



US Army Corps  
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Portland District

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**Appendix 1-E to Willamette Master  
Water Control Manual**

**Water Control Manual  
Dorena Lake**

Oregon

September 1953  
Revision 4, July 28, 2017

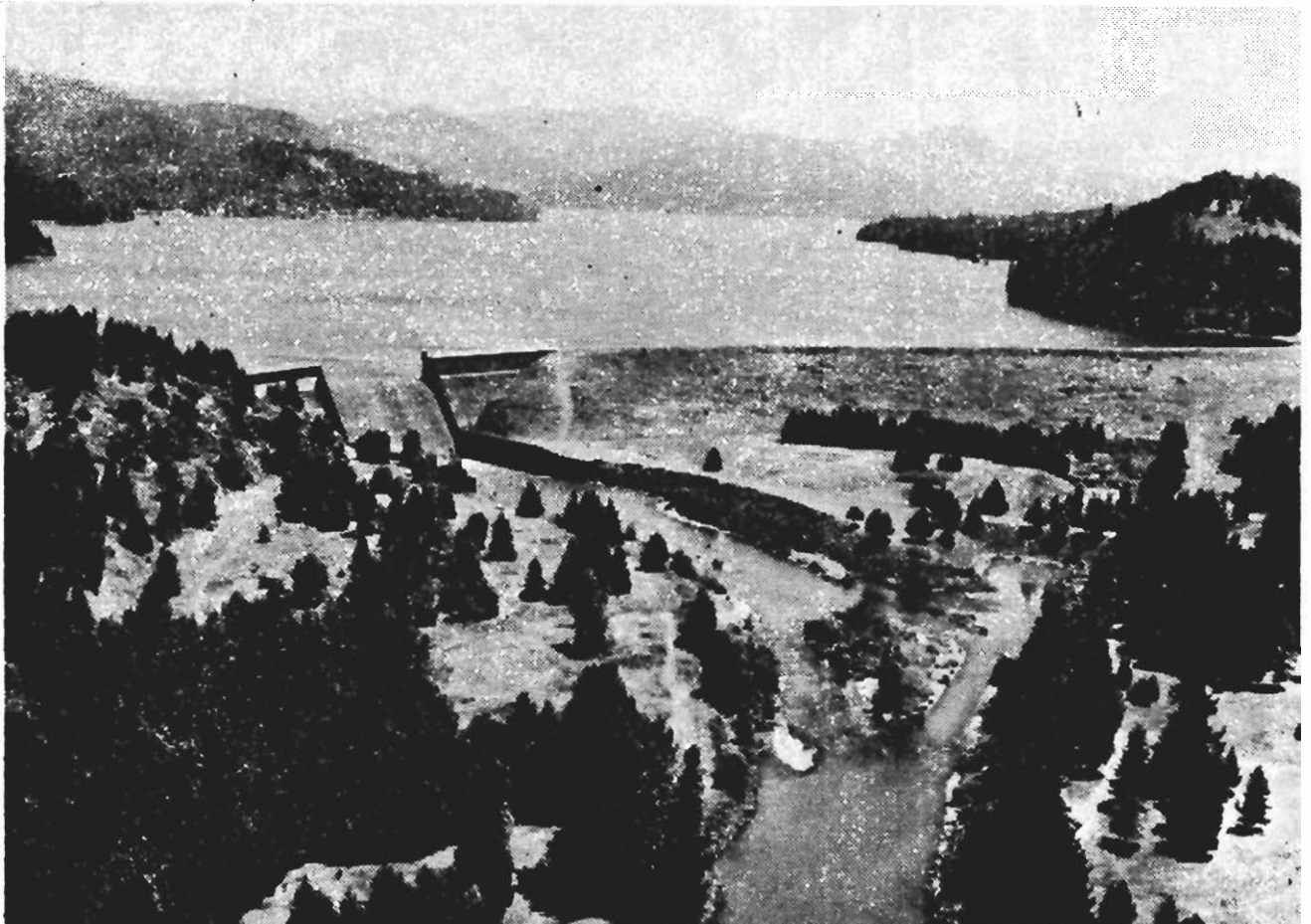


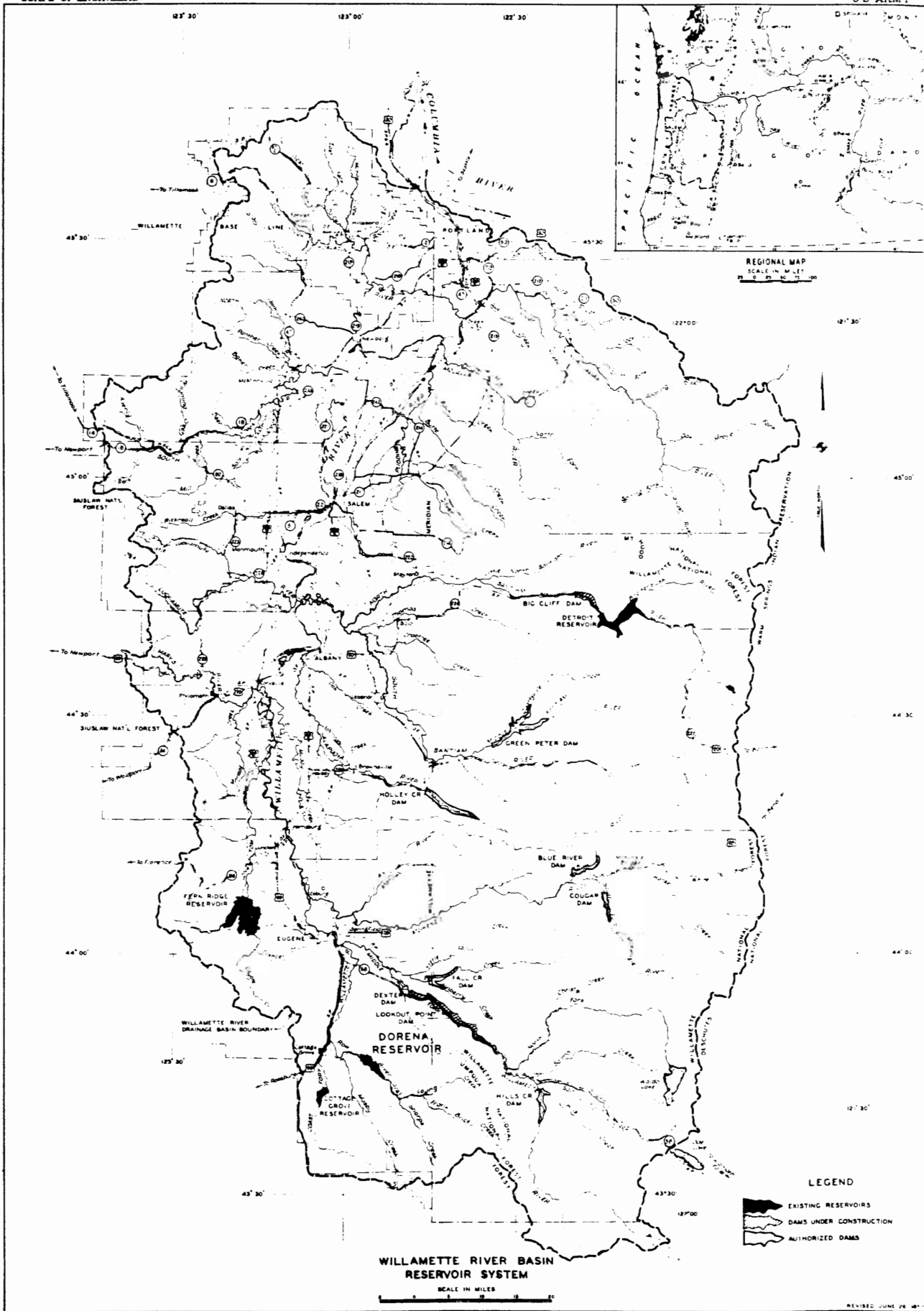
**US Army Corps  
of Engineers**  
Portland District

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# **Water Control Manual for Dorena Lake**

Oregon





WILLAMETTE RIVER BASIN  
RESERVOIR SYSTEM

SCALE IN MILES

**LEGEND**

- EXISTING RESERVOIRS
- DAMS UNDER CONSTRUCTION
- AUTHORIZED DAMS



DEPARTMENT OF THE ARMY  
CORPS OF ENGINEERS, NORTHWESTERN DIVISION  
PO BOX 2870  
PORTLAND OR 97208-2870

REPLY TO  
ATTENTION OF

July 28, 2017

CENWD-PDW

MEMORANDUM FOR: Lance Helwig, Chief, CENWP-EC

SUBJECT: Approval of Willamette Drought Contingency Plan

Thank you for responding to our comments on your submission of the Willamette Drought Contingency Plan. You have done an excellent job addressing our concerns, and the plan is approved. Please contact Ron Malmgren (503) 808-3975, if you have any further questions regarding this subject.

A handwritten signature in blue ink, appearing to read "Steven B. Barton".

STEVEN B. BARTON, P.E.  
Chief, Columbia Basin Water  
Management Division

CF:  
CENWD-PDW-R (Ammann)  
CENWD-PDW-H (Proctor, Malmgren)  
CENWP-EC-H (Hart)



DEPARTMENT OF THE ARMY  
CORPS OF ENGINEERS, NORTHWESTERN DIVISION  
PO BOX 2870  
PORTLAND OR 97208-2870

REPLY TO  
ATTENTION OF

CENWD-PDW

12 October 2016

MEMORANDUM FOR Lance A. Helwig, Chief, Engineering & Construction Division

SUBJECT: Approval of Dorena Water Control Manual, 2016 Partial Update

Thank you for responding to our comments on your submission of the Dorena Water Control Manual, 2016 Partial Update. You have done an excellent job addressing our comments and this update to the manual. Please contact Ron Malmgren at (503) 808-3975 if you have any further questions regarding this subject.

A handwritten signature in black ink, appearing to read "Steven B. Barton".

Steven B. Barton, P.E.  
Chief, Columbia Basin Water  
Management Division

CF:  
CENWD-PDW-R (Ammann)  
CENWD-PDW-HP (Proctor, Malmgren)  
CENWP-EC-HR (Hart, Low)



## 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 Dorena Water Control Manual	Sep 1, 1953
Rev. 1	Table 11	Revised Reservoir Filling Table and added Evacuation Table	Feb 1970
Rev. 2	Added Appendix	Added Drought Contingency Plan as Appendix	Sept 1992
Rev. 3 <sup>1</sup>	Revised as noted.	<p>Added text due to addition of non-federal hydropower project, minor revision to refill and evacuation table, and contact information for Regulation Assistance Procedures. The following changes were made:</p> <ol style="list-style-type: none"> <li>1. Notice to Users, Table of Revisions, and Regulation Assistance Procedures updated</li> <li>2. Title Page (added revision dates)</li> <li>3. Table of Contents, all pages</li> <li>4. Pertinent Data, page viii, add reference to datum</li> <li>5. Pertinent Data, page x revised, add reference to hydropower pertinent data</li> <li>6. Page 1, Section 1-03, add reference to hydropower</li> <li>7. Page 2, renumbered and revised Section 1-04.a., added 1-04.b.</li> <li>8. Page 24, added Section 4-13</li> <li>9. Page 44, added Section 6-02.1, renumbered/added pages are 44a, 44b</li> <li>10. Page 79, revised Section 8-20</li> <li>11. Page 85, added Section 9-09.1</li> <li>12. Page 87, added Section 9-13.1</li> <li>13. Page 88, added Section 9-15.1</li> <li>14. Table 9 replaced, RO Rating, shows gate restrictions</li> <li>15. Table 11 renumbered and minor revision noted on table, now Table 11a and Table 11b</li> <li>16. Exhibit A, Drought Contingency Plan labeled Exhibit A by coversheet</li> <li>17. Exhibit B added, Hydropower Project Addendum</li> <li>18. Exhibit C added, Hydropower Project Sub-Agreement</li> <li>19. Plate 1, Organization Schematic updated</li> <li>20. Plate 5, Figure 5, added note no. 4. on gate restrictions</li> <li>21. Plate 22 added, General Layout of Hydropower Facility</li> </ol>	Oct 12, 2016
Rev. 2	Replaced Appendix A	Comprehensive Update of the Drought Contingency Plan	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<br>Work (503) 808-4960<br>Cell (503) 819-9823 | 5. Chief, Reservoir Regulation and Water Quality Section<br>Work (503) 808-4887<br>Cell (503) 819-4189            |
| 2. Backup Regulator<br>Work (503) 808-4869<br>Cell (503) 927-4642           | 6. Willamette Valley Control Room, Lookout Point Dam<br>(541) 937-9072<br>(541) 937-2131x0<br>Cell (541) 514-5623 |
| 3. Backup Regulator<br>Work (503) 808-4891<br>Cell (503) 475-2492           | Satellite (480) 768-2500<br>8816-2242-1180  |
| 4. Backup Regulator<br>Work (503) 808-4967<br>Cell (503) 318-3524           |   |

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

## TABLE OF CONTENTS

<u>Paragraph</u>		<u>Page</u>
FRONTISPIECE		
	Willamette River Basin Reservoir System	
ILLUSTRATIONS		
	Dorena Reservoir and Watershed	facing 1
	Dorena Spillway	facing 21
	Dorena Dam and Reservoir	facing 23
PERTINENT DATA		viii
SECTION I – INTRODUCTION		
1-01	Authority	1
1-02	Purpose and scope of manual	1
1-03	Project purpose	1
1-04	Revisions to reservoir regulation manual	1
1-04.a	Drought Contingency Plan	2
1-04.b	Dorena Hydropower Project	2
SECTION II – PROJECT HISTORY		
2-01	Flood damage history	3
2-04	Project authority	4
2-05	Principle changes in design	4
2-12	Resume of construction activities	8
2-15	Costs	9
2-16	Previous plans of regulation	9
2-20	High velocity revetment tests	10

## TABLE OF CONTENTS (CONT'D)

<u>Paragraph</u>		<u>Page</u>
SECTION III – BASIN DESCRIPTION		
3-01	Willamette River Basin	12
3-02	Coast Fork Willamette River Basin	12
3-08	Population	16
3-10	Industry and resources	16
3-13	Utilities	17
3-14	Transportation facilities	18
SECTION IV – PROJECT DESCRIPTION		
4-01	Dorena Dam	19
4-02	Dorena spillway	19
4-04	Outlet Works	20
4-06	Reservoir and shoreline	21
4-08	Downstream channel improvements	22
4-09	Public-use facilities	23
4-13	Hydropower Project	24
SECTION V – METEOROLOGY		
5-01	Climate	25
5-02	Climatological records	25
5-03	Precipitation	26
5-06	Temperatures	27
5-07	Evaporation	28
5-09	Storms	30
5-11	Discharge records	30
5-12	Stream flow characteristics	31

## TABLE OF CONTENTS (CONT'D)

<u>Paragraph</u>		<u>Page</u>
SECTION V – METEOROLOGY (CONT'D)		
5-14	Floods	34
5-17	Channel capacities and bankfull stages	35
5-18	Stream flow velocities	36
5-19	Determination of reservoir inflow	37
5-21	River and rainfall reporting network	38
5-24	Telemark telephone numbers	40
5-25	Snow surveys	41
5-26	Sedimentation	41
SECTION VI – SEASONAL REGULATION SCHEDULE		
6-01	General	44a
6-02.1	Power Operation	44a
6-03	Major flood season (1 Nov through 31 Jan)	44b
6-05	Conservation storing season (1 Feb through 19 May)	45
6-09	Conservation release season (20 May through 31 Oct)	47
SECTION VII – FLOOD CONTROL REGULATION		
7-01	Basic method of flood regulation	49
7-03	Flood control regulation schedule	49
7-05	Determination of uncontrolled local inflow	51
7-08	Precipitation index	52
7-13	Correction for low temperature	54
7-15	Changes in reservoir releases	56
7-18	Release of stored floodwaters	57
7-22	Reduction of flood stages on Willamette River	59

## TABLE OF CONTENTS (CONT'D)

<u>Paragraph</u>		<u>Page</u>
	SECTION VII – FLOOD CONTROL REGULATION (CONT'D)	
7-28	Special flood control regulation schedule	62
7-33	Examples of flood regulation	64
	SECTION VIII – CONSERVATION RELEASES REGULATION	
8-01	Water use priorities	69
8-02	Reservoir release schedules	69
8-05	Prior water rights	71
8-08	Minimum reservoir release	73
8-11	Irrigation	74
8-16	Navigation and pollution abatement	76
8-19	Recreation	78
8-20	Power	79
8-21	Mosquito control	79
	SECTION IX – RESPONSIBILITIES AND INSTRUCTIONS	
9-01	Duties of damtender	81
9-05	Duties of project engineer	83
9-06	Duties of Reservoir Regulation Subsection	83
9-09.1	Duties of Hydropower Operator	85
9-10	Continued reservoir regulation studies	85
9-11	Weather station	86
9-13	Water stage recorders	86
9-13.1	Powerhouse and Associated Gaging Stations	87
9-15	Collection and transmission of data	87
9-15.1	Data Collection Hydropower Project	88
9-19	Charts and reports	89
9-22	Emergency instructions	91

## TABLE OF CONTENTS (CONT'D)

## TABLES

NUMBER

1	Climatological Summary, Eugene, OR
2	Climatological Summary, Eugene Airport, OR
3	Climatological Summary, Cottage Grove, OR
4	Monthly Precipitation at Cottage Grove
5	Monthly Precipitation at Star
6	Monthly Precipitation at Disston 2 NE (Layng Creek)
7	Monthly Precipitation and Temperature at Dorena Dam
8	Monthly Run-off, Coast Fork Willamette River and Row River
9	Service Gate Rating, Dorena Dam
10	Capacity of Dorena Reservoir
11a	Seasonal Filling Schedule, Dorena Reservoir
11b	Seasonal Evacuation Schedule, Dorena Reservoir
12	Flood Control Regulation Schedule
13	Rating Table, Row River above Pitcher Creek
14	Rating Table, Row River near Cottage Grove
15	Rating Table, Coast Fork River near Goshen
16	Rating Table, Willamette River at Eugene

## CHARTS

NUMBER

1	Daily Reservoir Data, Form NPPRF-87
2	Monthly Reservoir Regulation, Dorena Dam
3	Monthly Log of Reservoir Regulation

## TABLE OF CONTENTS (CONT'D)

## PLATES

NUMBER

1	Organization for Reservoir Regulation
2	Basin Map and Inventory of Hydroclimatic Data
3	Condensed Profiles
4	Dorena Dam – General Plan and Layout
5	Rating Curves
6	Reservoir Map
7	Climatic Characteristics
8	Stream Flow Characteristics
9	Run-off Summary
10	Daily Discharge Hydrographs – Row River above Pitcher Creek near Dorena
11	Daily Discharge Hydrographs – Rove River near Cottage Grove
12	Daily Discharge Hydrographs – Coast Fork Willamette River, Near Goshen and at Saginaw (sheet 1 of 2)
13	Daily Discharge Hydrographs – Coast Fork Willamette River, Near Goshen and at Saginaw (sheet 2 of 2)
14	Daily Discharge Hydrograph – Willamette River at Eugene and Springfield (sheet 1 of 2)
15	Daily Discharge Hydrograph – Willamette River at Eugene and Springfield (sheet 2 of 2)
16	Pool Elevation Hydrograph
17	Sedimentation Range – General Plan
18	Sedimentation Survey – Cross-Sections
19	Regulation Schedules
20	Examples of Regulation (sheet 1 of 2)
21	Examples of Regulation (sheet 2 of 2)
22	Hydroelectric Project, General Layout, Plan & Profile View

TABLE OF CONTENTS (CONT'D)

EXHIBITS

NUMBER

- A Drought Contingency Plan
- B Dorena Lake Dam Hydroelectric Project FERC No. 11945,  
Addendum to the Water Control Manual
- C Sub-Agreement Between The Department of the Army and  
Dorena Hydro, LLC for Access, Operations, and Maintenance  
of the Dorena Hydro-Electric Project Pursuant to F.E.R.C.  
License for Project No. 11945

Note: The Dorena Project was built on the mean sea level (msl) datum which is equivalent to NGVD29. For the purpose of this water control manual, the msl (NGVD29) datum is used for all elevations. At this time, the current nationwide vertical datum is NAVD88, however it is recognized that the project relies heavily on the msl (NGVD29) for all operations, therefore, the msl (NGVD29) datum will continue to be used. For information purposes, the NGVD29 datum is 3.81 feet lower than the NAVD88 datum for the Dorena Project.

## DORENA DAM AND RESERVOIR

### PERTINENT DATA

#### 1. General

Stream	Row River
River Mile	<del>6.5</del> 7.6
Drainage area	265 square miles
Type of dam	Earth fill with concrete spillway

#### 2. Reservoir

##### Elevation:

Minimum conservation pool	770.5 msl
Maximum conservation pool	832.0 msl
Full pool (spillway crest)	835.0 msl
Maximum pool	860.0 msl

##### Storage:

Minimum conservation pool	7,000 acre-feet (0.50 inches)
Maximum conservation pool	71,900 acre-feet (5.09 inches)
Full pool (spillway crest)	77,500 acre-feet (5.49 inches)
Maximum pool	131,000 acre-feet (9.26 inches)
Flood control storage	70,500 acre-feet (5.00 inches)

##### Area:

Minimum conservation pool	500 acres
Maximum conservation pool	1,770 acres
Full pool (spillway crest)	1,835 acres
Maximum pool	2,325 acres

3. Earth fill dam

Length of crest	2,600 feet
Elevation of crest	865.7 msl
Width of crest	23 feet
Maximum height	145 feet
Freeboard above maximum pool	5.7 feet

4. Spillway

Type	Uncontrolled, concrete, gravity, ogee
Length of crest	200 feet
Elevation of crest	835 msl
Capacity at maximum pool	97,500 second-feet
Stilling basin	Baffles and step-up

5. Outlets

Number	5
Type of gate	Slide, hydraulically operated
Size	5 feet x 6 feet
Invert elevation	739 msl
Capacity at min.cons. pool (all gates open)	5,440 second-feet
Capacity at full pool (all gates open)	9,275 second-feet

6. Floods

Spillway design flood:

Peak inflow	110,500 second-feet
Peak outflow	97,500 second-feet
Volume (6 days)	228,000 acre-feet
Volume (6 days)	16.13 inches

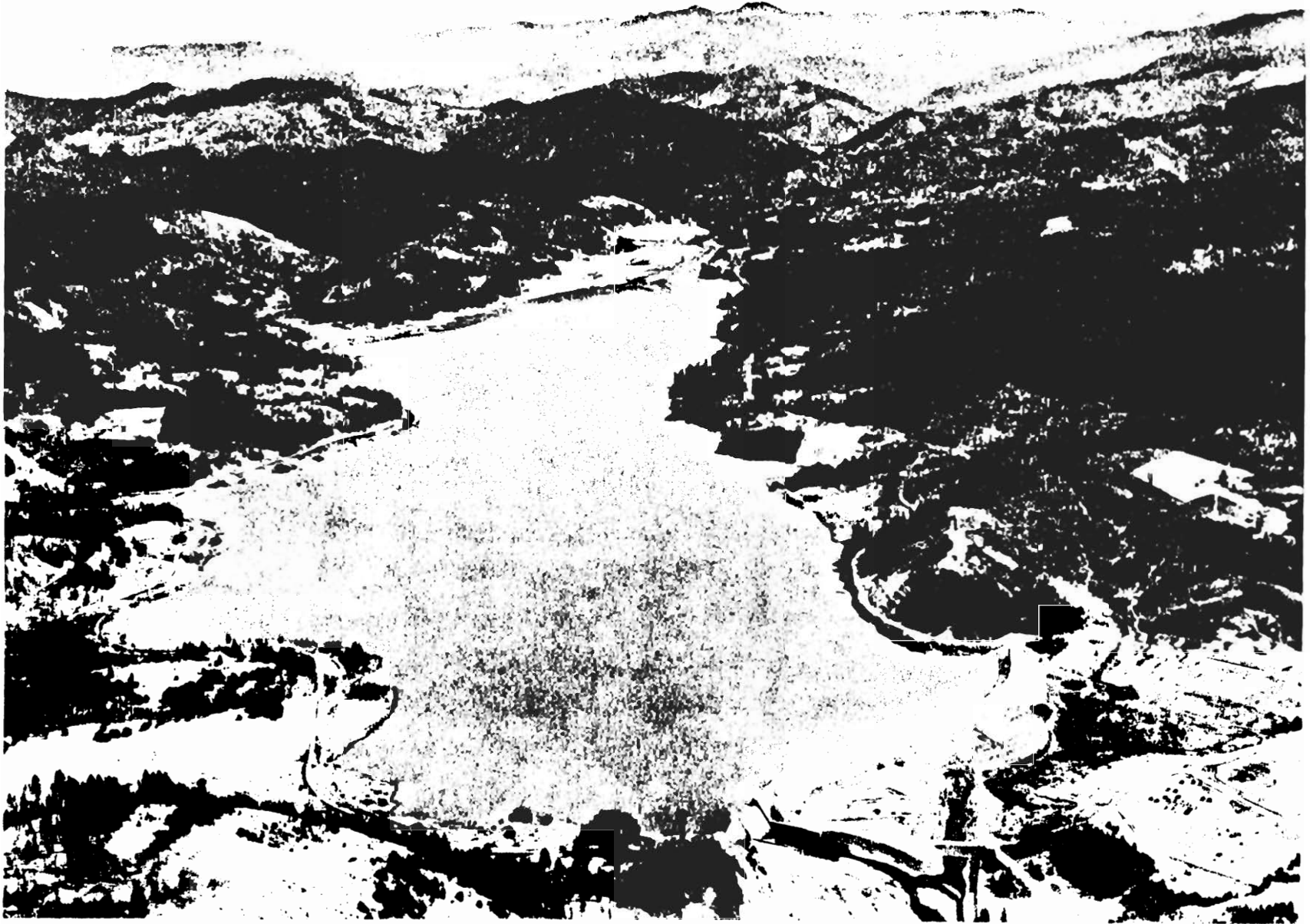
Maximum historical flood:

Date of flood peak	December 2, 1861
Peak inflow (estimated)	28,000 second-feet
Volume (7 days incl. base flow)	197,000 acre-feet
Volume (7 days incl. base flow)	13.94 inches

Maximum recorded floods,  
comparative data:

	<u>Flood of Dec. 1942-Jan.1943</u>	<u>Flood of Dec.1945</u>
Peak inflow in second-feet	20,000	21,000
Volume (incl. base flow) acre-ft.	130,500	62,000
Volume (incl. base flow) inches	9.23	4.39
Duration of flood in days	7	4

7. Powerhouse. See Exhibit B, Section 1.0



DORENA RESERVOIR AND WATERSHED



## DORENA 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 Dorena Reservoir. It contains historical, descriptive, organizational, and other pertinent data, as well as an explanation of the plan of operation. Information necessary for coordinated regulation of Dorena and Cottage Grove Reservoirs is also included.

1-03. Project purpose. - Dorena Dam and Reservoir comprise one unit in the comprehensive plan for the coordinated development and utilization of the water resources of the Willamette River Basin. The primary objective of Dorena project is flood control. Other interests which benefit from operation of the project include irrigation, fish life, navigation, stream purification, and recreation. The addition of a non-federal hydropower plant, which began operations in December of 2014, now provides power benefits.

1-04. Revisions to reservoir regulation manual. - Changes in and revisions of this manual, as may be required, will be made by the Reservoir Regulation Subsection of the Portland District. Changes will be made for the purpose of improving reservoir regulation tech-

nique or when developments occur which necessitate 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 constituted major changes in the approved regulation plan, will be submitted through the Northwestern Division (formerly North Pacific Division) office, Chief of Engineers, for prior approval. Whenever revisions are made, new pages containing the revised material will be printed and issued to each new person or office having a copy of this manual. Revised pages will show the date of revision.

a. Drought Contingency Plan. A drought contingency plan was added as an appendix to the manual in September 1992 to meet the requirements of ER 1110-2-1941, “Drought Contingency Plans”, dated 15 September 1981. The appendix is included as Exhibit A.

b. Dorena Hydropower Project. In 2016, information related to the Dorena Hydropower Project was incorporated into this water control manual. In October, 2008, the Federal Energy Regulatory Commission issued a license to construct, operate and maintain a hydropower project at Dorena Dam, identified as the Federal Energy Regulatory Commission (FERC) Project No. 11945-001. The FERC License is the official authorization for the facility, and the hydro project must remain in compliance with the FERC License. The non-federal hydropower project was installed and operations began in December of 2014. The FERC licensee and owner of the Hydropower Project as of 2016 is Dorena Hydro, LLC. The operator of the Hydropower Project is designated by the Licensee.

1) The document, *Dorena Lake Dam Hydroelectric Project FERC No. 11945, Addendum to the Water Control Manual*, prepared by the Northwest Power Services, Inc., dated November 5<sup>th</sup>, 2013, and updated October 3<sup>rd</sup>, 2016 by Dorena Hydro LLC or their representative in coordination with the USACE, is provided in Exhibit B and was written to be used as an addendum to this water control manual. The document provides pertinent data of the Hydropower Project, safety and operations emergency contact information, a description of the project, data collection and communication networks information for related gages, and describes how the Hydropower Project operator coordinates operations with the USACE.

2) In addition, Dorena Hydro LLC and the United States of America, acting by and through the USACE represented by the Portland District, Corps of Engineers, have entered into a Sub-Agreement addressing access, operations and maintenance of the Dorena Hydropower Project. The Sub-Agreement was implemented in December 2014 and is provided in Exhibit C.

3) The Dorena Hydroelectric Project, Operations and Maintenance Manual (Hydropower Project O&M Manual), prepared by Dorena Hydro, LLC, is another related document that is intended to provide direction and guidance to operating personnel in the day-to-day operation and maintenance of the Hydropower Project. It is a living document that provides water management guidelines for environmental compliance (provided in Section 5 of that document). For environmental compliance, the project operates under the FERC License, Clean Water Act permit from the USACE, state-issued 401 water quality certification, Oregon Water Rights, and other state and local permits. Refer to the most recent document for up to date information. A copy of the document is located in Portland District Reservoir Regulation & Water Quality Section (CENWP-EC-HR).

## SECTION II - PROJECT HISTORY

2-01. Flood damage history. - Prior to the construction of Cottage Grove and Dorena Dams, floods occurring on Row River and Coast Fork Willamette River caused inundation of up to 16,200 acres in the Coast Fork Basin and contributed to the inundation of up to 188,400 acres along Willamette River below the Coast Fork. The Eugene-Springfield industrial area, which has been subjected to many damaging floods in past years, is the major damage center in the southern part of Willamette Basin. Downstream from that area, the cities of Junction City, Harrisburg, Corvallis, Albany, Salem, Oregon City, and Portland, as well as many smaller communities and intervening agricultural areas, have been damaged by Willamette River floods.

2-02. Properties within the flood plains are valued at approximately \$20,410,000 along Row River and Coast Fork and \$336,775,000 along Willamette River. Without control by Cottage Grove and Dorena projects, average annual damages would amount to \$989,100 in the Coast Fork Basin at 1951 price levels, with developments as surveyed in 1948. The corresponding average annual damages along the main Willamette River without any reservoir control are estimated to be \$6,588,600. Flood damages have been appraised for the major floods which occurred in 1927, 1943, 1945, and estimated for a repetition of the 1861 flood and for lesser floods. With 1951 prices and developments in the flood plain, the damages due to recurrence of those uncontrolled floods would be as follows:

Year	Row River and Coast Fork	Willamette River
1861	\$2,250,000	\$43,100,000
1927	800,000	10,850,000
1943	1,240,000	14,100,000
1945	1,500,000	14,300,000

2-03. There are numerous floods of smaller magnitude that do damage, often several times during one year, particularly along Coast Fork. Operation of Dorena Reservoir is expected to reduce damages about 42 percent along Coast Fork and has been credited with a reduction of 2.8 percent in damages along the main stem of Willamette River. Average annual flood-control benefits creditable to Dorena Reservoir during the first four years of operation, exclusive of conservation and other benefits, amount to slightly less than \$700,000. Average annual benefits, based on economic development projected to 1975 but at 1952 prices, are estimated to be \$1,278,500.

2-04. Project authority. - Dorena project, as described in House Document No. 544, Seventy-fifth Congress, third session, was authorized by Congress in the Flood Control Act adopted 28 June 1938. That authorization also provided for Cottage Grove, Fern Ridge, Detroit, Lookout Point, Quartz Creek, and Sweet Home projects, all in Willamette River Basin. Plans for the latter two projects have been abandoned in favor of alternative sites.

2-05. Principal changes in design. - As authorized by the Flood Control Act of 1938, Dorena project consisted of a 113-foot high

earth-fill dam, with a gated concrete gravity spillway in the river section, to provide total storage space of 71,000 acre-feet, of which 70,000 acre-feet would be usable. The definite project report, dated 1 April 1940, and approved by the Office, Chief of Engineers on 4 June 1940, modified the original plan in several respects.

2-06. The definite project plan consisted of an earth dam across the valley floor, with a free-overflow chute spillway of increased capacity over the rock ledge on the right abutment. The outlet works consisted of an outlet tower with cylinder-gate control, and a tunnel discharging into the spillway stilling basin at the base of the spillway. The spillway capacity was increased, based on more reliable hydrologic data presented in Appendix A, Hydrology Report, to the definite project report. Changes in engineering policy, as set forth by the Office, Chief of Engineers, directed that gated spillway should not be constructed in conjunction with earth-fill dams when used for flood-control because of operational difficulties which might occur during flood emergencies, with resultant danger to the earth dam structure.

The definite project studies showed that, because of those revised criteria and increased requirements, the Dorena site could be developed more economically with a chute spillway on the right abutment and an intake tower and tunnel discharge conduit.

2-07. Hydraulic model studies of the spillway and outlet works for Dorena Dam were conducted at Bonneville Hydraulic Laboratory, Bonneville, Oreg., during 1940-41. The general purpose of the first model study was to determine by means of a 1 to 50 scale model the

adequacy of the approach channel, the spillway crest, the chute, the stilling basin, and the outlet works of Dorena Dam as presented in the definite project report.

2-08. Slides occurring during construction of the relocated highway, in materials similar to those forming the left abutment of the dam, lead to additional investigations and studies of that abutment and ultimately to relocation of the left end of the dam upstream to a more stable foundation. The Office, Chief of Engineers requested studies be made for a side-channel spillway in connection with the relocation of the left abutment. Results of those studies indicated that a 400-foot long side-channel spillway, as recommended by the Office, Chief of Engineers, would cost about \$800,000 more than a chute spillway. A supplemental report on Dorena Dam and Reservoir which recommended a new alignment, with a chute-type spillway, was submitted to Office, Chief of Engineers on 2 November 1944. That change in alignment reduced the useful storage capacity of the reservoir. To maintain the required 70,000 acre-feet of usable storage, the full pool elevation, spillway crest, and top of dam were raised 2 feet with the increased height of dam to be obtained by a parapet wall. This supplemental report and plan was approved by the Office, Chief of Engineers on 15 December 1944, except that the proposed parapet wall on the earth dam was directed to be replaced by additional height of embankment.

2-09. Operation difficulties experienced with the cylinder gates installed at Fort Peck Dam, Montana, led to further study during the early part of 1945 in connection with the Dorena outlet design. A re-

port, subject, "Design of Cylinder Gate, Dorena Dam, Oregon," which recommended certain modifications and additional model experiments, was submitted to Office, Chief of Engineers on 11 May 1945. The Office, Chief of Engineers concluded that the spillway and outlet works should be incorporated in a gravity dam section at the right abutment with the earth dam enveloping the left end of the gravity section and suggested a stilling basin design.

2-10. Plans and specifications for Dorena Dam were completed by the Seattle District because of the large volume of civil works in the Portland District. A letter from the Office, Chief of Engineers dated 6 September 1945, subject, "Suggested Stilling Basin Design," was used as a basis for the preliminary design of Dorena stilling basin. The spillway crest was designed according to recommendations of Circular Letter 3281 (Civil Works No. 27) dated 2 September 1944. Authority to conduct hydraulic model studies for Dorena Dam spillway and stilling basin was granted 18 March 1946. (Final Dwg. DO-212-3.) The model work was initiated immediately thereafter and data from the final test were submitted to Office, Chief of Engineers on 22 July 1947. That test, incorporating a sloping stilling basin, formed the basis of the final design approved by the Office, Chief of Engineers on 29 August 1947. A revised definite project report was not prepared for the project.

2-11. The finally adopted project consisted of an earth-fill dam section from the left abutment across the valley floor to a concrete-gravity spillway dam, containing 5 outlet conduits, immediately

adjacent to the right abutment. The free-overflow spillway with a clear length of 200 feet is designed to discharge 97,500 second-feet at maximum pool, elevation 860.0, mean sea level. Section IV of this manual gives a detailed description of the project, and the photograph preceding Section IV illustrates Dorena Dam and spillway as constructed.

2-12. Resume of construction activities. - Reservoir clearing was started in September 1940, and actual construction on the highway and railroad relocation was initiated in June 1941. World War II forced deferment of all work in 1943, before construction was initiated on the dam. Construction of the dam and appurtenant works was started in May 1947 under a continuing contract. Relocation of railroad, highway, water pipe line serving the city of Cottage Grove, and other utilities was completed in fiscal year 1948, as was the construction camp with schools, roads, utilities, etc.

2-13. Closure of the incomplete spillway structure was accomplished 15 October 1949, and the project was dedicated by the Willamette River Basin Commission on 15 October 1949, when it was considered to be officially operative. The reservoir pool rose slowly after September 1949 and reached minimum conservation pool, elevation 770.5, on 27 November 1949. Filling of the reservoir for conservation purposes was initiated in February 1950, and maximum conservation pool, elevation 832, was reached in May 1950.

2-14. A contract for a 730-foot trash boom for the protection of the outlet structure was awarded in June 1950. Construction camp demobilization was completed in 1950, and restoration of the area in

1951. Two permanent damtenders' quarters were constructed in 1952, as were certain downstream channel improvements. The project was considered to be complete on 30 May 1953.

2-15. Costs. - The originally authorized cost of Dorena Dam and Reservoir, as presented in House Document No. 544, was \$3,490,000. A number of factors, including project modifications and improvements, delays occasioned by World War II, difficult foundation conditions, substantial price rises, additional authorizations for school and other facilities, and necessary channel improvements, necessitated several upward revisions of the cost estimates as the project was being constructed. The 1948 fiscal year estimate was \$9,894,000, and the 1949 fiscal year estimate was \$11,000,000. Total project cost upon completion in May 1953 amounted to \$13,517,102.

2-16. Previous plans of regulation. - Appendix B, Flood Control, to the report published as House Document 544 presented the initial regulation plan for the seven originally authorized Willamette Basin reservoirs, including Dorena. A seasonal operating plan was set forth, wherein the reservoirs were to be drawn down in September-November, held evacuated for flood control during December-January, and refilled during February-April. That plan called for a forecast to be made on 1 January and for possible modification of the regulation in accordance with the forecast. The flood-control schedule was based on a reservoir inflow-outflow relationship so as not to exceed the available channel capacity below the dam.

2-17. Appendix A, Hydrology, to the Definite Project Report,

dated 1 April 1940, provided for the same seasonal regulation and forecast as presented in the survey report. The flood-control schedule was changed slightly but retained an inflow-outflow relationship.

2-18. Later studies, contained in the report published as House Document No. 531, Eighty-first Congress, second session, altered the seasonal schedule slightly in that the major flood season was lengthened and the reservoir was to be drawn down to minimum conservation pool by 15 November. It also specified certain minimum flows for preservation of fish life in accordance with recommendations of concerned Federal and State agencies.

2-19. A provisional reservoir regulation manual, dated 17 October 1949, extended the conservation storing season to 18 May and provided for the reservation of limited storage for the control of late spring and summer floods. An inflow-outflow relationship was retained for the flood-control schedule, and criteria were prescribed for frequency of gate adjustments. Regulation of Dorena Reservoir in the interim between the time it became operative and issuance of this report was in accordance with that provisional reservoir regulation manual.

2-20. High velocity revetment tests. - In September-October 1951, a series of high velocity revetment tests was conducted in the channel immediately downstream from Dorena Dam. Purpose of the investigation, designated Civil Works Investigation No. 485, was to determine the size of dumped stone revetment most suitable for use in lining the banks of flood channels subject to high velocity flow. Four sizes of rock revetment were tested against velocities ranging from 7 to 20

feet per second in a special test channel length of 200 feet. Results of the tests are described in the report, "Civil works Investigation No. 485, High Velocity Revetment Tests", dated 1 January 1952.



### 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-south length of about 150 miles and an average width of 75 miles, is located south of Columbia River and enters that stream in the vicinity of Portland, Oreg. Willamette River is one of the major tributaries to Columbia River west of the Cascade Range. Two parallel mountain barriers, the Coast and Cascade Ranges, form the western and eastern boundaries to Willamette Basin, respectively. Maximum elevations exceed 10,000 feet in the Cascade Range and 4000 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 6000 feet. The frontispiece illustrates the stream system of Willamette River Basin.

3-02. Coast Fork Willamette River Basin. - The basin of Coast Fork Willamette River, in which both Dorena and Cottage Grove projects are located, lies on the northern slope of the Calapooya Mountains and adjoining foothills. It is roughly fan-shaped, 36 miles long and 30 miles wide, with the major axis north and south. The drainage area of the Coast Fork is 669 square miles, which is 33 percent of the drainage area of Willamette River above the city of Eugene and 6 percent of the total Willamette Basin. Except for small areas at the upper headwaters of some of the tributary streams, the Coast Fork Basin lies wholly within Lane County. The western edge of the basin is approximately 50 miles from the Pacific Ocean.

3-03. Dorena Reservoir is located in the Row River Basin 7.3 miles above the confluence of Row River with Coast Fork Willamette River. An aerial photograph of the reservoir and watershed is shown opposite page 1. Cottage Grove Reservoir is located on Coast Fork Willamette River, 7.7 miles above the confluence with Row River and 25.4 miles above the confluence with Middle Fork Willamette River. Dorena and Cottage Grove Dams have tributary basins of 265 and 104 square miles, respectively, which in combination amount to more than one-half of the total area of the Coast Fork watershed.

3-04. Row River Basin has a drainage area of 375 square miles and is roughly pear-shaped. Dorena Dam is located on the main stem above Mosby Creek at a point where the valley narrows to less than one mile in width. Row River originates in the steep northerly slopes of the Calapooya Mountains. Elevations of the area tributary to Dorena Dam range from 740 feet at the dam to 5953 feet at the highest point, with a mean elevation of 2620 feet. Plate 2 locates Dorena and Cottage Grove Dams on basin map of Coast Fork Willamette River. Area-elevation curves for the areas above Dorena and Cottage Grove Dams are shown on plate 3.

3-05. The area tributary to Dorena Dam is a typical rough mountain area in which the valleys are narrow and the slopes unbroken and steep. The soils are thin and for the most part residual and are underlain by andesite and basalt rock. In the headwaters of Sharps Creek the principal rocks are a series of Tertiary volcanic rocks which are a part of the more general series of extrusives that constitute most of the western Cascade Range in Oregon. There are ore veins within the volcanic

structure which yield gold, zinc, lead, copper, and silver. The watershed above the reservoir is timbered with second-growth Douglas fir, hemlock, red cedar, and some white fir, maple, and oak. Logged-over tracts are being continually reseeded and there are only a few small farms along the water courses. Much of the area is covered with dense undergrowth, which is typical of western Oregon forests.

3-06. Principal tributaries to Row River above Dorena Dam are Layng Creek and Brice Creek, which converge about 13.2 miles above the dam, and Sharps Creek, which joins Row River from the left about 10.4 miles above the dam. Rat and Teeter Creeks join Row River from the right within the limits of the reservoir. The following tabulation shows pertinent data for the principal tributaries above the dam:

Stream	Enters Row River at mile	Drainage area		Average slope in feet per mile
		Square miles	% of basin area	
Brice Creek	20.5	56.2	21.2	140
Layng Creek	20.5	68.2	25.7	155
Sharps Creek	17.7	65.7	24.8	100
Teeter Creek	9.8	24.7	9.3	240
Rat Creek	8.6	10.2	3.9	325
Row River at Dorena Dam	7.3	265	100	35

3-07. Mosby Creek, the largest uncontrolled tributary in the Coast Fork Basin, with a drainage area of 96 square miles, enters Row River 3.8 miles below Dorena Dam. Below the confluence with Row River, the Coast Fork flows through agricultural areas with relatively flat

gradients. Condensed profiles of Coast Fork and Row River are shown on plate 3. The following tabulation lists drainage areas and river miles at significant points on Coast Fork and Row Rivers:

Stream	' Drainage area, ' ' square miles	River miles	
		'Coast Fork'	Row R.
Coast Fork Willamette at mouth	669	0	
Coast Fork Willamette nr. Goshen	642	5.5	
Bear Creek		6.8	
Giddings Creek		13.8	
Coast Fork Willamette at mouth of			
Row River	148	17.7	
Coast Fork at U.S.C.E. gage at			
Cottage Grove	147	18.5	
Coast Fork at Cottage Grove Dam	104	25.4	
Coast Fork at London	69	31.4	
Silk Creek at mouth	16.5	19.9	
Row River at mouth	375	17.7	0
Row River at mouth of Mosby Creek	273		3.5
Row River at U.S.G.S. gaging station near Cottage Grove	270		5.1
Row River at Dorena Dam	265		7.3
Row River at U.S.G.S. gaging station above Pitcher Creek near Dorena	211		12.4
Mosby Creek at mouth	96		3.5

3-08. Population. - On the basis of the 1950 census, the population of the area within a 25-mile zone adjacent to Dorena Dam was approximately 70,600. As there was an increase of approximately 75 percent between the 1940 and 1950 census, it is estimated that by projecting this rate of increase in population the 1953 population is about 77,000. This zone includes three cities with a 1950 population of 3,500 or over: Springfield, 10,800; Eugene, 35,900; and Cottage Grove, 3,500. Springfield has had the greatest growth, having tripled in population between 1940 and 1950.

3-09. There is no significant urban development above or below the project in Row River Basin. On Willamette River the six largest cities which receive flood-control benefits from the project and their 1950 population are: Springfield, 10,800; Eugene, 35,900; Corvallis, 16,200; Albany, 10,100; Salem, 43,100; and Portland, 373,600.

3-10. Industry and resources. - Springfield and Eugene are the industrial centers of the area. The principal sources of raw materials for these centers are agricultural and timber products, upon which much of the economy of the area is based. The annual lumber production within the basin of Row River is estimated to be approximately 44,000,000 board feet, and in the basin of Coast Fork Willamette River it is estimated to be approximately 343,000,000 board feet, based on 1950 data. There are approximately 100 lumbermills and wood product plants in the Coast Fork Basin.

3-11. Usage of agricultural lands within the Coast Fork Basin is divided by area approximately as follows: grain, 50 percent; pasture,

30 percent; wild hay, 5 percent; small fruits, 5 percent; and miscellaneous crops, 10 percent. Most of the agricultural lands are on the valley floor well downstream from Dorena and Cottage Grove Dams, and there is practically no agricultural development of the rocky and precipitous terrain above Dorena Reservoir. At present there are no large-scale irrigation works in the area although a number of farmers irrigate by sprinkling, using water pumped from the streams. It is expected that irrigation will be practiced much more extensively in the future, as discussed in Section VIII.

3-12. Two small mines in the upper Row River Basin have been in active production for 60 years. During this period, the yield has been approximately 6,000 ounces of gold, 19,000 ounces of silver, 200,000 ounces of copper, 75,000 ounces of lead, and 6,000 ounces of zinc. Champion Mine, located near the headwaters of Champion Creek, a tributary of Brice Creek, and the Bohemia (Music) Mine, located at the headwaters of Sharps Creek, ship ore concentrates through the towns of Disston and Cottage Grove.

3-13. Utilities. - Row River Basin is supplied with electric power by a rural electrification cooperative line from Eugene. The Bonneville Power Administration now has a 230-kilovolt transmission line from Detroit Dam through Lyons and Lebanon to Goshen. The rural electrification line from Eugene now connects with the Bonneville Power Administration line at Goshen, and power soon will be supplied to the area from Detroit and Lookout Point Dams, major Corps of Engineers units of the Willamette River Basin project.

3-114. Transportation facilities. - Row River Basin is served by major highway and railroad transportation facilities at Cottage Grove, 6.5 miles below Dorena Dam. U. S. Highway 99, which runs north and south through Willamette Valley, is joined at Cottage Grove by Market Road No. 30, providing access to the Row River Basin. The water supply pipe line of the town of Cottage Grove runs along the south side of the reservoir, generally paralleling the south bank access road, County Road No. 830. The Siskiyou Line of the Southern Pacific Railroad goes through Cottage Grove and adequately supplies the area with passenger and freight rail service. A short-line railroad, the Oregon Pacific and Eastern, runs between Disston and Cottage Grove, skirting the north bank of Dorena Reservoir. Originally built and used for many years for ore shipments, this short line now is used principally for shipment of milled lumber. Plate 6 shows the location of the above-described roads and railroad serving the area.



#### SECTION IV - PROJECT DESCRIPTION

4-01. Dorena Dam. - As shown in the illustration to the left, Dorena Dam is an earth-fill structure with a concrete-gravity spillway section located adjacent to the right abutment. Over-all length of the dam is 3,300 feet. The earth-fill portion of the dam has a crest elevation of 865.7 feet and a maximum length of 2,600 feet. The core is of impervious clay, with pervious zones of random clay and gravel on both the upstream and downstream slopes. Both upstream and downstream slopes are faced with 2 feet of dumped stone. In addition, the upstream face has a one-foot layer of select gravel under the dumped-stone revetment, which serves as a zone of drainage. The top of the earth-fill portion of the dam is graveled and serves as a 20-foot access road to the left abutment of the spillway structure. The permanent housing area is on the left bank about one-half mile below the dam. Plate 4 shows a general plan with sections and elevations of the dam and spillway as constructed.

4-02. Dorena spillway. - Dorena spillway is a free-overflow structure with a clear length of 200 feet and a crest elevation of 835 feet. See illustration opposite page 21. It is designed to discharge 97,500 second-feet at maximum pool elevation 860 feet. The spillway discharges into a stilling basin which is equipped with two rows of baffles and slopes downstream from elevation 716.05 to elevation 710. At the lower end of the stilling basin there is a 16-foot step-up. Downstream from the step-up the channel is approximately level at elevation 726.

4-03. Downstream from the stilling basin, the river banks are riprapped for a short distance. The area on the left bank behind the training wall is filled to provide a suitable approach to the control house, which is located adjacent to the left bank training wall at the toe of the downstream slope of the dam. The discharge rating for the spillway is illustrated on plate 5, and the following tabulation gives the spillway discharge in units of 1,000 second-feet:

Pool elev.	Q	Pool elev.	Q	Pool elev.	Q
835.0 <sup>1</sup>	0.0	844.0	18.2	852.0	51.9
836.0	0.6	845.0	21.6	853.0	57.0
837.0	1.7	846.0	25.3	854.0	62.3
838.0	3.2	847.0	29.2	855.0	67.8
839.0	5.0	848.0	33.3	856.0	73.4
840.0	7.1	849.0	37.6	857.0	79.2
841.0	9.5	850.0	42.2	858.0	85.2
842.0	12.1	851.0	46.9	859.0	91.3
843.0	15.0			860.0 <sup>2</sup>	97.5 <sup>3</sup>

<sup>1</sup> Spillway crest = full pool

<sup>2</sup> Maximum pool.

<sup>3</sup> Spillway design flood outflow = 97,500 second-feet.

4-04. Outlet works. - The outflow from Dorena Reservoir is passed through five conduits, each equipped with an upstream and downstream hydraulically operated slide gate. The conduits are located in the concrete spillway section and pass the water through the structure onto the spillway face. The control gates in each conduit are 5 feet by 6 feet.



The downstream gate is used for regulation and the upstream gate is used for emergency closures. Operation of the gates is from gate chamber in the control tunnel located 83.4 feet below the spillway crest.

4-05. Combined capacity of the five service outlets is 5,440 second-feet when the reservoir is at minimum conservation pool, elevation 770.5, and 9,275 second-feet when the reservoir is at full pool, elevation 835. Discharge ratings for one outlet conduit are presented in graphical form on plate 5 and in tabular form in table 9. That table shows discharges for partial gate openings between 0.1 and 6.0 feet for each one-foot increase of pool elevation from 760 to 840 feet.

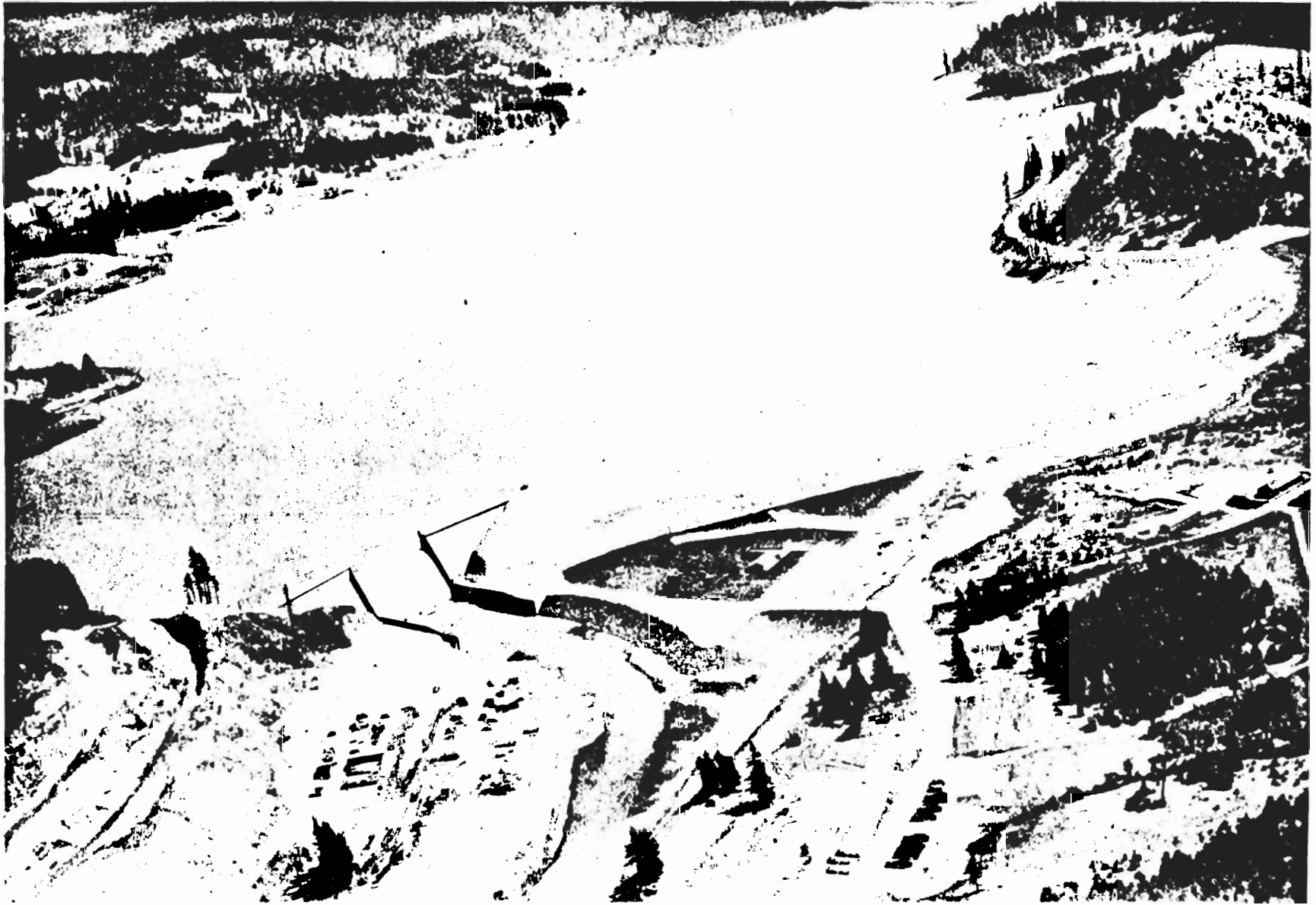
4-06. Reservoir and shoreline. - The view facing page 1 illustrates Dorena Reservoir and watershed and the area southward to the Calapooya Mountains. As shown, there is a small amount of relatively flat land immediately adjacent to the right bank of the reservoir and the timber-covered foothills rise abruptly from the left shore. Evidence of erosion along the shoreline is very slight, and wind action is not a problem. Dorena Reservoir has a shoreline about 12 miles long, of which approximately 7 miles are on the right bank and 5 miles on the left bank.

4-07. Capacity of Dorena Reservoir at full pool, elevation 835, is 77,500 acre-feet, and at minimum conservation pool, elevation 770.5, it is 7,000 acre-feet. Maximum depth of the reservoir is about 80 feet, except in the old channel of Row River which is about 10 feet lower than the general bottom elevation. Reservoir area and capacity curves

are shown on plate 5. Table 10 shows the reservoir capacity for each 0.1-foot change in elevation between 760 feet and 860 feet.

4-08. Downstream channel improvements. - In the interest of reservoir regulation and to prevent erosion during evacuation of stored floodwaters, certain improvements for channel rectification and bank protection have been constructed along Row River and Coast Fork Willamette River below Dorena Reservoir. The following tabulation lists the channel improvements which have been constructed with funds for Dorena project.

River mile	Bank	Location	Length, feet	Type	Date built	Remarks
<u>ROW RIVER</u>						
0.7	Left	Hemenway	1275	Dumped stone	1952	Snags removed from channel nr. downstream end
0.4	Right	Veatch	986	do	1952	Revetment only
<u>COAST FORK</u>						
11.5	do	Rinehart	2400	do	1951	do
11	Left	Benter	2000	do	1951	do
9.8	Right	Haskin	2020	do	1951	Overflow closures included
10.1	Left	Sly	890 1455	do spoil bank	1952	Snags removed from channel near downstream end
9.3	do	Jenkins	514 2140	Dumped stone do	1952 1951	Channel closure constructed 1952
9.0	Right	Melton	2350	do	1951	Snags removed from channel nr. upstream end
8.6	Left	L. Melton	1046	do	1952	Revetment only
2.7	do	Mikesell	143	Overflow closure	1952	No revetment
2.2	do	Estep	85	do	1952	do
2.1	do	McBee	52	do	1952	do



DORENA DAM AND RESERVOIR

4-09. Public-use facilities. - A plan for development of Dorena Reservoir in the interest of public use is described in a preliminary report entitled "Master Plan, Reservoir Management and Public Use, Dorena Reservoir," dated March 1950. The plan provides for one major day-use area on the south shore of the reservoir, a minor day-use area, an access point and launching ramp on the north shore, a sight-seeing area for the spillway and downstream channel, and two scenic overlooks near the dam. To date, only a small part of the work outlined in that plan has been done. Current policy is to limit, to the minimum necessary for safety and sanitation, the extent of public-use developments by the Federal Government. Accordingly, future development of recreational facilities will have to be accomplished at State or local level.

4-10. The Baker Bay area, which has been selected as a major day-use area, has a small natural bay that can be developed for swimming and boating. It is located on the south shore about one mile above the dam and contains 34 acres. The only development work which has been accomplished at this location consists of grading and graveling an access road to the area.

4-11. The Row Point area, which has been selected as a minor day-use area, is located on the north shore about three-fourths mile above the dam. The area consists of two small points lying adjacent to each other and totals about 7 acres. No development work has been done at this location.

4-12. A spillway overlook near the right abutment has been im-

proved by grading, surfacing, placing of guard rails, and installation of an information sign. Rat Creek launching ramp, on the north shore of the reservoir near Rat Creek, is served by an access road crossing the Oregon Pacific and Eastern Railroad. To make this area safe and usable by more than 3 or 4 cars, removal of a small hill which obscures visibility along the railroad will be necessary. No work other than cleanup has been done, however, and no further work is contemplated by the Portland District at either the overlook or the launching ramp area. A map of Dorena Reservoir, locating the public-use areas is shown on plate 6.

4-13. Hydropower Project. The Hydropower Project, includes an intake structure and trashrack, a 120-inch diameter, 433 foot-long penstock that bifurcates into two sections leading to either the Kaplan turbine or the Francis turbine, upstream closure valve, a siphon house with emergency closure valves, Kaplan guard valve vault, a powerhouse that contains the 6.1 MW capacity Kaplan turbine and the 1.4 MW capacity Francis turbine, a tailrace dewatering system, a tailrace fish barrier, a rubber dam and outlet training wall. The Francis turbine operates for a flow range of 80 cfs to 220 cfs and reservoir levels of El. 779 ft to El. 835 ft, and the Kaplan turbine operates for a flow range of 200 cfs to 812 cfs for all reservoir levels (operable from El. 769.4 ft to El. 835.9 ft). Only one turbine will be operating at any given time; however, an exception may occur when transitioning between the two units, which would be for a very brief period. The Hydropower Project structures are located on the right hand side (looking downstream) of the spillway and stilling basin. The general plan and layout of the Hydroelectric Project is provided in Plate 22. The Hydropower Project operation does not alter the day-to-day flow release from Dorena and will release flows in accordance with the CENWP-EC-HR flow schedules. Exhibit B provides a full detailed description of the hydropower project and the purpose and operation of each element of the hydropower project. Section 3 of the Hydropower Project O&M Manual (referenced in Section 1-04.b.3 of this manual), provides additional project description details.

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## SECTION V - METEOROLOGY AND HYDROLOGY

5-01. Climate. - The climate of Willamette River Basin, including Row River Basin, is of the temperate marine west-coast type, characterized by wet winters and dry summers. Principal climatic controls are the geographical location near the center of the middle-latitude westerly winds, the proximity to the Pacific Ocean, and the topography. The general circulation of the atmosphere over the Pacific Northwest is largely controlled by the Aleutian Low and the North Pacific High. Since these semi-permanent pressure centers tend to follow the annual march of the solar altitude and are therefore normally farthest south in the winter and north in the summer, the storm path often lies across the Pacific Northwest during the winter months. The region is therefore subject to frequent winter cyclonic storms of potential flood-producing magnitude, but is generally free from highly destructive storms such as tornadoes.

5-02. Climatological records. - Climatological data are now published for two active stations in the immediate project area, Disston 2 NE (Layng Creek) and Dorena Dam, both of which have recording precipitation gages. Temperature, humidity, and evaporation data also are obtained at Dorena Dam. Precipitation records from Culp Creek station, established by the Corps of Engineers, and Star, now discontinued, also are available. In addition, precipitation data are obtained at 3 nearby stations in the upper Coast Fork Basin: Blackbutte, London, and Cottage Grove Dam. The longest and most complete climatological record in the general area is that for Eugene and Eugene Airport.

Records for the City of Eugene cover the period October 1890 to June 1945, and the first-order Weather Bureau station in current operation at Eugene Airport was established in January 1943. In the Coast Fork Basin, Cottage Grove, where observations began in August 1916, has the longest record. Snow surveys have been made since 1939 at Champion Mine, located at the headwaters of Champion Creek in the upper headwaters of the area tributary to Dorena Dam. Plate 2 presents the location and inventory of hydroclimatic data for all stations in the Row River Basin and also the stations in the Coast Fork Willamette River Basin serving Cottage Grove Dam.

5-03. Precipitation. - The normal annual precipitation over Row River Basin above Dorena Dam is estimated to be 54 inches, varying from about 50 inches over the northern half of the project area to more than 80 inches in the mountainous area bordering the project area on the southern side. Coast Fork Willamette River Basin above Cottage Grove Dam has an estimated normal annual precipitation of 53 inches, ranging from 48 inches at the dam to more than 60 inches in the upper headwaters. Plate 7 illustrates the isohyetal map of normal annual precipitation for the entire Coast Fork Willamette River Basin.

5-04. Sixty-five percent of the annual precipitation normally falls in the 5-month period, November through March. In each of the driest months of July and August the normal precipitation is less than one-half inch. The marked seasonal regime is further illustrated by the chart on plate 7 which shows maximum 24-hour precipitation, by months, for several stations in the area. Without exception, the maximum one-

day intensities occurred during the winter months. Also shown on plate 7 are histograms of monthly minimum, average, and maximum precipitation for Cottage Grove and Eugene. Tables 1 through 3 summarize the climatological records of Eugene, Eugene Airport, and Cottage Grove, and tables 4 through 7 show precipitation by months for the period of record for four additional stations near Dorena Dam.

5-05. Since the mean elevation of Row River Basin above Dorena Dam is 2620 feet and there are areas within the basin that rise to nearly 6000 feet, a significant portion of the precipitation falls in the form of snow. The average annual snowfall in the basin varies from a few inches in the low elevations to well over 100 inches in the mountains bordering the basin on the south. Snow cover below 2000 feet may be converted into run-off several times during each winter season, and the accumulation at any time seldom exceeds 2 feet. Above 3500 feet, which represents about 20 percent of the basin above Dorena Dam, the tendency is for the snow to pack and the water equivalent of the snow cover to accumulate well into the spring season. Intense rains, accompanied by high temperatures, occasionally result in a pronounced snowmelt which augments the run-off from rain. This sequence of hydrologic events may happen at any time from the middle of November until the last of March. Plate 7 shows graphically the depth and water equivalent of the snowpack measured at Champion Mine, elevation 4500 feet. These measurements are made on or about the first and fifteenth of the month, starting on 1 January and terminating on 1 April.

5-06. Temperatures. - The moderating effects of maritime air re-

sult in comparatively small variations of temperature in the Row River Basin. The temperature record for Dorena Dam, shown in condensed form in table 7, covers only a short period and may not be representative of long-term conditions. Summaries of longer and more complete records of temperatures are shown graphically on plate 7 and in tabular form in tables 1 through 3. Temperature extremes observed at Cottage Grove, six miles downstream from Dorena Dam and 140 feet lower in elevation, are 105° F. and -7° F. in the 35-year period of record.

5-07. Evaporation. - Evaporation losses from the surface of Dorena Reservoir are significant during the 7-month period, April through October, when temperatures are highest and the surface area of the pool is the greatest. During the rainy season when humidities are high, temperatures are low, and the reservoir is held evacuated for flood control, evaporation losses are insignificant. Evaporation in inches and total wind movement in miles at Dorena Dam, as measured by a standard 4-foot diameter by 10-inch depth evaporation pan and 3-cup anemometer, are shown in the following tabulation:

Year		May	June	July	August	September
		B				
1950	Evap.	6.31	5.07	9.00	8.58	4.95
	Wind	2210	1850	2468	2192	1830
1951	Evap.	5.62	9.24	9.38	8.48	5.31
	Wind	2140	2378	2151	2100	1541
		B	B			B
1952	Evap.	5.65	4.84	9.22	7.24	4.99
	Wind	1912	1595	2165	1900	1430

B = Adjusted to full month.

5-08. Since evaporation records at Dorena Dam are for a period of only 3 years, average monthly evaporation from land pans has been estimated on the basis of longer records obtained at Cottage Grove Dam, Fern Ridge Dam, and Corvallis. A conversion factor of 0.7 was applied to the land-pan rates to determine estimated average monthly evaporation from Dorena Reservoir. The following tabulation gives estimated monthly averages of reservoir surface, evaporation, and precipitation:

Month	Avg. area, acres	Evap., inches	Precip., inches	Evap., ac.-ft.	Precip., ac.-ft.
April	1400	2.0	4.2	230	490
May	1760	3.6	3.3	530	480
June	1830	4.5	2.5	690	380
July	1830	6.3	0.4	950	60
August	1770	5.6	0.4	830	60
September	1560	3.5	2.0	460	260
October	1070	<u>1.3</u>	<u>4.6</u>	<u>120</u>	<u>410</u>
Totals		26.8	17.4	3810	2140

On the basis of these average monthly evaporation rates, it is estimated that the average annual evaporation from Dorena Reservoir would be about 3800 acre-feet, or approximately 6 percent of the usable storage. Rainfall during the evaporation season would normally compensate for about 2100 acre-feet, or 56 percent of the evaporation loss, resulting in an estimated average net loss in storage due to evaporation of 1700 acre-feet annually.

5-09. Storms. - Flood-producing storms occur chiefly during the winter season but are not uncommon in late fall and early spring. The sharp increase in frequency, duration, and severity of storms in late fall is a result of the southward displacement and renewed activity of the semi-permanent Aleutian low-pressure system. Frequently a series of waves develops along the Polar Front marking the southern-most extent of the colder air mass and, moving generally eastward, produces successive storms along the coastal areas. The moisture-laden air masses are often conditionally unstable, so when they are orographically lifted by the mountain barriers general and often copious precipitation results. All general winter storms of the Pacific Coast of the United States and Canada are of one basic type, having similar origins, air-mass trajectories, and Pacific Ocean moisture sources.

5-10. During the summer season, the reversal of the thermal gradient between the continental land mass and the ocean water surface tends to weaken the Aleutian Low. The summer storm path usually lies far to the north, and the decrease in frequency, duration, and intensity of precipitation with the advent of summer is so marked as to eliminate that season as a major flood period. A limited flood potential exists during late spring because of the possible occurrence of relatively weak storms, and summer thunderstorms in the mountains may cause short periods of high water locally. Although no flooding in the lower valley results from such storms, some storage space is reserved in Dorena Reservoir for control of possible late spring and summer floods.

5-11. Discharge records. - Discharge records for Coast Fork

Willamette River date back to October 1905, but no one station has a continuous discharge record from that time to date. The first stream gaging station in the basin was on Coast Fork Willamette River near Goshen, approximately 4 miles above the confluence of the Coast and Middle Forks. That station was in operation for 7 years, 1906 through 1912, and was re-established in October 1950 as a key control for regulation of Dorena and Cottage Grove Reservoirs. In September 1935 a staff gage was established on Row River at Star, approximately 2 miles upstream from Dorena Reservoir, and in October 1938 the staff gage was replaced with a water-stage recorder. That station, which is now designated Row River above Pitcher Creek near Dorena, records the run-off contribution from 80 percent of the total area contributing to the reservoir inflow. In January 1939 a staff gage was installed  $1\frac{1}{2}$  miles downstream from the present site of Dorena Dam, and in October 1939 the staff gage was replaced with a water-stage recorder. The discharge measured at that station constitutes a continuous record of outflow from Dorena Reservoir. A water-stage recorder at Dorena Dam has provided a record of reservoir elevations since the project became operative. Plate 2 shows the locations of these Row River stream gaging stations, as well as the stations serving Coast Fork Willamette River. Periods of record and drainage areas above the stations also are shown.

5-12. Stream flow characteristics. - The stream flow patterns of Row River and Coast Fork Willamette River are similar to the annual rainfall pattern of western Oregon in that low flows prevail from June through October, the season of low precipitation, and high flows

normally occur during the period November through March, which is the period of heavy precipitation. Approximately 75 percent of the annual run-off occurs during the period November through March. During the latter period, 65 percent of the mean annual rainfall occurs. As the ground becomes partially saturated in the fall, the streams respond readily to any rain in excess of the infiltration capacity of the topsoil, which may vary from 0.1 inch to 0.03 inch per hour, depending upon the degree of saturation. The maximum annual high water usually occurs in November, December, or January, and several freshets usually occur each year during the rainy season. Figure 5 of plate 8 illustrates the tendency for the highest discharges to occur in midwinter. Snowmelt from the higher elevations usually maintains fairly high base flow until early summer. The following tabulation shows monthly mean, maximum, and minimum run-off in percent of the normal annual run-off for Row River at Dorena Dam:

Month	Run-off in percent of mean annual		
	Mean	Maximum	Minimum
October	3.5	19.0	0.4
November	12.0	22.1	0.5
December	15.7	40.7	2.0
January	15.5	30.6	5.1
February	15.8	23.1	3.9
March	13.5	22.6	2.6
April	10.3	19.5	4.0
May	7.4	12.9	2.0
June	3.9	9.4	0.9
July	1.1	2.0	0.4
August	0.5	1.0	0.2
September	0.6	1.7	0.2
Annual	100.0	--	--

5-13. At Dorena Dam the average annual run-off for the period of record is 726 second-feet. This amounts to 525,400 acre-feet, or 36.5 inches over the tributary area. Summaries of monthly and annual stream flow data for two Row River stations, two on Coast Fork Willamette River above Row River, one on the Coast Fork below Row River and one on Willamette River below Middle Fork Willamette River are presented in graphical form on plate 9 and in tabular form in table 8. Plate 9 also shows flow duration curves for each station expressed in percent of time. Daily discharge hydrographs, including mean daily discharge, maximum annual and instantaneous discharges, minimum annual daily discharge,

and total annual run-off, for the more important of the above stations are presented on plates 10 through 15. Daily pool elevations of Dorena Reservoir for the entire period the project has been in operation are shown on plate 16.

5-14. Floods. - Floods on Row River usually result from heavy rainstorms of one to three days duration, often augmented by snowmelt run-off. Because of the abrupt terrain and steep water-course gradients in the upper Row River Basin, the flood run-off is relatively flashy. This characteristic is illustrated by the daily discharge hydrograph of the stream gaging station above Dorena Reservoir, as shown on plate 10. Duration of floods is usually one to four days, but a series of storm waves may extend the period of downstream flooding to a week or more, particularly in the critical Eugene area. The snowmelt contribution usually increases the flood volume more than the flood peak and may at times create reservoir regulation problems because of the additional volume of water which must be stored to control a flood. Typical flood recessions for several significant locations on Willamette River and tributaries are shown on figures 1 and 2 of plate 8.

5-15. The largest historical flood for which limited information is available occurred in December 1861 and had an estimated peak discharge at Dorena Dam of 28,600 second-feet and a 6.5-day volume of 190,000 acre-feet. In February 1890 a flood occurred which nearly equaled that of 1861. Neither of these historical floods approached the peak inflow of the spillway design flood, 111,500 second-feet. Section VII of this manual contains a discussion of the regulation of

these floods, as well as of more recent floods, which could be effected by Dorena Reservoir.

5-16. Computed peak reservoir inflows were used as a basis for a flood frequency study. Figure 4 of plate 8 shows the resulting frequency curve, derived by the method described in Engineer Bulletin C.W. 51-1. The following tabulation shows peak inflows for selected recurrence intervals:

Average recurrence interval in years	Peak inflow into Dorena Reservoir
2	12,000
5	18,000
10	22,000
25	27,000
50	31,000
100	35,000
200	39,000

5-17. Channel capacities and bankfull stages. - Channel capacities of Row River below Dorena Dam, Coast Fork Willamette River near Goshen, and Willamette River at Eugene were given primary consideration in the derivation of the reservoir regulation schedules for Dorena Reservoir as presented in Section VII of this manual. Because of the necessity for coordinating the regulation of Dorena and Cottage Grove Reservoirs, the channel capacities of Coast Fork Willamette River below Cottage Grove Dam and at the city of Cottage Grove also are of importance. Channel capacities and bankfull stages for the above index stations are

presented in the following tabulation:

Stream	Station or location	Dr. area, sq. miles	Channel capacity	Bankfull stage, ft.	General reach
Row River	Nr. Dorena	270	5,000	8.2	Dorena Dam to Mosby Cr.
Row River	At Mouth	375	7,000	—	Mosby Cr. to mouth of Row
Coast Fork	Bel. Cottage Grove Dam	104	3,000	8.0	Bel. Cottage grove Dam
Coast Fork	At Cottage Grove	147	3,400	10.3	City of Cottage Gr.
Coast Fork	Nr. Goshen	642	12,000	11.4	L. Coast Fk.
Willamette	At Eugene	2,030	39,500	7.0	Middle Fk. to McKenzie R.

5-18. Stream flow velocities. - Average stream flow velocities in the river reach immediately above Dorena Reservoir vary from less than one foot per second during low summer flows to 9 or more feet per second during flood periods. Velocity data are not available for the steep headwaters reaches, for which a condensed profile is shown on plate 3, but upstream velocities are greater because of the steeper gradients. Below Dorena Dam average water velocity when the reservoir release is 5,000 second feet, the normal maximum release is 5.6 feet per second at the stream gaging station. Stream flow velocities in middle and lower Coast Fork, which are of importance because of the relationship with bank erosion, vary from less than one foot per second at low flows to more than 7 feet per second when the flow exceeds the channel capacity. Overbank velocities are estimated to average 2 to 4 feet per

second. The following tabulation, developed from measurements made by the U. S. Geological Survey, gives average water velocity in feet per second at various discharges:

Discharge, 'second-feet'	Row River		Coast Fork	
	Abv. Pitcher Cr.	Nr. Cottage Gr.	at Saginaw	Nr. Goshen
100	0.5 - 0.9	0.7 - 1.4	0.3 - 1.3	0.9 - 1.3
500	1.3 - 1.5	1.6 - 2.0	0.5 - 2.2	2.2 - 2.6
1,000	2.1	2.6	1.0 - 2.4	2.6 - 3.1
5,000	5.1	5.6	3.9	3.6
10,000	7.6	--	5.8	4.2
15,000	9+	--	7+	5-

5-19. Determination of reservoir inflow. - Average or total reservoir inflow over a period of time may usually be best estimated by adding algebraically 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 applied with accuracy to determine inflow during very short periods of time. 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 reservoir losses, but during much of the year the losses are minor as compared to the inflow. During the dry season, however, the inflow into Dorena Reservoir may recede to the extent that evaporation rates approach the inflow rates.

5-20. Instantaneous reservoir inflow may be estimated by applying

ing a factor to the instantaneous discharge of Row River above Pitcher Creek near Dorena. Run-off from 80 percent of the area tributary to the dam is gaged at that station and, on the average, 82 percent of the annual run-off at the dam is recorded at the gaging station. As shown by figure 3 of plate 8, the flood peak relationships between the inflow station and the discharge at the dam vary somewhat, but have an average value of about 1.2. When the discharge of Row River above Pitcher Creek near Dorena is multiplied by a factor of 1.2 the product is usually a reasonable estimate of the instantaneous reservoir inflow. 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 flood periods due to the fact that precipitation distribution, freezing level, and snow cover in the basin varies from one storm to another. The stream gaging station on Row River above the reservoir is equipped with an automatic telephone transmitting device (Telemark), which transmits the stage height as a series of audible buzzes when the station is called by telephone.

5-21. River and rainfall reporting network. - The Willamette River Basin reporting network consists of approximately 70 strategically dispersed stations. The stations are more closely spaced in areas where reservoirs are in operation. Twenty of the stations, located mainly in the vicinity of operating projects, are operated by or report directly to the Corps of Engineers. Twenty-five stations are in the cooperative FC-5 network, operated by the U. S. Weather Bureau with funds transferred from the Corps of Engineers. The Weather Bureau contributes to the

program by operating an additional 25 reporting stations. A free and continuous exchange of information is maintained between the two agencies.

5-22. Some of the stations in the network report precipitation river data only, while others report, in addition to precipitation and river stages, other pertinent information such as temperature, snow depth, current weather, etc. In some instances reports are sent only when the 24-hour precipitation is one inch or more or when the stream is near or above bankfull. Other stations report daily during the winter months, and a few key stations report daily the entire year. During critical storm conditions, additional or more frequent reports may be obtained from selected stations. 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.

5-23. The following reporting stations are directly related to the regulation of Dorena Reservoir:

Station name	Elev., ft. m.s.l.	Dr. area, sq. miles	Data reported	Remarks
Culp Creek	970	—	Precip., wea.	Wet season only
Row R. above Pitcher Creek	856	211	Res. inflow index	Telemark
Dorena Dam	760	265	Res. elev. & outflow, precip., wea.	Obsv. by damtender
Cottage Grove Dam	830	104	Res. elev. & outflow, precip., wea.	Obsv. by damtender
Coast Fk. Nr. Goshen	474	642	River stage	Telemark
Willamette R. at Eugene	400	2030	River stage	Wea. Bu. sta.
Eugene Airport	364	—	Complete wea. report	Every 6 hrs. by teletype Service "C"

5-24. Telemark telephone numbers. - The Portland District operates automatic telephone transmitting devices (Telemarks) at 9 stream gaging stations of major significance to the regulation of Willamette Basin reservoirs. In addition to the Corps of Engineers stations, which are all on tributaries of Willamette River, the Weather Bureau operates two Telemark stations on the main stem of Willamette River. The gage heights are transmitted as a series of audible buzzes when the equipment is activated by an incoming telephone call from any telephone connected with the Bell system. Telephone numbers of the Telemark-equipped stations which are of significance to the regulation of Dorena and Cottage Grove Reservoirs are:

Location	Stream	Telephone No.	Agency
Ab. Pitcher Cr. near Dorena	Row River	Cottage Grove 6-8613	C.E.
Nr. Goshen	Coast Fk. Will. R.	Eugene 6-1321	C.E.
At London	Coast Fk. Will. R.	Cottage Grove 909	C.F.
At Lowell	Mid. Fk. Will. R.	Lowell 386	C.E.
Near Coburg	McKenzie River	Eugene 5-6482	C.E.
At Harrisburg	Willamette River	To be assigned	W.B.
At Salem	Willamette River	Salem 4-5283	W.B.

5-25. Snow surveys. - Under a formal contract with the Oregon Agricultural Research Foundation, the Portland District, Corps of Engineers, finances a number of snow surveys in the Willamette River Basin. Profiles of snow depth and water equivalent are extended up four Willamette River tributaries, of which Row River is the southernmost. Seven by-monthly surveys are made, starting 1 January and ending 1 April. Measurements are made at the following locations in the Row River Basin:

Location	Elevation
Snow line	Variable
Layng Creek R.S.	1200
Lund Park	1740
Weaver Creek	2440
Golden Curry	3136
Champion	4500

5-26. Sedimentation. - The geology and vegetative cover above Dorena Reservoir are such that it is improbable that large volumes of

material will be transported either in suspension or as bed load and deposited in the reservoir. The soil cover is generally shallow, and only small areas at the junctions of the tributary streams contribute appreciably to sedimentation. Under the soil mantle, the rock intrusions are so heavy that little if any of the underlying material is being or can be transported into the reservoir as bed load. Unless widespread and severe timber cuts are made in the mountainous upstream areas, which are largely under U. S. Forest Service control, no substantial upstream erosion is anticipated.

5-27. In connection with a program of suspended sediment surveys in Willamette River Basin, sedimentation concentrations in Row River above Dorena Dam were sampled at frequent intervals during the period October 1948 through July 1951. The equivalent of 25 acre-feet of sediment was transported into the reservoir in a 2-year period. This would indicate that suspended sediment would not be a problem at Dorena. A reservoir survey made at Cottage Grove Reservoir in 1948 indicated that silting of the reservoir was occurring at an annual rate of 0.25 acre-foot per square mile of drainage area. The results were for a period of years in which there was an unusually large number of major floods. On the basis of those data, it is estimated that Dorena Reservoir probably would not lose more than 50 acre-feet of storage space annually to silting action. At that rate and assuming that part of the deposition would be below the minimum conservation pool level, the reduction in the active storage space over the 50-year economic life of the project would be small.

5-28. More specific information on actual loss of storage space in Dorena Reservoir will be provided in the future by reservoir sedimentation surveys, to be conducted at approximate 10-year intervals, or as needed. To facilitate such future surveys, permanent range lines and initial cross-sections were established in 1952 and are shown on plates 17 and 18.



## SECTION VI – SEASONAL REGULATION SCHEDULE

6-01. General. The primary function of Dorena Reservoir is flood risk management (the term “flood control” is used in the original water control manual and will be revised to “flood risk management” when the entire water control manual is updated). It is regulated so as to provide maximum over-all benefits insofar as is possible without jeopardizing the flood-control function. Other interests which benefit directly from this multiple-purpose project include irrigation, fish life, navigation, pollution abatement, recreation, and hydropower. Economic and physical limitations preclude the provision of separate storage capacity for all the above functions, necessitating multiple-use of the same storage space for flood-control and conservation purposes by means of a proper seasonal regulation schedule. Seasonal variations of storage allocations in Dorena Reservoir are entirely feasible because of the seasonal precipitation and run-off characteristics of the basin, as described in Section V.

6-02. For purposes of scheduling regulation of Dorena Reservoir, the year is divided into three seasons: (1) major flood season, 1 November through 31 January; (2) conservation storing season, 1 February through 19 May; and (3) conservation release season, 20 May through 31 October. These three functional divisions of the seasonal schedule are illustrated graphically in figure 1 of plate 19. Actual regulation and its conformity to this schedule is shown graphically on plate 16, the pool elevation hydrograph of Dorena Reservoir since 1950. The total flow releases from the reservoir, whether for power or other purposes, are as determined by the CENWP-EC-HR and are measured at the USGS DORO gage.

6-02.1. Power Operation. The Hydropower Project will control the Dorena Project flow releases up to 812 cfs, generally to generate hydroelectric power. The theoretical flow range limits for the turbine units is 80 to 812 cfs. When flow releases mandated by CENWP-EC-HR are less than 80 cfs and the powerhouse is not on line, the Hydropower Project operator is responsible for flow regulation through the USACE RO gates (see section 9-09.1. for hydropower operator responsibilities). While the suggested minimum gate opening (see table 9) results in flows greater than 80 cfs, the Hydropower Project will follow the instructions from CENWP-EC-HR. In a situation where flow releases are to be less than 80 cfs for prolonged periods of time, control may be passed to the USACE until such time flow releases are within the operational range of the turbines.

For flows from 80 cfs to 812 cfs, the Hydropower Project operator will generally have primary control of flows and the flow will be released through the Hydropower Project. An exception to this is when there is a transition of operations between the Hydropower Project and the regulating outlet (RO), at project releases between approximately 812 cfs and 917 cfs. The minimum allowable release through the RO is based on the minimum RO gate opening of 0.6 feet (10% of the total stroke). At this gate opening the flow is limited to the range of 105 cfs (at low pool) to 178 cfs (at full pool). If the required project flow above 812 cfs is less than the flow at minimum gate opening, then the Hydropower Project assigned flow is limited to 812 cfs minus the minimum gate opening flow. Examples of the transition under this situation are provided in Section 5.4 of Exhibit B. The USACE will have primary control above 812 cfs.

Section 5 of Exhibit B, provides details of how water is to be released for various flow ranges and how the hydropower operators communicate with the Lookout Point control room operators in making these changes.

Section 5.5 of Exhibit B provides ramping rate restrictions for flow changes between 80 and 812 cfs and the Hydropower Project will conform to ramping rates as prescribed in their license which are slightly different than those imposed on the USACE. The Hydropower Project will operate in this fashion throughout all three seasons described in Section 6-02 of this manual. It should be noted that the Hydropower Project has a water right restriction that limits the maximum amount of flow through the plant to 812 cfs.

6-03. Major flood season (1 November through 31 January). A maximum of flood-control space is provided in Dorena Reservoir from 1 November through 31 January, the period of maximum flood potential.

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During that season, the reservoir is held evacuated to minimum conservation pool, elevation 770.5, except as temporary higher pool elevations are reached incident to control and regulation of floods. Section VII, Flood-Control Regulation, describes in detail the flood-control regulation schedules for Dorena Reservoir.

6-04. Evacuation of stored floodwaters will not be initiated until Row River and Coast Fork Willamette River have receded below bankfull stage. Releases from Dorena Reservoir will then be increased as rapidly as the predetermined coordination with releases from Cottage Grove Reservoir will permit. Before floodwaters are evacuated from either of these reservoirs, it will be determined that the increased flow from Coast Fork Willamette River will not increase or unduly prolong overbank stages on Willamette River at Eugene or Harrisburg. As additional storage is provided at Lookout Point Reservoir, this phase of Dorena Reservoir flood regulation will become increasingly important.

6-05. Conservation storing season (1 February through 19 May). - After 1 February, the flood potential of Row River gradually decreases, which permits storing of water for conservation prior to the conservation release season. As shown on figure 1 of plate 19, the reservoir is to be filled uniformly over the period so as not to exceed an accumulated uniform rate of 600 acre-feet per day. Table 11 gives scheduled pool elevations and the corresponding storages, by days. If this filling rate is maintained, the reservoir will reach maximum conservation pool, elevation 832, by 20 May. In leap years, that elevation will be attained one day earlier. Available storage for

control of late spring and summer floods, between maximum conservation pool and full pool, elevation 835, is 5,600 acre-feet. Usable storage available for conservation purposes, between minimum and maximum conservation pools, is 64,900 acre-feet.

6-06. Departures from the uniform filling schedule may be caused by necessary regulation of a flood occurring during the conservation storing season. Regulation of a flood during this season will be in accordance with Section VII of this manual. Following the flood, excess floodwaters will be released until the pool is drawn down to the scheduled reservoir elevation for that date.

6-07. It is possible for the reservoir inflow to recede to the extent that it becomes inadequate to meet the scheduled filling rate. In addition to providing the necessary increment of storage, the inflow must satisfy the evaporation losses and the prescribed minimum release of 190 second-feet. When this does not occur, reservoir filling will fall behind schedule because storing of water does not take precedence over approved minimum release requirements. This condition will occur infrequently because of the snowmelt contribution to Dorena Reservoir inflow during the filling season. Any such deficiency may be made up later if sufficient water becomes available and, if necessary and feasible, the filling period may be extended beyond 19 May.

6-08. An exceptionally deep snow pack over Row River Basin after 1 February would create an added flood hazard during the conservation storing season. Under such circumstances, the primary interests of flood control may indicate that filling should be deferred temporarily

until the flood potential of the basin is reduced to near-normal proportions. Such action, which will be required only infrequently, will be taken only upon specific authorization of the Reservoir Regulation Subsection. Following the delayed filling, water may be stored at a rate in excess of 600 acre-feet per day, provided the prescribed minimum releases are maintained.

6-09. Conservation release season (20 May through 31 October). - Functional regulation of Dorena Reservoir during the season 20 May through 31 October provides for the release of water so as to obtain the greatest over-all conservation benefits. Since demands for stored water, stream flow conditions, and the required coordination with other reservoirs vary widely from year to year, it is not practicable to establish definite schedules for supplementary low-water releases. A provisional schedule, predicated on forecast stream flow and water demand, will be prepared each year prior to initiation of scheduled releases for conservation purposes and will be revised periodically as indicated by changing conditions. Section VIII of this manual contains a detailed discussion of the various conservation functions and their interrelationships.

6-10. Increases in the rate of controlled release for conservation uses normally will not exceed 200 second-feet in any one-hour period or 500 second-feet in any 24 hours. Should unusual circumstances necessitate that these rates be exceeded, all practicable advance notice will be extended to downstream interests. This limitation does not apply in case of a flood or freshet, when the reservoir would be regulated for flood-

control as described in Section VII. Floods are uncommon during the conservation release season, but they have occurred in late October, at which time much of the reservoir storage is available for flood control. Stored water remaining in the conservation pool is not to be retained later than indicated by the limiting draw-down line shown on figure 1 of plate 19, except in the event of a flood.

## SECTION VII - FLOOD-CONTROL REGULATION

7-01. Basic method 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 of Dorena Reservoir is a compromise procedure based on the third method. 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. The key downstream control which limits releases under this method is the channel capacity of Coast Fork Willamette River near Goshen, where the flows are modified by both Cottage Grove and Dorena Reservoirs.

7-02. If the forecast of volume and peak inflow for a large flood or series of smaller floods indicates that the reservoir capacity will be exceeded under normal storing conditions, the regulation schedule as prepared for operation under method (1) will be superseded by a set of special regulation curves which permit a gradual increase in reservoir release. The release rates, which are variable and depend upon reservoir pool elevation and rate of rise, are established so that a maximum use is made of the remaining storage, including surcharge storage above the spillway crest.

7-03. Flood-control regulation schedule. - The normal flood-

control regulation for Dorena Reservoir is illustrated by figure 2, plate 19, and the same relationships are shown in tabular form in table 12. The scheduled pool elevation is to be maintained as long as possible without exceeding the release prescribed by the flood-control schedule in figure 2. When the reservoir inflow increases to the extent that this is no longer possible, the releases will be as shown in figure 2 and the excess inflow will be stored in the space reserved for flood-control. The same basic schedule will be used to control floods during all three of the regulation seasons described in Section VI. A similar flood regulation schedule is used for Cottage Grove Reservoir so as to coordinate the regulation of the two reservoirs under flood conditions. The schedules are constructed so that Dorena Reservoir will store floodwater at a rate 2.33 times that of Cottage Grove Reservoir, the ratio of the flood-control spaces in the two reservoirs during the major flood season.

7-04. The flood-control regulation schedules for Dorena and Cottage Grove Reservoirs are designed to maintain the discharge of Coast Fork Willamette River near Goshen at or slightly below 12,000 second-feet. This discharge corresponds to a state of 11.4 feet and has been established as a conservative bankfull capacity which should not be exceeded as the result of normal scheduled releases from Cottage Grove and Dorena Reservoirs. The 273 square miles of uncontrolled area between Cottage Grove and Dorena Dams and Goshen will at times contribute sufficient run-off to raise the stage of Coast Fork Willamette River near Goshen above 11.4 feet, even when the releases

from the two reservoirs are held at the minimum of 100 second-feet each. When this condition occurs the Dorena Reservoir release is to be held at 100 second-feet until the flood recedes, or until greater releases are indicated by figure 3, plate 19, as described in paragraphs 7-28 through 7-32.

7-05. Determination of uncontrolled local inflow. - The initial effect of a change in the outflow from Dorena Reservoir will usually reach Goshen about 5 hours later and an additional 2 hours is required for the major effect of the change to be reflected at Goshen. The travel time of water released from Dorena Reservoir will vary with the magnitude of the release, the volume of local inflow, and the amount of change in the outflow. Figure 6 of plate 8 illustrates the variation in travel time of the initial effects of gate changes at various rates of reservoir outflow. As shown, the travel time of low reservoir releases may be more than 50 percent greater than the travel time of moderate reservoir releases.

7-06. Because of the interrelated effects of the factors affecting travel time, it is difficult to make exact determinations of the travel time of the releases following each gate opening. For operational purposes, it is satisfactory to estimate the local inflow from the uncontrolled area between Dorena and Cottage Grove Dams and Goshen as the difference between the observed discharge near Goshen and the combined reservoir releases 7 hours earlier. Using figure 2, plate 19, Flood-Control Regulation Schedule, this estimated uncontrolled run-off in conjunction with the precipitation index is then used to determine

the prescribed reservoir release. The fixed travel time of 7 hours is reasonably accurate for the determination of reservoir releases up to the normal maximum release of 5,000 second-feet. At very low releases the error becomes appreciable, but this is of little operational importance. When the reservoir is not being regulated for flood control, travel time variations are of minor significance.

7-07. The stream gaging station on Coast Fork Willamette River near Goshen is equipped with an automatic telephone transmitting device (Telemark), which transmits the gage height as a series of audible buzzes when the station Telemark is activated by an incoming telephone call. The Telemark is connected with the Bell Telephone system and may be reached by a direct call from any telephone connected with the Bell system. Failure of the telephone facilities during a flood will require the gage height to be reported by messenger. Under severe flood conditions the reservoir release will be reduced to the minimum, and frequent reports of the gage height near Goshen will not be as essential. The discharge rating of the stream gage on Coast Fork Willamette River at Goshen is shown in table 15.

7-08. Precipitation index. - Effective flood-control regulation of Dorena and Cottage Grove Reservoirs is contingent upon forecasts of run-off from the uncontrolled drainage area between the dams and the downstream control station, Coast Fork Willamette River near Goshen. The reservoir releases are adjusted so that when they are combined with the run-off from the uncontrolled area, the resultant flows will not exceed 12,000 second-feet near Goshen. That discharge may be exceeded,

however, by the run-off from the uncontrolled area alone, or when a large flood exceeds the capacity of Dorena or Cottage Grove Reservoirs.

7-09. The more important factors governing run-off from the uncontrolled area are the amount, areal and time distributions, and phase (rain or snow) of the precipitation over that area. Ground moisture conditions, vegetal cover, and air and ground temperatures also have some effect on the run-off. For reservoir regulation purposes, the uncontrolled run-off is forecast indirectly by means of a precipitation index which incorporates in simplified form the most critical of the foregoing factors. Normally the same index will be utilized for the regulation of both Dorena and Cottage Grove Reservoirs.

7-10. The precipitation index will be computed from the average of the observed precipitation at Dorena and Cottage Grove Dams. The weather stations at both projects have recording precipitation gages so that the precipitation during any time interval can be read from the charts. Although the stations are located at the head of the uncontrolled area, precipitation sampled by the gages is reasonably representative of that which falls on that area, particularly during storm periods.

7-11. The precipitation index in the flood-control regulation schedule, figure 2 of plate 19, is to be taken as twice the observed precipitation during the last 6 hours, plus the precipitation which occurred during the 6-hour period previous to the last 6 hours. Maximum weight is given to the precipitation which fell in the last 6 hours because it is of greatest significance in determining the run-off from the uncontrolled area which will appear near Goshen 6 to 12 hours later.

The initial effect of rain on that area appears near Goshen almost immediately, but the peak run-off usually occurs 8 to 12 hours after the most intense burst of rainfall. In the event that the precipitation data cannot be obtained from one or both of those stations, the areal average will be estimated as closely as possible on the basis of such precipitation and weather information as may be available. Complete weather reports from Eugene Airport, 15 miles from the uncontrolled area, can be received every 6 hours in the Portland District Office by means of CAA weather teletype Service "C". In addition to 6- and 24-hour precipitation, the teletype reports include current and past weather conditions, temperature and dew point, barometric pressure and tendency, snow on ground, and other weather information.

7-12. Since precipitation which may fall after the time of the run-off forecast has some effect on the discharge near Goshen 6 to 12 hours later, use of forecasted precipitation would result in more exact regulation. A high degree of forecasting accuracy and dependability would be required, however, and forecasted precipitation has not been incorporated directly into the regulation schedule. The Reservoir Regulation Subsection maintains continuous vigilance of weather conditions and, when indicated by weather forecasts, the reservoir releases may be varied from those shown in the schedule so as to obtain more effective regulation.

7-13. Correction for low temperatures. - During periods of cold weather, when some or all of the precipitation may fall as snow, the run-off may be so materially delayed as to show little correlation with

the precipitation 6 to 12 hours earlier. Modification of the precipitation index to account for the effects of low temperatures is based on the average of the maximum and minimum temperatures for the previous 24 hours. Averages of the daily means at Dorena and Cottage Grove Dams are used, so the same temperature correction will be applied for both projects. Both weather stations are equipped with maximum and minimum thermometers as well as hygrothermographs. Whenever the average of the daily means is below 46° F. and Dorena and Cottage Grove Reservoirs are being operated for flood-control or for evacuation of floodwaters, the precipitation index will be adjusted by the factors shown in the following tabulation:

Avg. of daily mean temps. - Dorena and Cottage Grove Dams	Factor to apply to precipitation index
46° F. and above	1.00
43° F. to 45° F.	0.75
40° F. to 42° F.	0.50
37° F. to 39° F.	0.25
36° F. and below	0.00

7-14. Substantial modification of the flood-control regulation schedule to provide for the effects of snowmelt will rarely be required. Snowmelt run-off which has occurred is included in the determination of the total uncontrolled run-off, and the schedule is to some extent self-correcting for each subsequent determination. Special regulation for snowmelt run-off will be required only in event of an exceptionally sharp rise in temperature or other melt-producing conditions. When

indicated, the Reservoir Regulation Subsection will evaluate the snow-melt effects and modify the precipitation index accordingly.

7-15. Changes in reservoir releases. - It is both impractical and unnecessary to make frequent minor gate adjustments in order to maintain scheduled pool elevation when the reservoir inflow is low. More frequent gate adjustments are necessary when the inflow is high or changing rapidly. During the early stages of a flood or potential flood, it is particularly important that the gate adjustments be made promptly. If the delay in reducing the reservoir outflow is excessive, that outflow will combine with run-off from the uncontrolled area below the dams to produce possible overbank stages which would not have occurred if the adjustment had been made promptly. The following tabulation prescribes the maximum time between determinations of the proper reservoir release:

Maximum time in hours between determinations of prescribed release			
6-hour precip. average of Cottage Grove and Dorena	Uncontrolled inflow between dams and Goshen at time of last determination in second-feet		
	Under 3000	3000 to 6000	Over 6000
Less than 0.10	24 hours	24 hours	12 hours
0.10 to 0.29	24 hours	12 hours	12 hours
0.30 to 0.49	12 hours	6 hours	6 hours
0.50 or greater	6 hours	3 hours	3 hours

7-16. The above schedule specifies only the maximum time between determinations of the proper reservoir release. In the event the indicated change in reservoir release during or shortly after a flood

amounts to less than 300 second-feet, the gate adjustment may be omitted, if it is considered not to be hydrologically significant. During nonflood periods, considerably smaller adjustments are necessary to keep the reservoir at scheduled pool elevation or to release water for conservation purposes.

7-17. Sudden large increases in reservoir outflow will not be made. Increases in the rate of controlled release during a flood or post-flood evacuation will not exceed 750 second-feet in any one-hour period. This maximum controlled increase may be made either in a single step or in two or more adjustments. The maximum rate of increase of reservoir outflow for conservation uses or seasonal draw-down is 200 second-feet per hour, as set forth in paragraph 6-10. No adverse downstream effects will develop from abrupt decreases in reservoir outflow during a flood, and no maximum rates of decrease are specified.

7-18. Release of stored floodwaters. - Following a flood, the storage space in Dorena Reservoir allocated to flood control is emptied as rapidly as possible without exceeding a discharge of 12,000 second-feet in Coast Fork Willamette River near Goshen. In addition, as discussed in paragraphs 7-22 through 7-27, overbank stages on the main stem of Willamette River will not be increased or unduly prolonged by released floodwaters. Close coordination of the releases of all the reservoirs in Willamette River Basin is required to accomplish the latter objective during post-flood evacuation.

7-19. The flood-control regulation schedule, figure 2 of plate 19, is designed to maintain, in coordination with a similar schedule

for Cottage Grove Reservoir, the discharge near Goshen slightly below 12,000 second-feet during both storage and post-flood release of floodwaters. Those schedules may be used for evacuation of floodwaters provided satisfactory regulation is insured downstream from the confluence of Coast and Middle Forks and that the volumes of water stored in Cottage Grove and Dorena Reservoirs are not greatly disproportionate. Should there be pronounced irregularities in the distribution of precipitation or other factors influencing reservoir inflow, one reservoir may fill at a much faster proportionate rate than the other. In such cases the regulation schedule will be modified so as to draw the fullest reservoir down at a greater rate than indicated by figure 2 of plate 19. Releases from the other reservoir will be at a correspondingly lesser rate so the total release from the two reservoirs will not be increased.

7-20. The normal maximum controlled release from Dorena Reservoir is 5,000 second-feet. That release will not be exceeded except when greater releases are required by the special flood-control regulation schedule, figure 3 of plate 19. The corresponding normal maximum controlled release from Cottage Grove Reservoir is 3,000 second-feet.

7-21. During the major flood season, 1 November through 31 January, Dorena Reservoir will be evacuated after each flood to minimum conservation pool, elevation 770.5. During the conservation storing season, 1 February through 19 May, and the conservation release season, 20 May through 31 October, Dorena Reservoir will be evacuated after each flood to the scheduled elevation as shown on figure 1, plate 19. Should the

reservoir be below the upper limiting line at the start of a flood and the volume of floodwater stored be so small as not to cause the pool elevation to exceed that line, special evacuation of the floodwater will not be required.

7-22. Reduction of flood stages on Willamette River. - The valley of Coast Fork Willamette River and the Eugene-Springfield industrial area receive the greatest benefits from the regulation and reduction of floods by Dorena and Cottage Grove Reservoirs. The major damage center to receive flood protection from those reservoirs is the Eugene-Springfield area, located immediately below the confluence of Coast and Middle Forks Willamette River. Downstream areas along the main stem of Willamette River, including the cities of Harrisburg, Corvallis, Albany, and Salem, and the intervening agricultural areas, also benefit from the reduction of flood stages. To a lesser extent the effects of flood regulation by Dorena and Cottage Grove Reservoirs extends downstream as far as Portland and vicinity.

7-23. During the early portion of a flood, regulation for reduction of stages on Coast Fork normally results in effective regulation below the confluence with Middle Fork. The effect of reduced outflows from Dorena and Cottage Grove Reservoirs reach that confluence concurrently with overbank stages moving down Middle Fork. After October 1954, when Lookout Point Dam, with Dexter Reregulating Dam, come into flood-control operation, overbank stages on Middle Fork will be rare. Likewise, these reduced reservoir outflows will reach the mouth of McKenzie River in time to alleviate the effect of the peak from that

stream, even though overbank flows may occur at that point as the result of the run-off from the large uncontrolled area in the McKenzie River Basin. Satisfactory regulation for both Coast Fork and the main stem of Willamette River is obtained during the rising leg of the flood hydrograph by adhering to the flood-control regulation schedule, figure 2 of plate 19, for Dorena Reservoir, and to the companion schedule for Cottage Grove Reservoir.

7-24. Compliance with the criterion that post-flood evacuation should not increase or unduly prolong overbank stages on Willamette River will usually require that stored floodwaters be retained longer than would be indicated by the regulation schedule. An additional downstream control for this phase of reservoir regulation is the stage and discharge of Willamette River at Harrisburg, which is in a reach of relatively low river banks. Harrisburg is downstream from the mouth of McKenzie River and therefore includes the discharge of that major uncontrolled tributary as well as that of the partially controlled Middle and Coast Forks. Bankfull and major flood stages at Harrisburg are 11.5 and 17.5 feet, respectively, and the corresponding discharges are 44,000 and 124,000 second-feet.

7-25. If adequate storage space remains in Dorena and Cottage Grove Reservoirs, floodwater evacuation will not be initiated until Willamette River at Harrisburg has receded to a stage of 14 feet and is forecast to continue to recede at a near-normal rate as shown in figure 1 of plate 8. Continuation of the recession would bring the stage to approximately 11.5 feet by the time the water released from the reser-

voirs reaches Harrisburg, about 18 hours later. Should the river recede at a rate substantially faster or slower than normal, floodwater evacuation will be initiated 18 hours prior to the time that the stage at Harrisburg is forecast to fall to 11.5. The gaging station at Harrisburg is equipped with a Telemark, as is the station on McKenzie River at Coburg, so that frequent reports of stream flow conditions may be obtained during flood periods. Typical recession curves for several locations on Willamette River and tributaries of greatest significance in the regulation of Dorena and Cottage Grove Reservoirs are shown on plate 8.

7-26. Since some flood-control risk is necessarily involved in retaining stored floodwater in the reservoirs, it is essential that the water be retained no longer than is necessary. The possibility that additional rain may cause the full or partially full reservoirs to lose control must be carefully considered, and the degree of risk estimated by a consideration of the following factors:

- a. Volume of storage space remaining in Dorena and Cottage Grove Reservoirs.
- b. Present weather and stream flow conditions.
- c. Forecasted weather and stream flow conditions.
- d. Volume of storage space remaining in Lookout Point, Detroit, and Fern Ridge Reservoirs.
- e. Time of year.

7-27. Should the above factors indicate the risk in retaining stored floodwater to be excessive, evacuation may be initiated immedi-

ately following cessation of upstream flooding even though overbank stages at Harrisburg and other downstream locations may be substantially prolonged. When the degree of risk appears to be intermediate, the evacuation is delayed to an extent commensurate with the risk. Because of the difficulties in evaluating and weighing the factors in a quantitative manner under varying conditions, it is not practicable to apply a fixed schedule to this operation. Each flood situation must be considered individually by the Reservoir Regulation Subsection, utilizing all available data to arrive at the soundest possible solution to the problem.

7-28. Special flood-control regulation schedule. - In the event of a large flood or series of smaller floods which threaten to exceed the capacity of the reservoir, the schedule in figure 3 of plate 19 will be consulted periodically to determine if it is becoming applicable. As long as the pool elevation and rate of rise over the preceding three hours indicate a point to the left of the chart, figure 2 will continue to be used. When the pool elevation and rate of rise indicate a point within figure 3, the reservoir release will be increased to the rate indicated on the abscissa scale. The schedule will be checked every 2 hours thereafter, and if indicated by the curves the outflow will be adjusted.

7-29. When the reservoir is below the spillway crest, the release is limited by the capacity of the regulating outlets. As illustrated by the outlet capacity curve in figure 3, the capacity of the five outlets ranges from 5,440 second-feet when the reservoir is at minimum

conservation pool, elevation 770.5 to 9,275 second-feet when the reservoir is at full pool, elevation 835. In view of the limited outlet capacity and to avoid the creation of a possible damaging flood wave downstream from the dam, each 2-hour adjustment will not increase the reservoir outflow by more than 1,500 second-feet. This limitation is similar to that in effect during normal flood-control regulation, as discussed in paragraph 7-17, but requires only 2-hour adjustments. Should the special schedule, figure 3 of plate 19, indicate an outflow more than 1,500 second-feet greater than the current outflow, an increase of 1,500 second-feet will be made and, if indicated, repeated at subsequent 2-hour adjustments.

7-30. If the flood or flood series is exceptionally large in volume, the release through the service gates may be progressively increased, as required by figure 3 but not over 1,500 second-feet in 2 hours, until the gates are completely open. As the pool level rises above the spillway crest, the gates will be gradually closed to limit the outflow to the rate indicated by figure 3. By the time the pool level attains elevation 843, the gates will be completely closed and the entire outflow will be passing over the free overflow spillway.

7-31. After the reservoir starts to fall, the current gate openings will be maintained until the total outflow recedes to 5,000 second-feet. If the gates are completely closed when the reservoir starts to fall, they will be kept closed until the spillway discharge recedes to 5,000 second-feet, at a pool elevation of 839. As the pool continues to fall, the service gates will be progressively opened to

maintain the combined outflow over the spillway and through the gates at 5,000 second-feet until the pool recedes to the spillway crest, elevation 835. Normal evacuation of floodwaters, based on downstream conditions as discussed in paragraphs 7-18 through 7-21, will then be initiated.

7-32. A similar special flood-control regulation schedule is to be used for Cottage Grove Reservoir in case of an exceptionally large flood or flood series. It is possible that the regulation of both reservoirs would revert to the special schedules simultaneously, but it is more likely that their use would be necessitated at different times. It is also possible that the special schedule would be required at one of the reservoirs and not the other. Except in event of failure of communication facilities, the special flood-control regulation schedules will be put into effect only at the direction of the Reservoir Regulation Subsection.

7-33. Examples of flood regulation. - Graphical examples of the application of the regulation schedules to several floods of record are shown on plates 20 and 21. Effectiveness of Dorena and Cottage Grove Reservoirs in controlling the spillway design flood and the floods of November-December 1861, February 1890, December 1942, and January 1948 is illustrated. It was assumed in each case that Dorena and Cottage Grove Reservoirs were at minimum conservation pool at the beginning of the flood period. The following data are shown for each flood: precipitation by 3-hour periods, Dorena and Cottage Grove Reservoir inflows and regulated outflows, natural discharge of Coast

Fork Willamette River near Goshen, regulated discharge near Goshen, uncontrolled local inflow above Goshen, and Dorena and Cottage Grove Reservoir pool elevations.

7-34. Hypothetical regulation of the spillway design floods for Dorena and Cottage Grove Reservoirs, which were assumed to occur concurrently, is illustrated on plate 21. Peak inflows into Dorena and Cottage Grove Reservoirs are 111,500 second-feet and 42,800 second-feet, respectively, and the peak discharge near Goshen was computed to be 201,000 second-feet. Following the flood-control regulation schedules the releases from both reservoirs would be reduced to the minimum of 100 second-feet shortly after the rain began. Those minimum releases would be maintained for several hours, after which the special curves would require that the controlled outflows be increased well before the pool elevations would reach the spillway crests. Maximum outflows would be 68,800 second-feet from Dorena Reservoir and 36,000 second-feet from Cottage Grove Reservoir, reducing the inflows by 38 and 16 percent, respectively. The peak discharge of Coast Fork Willamette River near Goshen would be reduced to 138,000 second-feet, a reduction of 31 percent. Maximum water surface elevation in Dorena Reservoir would have been 855.1, 20.1 feet above the spillway crest and 4.9 feet below maximum pool.

7-35. The flood of December 1861, also illustrated on plate 21, is the largest flood of record for which limited historical data are available. Estimated peak discharges were 28,000 second-feet at Dorena Dam, and 59,200 second-feet near Goshen. Heavy rain extended over a

period of 5 consecutive days, so the flood volumes were great and the reservoirs would have filled relatively early in the flood period. Regulation of Dorena and Cottage Grove Reservoirs would be similar to that required for the spillway design flood. The special flood-control regulations would supersede the normal schedules, and both spillways would become operative. Maximum outflows would be 25,800 second-feet from Dorena Reservoir and 11,000 second-feet from Cottage Grove Reservoir. The peak discharge of Coast Fork Willamette River near Goshen would be reduced to 47,000 second-feet, and the duration of overbank stages reduced from 6 to 4 days near Goshen. Maximum water surface elevation in Dorena Reservoir would have been 846, 11 feet above the spillway crest.

7-36. The flood of February 1890 is estimated to have been only slightly smaller than the 1861 flood. As shown on plate 20, the flood was double-crested at both Cottage Grove and Dorena Reservoirs. The first flood peak would be largely controlled by the reservoirs, but because of the large volume of water which would have had to be stored during the first half of the flood, the second crest would be less effectively controlled. Near Goshen the first peak would have been reduced from 56,800 second-feet to 25,400 second-feet, but the second peak would have been reduced from 53,500 second-feet only to 33,000 second-feet. Maximum water surface in Dorena Reservoir would have been 842.6, 7.6 feet above the spillway crest.

7-37. Floods of the magnitude of those of 1861 and 1890 would cause great damage in the Willamette River flood plain under present

conditions of development. Even with optimum regulation of the reservoirs and pronounced reduction in stages shortly below the dams, downstream flooding would be extensive and prolonged. The principal reason is that only a relatively small percentage of the Willamette River Basin area is controlled by reservoirs and the run-off from the uncontrolled areas would create damaging high water with a repetition of these floods. A less important reason is that because of limited capacity some of the reservoirs in the basin, including Dorena and Cottage Grove Reservoirs, would completely fill and then lose control during a major flood. The latter effect will be reduced to a minimum by application of the special flood-control regulation schedules, but cannot be completely eliminated when the flood volume is greatly in excess of the reservoir capacity.

7-38. Regulation of the flood of December 1942 - January 1943 is illustrated on plate 20. At that time Cottage Grove Reservoir was in operation but Dorena Reservoir had not yet been constructed. Cottage Grove Reservoir regulation, shown on plate 20, is in accordance with the revised schedules rather than as was actually accomplished at the time. Application of the special schedules would have been required at both reservoirs, but the maximum releases would have been much less than for the floods of 1861 and 1890. The peak discharge near Goshen would have been reduced from the natural discharge of 43,500 second-feet to 24,600 second-feet, which is, however, over twice the bankfull discharge of 12,000 second-feet. Maximum water surface elevation in Dorena Reservoir would have been 836.5, only 1.5 feet above the spillway crest.

7-39. The flood of January 1948 is an example of a smaller, more frequent flood which could have been controlled at the dams by means of the regular flood-control regulation schedules without resorting to the special schedules. As shown on plate 20, the releases from both reservoirs would have been maintained at the minimum of 100 second-feet during the main flood period and until the flood receded. Close checks would have been made of the reservoir elevations and rates of pool rise to determine whether the special schedules should be effected, but they did not become applicable for either reservoir. The peak discharge near Goshen would have been reduced from 39,400 second-feet to 24,000 second-feet, of which nearly all would have been contributed by the uncontrolled areas below the dams. Maximum elevation attained by Dorena Reservoir would have been 824.3, 10.7 feet below the spillway crest.

## SECTION VIII - CONSERVATION RELEASES REGULATION

8-01. Water-use priorities. - During the conservation releases season, 20 May through 31 October, water stored in Dorena Reservoir is available for distribution to the various conservation needs. Order of priority on water stored in Dorena Reservoir and other reservoirs in the Willamette Basin closely follows that prescribed by law. Prior water rights granted in accordance with Oregon law will be honored to the extent of the natural inflow to the reservoir, and releases for that purpose are given first priority. Minimum reservoir releases, which are closely related to the releases necessary to sustain fish life, have been assigned second priority. This flow requirement is relatively small. Irrigation over and above that possible with natural flows under existing water rights has next priority on the stored water in accord with Section 8, Flood Control Act of 1944. Navigation and pollution abatement will be benefited by the same water, but releases for these purposes will be made only after the higher priority interests are served. Recreation has a low priority on the stored water from a legal viewpoint, but it is intended to give recreation as much consideration as is practical without seriously affecting other interests. Since neither storage capacity nor water supply are sufficient to provide fully for all these functions, the regulation schedule necessarily requires that equitable consideration be accorded all conservation interests.

8-02. Reservoir release schedules. - The schedule of reservoir releases during this season provides for a balanced distribution of water among the above conservation uses throughout the low water period.

Demands vary widely, however, both from year to year and during the course of a 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 supplementary low water releases. 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 preliminary schedule, which will be predicated on forecasted stream flow and estimated demands for stored water, will be revised periodically as required by changing weather and stream flow conditions.

8-03. In some years the inflows into Dorena and Cottage Grove Reservoirs during the conservation storing season will not be adequate to fill the reservoirs to maximum conservation pool. Average spring season inflows into Dorena Reservoir are usually proportionately greater than those into Cottage Grove Reservoir because of the higher basin elevation above Dorena Reservoir. During the 23-year period 1926 through 1948, Dorena Reservoir would have filled to maximum conservation pool only 16 times and Cottage Grove Reservoir only 12 times. In the same period 75 to 100 percent of the conservation space in Dorena Reservoir would have been filled 6 times and in Cottage Grove Reservoir 8 times. Less than 75 percent of the conservation space in Dorena and Cottage Grove Reservoirs would have been filled 1 and 3 times, respectively. There will be times, particularly when the reservoirs do not fill, that the water supply in storage, less the evaporation, will be inadequate

to meet the normal conservation demands. In such years the low water schedule will be adjusted to provide water during the entire low-water season rather than to satisfy all demands during the early part of the season and then possibly run short of water at a critical time in late summer or early fall. The provisional schedule of reservoir releases will incorporate a factor of safety in the form of a small reserve of stored water as insurance against an unpredicted deficiency late in the low-water season.

8-04. Since control of floods is the primary function of Dorena Reservoir, under no circumstances will regulation for conversation uses of water be permitted to jeopardize flood control. After 1 September the flood potential of the basin begins to increase, and between that date and 1 November the reservoir pool should not exceed the elevations shown on figure 1 of plate 19, except as indicated in paragraph 8-10 or in case of a flood. Also shown on figure 1 of plate 19 are the lowest pool elevations which will provide adequate storage to satisfy minimum flows and evaporation demands. The reservoir will be drawn down to minimum conservation pool, elevation 770.5 by 1 November.

8-05. Prior water rights. - The present water laws of Oregon provide that all water within the state belongs to the public and, subject to existing rights, may be appropriated for beneficial use. Such appropriation must be made in strict accordance with the statutory provisions governing such matters. Administration of the water laws 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.

8-06. About 33 water rights, appropriating 50 second-feet of flows from Row River and tributaries, are in force. The three areas into which the Row River Basin may be divided for comparative purposes are Row River Basin above Dorena Dam, Row River Basin below Dorena Dam, and Mosby Creek. Water rights within these areas amount to 38.75, 2.28, and 8.75 second-feet, respectively. The following tabulation summarizes, as of 1951, the approximate allocations of water in second-feet to the various types of water uses in accordance with the uses for which the water rights were issued:

Type or water right	Row R. and tributaries above Dorena Dam	Row R. and tributaries below Dorena Dam	Mosby Creek and tributaries	Total Row R. Basin
Domestic	0.13	0.23	—	0.36
Municipal	14.00	—	—	14.00
Irrigation	1.82	2.05	3.72	7.60
Manufacture	12.60	—	—	12.60
Miscellaneous <sup>1</sup>	<u>10.20</u>	<u>—</u>	<u>5.03</u>	<u>15.22</u>
Total	<u>38.75</u>	<u>2.28</u>	<u>8.75</u>	<u>49.78</u>

<sup>1</sup> Includes more than one of items 1 through 4.

8-07. From the standpoint of reservoir regulation during the conservation releases season, water rights on Row River below Dorena Dam are of primary importance, and water rights on Coast Fork below Row River are also of importance. Water rights on Row River below Dorena Dam amounts to only 2.28 second-feet, but in the Coast Fork Basin below

Row River they total about 60 second-feet, of which 45 second-feet are on the main stem of Coast Fork. During the low-water season, the flow of Coast Fork Willamette River consists largely of water released from Dorena and Cottage Grove Reservoirs. The minimum reservoir releases, as discussed in the following paragraphs, are well in excess of the downstream water rights.

8-08. Minimum reservoir releases. - Minimum release requirements for Dorena Reservoir provide stream flow for fish life and for esthetic purposes during the low-water season. Row River does not support regular runs of anadromous fish, and fish are not considered to be a major problem on that stream. Nevertheless, fish life was considered in the selection of minimum releases from the reservoir, and the U. S. Fish and Wildlife Service and the Oregon State Fish and Game Commissions participated in the determination.

8-09. As shown in figure 1, plate 19, planned minimum releases from Dorena Reservoir are 190 second-feet during February through June and 100 second-feet during July through 31 October. These releases are in excess of the minimum natural flows, and the latter figure is also in excess of the minimum mean monthly flow under natural conditions for the same period. Corresponding minimum releases for Cottage Grove Reservoir are 75 and 50 second-feet.

8-10. The minimum reservoir release during the major flood season, 1 November through 31 January, is not definitely prescribed because the reservoir is then maintained at minimum conservation pool, elevation 770.5, except in case of a flood. Reservoir outflow during this season

therefore equals the inflow less losses. Should the fall season be unusually dry and the expected stream flow critically low during early November, a small volume of conservation water, about 1,000 acre-feet, may be retained past 31 October. This operation, which would be scheduled by the Reservoir Regulation Subsection as a special measure, would provide for a minimum low-water release of 100 second-feet during early November. As soon as seasonal rains insure these minimum flows, Dorena Reservoir will be drawn down to minimum conservation pool so as to provide a maximum of flood-control protection, as described in Section VII.

8-11. Irrigation. - The average precipitation over the portion of Coast Fork Willamette River valley subject to cultivation is only 7 inches in the 5-month period, May-September, which is the normal irrigation season. Normally two-thirds of this amount falls in May and September. Inadequate precipitation during the summer months greatly limits production of all summer growing annual and perennial crops. With irrigation, yields are increased 50 to 100 percent, and crop quality is also improved to a marked extent.

8-12. At the present time there are no irrigation works in Coast Fork Willamette River Basin. Some water is pumped from Coast Fork and tributary streams, including Row River below Dorena Dam, but the volume of the diversions is not large. A greater amount of water is diverted from the main stem of Willamette River and from shallow wells near the stream, during the low-water season. The distribution systems are principally portable pipe, and the water is generally applied by

sprinklers. The acreage under irrigation is increasing, however, and future irrigation will become increasingly dependent on water released from Dorena and Cottage Grove and other reservoirs.

8-13. Studies by the Bureau of Reclamation indicates that a proposed irrigation project in Coast Fork Willamette River Basin, termed the Cottage Grove Project, would have annual water requirement of 19,500 acre-feet. About 20 percent of this water may be diverted from natural flows, but the remainder must come from storage. Dorena Reservoir will provide the greater portion of the required water because the conservation storage of Dorena Reservoir is much greater than that of Cottage Grove Reservoir, 64,900 acre-feet as against 28,900 acre-feet. Furthermore, Dorena Reservoir will be drawn down more rapidly than Cottage Grove Reservoir so as to maintain Cottage Grove Reservoir as high as practicable for recreation purposes. Those two reservoirs also will supply a portion of the irrigation water to be required on the main stem of Willamette River. The following tabulation shows the estimated monthly distribution of the projected requirements for irrigation in Coast Fork Willamette River Basin:

Month	:	Acre-feet	:	Percent of total
May		840		4.3
June		3,720		19.1
July		5,760		29.6
August		5,940		30.4
September		<u>3,240</u>		<u>16.6</u>
Total		19,500		100.0

8-14. Arrangements for the sale and distribution of water released from Dorena Reservoir for irrigation have been made. The Corps of Engineers will furnish the water to the Bureau of Reclamation who will administer the distribution to the various projects. All field agreements will be made by the users with the Bureau of Reclamation and that agency will secure payment to the United States Government for water released from Dorena Reservoir and used for irrigation.

8-15. The primary interest of the Corps of Engineers is to see that all benefits stipulated in the project authorization are realized by the public and that reimbursable irrigation costs, as contemplated under existing legislation, are paid back to the United States Government. The Portland District of the Corps of Engineers will furnish irrigation water from Dorena and Cottage Grove Reservoirs after the Bureau of Reclamation makes the necessary arrangements with local interests. Water thus furnished will be dispatched as requested by the Bureau of Reclamation on the basis of day to day instructions from the Reservoir Regulation Subsection. It is to be clearly understood that the Corps of Engineers is solely responsible for operation of Dorena Reservoir and that the requirements of the irrigators, as determined by the Bureau of Reclamation, will be met subject to the basic operation for flood control.

8-16. Navigation and pollution abatement. - Since release of impounded water in the interest of navigation would likewise be in the interest of pollution abatement, these two conservation uses are considered together. Commercial navigation is nonexistent on Row River and Coast Fork Willamette River, but is of importance on middle and

lower Willamette River. Because of normal low-water flows during the summer and the extensive pumping for irrigation, the natural flows of Willamette River often are inadequate for navigation during the late summer and early fall months.

8-17. Willamette River and major tributaries have become increasingly polluted in recent years as a result of raw domestic sewage and industrial waste discharged into the streams. The harmful effects of stream pollution on public health, fish life, and recreational pursuits have become serious problems, particularly during late summer and early fall when low flows coincide with heavy concentrations of wastes from cannery operations. In 1939 an Oregon State Sanitary Authority was created whose functions and duties include the formulation of rules and regulations pertaining to the control of pollution of waters of the State and the enforcement of compliance with the laws of the State of Oregon relating to pollution of waters of the State. Since World War II, many communities and major industries have taken steps to discontinue the discharge of contaminants into the streams. It is expected that in the future the sanitary condition of Willamette River will improve because of the effects of additional sewage and industrial waste treatment plants and the increased low-water flows from additional multiple-purpose reservoirs.

8-18. Judicious release of water from Dorena and other Willamette Basin reservoirs will simultaneously extend appreciable benefits to navigation and pollution abatement. Navigation is benefited by increasing or maintaining the water depths; stream purification is furthered

by diluting the concentration of polluting material and by furnishing a large quantity of dissolved oxygen. In the average year, and particularly during the period before irrigation demands are fully developed, water will be available from Dorena and Cottage Grove Reservoirs to increase or maintain low-water flows. Normally releases for this purpose will be initiated in late July or early August. When all the authorized reservoirs in the Willamette Basin project are completed, it is proposed to maintain a minimum flow of 5,000 second-feet at Albany and 6,000 second-feet at Salem during the low-water season. These minimum flows can be maintained in all but the most critical low-water years. With the existing system of reservoirs, however, it will not be possible to do so in many of the years, and the objective will be to maintain as high a flow in Willamette River as possible during the low-water season, consistent with other conservation requirements. In the development of the provisional conservation release schedule discussed in paragraph 8-02, consideration will be given to the needs of navigation and pollution abatement as well as to needs of other conservation interests.

8-19 Recreation. - Dorena Reservoir has considerable appeal as a recreational center for the nearby populous Eugene-Springfield area. There is a pronounced recreational demand even though the pool level usually falls substantially during the recreation season. To obtain maximum recreational benefits, the reservoir must be maintained at or near maximum conservation pool, elevation 832, during the summer months. As pointed out in the previous paragraphs, the requirements of higher priority conservation uses necessitate the release of stored water

during the low-water season. Recreational usage tends to decrease as the pool is lowered, and when substantial conservation releases are made in midsummer, the effect is to shorten the recreation season.

8-20. Power. The Hydropower Project will use the flow of water that is released through Dorena Dam to generate hydroelectric power. There are no generation requirements that would require flow releases. See Section 6-02.1 regarding power operations.

8-21. Mosquito control. The U.S. Public Health Service has indicated that potential malaria carrying mosquitoes, *Anopheles freeborni*, could become established at Dorena Reservoir if conditions favoring mosquito production develop. Should the reservoir as presently operated become a serious producer of malaria vectors, it may become necessary to inaugurate a mosquito control program. Such a program would necessitate the removal or destruction of cattails and other water-loving plants in the reservoir area, drainage or treatment of ponded stagnant water within the zone of fluctuation, to minimize mosquito production by stranding floatage and reducing marginal vegetation.

8-22. Establishment of a pool fluctuation schedule will be resorted

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to only if the hazard should become serious and other measures prove ineffectual. A disadvantage of this method is that reservoir inflow during the conservation releases season is usually inadequate for the pool to recover to the original elevation after being partially drawn down. In most years normal conservation demands will cause the pool elevation to recede during the low-water season, producing results similar to those of a special pool fluctuation schedule.

## SECTION IX - RESPONSIBILITIES AND INSTRUCTIONS

9-01. Duties of damtender. - A vital duty of the Dorena damtender is to regulate the reservoir as directed by the Reservoir Regulation Subsection of the Engineering Division. Other duties include all normal inspection and maintenance of the dam, buildings, equipment, grounds, and public-use facilities. The damtender is responsible for the physical operation of the gates and other control works and for the collection and transmission to the Reservoir Regulation Subsection of meteorologic and hydrologic data necessary for efficient regulation. Other duties include supervision of the assistant damtender and other employees who may be assigned to Dorena project. He is also required to meet and maintain good relations with the public.

9-02. It is important that the damtender does not leave the project unattended. When the damtender is absent from the area, or otherwise not available for duty, the assistant damtender must be present. Should an emergency necessitate that both men be away from the project simultaneously, the Project Engineer, Upper Willamette Valley Project Office, will be notified as far in advance as practicable so a temporary damtender may be assigned to the project. Proper discharge of duties during floods requires that the damtender or his assistant be on call at any hour of the day or night.

9-03. Although the Reservoir Regulation Subsection usually prescribes the changes in reservoir release, the need for prompt action at the start of a flood precludes the damtender from awaiting instruc-

tions for an undue period of time before making gate adjustments. Since the flood-control regulation of Dorena and Cottage Grove Reservoirs is based on data which are collected by the damtenders, there will be times when they must initiate normal flood regulation. Precipitation and temperature required for the computation of the precipitation index may be exchanged between damtenders by telephone. Information on reservoir releases and discharge near Goshen, required for the determination of run-off from the uncontrolled area, also can be exchanged, as can other pertinent information such as weather conditions and pool elevations. It is particularly important that the indicated reservoir release be checked frequently during the early stages of a flood or potential flood. Also during a flood, the damtender will follow all special regulation instructions received from the Reservoir Regulation Subsection.

9-04. During non-flood periods, reservoir regulation instructions issued to the damtender are usually not urgent and are handled on a more or less routine basis. Satisfactory regulation is normally accomplished during such times by maintaining the pool elevation, reservoir release, or filling schedule prescribed by this manual or by previous regulation instructions. A systematic daily check of the regulation of all the reservoirs is made by the Reservoir Regulation Subsection during non-flood periods to insure that maximum benefits, consistent with the currently required regulation, are being obtained from the operation of the project as a whole. Any necessary instructions, unless of an urgent nature, are issued at the time of that check, normally 8 A.M.

9-05. Duties of Project Engineer. - The Project Engineer, Upper Willamette Valley Project Office, is responsible for the operation and maintenance of Dorena, Cottage Grove, and Fern Ridge Dams and Reservoirs. The functional statements on plate 1 list the duties and responsibilities of the Project Engineer which pertain to reservoir regulation. Normally, hydrologic and reservoir data related to the respective projects are collected at the Upper Willamette Valley Project Office and forwarded to Portland by telephone. Routine regulation instructions from Portland also go through the Project Engineer's office. In time of emergency, however, direct communications between the Reservoir Regulation Subsection and the damtenders are authorized.

9-06. Duties of Reservoir Regulation Subsection. - Functional regulation of multiple-purpose reservoirs is the responsibility of the Reservoir Regulation Subsection. Duties include the development of methods of regulation and detailed regulation schedules for multiple-purpose reservoirs, the issuance of reservoir regulation instructions, the preparation of reservoir regulation manuals, the maintenance of a continuing program to improve reservoir regulation technique, and the preparation of reservoir regulation reports. Other functions of the Reservoir Regulation Subsection are listed on plate 1.

9-07. A primary responsibility of the Reservoir Regulation Subsection in the event of a flood is to insure that all Corps of Engineers reservoirs in the Willamette Basin are regulated so as to reduce downstream flood damages to the greatest extent practicable. The flood-control schedules in this and similar manuals will normally be followed, but modifications of the schedules may be made when required so as to achieve the most effective regulation. During the major flood season and at other times when floods are threatening or occurring, arrangements are made to collect and analyze the current hydrologic reports at night

and over the weekends, as well as during normal working hours. 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, with the other employee acting 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 Reservoir Regulation Subsection before making significant modifications of the approved schedules. The Upper Willamette Valley Project office and the Dorena dam tender will be furnished with a list of District personnel authorized to issue reservoir regulation instructions for Dorena Reservoir. This list will be revised as necessary to reflect changes in personnel. All instructions regarding reservoir regulation are to be logged by the operating personnel at the dam and the party issuing the instructions should confirm his instructions in writing, giving date, time and name of the party to whom the instructions were given.

9-08. The Reservoir Regulation Subsection obtains and utilizes short- and long-range weather forecasts and quantitative precipitation forecasts. 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. Detailed verification studies of the quantitative precipitation forecasts are made for zone SA18, which comprises the southern two-thirds of Willamette River Basin, utilizing precipitation data for 18 stations in the zone.

9-09. 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 work-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.

9-09.1. Duties of Hydropower Operator. Duties of the Hydropower Project operator are provided in Section 3.3, 4.3, and 5.8 of Exhibit B. There will be an operator on-call 24 hours-a-day, seven days-a-week. As of 2016, the Corps has determined that the Hydropower Project Operator should visit the project no less than 2 times-per-week to visually observe equipment and surrounding environment for any changes or issues (Exhibit C, Article IV, 1.e.b). The operator makes daily visits to perform routine maintenance and monitoring/recording duties. The operator has remote access to the plant from a secured off-site location with a dedicated computer at their residence. In times of scheduled flow changes, the operator will be on-site to assist in that procedure. The operator will monitor water quality for temperature and dissolved oxygen using water from the penstocks and will use the water quality aeration system, as needed, to increase the dissolved oxygen in the water prior to release into the Row River, as described in Section 5.10 of Exhibit B. Additional detail regarding water quality monitoring and reporting, and fish observation reporting is provided in Section 5 of the Hydropower Project O&M Manual.

9-10. Continued reservoir regulation studies. In the interest of obtaining maximum benefits from the operation of multiple-purpose reservoirs in the Willamette Basin, a program of continuous vigilance and study of each current flood for possible improvements in the regulation schedules and rule curves will be conducted by the Reservoir Regulation Subsection. The program includes not only flood regulation but also the conservation aspects of reservoir regulation. As additional multiple-purpose reservoirs in Willamette Basin become operative, a greater significance will be attached to coordinating the regulation of Dorena Reservoir with these new projects, a matter to be given full consideration on the basis of actual operating experience. Improvements in forecasting technique and new developments in reservoir regulation will be watched and analyzed for possible application to regulation of

Dorena Reservoir and other reservoirs in the Portland District.

9-11. Weather station. - Maintenance and operation of the weather station at Dorena Reservoir are the responsibility of the damtender. Equipment and instruments at the station include an instrument shelter house, maximum and minimum thermometers, hygrothermograph, psychrometer, evaporation pan, anemometer, manual precipitation gage, and recording precipitation gage. The evaporation pan is the standard Weather Bureau type, of galvanized iron 48 inches in diameter. The anemometer is of the rotating cup type, mounted just above the northwest corner of the supports for the evaporation pan. The recording precipitation gage has a dual traverse and is of 12-inch capacity.

9-12. 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 the designated office. At intervals, the station is checked by a hydrologic inspector of the Weather Bureau, and any difficulties such as damaged or malfunctioning equipment are to be reported to this inspector. Supplies such as recorder charts and ink, weather forms, mailing envelopes, etc. will usually be furnished by the Weather Bureau. The temperature, precipitation and evaporation data are published in monthly and annual bulletins of climatological data for Oregon. Plate 2, Basin Map and Inventory of Hydroclimatic Data, shows the period of time for which records of the Dorena Dam weather station are available.

9-13. Water Stage recorders. - Data of primary importance to the regulation of Dorena Reservoir are obtained from four water level

recording stations. The pool elevation recorder is located on the top of the dam and is equipped with a transmitting device using self-synchronizing motors so that a continuous record of pool elevation is received in the adit control room. An upstream gage located above the reservoir provides an index to the inflow, and a downstream station 2 miles below the dam records the reservoir outflow. The fourth station, located on Coast Fork near Goshen, is the key downstream control point for the flood control of Dorena and Cottage Grove Reservoirs. Location, elevation, and area tributary to these stations is shown on plate 2.

9-13.1. Powerhouse and Associated Gaging Stations. A gaging station has been installed by the licensee and is approximately 300 feet downstream of the powerhouse on the north side of the river. The gage is a pressure transducer located in a wet well. Section 4.1.3 of Exhibit B discusses the operation and maintenance of this new station. Water quality gages measure temperature, turbidity, and dissolved oxygen at three locations; in the powerhouse, in the tailrace, and 0.25 miles downstream of the dam. Additional information on these gages and transmission of this data are provided in Section 5.2.2 of the Hydropower Project O&M Manual.

9-14. The U.S. Geological survey has the responsibility of maintaining and operating the water stage recorders. Personnel of that agency service and repair the instruments, change the charts, meter the streams, and process the data. The Dorena damtender, in addition to collecting and transmitting the water stage data to the Reservoir Regulation Subsection through the Upper Willamette Valley Project Office, has the responsibility of making occasional inspections of the stations. Any serious malfunctioning should be reported promptly to the Portland District Office, or to field personnel of the Geological Survey. Data from both the reservoir station and the stream gaging stations are published by the Geological Survey in annual water supply papers. Tables 13, 14, and 15 are rating tables for the three stream gaging stations, and table 16 is the rating table for the station on Willamette River at Eugene.

9-15. Collection and transmission of data. The following data are to be obtained by the Dorena damtender on a routine basis each morning and transmitted to the Upper Willamette Valley Project Office each work day for forwarding to the Reservoir Regulation Subsection:

a. Dorena Reservoir. Reservoir pool elevation and tendency, storage, reservoir outflow, 24-hour precipitation by 6-hour period, and current weather. Also other data, when significant, such as temperature and depth of snow on ground.

b. Pitcher Creek. Stage and discharge of Row River above Pitcher Creek.

c. Culp Creek. Current weather and 24-hour precipitation.

9-15.1. Data Collection for Hydropower Project. Section 4.0 of Exhibit B discusses data collection and communication networks for the power plant flow meter and for the gaging station installed approximately 300 feet downstream of the discharge point of the hydroelectric plant. Additional details of data collection, monitoring, reporting, and maintenance of the gages are provided in Section 5.2.2 of the Hydropower Project O&M Manual.

9-16. The following data are obtained by the Cottage Grove damtender on a routine basis each morning and transmitted to the Upper Willamette Valley Project Office each day for forwarding to the Reservoir Regulation Subsection:

a. Cottage Grove Reservoir. Reservoir pool elevation and tendency, storage, reservoir outflow, 24-hour precipitation by 6-hour period, and current weather. Also, other information when significant.

b. London. Stage and discharge of Coast Fork Willamette River at London.

c. Blackbutte. Current weather and 24-hour precipitation.

9-17. The following data, in addition to those received from Dorena, Cottage Grove, and Fern Ridge Dams, are obtained by the Upper Willamette Valley Project Office on a routine basis each work-day morning and forwarded to the Reservoir Regulation Subsection.

a. Eugene. Stage of Willamette River at Eugene.

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b. Goshen. - Stage and discharge of Coast Fork Willamette River at Goshen.

c. Coburg. - Stage and discharge of McKenzie River at Coburg.

d. Lowell. - Stage and discharge of Middle Fork Willamette River at Lowell. This report will at some future date be transmitted from Lookout Point Dam, at which time the relay through the Eugene Area Maintenance Office will be discontinued.

9-18. Under routine conditions during the conservation storing and conservation releases seasons, the foregoing data are required only once a day and need not be transmitted to the Portland office on weekends or holidays. During the major flood season the data will be transmitted to the Reservoir Regulation Subsection weekends and holidays, as well as week days. Should a flood be threatening or occurring, reports will be requested as often as needed, regardless of season. Under such conditions, additional information, such as tendencies, time and magnitude of peak flows, supplementary downstream reports, etc., will be requested as needed. The schedule in paragraph 7-15 gives the maximum time between determinations of the proper reservoir release as a function of precipitation intensity.

9-19. Charts and reports. - Form NPPRF 87, Daily Reservoir Data, is used by both the Upper Willamette Valley Project Office and the Reservoir Regulation Subsection to record pertinent current hydrologic and reservoir data from Dorena, Cottage Grove, and Fern Ridge Reservoirs. It also is used to record stream flow and weather data from other stations

and locations. Under routine conditions one copy a day is required, but during high-water periods several forms may be required each day. For confirmation purposes, a copy of each report is mailed to the Reservoir Regulation Subsection. Copy of the form is shown as chart 1.

9-20. The Monthly Reservoir Regulation Chart for Dorena Reservoir, prescribed by paragraph 4220.01d of Orders and Regulations, is shown as chart 2. It is a graphical record of reservoir pool elevation, stored water in acre-feet, reservoir inflow and outflow, and precipitation. Discharge of Coast Fork Willamette River near Goshen is also shown. Copies of this chart are transmitted to the Office, Chief of Engineers at the end of each month, and information copies are furnished the dam-tender, the Project Engineer, and the Operations Division. The Willamette River Basin Commission, a state organization which works closely with the Corps of Engineers on matters pertaining to the control and utilization of the water resources of the Willamette River Basin, also is furnished copies of Monthly Charts of Reservoir Regulation for all operating reservoirs in the basin.

9-21. Another permanent reservoir regulation record is maintained on NFP Form 133C, Monthly Log of Reservoir Regulation, Dorena Dam and Reservoir. It is the responsibility of the dam-tender to keep the required records of reservoir outflow, pool elevation, gate openings, and other pertinent data required for this log. All significant gate adjustments are recorded and at least one entry each day is made. The remarks column is utilized for pertinent information relating to reservoir regulation which would not otherwise be recorded. Unusual deviations from

the regulation schedule are explained briefly in the remarks column, and the authority for the action indicated. Other data which may be recorded are unusual weather or snow conditions, difficulties in obtaining necessary data, and malfunctioning of gages or equipment. Chart 3 shows a copy of the log.

9-22 Emergency instructions. - It is not possible to anticipate every possible flood or emergency event, or combination of events, and provide for them in a reservoir regulation manual. Should an emergency occur or appear to be developing, the Project Engineer or the damtender will promptly contact the District office and report field conditions and receive instructions. Should communications to Portland fail during a flood, the Project Engineer will direct the regulation of Dorena Reservoir, as well as Cottage Grove and Fern Ridge Reservoirs, using the schedules on plate 19 of this manual for Dorena. In the event that communications to the Upper Willamette Valley Project Office fail, but remain operative between Dorena and Cottage Grove Dams, the damtenders at the two projects will exchange data, compute the precipitation index and uncontrolled run-off at Goshen, and initiate normal flood-control regulation, using figure 2 of plate 19. The above procedures 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.

9-23. Should communications fail between Dorena, Cottage Grove, and Fern Ridge Dams, but remain operative to the stream gaging station at Goshen, the Dorena and Cottage Grove damtenders will each individually

compute a precipitation index, using precipitation data from his station. Each damtender will then initiate normal flood-control regulation, applying the same uncontrolled run-off but probably different precipitation indices to figure 2 of plate 19. If communications to the Goshen tele-mark fail and the flood conditions do not appear to be critical, the damtender or assistant will drive to the Goshen station to determine the stage and discharge.

9-24. In the event of a complete failure of communications during a major flood, the releases from both Dorena and Cottage Grove Reservoirs will be maintained at 100 second-feet until communications are re-established and greater releases are permitted by downstream channel conditions or until larger releases are required by the special flood-control regulation schedules. After the special schedules, figure 3 of plate 19 in the case of Dorena Reservoir, become applicable, the outflow will be adjusted every 2 hours on the basis of the hourly rate of rise over the preceding 3 hours and the current reservoir elevation. If communications to Portland have not been reestablished by the time the reservoir elevation starts to fall, the damtender will regulate strictly according to paragraph 7-31 of this manual. After the pool recedes to the spillway crest following a major flood, evacuation of floodwaters will not be initiated until communications are reestablished.

TABLE 1  
 Climatological Summary  
 Eugene, Oregon  
 (Elevation 450 feet)  
 Period of record 1891-44

Item and description	Years of record	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Precipitation, inches														
Average	54	5.31	4.65	3.97	2.71	2.37	1.53	0.35	0.48	1.08	2.90	5.64	6.04	37.83
Percent of average annual	--	14	12	11	7	6	4	1	1	5	8	15	16	100
Maximum	54	10.92	12.10	10.49	7.17	4.76	5.57	3.38	3.14	5.21	7.77	12.32	13.38	55.21
Year of maximum	--	1936	1904	1904	1937	1915	1937	1916	1899	1927	1924	1942	1920	1937
Minimum	54	2.14	0.10	0.40	0.43	0.19	0.02	0.00	0.00	0.03	T	0.25	2.01	23.95
Year of minimum	--	1920	1920	1926	1909	1931	1918	1904	1892	1942	1895	1890	1930	1944
Greatest in 24 hours <sup>2</sup>	54	3.39	2.30	1.94	1.79	1.46	1.58	1.59	1.54	1.74	2.00	3.12	3.18	3.39
Year of greatest 24 hours	--	1933	1919	1916	1907	1932	1897	1916	1896	1941	1893	1941	1917	Jan. 1933
Avg. No. days with .01 inch or more	53	19	17	17	14	12	8	2	3	7	12	17	18	146
Average snowfall	54	2.4	1.1	0.8	T						T	0.1	0.8	5.2
Maximum snowfall	52	26.0	15.0	15.7	2.0						1.0	3.0	8.5	44.9
Year of maximum snowfall	--	1916	1893	19.6	1911						1935	1896	1912	1916
Greatest 24-hour snowfall <sup>2</sup>	54	7.3	10.1	10.7	2.0						1.0	2.5	6.5	10.7
Year of greatest 24-hour snowfall	--	1916	1917	1916	1911						1935	1896	1924	Mar. 1916
Temperature, °F.														
Average	44	39.8	42.8	46.4	50.9	55.8	61.0	66.4	65.7	60.7	53.7	46.0	41.2	52.5
Average daily maximum	44	45.6	50.3	55.6	61.7	67.5	73.2	81.4	80.7	74.1	64.1	53.3	47.3	62.9
Average daily minimum	44	33.9	35.3	37.1	40.1	44.0	48.8	51.3	50.7	47.3	43.3	38.7	35.2	42.1
Absolute maximum	44	69	78	80	89	92	100	104	100	98	91	75	67	104
Year of absolute maximum	--	1931	1932	1923	1926	1931	1925	1924	1932	1931	1934	1908	1924	1926
Absolute minimum	44	6	0	18	25	30	34	39	35	30	25	12	-4	-4
Year of absolute minimum	--	1904	1890	1913	1936	1913	1914	1926	1914	1926	1917	1896	1924	Dec. 1924

<sup>1</sup> Later dates also.  
<sup>2</sup> Observation time to observation time.

STATION HISTORY

Places of observation	Period of record
University of Oregon campus	October 1890 to March 1912
533 East 10th Street	April 1912 to August 14, 1915
Kinomid Park	August 14, 1915 to Sept. 1917
Mill Race and Alder	Oct. 1917 to Nov. 1918
477 3rd Avenue East	Dec. 1918 to Dec. 1924
345 Mill Street	Jan. 1925 to June 1945

Station closed June 1945.

TABLE 2  
 Climatological Summary  
 Eugene Airport, Oregon  
 (Elevation 364 feet)  
 Period of record 1947-50

Item and description	Years of record	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Precipitation, inches														
Average	8	5.73	5.04	4.76	2.26	1.81	1.28	0.51	0.49	1.26	5.06	6.64	4.96	34.82
Percent of average annual	8	14	13	12	6	5	3	1	1	3	13	17	12	100
Maximum	8	12.92	9.73	6.72	3.46	3.25	3.62	2.63	1.70	2.70	12.66	11.60	8.67	54.09
Year of maximum	-	1950	1949	1945	1945	1948	1947	1947	1943	1946	1950	1945	1948	1950
Minimum	8	1.68	2.14	1.42	0.83	0.47	0.04	0.01	0.02	0.06	1.26	2.81	2.69	23.26
Year of minimum	-	1949	1943	1944	1949	1947	1945	1944 <sup>1</sup>	1946	1943	1944	1943	1944	1944
Greatest in 24 consecutive hours	8	3.27	2.65	1.81	0.87	1.49	0.57	1.30	1.04	1.19	3.09	3.65	3.20	3.65
Year of greatest 24 hours	-	1948	1949	1946	1945	1949	1949	1947	1943	1946	1947	1950	1945	Nov. 1950
Avg. No. days with .01 or more	8	17	16	19	14	9	9	2	4	5	14	17	24	150
Average snowfall <sup>2</sup>	8	7.5	0.7	T.	T.	T.						T.	0.1	8.3
Maximum snowfall <sup>2</sup>	8	36.1	4.8	0.1	T.	T.						T.	1.0	36.8
Year of maximum snowfall	-	1950	1940	1950	1944 <sup>1</sup>	1950						1945 <sup>1</sup>	1948	1950
Greatest 24-hour snowfall <sup>2</sup>	8	7.2	2.3	0.1	T.	T.						T.	1.0	7.2
Year of greatest 24-hour snowfall	-	1950	1949	1950	1944 <sup>1</sup>	1950						1945 <sup>1</sup>	1948	Jan. 1950
Temperature, °F.														
Average	8	36.3	42.7	45.8	50.5	56.6	61.1	66.5	65.8	61.8	52.5	45.4	40.6	52.1
Average daily maximum	8	43.3	50.9	54.9	61.1	68.9	73.7	82.2	81.1	76.9	62.9	53.0	47.0	63.0
Average daily minimum	8	29.2	34.4	36.5	39.8	44.2	48.5	50.7	50.4	46.6	42.0	37.8	34.2	41.2
Absolute maximum	8	60	65	74	86	91	93	105	100	101	85	71	64	105
Year of absolute maximum	-	1945	1946 <sup>1</sup>	1947	1947	1947	1946 <sup>1</sup>	1946	1944	1944	1945	1949	1950	July 1946
Absolute minimum	8	-3	-3	25	30	32	37	41	40	32	24	24	16	-3
Year of absolute minimum	-	1950	1950	1944	1943 <sup>1</sup>	1948	1949	1949	1946	1945	1949	1948	1944	Jan. 1950 <sup>1</sup>
Avg. degree-days, below 65° base	8	892	631	504	438	264	130	35	35	130	300	588	755	4801
Miscellaneous data														
Average number of days clear	8	3	3	3	4	6	7	15	13	13	4	1	2	74
Average number of days partly cloudy	8	6	7	7	7	10	8	9	10	8	8	8	6	94
Average number of days cloudy	8	22	18	21	19	15	15	7	8	9	19	21	23	107
Average hourly wind speed, m.p.h.	2	7.8	8.9	8.2	7.7	7.7	8.0	8.7	7.4	7.2	7.1	7.3	7.8	7.8
Prevailing wind direction	8	S.	S.	S.	N.	N.	N.	N.	N.	N.	S.	S.	S.	N.

<sup>1</sup> Later dates also.  
<sup>2</sup> Includes hail and sleet.

STATION HISTORY

All observations taken at Mahlon Sweet Field, 0 miles northwest of city center, Eugene, Oregon.

TABLE 3  
 Climatological Summary  
 Cottage Grove, Oregon  
 (Elevation 650 feet)  
 Period of record 1917-52

Item and description	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Precipitation, inches													
Normal	6.25	5.22	4.65	3.57	2.28	1.54	0.18	0.18	1.90	3.34	6.46	6.98	42.85
Percent of normal annual	15	12	11	8	5	4	0	1	5	8	15	16	100
Maximum	13.42	10.47	9.02	8.78	4.72	6.42	3.16	2.22	5.38	15.35	13.02	16.12	63.46
Year of maximum	1950	1940	1928	1937	1941	1937	1947	1926	1920	1950	1942	1942	1950
Minimum	2.57	0.37	0.54	0.64	0.28	0.00	0.00	0.00	0.08	0.00	0.53	2.21	29.02
Year of minimum	1949	1920	1926	1930	1931	1918 <sup>1</sup>	1922 <sup>1</sup>	1926 <sup>1</sup>	1932	1917	1936	1943	1944
Greatest in one day	4.22	3.00	2.15	2.33	2.20	1.55	1.25	0.80	1.68	2.95	3.78	4.10	4.22
Year of greatest in one day	1933	1927	1932	1937	1940	1942	1947	1943	1920	1924	1917	1945	Jan. 1933
Avg. No. days with .01 inch or more	18	16	17	14	11	7	2	2	7	10	15	18	136
Average snowfall	2.9	1.2	0.3	0.2	0	0	0	0	0	T	T	1.1	5.7
Maximum snowfall	46.8	21.3	18.5	3.0	0	0	0	0	0	0.2	T	9.5	48.6
Year of maximum snowfall	1950	1917	1951	1929	--	--	--	--	--	1935	1921 <sup>1</sup>	1916	1950
Temperature, degrees F.													
Normal	39.7	42.5	46.1	50.1	54.6	59.0	64.8	64.8	59.7	53.3	45.6	40.8	51.8
Average daily maximum	46.0	50.6	55.6	61.3	67.3	73.8	81.3	81.7	74.7	64.2	53.5	47.1	63.1
Average daily minimum	32.6	34.4	36.1	38.6	41.9	46.3	48.3	47.0	45.2	42.3	37.0	34.5	40.5
Absolute maximum	68	76	87	87	93	100	105	102	105	93	74	73	105
Year of absolute maximum	1931	1932	1926	1926	1931	1926	1926 <sup>1</sup>	1927 <sup>1</sup>	1944	1934	1940	1926	July 1926 <sup>1</sup> Sept. 1944
Absolute minimum	-1	0	21	23	27	32	27	31	24	19	11	-7	-7
Year of absolute minimum	1949	1950	1917 <sup>1</sup>	1918	1939	1920	1944	1927	1926	1916	1935	1921	Dec. 1921

<sup>1</sup> Later dates also, month, or years.

STATION HISTORY

Located in Cottage Grove on Quincy Avenue at elevation 670 from August 1916 to July 1917, when it was moved to its present location one mile south of the Cottage Grove post office at elevation 650.

TABLE 4  
Corps of Engineers, U.S. Army  
Portland, Oregon District

Sheet No. 1 of 2

Station, COTTAGE GROVE County, Lane State, Oregon

Latitude, 43° 47' Longitude, 123° 04' Elevation, 650 feet

Data, Monthly and annual precipitation, inches

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1916								0.74	1.15	1.37	7.43	6.59	-
1917	3.90	5.32	5.58	5.34	2.82	0.82	0.01	T	1.61	0.00	9.04	7.46	41.90
1918	5.82	7.85	3.73	1.34	1.55	0.00	0.17	1.08	1.00	2.02	6.49	3.36	34.41
1919	10.47	9.68	8.11	4.95	2.32	0.87	0.02	0.17	2.98	2.88	7.68	6.03	56.16
1920	3.26	0.37	5.67	5.28	0.42	2.77	0.38	1.07	5.38	4.97	7.77	12.19	49.53
1921	6.54	6.45	3.53	3.45	1.92	1.41	0.03	0.11	1.80	2.83	10.41	3.56	42.04
1922	4.95	4.31	7.37	4.02	1.34	0.15	0.00	0.62	1.78	3.85	4.87	10.41	43.67
1923	11.57	1.79	3.52	3.71	2.28	2.19	1.14	0.47	1.95	4.37	4.23	6.54	43.76
1924	3.05	4.03	2.69	1.31	0.81	0.79	0.00	0.79	2.52	9.81	11.23	5.49	42.52
1925	8.42	8.73	2.25	6.12	3.91	0.85	0.05	0.82	2.28	0.30	5.31	4.76	43.80
1926	3.57	10.30	0.54	2.21	3.52	0.13	0.00	2.22	1.97	3.55	11.21	5.73	44.95
1927	9.03	9.84	3.94	2.18	3.08	1.39	T	0.21	4.70	3.22	7.92	4.07	49.58
1928	5.59	2.42	9.92	4.78	0.50	0.60	0.46	0.00	1.23	2.64	3.65	6.72	38.51
1929	7.19	0.67	3.05	5.46	1.29	2.90	0.00	0.06	0.25	1.29	0.69	13.27	36.12
1930	3.82	6.19	1.55	4.17	3.17	0.73	0.00	0.02	1.82	1.83	4.62	2.70	30.62
1931	3.67	3.11	5.90	3.16	0.28	2.62	0.00	0.00	1.17	4.75	7.18	8.66	40.50
1932	6.04	2.33	8.02	4.84	3.02	0.55	0.19	0.36	0.08	3.97	8.15	7.39	44.94
1933	10.14	4.83	4.78	1.29	4.31	2.50	0.00	0.39	3.06	2.35	1.83	8.01	43.49
1934	6.56	1.72	3.75	2.16	1.88	0.56	0.14	0.03	0.66	5.57	10.17	8.19	41.39
1935	5.75	3.94	4.97	3.46	0.43	0.65	0.14	0.17	1.06	4.89	3.60	4.17	33.23
1936	10.75	6.14	3.04	2.41	4.56	2.76	0.25	0.00	1.99	0.19	0.53	6.17	38.79
MEANS													

REMARKS









**TABLE 7**  
Corps of Engineers, U.S. Army  
Portland, Oregon District

Station, DORENA DAM County, Lane State, Oregon

Latitude, 43° 47' Longitude, 122° 58' Elevation, 757 feet

Data, Monthly and annual precipitation and temperature.

Year	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Precipitation, inches													
1949	2.33	8.07	4.91	1.59	3.53	0.99	T	0.08	1.76	2.52	5.05	5.82	36.65
1950	14.92	3.92	6.36	2.40	1.99	2.67	0.22	0.58	1.10	14.71	7.66	5.43	61.96
1951	9.03	6.04	5.03	1.29	2.24	T	0.04	0.35	0.65	9.67	7.33	9.53	51.29
1952	4.85	4.47	5.95	1.42	1.41	5.60	0.00	0.04	1.71	0.63	1.24	9.10	36.42
1953	10.93	7.41	4.86										
Temperature means, degrees F.													
1950	-	-	-	-	53.1	60.1	65.9	67.6	61.7	53.6	47.2	47.3	
1951	39.9	42.5	40.8	52.1	54.8	62.2	65.4	63.9	61.9	52.7	45.9	38.0	51.7
1952	37.9	42.4	42.0	49.7	54.0	56.3	64.5	64.0	62.4	56.3	38.6	40.4	50.7
1953	44.1	42.5	43.0										
MEANS													

REMARKS

TABLE 8  
 Monthly Run-off  
 Coast Fork Willamette River and Row River

River, station, location, and drainage area	Units of run-off	Mean monthly run-off <sup>1</sup>												Mean annual run-off
		January	February	March	April	May	June	July	August	September	October	November	December	
Row River above Pitcher Creek near Dorena, Oregon Drainage area = 211 sq. mi.	c.f.s.	1,026	1,155	1,054	859	551	292	75	34	40	184	734	955	573
	inches	5.61	5.75	5.76	4.43	2.90	1.55	0.41	0.19	0.21	1.00	3.88	5.21	36.90
	acre-feet	63,100	64,700	64,800	49,900	32,600	17,400	4,600	2,100	2,400	11,300	43,700	58,600	416,200
Row River near Cottage Grove, Oregon Drainage area = 270 sq. mi.	c.f.s.	1,327	1,482	1,162	910	637	349	94	45	55	300	1,060	1,343	725
	inches	5.67	5.76	4.92	3.76	2.72	1.44	0.40	0.19	0.23	1.28	4.38	5.74	36.49
	acre-feet	81,600	83,000	70,800	54,100	39,200	20,800	5,800	2,800	3,300	18,400	63,100	82,600	525,500
Mosby Creek near Cottage Grove, Oregon Drainage area = 96 sq. mi.	c.f.s.	426	525	427	270	152	95	25	12	14	84	313	437	230
	inches	5.11	5.74	5.14	3.14	1.82	1.11	0.29	0.14	0.16	1.01	3.64	5.26	32.56
	acre-feet	26,200	29,400	26,300	16,100	9,300	5,700	1,500	700	800	5,200	18,600	26,900	166,700
Coast Fork Willamette River near London, Oregon Drainage area = 69 sq. mi.	c.f.s.	388	435	353	240	140	88	35	21	22	77	244	346	198
	inches	6.49	6.63	5.90	3.88	2.34	1.41	0.58	0.35	0.35	1.29	3.94	5.80	38.96
	acre-feet	23,900	24,400	21,700	14,300	8,600	5,200	2,100	1,300	1,300	4,800	14,500	21,300	143,400
Coast Fork Willamette River below Cottage Grove Dam Drainage area = 104 sq. mi.	c.f.s.	550	596	446	289	188	104	34	19	27	123	352	540	271
	inches	6.09	6.02	4.94	3.10	2.09	1.12	0.38	0.22	0.29	1.37	3.77	5.99	35.38
	acre-feet	33,800	33,400	27,400	17,200	11,600	6,200	2,100	1,200	1,600	7,600	20,900	33,200	196,200
Coast Fork Willamette River near Goshen, Oregon Drainage area = 642 sq. mi.	c.f.s.	3,118	3,436	2,757	2,036	1,201	710	187	88	107	462	2,020	2,630	1,552
	inches	5.60	5.62	4.95	3.54	2.15	1.23	0.34	0.16	0.19	0.83	3.51	4.72	32.84
	acre-feet	191,700	192,400	169,500	121,200	73,800	42,200	11,500	5,400	6,400	28,400	120,200	161,700	1,124,400
Willamette River at Eugene, Oregon Drainage area = 2,030 sq. mi.	c.f.s.	9,094	9,404	7,970	7,246	5,448	3,754	1,499	922	947	1,781	5,728	8,103	5,133
	inches	5.17	4.87	4.53	3.98	3.09	2.06	0.85	0.52	0.52	1.01	3.15	4.60	34.35
	acre-feet	559,600	527,200	490,400	430,900	334,500	273,000	92,000	56,300	56,300	109,300	341,000	498,000	3,718,700

<sup>1</sup> Based on natural discharges.

Table 9, Sheet 1 of 2  
**Regulating Outlet Rating Table for Dorena Dam**  
**One Service Gate in Operation**

Pool Elevation Feet	Discharge in CFS																				Pool Elevation Feet		
	Gate Opening In Feet																						
	0.1	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6	2.8	3	3.6	4	4.5	5		5.5	6
760	14	27	55	84	110	138	165	193	220	247	273	300	330	358	384	415	480	555	620	690	750	830	760
761	14	27	57	86	113	141	169	197	225	253	279	306	337	366	392	423	490	566	635	708	773	860	761
762	15	28	58	88	116	145	173	202	230	258	285	313	343	373	399	430	501	578	650	726	798	890	762
763	15	29	59	90	118	148	176	206	235	264	291	319	349	380	407	435	512	589	664	743	818	917	763
764	15	29	61	92	121	151	180	210	240	269	297	325	355	387	415	446	522	600	676	759	837	943	764
765	16	30	63	94	124	154	183	214	245	274	303	331	362	394	422	454	532	611	690	775	867	969	765
766	16	31	64	96	126	157	186	218	249	279	309	337	368	401	429	461	542	622	704	791	876	992	766
767	16	31	65	97	128	160	190	222	254	276	315	343	375	407	437	469	551	633	717	807	895	1015	767
768	16	32	66	99	130	163	193	226	259	290	320	346	381	414	444	476	561	644	730	823	912	1037	768
769	16	32	67	101	133	166	196	230	264	295	326	354	387	420	451	484	570	654	742	838	928	1068	769
770	16	34	68	103	135	169	200	234	268	299	330	359	393	427	458	491	580	664	754	853	946	1077	770
771	17	34	69	105	137	172	203	238	273	304	336	365	399	434	465	498	589	675	766	866	965	1090	771
772	17	35	71	106	140	175	206	242	277	308	341	370	405	440	472	506	598	685	778	880	980	1116	772
773	17	35	72	107	143	177	209	245	281	313	346	376	411	446	479	513	607	693	790	894	996	1135	773
774	17	36	73	109	145	180	213	249	288	315	351	381	417	453	486	520	616	705	802	908	1012	1143	774
775	17	36	74	111	147	183	216	253	290	323	357	386	423	459	493	527	625	715	813	921	1028	1170	775
776	17	37	75	113	148	189	219	259	294	328	362	392	428	466	499	535	634	724	825	934	1043	1187	776
777	18	37	76	116	150	188	222	259	298	332	366	397	434	472	506	542	643	734	836	947	1057	1203	777
778	18	38	77	116	153	190	225	263	302	336	371	403	440	478	513	549	661	744	847	960	1071	1219	778
779	18	33	74	120	168	193	230	272	311	352	408	408	446	484	519	556	659	753	867	973	1086	1236	779
780	18	39	79	118	157	196	231	270	310	345	381	413	452	490	525	563	668	762	868	985	1099	1250	780
781	18	39	80	120	168	198	234	274	314	349	386	418	458	498	532	570	676	771	878	998	1113	1266	781
782	18	40	81	122	160	200	237	277	318	364	390	423	463	502	538	577	684	780	889	1010	1140	1280	782
783	19	40	82	124	163	203	239	281	321	358	395	428	466	508	545	584	692	790	900	1021	1140	1296	783
784	19	41	83	125	165	206	242	284	325	362	400	433	474	527	552	590	700	800	910	1032	1153	1310	784
785	19	41	84	126	167	208	245	287	328	366	406	438	479	520	558	597	708	809	920	1044	1166	1324	785
786	19	42	85	127	168	210	247	290	332	370	409	443	485	526	565	604	716	818	930	1055	1179	1337	786
787	19	42	86	128	170	213	250	293	336	374	414	448	490	532	571	610	724	827	940	1066	1191	1350	787
788	20	43	87	130	172	215	253	296	340	378	418	453	496	538	577	617	732	835	950	1077	1203	1363	788
789	20	47	80	138	184	223	256	311	344	382	423	458	501	544	584	624	739	845	960	1087	1215	1377	789
790	20	44	89	133	176	219	258	303	347	386	428	463	506	549	590	630	746	854	969	1098	1227	1390	790
791	20	44	90	134	178	222	261	306	350	390	432	458	512	555	595	637	754	863	979	1109	1239	1403	791
792	21	45	91	135	180	224	264	309	354	394	436	473	517	560	602	644	763	871	989	1119	1251	1416	792
793	21	45	92	137	182	226	267	312	357	398	440	478	523	565	608	650	769	879	998	1130	1263	1428	793
794	21	45	93	138	183	228	269	315	360	402	445	482	528	571	614	657	777	888	1008	1140	1274	1440	794
795	21	46	94	139	185	230	272	318	364	406	449	486	534	577	620	663	784	897	1018	1150	1285	1452	795
796	22	46	94	141	187	232	275	321	367	410	454	491	538	583	626	669	791	906	1027	1160	1296	1465	796
797	22	47	95	142	188	235	277	324	370	414	458	496	543	588	632	676	799	915	1037	1171	1307	1476	797
798	22	47	96	143	190	237	279	327	374	418	462	500	549	594	638	682	806	923	1046	1181	1318	1487	798
799	22	47	97	144	191	239	282	330	377	421	466	505	554	599	644	688	813	931	1055	1191	1329	1499	799
800	23	48	97	145	193	241	286	333	380	425	470	510	559	604	650	694	820	940	1065	1200	1340	1510	800

- Notes:
- Elevations reference the Dorena Project datum (approximately NGVD29).  
 Conversion from the project datum (approximately NGVD29) to NAVD88 not determined at this time.
  - Flow data in this table is unchanged from Table 9 of the Dorena Water Control Manual dated 1953.

Minimum Flood Control Pool Elevation: 770.5 Feet  
 Maximum Flood Control Pool Elevation: 860 Feet  
 RO Invert Elevation: 739 Feet

SHEET 1 OF 2


 Avoid operating in this range. Gate openings from 0.01 to 0.59 and 4.81 to 5.99 violate gate opening operating criteria.

Table 9, Sheet 2 of 2  
**Regulating Outlet Rating Table for Dorena Dam**  
**One Service Gate in Operation**

Pool Elevation Feet	Discharge in CFS																				Pool Elevation Feet		
	Gate Opening In Feet																						
	0.1	0.2	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.6	2.8	3	3.6	4	4.5	5		5.5	6
801	23	48	98	147	194	243	287	336	384	428	474	515	564	609	655	700	828	948	1073	1210	1350	1522	801
802	23	48	98	148	196	245	289	338	387	432	478	519	568	615	661	706	835	956	1082	1220	1361	1533	802
803	23	48	99	149	197	247	292	341	390	436	482	523	573	620	667	712	842	964	1091	1230	1372	1544	803
804	23	48	100	150	199	248	294	343	393	439	486	528	578	625	673	719	849	972	1100	1239	1383	1555	804
805	24	49	100	151	200	250	296	346	396	443	490	532	583	630	679	725	856	980	1109	1249	1393	1566	805
806	24	49	101	152	202	252	298	349	399	446	494	536	588	635	685	731	863	989	1118	1258	1401	1577	806
807	24	50	102	153	205	255	300	352	402	450	498	540	593	640	690	738	870	997	1128	1268	1414	1587	807
808	24	50	103	154	205	257	305	355	405	455	502	545	596	645	696	744	877	1005	1137	1277	1424	1598	808
809	24	50	103	155	207	258	306	358	408	456	506	549	603	651	702	750	883	1013	1145	1288	1434	1608	809
810	24	51	104	156	208	260	308	360	411	460	510	554	608	656	708	756	890	1021	1153	1295	1444	1618	810
811	25	51	104	157	209	261	310	363	414	464	513	558	613	661	713	762	897	1029	1162	1304	1454	1628	811
812	25	52	105	158	210	263	312	365	417	467	517	562	618	666	718	768	903	1037	1170	1313	1464	1638	812
813	25	52	105	159	212	265	314	368	420	471	520	566	622	671	724	774	910	1044	1179	1322	1474	1648	813
814	25	53	106	160	213	267	316	370	423	474	524	570	627	676	730	780	917	1052	1188	1331	1484	1658	814
815	25	53	107	161	214	268	318	373	425	477	528	575	631	681	735	786	924	1060	1197	1340	1494	1668	815
816	25	53	108	162	215	270	320	375	428	480	532	579	636	686	741	792	930	1068	1206	1349	1504	1678	816
817	26	54	108	163	217	271	323	378	431	484	535	583	640	691	746	798	937	1075	1213	1358	1513	1688	817
818	26	54	109	164	218	273	324	380	434	487	539	587	645	695	742	804	943	1083	1222	1367	1523	1698	818
819	26	54	110	165	219	275	327	383	437	490	543	591	650	700	758	810	950	1091	1230	1375	1533	1707	819
820	26	54	110	165	220	276	329	385	439	493	546	596	655	705	764	815	955	1099	1239	1384	1543	1716	820
821	27	55	111	166	222	277	331	387	442	497	550	600	659	710	769	821	963	1107	1248	1393	1552	1728	821
822	27	55	111	167	223	279	333	390	445	500	554	603	664	715	774	827	969	1114	1256	1401	1562	1736	822
823	27	55	112	168	224	280	335	392	447	504	557	607	669	720	779	833	975	1122	1263	1410	1571	1745	823
824	27	56	112	169	225	282	337	394	450	507	560	611	673	725	784	839	982	1129	1271	1418	1581	1754	824
825	27	56	112	170	227	284	339	396	453	510	563	615	678	729	790	845	988	1137	1280	1427	1590	1764	825
826	27	56	113	171	228	285	341	398	455	513	567	620	682	734	795	850	994	1144	1288	1438	1599	1773	826
827	28	56	114	172	229	287	343	401	458	516	571	624	686	739	801	855	1000	1152	1296	1444	1608	1785	827
828	28	57	114	173	230	288	345	403	460	519	575	628	690	743	806	861	1006	1159	1304	1452	1618	1792	828
829	28	57	115	173	231	289	347	405	463	522	578	632	695	748	811	867	1013	1169	1312	1460	1627	1801	829
830	28	57	115	174	232	290	349	408	466	525	581	636	700	753	816	873	1019	1174	1320	1469	1636	1810	830
831	28	57	115	175	233	292	351	410	468	528	585	640	704	758	822	879	1025	1182	1328	1477	1645	1819	831
832	28	58	116	176	234	294	353	412	470	530	588	644	708	762	828	885	1031	1190	1336	1485	1655	1828	832
833	29	58	117	177	236	295	355	414	473	533	591	647	713	767	833	890	1038	1197	1344	1493	1663	1837	833
834	29	58	118	177	237	296	357	416	476	536	595	651	717	771	838	896	1044	1204	1362	1501	1672	1846	834
835	29	59	118	178	238	297	358	418	478	540	598	655	721	776	843	901	1050	1212	1368	1510	1681	1855	835
836	29	59	119	179	239	299	360	421	480	543	601	659	726	780	849	907	1056	1219	1372	1518	1690	1864	836
837	29	59	119	180	240	300	362	423	483	546	604	663	730	785	854	913	1062	1226	1376	1526	1699	1873	837
838	29	59	120	180	241	302	364	419	485	549	607	666	735	790	859	918	1078	1233	1384	1534	1708	1882	838
839	29	59	120	181	242	303	366	427	487	552	610	670	739	794	864	924	1084	1241	1391	1542	1717	1891	839
840	30	60	121	182	243	305	368	429	490	555	614	674	744	799	869	930	1090	1248	1399	1550	1725	1900	840

- Notes:
- Elevations reference the Dorena Project datum (approximately NGVD29). Conversion from the project datum (approximately NGVD29) to NAVD88 not determined at this time.
  - Flow data in this table is unchanged from Table 9 of the Dorena Water Control Manual dated 1953.

Minimum Flood Control Pool Elevation: 770.5 Feet  
 Maximum Flood Control Pool Elevation: 860 Feet  
 RO Invert Elevation: 739 Feet

SHEET 2 OF 2

Avoid operating in this range. Gate openings from 0.01 to 0.59 and 4.81 to 5.99 violate gate opening operating criteria.

TABLE NO. 10.  
CAPACITY OF DORENA RESERVOIR  
IN ACRE-FEET

El. in ft.	Capacity	Diff.	El. in ft.	Capacity	Diff.	El. in ft.	Capacity	Diff.	El. in ft.	Capacity	Diff.	El. in ft.	Capacity	Diff.	El. in ft.	Capacity	Diff.	El. in ft.	Capacity	Diff.	El. in ft.	Capacity	Diff.	El. in ft.	Capacity	Diff.			
760.0	2,803	29	765.0	4,511	39	770.0	6,727	50	775.0	9,399	57	780.0	12,393	63	785.0	15,693	71	790.0	19,447	80	795.0	23,672	90	800.0	28,397	100	805.0	33,622	110
.1	2,832	30	.1	4,550	39	.1	6,777	50	.1	9,456	57	.1	12,456	63	.1	15,754	71	.1	19,527	80	.1	23,762	90	.1	28,497	100	.1	33,732	110
.2	2,862	30	.2	4,589	40	.2	6,827	50	.2	9,513	57	.2	12,519	63	.2	15,835	71	.2	19,607	80	.2	23,852	90	.2	28,597	100	.2	33,862	110
.3	2,892	30	.3	4,629	40	.3	6,877	50	.3	9,570	58	.3	12,572	63	.3	15,906	71	.3	19,687	80	.3	23,942	90	.3	28,697	100	.3	33,952	110
.4	2,922	30	.4	4,669	40	.4	6,927	50	.4	9,628	58	.4	12,645	63	.4	15,977	71	.4	19,767	80	.4	24,032	90	.4	28,797	100	.4	34,062	110
.5	2,952	30	.5	4,709	40	.5	6,977	50	.5	9,686	58	.5	12,708	63	.5	16,048	71	.5	19,847	80	.5	24,122	90	.5	28,897	100	.5	34,172	110
.6	2,982	30	.6	4,749	40	.6	7,027	50	.6	9,744	58	.6	12,771	63	.6	16,120	72	.6	19,928	81	.6	24,213	91	.6	28,998	101	.6	34,282	110
.7	3,013	31	.7	4,789	40	.7	7,078	51	.7	9,802	58	.7	12,834	63	.7	16,192	72	.7	20,009	81	.7	24,304	91	.7	29,099	101	.7	34,393	111
.8	3,044	31	.8	4,830	41	.8	7,129	51	.8	9,860	58	.8	12,897	63	.8	16,264	72	.8	20,090	81	.8	24,395	91	.8	29,200	101	.8	34,504	111
.9	3,075	31	.9	4,871	41	.9	7,180	51	.9	9,918	58	.9	12,960	64	.9	16,336	72	.9	20,171	81	.9	24,486	91	.9	29,301	101	.9	34,615	111
761.0	3,106	31	766.0	4,912	41	771.0	7,231	51	776.0	9,976	58	781.0	13,024	64	786.0	16,408	72	791.0	20,252	82	796.0	24,577	92	801.0	29,402	102	806.0	34,726	111
.1	3,137	32	.1	4,953	41	.1	7,282	51	.1	10,034	58	.1	13,088	64	.1	16,480	72	.1	20,334	82	.1	24,669	92	.1	29,504	102	.1	34,837	111
.2	3,169	32	.2	4,994	42	.2	7,333	51	.2	10,092	58	.2	13,152	64	.2	16,553	73	.2	20,416	82	.2	24,761	92	.2	29,606	102	.2	34,948	112
.3	3,201	32	.3	5,036	42	.3	7,385	52	.3	10,151	59	.3	13,216	64	.3	16,626	73	.3	20,498	82	.3	24,853	92	.3	29,708	102	.3	35,060	112
.4	3,233	32	.4	5,078	42	.4	7,437	52	.4	10,210	59	.4	13,280	64	.4	16,699	73	.4	20,580	82	.4	24,946	92	.4	29,810	102	.4	35,172	112
.5	3,265	32	.5	5,120	42	.5	7,489	52	.5	10,269	59	.5	13,344	64	.5	16,772	73	.5	20,662	83	.5	25,037	93	.5	29,912	103	.5	35,284	112
.6	3,297	32	.6	5,162	43	.6	7,541	52	.6	10,328	59	.6	13,408	64	.6	16,845	73	.6	20,745	83	.6	25,130	93	.6	30,015	103	.6	35,396	112
.7	3,329	33	.7	5,205	43	.7	7,593	52	.7	10,387	59	.7	13,472	64	.7	16,919	74	.7	20,828	83	.7	25,223	93	.7	30,118	103	.7	35,508	113
.8	3,362	33	.8	5,248	43	.8	7,645	52	.8	10,446	59	.8	13,537	65	.8	16,993	74	.8	20,911	83	.8	25,316	93	.8	30,221	103	.8	35,621	113
.9	3,395	33	.9	5,291	43	.9	7,698	53	.9	10,505	59	.9	13,602	65	.9	17,067	74	.9	20,994	83	.9	25,409	93	.9	30,324	103	.9	35,734	113
762.0	3,428	33	767.0	5,334	43	772.0	7,751	53	777.0	10,564	59	782.0	13,667	65	787.0	17,141	74	792.0	21,077	84	797.0	25,502	94	802.0	30,427	104	807.0	35,847	113
.1	3,461	33	.1	5,377	44	.1	7,804	53	.1	10,623	60	.1	13,732	65	.1	17,215	74	.1	21,161	84	.1	25,596	94	.1	30,531	104	.1	35,960	113
.2	3,494	34	.2	5,421	44	.2	7,857	53	.2	10,683	60	.2	13,797	65	.2	17,289	75	.2	21,245	84	.2	25,690	94	.2	30,635	104	.2	36,073	113
.3	3,528	34	.3	5,465	44	.3	7,910	53	.3	10,743	60	.3	13,862	65	.3	17,364	75	.3	21,329	84	.3	25,784	94	.3	30,739	104	.3	36,186	114
.4	3,562	34	.4	5,509	44	.4	7,963	53	.4	10,803	60	.4	13,927	65	.4	17,439	75	.4	21,413	84	.4	25,878	94	.4	30,843	104	.4	36,300	114
.5	3,596	34	.5	5,553	44	.5	8,016	53	.5	10,863	60	.5	13,993	66	.5	17,514	75	.5	21,497	85	.5	25,972	95	.5	30,947	105	.5	36,414	114
.6	3,630	34	.6	5,597	45	.6	8,070	54	.6	10,923	60	.6	14,059	66	.6	17,589	75	.6	21,582	85	.6	26,067	95	.6	31,052	105	.6	36,528	114
.7	3,664	35	.7	5,642	45	.7	8,124	54	.7	10,983	60	.7	14,125	66	.7	17,664	76	.7	21,667	85	.7	26,162	95	.7	31,157	105	.7	36,642	114
.8	3,699	35	.8	5,687	45	.8	8,178	54	.8	11,043	60	.8	14,191	66	.8	17,740	76	.8	21,752	85	.8	26,257	95	.8	31,262	105	.8	36,756	115
.9	3,734	35	.9	5,732	45	.9	8,232	54	.9	11,103	60	.9	14,257	66	.9	17,816	76	.9	21,837	85	.9	26,352	95	.9	31,367	105	.9	36,911	115
763.0	3,769	35	768.0	5,777	45	773.0	8,286	54	778.0	11,163	60	783.0	14,323	66	788.0	17,892	76	793.0	21,922	86	798.0	26,352	95	803.0	31,472	106	808.0	36,986	115
.1	3,804	35	.1	5,823	46	.1	8,340	54	.1	11,224	61	.1	14,390	67	.1	17,968	76	.1	22,008	86	.1	26,447	96	.1	31,578	106	.1	37,101	115
.2	3,839	35	.2	5,869	46	.2	8,394	54	.2	11,285	61	.2	14,457	67	.2	18,044	76	.2	22,094	86	.2	26,539	96	.2	31,684	106	.2	37,216	115
.3	3,875	36	.3	5,915	46	.3	8,449	55	.3	11,346	61	.3	14,524	67	.3	18,120	77	.3	22,180	86	.3	26,735	96	.3	31,790	106	.3	37,331	115
.4	3,911	36	.4	5,961	46	.4	8,504	55	.4	11,407	61	.4	14,591	67	.4	18,197	77	.4	22,266	86	.4	26,831	96	.4	31,896	106	.4	37,446	116
.5	3,947	36	.5	6,007	47	.5	8,559	55	.5	11,468	61	.5	14,658	68	.5	18,274	77	.5	22,352	87	.5	26,927	97	.5	32,002	107	.5	37,562	116
.6	3,983	36	.6	6,054	47	.6	8,614	55	.6	11,529	61	.6	14,726	68	.6	18,351	77	.6	22,439	87	.6	27,024	97	.6	32,109	107	.6	37,678	116
.7	4,019	37	.7	6,101	47	.7	8,669	55	.7	11,590	61	.7	14,794	68	.7	18,428	77	.7	22,526	87	.7	27,121	97	.7	32,216	107	.7	37,794	116
.8	4,056	37	.8	6,148	47	.8	8,724	55	.8	11,651	61	.8	14,862	68	.8	18,505	78	.8	22,613	87	.8	27,218	97	.8	32,323	107	.8	37,910	116
.9	4,093	37	.9	6,195	47	.9	8,779	55	.9	11,712	61	.9	14,930	68	.9	18,583	78	.9	22,710	87	.9	27,315	97	.9	32,430	107	.9	38,026	117
764.0	4,130	37	769.0	6,242	48	774.0	8,835	56	779.0	11,773	62	784.0	15,008	69	789.0	18,661	78	794.0	22,787	88	799.0	27,112	98	804.0	32,537	108	809.0	38,143	117
.1	4,167	37	.1	6,290	48	.1	8,891	56	.1	11,835	62	.1	15,067	69	.1	18,739	78	.1	22,875	88	.1	27,510	98	.1	32,645	108	.1	38,260	117
.2	4,204	38	.2	6,338	48	.2	8,947	56	.2	11,897	62	.2	15,136	69	.2	18,817	78	.2	22,963	88	.2	27,608	98	.2	32,753	108	.2	38,377	117
.3	4,242	38	.3	6,386	48	.3	9,003	56	.3	11,959	62	.3	15,205	69	.3	18,895	78	.3	23,081	88	.3	27,706	98	.3	32,861	108	.3	38,494	117
.4	4,280	38	.4	6,434	48	.4	9,059	56	.4	12,021	62	.4	15,274	69	.4	18,973	79	.4	23,139	88	.4	27,804	98	.4	32,969	108	.4	38,611	117
.5	4,318	38	.5	6,482	49	.5	9,115	56	.5	12,083	62	.5	15,343	70	.5	19,052	79	.5	23,227	89	.5	27,902	99	.5	33,077	109	.5	38,728	118
.6	4,356	38	.6	6,531	49	.6	9,171	57	.6	12,145	62	.6	15,413	70	.6	19,131	79	.6	23,316	89	.6	28,001	99	.6	33,186	109	.6	38,846	118
.7	4,394	39	.7	6,580	49	.7	9,228	57	.7	12,207	62	.7	15,483	70	.7	19,210	79	.7	23,405	89	.7	28,100	99	.7	33,295	109	.7	38,964	118
.8	4,433	39	.8	6,629	49	.8	9,285	57	.8	12,269	62	.8	15,553	70	.8</														

TABLE NO. 10  
CAPACITY OF DORENA RESERVOIR  
IN ACRE-FEET

El. in ft.	Capacity	Diff.	El. in ft.	Capacity	Diff.	El. in ft.	Capacity	Diff.	El. in ft.	Capacity	Diff.	El. in ft.	Capacity	Diff.	El. in ft.	Capacity	Diff.	El. in ft.	Capacity	Diff.	El. in ft.	Capacity	Diff.						
810.0	39,318	119	815.0	45,499	129	820.0	52,306	144	825.0	59,909	160	830.0	68,317	177	835.0	77,522	191	840.0	87,297	201	845.0	97,572	211	850.0	108,307	219	855.0	119,441	227
.1	39,437	119	.1	45,628	130	.1	52,430	144	.1	60,069	160	.1	68,494	177	.1	77,713	191	.1	87,498	201	.1	97,783	211	.1	108,526	219	.1	119,668	227
.2	39,556	119	.2	45,758	130	.2	52,554	145	.2	60,229	161	.2	68,671	177	.2	77,904	191	.2	87,699	201	.2	97,994	211	.2	108,745	219	.2	119,895	227
.3	39,675	119	.3	45,888	130	.3	52,730	145	.3	60,390	161	.3	68,848	178	.3	78,095	191	.3	87,900	201	.3	98,205	211	.3	108,964	219	.3	120,122	227
.4	39,794	119	.4	46,018	130	.4	52,884	145	.4	60,551	161	.4	69,026	178	.4	78,286	191	.4	88,101	201	.4	98,416	211	.4	109,183	219	.4	120,369	227
.5	39,913	119	.5	46,148	131	.5	53,029	145	.5	60,712	161	.5	69,204	178	.5	78,477	191	.5	88,302	201	.5	98,627	211	.5	109,402	219	.5	120,577	228
.6	40,033	120	.6	46,278	131	.6	53,175	146	.6	60,874	162	.6	69,382	178	.6	78,669	192	.6	88,504	202	.6	98,839	212	.6	109,621	219	.6	120,805	228
.7	40,153	120	.7	46,410	131	.7	53,321	146	.7	61,036	162	.7	69,501	179	.7	78,861	192	.7	88,706	202	.7	99,051	212	.7	109,841	220	.7	121,033	228
.8	40,273	120	.8	46,541	131	.8	53,467	147	.8	61,198	163	.8	69,740	179	.8	79,053	192	.8	88,908	202	.8	99,253	212	.8	110,061	220	.8	121,261	228
.9	40,393	120	.9	46,672	131	.9	53,614	147	.9	61,361	163	.9	69,919	180	.9	79,245	192	.9	89,110	202	.9	99,475	212	.9	110,281	220	.9	121,489	228
811.0	40,513	120	816.0	46,804	132	821.0	53,761	147	826.0	61,524	163	831.0	70,099	180	836.0	79,437	193	841.0	89,312	202	846.0	99,687	212	851.0	110,501	220	856.0	121,717	228
.1	40,634	121	.1	46,936	132	.1	53,908	147	.1	61,687	163	.1	70,279	180	.1	79,637	193	.1	89,515	203	.1	99,899	212	.1	110,721	220	.1	121,946	229
.2	40,755	121	.2	47,068	132	.2	54,056	148	.2	61,851	164	.2	70,459	181	.2	79,823	193	.2	89,718	203	.2	100,112	213	.2	110,944	221	.2	122,175	229
.3	40,876	121	.3	47,200	133	.3	54,204	148	.3	62,015	164	.3	70,640	181	.3	80,016	193	.3	90,329	203	.3	100,329	213	.3	111,162	221	.3	122,404	229
.4	40,997	121	.4	47,333	133	.4	54,352	149	.4	62,179	165	.4	70,821	181	.4	80,209	193	.4	90,538	203	.4	100,538	213	.4	111,383	221	.4	122,633	229
.5	41,118	122	.5	47,466	133	.5	54,501	149	.5	62,344	165	.5	71,002	182	.5	80,402	194	.5	90,824	203	.5	100,751	213	.5	111,604	221	.5	122,862	229
.6	41,240	122	.6	47,599	133	.6	54,650	149	.6	62,509	165	.6	71,184	182	.6	80,596	194	.6	90,531	204	.6	100,964	213	.6	111,825	221	.6	123,091	229
.7	41,362	122	.7	47,732	133	.7	54,799	150	.7	62,674	166	.7	71,366	182	.7	80,790	194	.7	90,735	204	.7	101,177	214	.7	112,046	221	.7	123,321	230
.8	41,484	122	.8	47,866	134	.8	54,949	150	.8	62,840	166	.8	71,548	183	.8	80,984	194	.8	90,939	204	.8	101,391	214	.8	112,267	222	.8	123,551	230
.9	41,606	122	.9	48,000	134	.9	55,099	150	.9	63,006	166	.9	71,731	183	.9	81,178	194	.9	91,143	204	.9	101,605	214	.9	112,489	222	.9	123,781	230
812.0	41,728	123	817.0	48,134	135	822.0	55,249	151	827.0	63,172	167	832.0	71,914	183	837.0	81,372	195	842.0	91,347	205	847.0	101,819	214	852.0	112,711	222	857.0	124,011	230
.1	41,851	123	.1	48,269	135	.1	55,400	151	.1	63,339	167	.1	72,097	183	.1	81,567	195	.1	91,552	205	.1	102,033	214	.1	112,933	222	.1	124,241	230
.2	41,974	123	.2	48,404	135	.2	55,551	151	.2	63,506	167	.2	72,280	184	.2	81,762	195	.2	91,757	205	.2	102,247	214	.2	113,155	222	.2	124,471	230
.3	42,097	123	.3	48,539	136	.3	55,702	152	.3	63,673	168	.3	72,464	184	.3	81,957	195	.3	91,962	205	.3	102,461	215	.3	113,377	222	.3	124,702	231
.4	42,220	123	.4	48,675	136	.4	55,854	152	.4	63,841	168	.4	72,648	184	.4	82,152	195	.4	92,167	205	.4	102,676	215	.4	113,599	223	.4	124,933	231
.5	42,343	124	.5	48,811	136	.5	56,006	152	.5	64,009	168	.5	72,832	185	.5	82,347	196	.5	92,372	206	.5	102,891	215	.5	113,822	223	.5	125,164	231
.6	42,467	124	.6	48,947	136	.6	56,158	153	.6	64,177	169	.6	73,017	185	.6	82,543	196	.6	92,578	206	.6	103,106	215	.6	114,045	223	.6	125,395	231
.7	42,591	124	.7	49,083	137	.7	56,311	153	.7	64,346	169	.7	73,202	185	.7	82,739	196	.7	92,784	206	.7	103,321	215	.7	114,268	223	.7	125,626	231
.8	42,715	124	.8	49,220	137	.8	56,464	153	.8	64,515	169	.8	73,387	185	.8	82,935	196	.8	92,990	206	.8	103,536	215	.8	114,491	223	.8	125,858	232
.9	42,839	124	.9	49,357	137	.9	56,617	153	.9	64,684	169	.9	73,572	185	.9	83,131	196	.9	93,196	206	.9	103,751	215	.9	114,714	223	.9	126,090	232
813.0	42,963	124	818.0	49,494	137	823.0	56,771	154	828.0	64,854	170	833.0	73,758	186	838.0	83,327	196	843.0	93,402	206	848.0	103,966	216	853.0	114,937	223	858.0	126,322	232
.1	43,088	125	.1	49,632	138	.1	56,925	154	.1	65,024	170	.1	73,944	186	.1	83,524	197	.1	93,609	207	.1	104,182	216	.1	115,161	224	.1	126,554	232
.2	43,213	125	.2	49,770	138	.2	57,079	155	.2	65,194	171	.2	74,130	186	.2	83,721	197	.2	93,816	207	.2	104,398	216	.2	115,385	224	.2	126,786	232
.3	43,338	125	.3	49,908	139	.3	57,234	155	.3	65,365	171	.3	74,316	186	.3	83,918	197	.3	94,023	207	.3	104,614	216	.3	115,609	224	.3	127,018	232
.4	43,463	125	.4	50,047	139	.4	57,389	155	.4	65,536	171	.4	74,503	187	.4	84,115	197	.4	94,230	207	.4	104,830	216	.4	115,833	224	.4	127,251	232
.5	43,588	126	.5	50,186	139	.5	57,544	155	.5	65,707	172	.5	74,690	187	.5	84,312	197	.5	94,437	207	.5	105,046	216	.5	116,057	224	.5	127,484	233
.6	43,714	126	.6	50,325	139	.6	57,699	156	.6	65,879	172	.6	74,877	187	.6	84,510	198	.6	94,645	208	.6	105,262	216	.6	116,281	225	.6	127,717	233
.7	43,840	126	.7	50,464	140	.7	57,854	156	.7	66,051	172	.7	75,064	188	.7	84,708	198	.7	94,853	208	.7	105,479	217	.7	116,506	225	.7	127,950	233
.8	43,966	126	.8	50,604	140	.8	58,011	156	.8	66,223	173	.8	75,252	188	.8	84,906	198	.8	95,061	208	.8	105,696	217	.8	116,731	225	.8	128,183	233
.9	44,092	127	.9	50,744	140	.9	58,167	157	.9	66,396	173	.9	75,440	188	.9	85,104	198	.9	95,269	208	.9	105,913	217	.9	116,956	225	.9	128,417	234
814.0	44,219	127	819.0	50,884	141	824.0	58,324	157	829.0	66,569	173	834.0	75,628	188	839.0	85,302	199	844.0	95,477	209	849.0	106,130	217	854.0	117,181	225	859.0	128,651	234
.1	44,346	127	.1	51,025	141	.1	58,481	157	.1	66,742	174	.1	75,816	189	.1	85,501	199	.1	95,686	209	.1	106,347	217	.1	117,406	225	.1	128,885	234
.2	44,473	127	.2	51,166	141	.2	58,638	158	.2	66,914	174	.2	76,005	189	.2	85,700	199	.2	95,893	209	.2	106,564	217	.2	117,631	226	.2	129,119	234
.3	44,600	128	.3	51,307	142	.3	58,796	158	.3	67,090	174	.3	76,194	189	.3	85,899	199	.3	96,104	209	.3	106,781	218	.3	117,857	226	.3	129,353	234
.4	44,728	128	.4	51,449	142	.4	58,954	158	.4	67,264	175	.4	76,383	189	.4	86,098	199	.4	96,313	209	.4	106,999	218	.4	118,083	226	.4	129,587	234
.5	44,856	128	.5	51,591	142	.5	59,111	159	.5	67,439	175	.5	76,572	189	.5	86,297	199	.5	96,522	209	.5	107,217	218	.5	118,309	226	.5	129,822	

Table 11a. Dorena Reservoir Seasonal Filling Schedule

Date	February		March		April		May	
	Elev.	Storage	Elev.	Storage	Elev.	Storage	Elev.	Storage
31-Jan	770.50	7,094						
1	770.50	7,094	795.17	23,935	812.62	42,581	825.35	60,626
2	771.63	7,695	795.83	24,537	813.10	43,183	825.72	61,227
3	772.75	8,297	796.49	25,138	813.58	43,784	826.09	61,829
4	773.84	8,898	797.14	25,740	814.05	44,386	826.46	62,430
5	774.91	9,500	797.78	26,341	814.51	44,987	826.82	63,032
6	775.96	10,101	798.41	26,943	814.98	45,589	827.18	63,633
7	776.99	10,703	799.03	27,544	815.43	46,190	827.54	64,235
8	778.00	11,304	799.65	28,146	815.89	46,792	827.90	64,836
9	778.99	11,906	800.25	28,747	816.34	47,393	828.25	65,438
10	779.96	12,507	800.85	29,349	816.78	47,995	828.60	66,039
11	780.91	13,109	801.44	29,950	817.23	48,596	828.95	66,641
12	781.84	13,710	802.03	30,552	817.66	49,198	829.30	67,242
13	782.75	14,312	802.61	31,153	818.10	49,799	829.64	67,844
14	783.64	14,913	803.18	31,755	818.53	50,401	829.98	68,445
15	784.51	15,515	803.75	32,356	818.96	51,002	830.32	69,047
16	785.37	16,116	804.31	32,958	819.39	51,604	830.66	69,648
17	786.21	16,718	804.87	33,559	819.81	52,205	831.00	70,250
18	787.03	17,319	805.42	34,161	820.23	52,807	831.33	70,851
19	787.83	17,921	805.96	34,762	820.64	53,408	831.66	71,453
20	788.63	18,522	806.51	35,364	821.05	54,010	832.00	72,054
21	789.40	19,124	807.04	35,965	821.46	54,611		
22	790.17	19,725	807.57	36,567	821.86	55,213		
23	790.92	20,327	808.10	37,168	822.26	55,814		
24	791.66	20,928	808.62	37,770	822.66	56,415		
25	792.38	21,530	809.14	38,371	823.05	57,017		
26	793.10	22,131	809.65	38,973	823.44	57,618		
27	793.80	22,733	810.16	39,574	823.83	58,220		
28	794.49	23,334	810.66	40,175	824.21	58,821		
29			811.16	40,777	824.60	59,423		
30			811.65	41,378	824.97	60,024		
31			812.14	41,980				

Notes:

1. Pool elevation and corresponding storage applicable to 0000 (12:00 a.m.) observation.
2. In leap years reservoir will be one day ahead of above schedule after 28 February.
3. For 01 Feb through 19 May, filling rate = 601 acre-feet/day = 303 cfs/day.
4. For the 2016 revision, the time of storage applicable is changed from 0730 to 0000.

Table 11b. Dorena Reservoir Seasonal Evacuation Schedule

Date	September		October		November		December	
	Elev.	Storage	Elev.	Storage	Elev.	Storage	Elev.	Storage
31-Aug	832.00	72,054						
1	832.00	72,054	810.60	40,106	770.50	7,094		
2	831.41	70,989	809.71	39,042				
3	830.81	69,924	808.80	37,977				
4	830.21	68,859	807.87	36,912				
5	829.61	67,794	806.94	35,847				
6	829.00	66,729	805.98	34,782				
7	828.38	65,664	805.01	33,717				
8	827.76	64,600	804.03	32,652				
9	827.12	63,535	803.02	31,587				
10	826.48	62,470	802.00	30,522				
11	825.83	61,405	800.96	29,457				
12	825.17	60,340	799.90	28,392				
13	824.50	59,275	798.81	27,327				
14	823.82	58,210	797.70	26,263				
15	823.14	57,145	796.56	25,198				
16	822.44	56,080	795.39	24,133				
17	821.73	55,015	794.18	23,068				
18	821.01	53,950	792.95	22,003				
19	820.28	52,885	791.67	20,938				
20	819.54	51,821	790.36	19,873				
21	818.78	50,756	789.00	18,808				
22	818.02	49,691	787.60	17,743				
23	817.25	48,626	786.15	16,678				
24	816.46	47,561	784.66	15,613				
25	815.66	46,496	783.11	14,548				
26	814.85	45,431	781.49	13,484				
27	814.03	44,366	779.82	12,419				
28	813.20	43,301	778.08	11,354				
29	812.35	42,236	776.29	10,289				
30	811.48	41,171	774.43	9,224				
31			772.50	8,159				

Notes:

1. Pool elevation and corresponding storage applicable to 0000 (12:00 a.m.) observation.
2. For 01 Sep through 31 Oct, evacuation rate = 1,065 acre-feet/day = 537 cfs/day.
3. For the 2016 revision, the time of storage applicable is changed from 0730 to 0000.

TABLE 12  
Dorena Reservoir  
Flood control regulation schedule  
Prescribed reservoir release in second-feet

Uncon- trolled inflow	Precipitation index																					Uncon- trolled inflow		
	0	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
0	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,750	4,400	4,010	3,670	3,280	2,900	2,500	2,080	1,650	1,200	800	640	330	0
200	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,720	4,380	3,990	3,650	3,270	2,870	2,450	2,020	1,570	1,120	720	620	210	200
400	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,690	4,350	3,970	3,640	3,260	2,860	2,440	2,010	1,560	1,110	710	600	300	100
600	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,660	4,320	3,950	3,620	3,240	2,840	2,420	1,990	1,540	1,090	690	580	280	100
800	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,630	4,290	3,930	3,600	3,220	2,820	2,400	1,970	1,520	1,070	670	560	270	100
1,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,600	4,260	3,910	3,580	3,200	2,800	2,380	1,950	1,500	1,050	650	540	250	1,000
1,200	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,570	4,230	3,880	3,550	3,170	2,770	2,350	1,920	1,470	1,020	630	520	240	1,000
1,400	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,540	4,200	3,850	3,520	3,140	2,740	2,320	1,890	1,440	990	610	500	230	1,000
1,600	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,510	4,170	3,820	3,490	3,110	2,710	2,290	1,860	1,410	970	590	480	220	1,000
1,800	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,470	4,130	3,790	3,460	3,080	2,680	2,260	1,830	1,380	950	570	460	210	1,000
2,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,440	4,100	3,760	3,430	3,050	2,650	2,230	1,800	1,350	930	550	440	200	1,000
2,200	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,400	4,060	3,730	3,400	3,020	2,620	2,200	1,770	1,320	910	530	420	190	1,000
2,400	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,360	4,020	3,700	3,370	2,990	2,590	2,170	1,740	1,290	890	510	400	180	1,000
2,600	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,320	3,980	3,670	3,340	2,960	2,560	2,140	1,710	1,260	870	490	380	170	1,000
2,800	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,280	3,940	3,640	3,310	2,930	2,530	2,110	1,680	1,230	850	470	360	160	1,000
3,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,240	3,900	3,610	3,280	2,900	2,500	2,080	1,650	1,200	830	450	340	150	1,000
3,200	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,200	3,860	3,570	3,240	2,860	2,460	2,040	1,620	1,170	810	430	320	140	1,000
3,400	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,160	3,820	3,540	3,210	2,830	2,430	2,010	1,590	1,140	790	410	300	130	1,000
3,600	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,120	3,780	3,510	3,180	2,800	2,400	1,980	1,560	1,110	770	390	280	120	1,000
3,800	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,080	3,740	3,470	3,140	2,760	2,360	1,940	1,530	1,080	750	370	260	110	1,000
4,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,040	3,700	3,430	3,100	2,720	2,320	1,900	1,500	1,050	730	350	240	100	1,000
4,200	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	4,000	3,660	3,390	3,060	2,680	2,280	1,860	1,470	1,020	710	330	220	90	1,000
4,400	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,960	3,620	3,350	3,020	2,640	2,240	1,820	1,440	990	690	310	200	80	1,000
4,600	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,920	3,580	3,310	2,980	2,600	2,200	1,780	1,410	970	670	290	180	70	1,000
4,800	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,880	3,540	3,270	2,940	2,560	2,160	1,740	1,380	950	650	270	160	60	1,000
5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,840	3,500	3,230	2,900	2,520	2,120	1,710	1,350	930	630	250	140	50	1,000
5,200	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,800	3,460	3,190	2,860	2,480	2,080	1,680	1,320	910	610	230	120	40	1,000
5,400	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,760	3,420	3,150	2,820	2,440	2,040	1,650	1,290	890	590	210	100	30	1,000
5,600	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,720	3,380	3,110	2,780	2,400	2,000	1,620	1,260	870	570	190	80	20	1,000
5,800	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,680	3,340	3,070	2,740	2,360	1,960	1,590	1,230	850	550	170	60	10	1,000
6,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,640	3,300	3,030	2,700	2,320	1,920	1,560	1,200	830	530	150	40	0	1,000
6,200	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,600	3,260	2,990	2,660	2,280	1,880	1,530	1,170	810	510	130	20	0	1,000
6,400	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,560	3,220	2,950	2,620	2,240	1,840	1,500	1,140	790	490	110	0	0	1,000
6,600	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,520	3,180	2,910	2,580	2,200	1,800	1,470	1,110	770	470	90	0	0	1,000
6,800	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,480	3,140	2,870	2,540	2,160	1,760	1,440	1,080	750	450	70	0	0	1,000
7,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,440	3,100	2,830	2,500	2,120	1,720	1,410	1,050	730	430	50	0	0	1,000
7,200	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,400	3,060	2,790	2,460	2,080	1,680	1,380	1,020	710	410	30	0	0	1,000
7,400	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,360	3,020	2,750	2,420	2,040	1,640	1,350	990	690	290	10	0	0	1,000
7,600	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,320	2,980	2,710	2,380	2,000	1,600	1,320	970	670	270	0	0	0	1,000
7,800	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,280	2,940	2,670	2,340	1,960	1,560	1,290	950	650	250	0	0	0	1,000
8,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,240	2,900	2,630	2,300	1,920	1,520	1,260	930	630	230	0	0	0	1,000
8,200	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,200	2,860	2,590	2,260	1,880	1,480	1,230	910	610	210	0	0	0	1,000
8,400	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,160	2,820	2,550	2,220	1,840	1,440	1,200	890	590	190	0	0	0	1,000
8,600	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,120	2,780	2,510	2,180	1,800	1,400	1,170	870	570	170	0	0	0	1,000
8,800	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,080	2,740	2,470	2,140	1,760	1,360	1,140	850	550	150	0	0	0	1,000
9,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,040	2,700	2,430	2,100	1,720	1,320	1,110	830	530	130	0	0	0	1,000
9,200	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	3,000	2,660	2,390	2,060	1,680	1,280	1,080	810	510	110	0	0	0	1,000
9,400	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	2,960	2,620	2,350	2,020	1,640	1,240	1,050	790	490	90	0	0	0	1,000
9,600	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	2,920	2,580	2,310	1,980	1,600	1,200	1,020	770	470	7				

**TABLE 13**  
 UNITED STATES  
 DEPARTMENT OF THE INTERIOR  
**GEOLOGICAL SURVEY**  
 WATER RESOURCES DIVISION

File No. Washington  
Field 5215

Rating table for Row River above Pitcher Creek near Darana, Oreg  
 from Jan 19, 1953 to 19

Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs
3.00			3.00	195	23	5.00	4,080	70	7.00	3,200	130	9.00	6,170	190
			3.10	218	25		4,150		7.10	3,130	130	9.10	6,360	
			3.20	243	27		4,220	70	7.20	3,260	140	9.20	6,520	190
			3.30	270	30		4,290	80	7.30	3,400		9.30	6,740	210
			3.40	300			4,370		7.40	3,540	140	9.40	6,950	
	17	5.5	3.50	330	30		4,450		7.50	3,680	150	9.50	7,160	210
	22.5	6.0	3.60	360	35		4,530	80	7.60	3,830		9.60	7,370	230
	28.5	6.5	3.70	395	40		4,610	90	7.70	3,980	150	9.70	7,600	
	35	8	3.80	435	40		4,700		7.80	4,130	160	9.80	7,830	230
	42	9	3.90	475	45		4,790	90	7.90	4,290		9.90	8,060	240
2.00	52	9	4.00	520	50	6.00	4,880	100	8.00	4,450		10.00	8,300	2400
	61	10	4.10	570			4,980		8.10	4,610	160	10.10	10,700	2800
	71	12	4.20	620			5,080	100	8.20	4,770	170	10.20	13,500	3300
	82	13	4.30	670	50		5,180	110	8.30	4,940		10.30	16,800	3800
	96	14	4.40	720	60		5,290		8.40	5,110		10.40	20,600	4300
	110	15	4.50	780			5,400	110	8.50	5,280	170	10.50	24,900	
	125	15	4.60	840			5,510	120	8.60	5,450	180			
	140	16	4.70	900			5,630		8.70	5,630				
	156	18	4.80	960			5,750	120	8.80	5,810				
	174	21	4.90	1,020	60		5,870	130	8.90	5,990	180			

The above table is not applicable for ice or obstructed channel conditions. It is based on 9 discharge measurements made during 1952-53 (147-152) 1953-54 (153-155) and is the same as previous table above 4.5 ft.

and is well defined between 30 cfs and 10,000 cfs.

Computed by JMA

Checked by LWD

Date 8-2-54

# Table 14

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
GEOLOGICAL SURVEY  
WATER RESOURCES DIVISION

9-210  
(Sept. 1952)

File No. Washington  
Field 5218

Rating table for Raw River near Cottage Grove, 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	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs	Feet	Cfs	Cfs
6.00			3.00	530	50	5.00	1,800	80	7.00	3,600	100	9.00	6,000	
.10			.10	580	50	.10	1,880		.10	3,700	100	.10		
.20			.20	630	55	.20	1,960		.20	3,800	110	.20		
.30			.30	685		.30	2,040		.30	3,910		.30		
.40	25	8.5	.40	740		.40	2,120	80	.40	4,020		.40		
.50	33.5	11.5	.50	795	55	.50	2,200	90	.50	4,130		.50		
.60	45	15	.60	850	60	.60	2,290		.60	4,240		.60		
.70	60	20	.70	910		.70	2,380		.70	4,350	110	.70		
.80	80	25	.80	970		.80	2,470		.80	4,460	120	.80		
.90	105	30	.90	1,030		.90	2,560		.90	4,580		.90		
2.00	135		4.00	1,090	60	6.00	2,650		8.00	4,700		10.00		
.10	165	30	.10	1,150	70	.10	2,740		.10	4,820		.10		
.20	195	35	.20	1,220		.20	2,830		.20	4,940	20	.20		
.30	230		.30	1,290		.30	2,920		.30	5,060	130	.30		
.40	265	35	.40	1,360		.40	3,010	90	.40	5,190		.40		
.50	300	40	.50	1,430		.50	3,100	100	.50	5,320		.50		
.60	340	45	.60	1,500		.60	3,200		.60	5,450	30	.60		
.70	385	45	.70	1,570	70	.70	3,300		.70	5,580	140	.70		
.80	430	50	.80	1,640	80	.80	3,400		.80	5,720		.80		
.90	480	50	.90	1,720	80	.90	3,500	100	.90	5,860	140	.90		

The above table is not applicable for ice or obstructed channel conditions. It is based on 27 discharge measurements made during 113-139 made Aug 7, 1951 to Mar. 29, 1954

and is          well defined between 18 cfs and 5,000 cfs and is same as table 10-17-51 above 4 ft.

Computed by JMA  
Checked by RTM  
Date 4-27-54

TABLE 15

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
GEOLOGICAL SURVEY  
WATER RESOURCES DIVISION

9-210

File No. { Washington  
Field 525

Rating table for Coast Fork Willamette River near Goshen, Oreg.  
from Oct 1 1950, to 19

Gage height	Discharge	Differ- ence	Gage height	Discharge	Differ- ence	Gage height	Discharge	Differ- ence	Gage height	Discharge	Differ- ence	Gage height	Discharge	Differ- ence
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	1,310	80	6.00	3,150	110	8.00	5,750	150	10.00	9,110	190
.10	100	30	.10	1,390		.10	3,260		.10	5,900		.10	9,300	200
.20	130	35	.20	1,470		.20	3,370	110	.20	6,050		.20	9,500	
.30	165	35	.30	1,550	80	.30	3,480	120	.30	6,200		.30	9,700	
.40	200	40	.40	1,630	90	.40	3,600		.40	6,350	150	.40	9,900	
.50	240	50	.50	1,720		.50	3,720	120	.50	6,500	160	.50	10,100	
.60	290	55	.60	1,810		.60	3,840	130	.60	6,660		.60	10,300	
.70	345	60	.70	1,900		.70	3,970		.70	6,820		.70	10,500	
.80	405	70	.80	1,990		.80	4,100		.80	6,980		.80	10,700	
.90	475		.90	2,080		.90	4,230		.90	7,140	160	.90	10,900	200
3.00	545		5.00	2,170		7.00	4,360		9.00	7,300	170	11.00	11,100	220
.10	615		.10	2,260	90	.10	4,490		.10	7,470		.10	11,320	
.20	685	70	.20	2,350	100	.20	4,620		.20	7,640	170	.20	11,540	
.30	755	75	.30	2,450		.30	4,750	130	.30	7,810	180	.30	11,760	
.40	830	80	.40	2,550		.40	4,880	140	.40	7,990		.40	11,980	
.50	910		.50	2,650		.50	5,020		.50	8,170	180	.50	12,200	
.60	990		.60	2,750		.60	5,160	140	.60	8,350	190	.60	12,420	
.70	1,070		.70	2,850		.70	5,300	150	.70	8,540		.70	12,640	
.80	1,150		.80	2,950		.80	5,450		.80	8,730		.80	12,860	
.90	1,230	80	.90	3,050	100	.90	5,600	150	.90	8,920	190	12.00	13,080	220

The above table is not applicable for ice or obstructed channel conditions. It is based on 20 discharge measurements made during 1950-51 (2-11), 1951-52 (12-21)

and is well defined between 150 second-feet and 24,000 second-feet.

Computed by D.L.M.

Checked by J.A.H.

Date 7-10-52

Leaf 2

March, 1915

**TABLE 15**  
 UNITED STATES  
 DEPARTMENT OF THE INTERIOR  
**GEOLOGICAL SURVEY**  
 WATER RESOURCES DIVISION

File No. Washington.....  
Field 525

Rating table for Coast Fork Willamette River near Goshen, Oreg  
 from Oct. 1, 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.
12.00	13,300	220	14.00	18,200	280	16.00	24,000		.00			.00		
.10	13,520		.10	18,480		.10			.10			.10		
.20	13,740		.20	18,760		.20			.20			.20		
.30	13,960		.30	19,040		.30			.30			.30		
.40	14,180	220	.40	19,320		.40			.40			.40		
.50	14,400	240	.50	19,600		.50			.50			.50		
.60	14,640		.60	19,880		.60			.60			.60		
.70	14,880		.70	20,160		.70			.70			.70		
.80	15,120		.80	20,440		.80			.80			.80		
.90	15,360	240	.90	20,720	280	.90			.90			.90		
13.00	15,600	260	15.00	21,000	300	.00			.00			.00		
.10	15,860		.10	21,300		.10			.10			.10		
.20	16,120		.20	21,600		.20			.20			.20		
.30	16,380		.30	21,900		.30			.30			.30		
.40	16,640		.40	22,200		.40			.40			.40		
.50	16,900		.50	22,500		.50			.50			.50		
.60	17,160		.60	22,800		.60			.60			.60		
.70	17,420		.70	23,100		.70			.70			.70		
.80	17,680		.80	23,400		.80			.80			.80		
.90	17,940	260	.90	23,700	300	.90			.90			.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 P.L.M.

Checked by J.A.H.

Date 7-10-52

2 of 2

March, 1915

**TABLE 16**  
**Corps of Engineers, U. S. Army**  
**Portland, Oregon District**

Sheet No 1 of 2

Rating table for Willamette River at Eugene, Oregon

from January 19 54 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.
-3.00	1190	100	-1.00	4730	230	1.00	10,170	320	3.00	17,730	410	5.00	24,420	500
.00	1290	110	.00	4820	240	1.00	10,400	350	10.00	18,140	420	10.00	27,000	520
.10	1300	120	.20	4900	240	2.00	10,820	330	20.00	21,580	420	20.00	29,400	520
.20	1320	130	.30	4940	240	3.00	11,150	340	30.00	22,280	420	30.00	30,240	520
.30	1350	140	.40	5020	250	4.00	11,490	350	40.00	23,070	420	40.00	31,150	520
.40	1370	150	.50	5080	250	5.00	11,830	340	50.00	23,770	420	50.00	32,100	530
.50	1390	160	.60	5140	250	6.00	12,200	370	60.00	24,500	420	60.00	33,000	530
.60	1410	170	.70	5200	240	7.00	12,600	360	70.00	25,280	410	70.00	34,100	530
.70	1430	180	.80	5260	230	8.00	13,040	340	80.00	26,100	410	80.00	35,200	520
.80	1450	190	.90	5320	230	9.00	13,500	310	90.00	26,950	410	90.00	36,400	520
-2.00	2180	120	0.00	5380	210	2.00	13,980	420	4.00	27,820	420	6.00	37,700	540
.90	2190	130	1.00	5440	210	10.00	14,480	420	10.00	28,720	420	10.00	38,700	540
1.00	2210	140	2.00	5500	210	20.00	15,000	420	20.00	29,680	420	20.00	39,800	540
1.10	2230	150	3.00	5560	210	30.00	15,540	420	30.00	30,680	420	30.00	41,000	540
1.20	2250	160	4.00	5620	210	40.00	16,100	420	40.00	31,720	420	40.00	42,300	540
1.30	2270	170	5.00	5680	300	50.00	16,680	420	50.00	32,800	420	50.00	43,700	540
1.40	2290	180	6.00	5740	300	60.00	17,280	420	60.00	33,920	420	60.00	45,200	540
1.50	2310	190	7.00	5800	310	70.00	17,900	420	70.00	35,080	420	70.00	46,800	540
1.60	2330	200	8.00	5860	310	80.00	18,540	420	80.00	36,280	420	80.00	48,500	540
1.70	2350	210	9.00	5920	310	90.00	19,200	420	90.00	37,520	420	90.00	50,300	540
1.80	2370	220	10.00	5980	320	1.00	19,880	420	1.00	38,800	420	1.00	52,200	540
1.90	2390	230	11.00	6040	320	2.00	20,580	420	2.00	40,120	420	2.00	54,200	540

The above table should not be used for flows under ice conditions or with channel otherwise obstructed. It is based on discharge measurements made during \_\_\_\_\_

and is well defined between \_\_\_\_\_ second feet and \_\_\_\_\_ second feet

Computed by R. S. [unclear]  
 Checked by [unclear]  
 Date 2/15/54

**TABIE 16**

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

Sheet No. 2 of 2

Rating table for Willamette River at Eugene, Oregon

from January 19 54, 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.
7 00	37,130	550	9 00	49,280	700	11 00	64,200	860	13 00	82,300	1000	15 00	102,100	1130
10	37,730	560	10	49,930	700	10			10			10		
20	38,290	560	20	50,630	710	20			20			20		
30	38,850	560	30	51,330	720	30			30			30		
40	39,410	560	40	52,110	730	40			40			40		
50	39,970	560	50	52,840	740	50			50			50		
60	40,530	560	60	53,580	750	60			60			60		
70	41,090	570	70	54,330	750	70			70			70		
80	41,660	580	80	55,080	750	80			80			80		
90	42,240	590	90	55,840	760	90		860	90		1300	90		1130
8 00	42,830	600	100	56,600	760	12 00	72,300	1000	14 00	92,300	1130	16 00	115,400	1230
10	43,430	610	10	57,360		10			10			10		
20	44,040	620	20	58,120		20			20			20		
30	44,660	630	30	58,880		30			30			30		
40	45,270	640	40	59,640		40			40			40		
50	45,890	650	50	60,400		50			50			50		
60	46,520	660	60	61,160		60			60			60		
70	47,140	670	70	61,920		70			70			70		
80	47,770	680	80	62,680		80			80			80		
90	48,400	690	90	63,440	760	90	81,800	1000	100	102,100	1130	100	122,470	1230

The above table should not be used for flows under ice conditions or with channel otherwise obstructed. It is based on discharge measurements made during \_\_\_\_\_

and is well defined between \_\_\_\_\_ second-feet and \_\_\_\_\_ second-feet

Computed by O.C.J.

Checked by H.C.L.

Date 8/5/54

NPPRF 87  
Sep53

DAILY RESERVOIR DATA

TIME 8:01 AM DATE 22 September 1953

FERN RIDGE RESERVOIR

Station	Stage Ft.	Change 24-hr.	Discharge c.f.s.	Tendency	Current Weather		Precip. 24-hr.
Noti (near)	0.80	+0.02	23	Rising	Cloudy		.03
Crow (near)	0.5	0	2.6	Steady	Cloudy		.05
Monroe	5.42	+0.33	840		Dam-site	Cloudy	.04
Reservoir	Pool elev. feet	Ten'cy	Storage Ac. Ft.	Change 24-hr.	Inflow	Release	Sum
	369.37	Falling	67,474	-1,764	38	798	.12 Av. .04

COTTAGE GROVE RESERVOIR

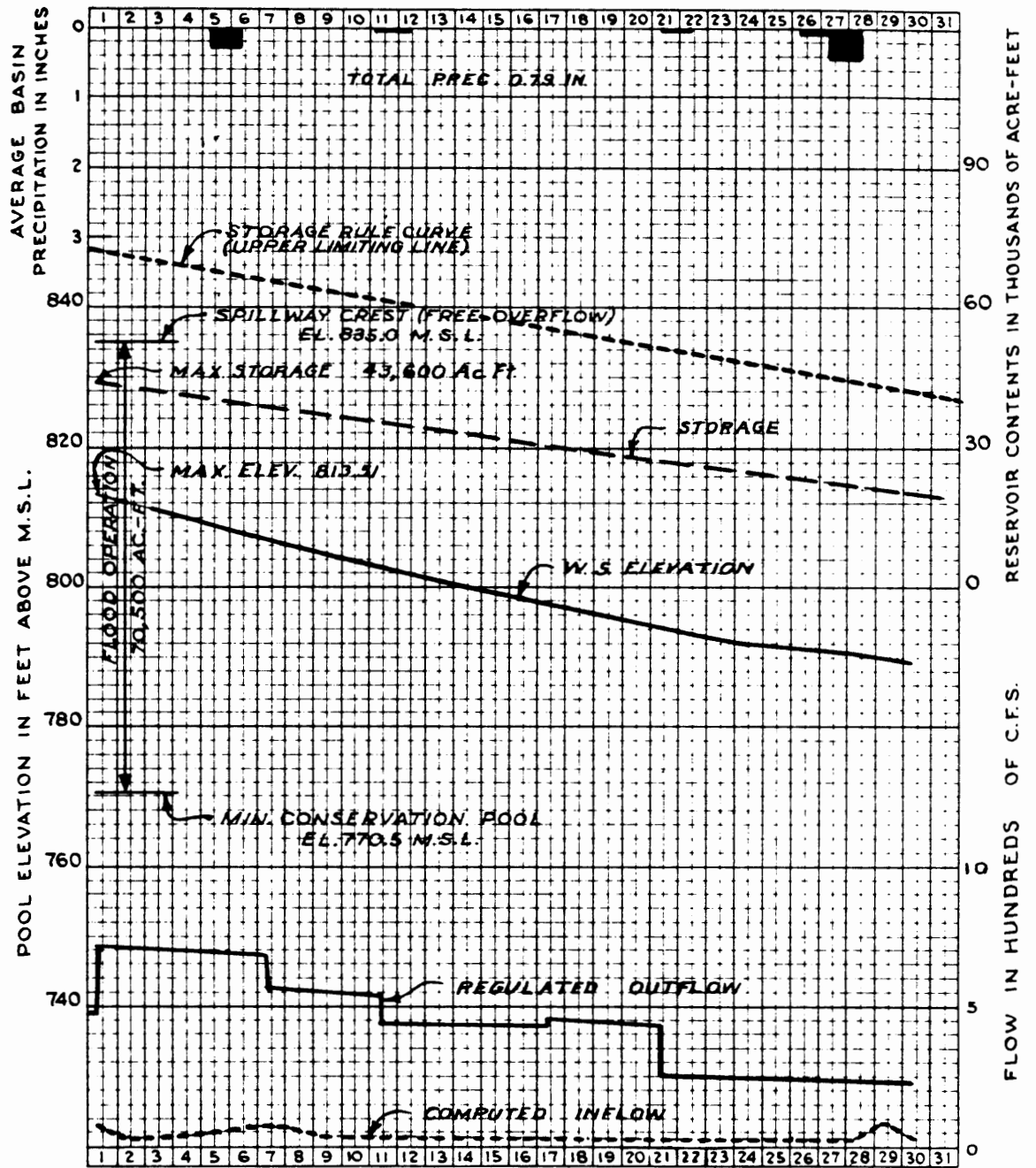
Station	Stage Ft.	Change 24-hr.	Discharge c.f.s.	Tendency	Current Weather		Precip. 24-hr.
London	1.2	0	18	Steady	Cloudy		.03
Cottage Grove (below)	3.87	+0.03	251	Steady	Dam-site	Cloudy	.01
Blackbutte					Cloudy		.03
Reservoir	Pool elev. feet	Ten'cy	Storage Ac. Ft.	Change 24-hr.	Inflow	Release	Sum
	774.16	Falling	16,265	-480	27	251	.07 Av.:02

DORENA RESERVOIR

Station	Stage Ft.	Change 24-hr.	Discharge c.f.s.	Tendency	Current Weather		Precip. 24-hr.
Row River (abv. Pitcher)	1.6	0	23	Steady	Culp Cr.	Cloudy	.02
Dorena (below)					Dam-site	Cloudy	.01
Goshen	3.0	-0.3	545				
Reservoir	Pool elev. feet	Ten'cy	Storage Ac. Ft.	Change 24-hr.	Inflow	Release	Sum
	793.87	Falling	22,674	-570	28	253	.03 Av. .02

MISCELLANEOUS STATIONS

Station	Stage Ft.	Change 24-hr.	Discharge c.f.s.	Tendency	Current Weather	Precip. -hr.
Lowell	1.30	-0.01	770			
Coburg	1.0	0	2,060			
Eugene	-2.6	0	1,400			



MONTH OF SEPT. 1953

	ELEVATION	GROSS STORAGE Ac.Ft.
Minimum Conservation Pool	770.5	7,000
Full Pool	835.0	77,500
Total Outlet Capacity at Full Pool 9,300 c.f.s.		
Maximum Planned Release 5,000 c.f.s.		

MONTHLY RESERVOIR REGULATION

DORENA RESERVOIR  
 ROW RIVER BASIN  
 D.A. 265 SQ. MILES  
 NORTH PACIFIC DIVISION  
 PORTLAND DISTRICT

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

MONTHLY LOG OF RESERVOIR REGULATION  
 DORENA DAM AND RESERVOIR

Month and Year  
 September 1953

Reports Control Symbol  
 NPPVK-8

Day	Time (7:30 a.m. unless otherwise indicated)	Pool Elevation		Reservoir Inflow						Reservoir Discharge								Authority for Action Taken, Code	Remarks		
		Stage ft. m.s.l.	24-Hour change	Row River at Star		Teeter Cr. nr. Dorena Dam		Rat Cr. nr. Dorena Dam		Computed Total Inflow c.f.s.	Row River nr. Dorena		Gate Opening feet							Discharge through Gates c.f.s.	Discharge over Spillway c.f.s.
				Stage feet	Discharge c.f.s.	Stage feet	Discharge c.f.s.	Stage feet	Discharge c.f.s.		Stage feet	Discharge c.f.s.	Gate 1	Gate 2	Gate 3	Gate 4	Gate 5				
1		813.51	-0.69	1.9	48					59			0.0	0.6	0.6	0.6	0.0	480			
1	9:00 am	813.45								59			0.6	0.7	0.7	0.7	0.0	714	D	Naimark-Meteorology	
2		812.46	-1.05	1.8	38					46			0.6	0.7	0.7	0.7	0.0	710			
3		811.35	-1.11	1.8	38					46			0.6	0.7	0.7	0.7	0.0	691			
4		810.24	-1.11	1.8	38					46			0.6	0.7	0.7	0.7	0.0	702			
5		809.09	-1.15	1.8	38					46			0.6	0.7	0.7	0.7	0.0	692			
6		807.97	-1.12	1.9	48					59			0.6	0.7	0.7	0.7	0.0	694			
7		806.99	-1.18	2.0	58					71			0.6	0.7	0.7	0.7	0.0	687			
7	7:30 am	806.99								71			0.0	0.7	0.8	0.7	0.0	559	D	Naimark-Meteorology	
8		805.99	-0.90	1.9	48					59			0.0	0.7	0.8	0.7	0.0	556			
9		805.08	-0.91	1.8	38					46			0.0	0.7	0.8	0.7	0.0	550			
10		804.13	-0.95	1.8	38					46			0.0	0.7	0.8	0.7	0.0	549			
11		803.19	-0.94	1.8	38					46			0.0	0.7	0.8	0.7	0.0	543			
11	8:30 am	803.13								46			0.0	0.6	0.6	0.6	0.0	447	D	Johnson-Meteorology	
12		802.36	-0.83	1.8	38					46			0.0	0.6	0.6	0.6	0.0	444			
13		801.56	-0.80	1.7	30					36			0.0	0.6	0.6	0.6	0.0	444			
14		800.76	-0.80	1.7	30					36			0.0	0.6	0.6	0.6	0.0	441			
15		799.93	-0.83	1.7	30					36			0.0	0.6	0.6	0.6	0.0	435			
16		799.10	-0.83	1.7	30					36			0.0	0.6	0.6	0.6	0.0	432			
17		798.24	-0.86	1.7	30					36			0.0	0.6	0.6	0.6	0.0	429			
17	7:35 am	798.24								36			0.0	0.6	0.7	0.6	0.0	452	T		
18		797.32	-0.92	1.7	30					36			0.0	0.6	0.7	0.6	0.0	449			
19		796.36	-0.96	1.7	30					36			0.0	0.6	0.7	0.6	0.0	446			
20		795.42	-0.94	1.7	30					36			0.0	0.6	0.7	0.6	0.0	439			
21		794.52	-0.90	1.6	23					28			0.0	0.6	0.7	0.6	0.0	436			
21	1:15 pm	794.52								28			0.0	0.5	0.5	0.0	0.0	253	D	Naimark-Meteorology	
22		793.87	-0.65	1.6	23					28			0.0	0.5	0.6	0.0	0.0	253			
23		793.32	-0.55	1.6	23					28			0.0	0.5	0.6	0.0	0.0	252			
24		792.77	-0.55	1.6	23					28			0.0	0.5	0.6	0.0	0.0	252			
25		792.20	-0.52	1.6	23					28			0.0	0.5	0.6	0.0	0.0	252			
26		791.64	-0.56	1.6	23					28			0.0	0.5	0.6	0.0	0.0	248			
27		791.09	-0.55	1.6	23					28			0.0	0.5	0.6	0.0	0.0	248			
28		790.57	-0.52	1.7	30					37			0.0	0.5	0.6	0.0	0.0	246			
29		790.07	-0.50	2.0	58					71			0.0	0.5	0.6	0.0	0.0	244			
30		789.55	-0.42	1.8	38					46			0.0	0.5	0.6	0.0	0.0	244			

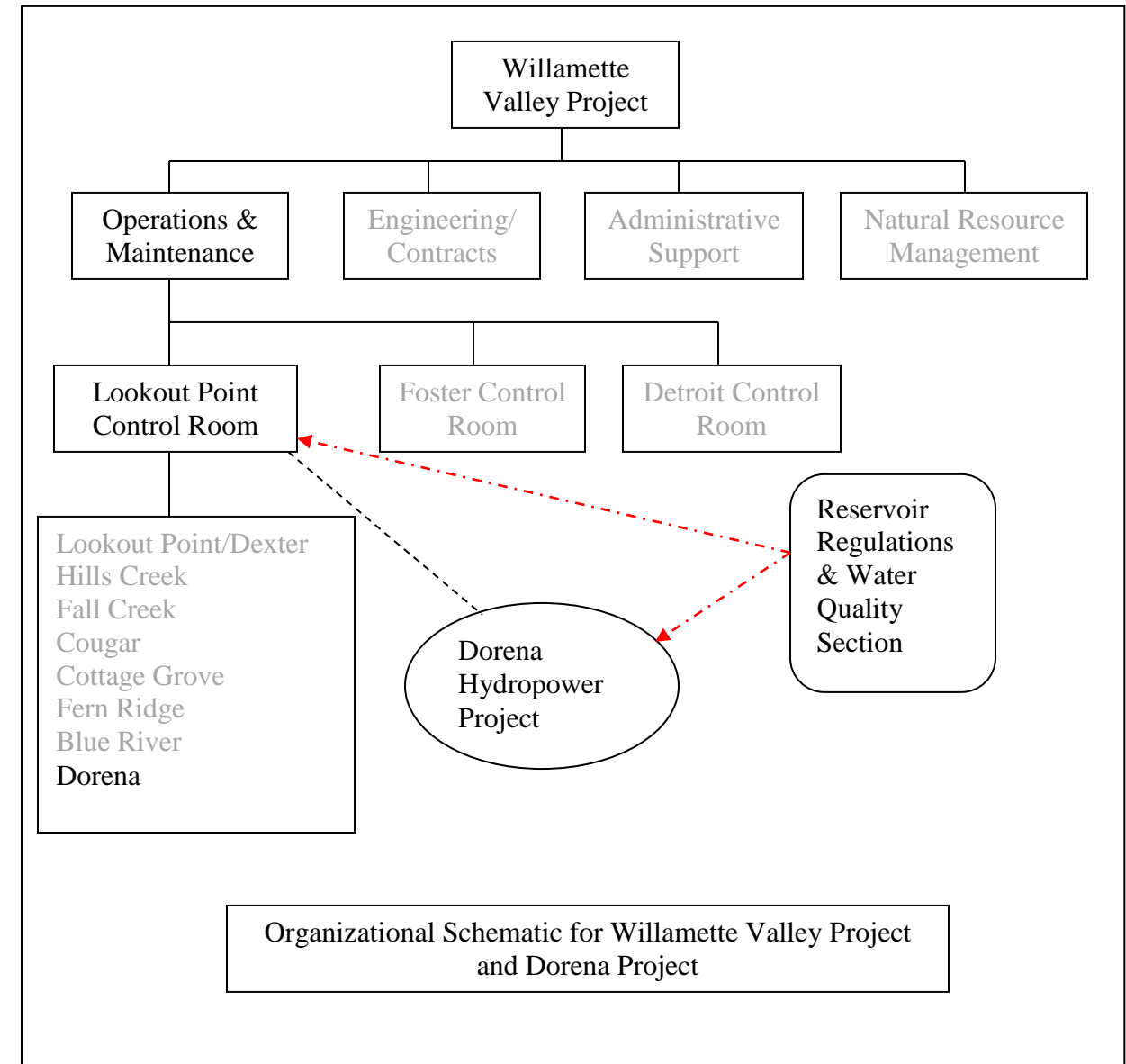
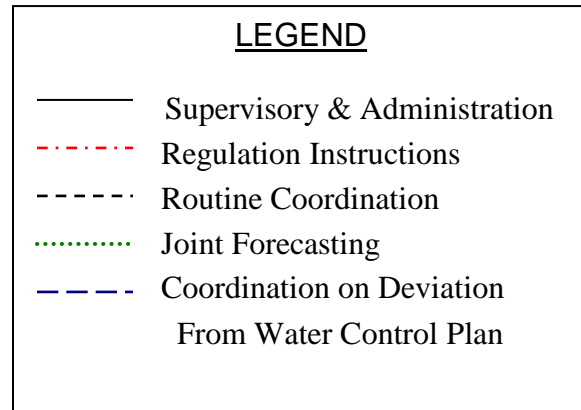
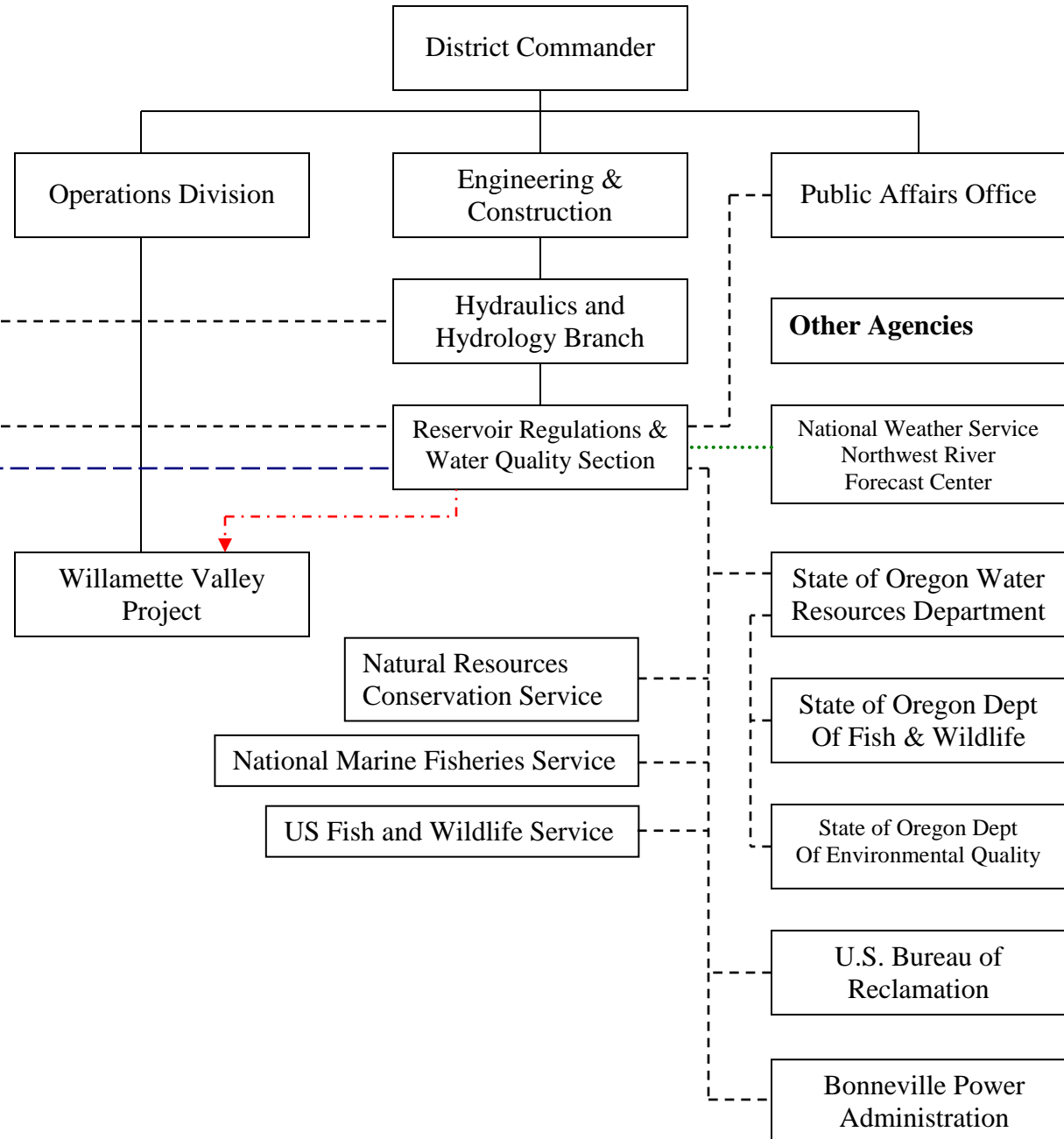
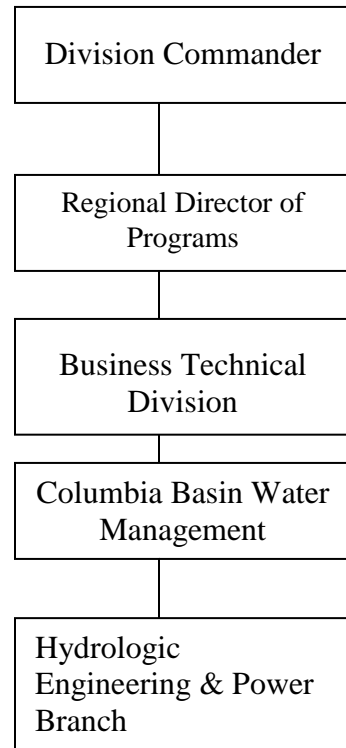
Authority for Action Taken: R - Resident Engineer D - District Office T - Dam Tender  
 If by authority of District Office, show name of authorizing person and Division.

Dam Tender  
 EARL H. STANLEY

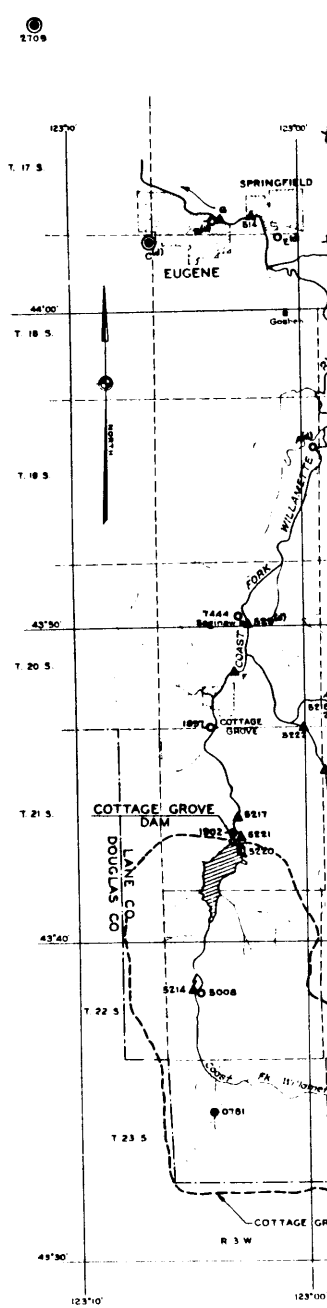
Resident Engineer  
*H. M. MYRAND*  
 H. M. MYRAND

**NORTHWESTERN DIVISION**

**PORTLAND DISTRICT**



**Plate 1: Organizational Schematic for Reservoir Regulation**  
 Willamette River Basin  
 U.S. Army Engineers, Portland District  
 April 2016



STATION				CALENDAR YEARS																											
No.	Name	Location	Elev.	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
0781	Blackbutte	8 235 3W	1700																												
1897	Cottage Grove	33 205 3W	650																												
1902	Cottage Grove Dam	28 215 3W	831																												
A	Creswell	14 195 3W	480																												
2340	Draston 10 SE (Champion Mine)	12 235 1E	437.5																												
2345	Draston 2 NE (Lange Jack)	51 215 1E	427.2																												
2374	Dorena Dam	15 205 3W	187																												
B	Eugene	29 175 3W	450																												
C	Eugene Airport 1 SW	1 185 4W	433																												
2709	Eugene Airport 8 NW	6 175 4W	364																												
8006	London	19 225 3W	860																												
D	Musick	12 235 1E	5500																												
7444	Soginaw	15 205 3W	614																												
E	Springfield	38 175 3W	472																												
8066	Star	24 215 2W	856																												
H	Culp Creek	32 215 1W	870																												

CLIMATOLOGICAL STATIONS

STATION				CALENDAR YEARS																											
No.	Name	Drainage Area	Location	Elev. of Zero Gage	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
5214	Coast Fork Willamette River at London	69	10 225 3W	832.55																											
5221	Coast Fk. Will R. below Cottage Grove Dam	104	7 215 3W	711.00																											
5217	Coast Fork Willamette R. near Cottage Grove	108	21 215 3W	895.07																											
F	Coast Fork Willamette R. at Cottage Grove	147	18 205 3W	808.01																											
529	Coast Fork Willamette River at Soginaw	529	15 205 3W	895.47																											
525	Coast Fork Willamette River at Goshen	642	29 185 2W	473.80																											
526	Row River near Draston	90	30 215 1E																												
5215	Row R. above Pitcher Cr. near Dorena (Star)	211	24 215 2W	856.16																											
5218	Row River near Cottage Grove (near Dorena)	270	36 205 3W	856.24																											
5222	Mosby Creek at mouth near Cottage Grove (4)	56	1 215 3W	856.62																											
514	Willamette River at Springfield	2030	34 175 3W	423.47																											
G	Willamette River at Eugene	2050	29 175 3W	399.57																											

STREAM GAGING STATIONS

RESERVOIR				CALENDAR YEARS																											
No.	Name	Min. Elev.	Full Elev.	Maximum	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
5210	Cottage Grove	1500	1900	807.6																											
5223	Dorena	770.5	832.0	855.0																											

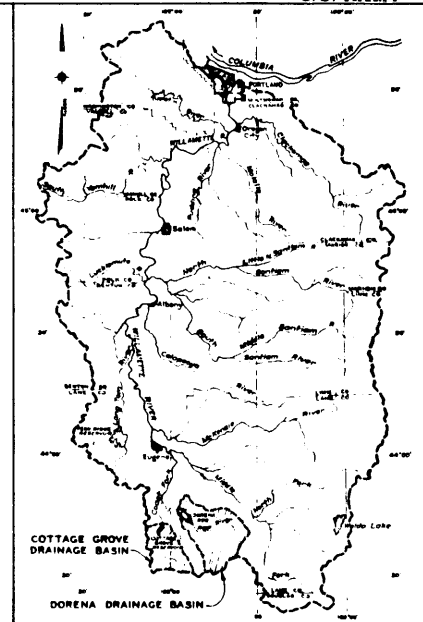
RESERVOIR GAGES

STATION				CALENDAR YEARS																											
No.	Name	Location	Elev.	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
522	Champion Mine	12 235 1E	4500																												

SNOW COURSE

Reference Notes:

- All stations with letters A, B, C, etc., have no assigned numbers
- Elevations are in feet above mean sea level
- Drainage areas are in square miles
- Mosby staff gage, (No 5222<sup>(4)</sup>), at point having 85 sq mi tributary area discontinued in May 1946 and recorder installed at mouth of Mosby Creek in Sept 1946
- Eugene daily staff readings fairly complete back to 1894. Readings used by U.S.G.S. from July 1919 to Sept 1928 for daily discharge values
- Snow surveys made about February 1, March 1, and April 1 of each year



WILLAMETTE RIVER BASIN  
SCALE IN MILES  
1 2 3 4 5 6 7 8 9 10

LEGEND

- CHARTS
- Recorder: Solid black bar
  - Non-recorder: Dashed line
  - Records complete or fairly complete: Solid black bar
  - Records spotty: Dashed line
  - Records fragmentary during May-Sept. but complete Oct-April: Dotted line
- MAP
- Recording: Solid black circle
  - Non-recording: Open circle
  - Precipitation station: Circle with vertical line
  - Precipitation and temperature: Circle with horizontal line
  - Precipitation, temperature, and evaporation: Circle with diagonal line
  - Complete meteorological station: Circle with cross
  - Snow course: Circle with horizontal line and vertical line
  - Stream gage: Triangle
  - Stream gage with telephonic connectors: Triangle with vertical line
  - Reservoir gage: Square
  - Station discontinued: (d)

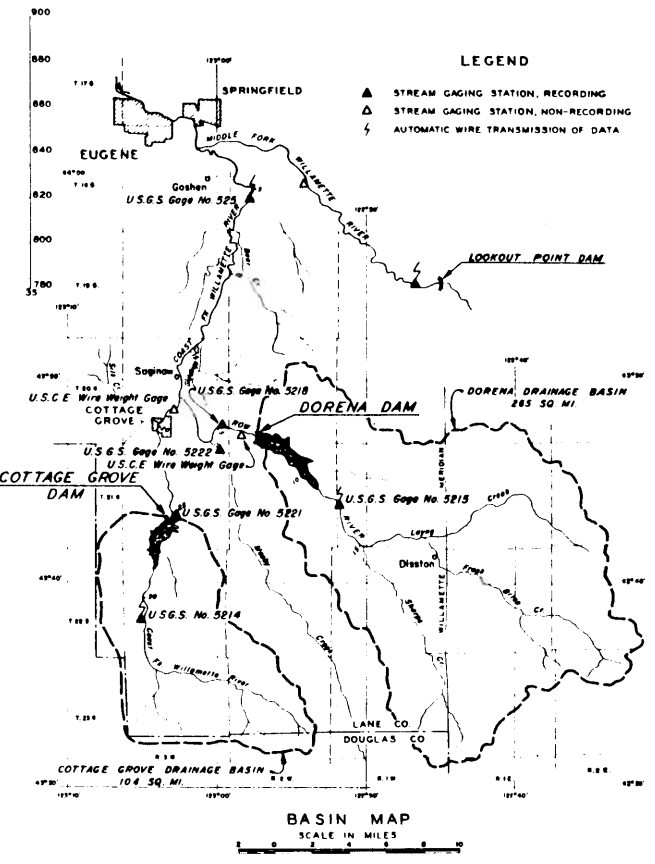
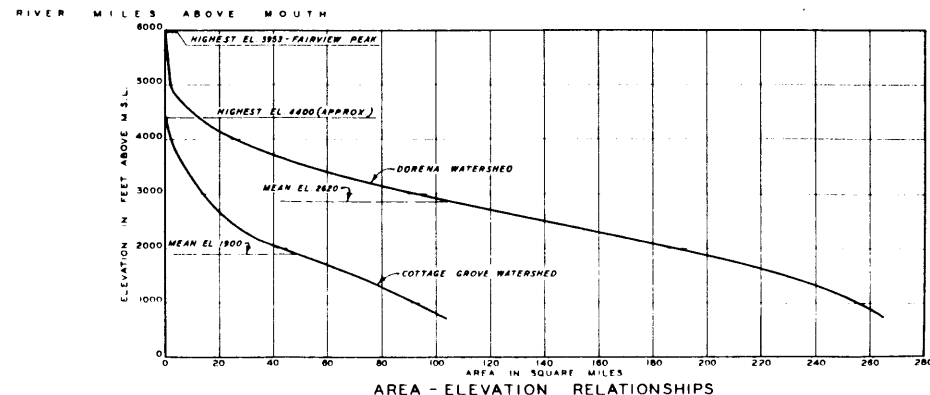
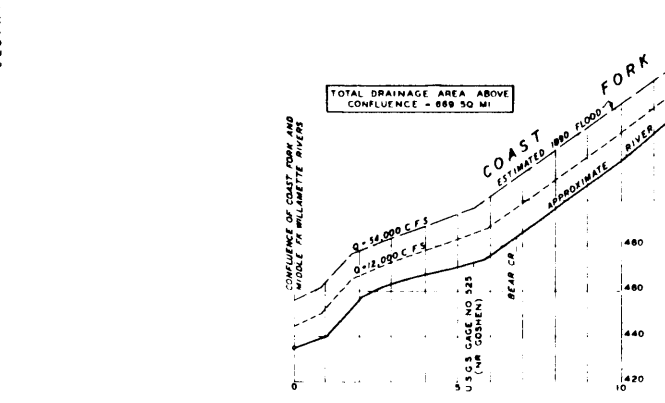
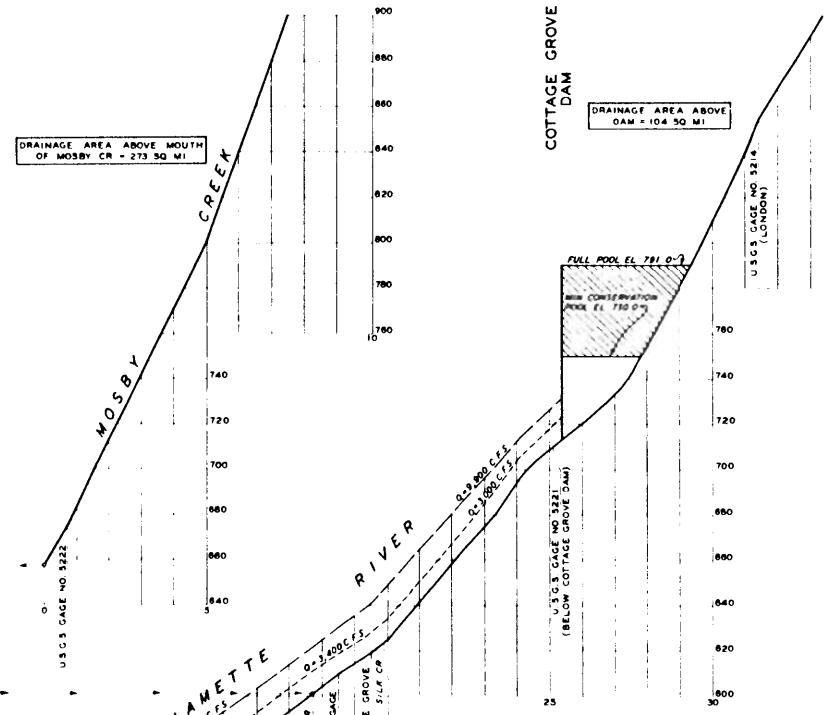
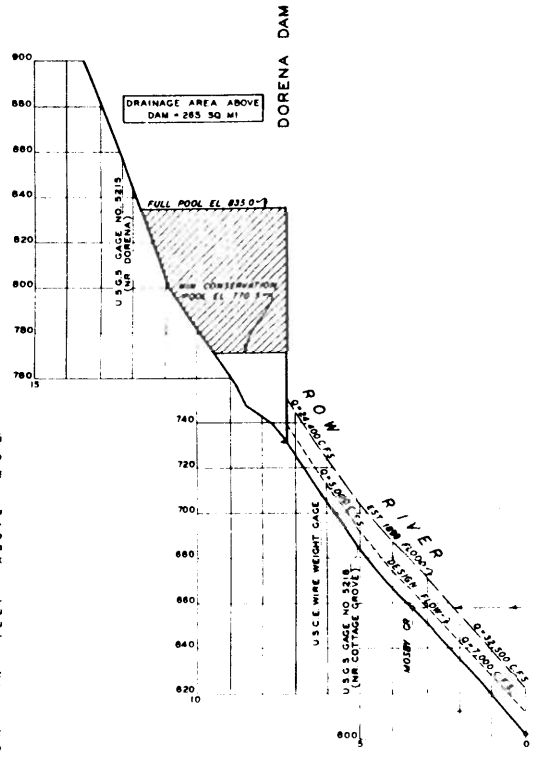
WILLAMETTE RIVER AND TRIBUTARIES, OREGON  
ROW RIVER

**DORENA RESERVOIR REGULATION  
BASIN MAP AND INVENTORY  
OF HYDROCLIMATIC DATA**

PORTLAND DISTRICT, CORPS OF ENGINEERS. SEPT. 1, 1933

Checked by: *[Signature]*  
Checked by: *[Signature]*  
Checked by: *[Signature]*  
Checked by: *[Signature]*

DO-20-21/3



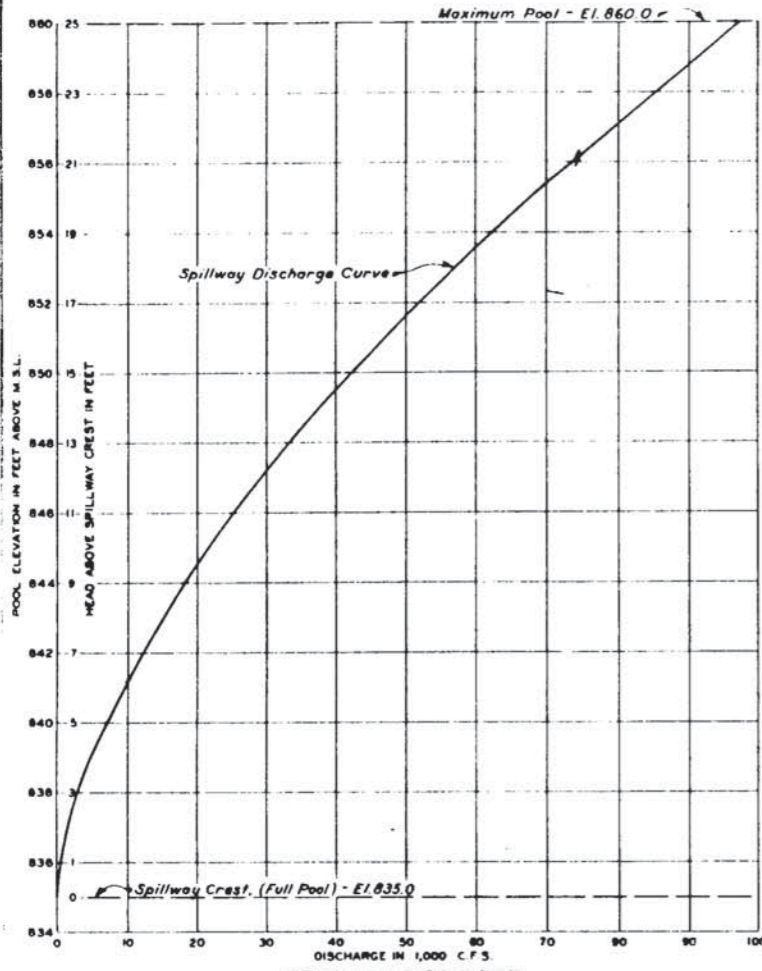
WILLAMETTE RIVER AND TRIBUTARIES, OREGON  
 ROW RIVER  
**DORENA RESERVOIR REGULATION**  
**CONDENSED PROFILES**  
 SCALES AS SHOWN  
 PORTLAND DISTRICT, CORPS OF ENGINEERS SEPT 1, 1953

SUPERVISOR: *[Signature]*  
 CHIEF HYDROLOGIST & DISTRICT ENGINEER: *[Signature]*  
 SUBMITTED: *[Signature]*  
 DRAWN BY: *[Signature]*  
 CHECKED BY: *[Signature]*

RECORDED: *[Signature]*  
 APPROVED: *[Signature]*  
 COL. WILLIAM H. HANSEN  
 DISTRICT ENGINEER

DO-20-21/4





SPILLWAY DISCHARGE  
FIGURE 1

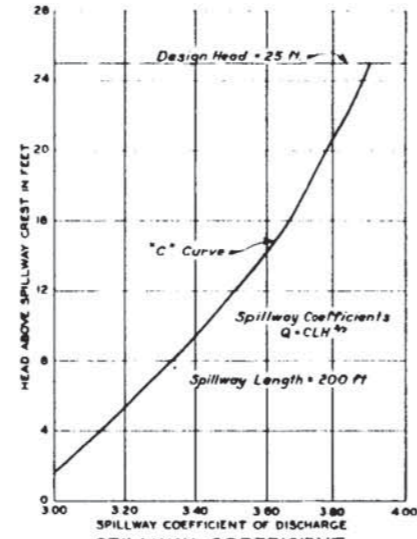
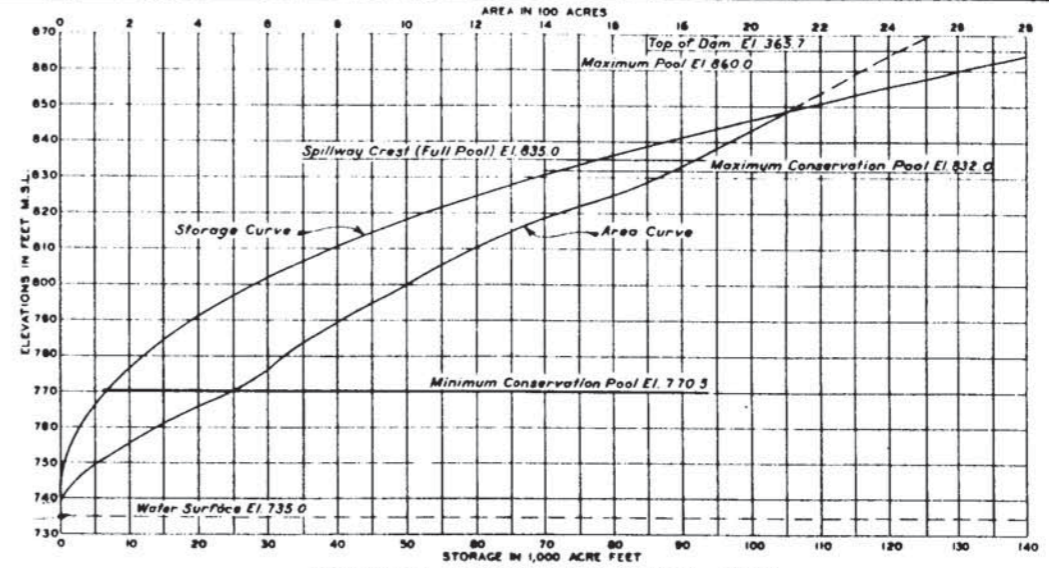


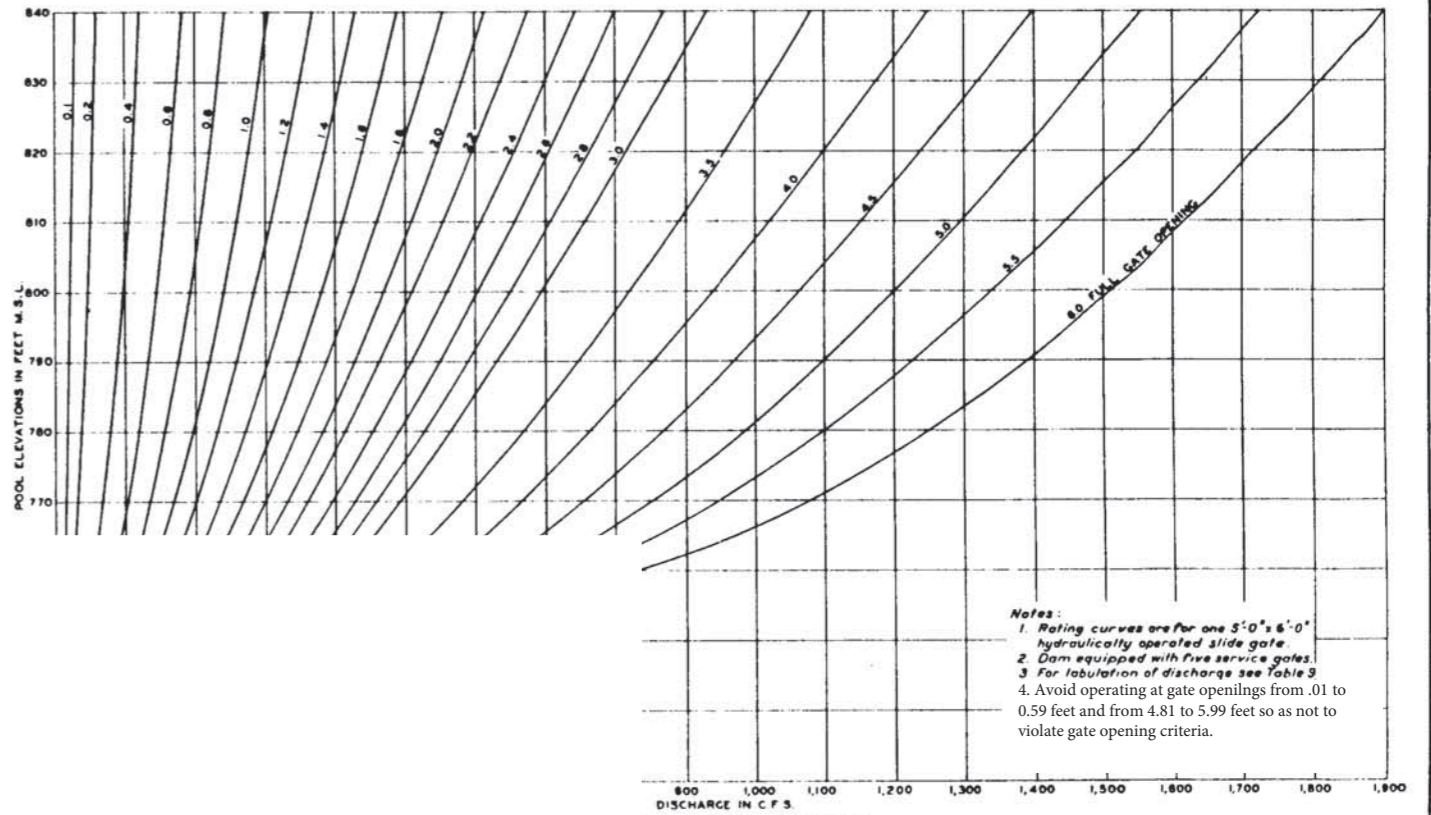
FIGURE 2

**SPILLWAY DISCHARGE TABLE**

ELEVATION FT ABOVE M.S.L.	HEAD FT ABOVE CREST	DISCHARGE Q, C.F.S.
835.0	0.0	0
836.0	1.0	600
837.0	2.0	1,700
838.0	3.0	3,200
839.0	4.0	5,025
840.0	5.0	7,125
841.0	6.0	9,500
842.0	7.0	12,150
843.0	8.0	15,075
844.0	9.0	18,250
845.0	10.0	21,675
846.0	11.0	25,325
847.0	12.0	29,200
848.0	13.0	33,300
849.0	14.0	37,625
850.0	15.0	42,175
851.0	16.0	46,925
852.0	17.0	51,875
853.0	18.0	57,000
854.0	19.0	62,300
855.0	20.0	67,775
856.0	21.0	73,425
857.0	22.0	79,225
858.0	23.0	85,175
859.0	24.0	91,275
860.0	25.0	97,500



RESERVOIR CAPACITY AND SURFACE AREA  
FIGURE 3



Gate Discharge  
FIGURE 5

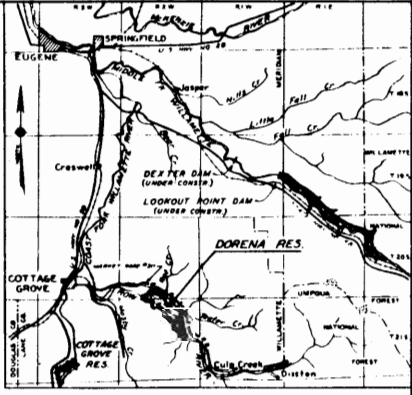
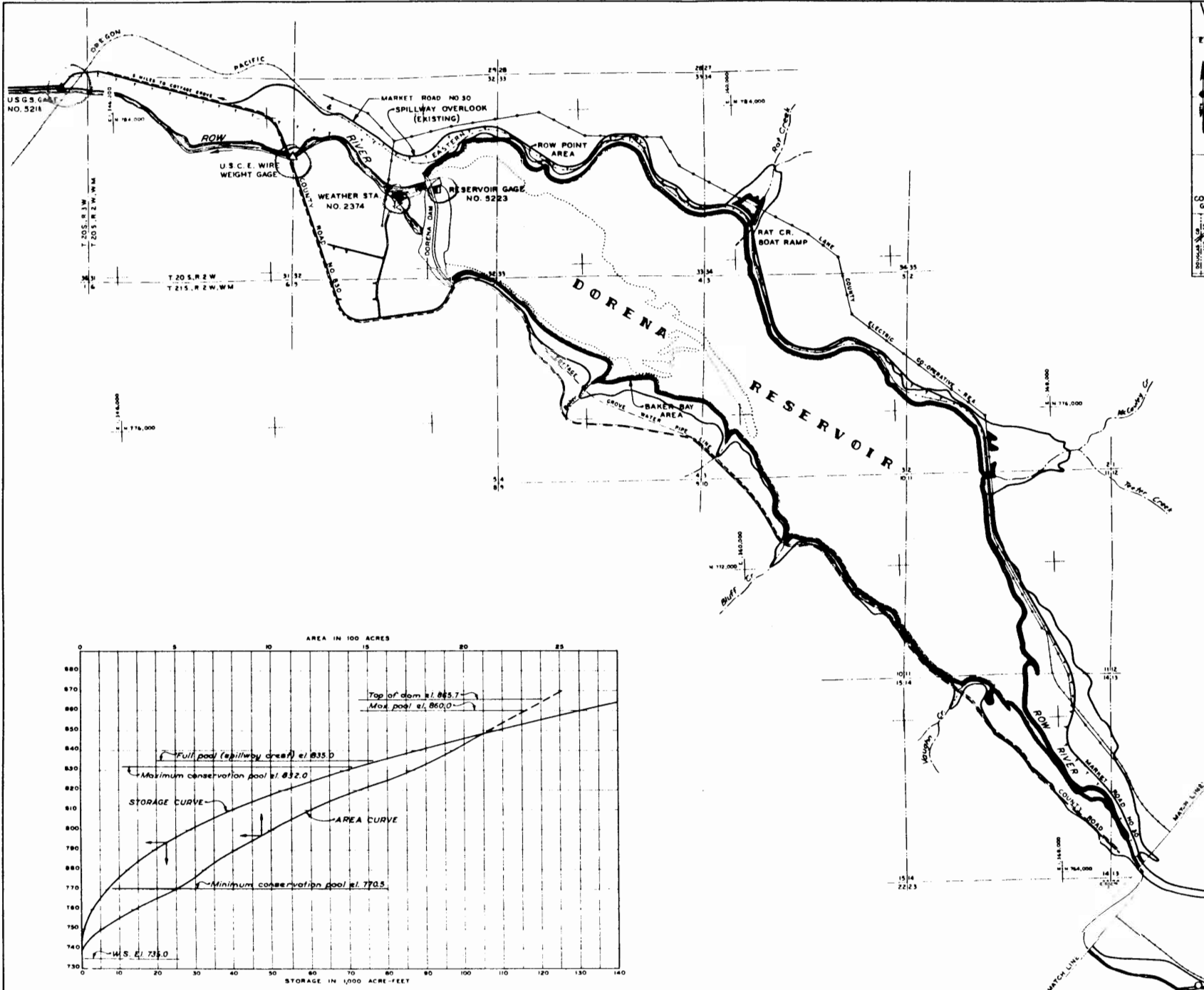
Notes:  
1. Rating curves are for one 5'-0" x 6'-0" hydraulically operated slide gate.  
2. Dam equipped with five service gates.  
3. For tabulation of discharge see Table 3.  
4. Avoid operating at gate openings from .01 to 0.59 feet and from 4.81 to 5.99 feet so as not to violate gate opening criteria.

WILLAMETTE RIVER AND TRIBUTARIES, OREGON  
ROW RIVER  
DORENA RESERVOIR REGULATION  
RATING CURVES  
SCALES AS SHOWN  
PORTLAND DISTRICT, CORPS OF ENGINEERS SEPT. 1, 1933

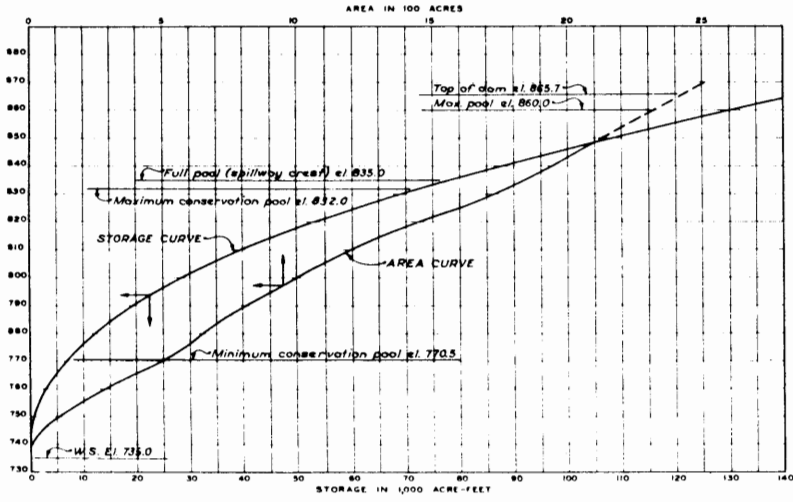
DESIGNED BY: *[Signature]*  
CHECKED BY: *[Signature]*  
SUBMITTED BY: *[Signature]*  
APPROVED BY: *[Signature]*

DRAWN BY: D.R.P.  
TABLED BY: D.R.P.  
CHECKED BY: W.A.W.

DO-20-21/6



VICINITY MAP  
SCALE IN MILES



RESERVOIR CAPACITY AND SURFACE AREA

- LEGEND
- MINIMUM CONSERVATION POOL EL. 770.5
  - FULL POOL EL. 835.0
  - MAXIMUM POOL EL. 860.0

WILLAMETTE RIVER AND TRIBUTARIES, OREGON  
ROW RIVER  
DORINA RESERVOIR REGULATION  
RESERVOIR MAP

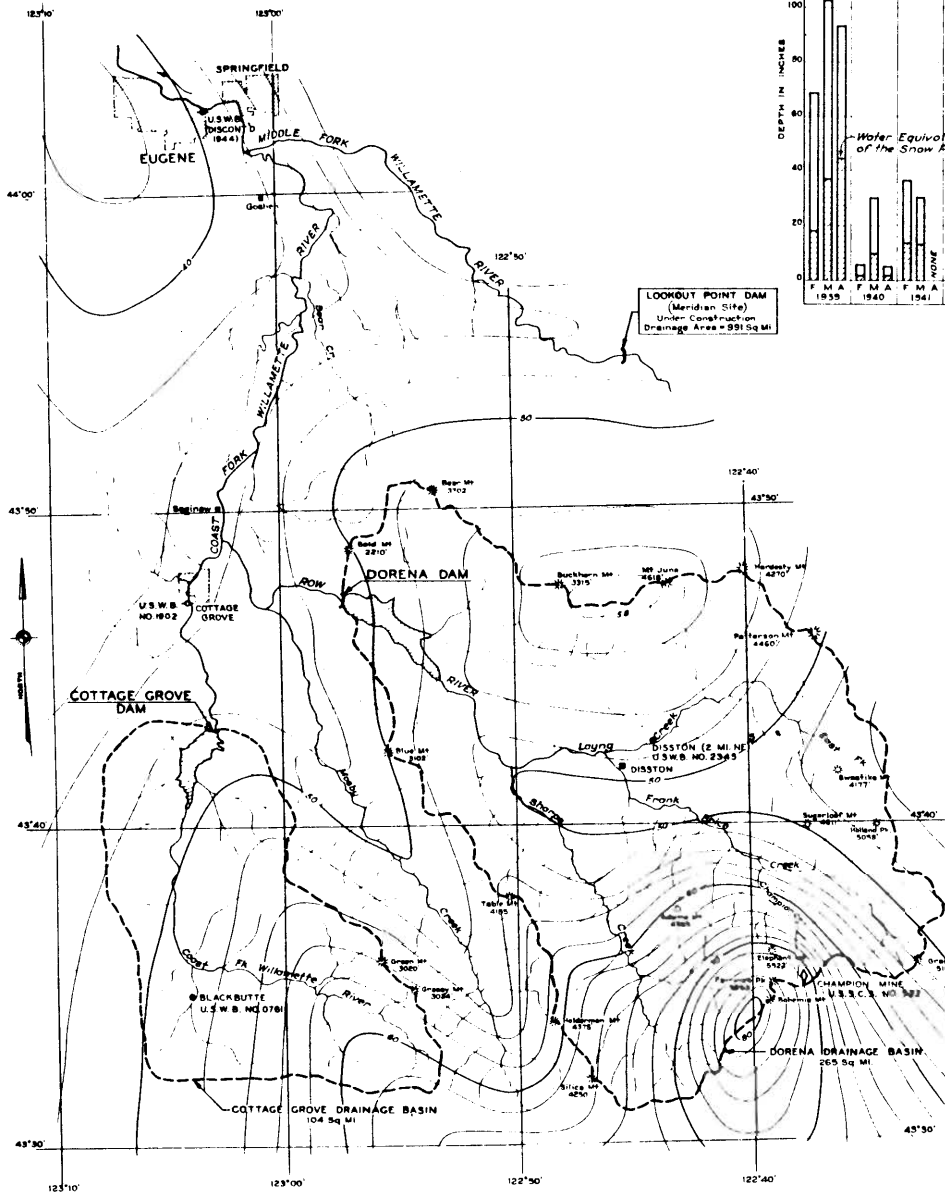
SCALE IN FEET  
0 1000 2000 3000 4000 5000

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

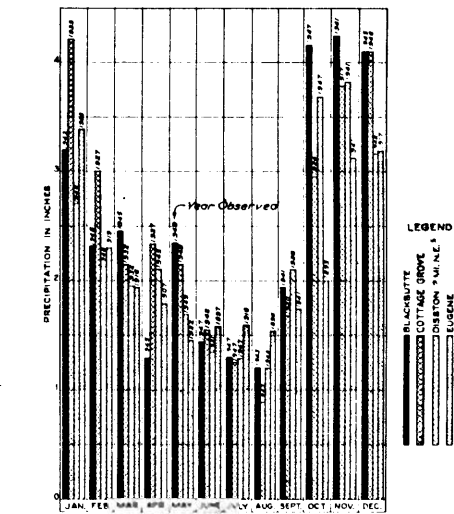
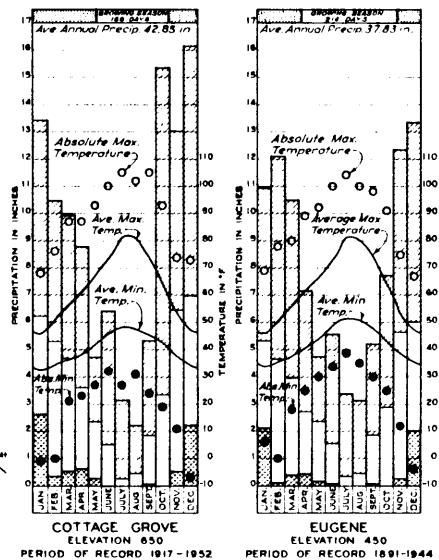
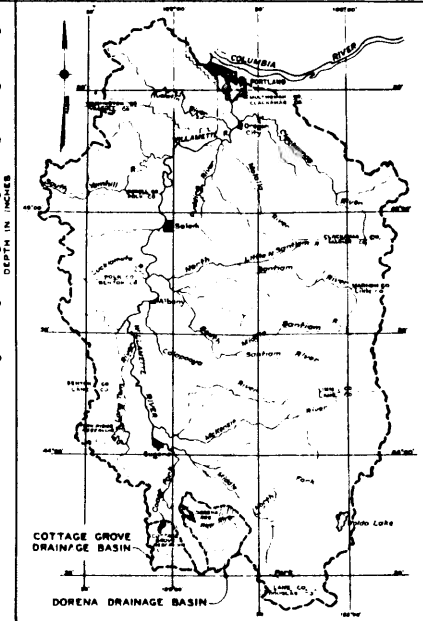
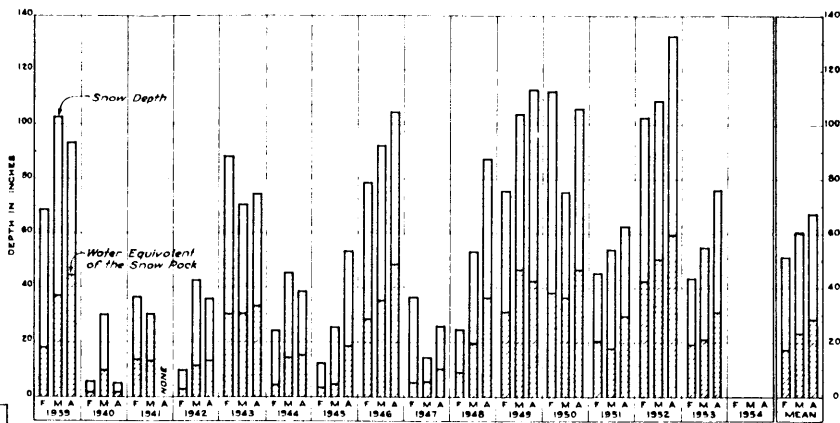
U.S.G.S. GAGE NO. 5215 (STAR)

DO-20-21/7

EUGENE AIRPORT WEATHER BUREAU



LOOKOUT POINT DAM  
(Meridian Site)  
Under Construction  
Drainage Area = 991 Sq. Mi.



- Reference Notes:**
1. 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.
  2. The observed maximum 24-hour precipitation is the amount tabulated for a 24-hour period between observation times, except where recording gages or times of beginning and ending of precipitation were used.
  3. Precipitation, temperature, and growing season data from records of U.S. Weather Bureau.
  4. Snow surveys by U.S. Soil Conservation Service within 2 days of date indicated.
  5. Disston (2 Mi. N.E.) also known as Loving Creek and previously as Rijado.

WILLAMETTE RIVER AND TRIBUTARIES, OREGON  
ROW RIVER

**DORENA RESERVOIR REGULATION  
CLIMATIC CHARACTERISTICS**

SCALE AS SHOWN

PORTLAND DISTRICT, CORPS OF ENGINEERS SEPT. 1, 1953

SUPERVISED BY: [Signature]

DESIGNED BY: [Signature]

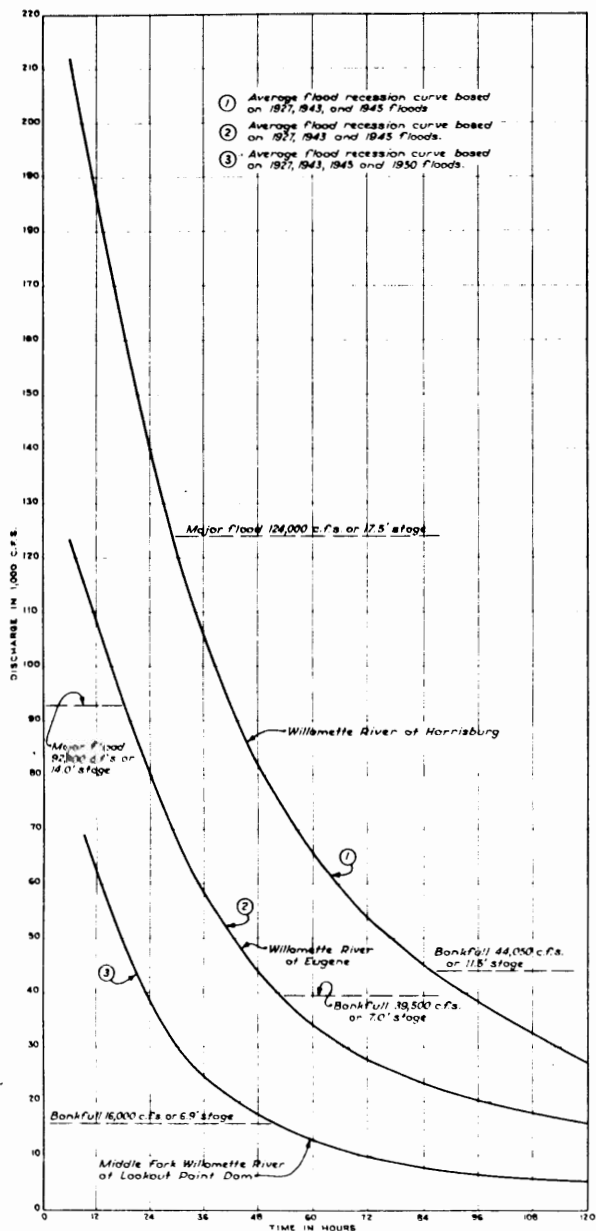
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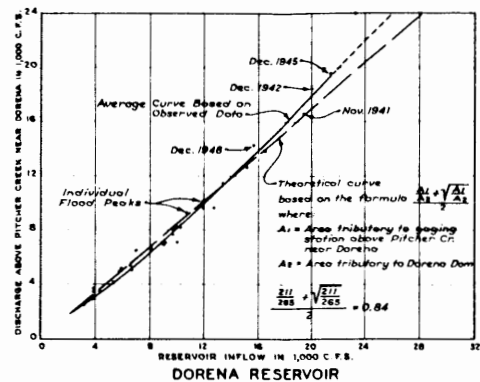
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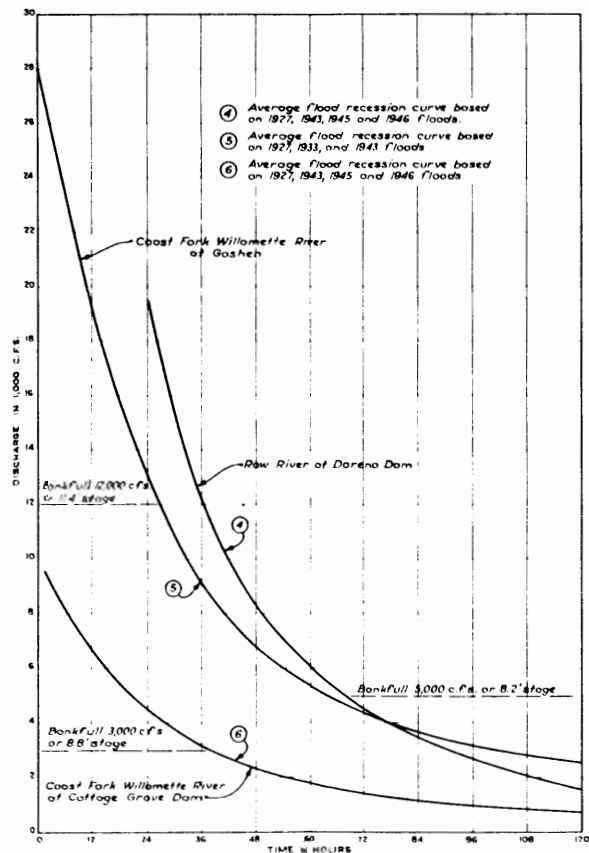
DO-20-21/8



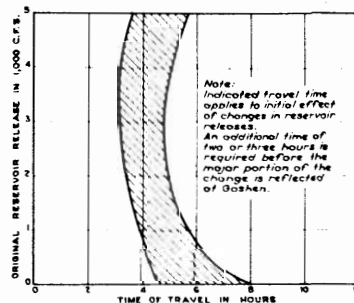
TYPICAL FLOOD RECEPTION CURVES  
WILLAMETTE RIVER  
FIGURE 1



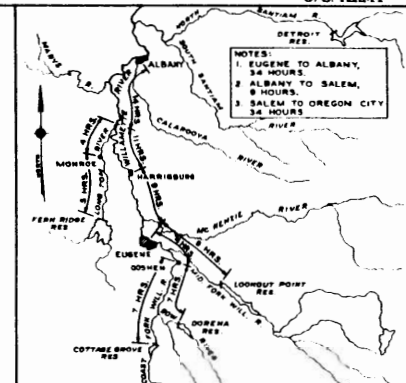
DORENA RESERVOIR  
PEAK DISCHARGE RELATIONSHIP  
ROW RIVER  
FIGURE 3



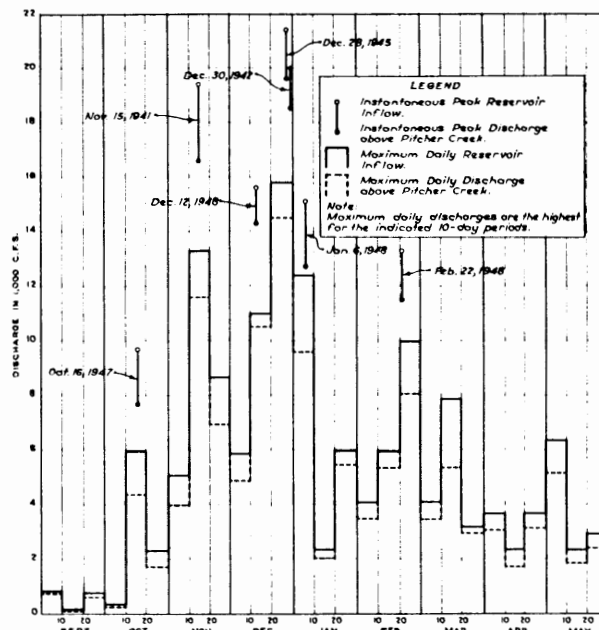
TYPICAL FLOOD RECEPTION CURVES  
COAST FORK WILLAMETTE RIVER  
FIGURE 2



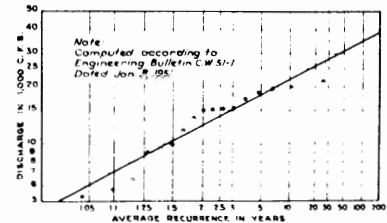
TRAVEL TIME VARIATION  
DORENA DAM TO GOSHEN  
FIGURE 6



AVERAGE TRAVEL TIME OF FLOOD FLOWS  
SCALE IN MILES  
FIGURE 7



PEAK AND MAXIMUM DISCHARGES - ROW RIVER  
PERIOD OF RECORD, WATER YEARS 1939-1949  
FIGURE 5

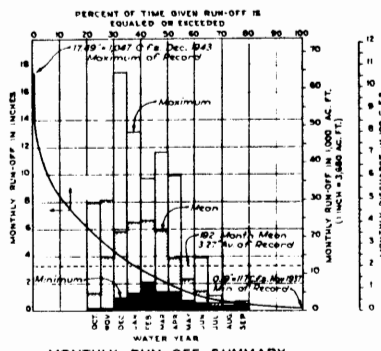


FLOOD FREQUENCY - DORENA RESERVOIR INFLOW  
ROW RIVER NEAR COTTAGE GROVE  
PERIOD OF RECORD, WATER YEARS 1930-1952  
FIGURE 4

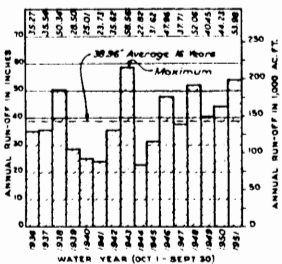
Notes:  
1. Prior to October 1947, Row River near Cottage Grove was designated as Row River near Dorena.  
2. Prior to October 1950, Row River above Pitcher Creek near Dorena was designated as Row River of Star.

WILLAMETTE RIVER AND TRIBUTARIES, OREGON  
ROW RIVER  
DORENA RESERVOIR REGULATION  
STREAM FLOW CHARACTERISTICS

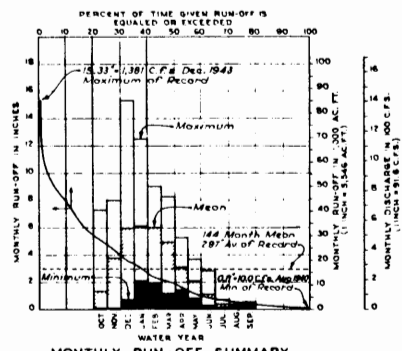
PORTLAND DISTRICT, CORPS OF ENGINEERS  
SUPERVISOR: [Signature]  
CHIEF ENGINEER: [Signature]  
SUBMITTED: [Signature]  
CHECKED BY: M. J. C. R. M.  
SCALE AS SHOWN  
SEPT. 1, 1953  
RECORDED  
DRAWN BY: [Signature]  
CHECKED BY: [Signature]  
DO-20-21/9



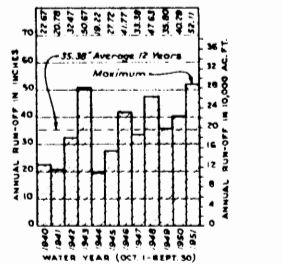
MONTHLY RUN-OFF SUMMARY



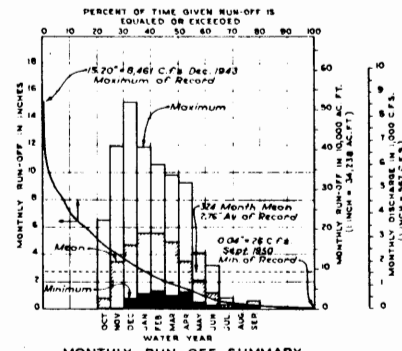
COAST FORK WILLAMETTE RIVER AT LONDON  
DRAINAGE AREA 69 SQUARE MILES 1



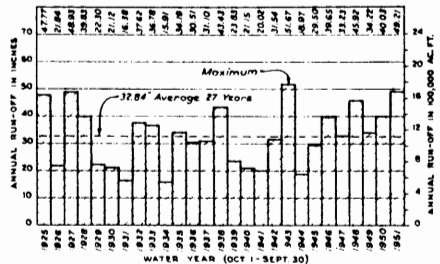
MONTHLY RUN-OFF SUMMARY



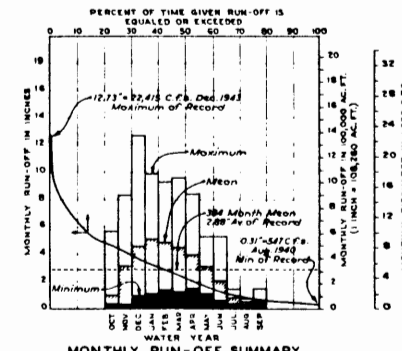
COAST FORK WILLAMETTE RIVER BELOW COTTAGE GROVE DAM  
DRAINAGE AREA 104 SQUARE MILES 1, 2  
Note: Drainage Area 108 sq mi (1940-1946 incl.) (1945-1946)  
104 " (1945-1946)



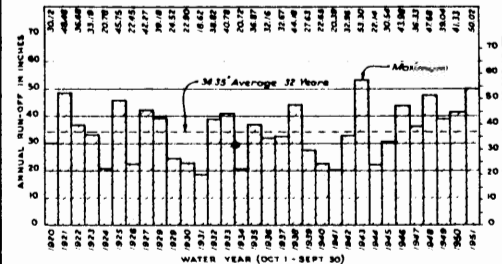
MONTHLY RUN-OFF SUMMARY



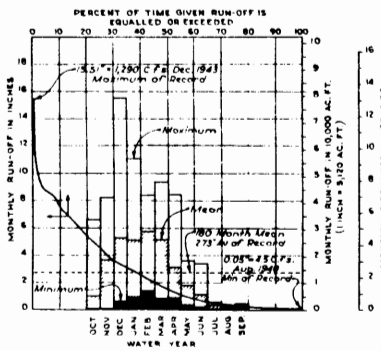
COAST FORK WILLAMETTE RIVER NEAR GOSHEN  
DRAINAGE AREA 642 SQUARE MILES 1, 3  
Note: Drainage Area 529 sq mi (1925-1940 incl.) (1951)  
642 " (1951)



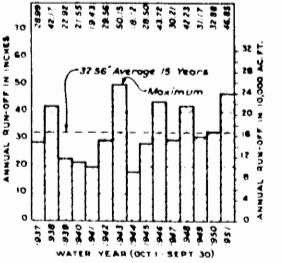
MONTHLY RUN-OFF SUMMARY



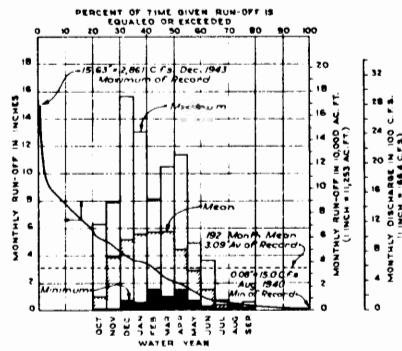
WILLAMETTE RIVER AT EUGENE  
DRAINAGE AREA 2,030 SQUARE MILES 2



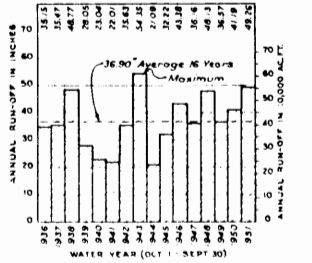
MONTHLY RUN-OFF SUMMARY



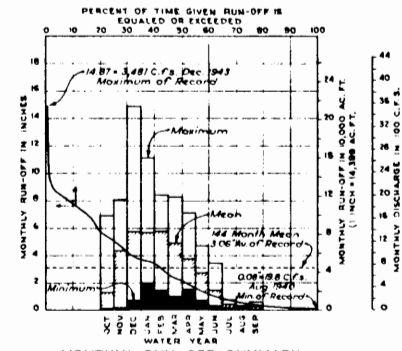
MOSBY CREEK NEAR COTTAGE GROVE  
DRAINAGE AREA 66 SQUARE MILES 2  
Note: Drainage Area 85 sq mi (1937-1946 incl.) (1946-1946)  
66 " (1946-1946)



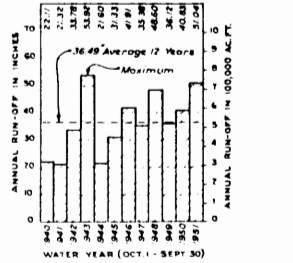
MONTHLY RUN-OFF SUMMARY



ROW RIVER ABOVE PITCHER CREEK  
DRAINAGE AREA 211 SQUARE MILES 1



MONTHLY RUN-OFF SUMMARY



ROW RIVER NEAR COTTAGE GROVE  
DRAINAGE AREA 270 SQUARE MILES 2

STREAM GAGING STATIONS

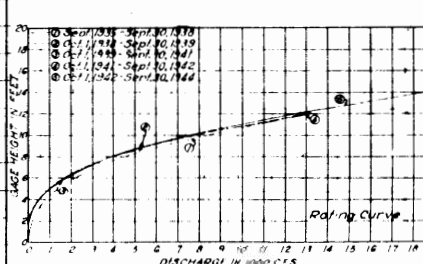
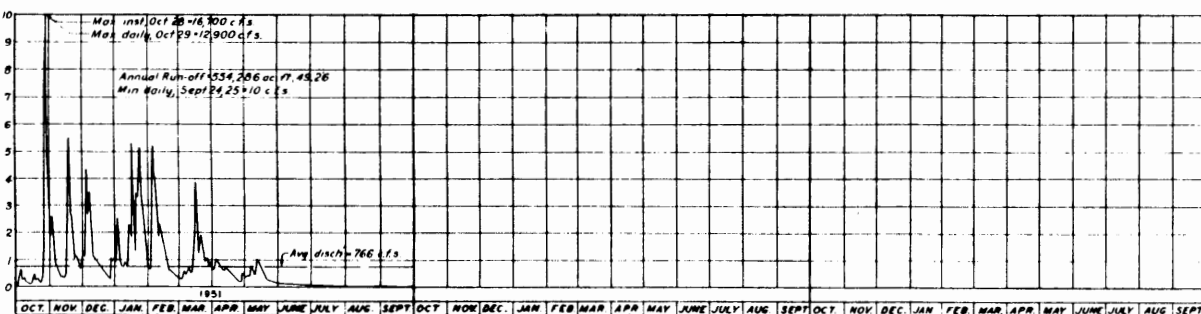
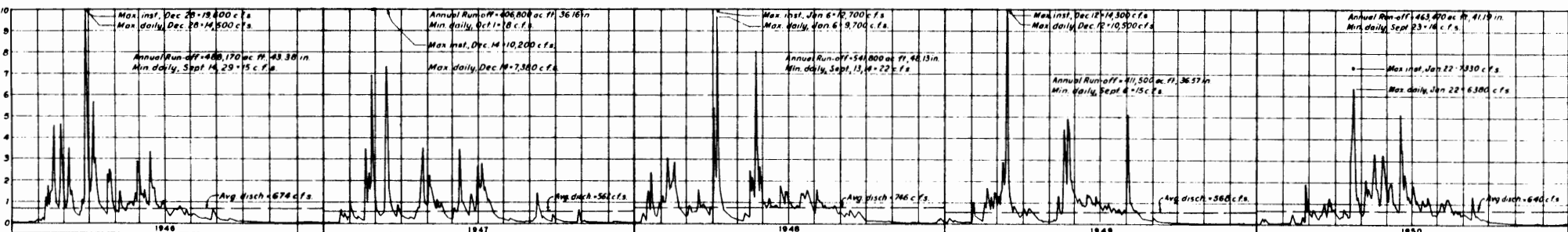
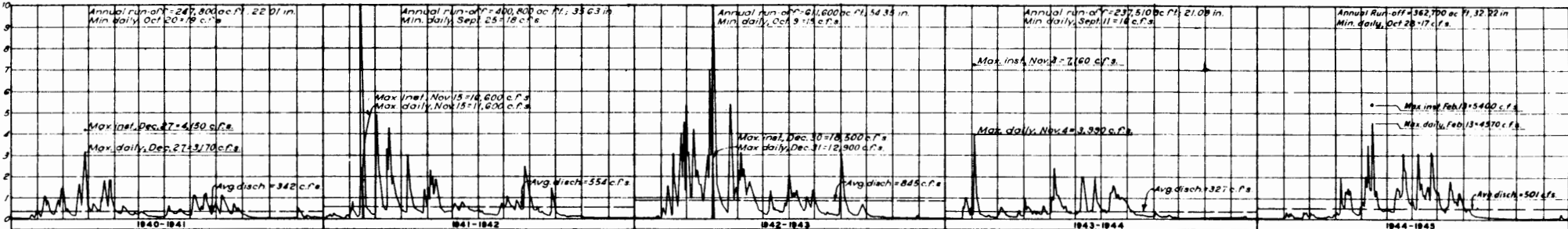
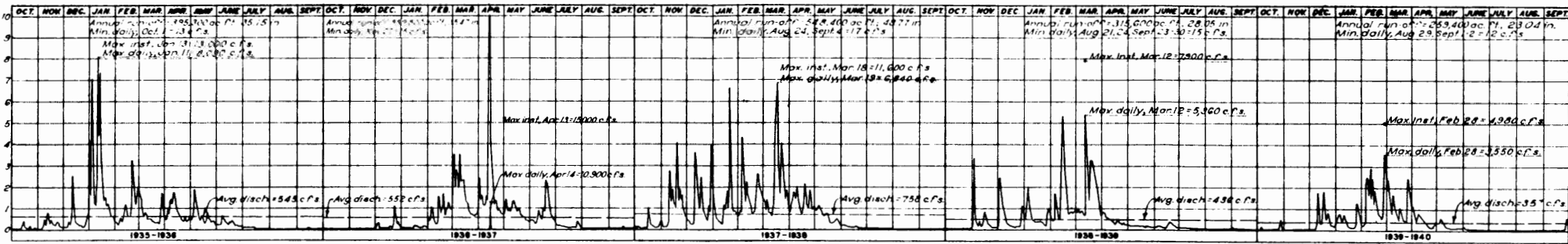
NAME	RIVER	U. S. G. S. FIELD NO.	TYPE
London	Coast Fork Willamette R.	5214	Telemark-Recording River Gage, rated
Below Cottage Grove Dam	"	5221	Recording River Gage, Rated
Goshen	"	525	Telemark-Recording River Gage, rated
Eugene	Willamette River	514	Recording River Gage, rated
Near Cottage Grove	Mosby Creek	5222	"
Above Pitcher Creek	Row River	5215	Telemark-Recording River Gage, rated
Near Cottage Grove	"	5218	Recording River Gage, rated

Notes:  
 1 Source of information: U.S.G.S. Water Supply Papers  
 Data for water years 1950 and 1951 are from unpublished reports  
 2 Refer to Plate 2 for station location and hydroclimatic data  
 3 Natural discharges as measured for area as noted  
 4 Natural discharges adjusted to area as noted  
 5 Regulated discharges adjusted to natural discharges for area noted

WILLAMETTE RIVER AND TRIBUTARIES, OREGON  
 ROW RIVER  
 DORENA RESERVOIR REGULATION  
 RUN-OFF SUMMARY

SCALES AS SHOWN  
 PORTLAND DISTRICT, CORPS OF ENGINEERS SEPT. 1, 1953  
 DRAWN BY: [Signature]  
 CHECKED BY: [Signature]  
 DESIGNED BY: [Signature]  
 REVISIONS BY: [Signature]  
 CHECKED BY: C. M. B. W. H. A. N.  
 DO-20-21/10

DISCHARGE IN 1000 C.F.S.



Row River at Star, Oregon  
 Drainage Area - 21,850 mi<sup>2</sup>  
 STATION - 10000

Records Available	Character	Location	Datum (M.S.L.)
Sept 1935	Continuous	Staff	N 1/2 Sec 24, T 21 S, R 2 W 1/2 in west of Star, 3 mi. above Teater Creek
Oct 1936	Continuous	Water-Stage Recorder	50' dam stream near Dorena
Sept 1944	Continuous	Recorder	From old staff gage

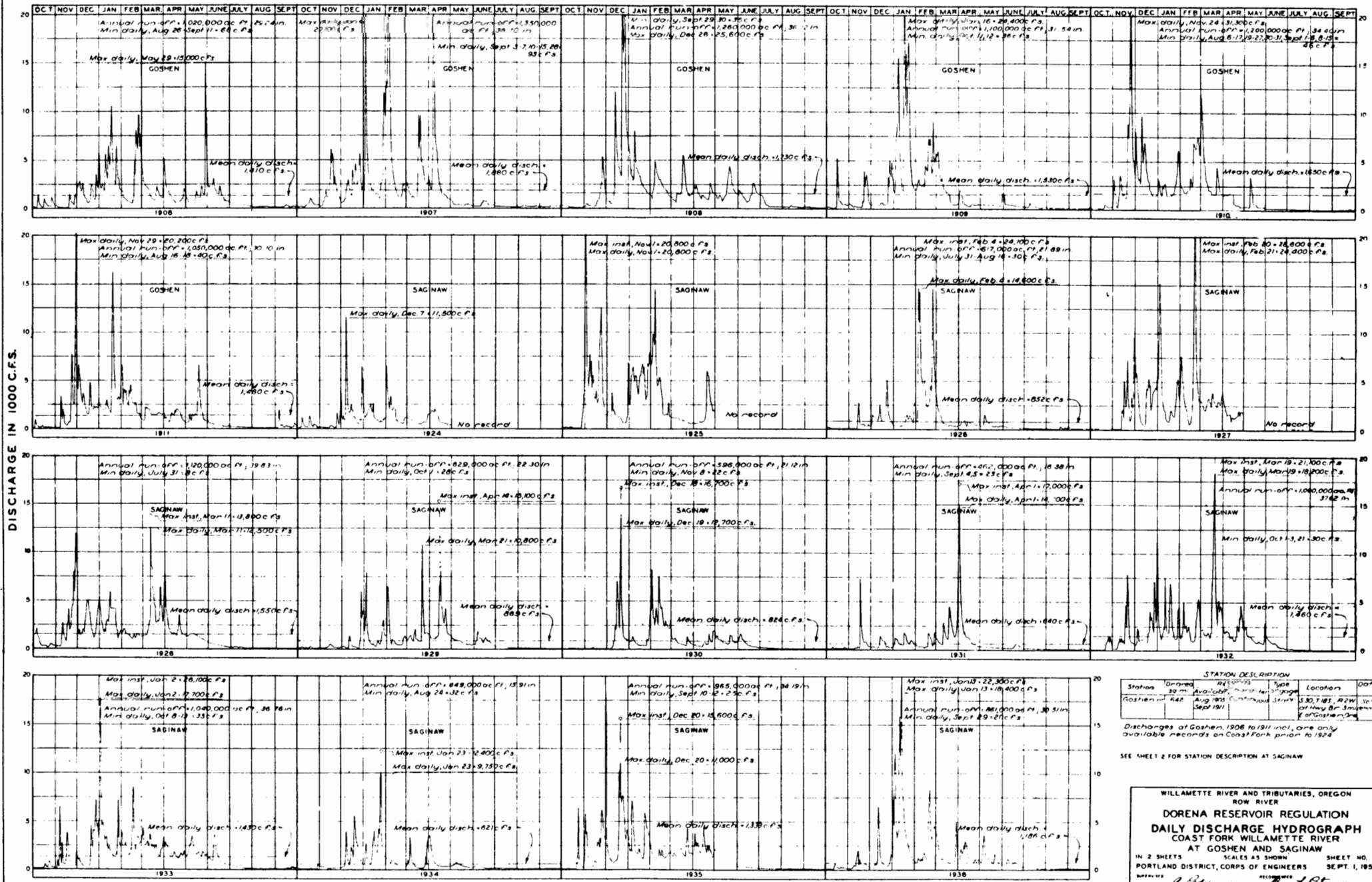
WILLAMETTE RIVER AND TRIBUTARIES, OREGON  
 ROW RIVER  
**DORENA RESERVOIR REGULATION**  
**DAILY DISCHARGE HYDROGRAPH**  
 ROW RIVER ABOVE PITCHER CREEK  
 NEAR DORENA  
 SCALES AS SHOWN

PORTLAND DISTRICT, CORPS OF ENGINEERS      SEPT 1, 1953

SUPERVISOR: *W. C. Anderson*  
 ASSISTANT SUPERVISOR: *W. C. Peterson*  
 SUBMITTED BY: *J. L. Bay*  
 DRAWN BY: *W. C. Anderson*  
 CHECKED BY: *W. C. Anderson*

DO-20-21/11





STATION DESCRIPTION					
Station	Installed	RTS	Type	Location	datum
Goshen #42	Aug 1905	Continuously	Stilling	1.50, 7.18, 22W of Hwy B, 3/4 mile E of Goshen, Ore.	36'

Discharges at Goshen, 1906 to 1911 incl, are only available records on Coast Fork prior to 1924

SEE SHEET 2 FOR STATION DESCRIPTION AT SAGINAW

WILLAMETTE RIVER AND TRIBUTARIES, OREGON  
 DORENA RESERVOIR REGULATION  
 DAILY DISCHARGE HYDROGRAPH  
 COAST FORK WILLAMETTE RIVER  
 AT GOSHEN AND SAGINAW

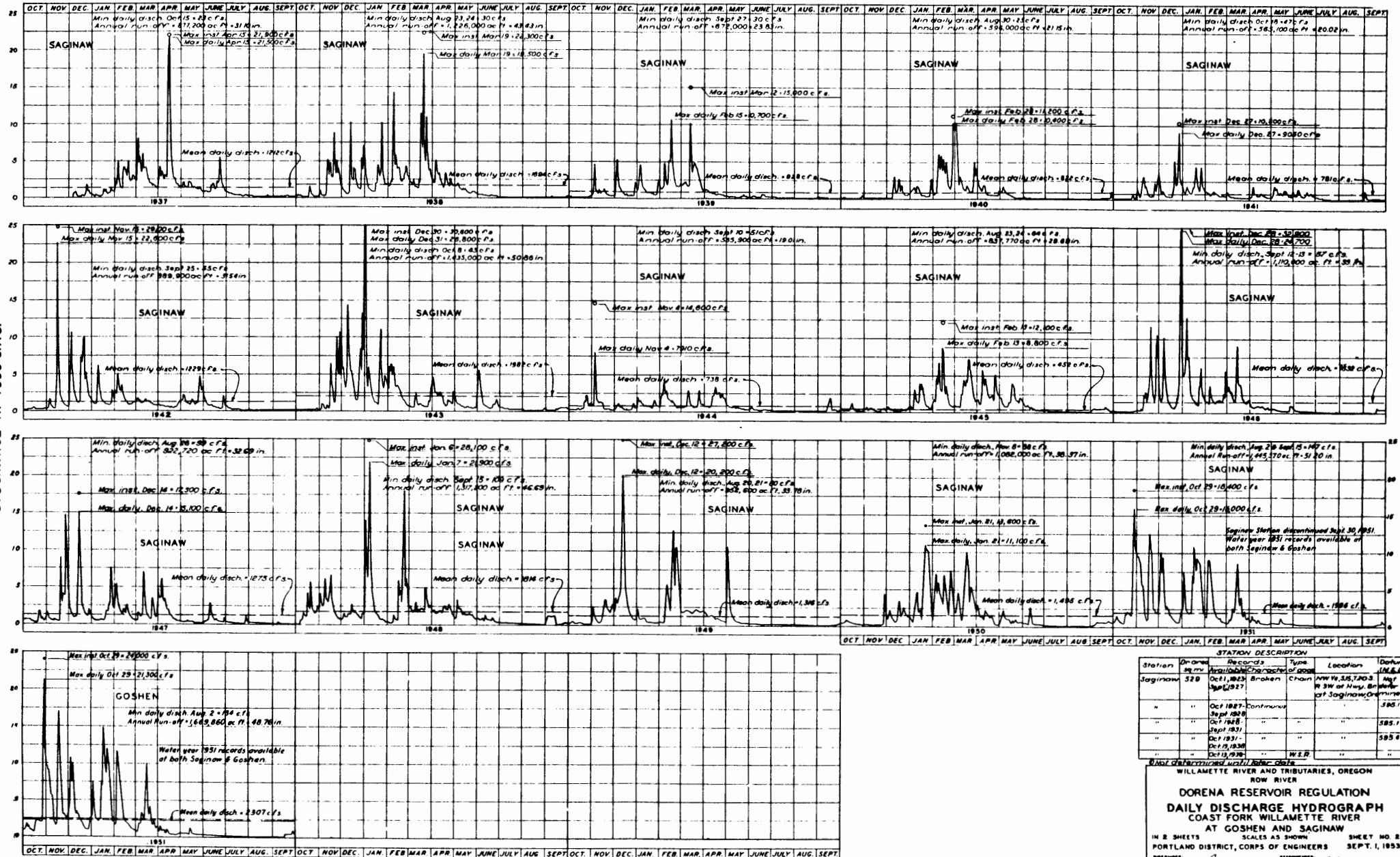
11 - 2 SHEETS SCALES AS SHOWN SHEET NO. 1  
 PORTLAND DISTRICT, CORPS OF ENGINEERS SEPT. 1, 1933

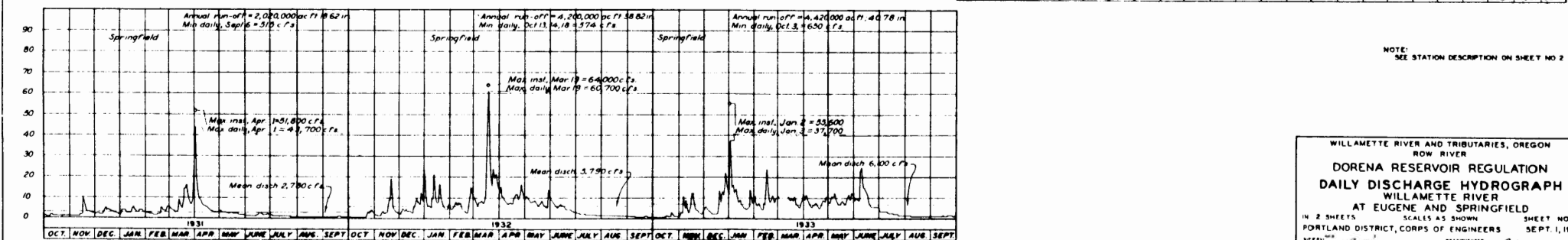
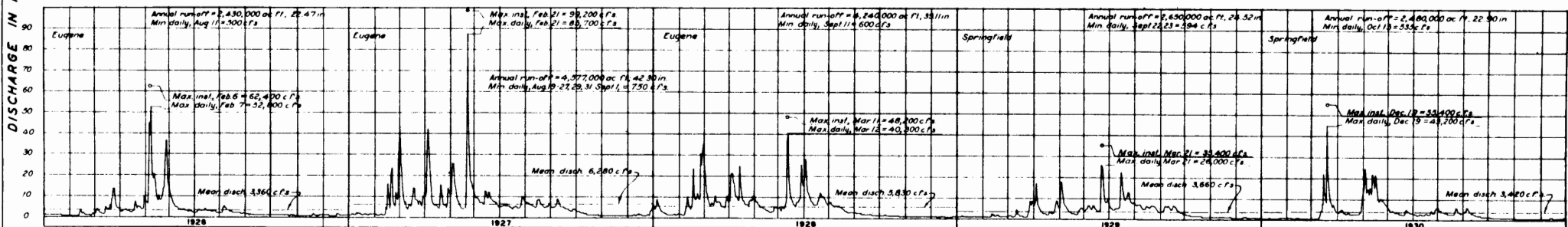
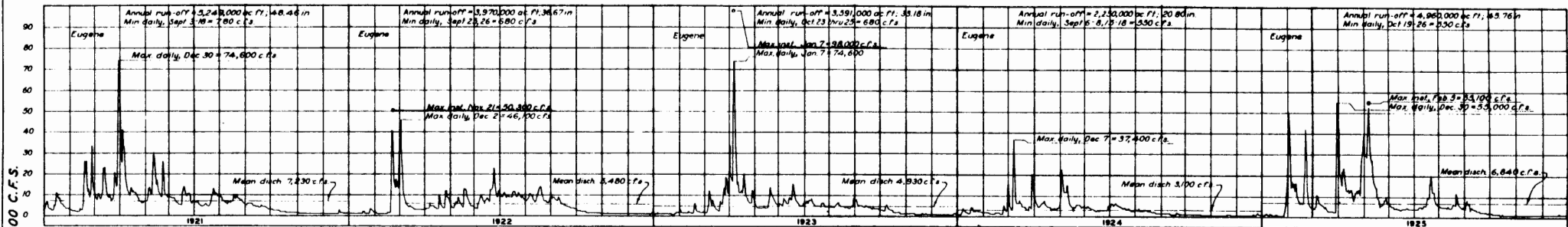
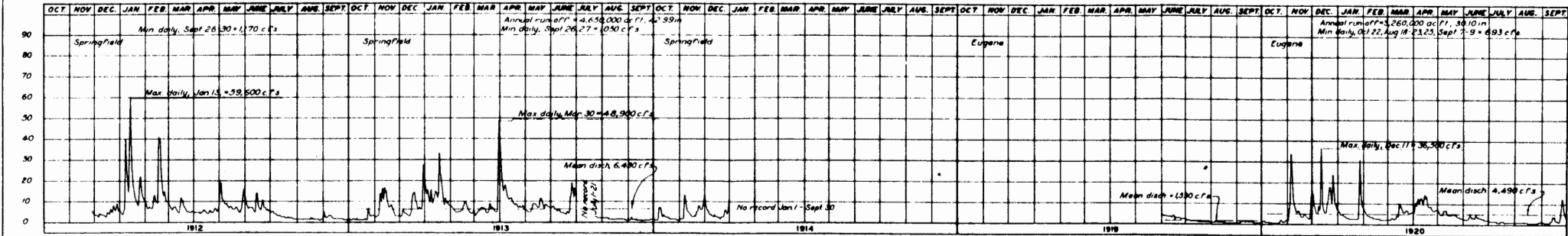
APPROVED: *Ben J. Peterson*  
 CHIEF, HYDROLOGICAL & METEOROLOGICAL SECTION

DESIGNED BY: *Paul J. Johnson*  
 CHIEF, CIVIL ENGINEERING SECTION

DRAWN BY: *John C. ...*  
 CHECKED BY: *...*

DO-20-21/13





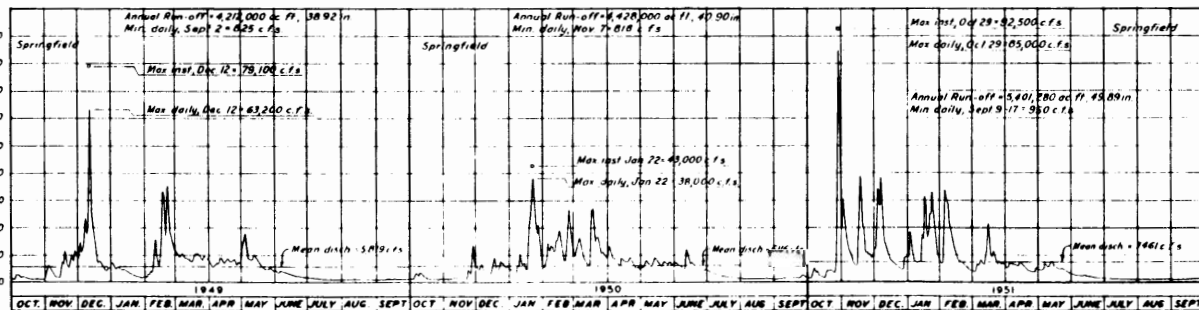
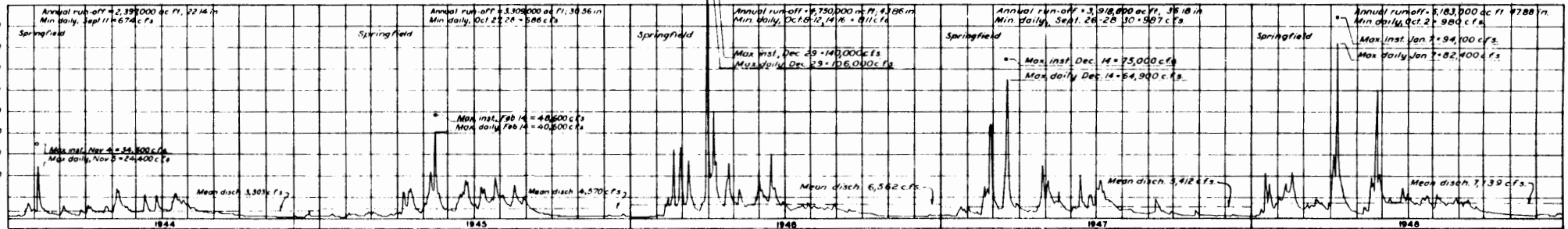
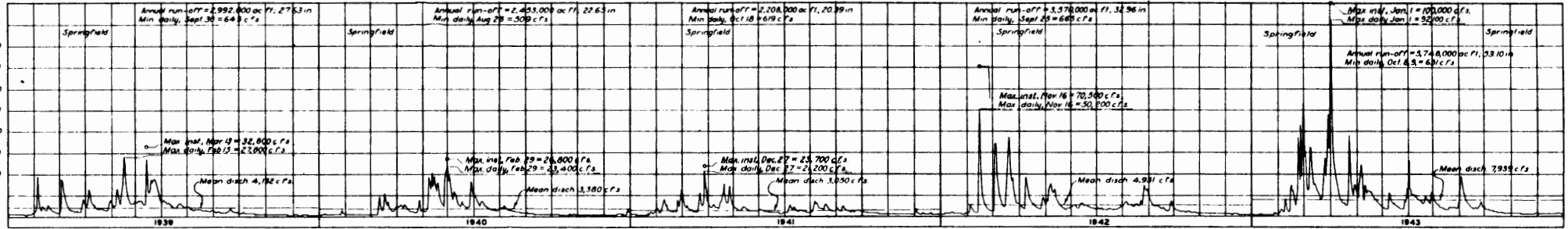
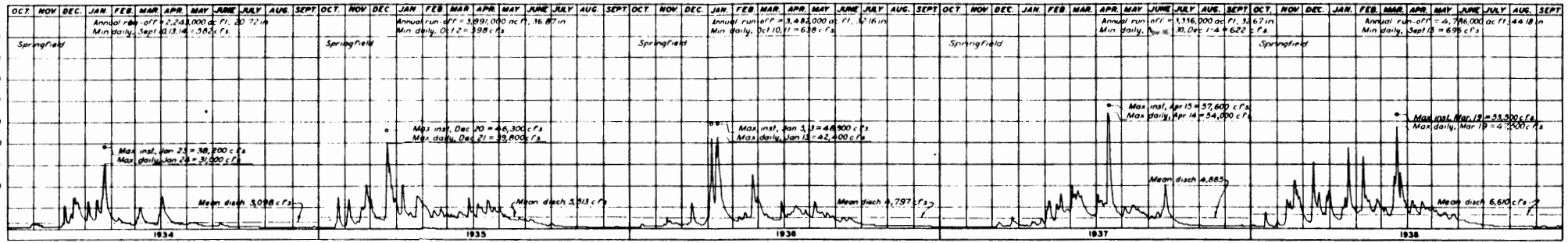
NOTE: SEE STATION DESCRIPTION ON SHEET NO 2

WILLAMETTE RIVER AND TRIBUTARIES, OREGON  
 BOW RIVER  
**DORENA RESERVOIR REGULATION**  
**DAILY DISCHARGE HYDROGRAPH**  
 WILLAMETTE RIVER  
 AT EUGENE AND SPRINGFIELD

IN 2 SHEETS SCALES AS SHOWN SHEET NO. 1  
 PORTLAND DISTRICT, CORPS OF ENGINEERS SEPT. 1, 1933

DESIGNED BY: *[Signature]*  
 CHECKED BY: *[Signature]*  
 DRAWN BY: *[Signature]*  
 APPROVED BY: *[Signature]*

DO-20-21/15



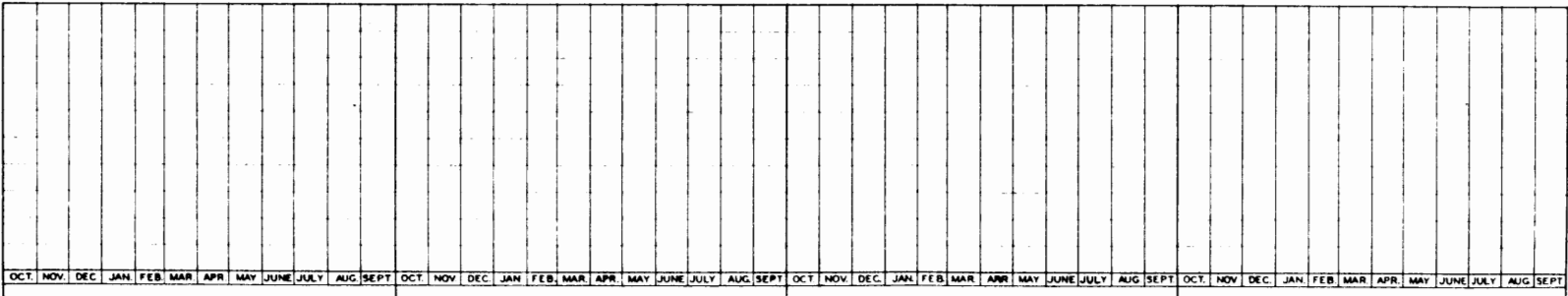
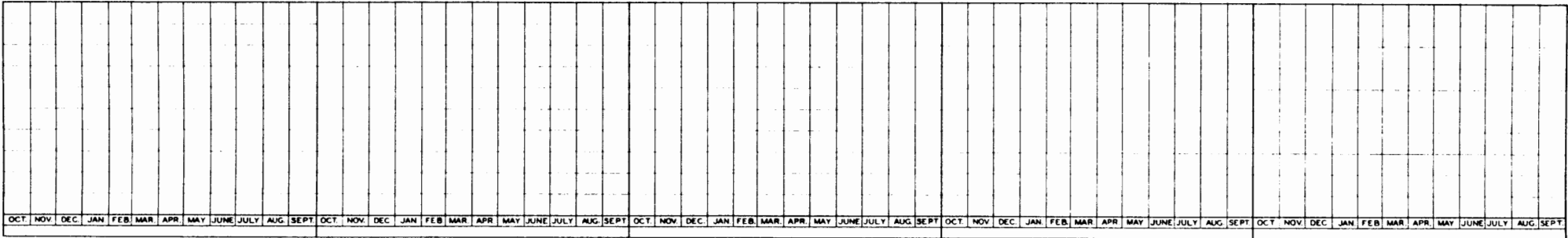
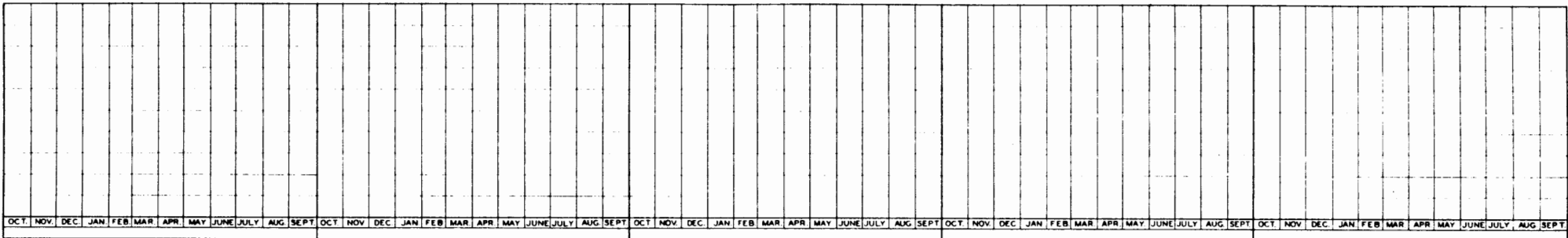
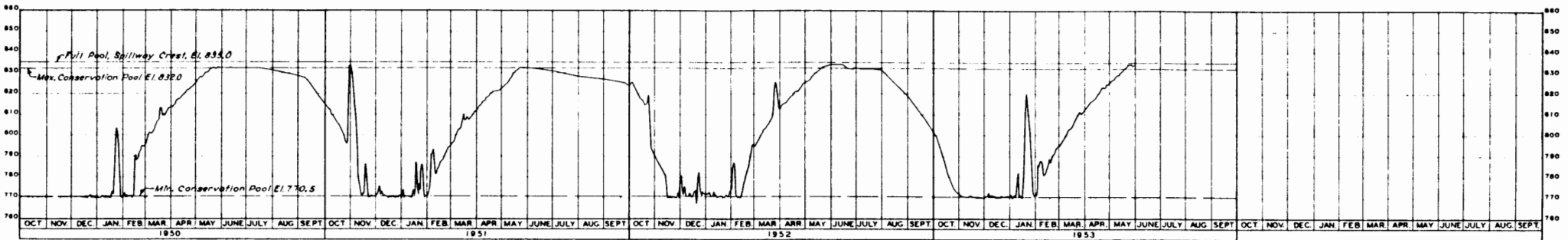
Station	Dis-Area	Structure	Type of	Location	Bottom
	Sq. Miles		Class		(ft.)
Springfield	2,030	Concrete	Continuous	S W Sec 35 T 7 S	2
"	2,030	Mar 1913	Broken	S W Sec 35 T 7 S	2
Eugene	2,030	Apr 1913	Staff	S W Sec 28 T 7 S	399.3
Springfield	2,030	Oct 1928	"	S W Sec 35 T 7 S	R 3 W
		Sept 1951	"	W S R SE Sec 34 T 7 S	424.16
				R 3 W	

① Not determined until later date. 2,030 sq mi area shown is earlier water supply paper in error.  
② Not determined.

WILLAMETTE RIVER AND TRIBUTARIES, OREGON  
ROW RIVER  
DORENA RESERVOIR REGULATION  
DAILY DISCHARGE HYDROGRAPH  
WILLAMETTE RIVER  
AT EUGENE AND SPRINGFIELD  
IN 2 SHEETS SCALES AS SHOWN SHEET NO. 2  
PORTLAND DISTRICT, CORPS OF ENGINEERS SEPT. 1, 1953

Checked by: *[Signature]*  
Approved by: *[Signature]*  
Drawn by: *[Signature]*  
Checked by: *[Signature]*

DO-20-21/16  
PLATE 15



WILLAMETTE RIVER AND TRIBUTARIES, OREGON  
 ROW RIVER  
**DORENA RESERVOIR REGULATION**  
**POOL ELEVATION HYDROGRAPH**

SCALES AS SHOWN  
 PORTLAND DISTRICT, CORPS OF ENGINEERS SEPT. 1, 1933

SUPERVISED BY: *[Signature]*  
 CHIEF, HYDROLOGY & METEOROLOGY SECTION  
 SUBMITTED BY: *[Signature]*  
 CHIEF, WILLAMETTE DIVISION

APPROVED BY: *[Signature]*  
 COL. J. C. [Name]  
 DISTRICT ENGINEER

DRAWN BY: L. W. [Name]  
 TRACED BY: B. V. [Name]  
 CHECKED BY: W. B. [Name]

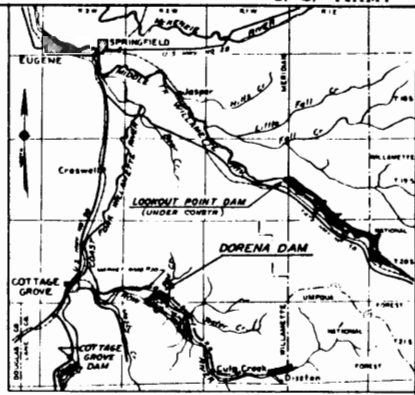
DO-20-21/17



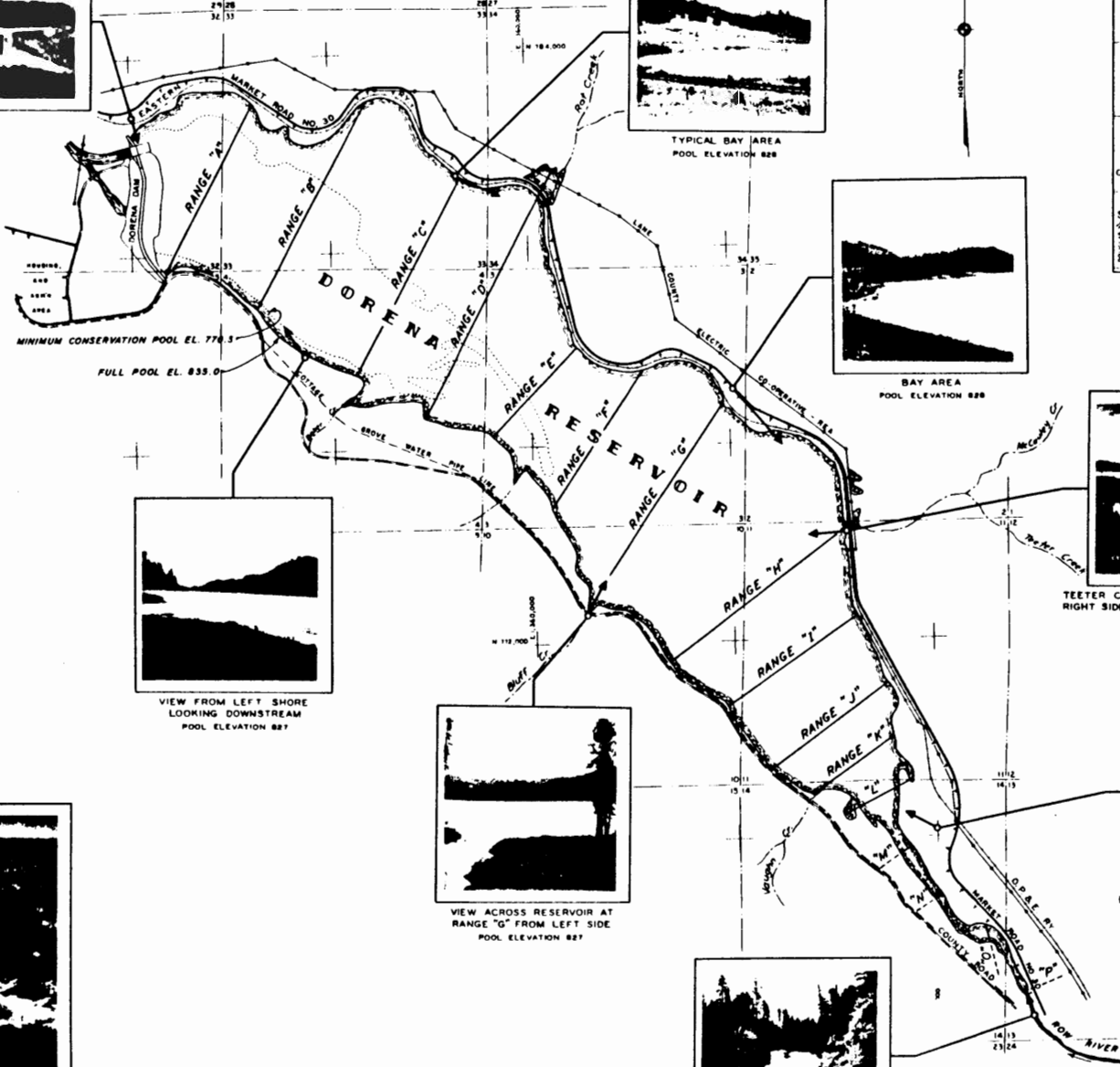
VIEW OF DORENA DAM AND RESERVOIR FROM BLUFF OVERLOOKING RIGHT ABUTMENT  
POOL ELEVATION 827



TYPICAL BAY AREA  
POOL ELEVATION 828



VICINITY MAP  
SCALE IN MILES



BAY AREA  
POOL ELEVATION 828



TEETER CR ENTERING DORENA RESERVOIR  
RIGHT SIDE OF RESERVOIR FROM RANGE "H"



LOOKING ACROSS HEAD OF RESERVOIR  
FROM RANGE "M"  
POOL ELEVATION 828



VIEW FROM LEFT SHORE  
LOOKING DOWNSTREAM  
POOL ELEVATION 827



VIEW ACROSS RESERVOIR AT  
RANGE "O" FROM LEFT SIDE  
POOL ELEVATION 827



ROW RIVER JUST ABOVE HEAD OF  
DORENA RESERVOIR



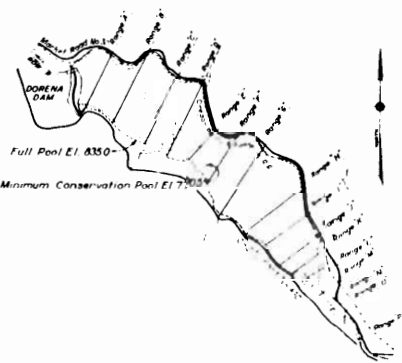
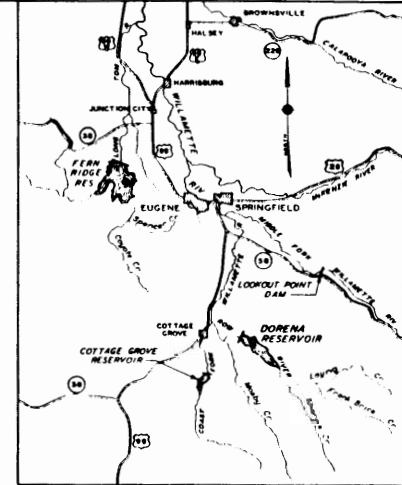
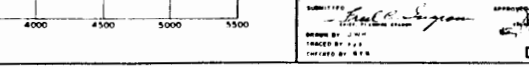
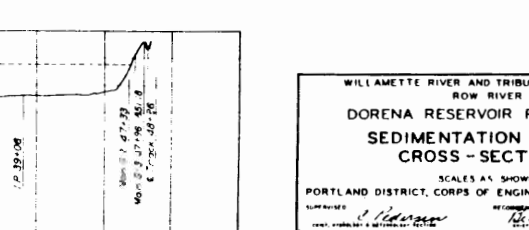
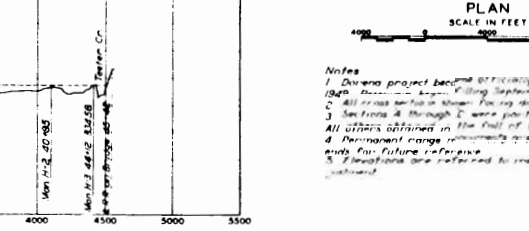
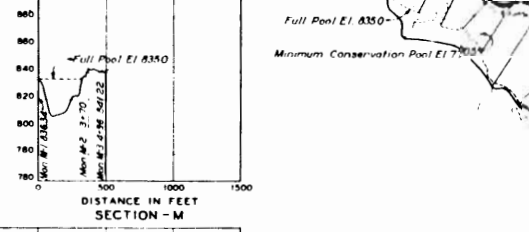
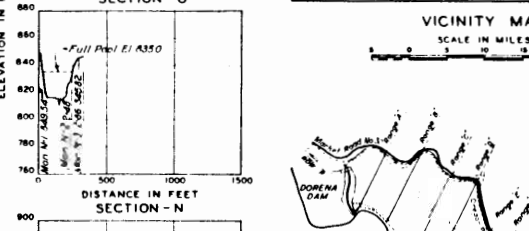
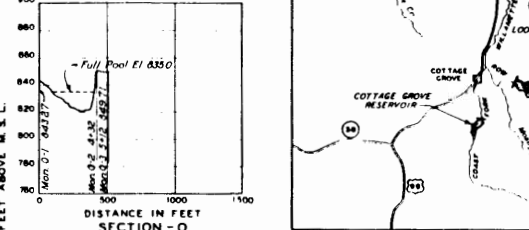
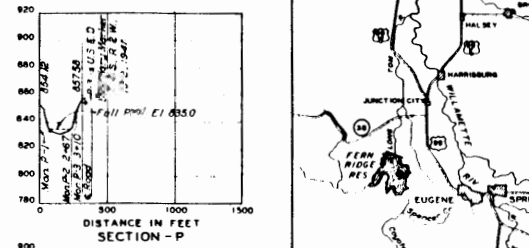
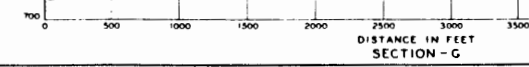
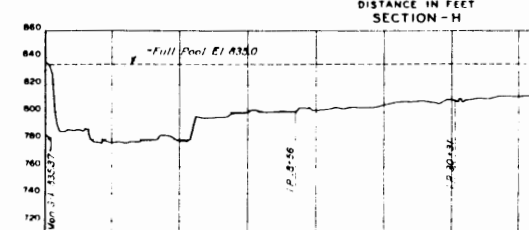
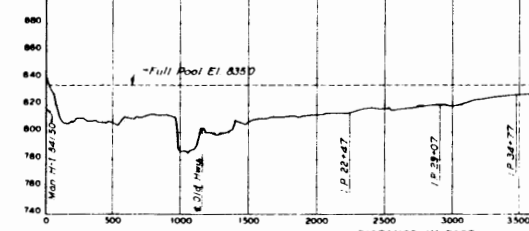
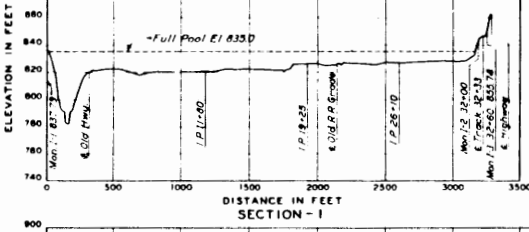
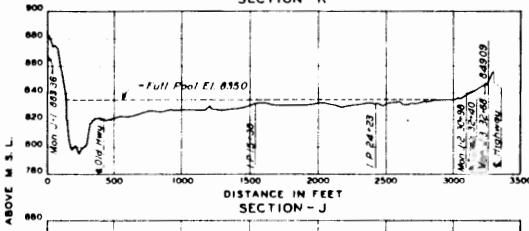
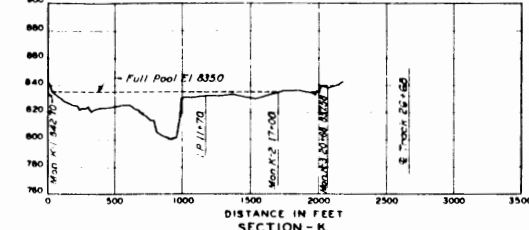
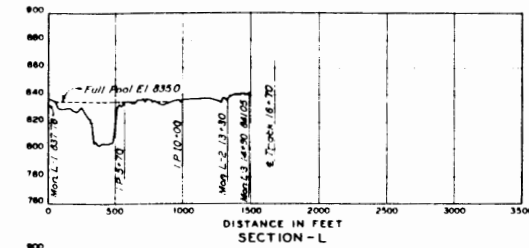
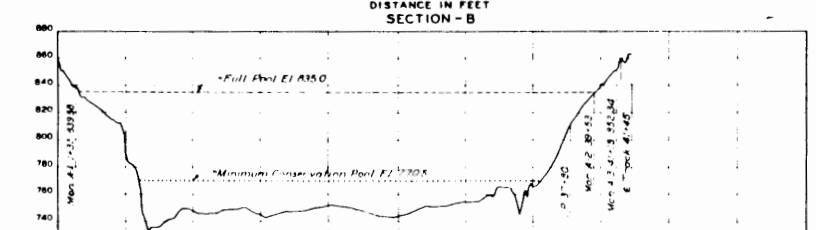
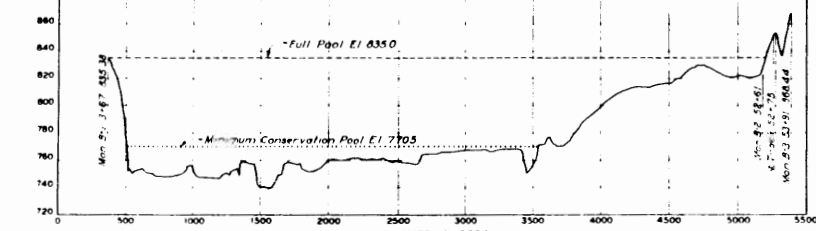
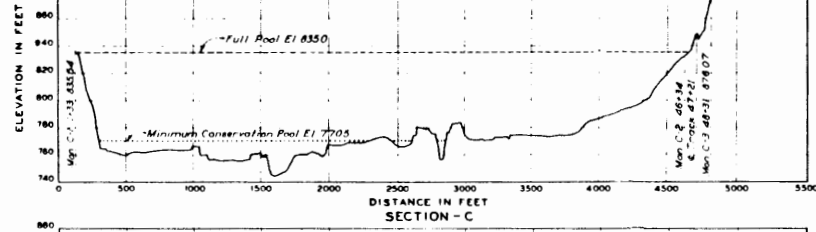
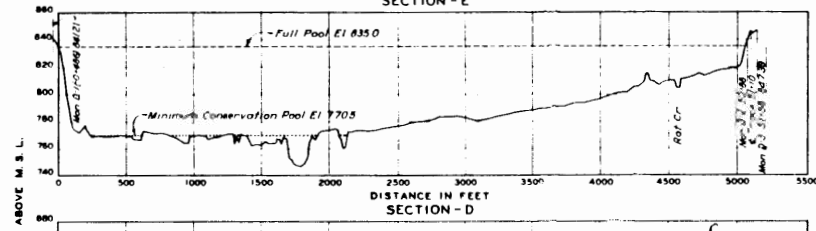
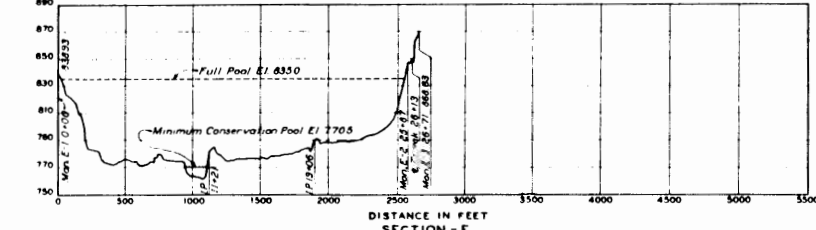
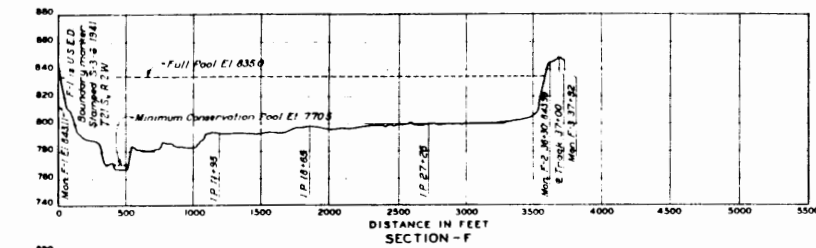
TYPICAL CONCRETE RANGE MARKER  
IN PLACE



DORENA RESERVOIR AND WATERSHED

NOTE:  
ARROWS POINT IN THE DIRECTION IN WHICH THE PICTURES  
WERE TAKEN. OPEN CIRCLES SHOW THE APPROXIMATE  
LOCATION OF EACH VIEW.

WILLAMETTE RIVER AND TRIBUTARIES, OREGON  
ROW RIVER  
**DORENA RESERVOIR REGULATION  
SEDIMENTATION RANGE  
GENERAL PLAN**  
SCALE: IN FEET  
PORTLAND DISTRICT, CORPS OF ENGINEERS, SEPT. 1, 1953  
DESIGNED BY *W. H. Peterson*  
CHECKED BY *W. H. Peterson*  
DRAWN BY *W. H. Peterson*  
DO-20-21/18



Notes  
 1. Dorena project became officially operative on 23 October 1929. Reservoir began filling September 1929.  
 2. All cross sections shown for any downstream section A through U were fully obtained in 1929.  
 3. All other sections shown in this report were obtained in 1929.  
 4. Permanent range measurements are indicated at the range ends for future reference.  
 5. Elevations are referred to mean sea level, 1929 adjustment.

WILLAMETTE RIVER AND TRIBUTARIES, OREGON  
 ROW RIVER  
**DORENA RESERVOIR REGULATION**  
**SEDIMENTATION SURVEY**  
**CROSS - SECTIONS**  
 SCALES AS SHOWN  
 PORTLAND DISTRICT, CORPS OF ENGINEERS, SEPT. 1, 1953

DESIGNED BY: *[Signature]*  
 DRAWN BY: *[Signature]*  
 CHECKED BY: *[Signature]*  
 APPROVED BY: *[Signature]*  
 DATE: *[Date]*  
 SHEET NO. 118

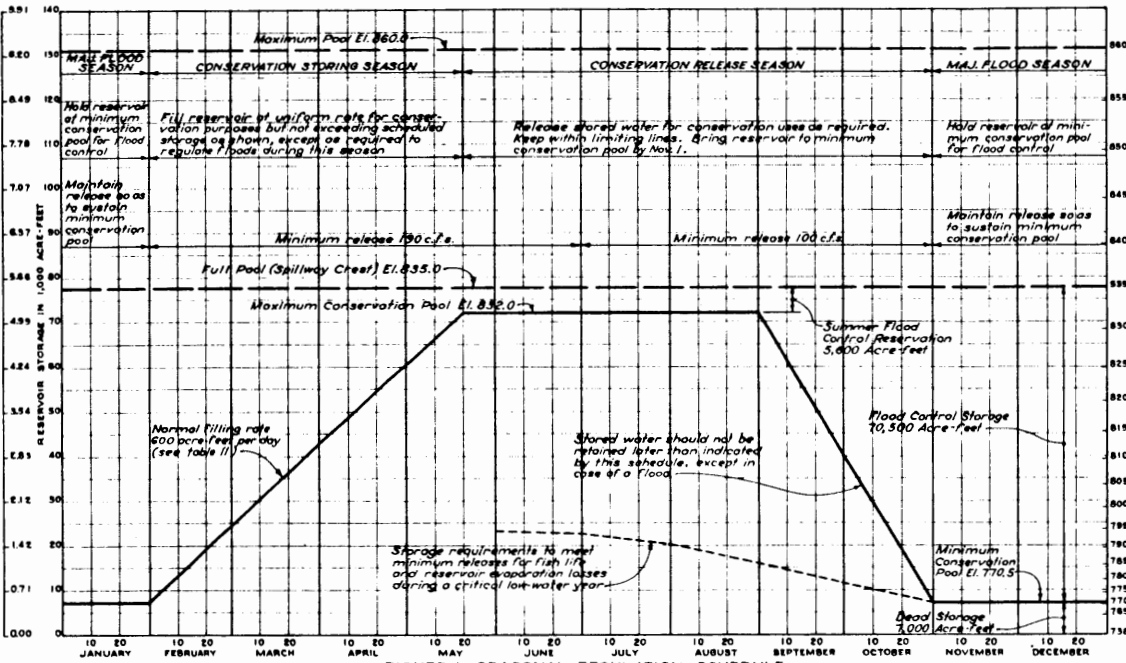


FIGURE 1, SEASONAL REGULATION SCHEDULE

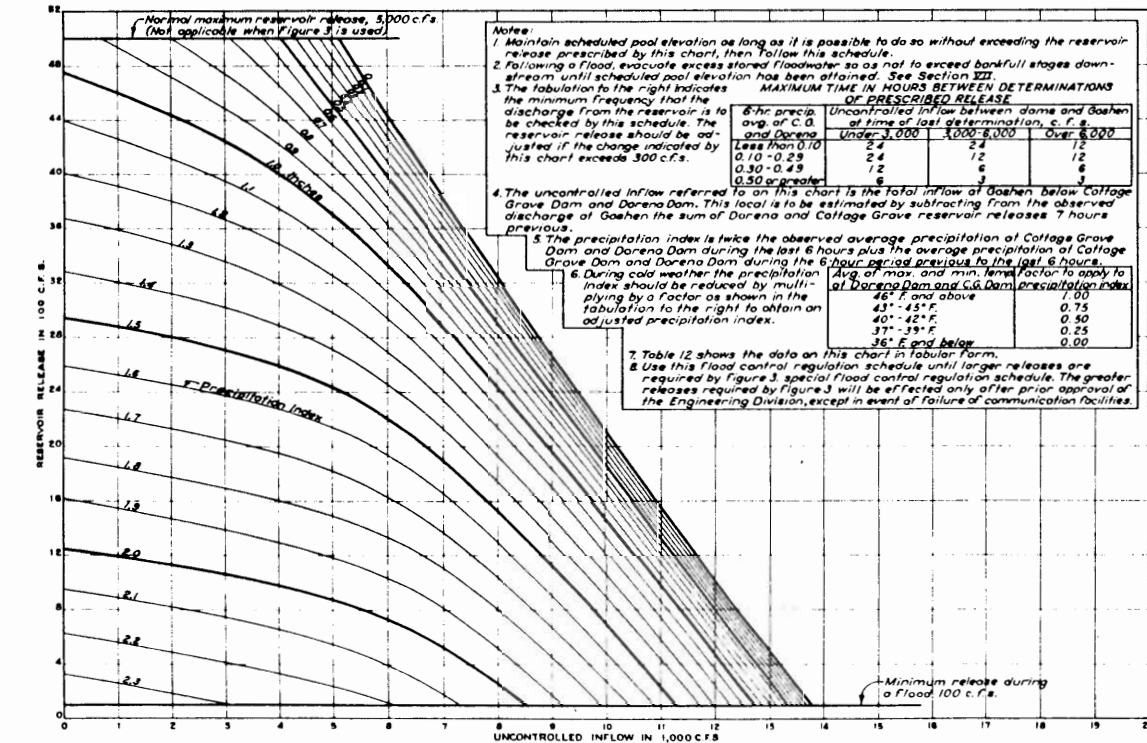


FIGURE 2, FLOOD CONTROL REGULATION SCHEDULE

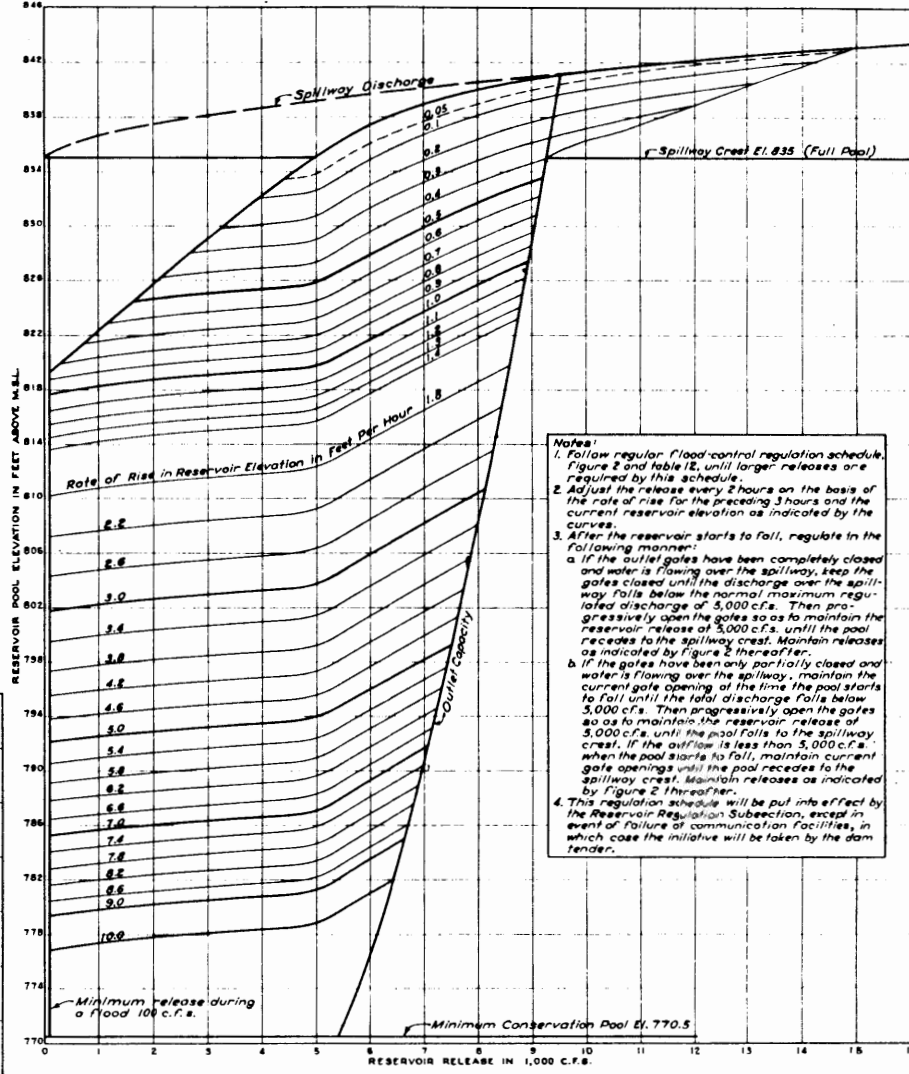


FIGURE 3, SPECIAL FLOOD CONTROL REGULATION SCHEDULE

Notes:  
 1. Follow regular flood control regulation schedule, Figure 2 and table 12, until larger releases are required by this schedule.  
 2. Adjust the release every 2 hours on the basis of the rate of rise for the preceding 3 hours and the current reservoir elevation as indicated by the curves.  
 3. After the reservoir starts to fall, regulate in the following manner:  
 a. If the outlet gates have been completely closed and water is flowing over the spillway, keep the gates closed until the discharge over the spillway falls below the normal maximum regulated discharge of 5,000 c.f.s. Then progressively open the gates so as to maintain the reservoir release of 5,000 c.f.s. until the pool recedes to the spillway crest. Maintain releases as indicated by Figure 2 thereafter.  
 b. If the gates have been only partially closed and water is flowing over the spillway, maintain the current gate opening at the time the pool starts to fall until the total discharge falls below 5,000 c.f.s. Then progressively open the gates so as to maintain the reservoir release of 5,000 c.f.s. until the pool falls to the spillway crest. If the outflow is less than 5,000 c.f.s. when the pool starts to fall, maintain current gate openings until the pool recedes to the spillway crest. Maintain releases as indicated by Figure 2 thereafter.  
 4. This regulation schedule will be put into effect by the Reservoir Regulation Subsection, except in event of failure of communication facilities, in which case the initiative will be taken by the dam tender.

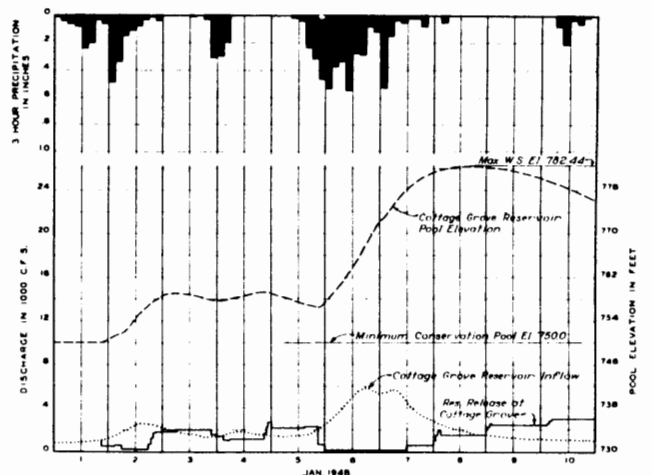
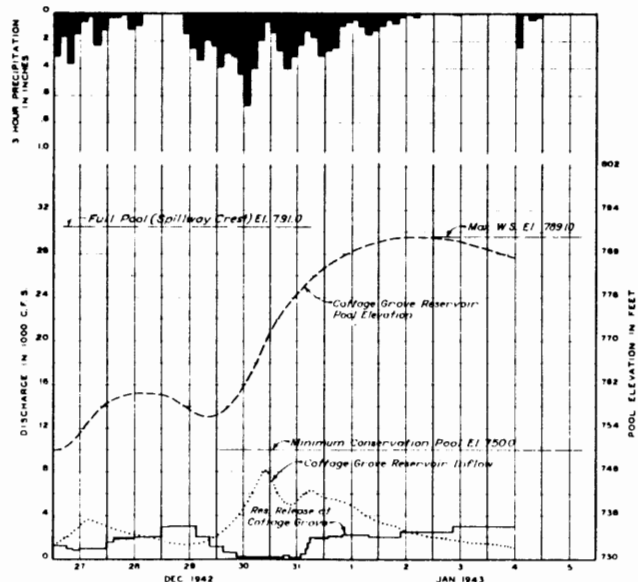
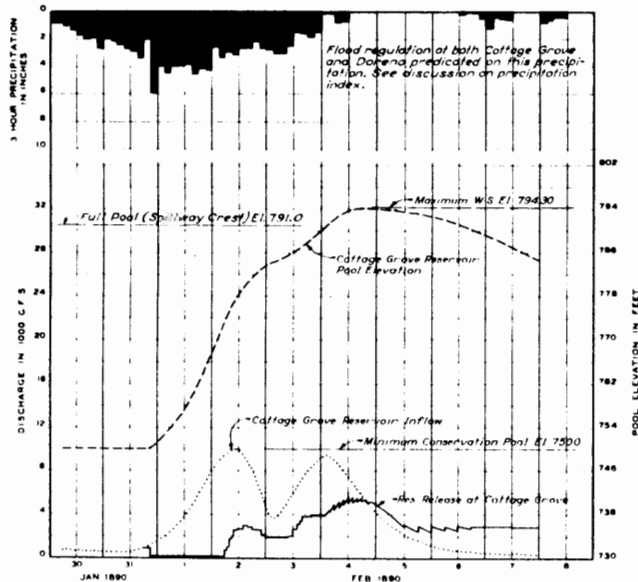
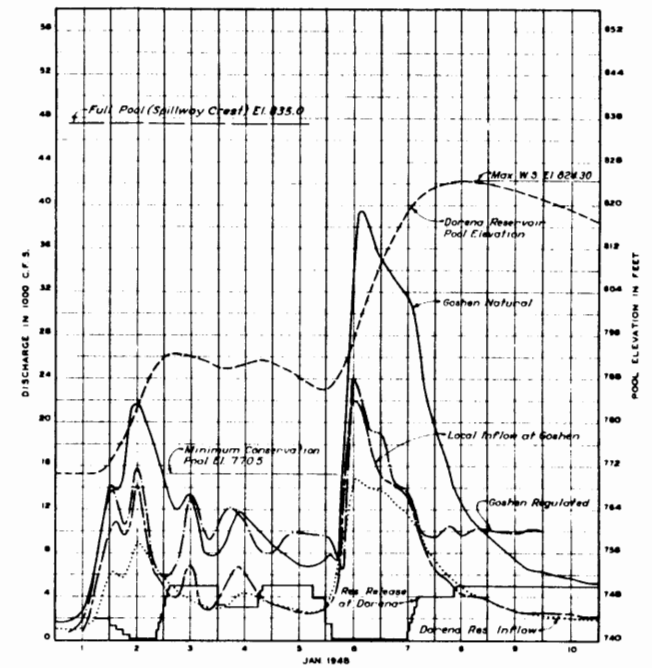
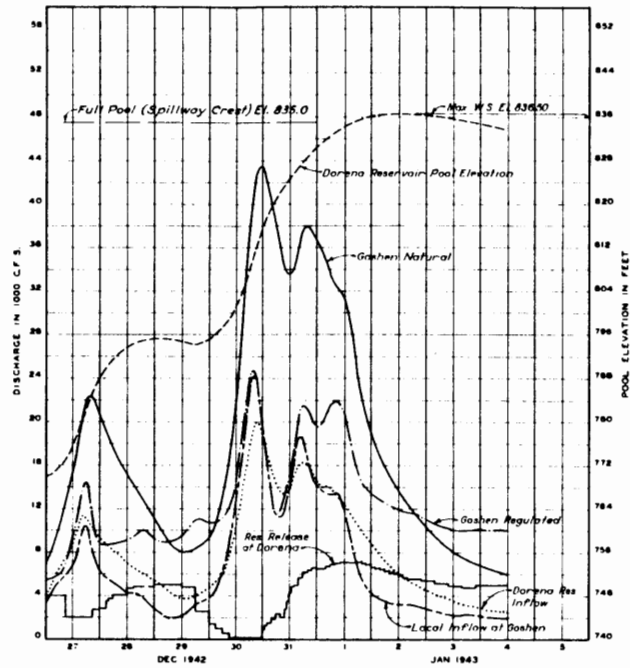
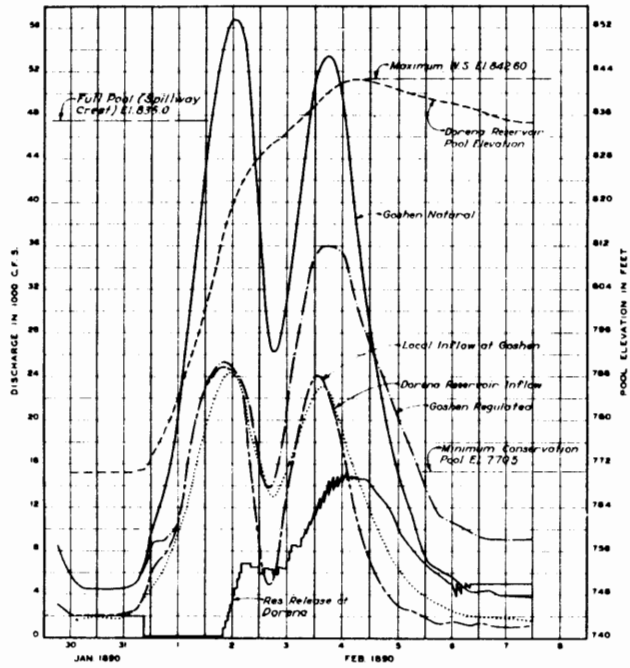
WILLAMETTE RIVER AND TRIBUTARIES, OREGON  
 ROW RIVER  
 DORENA RESERVOIR REGULATION  
 REGULATION SCHEDULES

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

SUPERVISOR: *E. Johnson*  
 CHECKED: *W. J. Johnson*  
 SUBMITTED: *W. J. Johnson*  
 DRAWN BY: *W. J. Johnson*  
 CHECKED BY: *W. J. Johnson*

RECORDED: *W. J. Johnson*  
 INDEXED: *W. J. Johnson*  
 APPROVED: *W. J. Johnson*  
 COLLECTOR: *W. J. Johnson*  
 CHECKED: *W. J. Johnson*

DO-20-21/20



FLOOD OF JANUARY - FEBRUARY 1890

FLOOD OF DECEMBER 1942 - JANUARY 1943

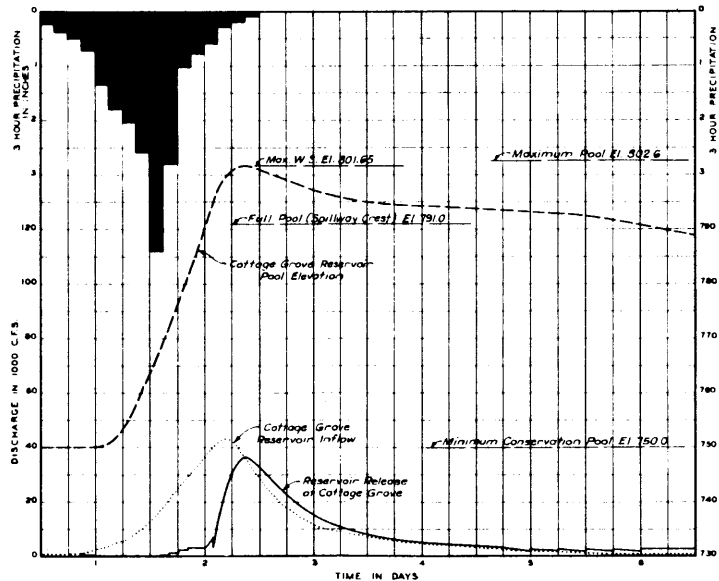
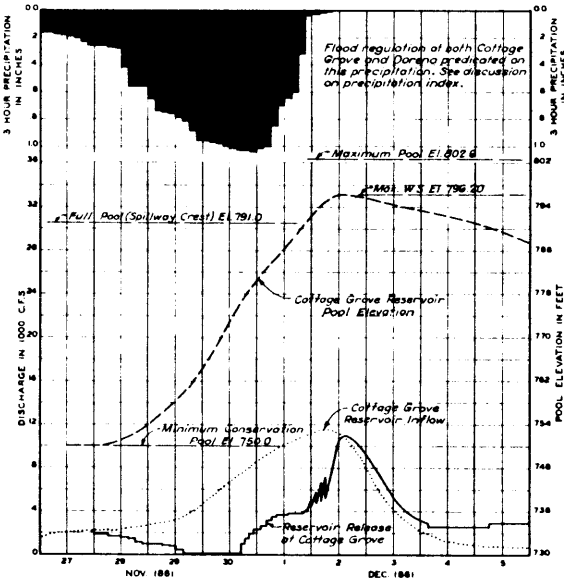
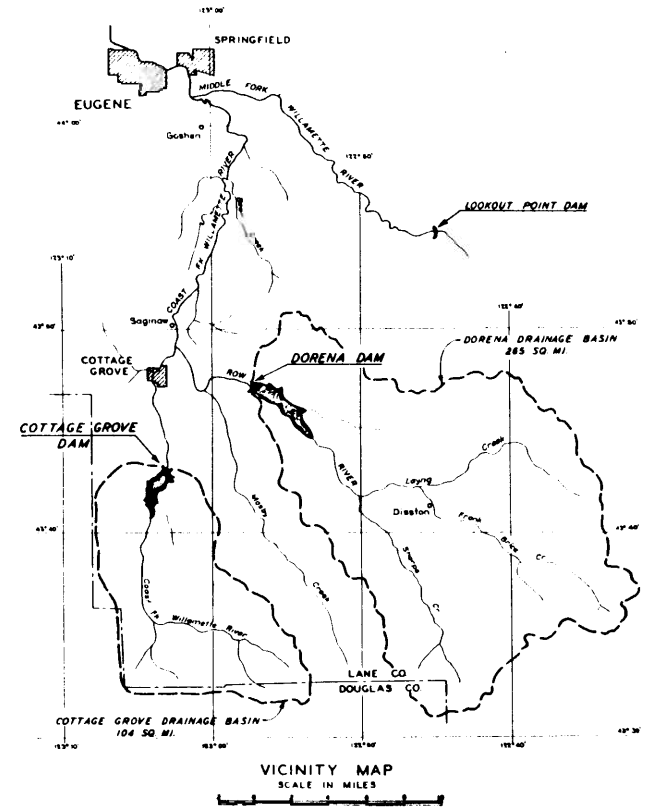
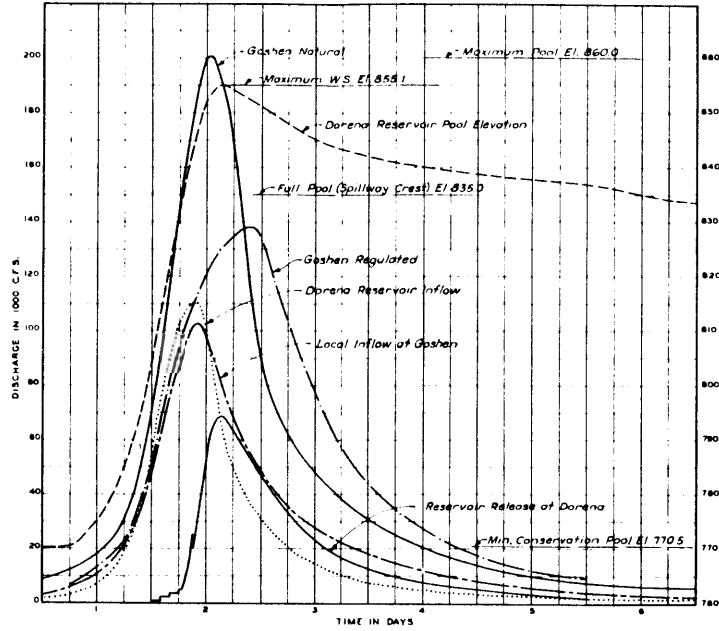
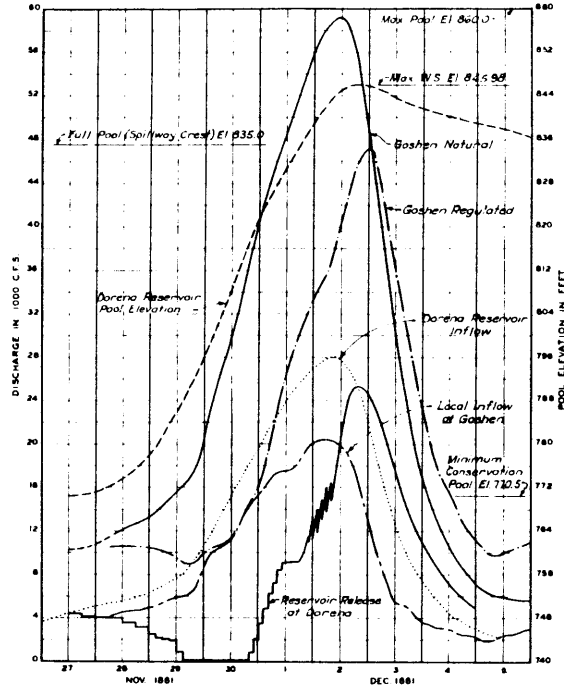
FLOOD OF JANUARY 1948

WILLAMETTE RIVER AND TRIBUTARIES, OREGON  
 ROW RIVER  
**DORENA RESERVOIR REGULATION**  
**EXAMPLES OF REGULATION**  
**MAJOR FLOODS**

IN 2 SHEETS SCALES AS SHOWN SHEET NO. 1  
 PORTLAND DISTRICT, CORPS OF ENGINEERS, SEPT. 1, 1953

DESIGNED BY: [Signature]  
 SUPERVISED BY: [Signature]  
 CHECKED BY: [Signature]  
 DRAWN BY: [Signature]  
 TRACED BY: [Signature]  
 ORDERED BY: W. A. M.

Note: Elevations are referred to Mean Sea Level



FLOOD OF NOVEMBER-DECEMBER 1861

SPILLWAY DESIGN FLOOD

WILLAMETTE RIVER AND TRIBUTARIES OREGON  
ROW RIVER  
**DORENA RESERVOIR REGULATION**  
**EXAMPLES OF REGULATION**  
**MAJOR FLOODS**

IN 2 SHEETS SCALES AS SHOWN SHEET NO. 2  
PORTLAND DISTRICT, CORPS OF ENGINEERS, SEPT. 1, 1953

DESIGNED BY: *[Signature]* RECOMMENDED BY: *[Signature]*  
CHECKED BY: *[Signature]* CHECKED BY: *[Signature]*  
DRAWN BY: *[Signature]* DRAWN BY: *[Signature]*  
TRACED BY: J.M. TRACED BY: J.M.  
CHECKED BY: W.A.M. CHECKED BY: W.A.M.

DO-20-21/22





US Army Corps  
of Engineers®  
Portland District

## EXHIBIT A

# DROUGHT CONTINGENCY PLAN FOR THE WILLAMETTE VALLEY PROJECT



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



# Drought Contingency Plan for the Willamette Valley Project

## Table of Contents

	<u>Page</u>
1.0 Introduction.....	1
1-01. Purpose .....	1
1-02. Requirements .....	1
1-03. Background.....	1
1-04. Responsibilities.....	1
2.0 Authorities.....	1
3.0 Droughts.....	3
3-01. Definition of Drought .....	3
3-02. Historical Oregon Droughts.....	3
3-03. Drought Signals and Indicators .....	5
3-04. Drought Monitoring and Climate Forecasts .....	6
a. USDA Drought Monitor .....	6
b. Natural Resources Conservation Service Oregon.....	6
c. Drought Severity .....	7
3-05. Drought in the Context of Climate Change.....	7
a. Drought Contingency Planning for Climate Change .....	8
b. Climate and Streamflow Projections .....	8
c. Implications for Water Management .....	9
4.0 Basin Description.....	9
4-01. Willamette Basin Description.....	9
4-02. Willamette Reservoir System .....	9
4-03. USACE Projects in the Willamette Valley Project .....	11
5.0 Water Uses and Availability .....	11
5-01. Water Uses.....	11
a. Irrigation.....	11
b. Fishery Enhancement.....	14
c. Recreation .....	14
d. Hydropower .....	14
e. Environmental.....	14
f. Municipal and Industrial Water Supply.....	14
g. Navigation.....	15
h. Water Quality.....	15
i. Effects on Cultural Resources.....	15
5-02. Available Storage .....	16
a. Quantity of Inactive Storage .....	16
b. Ability to Use Inactive Storage.....	16
c. Ability to Use Power Pool Storage .....	17
d. Quantity of Uncontracted Water Supply Storage .....	18
e. Ability to use Uncontracted Water and Procedures to Obtain Water .....	18
f. Use of Surplus Water.....	18
6.0 Oregon Water Rights .....	18

	<u>Page</u>
6-01 Appropriation Doctrine.....	18
6-02 Instream Water Rights.....	19
6-03 Irrigation Contracts.....	19
7.0 Flow Management .....	19
7-01. Reservoir Regulation Seasons .....	19
7-02. Willamette Conservation Plan.....	20
7-03. Forecasts .....	20
7-04. Methods and Tools .....	21
7-05. Project Minimum Flows .....	21
7-06. System Minimum Flow Objectives .....	22
7-07. Adaptive Management.....	24
8.0. Drought Management .....	25
8-01. Reservoir Regulation in Drought Conditions .....	25
8-02. Flow Objectives in Past Drought Years .....	25
8-03. Reservoir Regulations in Past Drought Years .....	26
a. Reducing Minimum Winter Flow .....	26
b. Winter Steelhead in the Santiam Basin.....	26
c. Chinook Spawning in the Santiam Basin.....	26
d. Mainstem Flows.....	27
8-04. Determination of Interim Draft Limits .....	27
8-05. Priorities.....	27
9.0 USACE’s Emergency Navigation.....	28
10.0 State of Oregon Drought Management .....	28
10-01. Authorities .....	28
10-02. Declaration of Drought.....	28
a. Drought Readiness Council.....	29
b. Water Supply Availability Committee.....	29
10-03. Drought Strategies .....	30
11.0 Coordination .....	30
11-01. USACE .....	30
11-02. Regional.....	30
11-03. State of Oregon.....	31
11-04. County Emergency Managers .....	31
12.0 Internal and External Communication.....	31
12-01. Congressional Briefs and Public Officials.....	31
12-02. Public Communication .....	31
12-03. Internet.....	32
13.0 Emergency Assistance for Drought .....	31
REFERENCES .....	33
WEBLINKS .....	34

<u>Tables</u>	<u>Page</u>
Table 4-1. List of Willamette Valley Project Water Control Manuals .....	11
Table 5-1. Willamette System Irrigation Contract Data .....	12
Table 5-2. Inactive Storage Volume by Project.....	17
Table 5-3. Powerpool Storage Volume by Project .....	17
Table 7-1. 2008 Biological Opinion and Congressional Minimum Reservoir Outflow.....	23
Table 7-2. Evaluation of Spring Runoff and Conservation Operation .....	24
Table 7-3. Minimum Mainstem Threshold Flows for Albany and Salem.....	24
Table 8-1. Past Drought Year Interagency Minimum Flow Objectives, Albany .....	25
Table 8-2. Past Drought Year Interagency Minimum Flow Objectives, Salem .....	26

<u>Figures</u>	<u>Page</u>
Figure 3-1. Willamette Basin Monthly Precipitation.....	4
Figure 3-2. Peak Annual Oregon Snowpack 1981-2015 .....	5
Figure 3-3. Oregon River Basins to Evaluate Drought Conditions .....	7
Figure 4-1. Willamette Valley Project Map.....	10
Figure 5-1. Water Service Contracts Reach Map .....	13
Figure 10-1. Standard Drought Declaration Process .....	29

Attachment 1. USACE-City Agreement Template, Temporary Withdrawal of Water

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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<sup>1</sup> 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.

<sup>1</sup> “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.

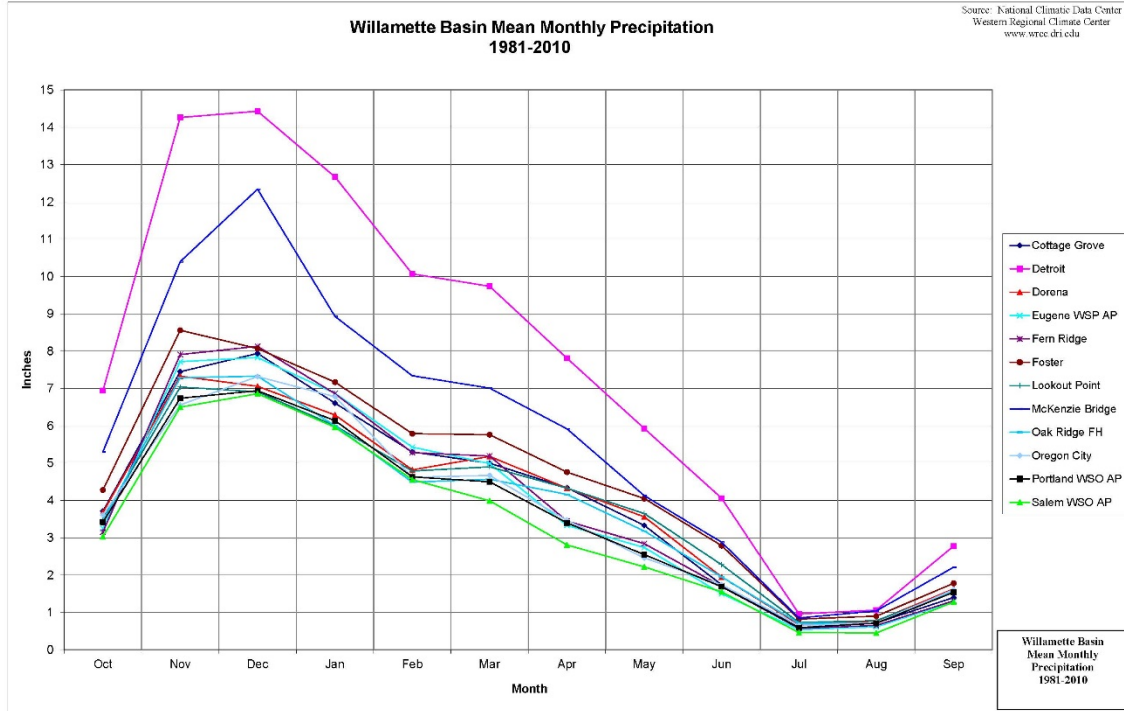


Figure 3-1. Willamette Basin Monthly Precipitation

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.*).

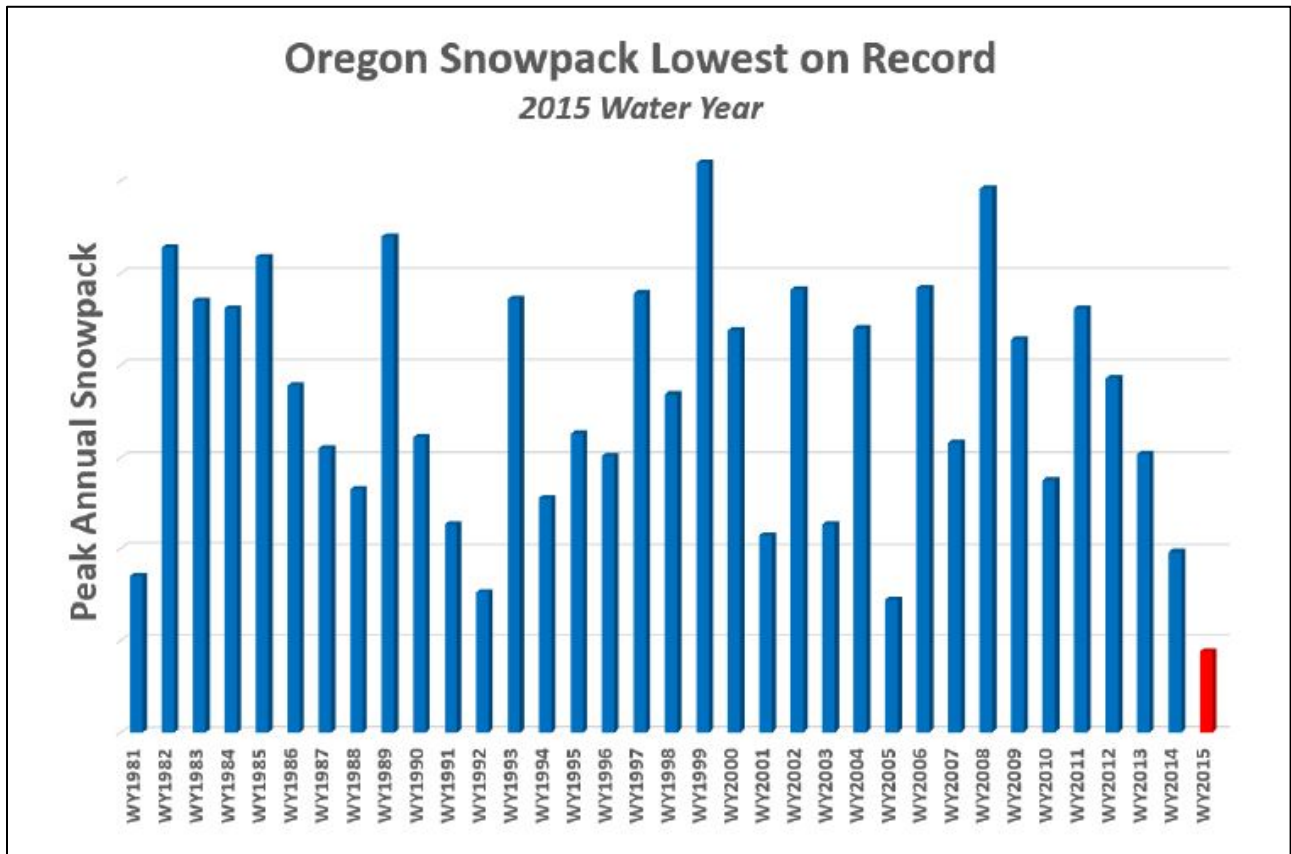
- 1904-1905: Drought period of about 18 months
- 1917-1931: Very dry period punctuated by brief wet spells (1920-21, 1927)
- 1939-1941: Three year intense drought
- 1976-1977: Brief, but intense statewide drought
- 1985-1994: Generally dry period, with statewide droughts in 1992 and 1994
- 2001-2002: 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.

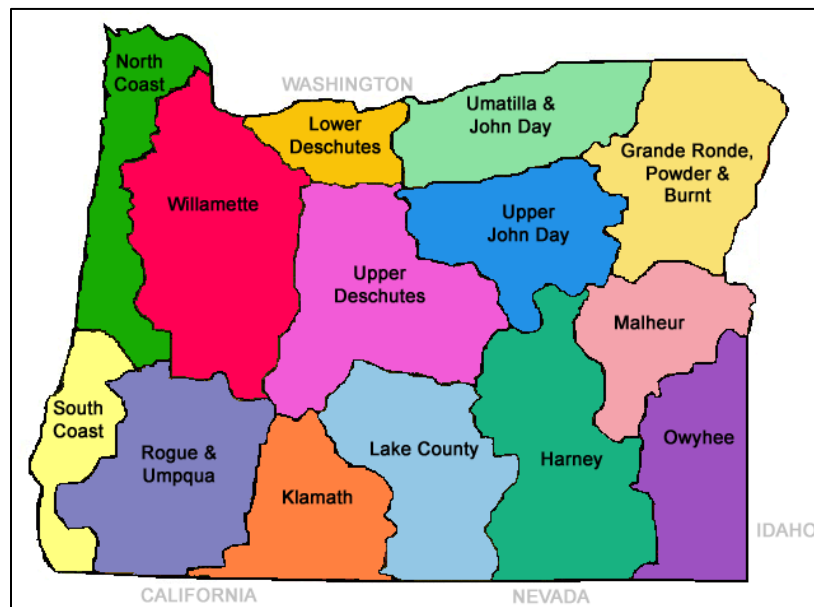


Figure 3-3. Oregon River Basins to Evaluate Drought Conditions

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 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 20<sup>th</sup>, 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.

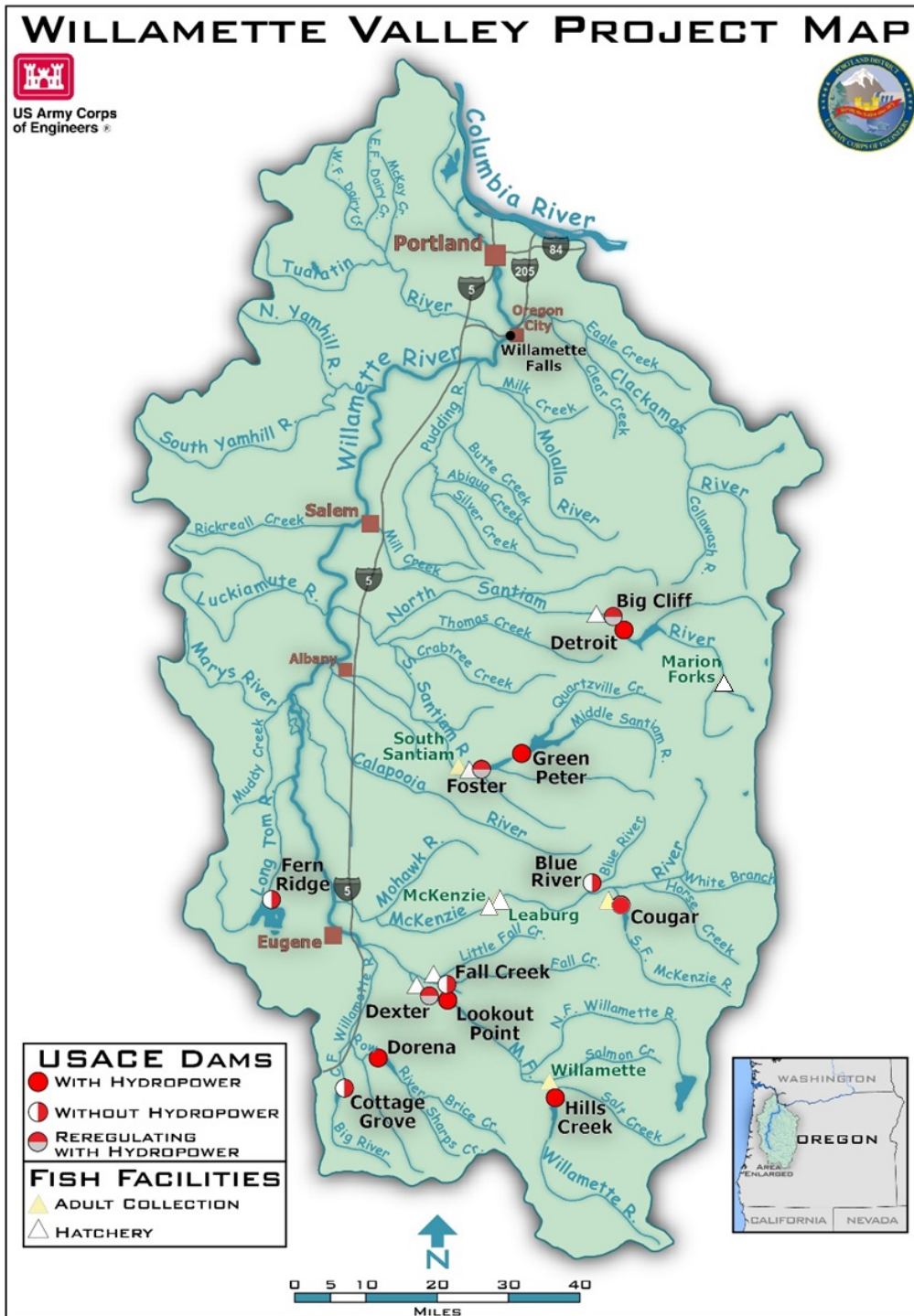


Figure 4-1. Willamette Valley Project Map

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

<b>Appendix</b>	<b>Project</b>
--	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

	<b>Reach</b>	<b>Reservoirs Providing Water</b>	<b>Number of Contracts</b>	<b>Acre-Foot Contracted</b>	<b>Acres Served</b>
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
<b>Total</b>			<b>228</b>	<b>74,899</b>	<b>40,262</b>

Source: Reclamation, as of February, 2017

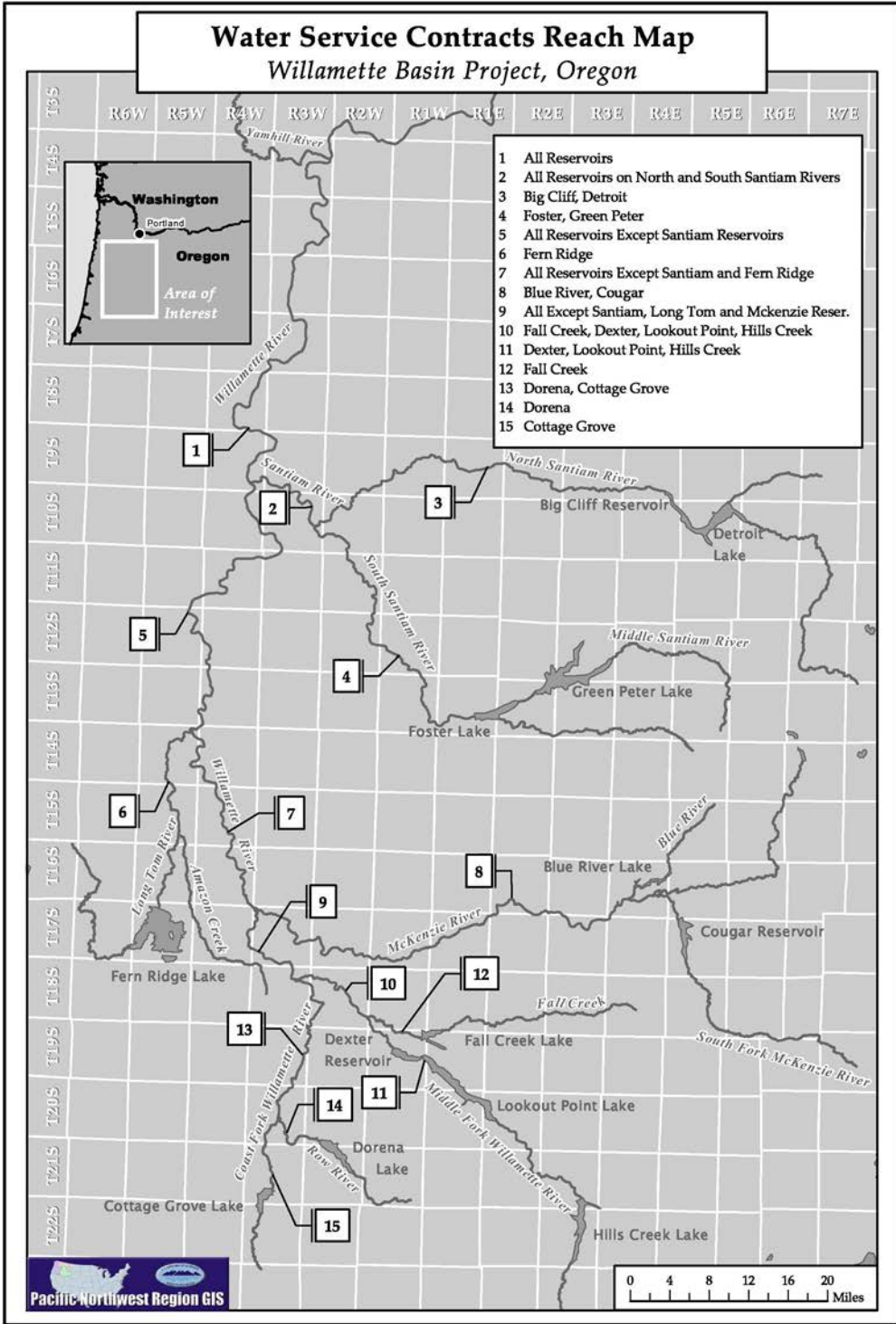


Figure 5-1. Water Service Contracts Reach Map

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<sup>1</sup>

<b>Project</b>	<b>Inactive Storage Volume (Acre-Feet)</b>	<b>Inactive Storage (Percent)</b>
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%
<b>Total</b>	<b>359,999</b>	<b>100.0%</b>

<sup>1</sup>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<sup>1</sup>

<b>Project</b>	<b>Powerpool Storage Volume (Acre-Feet)</b>	<b>Powerpool Storage (Percent)</b>
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%
<b>Total</b>	<b>171,452</b>	<b>100.0%</b>

<sup>1</sup>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 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 <sup>1</sup>
<b>Detroit/Big Cliff</b>	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				
<b>Blue River</b>	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				
<b>Cottage Grove</b>	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					
<b>Cougar</b>	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				
<b>Dorena</b>	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					
<b>Fall Creek</b>	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				
<b>Fern Ridge</b>	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					
<b>Green Peter/Foster</b>	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				
<b>Hills Creek</b>	1 Feb - 31 Aug	400	rearing	Feb-Nov	100	Feb-Jun	100
	1 Sep - 31 Jan	400	migration and rearing			Jul - Nov	100
<b>Lookout Point/Dexter</b>	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				

<sup>1</sup> 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) <sup>1</sup>	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 <sup>2</sup>	---	---

<sup>1</sup> Period of record 1936-1999 using flow objectives in columns 2, 4, and 5 in Table 7-3

<sup>2</sup> Maximum usable conservation storage.

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

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

<sup>1</sup> 2008 Biological Opinion Appendix D, Table D-2.

<sup>2</sup> Congressional minimum flows from House Document (HD) 531, Volume 5, paragraph 88.

<sup>3</sup> 2008 Biological Opinion Appendix D, Table D-1, biologically based minimum flow objectives.

<sup>4</sup> 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

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

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

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

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

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

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

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

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

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

By the end of spawning, in years of little precipitation and when projects were near or at minimum conservation pool, NOAA Fisheries had expressed a need to use power pool storage

and inactive pool storage to provide water for fish. Under this condition, major impacts could occur. Any use of power pool water must be discussed and agreed upon by the BPA.

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

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

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

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

## 9.0. USACE's Emergency Navigation

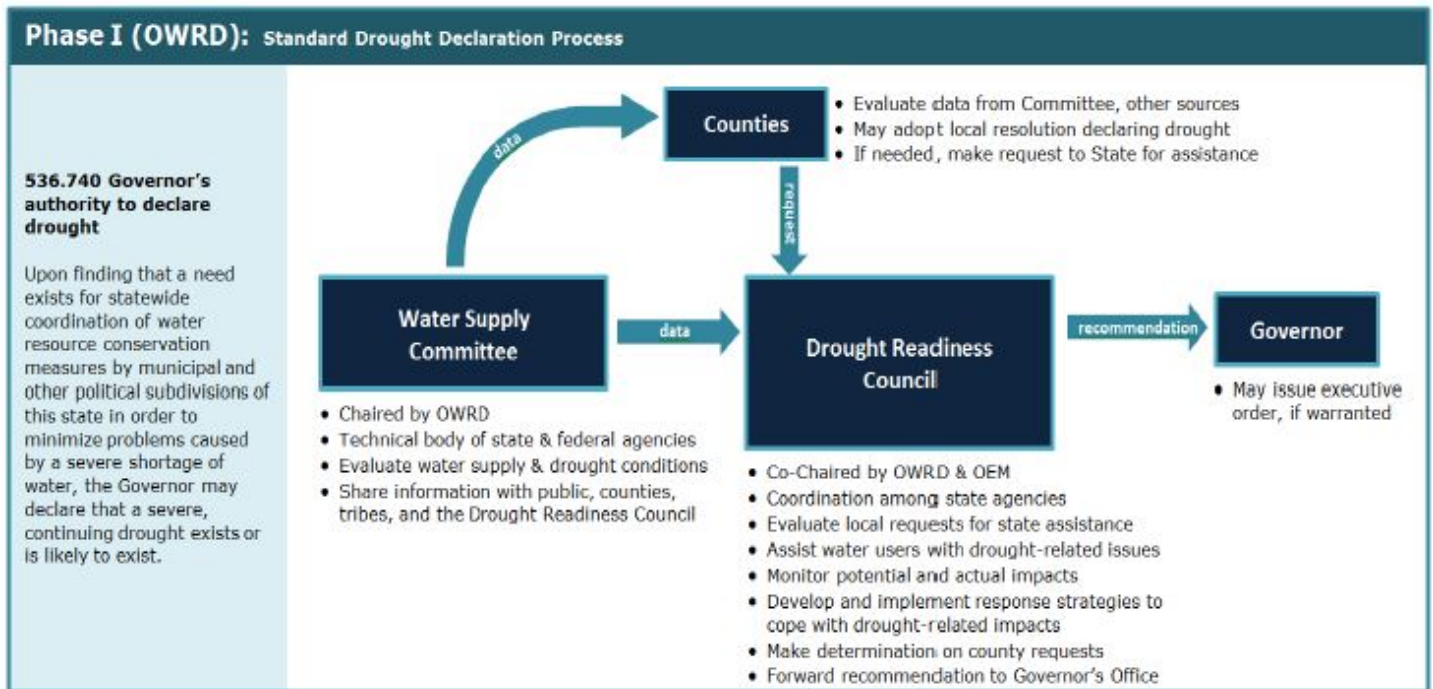
Although there is authorization for navigation in the mainstem Willamette River, there is currently little to no actual navigation for commercial purposes. There is no opportunity to move boats around the Willamette Falls at Oregon City except by trailer. Navigation did not seem to be an issue during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

## 10.0 State of Oregon Drought Management

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

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

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



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

Figure 10-1. Standard Drought Declaration Process

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

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

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

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

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

## 11.0 Coordination

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

11-02. Regional. The USACE coordinates with the region on reservoir operations to meet the ESA and all other purposes of the Willamette Valley Project through the WATER

forum. WATER works as a collaborative regional forum among the sovereign governments (federal/state/tribal) with responsibility for assisting the federal Action Agencies (USACE, BPA, and Reclamation) in the coordinated implementation of the ESA and related measures. WATER is also responsible for making recommendations to the Action Agencies in implementing the Willamette Biological Opinions' RPA.

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

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

## 12.0 Internal and External Communication

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

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

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

## 13.0 Emergency Assistance for Drought

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

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

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

## REFERENCES

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

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

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

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

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

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

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

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

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

WEBLINKS (as of May 2017)

NOAA's Climate Prediction Center ENSO status:

[http://www.cpc.ncep.noaa.gov/products/expert\\_assessment/ENSO\\_DD\\_archive.shtml](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](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](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](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 1964 (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

FOR THE [CITY]

By \_\_\_\_\_

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

By \_\_\_\_\_

[name of signatory]  
[position or title]

DATE: \_\_\_\_\_

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**

<b>Item</b>	<b>Type of Use</b>	<b>Computation</b>	<b>Cost</b>
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]%. [ ]% <sup>2</sup> x \$[total joint-use O&M for previous FY]	\$[total cost]
Operation and maintenance <sup>1</sup>	Joint-use actual for FY [previous FY]	[ ]% <sup>2</sup> x \$[total joint-use O&M for previous FY]	\$[share of O&M]
Repair, rehabilitation and replacement <sup>3</sup>	Joint-use actual for FY [previous FY]	[ ]% <sup>2</sup> 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: \_\_\_\_\_















































































































































































































