operation.
   (d) Minimum power generation within cavitation guaranty limit requires flows of 1080 CFS.

   3-day forecast: 11 Sept. 740 c.f.s.; 12 Sept. 740 c.f.s.; 13 Sept. 730 c.f.s.
   Last two hours tentative pending Grand Coulee going on control.

Scheduled and Actual Generation for 9 Sept. 1953

	A.M. 12	1	2	3	4	5	6	7	8	9	10	11	P.M. 12	1	2	3	4	5	6	7	8	9	10	11 (–12)
Sched-MW	0						0	17	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	0
Actual-MW	0					0	1	17	20	20	20	20	20	20	20	20	20	20	20	20	20	20	18	0

Est. inflow 760 CFS Est. outflow 973 CFS Res. elev. 12:01 A.M. 1524.27

Actual inflow 766 CFS Actual outflow 961 CFS Res. elev. 11:59 P.M. 1524.12

Remarks:

ART

TO: DISTRICT ENGINEER, PORTLAND, OREGON
ATTN.: CHIEF, ENGINEERING DIVISION
(Letter of Transmittal Unnecessary)

MONTHLY LOG OF RESERVOIR REGULATION
DETROIT DAM AND RESERVOIR

Month and Year: August 1953

NPPVK-8

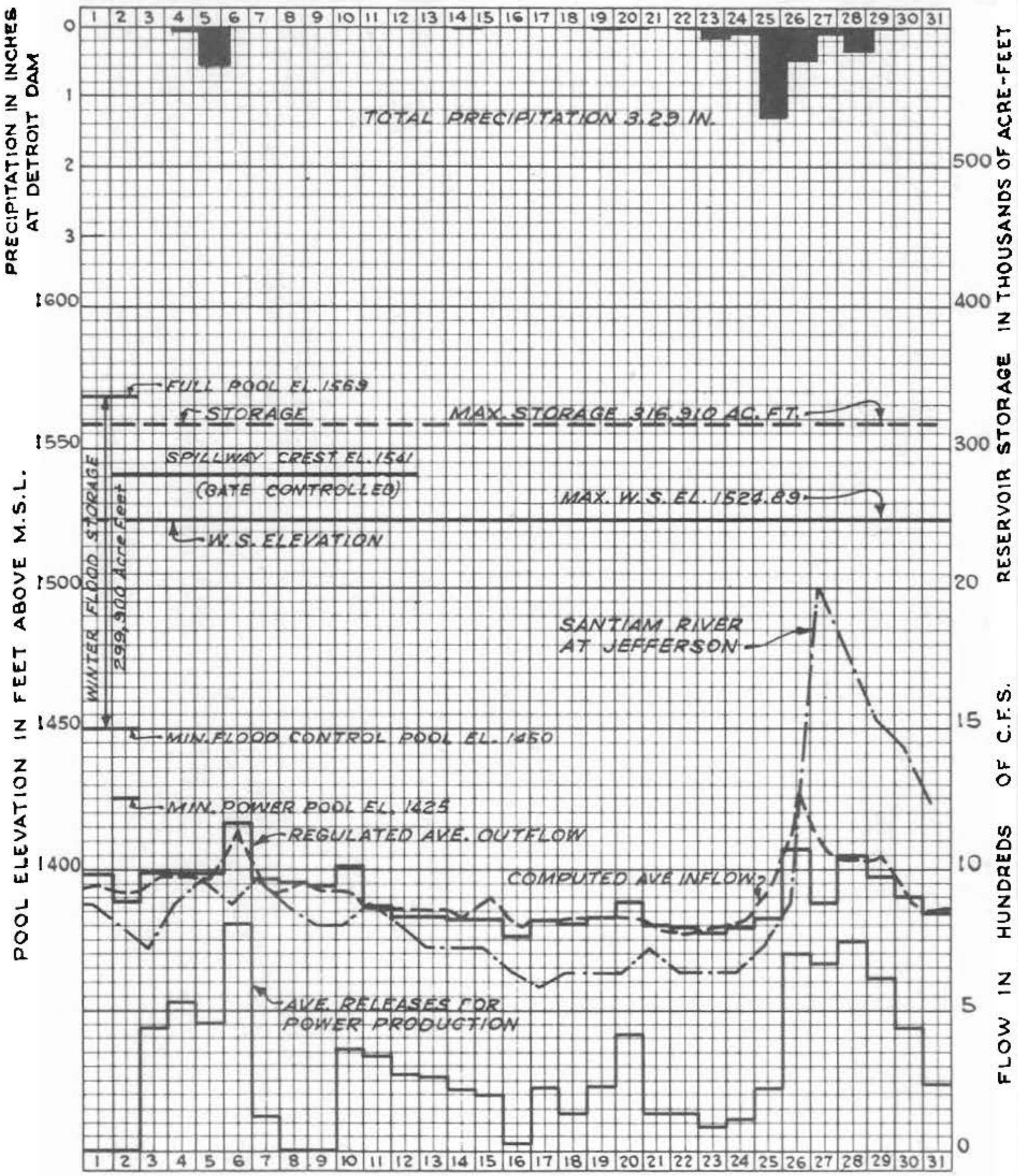
Day	Time (7:30a.m. unless otherwise indicated)	Pool Elevation: Stage ft. m.s.l.	Pool Elevation: 24-Hour change	Reservoir Inflow: Breitenbush R. above Canyon Cr. Stage feet	Breitenbush R. above Canyon Cr. Discharge c.f.s.	North Santiam R. below Boulder Cr. Stage feet	North Santiam R. below Boulder Cr. Discharge c.f.s.	Computed Total Inflow c.f.s.	Reservoir Discharge: North Santiam R. above Mayflower Cr. Stage feet	North Santiam R. above Mayflower Cr. Discharge c.f.s.	Gate Opening – feet, Lower Tier: Gate L-S	Lower Tier: Gate L-N	Upper Tier: Gate U-S	Upper Tier: Gate U-N	Discharge through Gates, c.f.s.	Discharge over Spillway, c.f.s.	Santiam River at Jefferson Discharge c.f.s.	Remarks
1	12:01 A										0	1.54	0	0				All water discharged thru
		1524.54	- .06	3.08	228	2.79	673	935	5.44	1092	0	1.54	0	0				Turbine was used for generation
	11:30A										0	1.3	0	0				
	3:05P										0	1.2	0	0				
2		1524.53	- .01	3.10	233	2.79	673	924	5.15	885	0	1.2	0	0				
3		1524.57	+ .04	3.12	239	2.80	680	979	5.15	885	0	0	0	0				Generating
	4:00P										0	0	1.3	0				Motoring
	6:00P										0	0	1.5	0				
4		1524.55	- .02	3.08	228	2.78	666	979	5.17	899	0	0	0	0				Generating
	4:00P										0	0	1.2	0				Motoring
	6:00P										0	0	1.3	0				
	7:55P										0	0	0	0				Generating
	10:01P										0	0	1.35	0				Motoring
5		1524.55	0	3.10	233	2.79	673	961	5.05	815	0	0	0	0				Generating
	4:05P										0	0	1.35	0				Motoring
	10:00P										0	0	1.45	0				
6	12:35A										0	0	2.15	0				
	4:15A										0	0	2.45	0				
		1524.60	+ .05	3.28	285	2.94	778	1151	5.77	1373	0	0	0.5	0				Generating
	8:45A										0	0	0	0				
	12: Mdt										0	0	1.7	0				
7		1524.55	- .05	3.11	236	2.82	694	922	5.31	997	0	0	0 0	0				
	10:30A										0	0	1.7	0				Motoring
	1:00 P										1.4	0	0	0				P.H. To reduce spray, Work
	4:20P										0	0	0	1.6				P.H. Work completed
	7:00P										0	0	1.6	0				
8		1524.51	- .04	3.07	226	2.80	680	955	5.26	962	0	0	1.6	0				
9		1524.51	0	3.04	218	2.77	659	913	5.25	955	0	0	1.6	0				
	2:15P										0	0	1.5	0				
10		1524.50	- .01	3.00	208	2.75	645	944	5.18	906	0	0	0	0				Generating
	3:00P										0	0	1.5	0				Motoring
	12: Mdt										0	0	.975	0				
11	6:00A								7.49	651	0	0	.975	0				
	6:45A										0	0	1.25	0				
	7:35A	1524.47	- .03	3.00	208	2.74	638	858			0	0	1.4	0				
	8:00A										0	0	0	0				Generating
	2:35P										0	0	1.4	0				Motoring
	3:35:P										0	0	1.2	0				
12		1524.45	- .02	2.96	199	2.75	645	852	4.95	750	0	0	1.2	0				
	8:10A										0	0	1.35	0				Generating
	9:00A										0	0	0	0				Motoring
	3:00P										0	0	1.35	0				
	4:00P										0	0	1.2	0				
13		1524.47	+ .02	292	191	2.73	631	863	4.95	750	0	0	1.2	0				
	8:10A										0	0	1.35	0				
	9:00A										0	0	0	0				Generating
	3:00P										0	0	1.35	0				Motoring
	4:00P										0	0	1.2	0				

Authority for Action Taken; (To be shown in remarks column) R–Resident Engr., P–Project Engr., PH–Powerhouse Superintendent, RR–Reservoir Regulation Subsection, PM–Prelim. Manual.

Powerhouse Superintendent: J. R. MASON

Resident Engineer: W. A. MACKIE

REPORTS CONTROL SYMBOL ENGKW-51



MONTH OF AUGUST 1953

	ELEVATION	GROSS STORAGE Ac. Ft.
Minimum Power Pool	1425	114,700
Min. Flood Control Pool	1450	155,000
Full Pool	1569	454,900

Maximum Planned Release 17,000 c.f.s.

MONTHLY RESERVOIR REGULATION

DETROIT RESERVOIR
NORTH SANTIAM RIVER BASIN
D. A. 438 SQ. MILES

NORTH PACIFIC DIVISION
PORTLAND DISTRICT

FORM RO-1

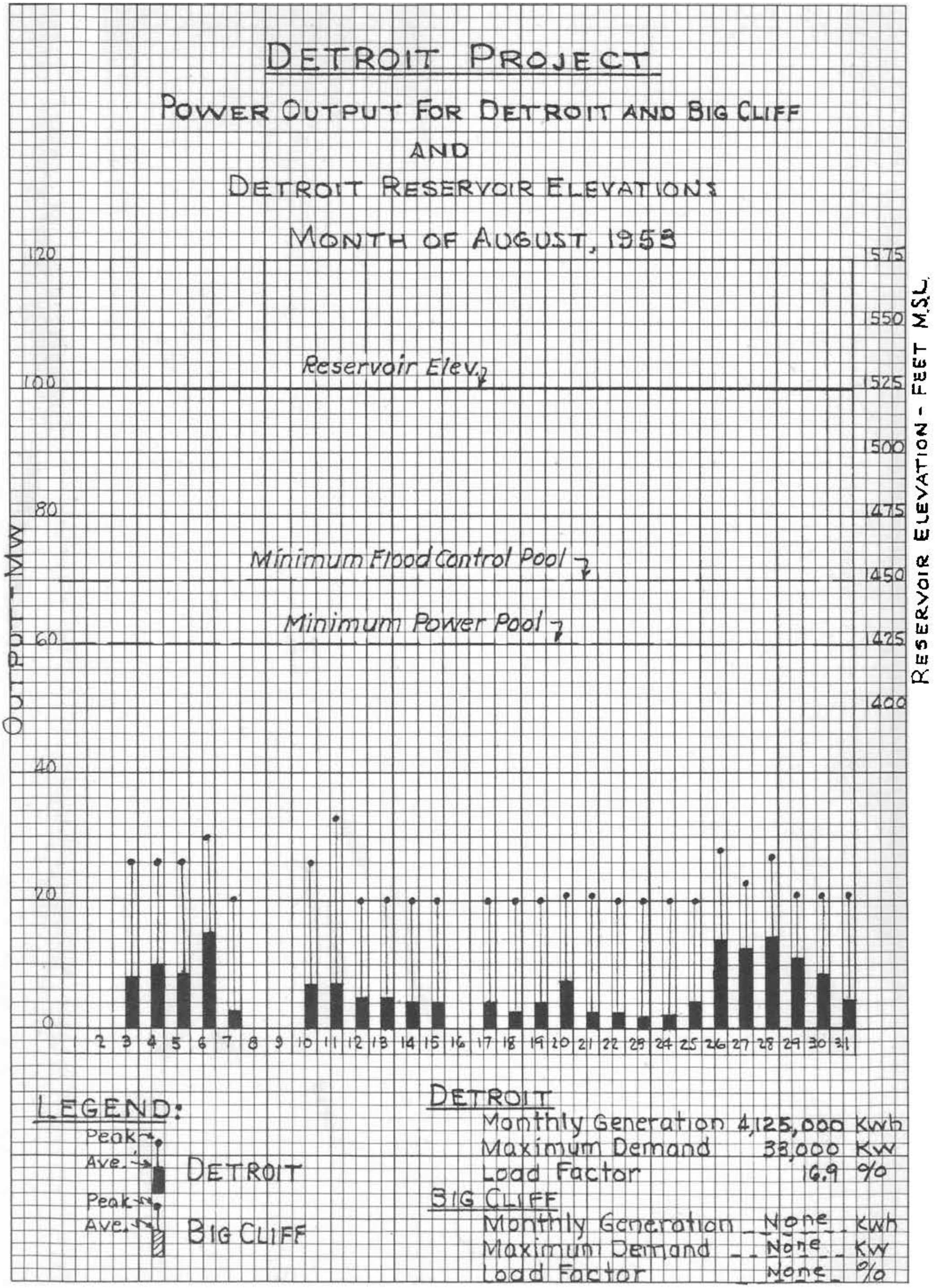
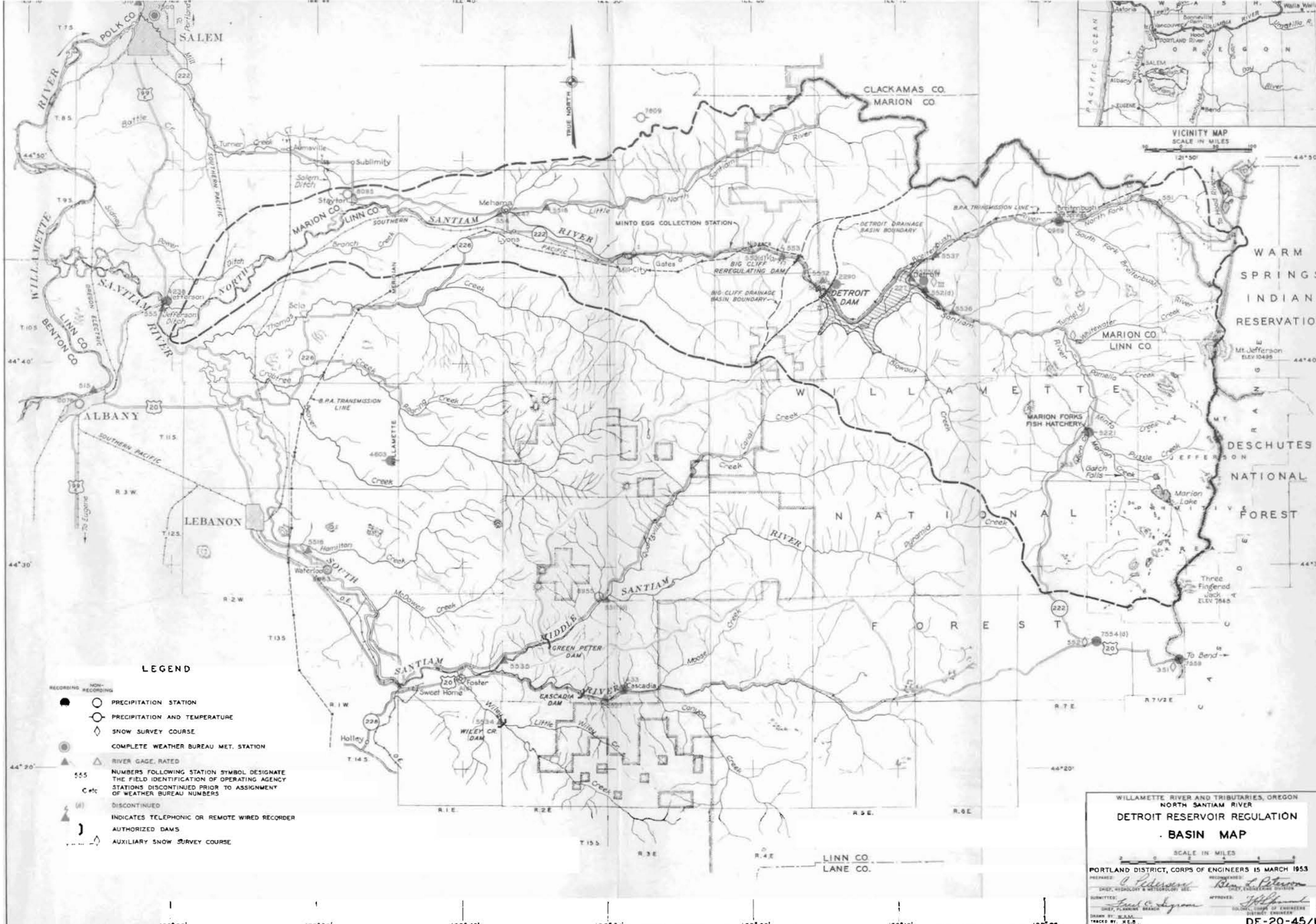

DETROIT PROJECT
POWER OUTPUT FOR DETROIT AND BIG CLIFF
AND
DETROIT RESERVOIR ELEVATIONS
MONTH OF AUGUST, 1953
OUTPUT - MW
RESERVOIR ELEVATION - FEET M.S.L.
0
20
40
60
80
100
120
400
425
450
475
1500
1525
1550
1575
Reservoir Elev.
Minimum Flood Control Pool
Minimum Power Pool
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
LEGEND:
Peak
Ave.
DETROIT
Peak
Ave.
BIG CLIFF
DETROIT
Monthly Generation 4,125,000 Kwh
Maximum Demand 33,000 Kw
Load Factor 16.9 %
BIG CLIFF
Monthly Generation None Kwh
Maximum Demand None Kw
Load Factor None %

CHART 10



SALEM
ALBANY
LEBANON
CLACKAMAS CO.
MARION CO.
LINN CO.
BENTON CO.
POLK CO.
WARM SPRINGS INDIAN RESERVATION
DESCHUTES NATIONAL FOREST
WILLAMETTE NATIONAL FOREST
DETROIT DAM
BIG CLIFF REREGULATING DAM
MINTO EGG COLLECTION STATION
GREEN PETER DAM
CASCADIA DAM
WILEY CR. DAM
MARION FORKS FISH HATCHERY
Mt. Jefferson ELEV 10495
Three Fingered Jack ELEV 7848
TRUE NORTH
VICINITY MAP
SCALE IN MILES
LEGEND
RECORDING
NON-RECORDING
PRECIPITATION STATION
PRECIPITATION AND TEMPERATURE
SNOW SURVEY COURSE
COMPLETE WEATHER BUREAU MET. STATION
RIVER GAGE, RATED
NUMBERS FOLLOWING STATION SYMBOL DESIGNATE THE FIELD IDENTIFICATION OF OPERATING AGENCY
STATIONS DISCONTINUED PRIOR TO ASSIGNMENT OF WEATHER BUREAU NUMBERS
DISCONTINUED
INDICATES TELEPHONIC OR REMOTE WIRED RECORDER
AUTHORIZED DAMS
AUXILIARY SNOW SURVEY COURSE
WILLAMETTE RIVER AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER
DETROIT RESERVOIR REGULATION
BASIN MAP
SCALE IN MILES
PORTLAND DISTRICT, CORPS OF ENGINEERS 15 MARCH 1953
DE-20-45/1

PLATE I

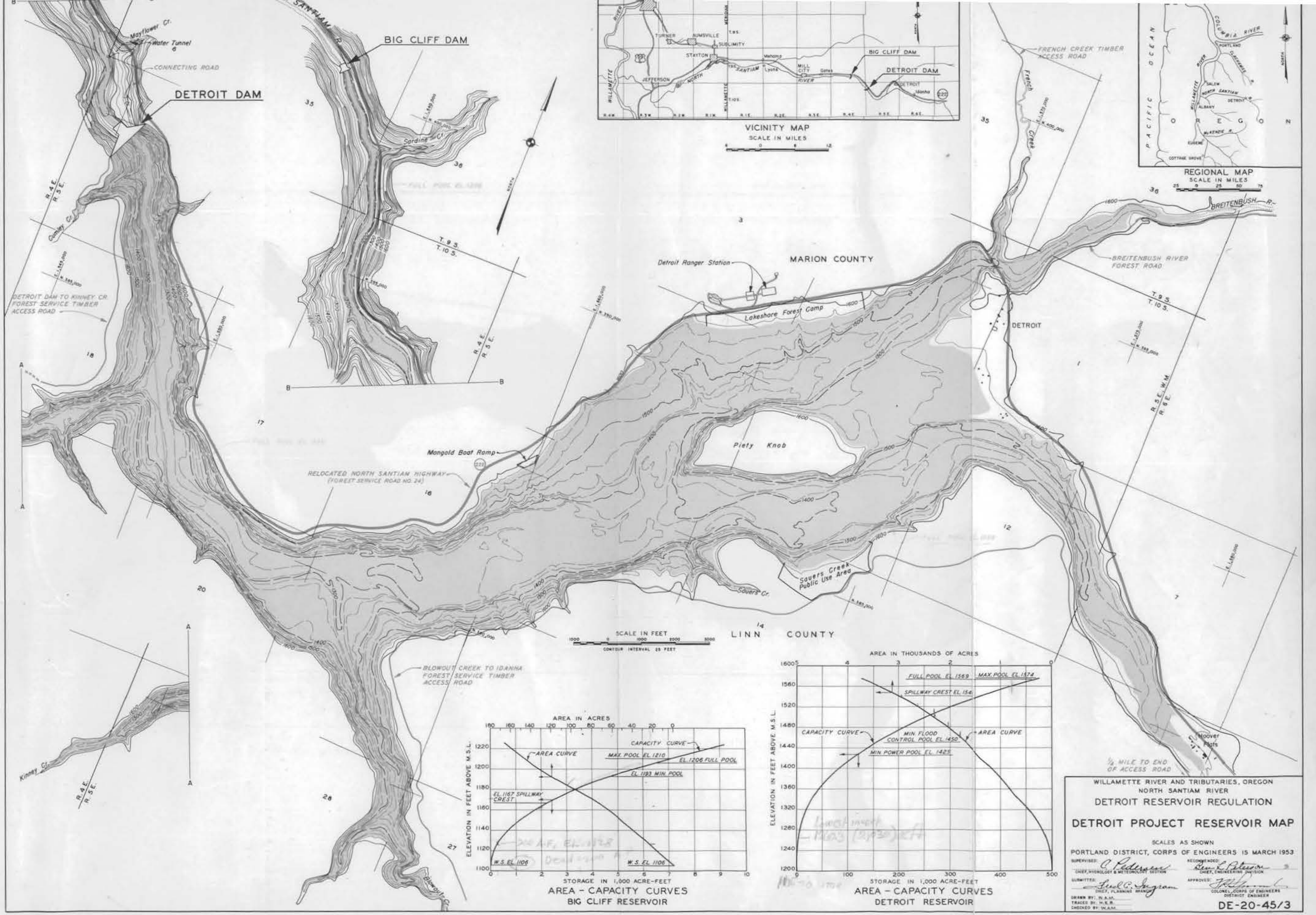
BIG CLIFF
DAM SITE

RESERVOIR CAPACITY

Newberg

Crest Ele

Serv
Galle



WILLAMETTE RIVER AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER

DETROIT RESERVOIR REGULATION

DETROIT PROJECT RESERVOIR MAP

SCALES AS SHOWN

PORTLAND DISTRICT, CORPS OF ENGINEERS 15 MARCH 1953

SUPERVISED: C. Pedersen — CHIEF, HYDROLOGY & METEOROLOGY SECTION
RECOMMENDED: Ben L. Peterson — CHIEF, ENGINEERING DIVISION
SUBMITTED: Lloyd C. Ingram — CHIEF, PLANNING BRANCH
APPROVED: COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY: N.A.M.
TRACED BY: H.E.R.
CHECKED BY: W.A.M.

DE-20-45/3

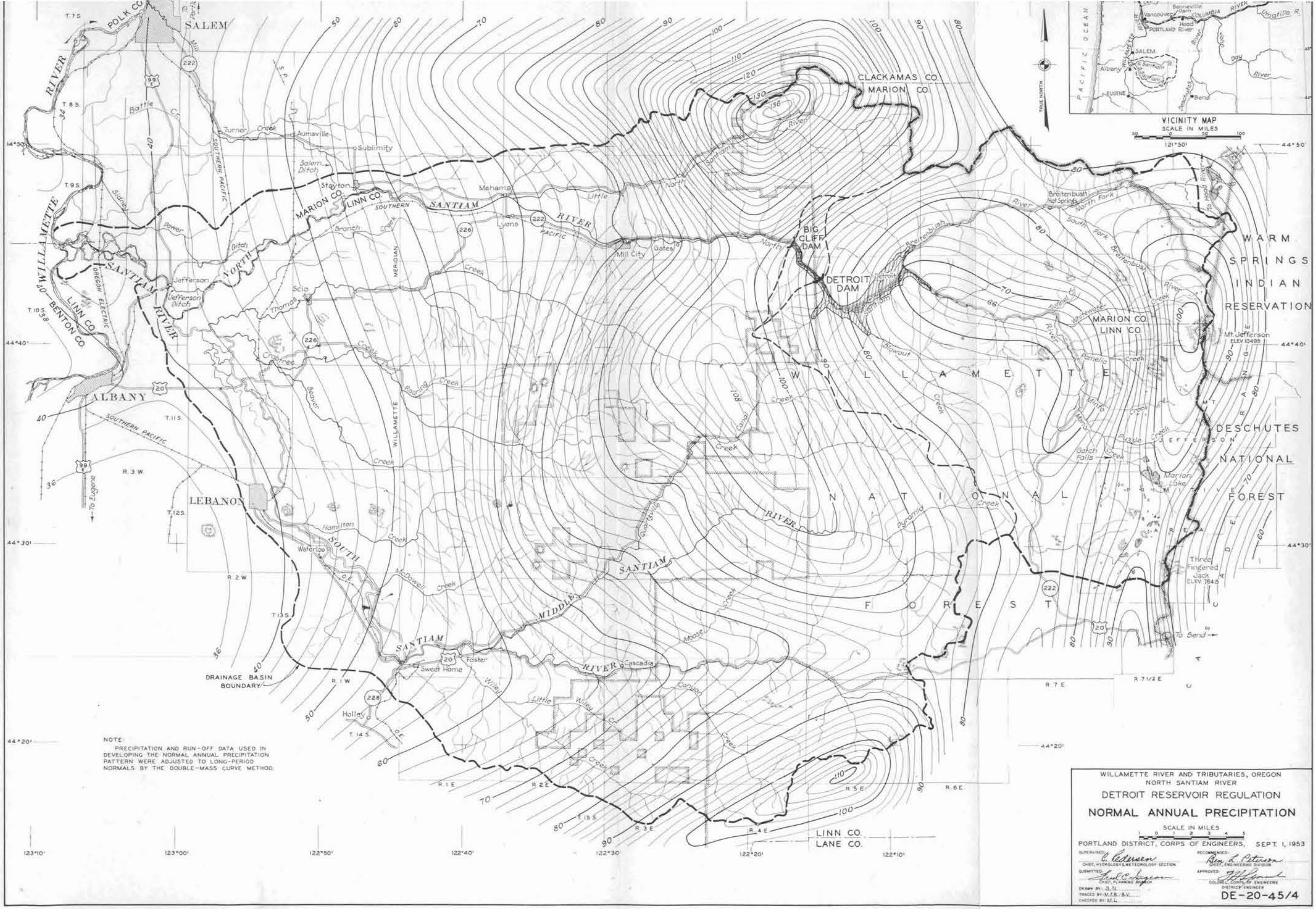
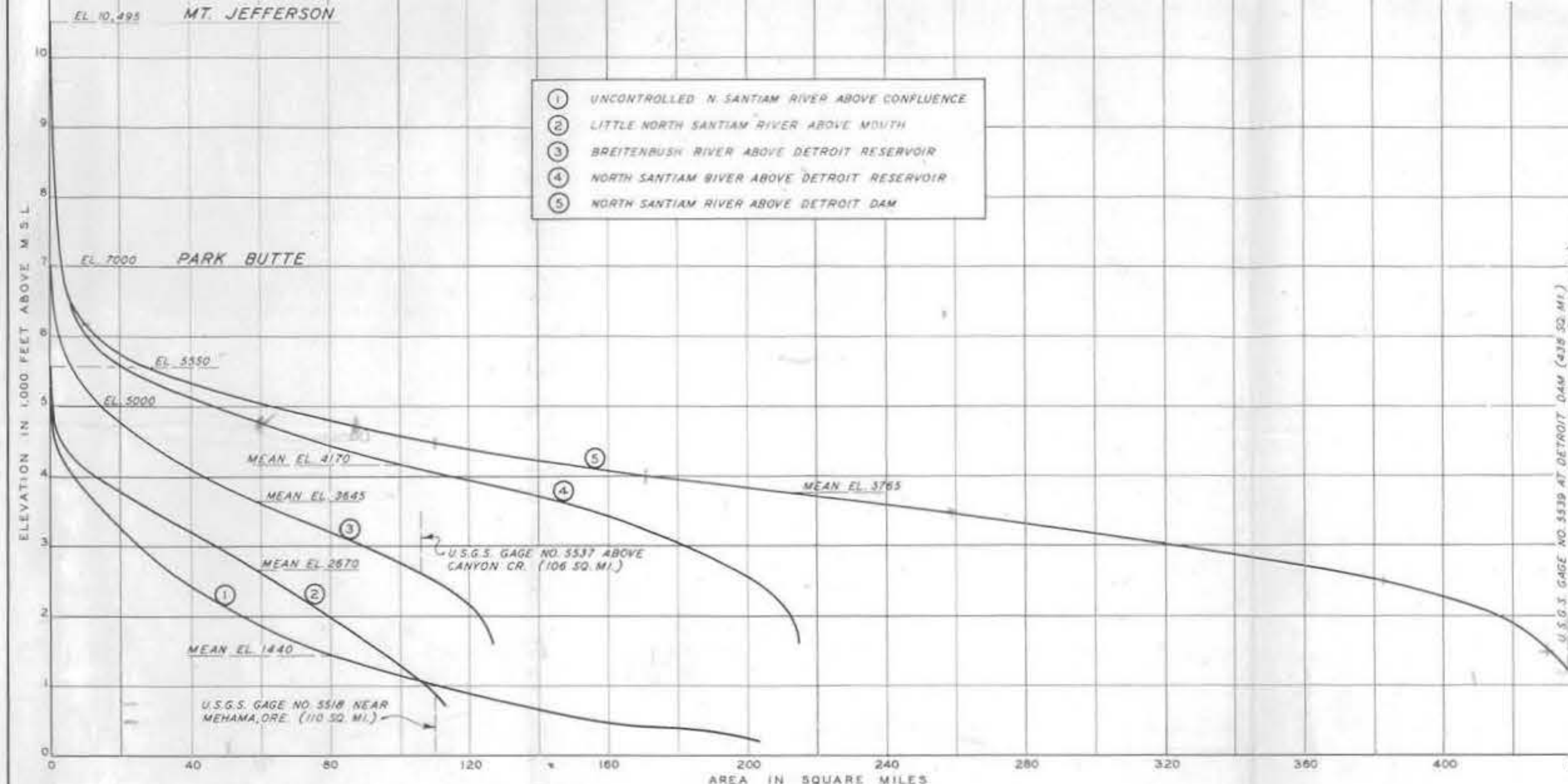
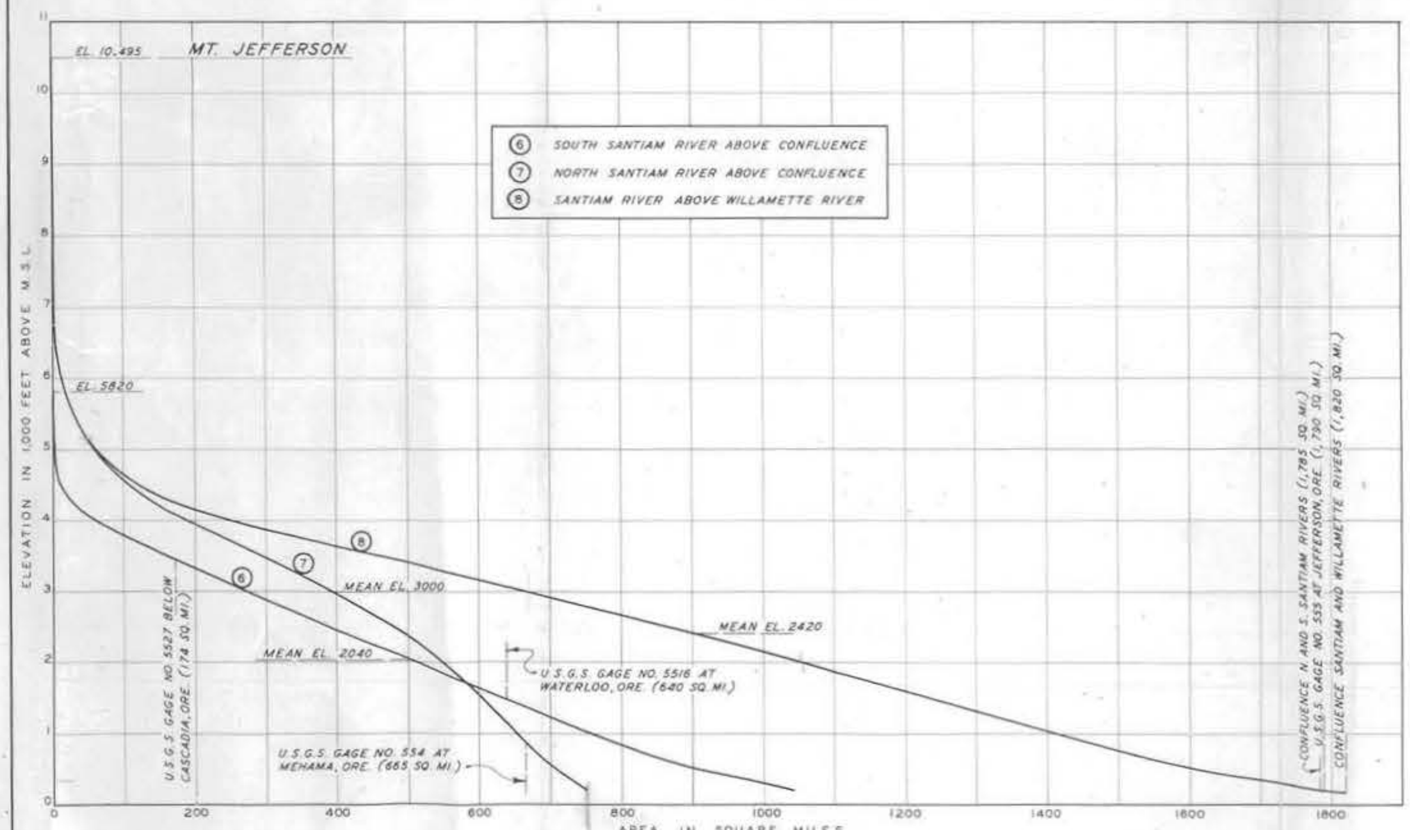

WILLAMETTE RIVER AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER
DETROIT RESERVOIR REGULATION
NORMAL ANNUAL PRECIPITATION
SCALE IN MILES
PORTLAND DISTRICT, CORPS OF ENGINEERS, SEPT. 1, 1953
DE-20-45/4
NOTE:
PRECIPITATION AND RUN-OFF DATA USED IN DEVELOPING THE NORMAL ANNUAL PRECIPITATION PATTERN WERE ADJUSTED TO LONG-PERIOD NORMALS BY THE DOUBLE-MASS CURVE METHOD.
DRAINAGE BASIN BOUNDARY
VICINITY MAP
SCALE IN MILES
PACIFIC OCEAN
TRUE NORTH
SALEM
ALBANY
LEBANON
Stayton
Sublimity
Aumsville
Jefferson
Scio
Mehama
Lyons
Mill City
Gates
Sweet Home
Foster
Cascadia
Holley
Waterloo
Hamilton
BIG CLIFF DAM
DETROIT DAM
Breitenbush Hot Springs
Mt. Jefferson
ELEV. 10499
Three Fingered Jack
ELEV. 7840
Marion Lake
Gatch Falls
CLACKAMAS CO.
MARION CO.
LINN CO.
BENTON CO.
POLK CO.
LANE CO.
WILLAMETTE NATIONAL FOREST
WARM SPRINGS INDIAN RESERVATION
DESCHUTES NATIONAL FOREST
WILLAMETTE RIVER
NORTH SANTIAM RIVER
SOUTH SANTIAM
MIDDLE SANTIAM RIVER
SOUTHERN PACIFIC
OREGON ELECTRIC
To Eugene
To Bend
44°50'
44°40'
44°30'
44°20'
123°10'
123°00'
122°50'
122°40'
122°30'
122°20'
122°10'

PLATE 4



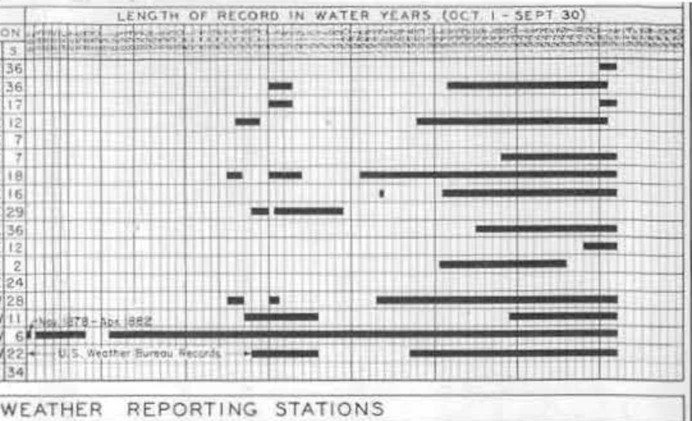
AREA-ELEVATION RELATIONSHIPS
SANTIAM RIVER TRIBUTARIES
FIGURE 1



AREA-ELEVATION RELATIONSHIPS
SANTIAM RIVER SYSTEM
FIGURE 2

U.S.G.S. FIELD NO.	U.S. GEOLOGICAL SURVEY, GAGE DESCRIPTION	NAME OF RIVER OR TRIBUTARY	D.A. IN SQ. MI.	ZERO OF GAGE M.S.L.	LOCATION T.	R.	S.
5537	above Canyon Cr. [1]	Breitenbush	106	1573.10	9S	5E	36
5525[d]	above French Cr.	Breitenbush	108	1559.64	9S	5E	36
5536	below Boulder Cr. [1]	N. Santiam	216	1600.34	10S	6E	17
552[d]	at Detroit (Old town)	N. Santiam	224	1475.68	10S	5E	12
5539	at Detroit Dam [1]	N. Santiam	438	0.00	10S	5E	7
5532	above Mayflower Cr. [1]	N. Santiam	438	1189.50	10S	5E	7
554	at Mehama [1]	N. Santiam	665	601.78	9S	2E	18
5518	near Mehama	L.N. Santiam	110	655.41	9S	2E	16
553[d]	at Niagara	N. Santiam	470	980.0	9S	4E	29
5527	below Cascadia	S. Santiam	174	759.38	13S	2E	36
5534	near Foster	Wiley Cr.	52	718.08	14S	1E	12
5517[d]	near Foster	Mid. Santiam	271	733.44	13S	2E	2
5535[2]	near Foster	Mid. Santiam	287	562.14	13S	1E	24
5516	at Waterloo [1]	S. Santiam	640	370.39	12S	1W	28
555	at Jefferson [1]	Santiam	1,790	199.63	10S	3W	11
515	at Albany	Willamette	4,840	171.70	11S	3W	6
516	at Salem	Willamette	7,280	113.61	7S	3W	22
553	at Niagara	N. Santiam	453	1093.78	9S	4E	34

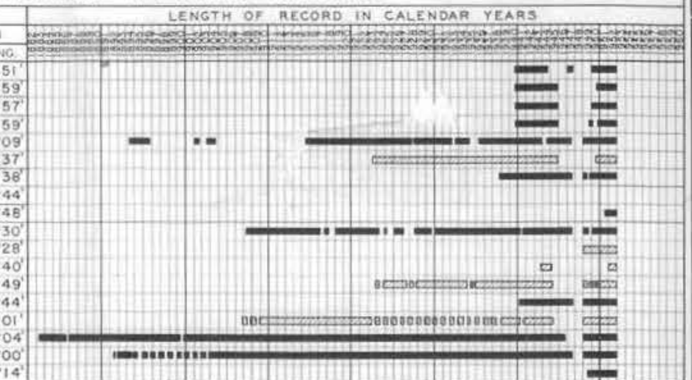
LENGTH OF RECORD IN WATER YEARS (OCT. 1 - SEPT. 30)



PART 2 - WEATHER REPORTING STATIONS

U.S.W.B. NO.	U.S. WEATHER BUREAU STATION NAME	WATERSHED	ELEV. M.S.L.	LOCATION LAT.	LONG.
7559	Santiam Pass	McKenzie	4800	44°26'	121°51'
7554	Santiam Junction	McKenzie	3750	44°28'	121°59'
5221	Marion Forks	N. Santiam	2445	44°37'	121°57'
0969	Breitenbush	Breitenbush	2220	44°47'	121°59'
2277	Detroit [1]	N. Santiam	1730	44°44'	122°09'
5447	Mehama [1]	N. Santiam	640	44°47'	122°37'
7809	Silver Cr. Falls S. Park	Pudding	1340	44°52'	122°38'
B[2]	Jordan Guard Sta.	Santiam	1000	44°44'	122°44'
8095	Stayton	N. Santiam	625	44°48'	122°48'
1433	Cascadia	S. Santiam	796	44°23'	122°30'
6955	Quartzville	Mid. Santiam	885	44°30'	122°28'
A[d]	Foster	S. Santiam	525	44°25'	122°40'
9083	Waterloo [1]	S. Santiam	410	44°30'	122°49'
4603	Lacomb [1]	S. Santiam	610	44°35'	122°44'
4238	Jefferson [1]	Santiam	230	44°43'	123°01'
0078	Albany [1]	Willamette	212	44°38'	123°04'
7500	Salem [1]	Willamette	195	44°55'	123°00'
2290	Detroit Dam [1]	N. Santiam	1585	44°44'	122°14'

LENGTH OF RECORD IN CALENDAR YEARS



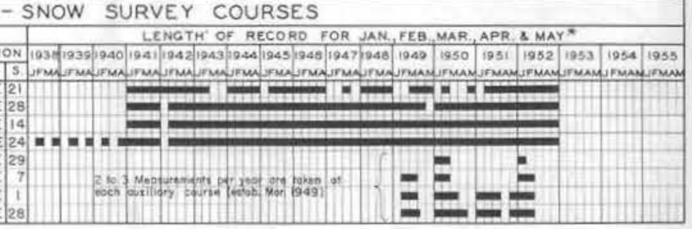
Stations A & B have no assigned Weather Bureau number.

LEGEND
Precipitation and Temperature — Precipitation only

PART 3 - SNOW SURVEY COURSES

S.C.S. NO.	SOIL CONSERVATION SERVICE SNOW COURSE NAME	WATERSHED	ELEV. M.S.L.	TYPE OF COURSE	LOCATION T.	R.	S.
551	Breitenbush Hot Springs	Breitenbush	2325	Standard	9S	7E	21
553	Marion Forks	N. Santiam	2730	Standard	11S	7E	28
552	Santiam Junction	McKenzie	3990	Standard	13S	7E	14
351	Hogg (Santiam) Pass	McKenzie	4755	Standard	13S	7½E	24
I	Mill City	N. Santiam	826	Auxiliary	9S	3E	29
II	Detroit Dam	N. Santiam	1580	Auxiliary	10S	5E	7
III	Detroit	N. Santiam	1750	Auxiliary	10S	5E	1
IV	Whitewater Bridge	N. Santiam	2175	Auxiliary	10S	7E	28

LENGTH OF RECORD FOR JAN., FEB., MAR., APR. & MAY*



* Reports of snow depth measurements are dated the first of the month following the month in which measurements were made. Prior to 1949, these reports were made as of Jan. 1st, Feb. 1st, Mar. 1st and Apr. 1st and in addition a report has been made on May 1st starting in 1949

(d) Discontinued
1 Stations included in hydrologic reporting network
2 Installed October, 1952

AREA - ELEVATION DATA

Elevation Band in ft. above m.s.l.	N. Santiam R. above Detroit Reservoir Sq. Mi.	%	Breitenbush R. above Detroit Reservoir Sq. Mi.	%	N. Santiam R. above Detroit Dam U.S.G.S. 5539 Sq. Mi.	%	Little N. Santiam R. above Mouth Sq. Mi.	%	Uncontrolled N. Santiam R. above Confluence Sq. Mi.	%	Total N. Santiam R. above Confluence Sq. Mi.	%	Total S. Santiam R. above Confluence Sq. Mi.	%	Santiam R. above Jefferson U.S.G.S. 555 Sq. Mi.	%	Santiam R. above Willamette R. Sq. Mi.	%
Total	215.0	100.0	128.0	100.0	438.0	100.0	113.0	100.0	202.0	100.0	748.0	100.0	1037.0	100.0	1790.0	100.0	1820.0	100.0
Above 175									202.0	100.0	748.0	100.0	1037.0	100.0	1790.0	100.0	1820.0	100.0
Above 500							113.0	100.0	156.3	77.4	705.5	94.3	898.0	86.6	1603.5	89.6	1604.8	88.2
Above 1000	215.0	100.0	128.0	100.0	438.0	100.0	107.7	95.3	110.0	54.5	653.8	87.4	758.9	73.2	1412.7	78.9	1412.8	77.6
Above 2000	212.5	98.8	122.8	95.9	416.7	95.1	79.1	70.0	53.9	26.7	549.7	73.5	516.6	49.8	1066.3	59.6	1066.3	58.6
Above 3000	182.0	84.7	89.0	69.5	322.6	73.7	47.7	42.2	25.0	12.4	395.3	52.8	274.1	26.4	669.4	37.4	669.4	36.8
Above 4000	113.7	52.9	44.0	34.4	170.8	39.0	13.2	11.7	6.2	3.1	190.2	25.4	65.4	6.3	255.6	14.3	255.6	14.0
Above 5000	47.0	21.9	14.4	11.3	61.9	14.1	0.2	0.2	0.0	0.0	62.1	8.3	2.0	0.2	64.1	3.6	64.1	3.5
Above 7000	3.6	1.7	0.0	0.0	3.6	0.8	0.0	0.0	0.0	0.0	3.6	0.5	0.0	0.0	3.6	0.2	3.6	0.2
Highest Point	10495		7000		10495		5550		5000		10495		5820		10495		10495	
Mean Elevation	4170		3645		3765		2670		1440		3000		2040		2455		2420	
Lowest Point	1600		1600		1200		700		200		200		200		200		175	

Areas planimetered on quadrangle maps, scale 1:62,500

WILLAMETTE RIVER AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER

DETROIT RESERVOIR REGULATION

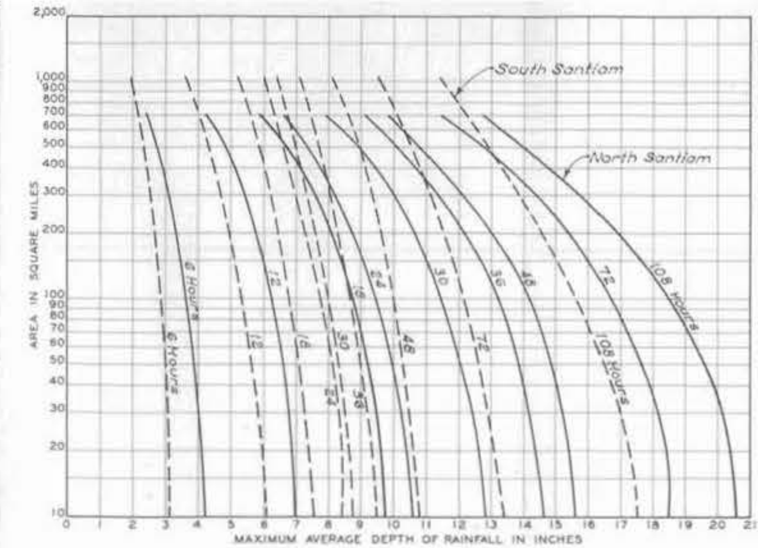
INVENTORY OF HYDROCLIMATIC DATA

SCALES AS SHOWN
PORTLAND DISTRICT, CORPS OF ENGINEERS, SEPT. 1, 1953

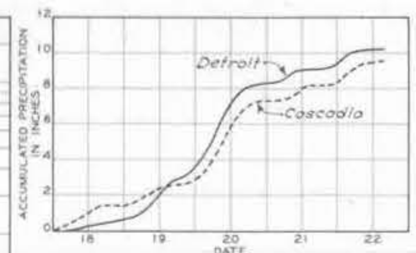
SUPERVISED: C. Pederson — CHIEF, HYDROLOGY & METEOROLOGY SECTION
RECOMMENDED: Ben L. Peterson — CHIEF, ENGINEERING DIVISION
SUBMITTED: [signature] — CHIEF, PLANNING BRANCH
APPROVED: [signature] — COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER
DRAWN BY: C.R.M.
TRACED BY: H.S.B.
CHECKED BY: W.A.M.

DE-20-45/5

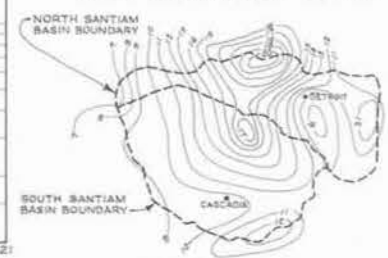
PLATE 5



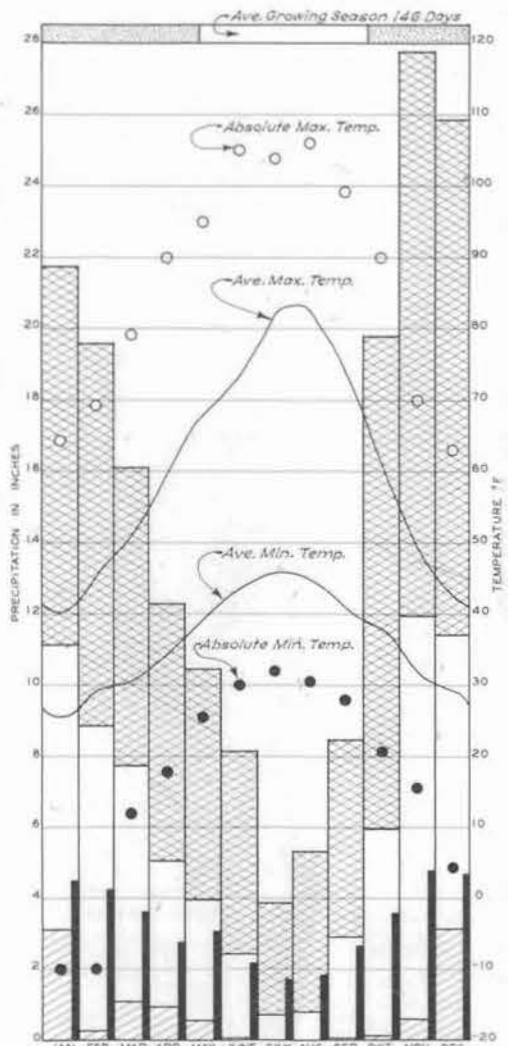
STORM OF NOVEMBER 1921
108 HOURS - 4 A.M. NOV. 18 TO 4 P.M. NOV. 22



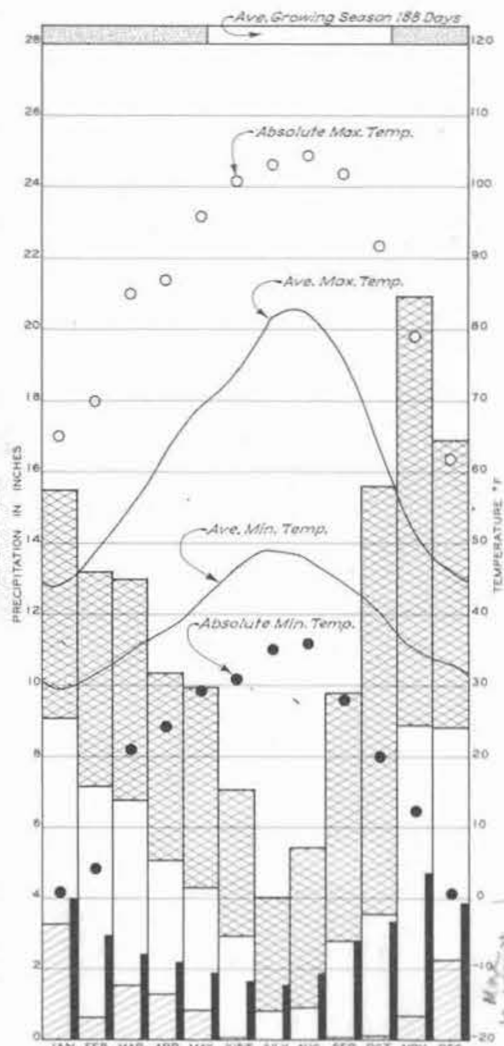
MASS PRECIPITATION CURVES



ISOHYETAL MAP

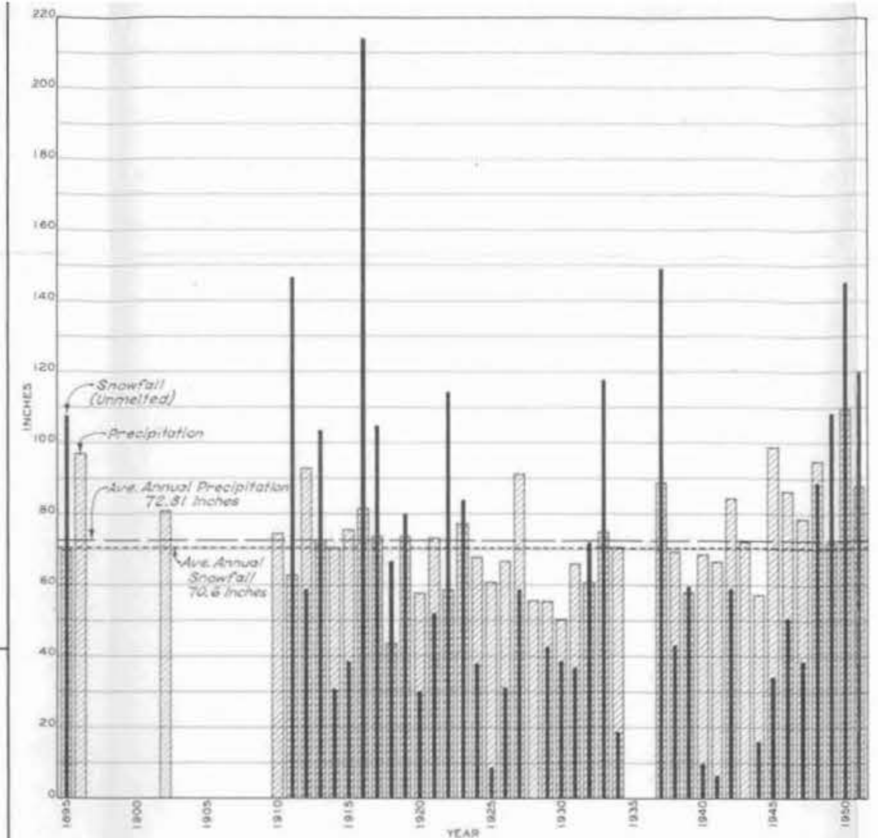


DETROIT, OREGON
ELEVATION 1450
PERIOD OF RECORD 1894-96, 1902-04, 1910-51

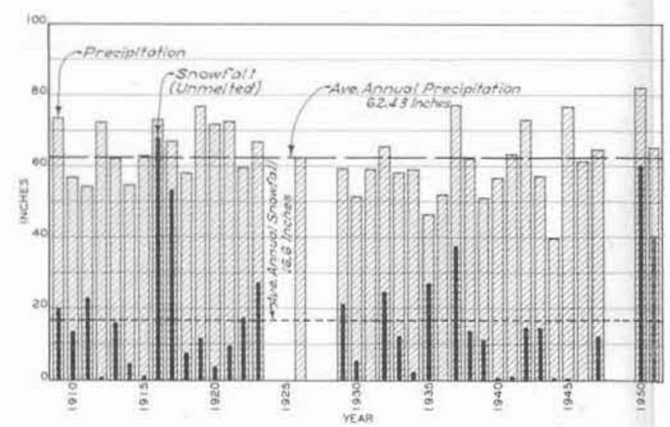


CASCADIA, OREGON
ELEVATION 796
PERIOD OF RECORD 1908-1951

MONTHLY PRECIPITATION AND TEMPERATURE



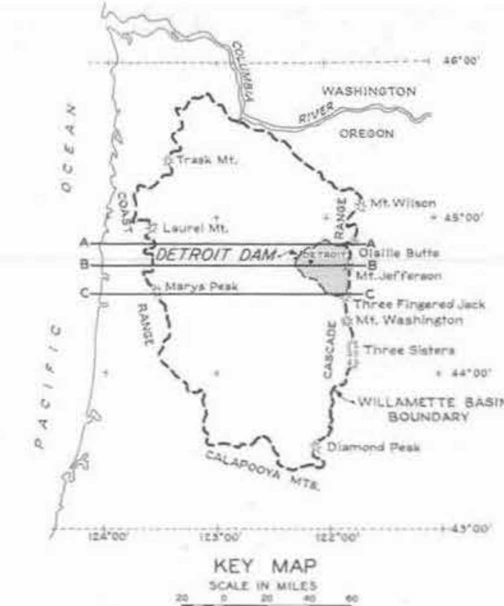
DETROIT, OREGON



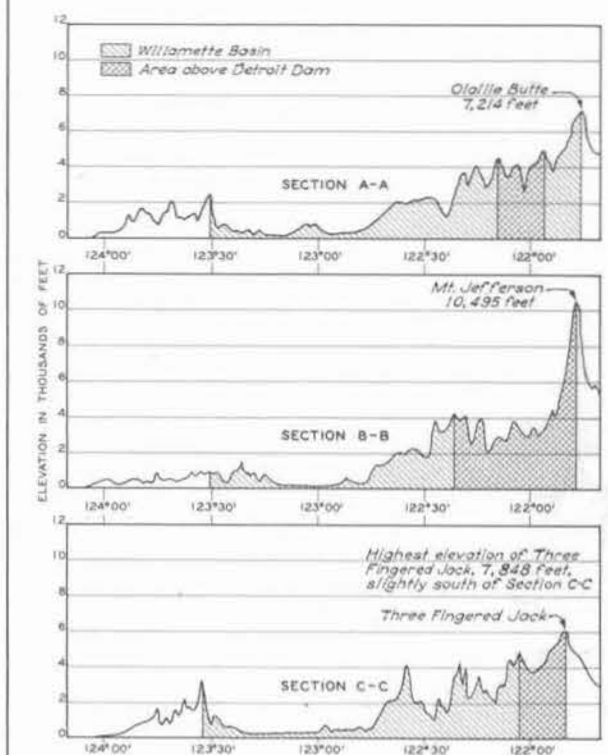
CASCADIA, OREGON

Notes:
1. No entry was made in years that data were missing or incomplete.
2. Annual snowfall is the total accumulation of unmelted snow that fell during the year.

ANNUAL PRECIPITATION AND SNOWFALL



KEY MAP



TOPOGRAPHIC PROFILES
ALONG SELECTED PARALLELS

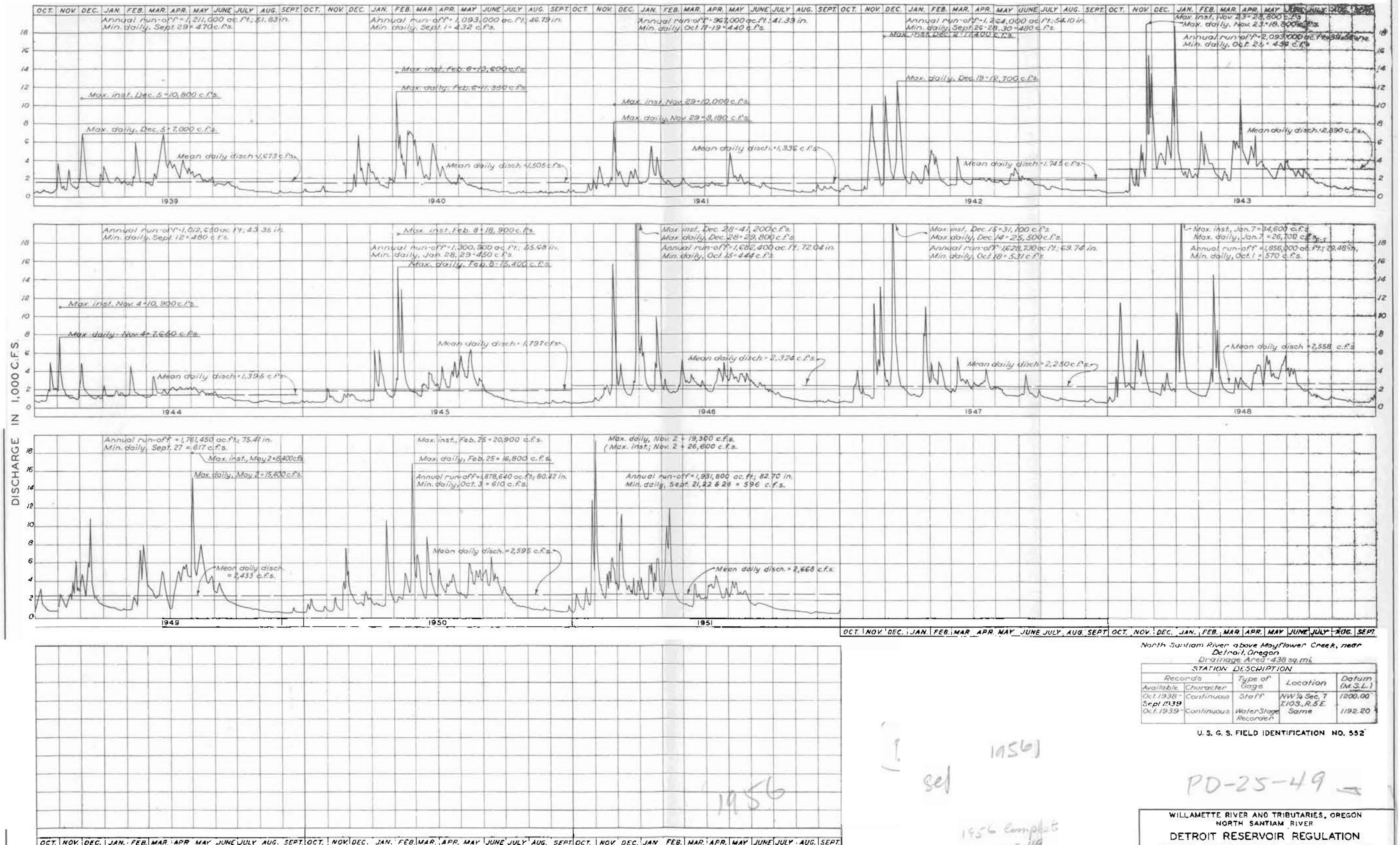
WILLAMETTE RIVER AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER
DETROIT RESERVOIR REGULATION

CLIMATIC CHARACTERISTICS

SCALES AS SHOWN
PORTLAND DISTRICT, CORPS OF ENGINEERS, SEPT. 1, 1953

DE-20-45/6

PLATE 6



North Santiam River above Mayflower Creek, near Detroit, Oregon
Drainage Area = 438 sq. mi.

STATION DESCRIPTION				
Records		Type of Gage	Location	Datum (M.S.L.)
Available	Character			
Oct. 1938 - Sept. 1939	Continuous	Staff	NW ¼ Sec. 7 T.10S., R.5E.	1200.00
Oct. 1939 -	Continuous	Water Stage Recorder	Same	1192.20

U. S. G. S. FIELD IDENTIFICATION NO. 552

PD-25-49

WILLAMETTE RIVER AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER

DETROIT RESERVOIR REGULATION

DAILY DISCHARGE HYDROGRAPH

NORTH SANTIAM RIVER
ABOVE MAYFLOWER CREEK
SCALES AS SHOWN

PORTLAND DISTRICT, CORPS OF ENGINEERS SEPT. 1, 1953

SUPERVISED: O. Pedersen
CHIEF, HYDROLOGY & METEOROLOGY SECTION

RECOMMENDED: Ben L. Peterson
CHIEF, ENGINEERING DIVISION

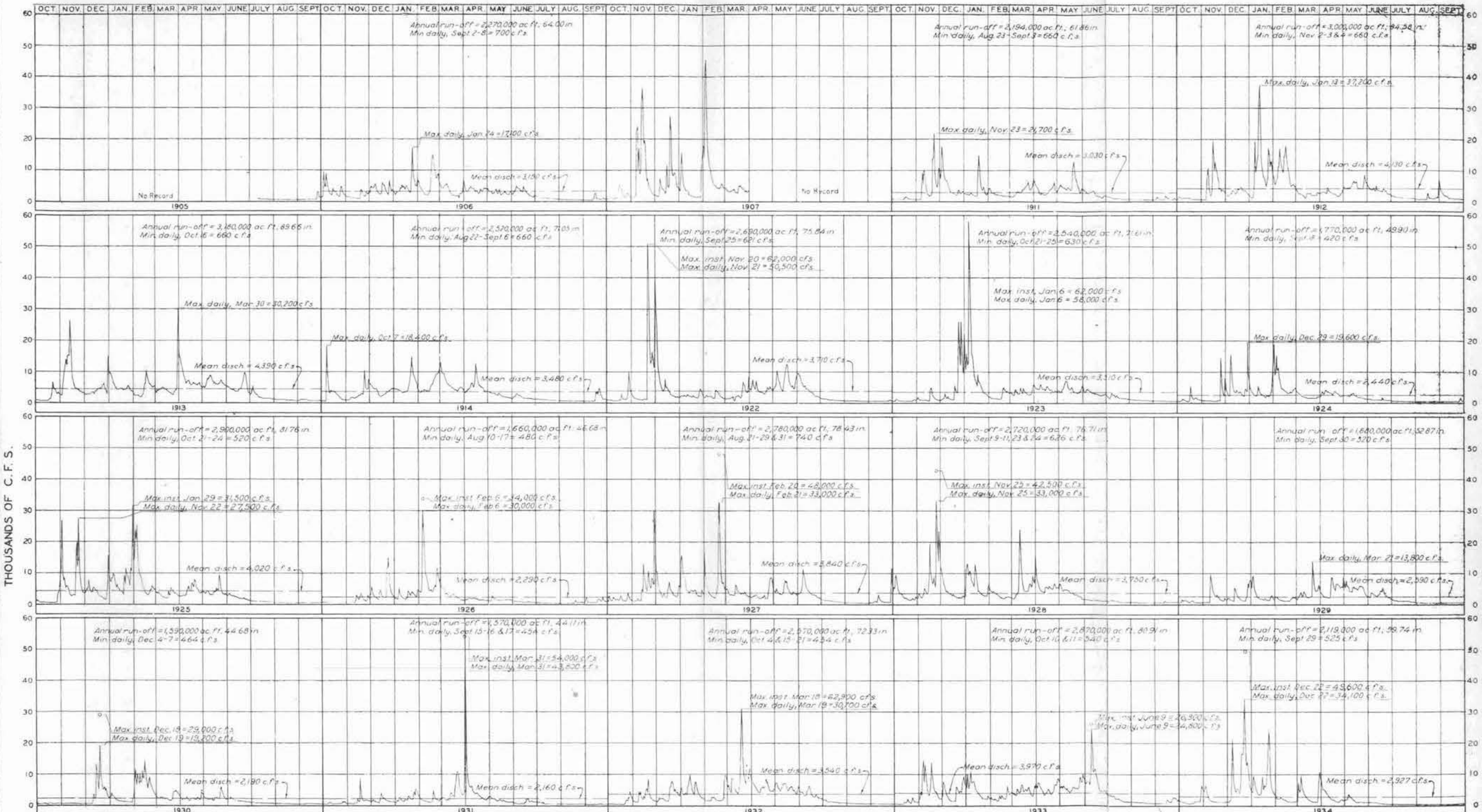
SUBMITTED: Fred C. [illegible]
CHIEF, PLANNING BRANCH

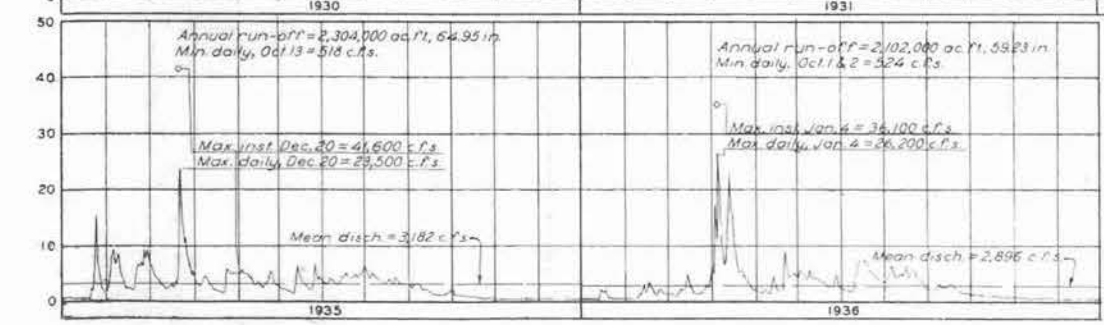
APPROVED: [illegible]
COLONEL, CORPS OF ENGINEERS
DISTRICT ENGINEER

DRAWN BY J.I.R.
TRACED BY C.S.G.-B.Y.
CHECKED BY L.H.M.

DE-20-45/13

PLATE 13





STATION DESCRIPTION

Station	Dr. Area Sq. Miles	Records Available	Records Character	Type of Gage	Location	Datum M.S.L.
Mehama	665 ①	July 1905 - Mar 1907	Broken	Staff	Sec. 18 T.9 S., R.2 E.	Not Detn.
"	665 ①	Oct 1910 - Sept 1913	"	"	Sec. 18 T.9 S., R.2 E.	Not Detn.
"	665	Sept 1921 - June 1933	"	"	NW ¼ Sec 18 T.9 S., R.2 E.	601.5 ②
"	665	June 1933 - Sept 1947	Continuous	W. S. Recorder	NW ¼ Sec 18 T.9 S., R.2 E.	601.78

U.S.G.S. FIELD IDENTIFICATION NO. 554

① Not determined until later date; 740 sq. mi. drainage area shown in Water Supply Papers prior to 1913 is in error.

WILLAMETTE RIVER AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER

DETROIT RESERVOIR REGULATION
DAILY DISCHARGE HYDROGRAPH
NORTH SANTIAM RIVER
AT MEHAMA, OREGON

IN 2 SHEETS — SCALES AS SHOWN — SHEET NO. 1

PORTLAND DISTRICT, CORPS OF ENGINEERS, SEPT. 1, 1958

PREPARED: C. Pedersen — RECOMMENDED: Ben L. Peterson

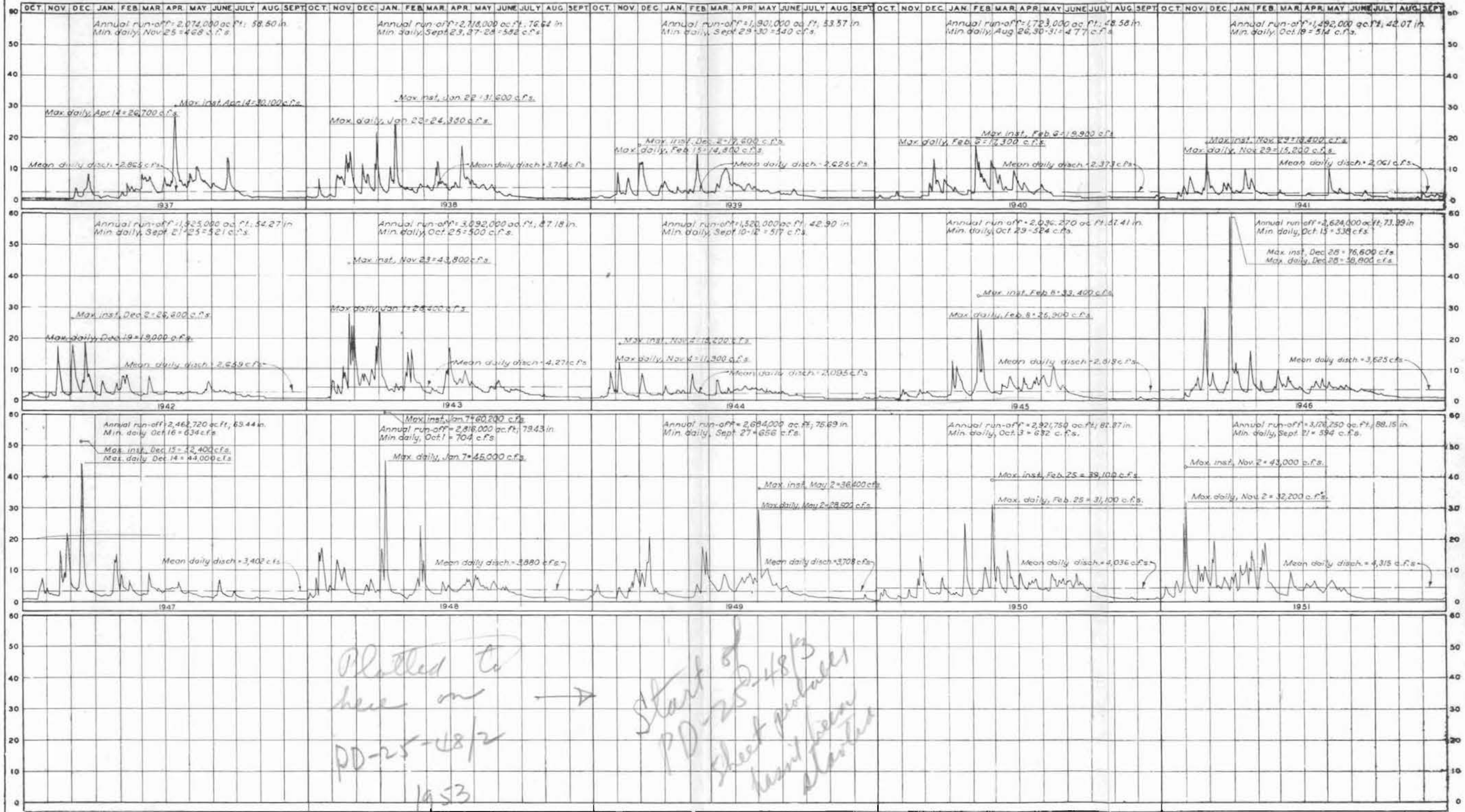
SUBMITTED: [signature] — APPROVED: [signature]

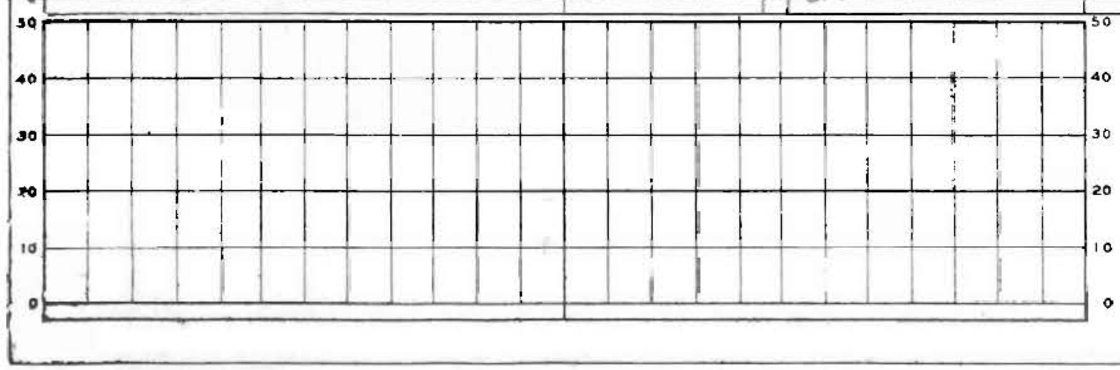
DRAWN BY: C.T.S.–L.M.M.
TRACED BY: R.J.S.
CHECKED BY: D.L.B.

DE-20-45/14

WB-05-3/32

PLATE 14





North Santiam River at Mehama, Oregon
Drainage Area: 665 sq.mi.

STATION DESCRIPTION

Records Available	Records Character	Type of Gage	Location	Datum (M.S.L.)
1933-	Continuous	Water-Stage Recorder	NW¼ Sec.18, T.9S. R.2E. 200 ft. down stream from staff gage location	401.78

U.S.G.S. FIELD IDENTIFICATION NO. 554

WB-05-3133

WILLAMETTE RIVER AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER

DETROIT RESERVOIR REGULATION

DAILY DISCHARGE HYDROGRAPH

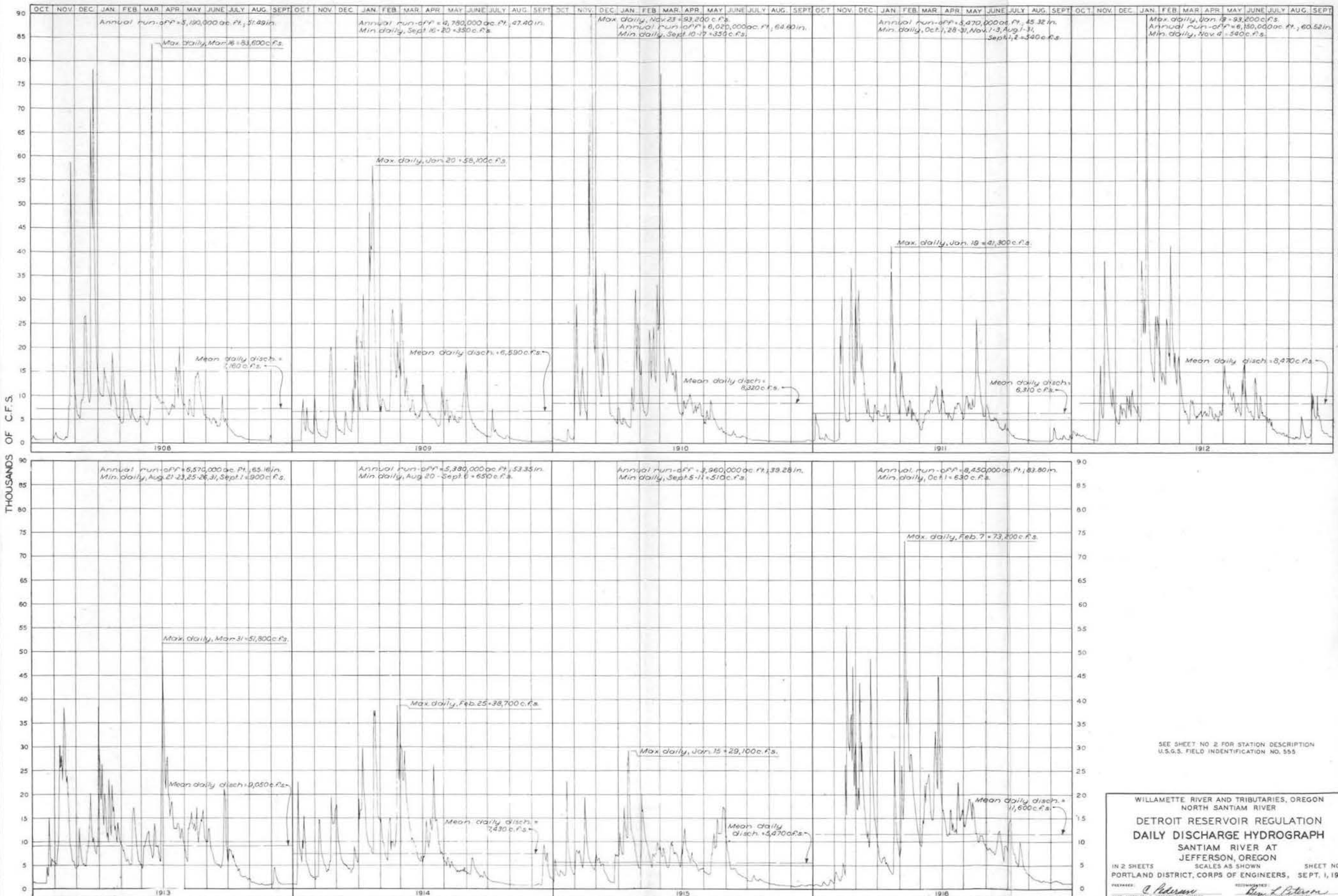
NORTH SANTIAM RIVER
AT MEHAMA, OREGON

IN 2 SHEETS SCALES AS SHOWN SHEET NO. 2

PORTLAND DISTRICT, CORPS OF ENGINEERS, SEPT. 1, 1953

DE-20-45/15

PLATE 15



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

WILLAMETTE RIVER AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER

DETROIT RESERVOIR REGULATION

DAILY DISCHARGE HYDROGRAPH

SANTIAM RIVER AT
JEFFERSON, OREGON

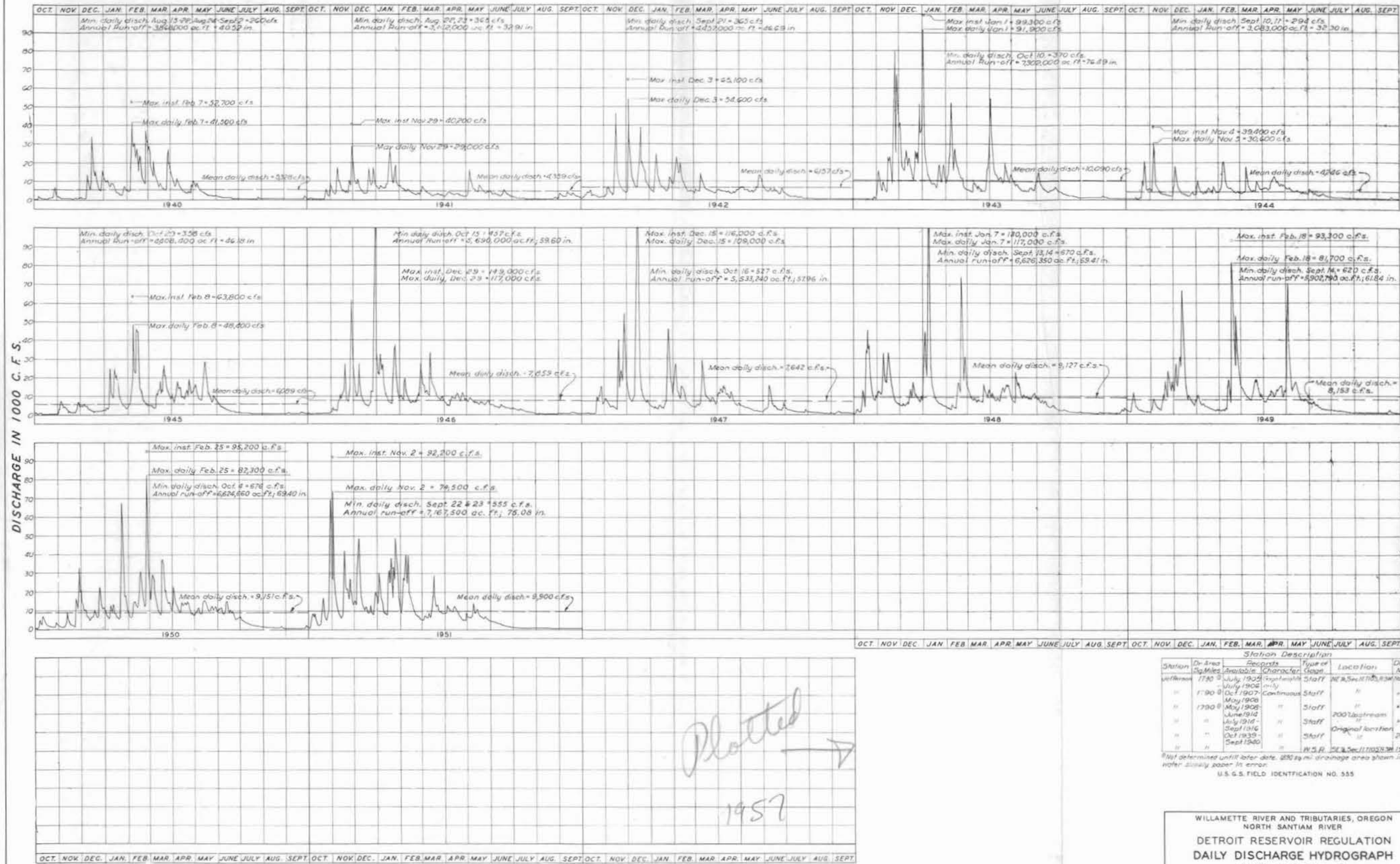
IN 2 SHEETS — SCALES AS SHOWN — SHEET NO. 1

PORTLAND DISTRICT, CORPS OF ENGINEERS, SEPT. 1, 1953

PREPARED: C. Pedersen — CHIEF, HYDROLOGY & METEOROLOGY SECTION
RECOMMENDED: Ben L. Peterson — CHIEF, ENGINEERING DIVISION
SUBMITTED: Fred C. Sayre — CHIEF, PLANNING BRANCH
APPROVED: — COLONEL, C.E. DISTRICT ENGINEER

DRAWN BY: L.M.W.-C.F.R.
TRACED BY: R.V.M.
CHECKED BY: R.L.C.

DE-20-45/16



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	Gage heights only	Staff	NE ¼ Sec. 11 T10S, R3W	Not det.
"	1790 ⓐ	Oct. 1907 - May 1908	Continuous	Staff	"	" "
"	1790 ⓐ	May 1908 - June 1914	"	Staff	"	" "
"	"	July 1914 - Sept 1916	"	Staff	200' Upstream "	" "
"	"	Oct. 1939 - Sept 1940	"	Staff	Original location "	202.63
"	"		"	W.S.R.	SE ¼ 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 AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER

DETROIT RESERVOIR REGULATION
DAILY DISCHARGE HYDROGRAPH
SANTIAM RIVER AT JEFFERSON, OREGON

IN 2 SHEETS — SCALES AS SHOWN — SHEET NO. 2

PORTLAND DISTRICT, CORPS OF ENGINEERS, SEPT. 1, 1953

PREPARED: C. Pedersen — CHIEF, HYDROLOGY & METEOROLOGY SECTION

RECOMMENDED: Ben L. Peterson — CHIEF, ENGINEERING DIVISION

SUBMITTED: Fred C. Ingram — CHIEF, PLANNING BRANCH

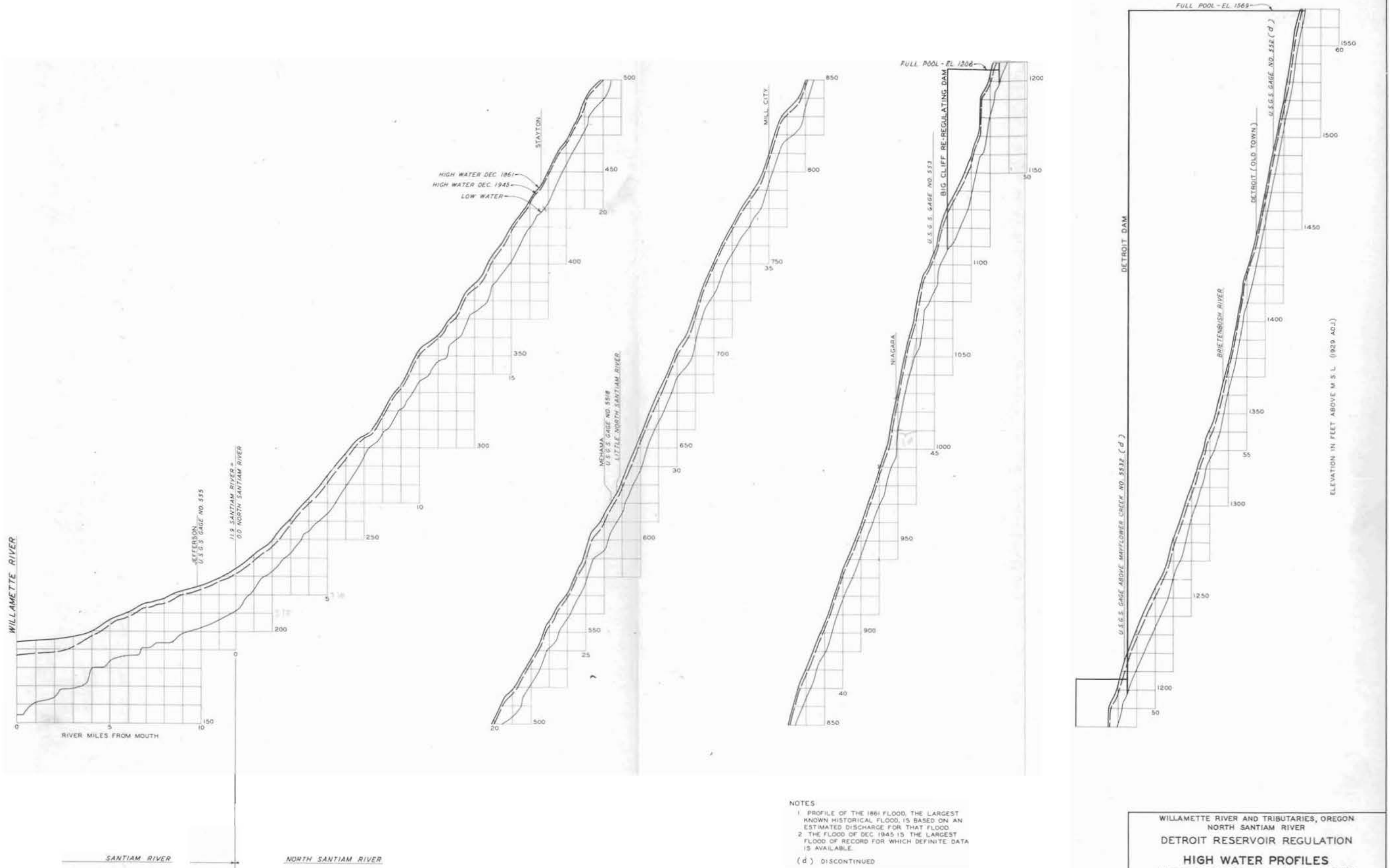
APPROVED: [signature] — COLONEL, C.E., DISTRICT ENGINEER

DRAWN BY: L.M.H. / C.P.B.
TRACED BY: M.E.B.
CHECKED BY: S.L.B.

DE-20-45/17

RD-25-10/2

PLATE 17



NOTES:

1. PROFILE OF THE 1861 FLOOD, THE LARGEST KNOWN HISTORICAL FLOOD, IS BASED ON AN ESTIMATED DISCHARGE FOR THAT FLOOD.
2. THE FLOOD OF DEC. 1945 IS THE LARGEST FLOOD OF RECORD FOR WHICH DEFINITE DATA IS AVAILABLE.

(d) DISCONTINUED

WILLAMETTE RIVER AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER

DETROIT RESERVOIR REGULATION

HIGH WATER PROFILES

FLOODS OF DEC. 1861 AND DEC. 1945

SCALES AS SHOWN

PORTLAND DISTRICT, CORPS OF ENGINEERS SEPT. 1, 1953

SUPERVISED: [signature] CHIEF, HYDROLOGY & METEOROLOGY SECTION	RECOMMENDED: Ben L. Peterson CHIEF, ENGINEERING DIVISION
SUBMITTED: [signature] CHIEF, PLANNING BRANCH	APPROVED: [signature] COLONEL, C.E. DISTRICT ENGINEER

DE-20-45/18

PLATE 18

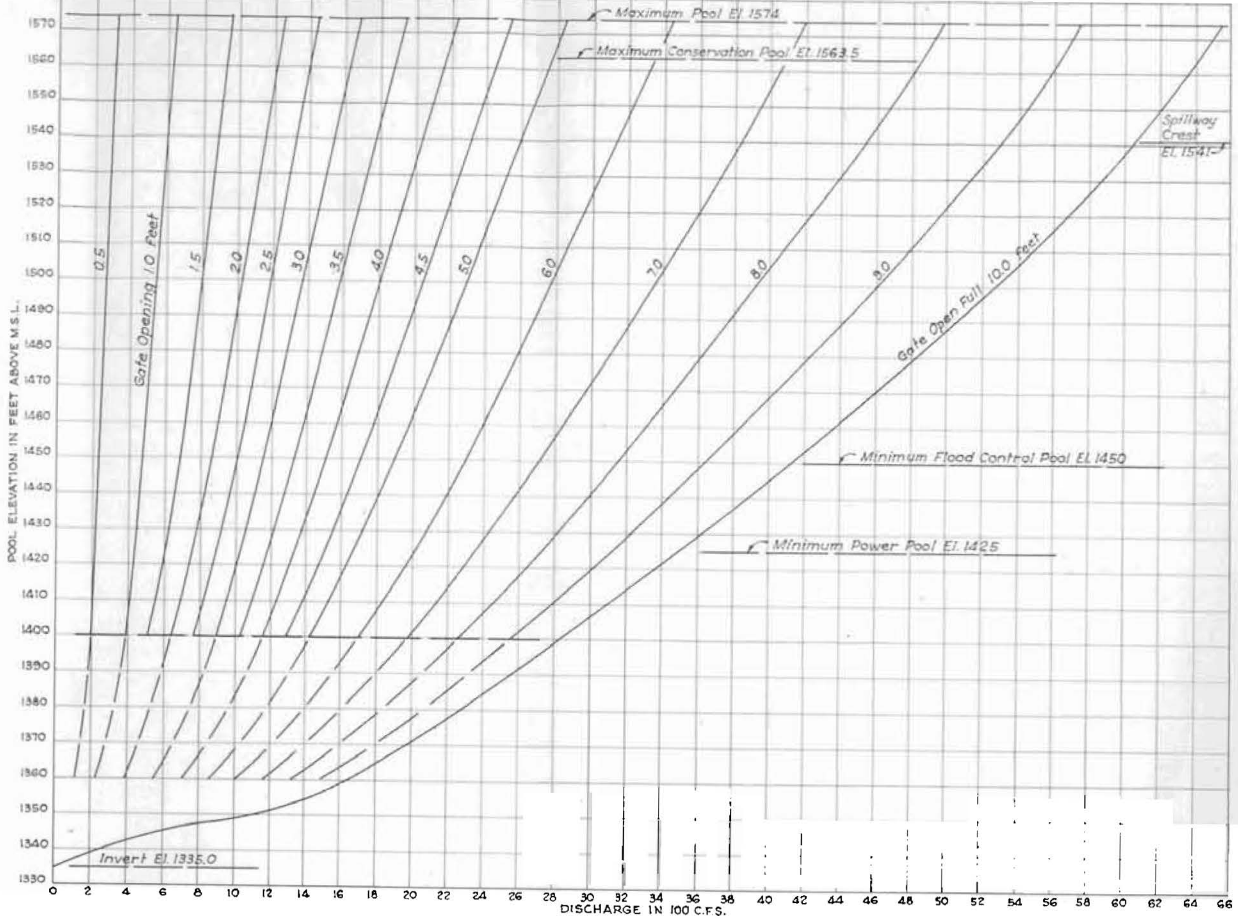


FIGURE 1. DETROIT RESERVOIR - UPPER SERVICE OUTLETS
DISCHARGE RATING FOR ONE GATE

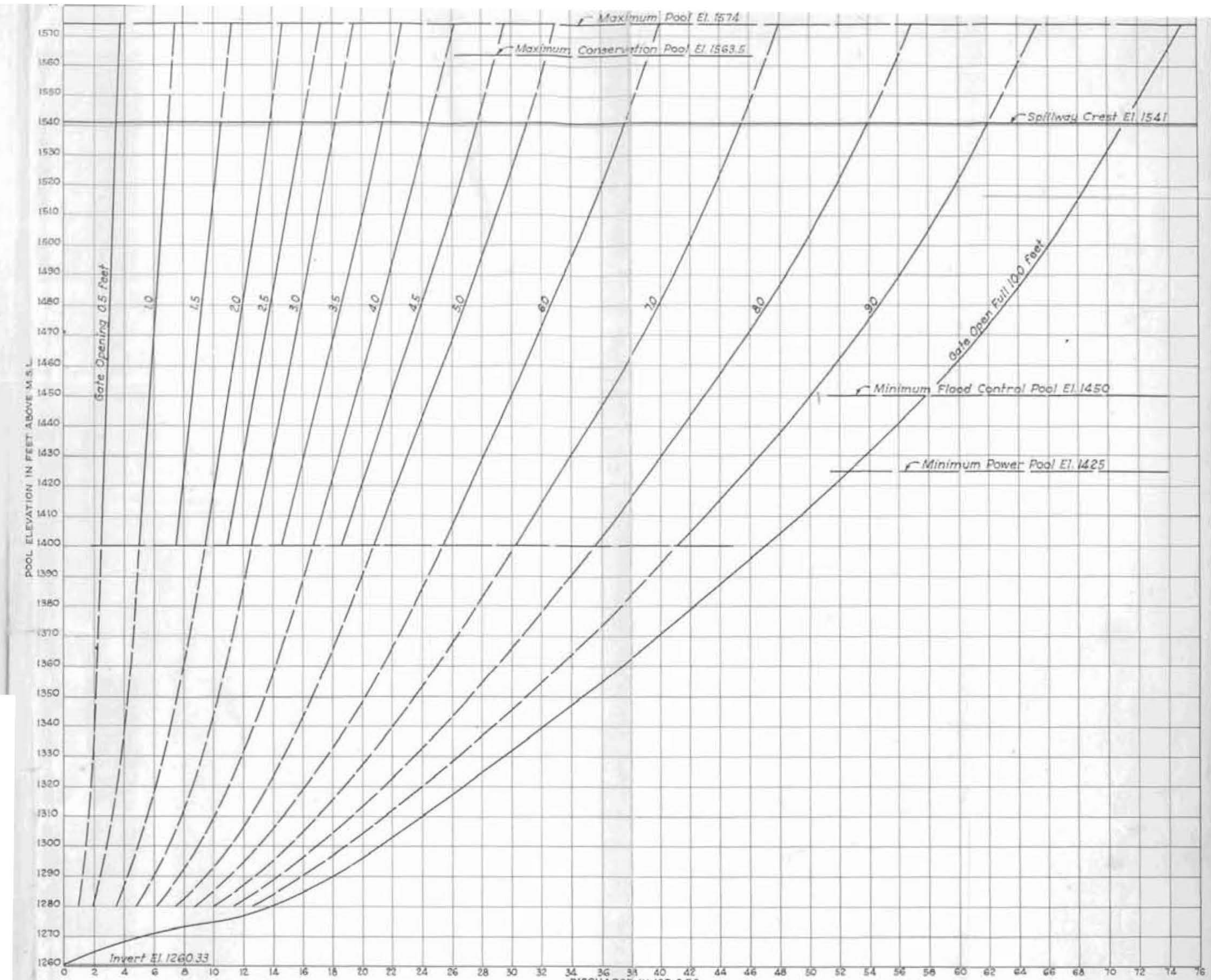


FIGURE 2. DETROIT RESERVOIR - LOWER SERVICE OUTLETS
DISCHARGE RATING FOR ONE GATE

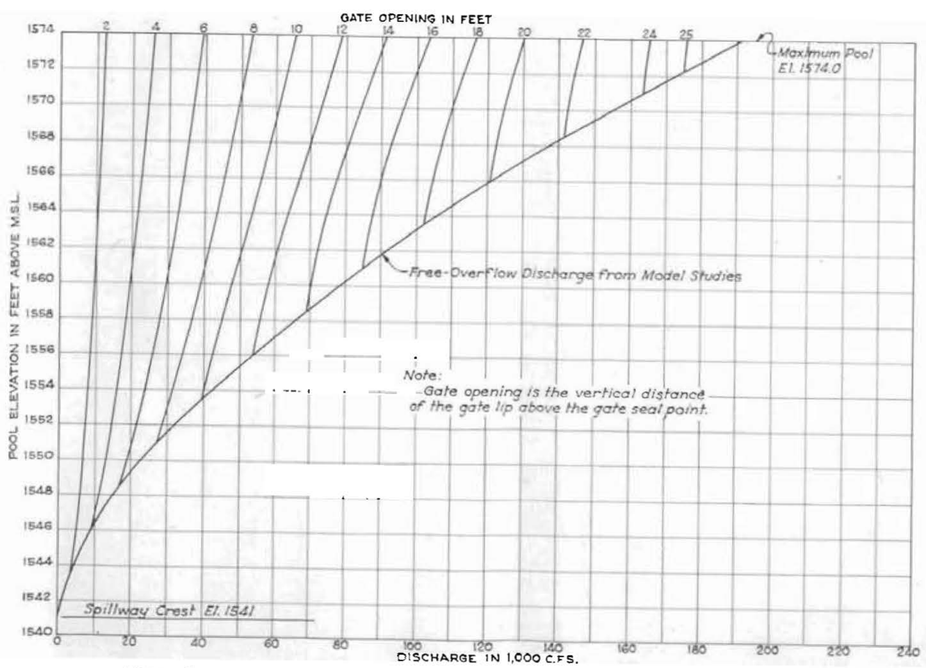


FIGURE 3. DETROIT SPILLWAY DISCHARGE RATING FOR SIX GATES

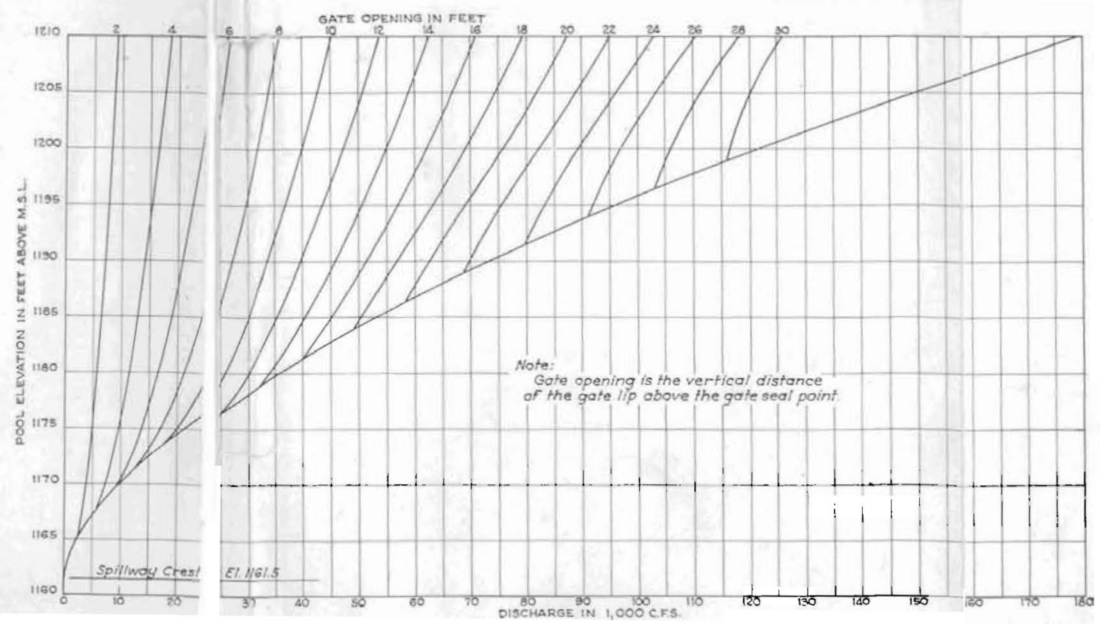


FIGURE 4. BIG CLIFF SPILLWAY DISCHARGE RATING FOR THREE GATES

Notes:

1. Detroit Dam has two tiers of service outlets of two outlets each. Gates are of vertical lift type, 5'-8" wide x 10'-0" high.
2. Service gate discharge curves for gate openings of 1 to 4 feet inclusive and 10 feet are constructed from prototype data. Gate opening curves from 5 to 9 feet inclusive are constructed to be consistent with observed prototype data.
3. Tabulations of discharges of upper and lower service gates are shown in Tables 4 and 5, respectively.
4. Detroit Dam spillway has six radial gates, each 42'-0" long x 31'-0" high.
5. Big Cliff Dam spillway has three radial gates, each 46'-0" long x 44'-6" high.
6. The free-overflow curve for Detroit was derived from model studies, and the rating curves for partial gate openings were computed. Both the free-overflow and partial gate opening curves for the Big Cliff spillway were computed.
7. Tabulations of discharge ratings of one spillway gate for Detroit and Big Cliff dams are shown in Tables 6 and 8 respectively.

WILLAMETTE RIVER AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER

DETROIT RESERVOIR REGULATION

GATE RATING CURVES

SCALES AS SHOWN
PORTLAND DISTRICT, CORPS OF ENGINEERS. SEPT. 1, 1953

SUPERVISED: C. Pedersen — CHIEF, HYDROLOGY & METEOROLOGY SECTION
RECOMMENDED: Ben L. Peterson — CHIEF, ENGINEERING DIVISION
SUBMITTED: Fred C. Jorgensen — CHIEF, PLANNING BRANCH
APPROVED: — COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER
DRAWN BY:
TRACED BY:
CHECKED BY:

DE-20-45/19

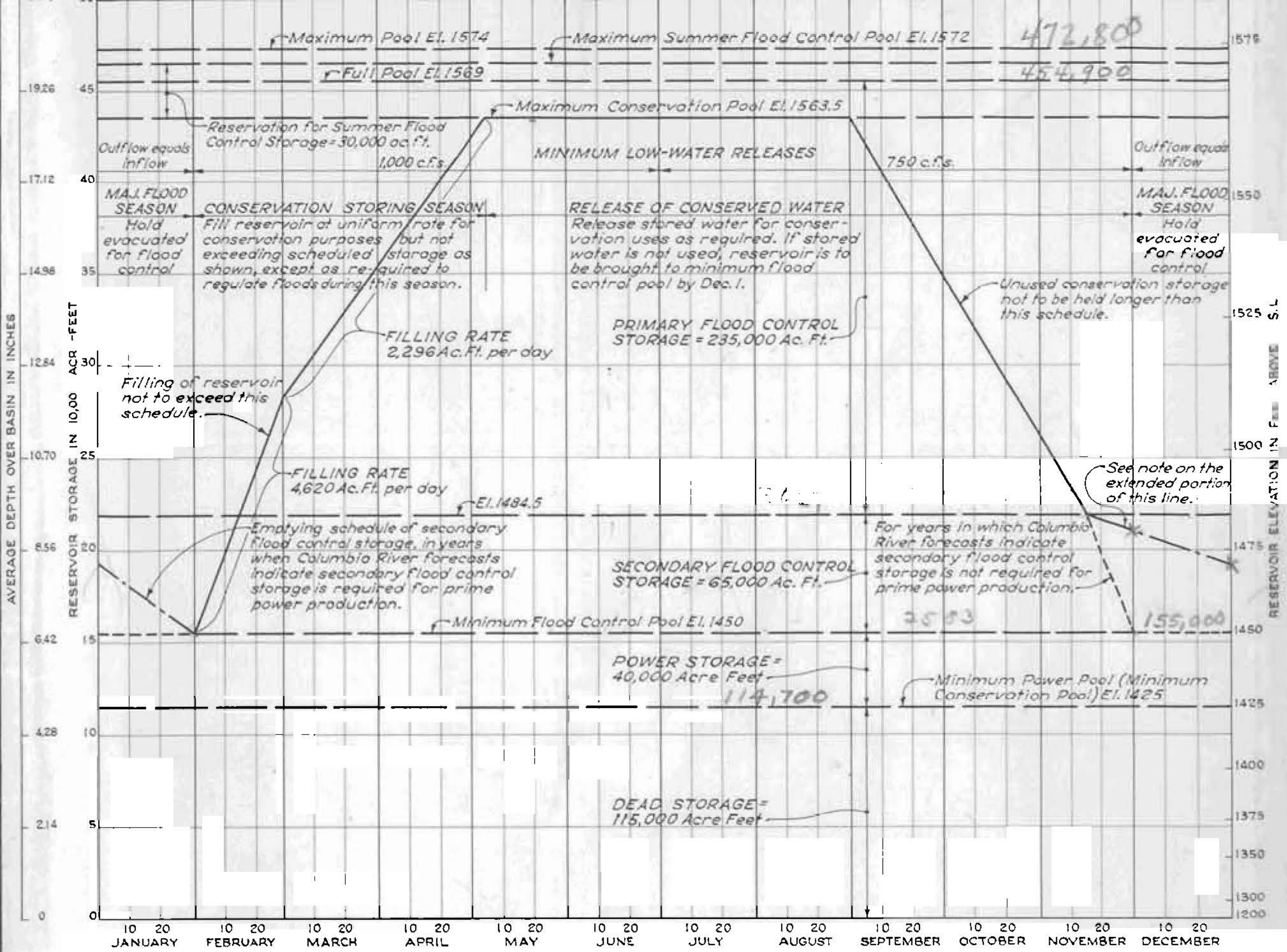
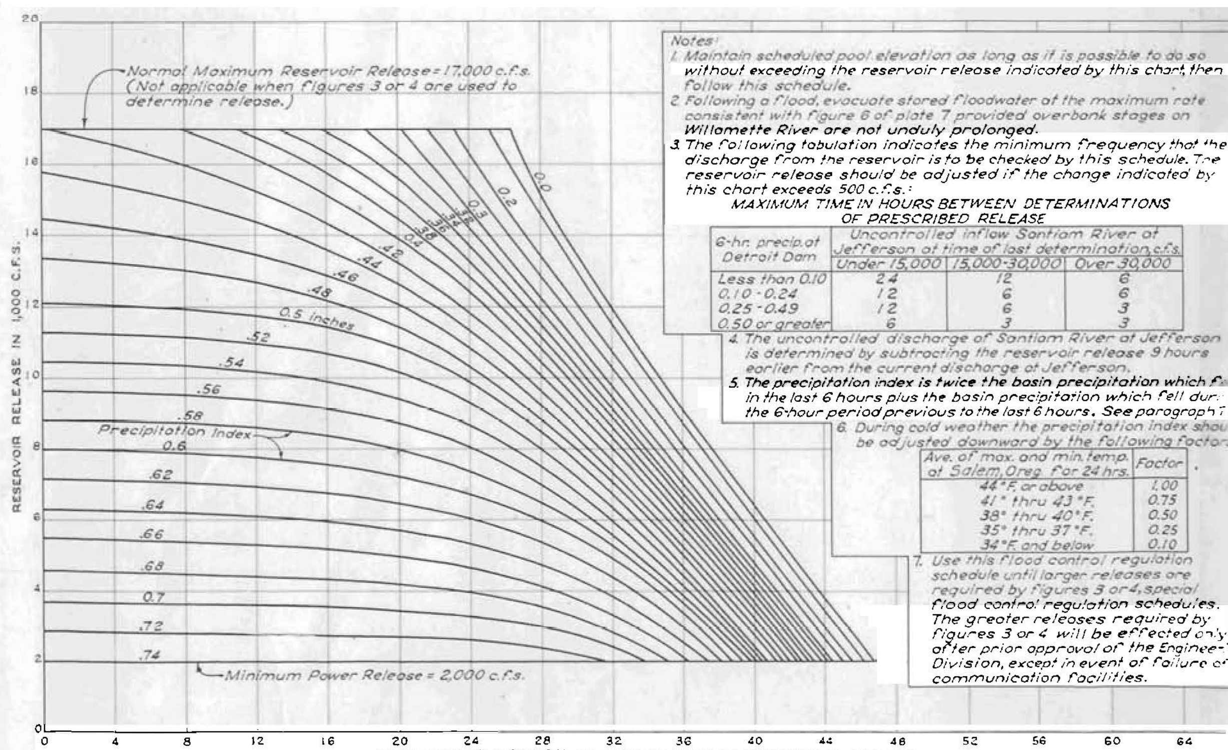


FIGURE 1

SEASONAL REGULATION SCHEDULE



6-hr. precip. at Detroit Dam	Uncontrolled inflow Santiam River at Jefferson at time of last determination, c.f.s. Under 15,000	15,000-30,000	Over 30,000
Less than 0.10	24	12	6
0.10 - 0.24	12	6	6
0.25 - 0.49	12	6	3
0.50 or greater	6	3	3

Ave. of max. and min. temp. at Salem, Oreg. for 24 hrs.	Factor
44° F. or above	1.00
41° thru 43° F.	0.75
38° thru 40° F.	0.50
35° thru 37° F.	0.25
34° F. and below	0.10

FIGURE 2

FLOOD CONTROL REGULATION SCHEDULE

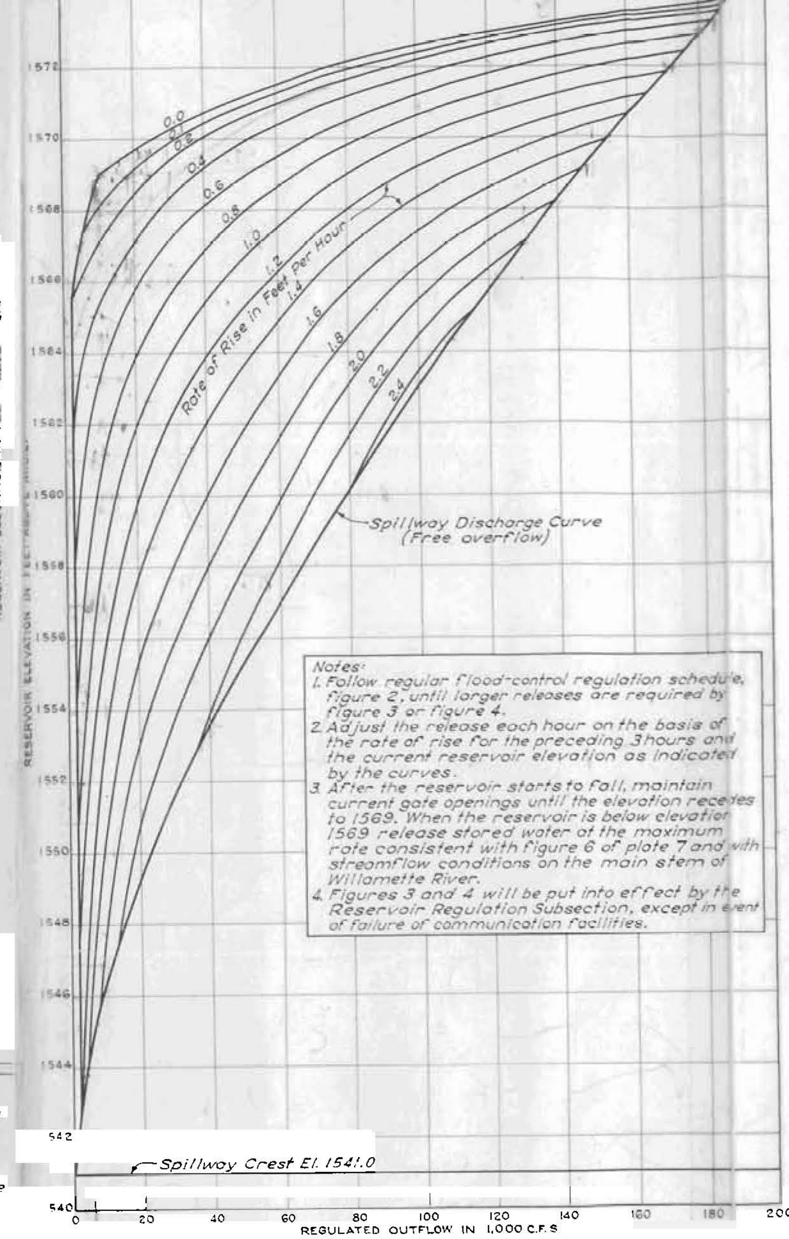


FIGURE 3

SPECIAL FLOOD CONTROL REGULATION SCHEDULE

NOVEMBER - MARCH

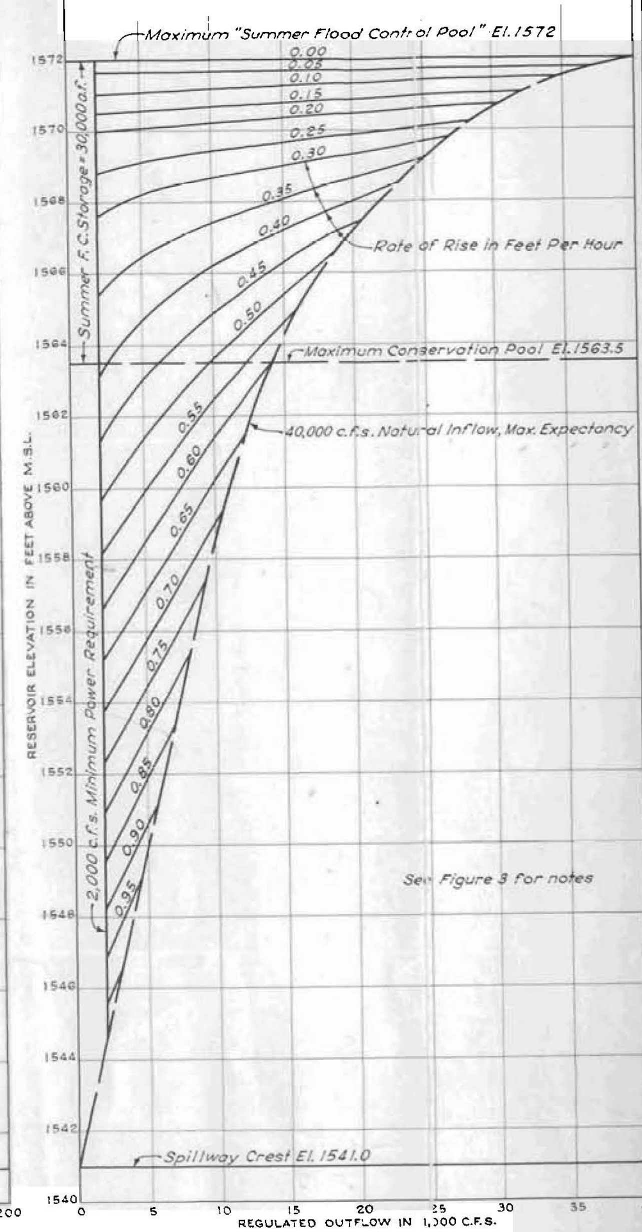


FIGURE 4

SPECIAL FLOOD CONTROL REGULATION SCHEDULE

APRIL - OCTOBER

WILLAMETTE RIVER AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER

DETROIT RESERVOIR REGULATION

REGULATION SCHEDULES

SCALES AS SHOWN

PORTLAND DISTRICT, CORPS OF ENGINEERS, SEPT. 1, 1953

SUPERVISED: C. Pedersen, CHIEF, HYDROLOGY & METEOROLOGY SECTION
RECOMMENDED: Ben L. Peterson, CHIEF, ENGINEERING DIVISION
SUBMITTED: CHIEF, PLANNING BRANCH
APPROVED: COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER
DRAWN BY
TRACED BY
CHECKED BY

DE-20-45/20

PLATE 20

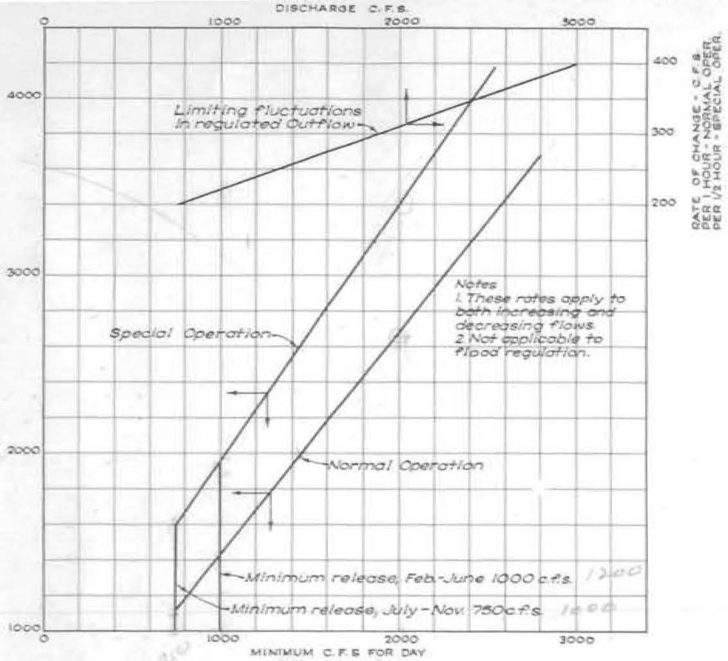


FIGURE 1
MAXIMUM AND MINIMUM RELEASES AND ALLOWABLE RATE OF CHANGE
BIG CLIFF RESERVOIR

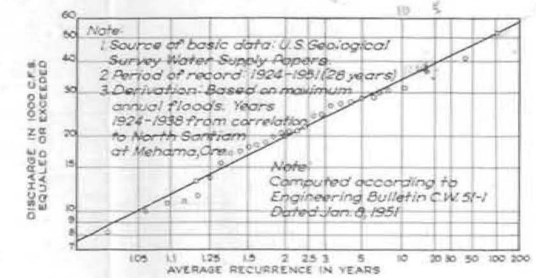


FIGURE 2
FLOOD FREQUENCY - DETROIT RESERVOIR INFLOW
NORTH SANTIAM RIVER NEAR DETROIT

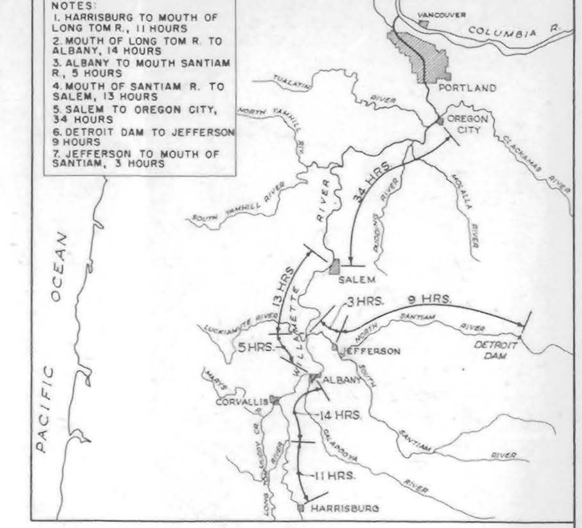


FIGURE 3
AVERAGE TRAVEL TIME OF FLOOD FLOWS
SCALE IN MILES

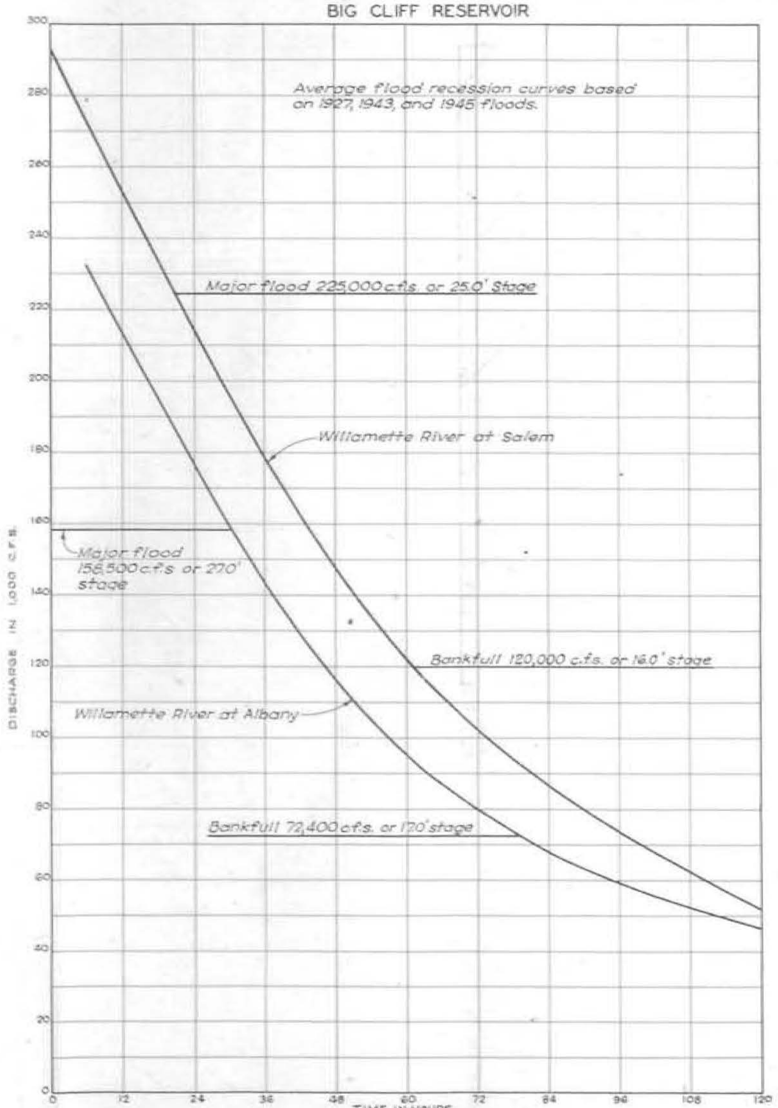


FIGURE 4
TYPICAL FLOOD RECESSION CURVES
WILLAMETTE RIVER

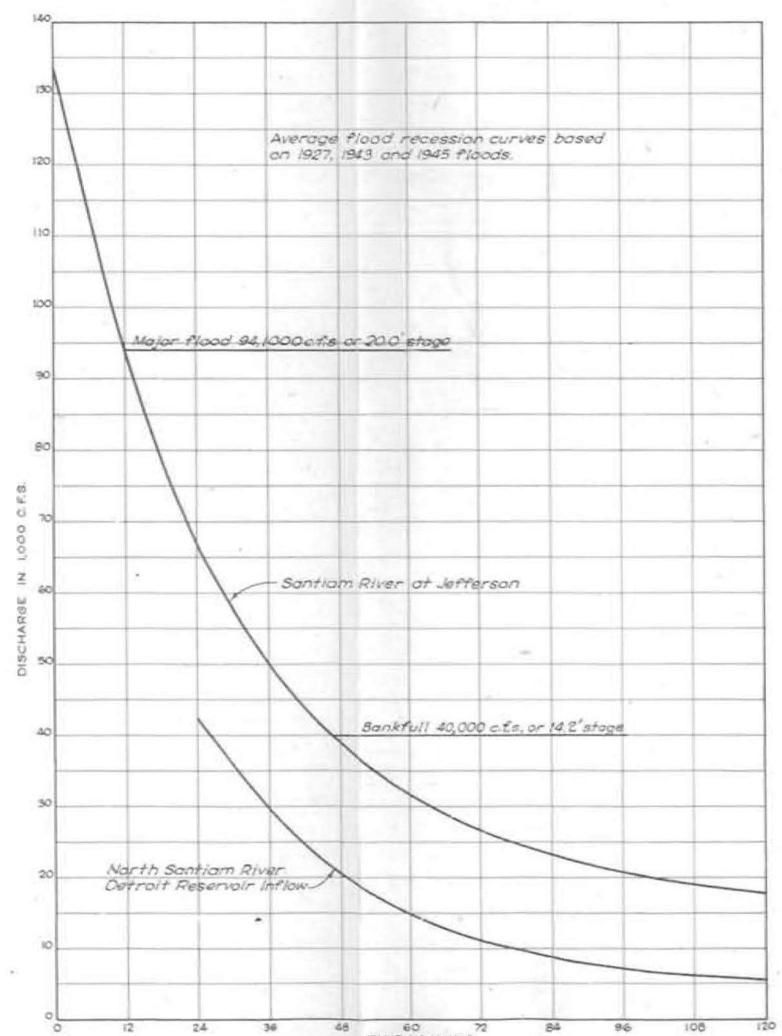


FIGURE 5
TYPICAL FLOOD RECESSION CURVES
SANTIAM RIVER

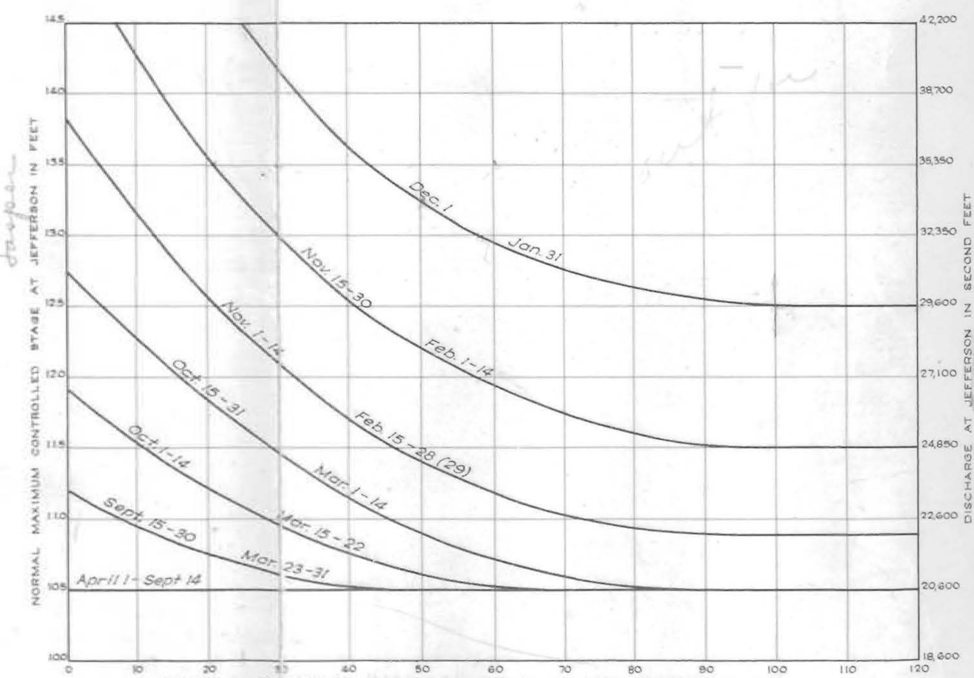


FIGURE 6
DOWNSTREAM CRITERIA FOR POST-FLOOD EVACUATION
DETROIT RESERVOIR

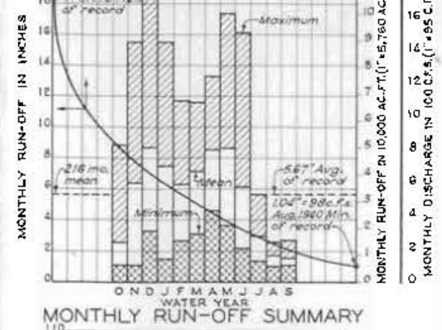
WILLAMETTE RIVER AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER
DETROIT RESERVOIR REGULATION
RESERVOIR REGULATION AIDS

SCALES AS SHOWN
PORTLAND DISTRICT, CORPS OF ENGINEERS, SEPT. 1, 1953

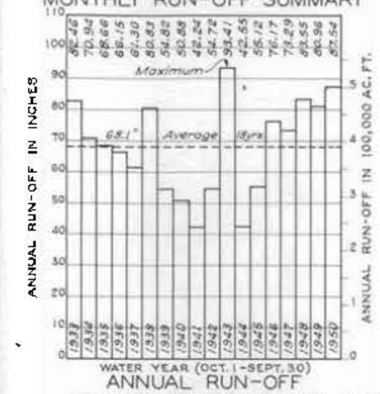
SUPERVISED: A. Pedersen — CHIEF, HYDROLOGY & METEOROLOGY SECTION
RECOMMENDED: Ben L. Peterson — CHIEF, ENGINEERING DIVISION
SUBMITTED: Paul C. Jurgensen — CHIEF, PLANNING BRANCH
APPROVED: — COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER
DRAWN BY: C.R.M.
TRACED BY: K.J.B.
CHECKED BY: W.A.M.

DE-20-45/7

PLATE 7



MONTHLY RUN-OFF SUMMARY

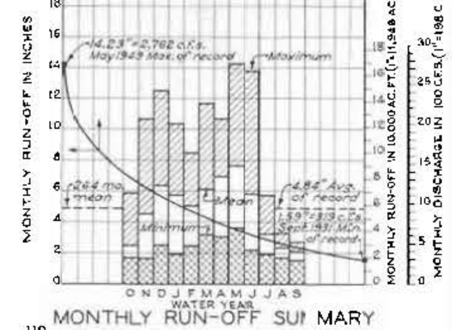


ANNUAL RUN-OFF

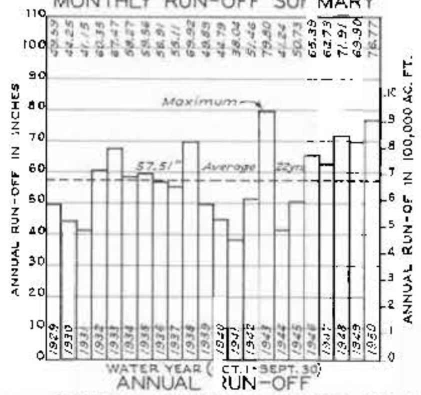
Records: Discharge records are available only for 1933-1950, 18 years. This study is based on the monthly discharges published by the U.S.G.S. for these 18 yrs. (216 months).

BREITENBUSH RIVER ABOVE FRENCH CREEK

DRAINAGE AREA = 106 SQ. MI.



MONTHLY RUN-OFF SUMMARY



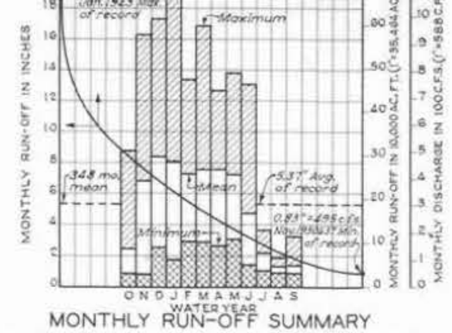
ANNUAL RUN-OFF

Records: Discharge records are available for 1907, 1908, 1909 and 1929-1950. This study is based on the monthly discharges published by the U.S.G.S. for the 22 year period 1929-1950 (264 months).

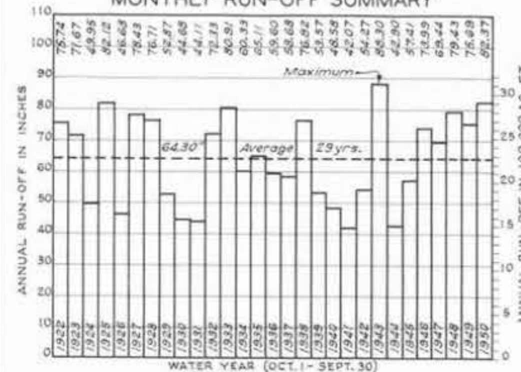
Note: The data used is based on measurements and records obtained at the original town site of Detroit, Oregon.

NORTH SANTIAM RIVER AT DETROIT, OREGON

DRAINAGE AREA = 224 SQ. MI.



MONTHLY RUN-OFF SUMMARY



ANNUAL RUN-OFF

Records: Discharge records are available for 1906, 1907, 1911-1914, and 1922-1950. This study is based on the monthly discharges published by the U.S.G.S. for the 29 year period 1922-1950 (348 months).

NORTH SANTIAM RIVER AT MEHAMA, OREGON

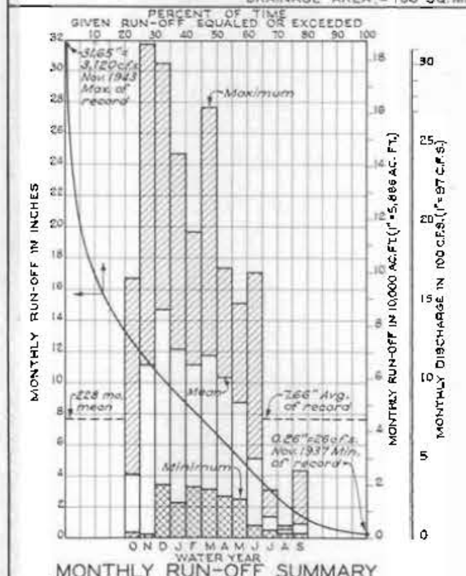
DRAINAGE AREA = 665 SQ. MI.

INDEX MAP

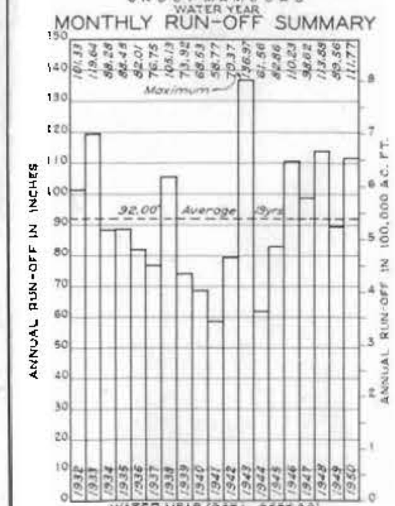
SCALE IN MILES

U.S.G.S. STATIONS

5525 BREITENBUSH RIVER ABOVE FRENCH CREEK
552 NORTH SANTIAM RIVER AT DETROIT, OREGON
554 NORTH SANTIAM RIVER AT MEHAMA, OREGON
5518 LITTLE NORTH SANTIAM RIVER NEAR MEHAMA, OREGON
5516 SOUTH SANTIAM RIVER AT WATERLOO, OREGON
555 SANTIAM RIVER AT JEFFERSON, OREGON



MONTHLY RUN-OFF SUMMARY

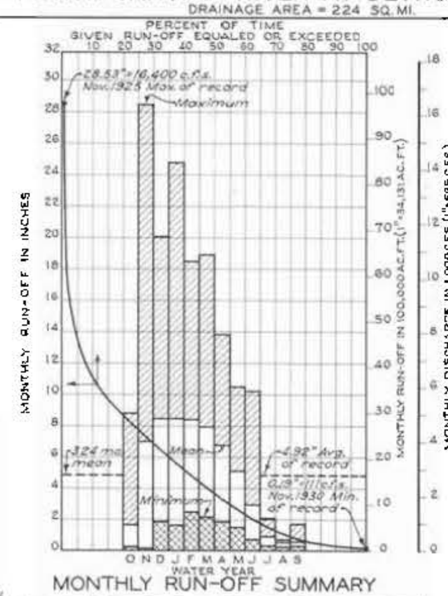


ANNUAL RUN-OFF

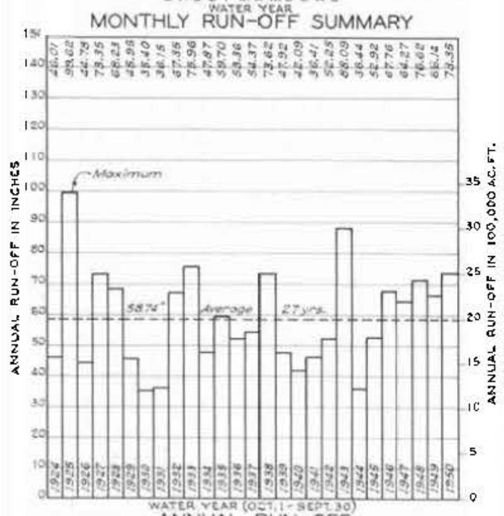
Records: Discharge records are available only for 1932-1950, 19 years. This study is based on the monthly discharges published by the U.S.G.S. for these 19 years (228 months).

LITTLE NORTH SANTIAM RIVE NEAR MEHAMA, OREGON

DRAINAGE AREA = 110 SQ. MI.



MONTHLY RUN-OFF SUMMARY

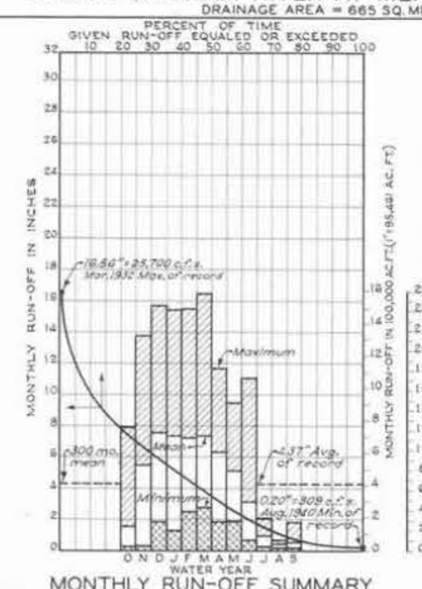


ANNUAL RUN-OFF

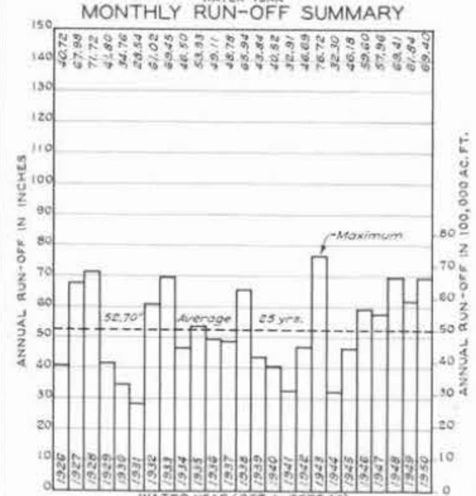
Records: Discharge records are available for 1906, 1907 and 1924-1950. This study is based on the monthly discharges published by the U.S.G.S. for the 27 year period, 1924-1950, (324 months).

SOUTH SANTIAM RIVER AT WATERLOO, OREGON

DRAINAGE AREA = 640 SQ. MI.



MONTHLY RUN-OFF SUMMARY



ANNUAL RUN-OFF

Records: Discharge records are available for 1940-1945 from observations at Jefferson. No adjustment was made for diversions above station. This study is based on the mean monthly flows for 1926-1939 obtained by correlation with North Santiam River at Mehama and South Santiam River at Waterloo plus the discharges published by the U.S.G.S. for the period 1940-1950, to obtain a total study period of 25 years (300 months) 1926-1950.

SANTIAM RIVER AT JEFFERSON, OREGON

DRAINAGE AREA = 1,790 SQ. MI.

Eugene
Lowell
Fall Creek

WILLAMETTE RIVER AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER

DETROIT RESERVOIR REGULATION

RUN-OFF SUMMARY

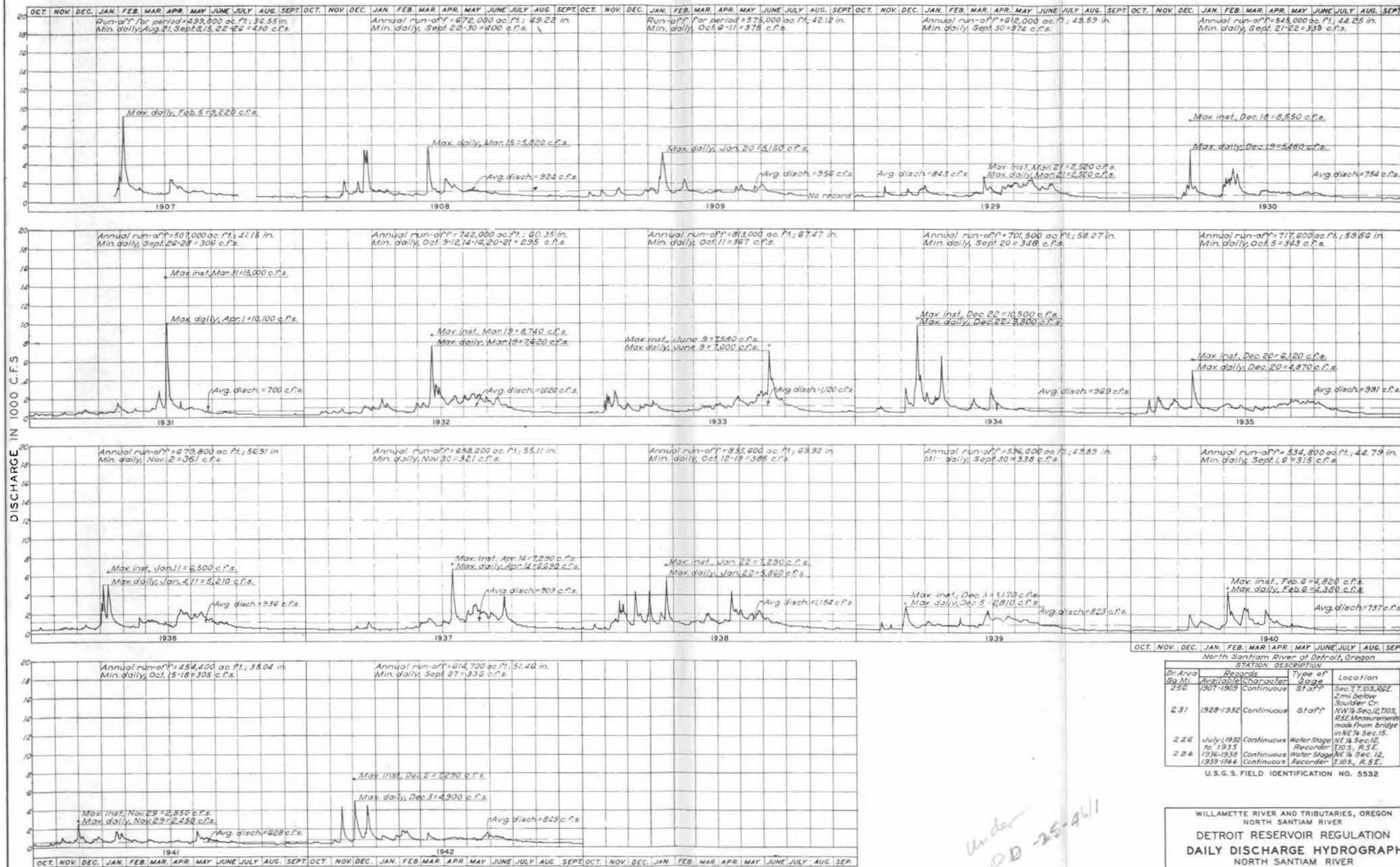
SCALES AS SHOWN

PORTLAND DISTRICT, CORPS OF ENGINEERS, SEPT. 1, 1953

SUPERVISED: C. Pedersen — CHIEF, HYDROLOGY & METEOROLOGY SECTION
RECOMMENDED: Ben L. Peterson — CHIEF, ENGINEERING DIVISION
SUBMITTED: CHIEF, PLANNING BRANCH
APPROVED: COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER
DRAWN BY: W.A.M.
TRACED BY: B.K.
CHECKED BY: W.A.M.

DE-20-45/8

PLATE 8



North Santiam River at Detroit, Oregon

STATION DESCRIPTION					
Dr. Area Sq. Mi.	Records Available	Records Character	Type of Gage	Location	Datum (M.S.L.)
256	1907-1909	Continuous	Staff	Sec. 7, T.10S., R.6E. 2 mi. below Boulder Cr.	
231	1928-1932	Continuous	Staff	NW ¼ Sec. 12, T.10S., R.5E. Measurements made from bridge in NE ¼ Sec. 15.	
226	July 1, 1932 to 1935	Continuous	Water Stage Recorder	NE ¼ Sec. 12, T.10S., R.5E.	1475.4
224	1936-1938 1939-1944	Continuous Continuous	Water Stage Recorder	NE ¼ Sec. 12, T.10S., R.5E.	1475.4 1475.68

U.S.G.S. FIELD IDENTIFICATION NO. 5532

WILLAMETTE RIVER AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER

DETROIT RESERVOIR REGULATION

DAILY DISCHARGE HYDROGRAPH

NORTH SANTIAM RIVER AT DETROIT, OREGON

IN 2 SHEETS — SCALES AS SHOWN — SHEET NO. 1

PORTLAND DISTRICT, CORPS OF ENGINEERS — SEPT. 1, 1953

SUPERVISED: C. Pedersen — CHIEF, HYDROLOGY & METEOROLOGY SECTION

RECOMMENDED: Ben L. Peterson — CHIEF, ENGINEERING DIVISION

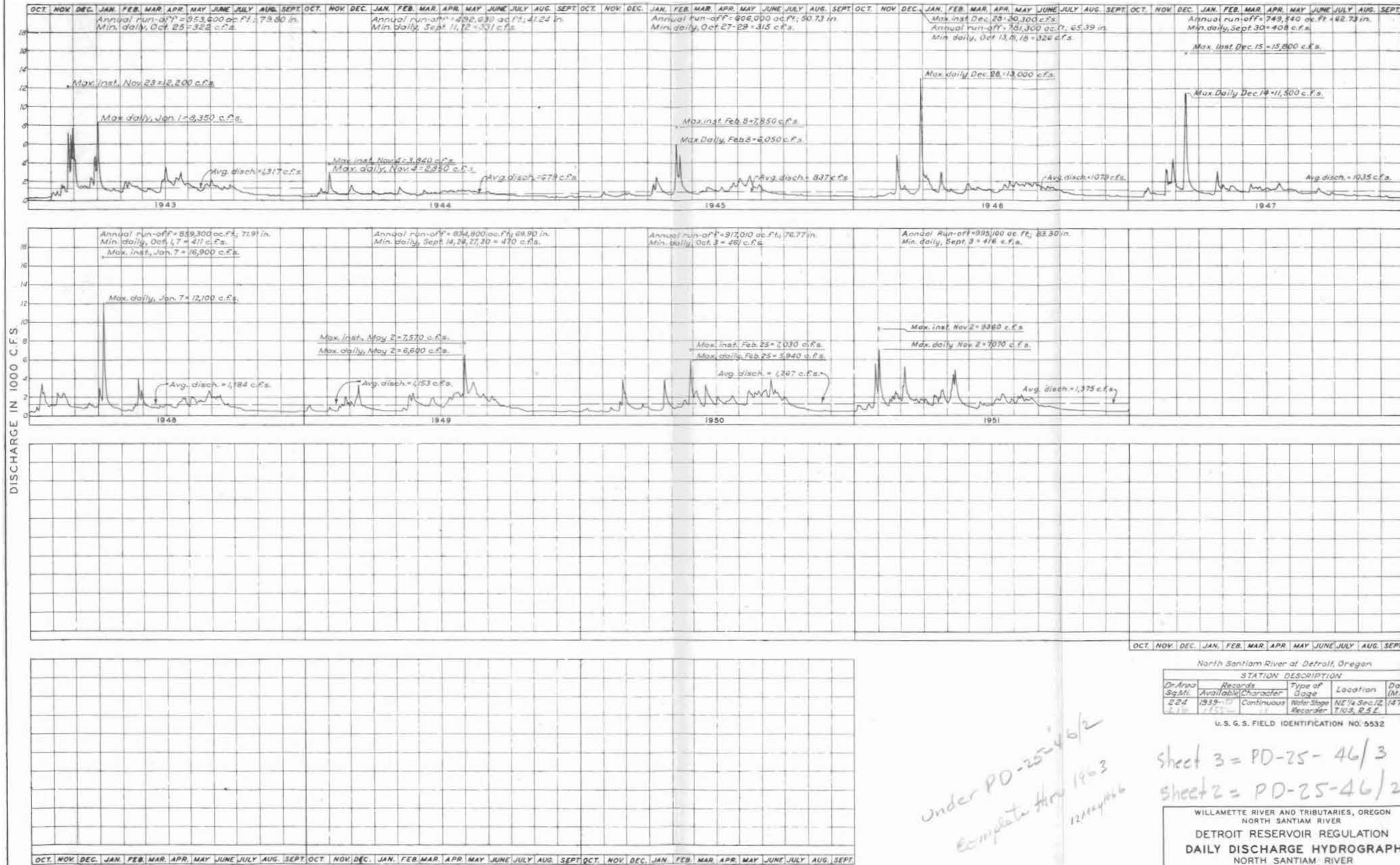
SUBMITTED: Fred C. Jorgeson — CHIEF, PLANNING BRANCH

APPROVED: [signature] — COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY J.I.R.
TRACED BY R.V./C.S.G.
CHECKED BY L.H.M.

DE-20-45/9

PLATE 9



North Santiam River at Detroit, Oregon

STATION DESCRIPTION					
Dr. Area Sq. Mi.	Records Available	Records Character	Type of Gage	Location	Datum (M.S.L.)
224	1939-	Continuous	Water Stage Recorder	NE 1/4 Sec. 12, T10S, R5E.	1475.68

U. S. G. S. FIELD IDENTIFICATION NO. 5532

Under PD-25-46/2
Complete thru 1963

Sheet 3 = PD-25-46/3
Sheet 2 = PD-25-46/2

WILLAMETTE RIVER AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER

DETROIT RESERVOIR REGULATION

DAILY DISCHARGE HYDROGRAPH

NORTH SANTIAM RIVER
AT DETROIT, OREGON

IN 2 SHEETS — SCALES AS SHOWN — SHEET NO. 2

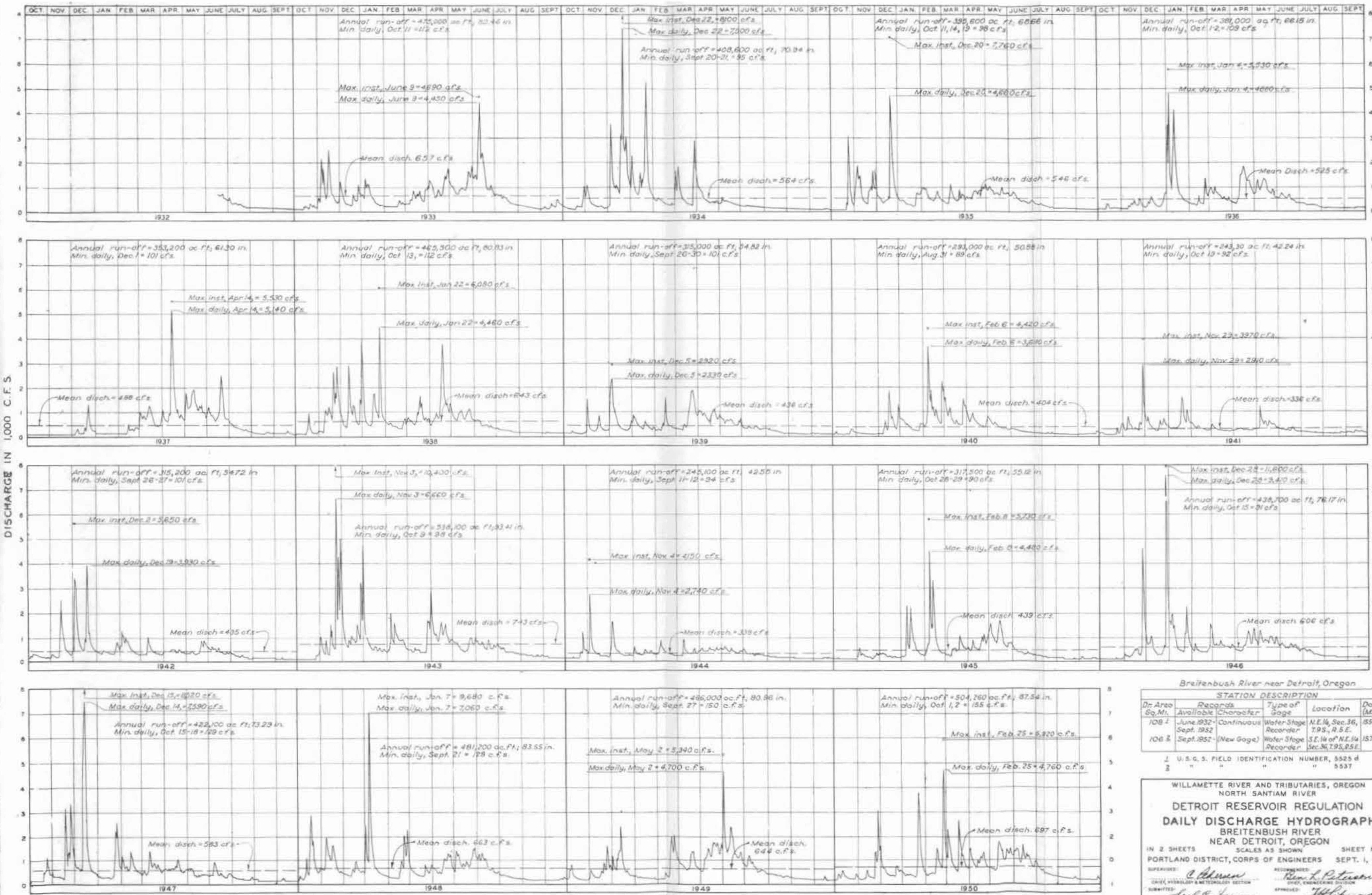
PORTLAND DISTRICT, CORPS OF ENGINEERS — SEPT. 1, 1953

SUPERVISED: C. Pedersen, CHIEF, HYDROLOGY & METEOROLOGY SECTION
RECOMMENDED: Ben L. Peterson, CHIEF, ENGINEERING DIVISION
SUBMITTED: Fred C. Ingram, CHIEF, PLANNING BRANCH
APPROVED: COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY
TRACED BY
CHECKED BY

DE-20-45/10

PLATE 10



Breitenbush River near Detroit, Oregon

STATION DESCRIPTION					
Dr. Area Sq. Mi.	Records Available	Records Character	Type of Gage	Location	Datum (M.S.L.)
108 1/	June 1932 - Sept. 1952	Continuous	Water Stage Recorder	N.E.¼, Sec. 36, T.9S., R.5E.	1559.64
106 2/	Sept. 1952 -	(New Gage)	Water Stage Recorder	S.E.¼ of N.E.¼ Sec. 36, T.9S., R.5E.	1573.10

1/ U.S.G.S. FIELD IDENTIFICATION NUMBER, 5525 d
2/ " " " " 5537

WILLAMETTE RIVER AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER

DETROIT RESERVOIR REGULATION

DAILY DISCHARGE HYDROGRAPH

BREITENBUSH RIVER
NEAR DETROIT, OREGON

IN 2 SHEETS SCALES AS SHOWN SHEET NO. 1

PORTLAND DISTRICT, CORPS OF ENGINEERS SEPT. 1, 1953

SUPERVISED: C. Ahlersen, CHIEF, HYDROLOGY & METEOROLOGY SECTION
RECOMMENDED: Ben L. Peterson, CHIEF, ENGINEERING DIVISION
SUBMITTED: Fred E. Ferguson, CHIEF, PLANNING BRANCH
APPROVED: T.H. Lipscomb, COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY E.F.A.
TRACED BY J.A.R./W.A.R.
CHECKED BY G.L.P.

DE-20-45/11

PLATE II

WILLAMETTE RIVER AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER

DETROIT RESERVOIR REGULATION

DAILY DISCHARGE HYDROGRAPH

BREITENBUSH RIVER
NEAR DETROIT, OREGON

IN 2 SHEETS | SCALES AS SHOWN | SHEET NO. 2

PORTLAND DISTRICT, CORPS OF ENGINEERS | SEPT. 1, 1953

SUPERVISED: C. Petersen — CHIEF, HYDROLOGY & METEOROLOGY SECTION

RECOMMENDED: Ben L. Peterson — CHIEF, ENGINEERING DIVISION

SUBMITTED: Fred E. Jaynes — CHIEF, PLANNING BRANCH

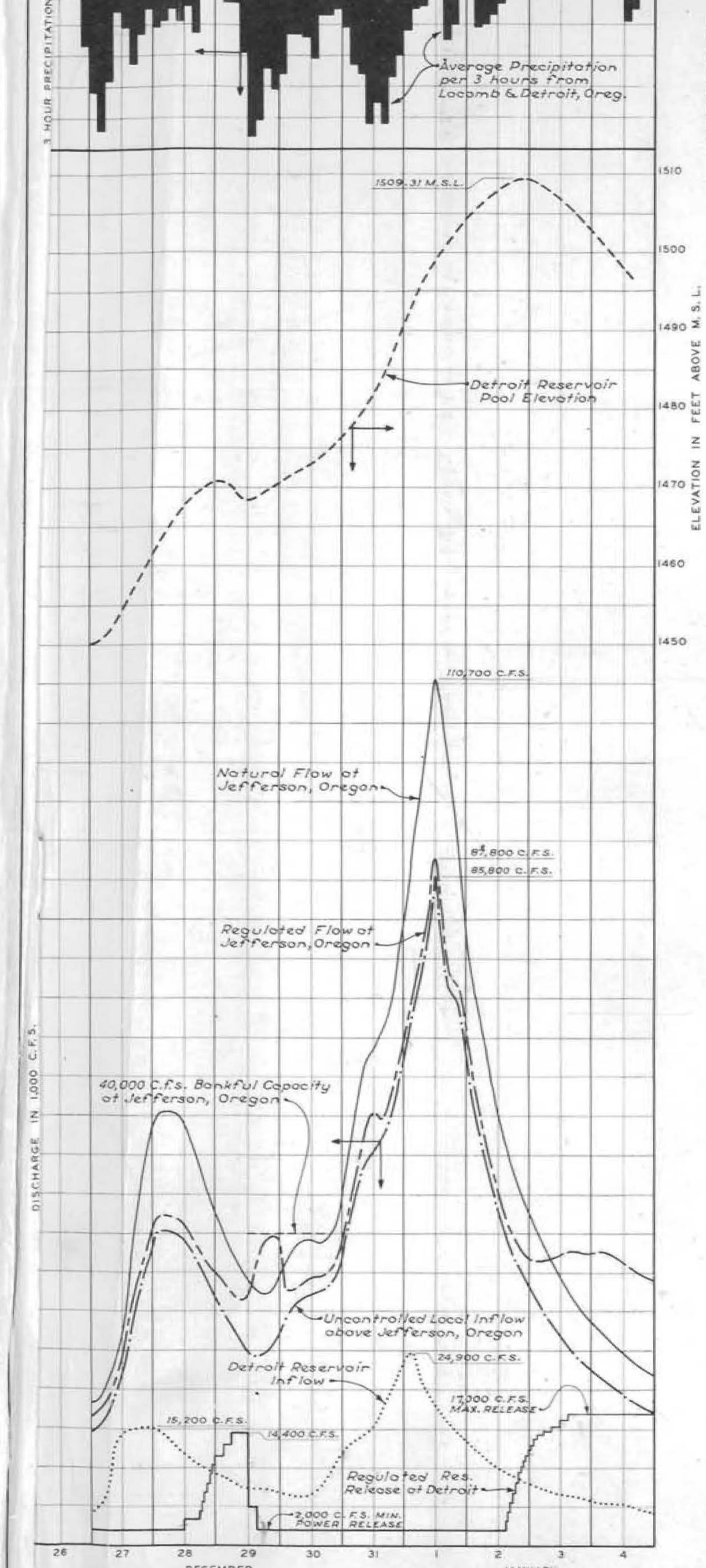
APPROVED: [signature] — COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY ....
TRACED BY W.J.M. ....
CHECKED BY ....

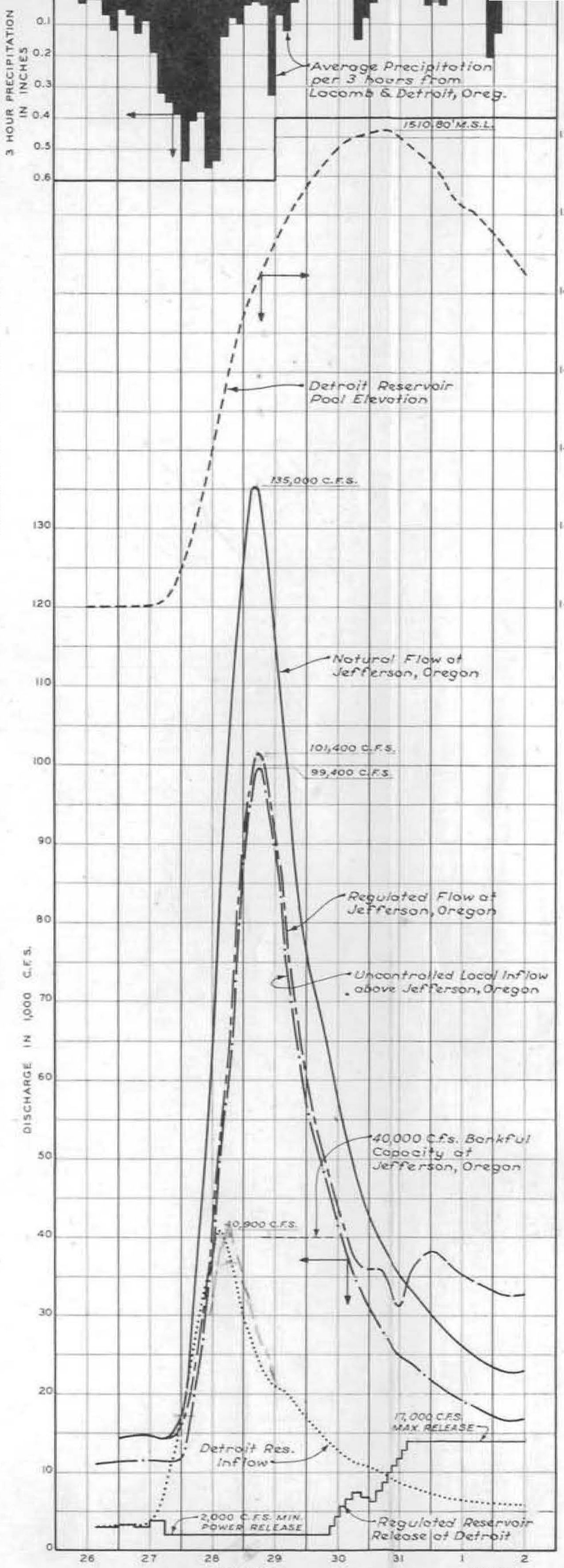
DE-20-45/12

PLATE 12

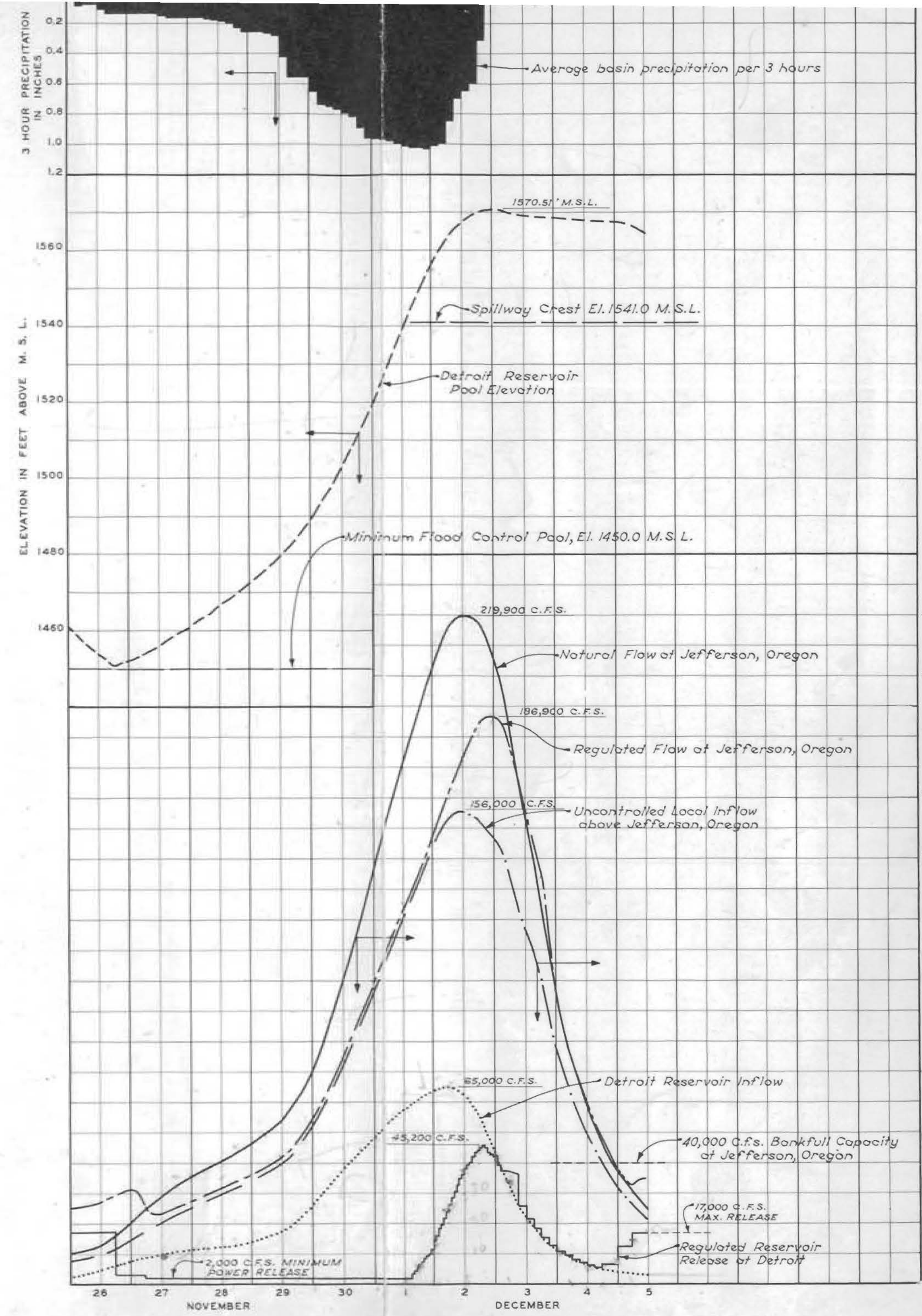
PD-25-47/2



FLOOD OF DECEMBER 1942 - JANUARY 1943



FLOOD OF DECEMBER 1945 - JANUARY 1946



FLOOD OF NOVEMBER - DECEMBER 1861

WILLAMETTE RIVER AND TRIBUTARIES, OREGON
NORTH SANTIAM RIVER

DETROIT RESERVOIR REGULATION

EXAMPLES OF RESERVOIR REGULATION

SCALES AS SHOWN

PORTLAND DISTRICT, CORPS OF ENGINEERS, SEPT. 1, 1953

SUPERVISED: C. Pedersen — CHIEF, HYDROLOGY & METEOROLOGY SECTION
SUBMITTED: Fred C. Ingram — CHIEF, PLANNING BRANCH
RECOMMENDED: Ben L. Peterson — CHIEF, ENGINEERING DIVISION
APPROVED: [signature] — COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER

DRAWN BY: W.A.M.
TRACED BY: W.A.M.
CHECKED BY: W.A.M.

DE-20-45/21

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

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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.

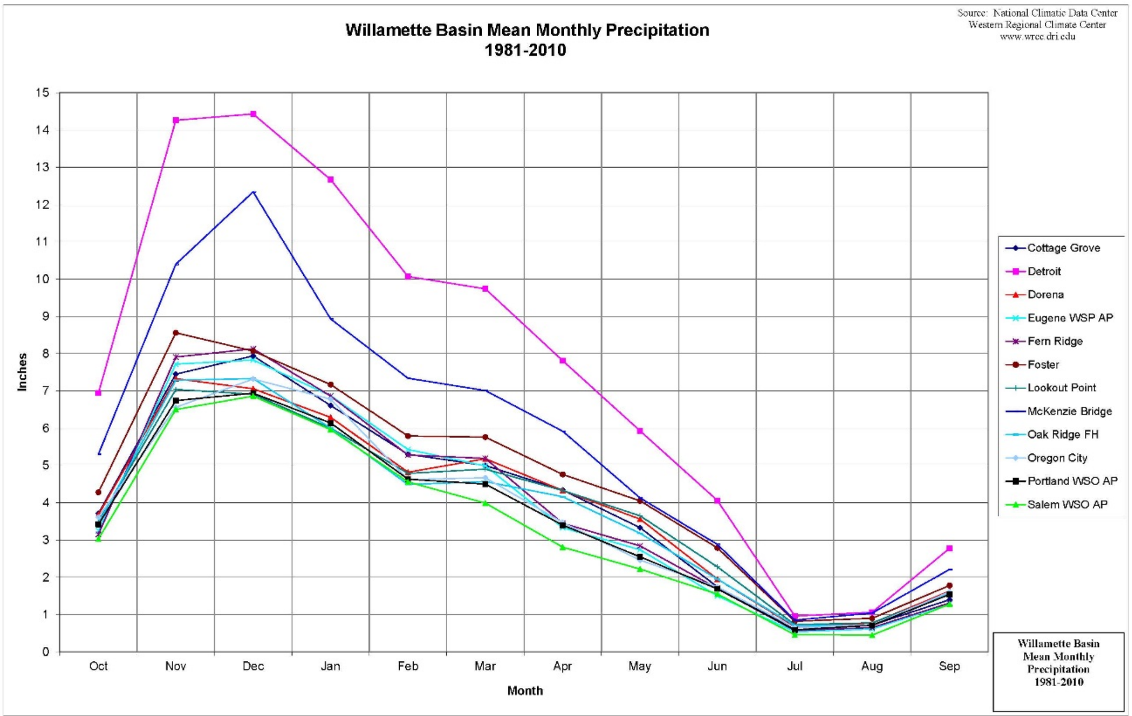


Figure 3-1. Willamette Basin Monthly Precipitation

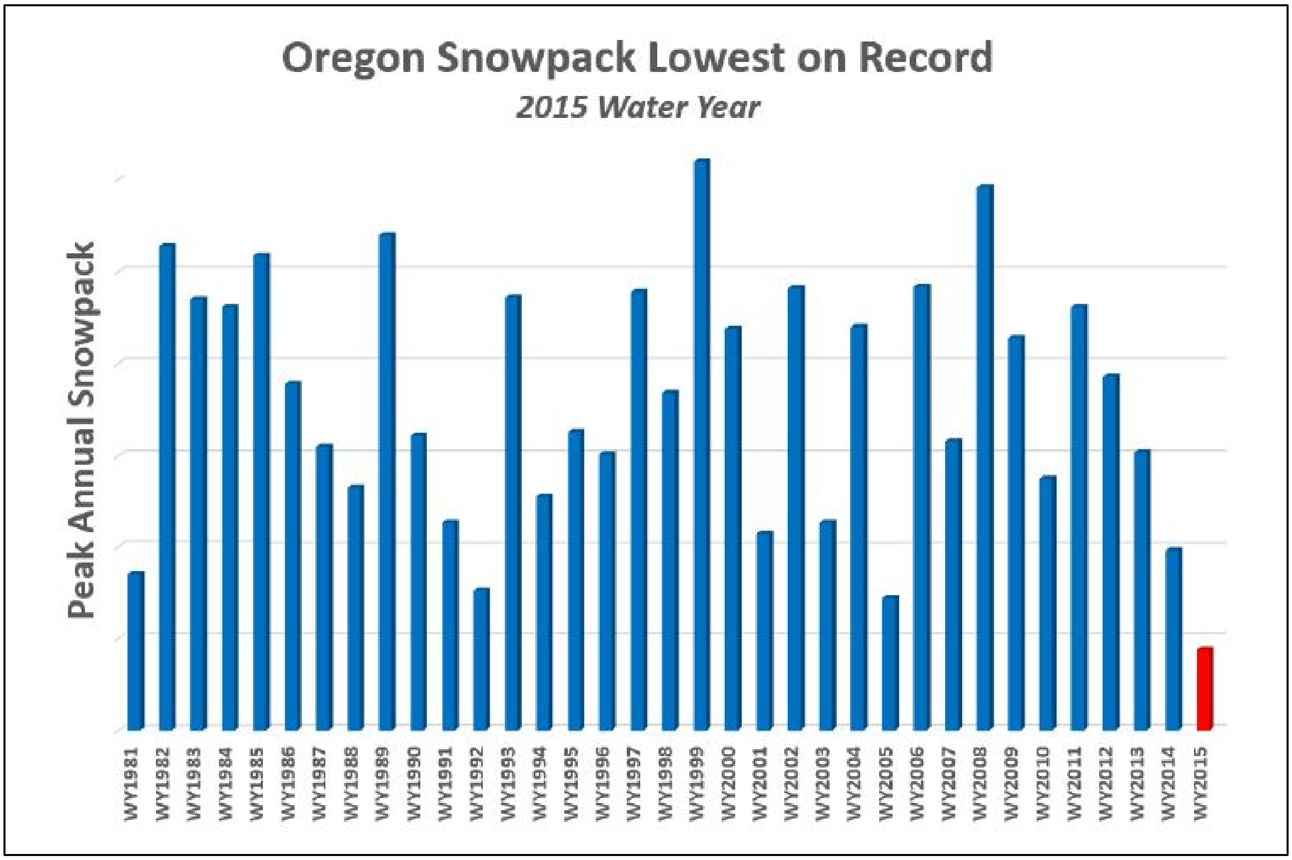
Eight significant hydrologic drought periods have occurred in Oregon since 1900 (*Oregon Emergency Management Plan, Natural Hazards Mitigation Plan, Drought Chapter*, February 2012, and the *2015 Drought After Action Report for Portland District Reservoir Operations*.).

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.

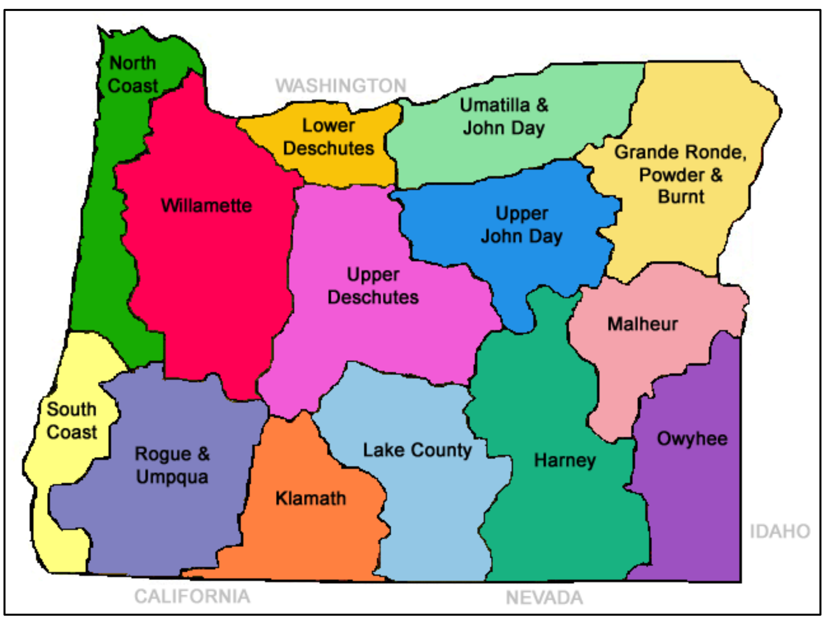


Figure 3-3. Oregon River Basins to Evaluate Drought Conditions

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.

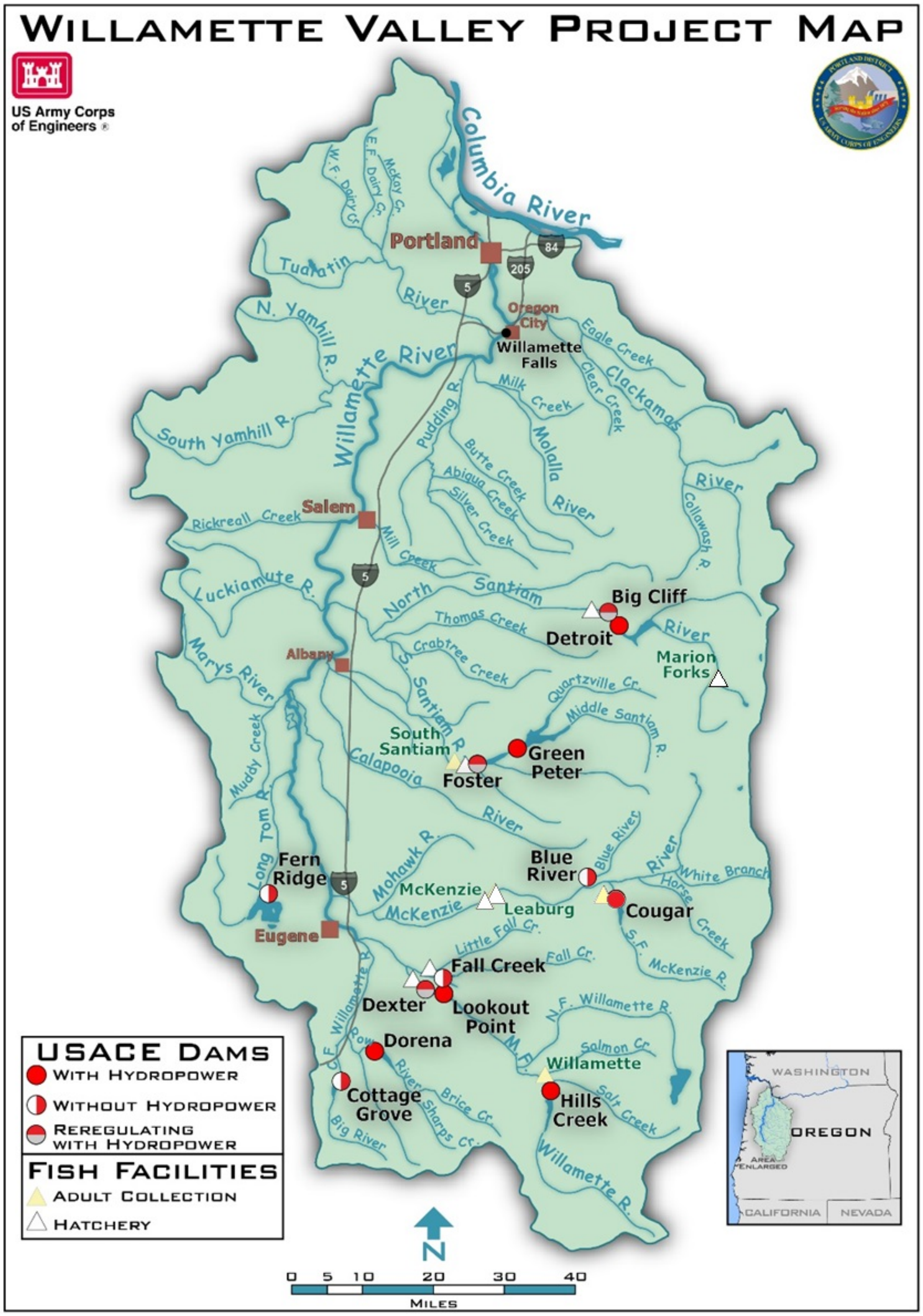


Figure 4-1. Willamette Valley Project Map

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

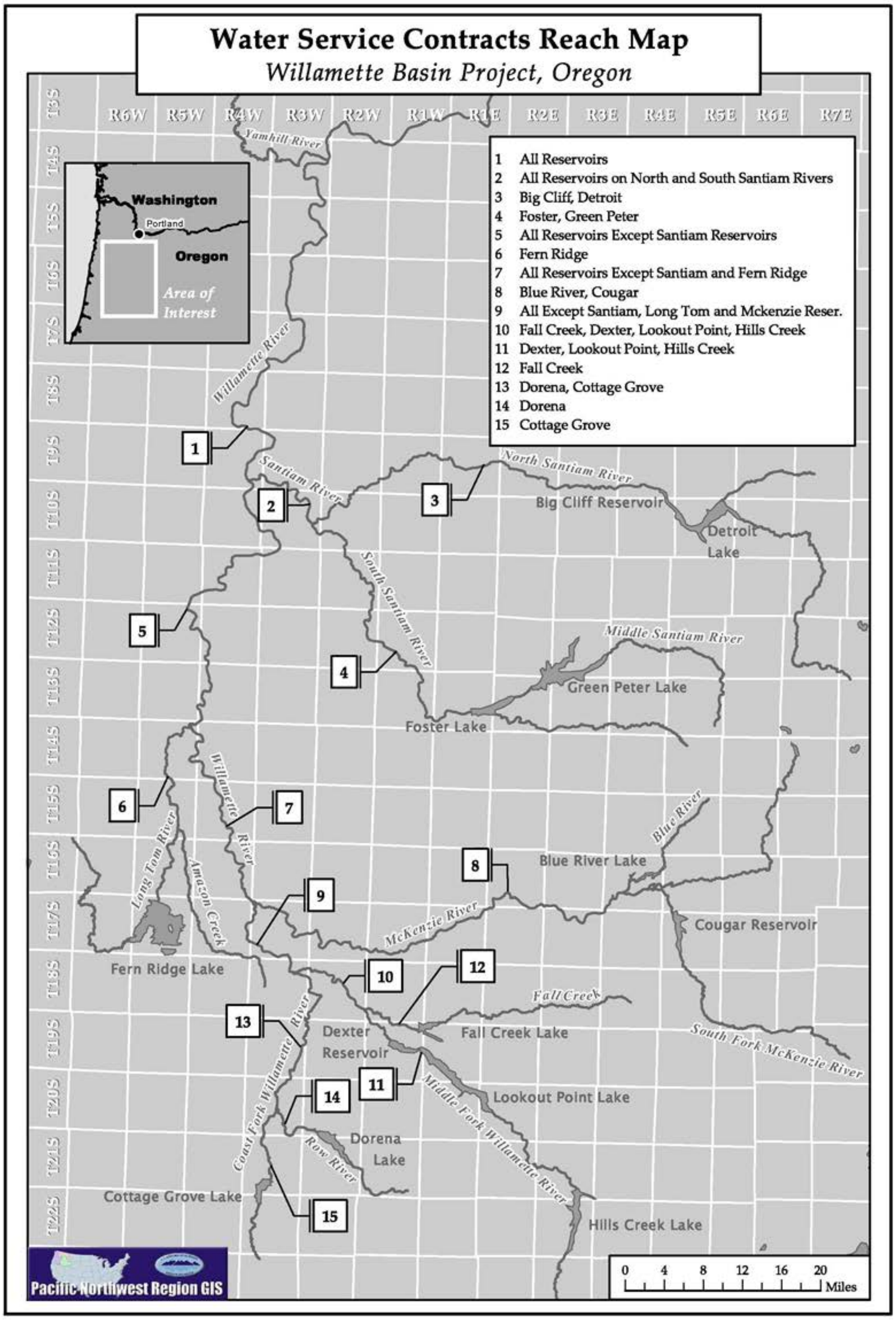


Figure 5-1. Water Service Contracts Reach Map

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)

	Albany		Salem			
1	2	3	4	5	6	7
Period	**Minimum Average Flow[1]**	**HD 531[2]**	**Minimum Instantaneous Flow[3]**	**Minimum Weekly Flow Threshold Abundant and Adequate[4]**	**Minimum Weekly Flow Threshold Deficit Years[4]**	**HD 531[2]**
April	--		14,300	17,800[3]	15,000	
May	--		12,000	15,000[3]	15,000	
1 – 15 June	4,500		10,500	13,000[3]	11,000	
16 – 30 June	4,500		7,000	8,700[3]	5,500	
July	4,500	5,000	--	6,000[1]	5,000	6,500
1 – 15 August	5,000		--	6,000[1]	5,000	
16 – 31 August	5,000		--	6,500[1]	5,000	
September	5,000		--	7,000[1]	5,000	
October	5,000		--	7,000[1]	5,000	

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

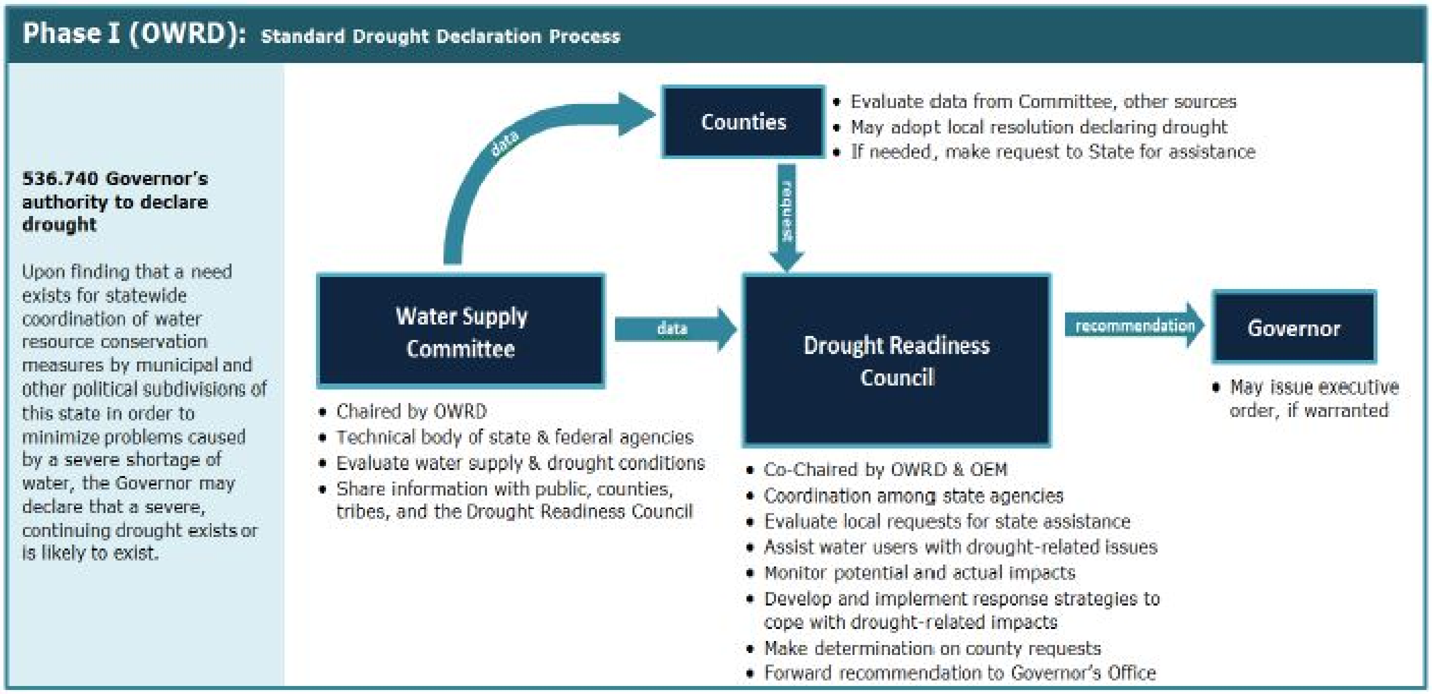
Although there is authorization for navigation in the mainstem Willamette River, there is currently little to no actual navigation for commercial purposes. There is no opportunity to move boats around the Willamette Falls at Oregon City except by trailer. Navigation did not seem to be an issue during 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.

<u>REFERENCES</u>

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: ___________________

Exhibit B

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, PORTLAND DISTRICT
PO BOX 2946
PORTLAND OR 97208-2946

CENWP-EC

17 JUL 2015

20150717 Approved as requested

MEMORANDUM FOR Jose L. Aguilar, Colonel, EN, Commanding (CENWP-DE)

SUBJECT: Implementation of Environmental Flows in the Willamette Valley

1. Attached herein is a Memorandum for Record (MFR) that provides detailed guidance for implementation of environmental flows in the Willamette Valley. This document demonstrates our compliance with Corps guidance to implement environmental flows where feasible at Corps projects and meets Corps commitments in agreements signed with The Nature Conservancy (NWP, NWD, National agreements). Environmental flows are part of the Sustainable Rivers Project (SRP) that these agreements created.

2. The MFR discusses the analyses, evaluations, and determination of low risk associated with implementation of environmental flows and identifies the conditions and constraints reservoir regulators should follow during implementation of SRP environmental flows in the Willamette Valley.

3. With your concurrence, this guidance will be added to several Willamette Valley water control manuals for future implementation. For additional information regarding the MFR, please contact Chris Budai, project manager, at extension 4725 or Keith Duffy, technical lead, at extension 4969.

LANCE A. HELWIG, P.E.
Chief, Engineering & Construction Division

2 Encls
1. E-Flow Implementation Guidance
2. REC

Division Approval October 1, 2015

CENWP-EC-HY 7 July 2015

MEMORANDUM FOR RECORD

SUBJECT: Implementation of Environmental Flows in the Willamette Valley

1. Purpose. This memorandum summarizes guidance for implementing environmental flows (e-flows) in the Willamette River Basin reaches; specifically the Middle Fork, McKenzie and the North and South Fork Santiam Rivers.

The U.S. Army Corps of Engineers Portland District (Corps) with the Nature Conservancy (TNC) developed an implementation plan for environmental flows at multiple projects within the basin. The SRP's goal is to 'operationalize' the environmental flow recommendations into acceptable guidance and recommendations for Willamette reservoir regulators and project operators for implementation. In order to achieve the project goal, this project's objectives were twofold:

1) Identify biological criteria and priorities (e.g., e-flow targets and benefits).
2) Given biological understanding and priority of different biological goals, outline the relevant items important to regulators tasked with implementing e flows.

The proposed environmental flow implementation described in this MFR has been found to conform to operational constraints as outlined in the Water Control Manuals. This has been verified through previous studies and analyses described in greater detail below.

Environmental flow implementation falls under the range of flood reduction operations outlined in the Water Control Manuals. Flood reduction operations occur primarily in the wintertime period (December through February). E-flow releases are not to be performed if they contradict NWP flood operation constraints. Flood operation considerations applicable to the e-flow implementation are summarized in Tables 1 through 4 below.

Upon acceptance of this Memorandum for the Record (MFR), the Water Control Manuals will be updated to incorporate operations for environmental flows.

2. Background. The Sustainable Rivers Program (SRP) began in 2002 as a partnership between TNC and the Corps with the objective of developing, implementing and refining a framework for beneficial flows downstream of dams. TNC and the Corps have signed memorandums of agreements (MOAs) at the national level as well as the district level to study current hydro regulation operations. SRP efforts in the Willamette River Basin focus on identifying opportunities to improve overall downstream ecosystem health and resiliency by modifying dam releases within the existing operational constraints. The releases that benefit downstream ecosystem health are termed environmental flows (e-flows). The e-flows targets were developed through a process of collecting and synthesizing relevant hydrologic and ecological information and expert knowledge into a set of e-flow recommendations.

a. Purpose of E-flows. Flow recommendations focused on fall flows (October-November), winter high flows (November-February) and smaller spring bankfull flows (flows at Action Stage, as identified by the National Weather Service) (March-June). Each seasonal flow is important to some aspect of ecosystem health. Fall flows enhance channel habitat and provide flows for outmigration. Winter high flows provide benefits to habitat by modifying channel features and recruiting large woody debris. Spring time flows are important for providing out-migration flows as well as scouring and flushing during bank full events.

b. Environmental Flow Recommendations. Environmental flow recommendations have been developed for the Middle Fork Willamette River, McKenzie River and the North, South and mainstem Santiam Rivers. The flow recommendations were defined by 1) event duration; 2) number of events per year; 3) range of flow magnitude; and 4) frequency. Summary reports were completed for each river system (also see References):

- Santiam Basin: *Summary Report: Environmental Flows Workshop for the Santiam River Basin, 2013.*
- Middle Fork and Coast Fork: *Summary Report Environmental Flows Workshop for the Middle Fork and Coast Fork of the Willamette River, 2007.*
- McKenzie River: *Environmental Flow Recommendations Workshop for the McKenzie River, Oregon, 2010.*

c. Constraints. The e-flow operations are constrained by Water Control Manual operational requirements for each project and the system as well as the Willamette Biological Opinions (BiOp) (National Marine Fisheries Service and U.S. Fish and Wildlife Service) implementation.

d. Forecast Uncertainty Analysis. The forecast uncertainty analysis performed by the Corps in 2011suggests that maximizing the number of e-flow discharges is feasible; however, evaluations of forecast error indicate that the release of e-flows should not be taken lightly. If anything, the modeling exercise emphasized the intricacy of the hydrologic and operational complexities of the Willamette system.

e. HEC-ResSim Analysis. HEC-ResSim was used to model potential operational changes to provide e-flows. The resulting report prepared in 2013, *Evaluation of E-Flow Implementation and Effects in the Willamette Basin using ResSim Modeling,* addressed concerns about potential increased flood risk and other adverse impacts from e-flow operations and provided recommendations on potential operational approaches. Two approaches were evaluated to determine how Willamette Valley Project operations could be modified to realize e-flow benefits within the constraints of the WCM: 1) Release More and 2) Store More. Both approaches modified the maximum evacuation release rule, as a function of elevation, from the baseline condition at the three projects, Lookout Point/Dexter on the Middle Fork Willamette, Cougar on the South Fork McKenzie River, and Detroit/Big Cliff on the North Santiam River.

The Release More scenario was recommended as a starting point for a strategy to implement e-flow releases in the Willamette River basin. The Release More scenario provided an overall increase in e-flow events (benefits) while affecting minimal change to flood risk reduction, water quality, hydropower and meeting BiOp targets. An unforeseen benefit from implementing the

Release More option was that flood storage availability increased under this alternative. The Store More option did not produce significant changes to total e-flows compared to the baseline. Further, the Store More option potentially increases flood risk by holding water longer and reducing the flood storage space during the wetter times of the year.

3. Implementation. The general intent is to maximize opportunities for achieving e-flows at the Willamette Valley projects considering operational constraints and forecast uncertainty. The following discussion of implementation provides guidance for reservoir regulators and project operators; however, implementation of e-flows is based on regulator/operator judgment and is not a highly prescriptive process.

E-flow operations require use of stored water to achieve environmental goals. The e-flow operation absorbs the incoming event then releases post event to minimize downstream flood risk. Once downstream gages have peaked and are receding below action stage (bankfull) levels, e-flow operations can commence. All intentional e-flow operations must operate below flood stage and within action stage (bankfull) constraints. That is, it is ok to release to bankfull, with some allowance for exceedance, but not to release to flood stage for e-flow purposes.

Just as for any high flow release scenario, error in forecasts should be considered when implementing e-flow operations. Release of large volumes of water combined with an error in the forecast can unintentionally result in reaching flood stage downstream. Previous SRP work has more fully quantified forecast uncertainty in the Middle Fork/Coast Fork Willamette and ReSim modeling has shown that e-flow releases are feasible within the uncertainty of forecasts without exceeding project water management constraints.

There may be high flow events where a sufficiently high volume will have to be passed with the result that the project release 'naturally' exceeds action stage (bank full)/flood stage. Although this could result in e-flows benefits, it is not the intent of e-flow operations to realize benefits in this manner (i.e., to purposely exceed action or flood stages). Rather e-flow operation seeks to obtain benefits while operating under the WCM and other operational constraints.

Flow recommendations focus on winter high flows (15-November through 15-February) and spring bankfull flows (15-March though 30 June). It is cautioned that e-flows cannot be guaranteed every year. The e-flow operations are 'opportunity driven' and would first be indicated by a forecast of a substantial weather system headed for the Willamette Valley and the three sub-basins of interest.

Overall, the e-flow benefit expected from the preferred e-flow operation is an increased number of wintertime events. Spring time e-flow events are expected to be minimally increased. Table 1 lists the range of e-flow operation goals downstream.

Maximizing e-flows is important to effectively manage aquatic habitat. The higher flows provide the mechanism for creating and managing fish spawning/incubation and other aquatic habitat needs over time. Salmon populations and other aquatic organisms are adapted to these variable flow conditions. Active management by fisheries and other technical experts should be part of the protocol.

Table 1. MF WILLAMETTE AT JASPER Maximum Flow and Duration E-Flow Objectives below Projects

Middle Fork Willamette River at Jasper USGS 14152000		
Winter E-Flow Target 1		
(15-Nov through 15-Feb)		**Operational Considerations**
Flow Above (cfs)	17,000	Releases from Fall Creek and Dexter may be combined to achieve these flows at Jasper.
Duration (days)	1	
Winter E-Flow Target 2:		
Min Flow (cfs)	15,000	
Max Flow (cfs)	17,000	
Duration (days)	3	
Winter E-Flow Target 3:		
Min Flow (cfs)	12,000	
Max Flow (cfs)	15,000	
Duration (days)	4	
Spring E-Flow Target A		
(15-Mar through 30 June)		**Operational Considerations**
Flow Above (cfs)	15,000	Releases from Fall Creek and Dexter may be combined to achieve these flows at Jasper.
Duration (days)	1	
Spring E-Flow Target B		
Min Flow (cfs)	12,000	
Max Flow (cfs)	15,000	
Duration (days)	3	
Spring E-Flow Target C		
Min Flow (cfs)	10,000	
Max Flow (cfs)	12,000	
Duration (days)	4	

Table 2. SF MCKENZIE AT COUGAR DAM Maximum Flow and Duration E-Flow Objectives below Projects

<table>
<tr><th colspan="3">South Fork McKenzie River below Cougar Dam
USGS 14159500</th></tr>
<tr><td colspan="2">Winter E-Flow Target 1</td><td></td></tr>
<tr><td colspan="2">(15-Nov through 15-Feb)</td><td>Operational Considerations</td></tr>
<tr><td>Flow Above (cfs)</td><td>6,000</td><td rowspan="10">Outflow above 5,000 cfs will inundate the adult fish collection facility's facility water system (FWS) intake structure which includes electrical gear and air burst system equipment.

Outflow above 5,000 cfs may scour redds (October – January).</td></tr>
<tr><td>Duration (days)</td><td>1</td></tr>
<tr><td colspan="2">Winter E-Flow Target 2:</td></tr>
<tr><td>Min Flow (cfs)</td><td>4,000</td></tr>
<tr><td>Max Flow (cfs)</td><td>6,000</td></tr>
<tr><td>Duration (days)</td><td>3</td></tr>
<tr><td colspan="2">Winter E-Flow Target 3:</td></tr>
<tr><td>Min Flow (cfs)</td><td>3,000</td></tr>
<tr><td>Max Flow (cfs)</td><td>4,000</td></tr>
<tr><td>Duration (days)</td><td>4</td></tr>
<tr><td colspan="2">Spring E-Flow Target A</td><td></td></tr>
<tr><td colspan="2">(15-Mar through 30 June)</td><td>Operational Considerations</td></tr>
<tr><td>Flow Above (cfs)</td><td>4,000</td><td rowspan="10"></td></tr>
<tr><td>Duration (days)</td><td>1</td></tr>
<tr><td colspan="2">Spring E-Flow Target B</td></tr>
<tr><td>Min Flow (cfs)</td><td>2,500</td></tr>
<tr><td>Max Flow (cfs)</td><td>4,000</td></tr>
<tr><td>Duration (days)</td><td>3</td></tr>
<tr><td colspan="2">Spring E-Flow Target C</td></tr>
<tr><td>Min Flow (cfs)</td><td>1,500</td></tr>
<tr><td>Max Flow (cfs)</td><td>2,500</td></tr>
<tr><td>Duration (days)</td><td>4</td></tr>
</table>

Table 3. NO SANTIAM AT MEHAMA Maximum Flow and Duration E-Flow Objectives below Projects

<table>
<tr><th colspan="3">North Santiam River at Mehama
USGS 14183000</th></tr>
<tr><td colspan="2">Winter E-Flow Target 1</td><td></td></tr>
<tr><td colspan="2">(15-Nov through 15-Feb)</td><td>Operational Considerations</td></tr>
<tr><td>Flow Above (cfs)</td><td>15,000</td><td rowspan="10">Fishermen's Bend resident owners should be notified by the shift operator via phone when Big Cliff (BCL) outflow will exceed 10,000 cfs.

E-flow operations necessitating releases at BCL greater than 10,000 cfs should not be undertaken because this MAY cause adverse flooding downstream at Fishermen's Bend. It should be noted that BCL outflow may exceed 10,000 cfs as part of normal flood operations.

Operational Considerations for Fishermen's Bend may be amended pending future analyses to quantify potential impacts.

High flows may impact the Minto Facility. Notify ODFW prior to increasing outflow.</td></tr>
<tr><td>Duration (days)</td><td>1</td></tr>
<tr><td colspan="2">Winter E-Flow Target 2:</td></tr>
<tr><td>Min Flow (cfs)</td><td>12,000</td></tr>
<tr><td>Max Flow (cfs)</td><td>15,000</td></tr>
<tr><td>Duration (days)</td><td>3</td></tr>
<tr><td colspan="2">Winter E-Flow Target 3:</td></tr>
<tr><td>Min Flow (cfs)</td><td>10,000</td></tr>
<tr><td>Max Flow (cfs)</td><td>12,000</td></tr>
<tr><td>Duration (days)</td><td>4</td></tr>
<tr><td colspan="2">Spring E-Flow Target A</td><td></td></tr>
<tr><td colspan="2">(15-Mar through 30 June)</td><td>Operational Considerations</td></tr>
<tr><td>Flow Above (cfs)</td><td>12,000</td><td rowspan="10">From March 15 – May 15 flows above 3,000 cfs will require a higher incubation release during the summer which would impact keeping the lake full for recreation and operational temperature control.

E-flow operations necessitating releases at BCL greater than 10,000 cfs should not be undertaken because this MAY cause adverse flooding downstream at Fishermen's Bend. It should be noted that BCL outflow may exceed 10,000 cfs as part of normal flood operations.

Releases higher than 3,000 cfs are allowed in the BiOp only if the lake elevation is above rule curve</td></tr>
<tr><td>Duration (days)</td><td>1</td></tr>
<tr><td colspan="2">Spring E-Flow Target B</td></tr>
<tr><td>Min Flow (cfs)</td><td>10,000</td></tr>
<tr><td>Max Flow (cfs)</td><td>12,000</td></tr>
<tr><td>Duration (days)</td><td>3</td></tr>
<tr><td colspan="2">Spring E-Flow Target C</td></tr>
<tr><td>Min Flow (cfs)</td><td>8,000</td></tr>
<tr><td>Max Flow (cfs)</td><td>10,000</td></tr>
<tr><td>Duration (days)</td><td>4</td></tr>
</table>

a. Operational Details. Implementation of e-flows is event driven, based on regulator/operator judgment and is not a highly prescriptive process. The preferred e-flow operation is to release stored flood water during the high water months (usually the winter and early spring). Under this operation, stored flood waters are released earlier by allowing the maximum outflows to go higher when the lake elevation is lower than current practice. This e-flow operation does not change project operating rules, in terms of release rate and normal operations during flood control season as identified in the Water Control Manuals.

Ramp rates must also be monitored to not exceed those identified in the Water Control Manuals and the Biological Opinions. If ramp rates are excessive, there may are adverse biological impacts.

The regulator should always exercise discretion. For example, it may be that the start of release be at an elevation above the secondary flood control pool. For example, Lookout Point elevation would be 856 feet and at Detroit reservoir, 1484.5 feet. Releases below these elevations should be capped at powerhouse capacity. Also, when scheduling releases one has to assure that there is enough stored water to ramp flows back down to inflow without drafting into the power pool and without violating ramp rates.

4. Communication. Normal coordination and communication procedures shall be followed as outlined in the *Standard Procedures for Regulation of the Willamette Basin Projects*.

a. Internal Communication. EC-H will pre-coordinate e-flow operations similar to how it coordinates operations related to BiOp implementation. Notification of pending opportunities for e-flow releases will be included in the normal Corps communication channels such as the Corps Weather and River Updates which indicate expected increases in river flows, such as bankfull or flood levels.

Each year, hydrologic conditions and information on fish spawning activity should be reviewed prior to initiating a high e-flow by consulting technical experts (hydrologists, biologists and operating engineers) in order to balance mission needs within and across years. This could be accomplished in a meeting at the start of each hydrologic year.

During e-flow releases, Corps staff may be directed to monitor downstream conditions to minimize any potential adverse impacts such as bank erosion. It is assumed that notifications may be updated frequently due to changing weather and river conditions.

b. External Communication. Additional external parties may desire to be notified of pending e-flow releases. For example the environmental flow representative at the TNC should be contacted when e-flow releases are likely, in order to monitor potentially beneficial downstream impacts. Other interested parties may be added upon request.

5. Monitoring. Monitoring of ecological benefits is part of the adaptive management process to help inform and refine e-flow targets over time. The SRP team is in the process of developing a monitoring plan for the Middle Fork, McKenzie and Santiam Rivers that focuses on geomorphic and vegetative responses to e-flow implementation. This includes development of a geodatabase and evaluation of indicators (e.g., channel bar formation, side channel inundation, vegetation changes, etc.) using aerial photos, ground survey and LiDAR. In order to maximize the monitoring process, it is foreseen that the Corps/stakeholder interaction should be more collaborative and informative. To this end, Corps reservoir regulators will provide early

indication when e-flow operations are pending in sufficient time for others to set up monitoring of specific indicators of interest.

6. Environmental Considerations. In a memorandum dated 2 June 2015, the implementation of the Sustainable Rivers Project Environmental Flows in the Willamette River was reviewed by PM-E.

7. References.

a. Bach, L., Nuckols, J. and Blevins, E. 2013. Summary Report: Environmental Flows Workshop for the Santiam River Basin, Oregon. The Nature Conservancy, Portland, OR.

b. Gregory, Stan, Ashkenas, Linda and Nygaard, Chris, 2007a. Summary Report to Assist Development of Ecosystem Flow Recommendations for the Coast Fork and Middle Fork of the Willamette River, Oregon. Oregon State University, Corvallis, OR.

c. Gregory, Stan, Ashkenas, Linda and Nygaard, Chris 2007b. Summary Report Environmental Flows Workshop for the Middle Fork and Coast Fork of the Willamette River, Oregon. Oregon State University

d. Risley, John, Wallick, J.R., Waite, Ian and Stonewall, Adam. 2010a. Development of an environmental flow framework for the McKenzie River basin, Oregon. U.S. Geological Survey Scientific Investigations Report 2010-5016, 94 p.

e. Risley, John C., Bach, Leslie and Wallick, J. Rose 2010b. Environmental Flow Recommendations Workshop for the McKenzie River, Oregon. The Nature Conservancy, Portland, OR.

f. Risley, J.C., Wallick, J.R., Mangano, J. F.,and Jones, K. L. An Environmental Streamflow Assessment for the Santiam River Basin, Oregon. U.S. Geological Survey Open File Report 2012-1133, 60 p. plus appendixes.

g. Risley, John., Wallick, Rose, Waite, Ian and Stonewall, Adam, 2010. Development of an environmental flow framework for the McKenzie River basin, Oregon. U.S. Geological Survey Open File Report 2010-5016, 94 p.

h. U.S. Army Corps of Engineers. 2013. Final Report Sustainable River Project Evaluation of E-Flow Implementation and Effects in the Willamette Basin using ResSim Modeling. Portland District, Portland, OR

i. U.S. Army Corps of Engineers. 2012. Standard Procedures for Regulation of the Willamette Basin Projects. Portland District, Portland, OR

j. U.S. Army Corps of Engineers. 2013. SRP Meeting Minutes 12-05-2013, Portland District, Portland, OR.

k. U.S. Army Corps of Engineers. 2011. Technical Memorandum. Middle Fork/Coast Fork Willamette Uncertainty Forecast Analysis Portland District, Portland, OR.

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