# Mud Mountain Dam
## White River Washington

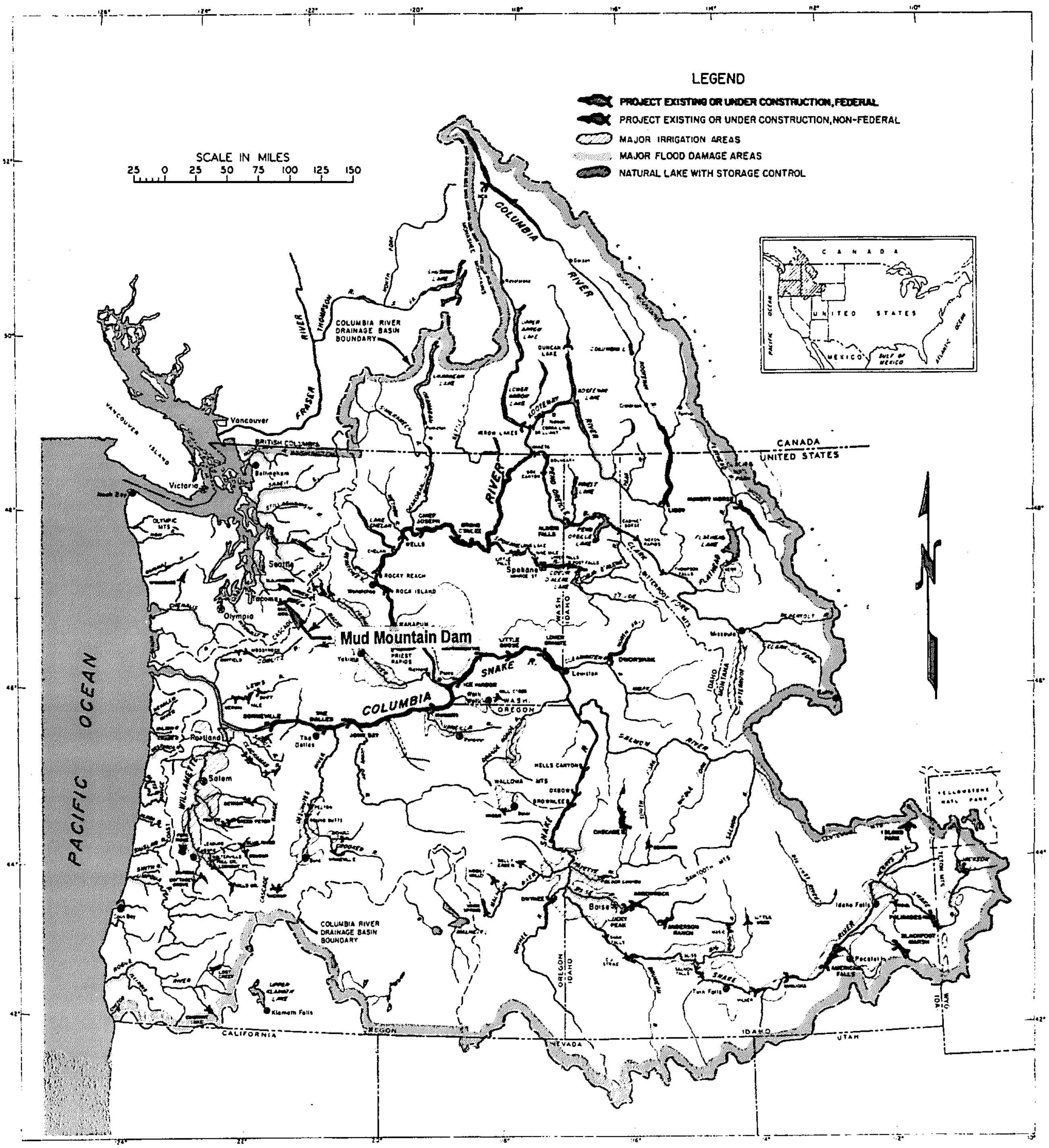
# Water Control Manual

US Army Corps
of Engineers®
Seattle District

September 2004

MUD MOUNTAIN DAM INTAKE STRUCTURE

# COLUMBIA RIVER AND COASTAL BASINS



## 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 insertions can be made to keep the manual current.

## REVISIONS TO MANUAL

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

## WATER CONTROL ASSISTANCE PERSONNEL

In the event that unusual conditions arise during non-duty hours, contact can be made by telephone to personnel of the Hydrology and Hydraulics Section, in the order listed:

**REDACTED CONTENT**

For instructions in case of emergency situations at Mud Mountain Dam, refer to Section 7.05e, Emergency Regulation Procedures.

## LIST OF ACRONYMS & ABBREVIATIONS

| | |
|---|---|
| CENWS | Seattle District, U.S. Army Corps of Engineers |
| CSP | Cooperative Streamgaging Program |
| DM | Design Memorandum |
| DO | Dissolved Oxygen |
| DOE | Washington State Department of Ecology |
| ERS | Environmental Resources Section |
| USFWS | U. S. Fish and Wildlife Service |
| HHS | Hydrology and Hydraulics Section |
| MMD | Mud Mountain Dam |
| NRCS | Natural Resources Conservation Service |
| NTU | Nephelometric Turbidity Units |
| NWD | Northwestern Division, U.S. Army Corps of Engineers |
| NWS | National Weather Service |
| O&M | Operation and Maintenance |
| PDF | Project Design Flood |
| PMF | Probable Maximum Flood |
| PSE | Puget Sound Energy |
| QPF | Quantitative Precipitation Forecast |
| RCC | Reservoir Control Center |
| RFC | River Forecast Center |
| RFS | River Forecast Systems |
| RK | River Kilometers |
| RM | River Mile |
| SDF | Spillway Design Flood |
| SPF | Standard Project Flood |
| SSARR | Streamflow Synthesis and Reservoir Regulation |
| USGS | United States Geological Survey |
| WDFW | Washington State Department of Fish and Wildlife |

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# MUD MOUNTAIN DAM

## PERTINENT DATA

### GENERAL

| | | |
|---|---|---|
| Federal Identification Number | | WA00300 |
| Owner/Operator | | Corps of Engineers, Seattle District |
| Date Constructed | | 1939-1942 and 1947-1948 |
| Purpose | | Flood Control |
| Downstream Hazard Potential | | Category 1 (High) |
| Size Classification | | Large |
| County | | King-Pierce Border |
| State | | Washington |
| Tributary | | White |
| River Basin | | Puyallup |
| Distances | River Km | River Mile |
| Above Mouth of White River | 47.6 | 29.6 |
| Above Mouth of Puyallup River | 64.3 | 40 |
| From Enumclaw, WA | 11.2 | 7 |
| (nearest post office, population 11,116) | | |
| From Tacoma, WA | 64.3 | 40 |
| (nearest principal city, population 193,556) | | |

### REAL ESTATE

| | Hectares | Acres |
|---|---|---|
| Owned in Fee | 754.08 | 1,863.33 |
| By Easement | 22.94 | 56.69 |
| Leased | 1.41 | 3.48 |
| Total Real Estate | 778.43 | 1,923.50 |
| Reservoir Guide Taking Elev. | 385.5 meters | 1,265 feet |

### HYDROLOGIC DATA

| | | |
|---|---|---|
| Drainage Area | 1,036 $km^2$ | 400 sq. mi. |
| Average Annual Discharge at USGS Streamgage White River near Buckley (Oct 1929-Nov 1933, Oct 1938-Sept 1992) | 40.46 $m^3/s$ | 1,429 cfs |
| Runoff, Mean Annual over 400 sq. mi. basin | 1,229.1 mm | 48.39 in |
| Runoff, Mean Annual | 127,615.5 ha-m | 1,035,000 AF |
| Peak Discharge, Historical, Estimated Dec 1933 | 792.4 $m^3/s$ | 28,000 cfs |
| Peak Discharge, Recorded Feb 26, 1932 | 481.1 $m^3/s$ | 17,000 cfs |
| Peak Discharge, deregulated, Feb 1996 | 837.0 $m^3/s$ | 29,560 cfs |
| Flood Regulation Control Station, Feb 1996 Puyallup River at Puyallup Peak Discharge, Deregulated, Estimated | 2152.1 $m^3/s$ | 76,000 cfs |

## RESERVOIR

| | Elevation Meters (Feet) | Pool Area Hectares (Acres) | Pool Capacity Hectare-meters (Acre-Feet) | Project Discharge Capacity Meters$^3$/Sec (cfs) |
|---|---|---|---|---|
| Empty Pool (Lowest Outlet Elevation) | 272.79 (895) | 0 (0) | 0 (0) | 0 (0) |
| Top of Flood Control (Spillway Crest) | 370.33 (1215) | 392.55 (970) | 13,109.1 (106,275) | 750.5 26,500 |
| Spillway Design Flood Pool | 381.67 (1252.2) | 530.15 (1,310) | 18,218.9 (147,700) | 6,938.4 (245,000) |
| Top of Dam | 383.13 (1,257) | 535.82 1,324 | 18,968.3 (153,775) | Not Applicable |

Reservoir Length, elev. 1215 feet 8.8 km 5.5miles

## EMBANKMENT

| | | |
|---|---|---|
| Type | Rockfill (concrete cutoff wall in earth core) | |
| Structural Height | 131.67 m | 432 feet |
| Crest Elevation | 383.13 m | 1,257 feet |
| Crest Length | 246.88 m | 810 feet |
| Width: at Base | 487.68 m | 1,600 feet |
| at Crest | 7.77 m | 25.5 feet |
| Design Freeboard | 1.46 m | 4.8 feet |
| Cutoff Wall: Length | 246.27 m | 808 feet |
| Height | 122.71 m | 402.6 feet |
| Width | 1.06 m | 3.5 feet |

## SPILLWAY

| | | |
|---|---|---|
| Location | Right abutment | |
| Type | Uncontrolled chute | |
| Length | 365.76 m | 1,200 feet |
| Crest Elevation | 370.33 m | 1,215 feet |
| Width | 96.01 m | 315 feet |
| Walls (average height) | 7.31 m | 24 feet |
| Design Capacity | 6,933.5 $m^3/s$ | 245,000 cfs |

## INTAKE TOWER AND TUNNELS

### Low-flow Entrance Structure

| | |
|---|---|
| Left Half. | 17.6 m high x 6.7 m wide |
| | 58 feet x 22 feet |
| Invert | 272.7 m  895 feet |
| Trash Rack (three cross beams) | 1.2 m high x 1.2 m deep |
| | 4 feet x 4 feet |
| Net Opening | 65.50 $m^2$  705 $ft^2$ |
| | |
| Right Half | 12.9 m high x 6.7 m wide |
| | 42.5 feet x 22 feet |
| Invert | 277.5 m  910.5 feet |
| Trash Rack (two cross beams) | 1.2 m high x 1.2 m deep |
| | 4 feet x 4 feet |
| Net Opening | 1.83 m wide x 21. 90 m deep |
| | 6 feet x 69.21 feet |
| Splitter Pier | |
| Stop Logs, one | 9.1 m high x 7.6 m wide |
| | 30 feet x 25 feet |
| one | 4.5 m high x 7.6 m wide |
| | 15 feet x 25 feet |
| one | 9.1 m high x 5.8 m wide |
| | 30 feet x 19.33 feet |

### Trashrack Tower

| | |
|---|---|
| Type | Cylindrical, free standing |
| Diameter | 16.4m  54 feet |
| Height | 42.6m  140 feet |
| Vertical Columns, 36 trapezoidal | 0.9 m deep x 0.51 m outer width |
| | 3 feet x 1.67 feet |
| | 0.36 m inner width,  1.67 feet |
| | |
| Compression Rings, 12 | 0.76 m high x 0.91 m deep |
| | 2.5 feet x 3 feet |
| | |
| Deck, Concrete girders | 0.36 m wide x 2.59 m deep |
| | 1.17 feet x 8.5 feet |
| Grating, bearing bars | 1.22 m x 0.11m at 0.36 m on center |
| | 48 in x 4.33 in at 14.17 in on center |
| Guard rail, concrete barrier | 1.06m high  3.5 feet |
| Vehicle Bridge, concrete deck over 4 prestressed girders | 5.4 m wide  18 feet |

**9-foot Tunnel, R3**

| | |
|---|---|
| Location | Right Bank |
| Type | Concrete, horseshoe |
| Length | 516.33 m   1,694 feet |
| Control | 6.7 m radius, 2.74 m<br>22 feet radius, 9 feet<br>2.74 m radial gate, 9 foot radial gate |
| Invert Elevation | 272.79 m   895 feet |
| Capacity | |
| At pool elevation 370.33 m<br>Elevation 1215 feet | 130.23 $m^3$/sec   4,600 cfs |
| Emergency Closure | Hydraulically operated roller gate |

**23-food Tunnel**

| | |
|---|---|
| Location | Right bank |
| Type | Concrete, circular |
| Exit | Flip bucket |
| Control | Two separate entrance conduits |
| Length | 533.4 m   1,750 feet |
| Gates, radial, each entrance | 7.9m radius, 2.13 m wide<br>26 foot radius, 7 feet wide<br>3.5 m high   11.5 feet high |
| Entrance R1 invert | 281.9 m   925 feet |
| Entrance R2 invert | 277.5 m   910 feet |
| Total Capacity, R1 + R2 | |
| At spillway crest | 597.18 $m^3$/sec   21,090 cfs |
| Maximum discharge<br>(during flood control regulation) | 367.9 $m^3$/sec   13,000 cfs |
| Emergency Closure | Hydraulically operated roller<br>gate each entrance |
| Tunnel exit | Flip bucket |

## AIR SHAFT TOWER

| | |
|---|---|
| Type | Rectangular, free Standing<br>6.7 m x 5.18 m<br>22 feet x 17 feet |
| Height | 86.56 m     284 feet |
| Between elevations | 297.48 m and 384 m<br>976 feet and 1260 feet |
| Air shafts | |
| 23-foot conduit No. 1 | 2.13 m x 1.83 m     7 feet x 6 feet |
| 23-foot conduit No. 2 | 2.13 m x 1.83 m     7 feet x 6 feet |
| 9-foot conduit | variable from 1.83 m x 1.52 m<br>6 feet x 5 feet to<br>2.74 m x 1.52 m<br>9 feet x 5 feet |
| Stair Shaft | 3.4m x 2.13 m     10 feet x 7 feet |
| between elevations | 329.7 m to 384 m<br>1082 feet to 1260 feet |
| Pedestrian Bridge | |
| Elevation | 384.04 m     1260 feet |
| Width | 2.43 m     8 feet |
| Length | 79.24 m     260 feet |

## ELEVATOR/STAIR TOWER

| | |
|---|---|
| Type | Rectangular, free standing<br>6.65 m x 5.66 m<br>21.83 feet x 18.58 feet |
| Height | 46.48 m     152.5 feet |
| Between elevations | 297.48 m and 343.81 m<br>976 feet and 1128.5 feet |
| Elevator Shaft | 2.54 m by 2.43 m<br>8.33 feet x 8 feet |
| Stair Shaft | 2.13 m x 4.44 m<br>7 feet x 14.58 feet |
| Utility Shaft | 2.54 m x 1.7 m<br>8.33 feet x 5.58 feet |
| Crossover Bridge to Air Shaft Tower | |
| Elevation | 329.18 m     1080 feet |

# MUD MOUNTAIN DAM
# WATER CONTROL MANUAL

## SECTION 1. INTRODUCTION

1.01 Authority. This manual is prepared in accordance with the following regulations:

ER 1110-2-240, Water Control Management, paragraph 7, dated 8 October 1982, which assigns to District Engineers the responsibility for development of plans and manuals for operation of reservoirs.

EM 1110-2-3600, Management of Water Control Systems, dated 30 November 1987, which provides technical guidance on management and operation of water control systems and general guidance on content of Water Control Manuals (WCM).

ER 1110-2-8156, Preparation of Water Control Manuals, dated 31 August 1995, which provides specification on WCM content and format.

ER 1110-1-4, Metric Measurements in USACE Publication Media, dated 31 March 1994.

Seattle District (CENWS) is delegated primary responsibility for regulation of Mud Mountain project by NPDR 1165-2-2, "Water Resources Policies and Authorities, WATER MANAGEMENT RESPONSIBILITIES", dated 2 January 1990, exhibit 1-1.

1.02 Purpose and Scope. This manual serves as a reference source for higher authority and as a guidance manual for U.S. Army Corps of Engineers (Corps) staff involved in real-time operation and regulation of the Mud Mountain Dam (MMD) project. The manual describes the river basins, project features, data collection facilities, forecasting procedures, reservoir regulation plans, and the effects of regulation.

1.03 Related Manuals and Reports. A list of published design memoranda (DM) for the Project and pertinent reports are listed in exhibit 1-2.

1.04 Project Owner. The owner is the U.S Army Corps of Engineers, an agency of the U.S. Government.

1.05 Operating Agency. The U.S. Army Corps of Engineers, Seattle District operates Mud Mountain Dam project under the general supervision of the Corps Northwestern Division (NWD) office. Prior to 1997, NWD and CENWS were known as North Pacific Division (NPD) and Seattle District (NPS). Normally, the project is attended on a 5-day week basis, from Monday through Friday, 8 hours a day. Under specific abnormal or emergency conditions as defined in the in paragraph 7.05 of this manual, the project will be attended as conditions dictate and/or as directed by the appropriate authority. The project office is located at Mud Mountain Dam, telephone 360-825-3211 or 206-764-3717.

1.06 Regulation and Operation Responsibility. As owner and operator of the project, the Corps is responsible for its regulation. The CENWS Hydrology and Hydraulics Section (HHS) of Engineering Division forecasts and regulates flows at Mud Mountain Dam. During floods, weather and river information is provided by the National Weather Service (NWS) River Forecast Center (RFC). HHS is located in the CENWS Office, 4735 East Marginal Way South, Seattle, Washington (telephone 206-764-3584). Direct correspondence may be addressed to:

Department of the Army, Seattle District
ATTN: Hydrology and Hydraulics Section
Post Office Box 3755
Seattle, WA 98124-3755

## SECTION 2. DESCRIPTION OF PROJECT

2.01 Location. The Mud Mountain project is located on the White River in Section 17, T19N, R7E, W.M. on the boundary between King and Pierce Counties, Washington. The axis of the dam is River Kilometer (RK) 47.6 (29.6 river miles (RM)) above the confluence of the White and Puyallup Rivers and 64.3 RK (40 RM) above the mouth of the Puyallup River at the city of Tacoma (Tacoma). The dam is approximately 72 Kilometers (km) (45 road miles) southeast of the city of Seattle (Seattle), 64 km (40 road miles) easterly of Tacoma, and 12.8 km (8 road miles) southeast of the town of Enumclaw. A basin map is shown on plate 2-1 and a dam area location map is shown on plate 2-2.

2.02 Purpose. The MMD is single purpose project providing flood control for the lower White and Puyallup River valleys.

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**REDACTED CONTENT**

**REDACTED CONTENT**

**REDACTED CONTENT**

2.06 Real Estate Acquisition. The Government currently has real estate interests in 778.4 hectares (ha) (1,923.46 acres) for the Project. Of this total, 754.08 ha (1,863.33 acres) were acquired in fee; 0.004 ha (0.01 acre) by license, 0.02 ha (0.05 acre) by permit; 22.9 ha (56.69 acres) by easement; and 1.4 ha (3.48 acres) by lease. The easements were acquired for road right-of-way, telephone, utility line, radio transmitter site, cable line, and storage area. The leased areas were acquired for piezometer sites, weir sites, joint use road right-of-way, and radio relay site. The guide taking line for the Project was at elevation 385.5 m (1265 feet) and the Corps acquired all real estate.

2.07 Public Facilities. The public recreation facilities include: a playground with play equipment; two large, six-table picnic shelters with barbecues, tap water, and 110-volt electric outlet; numerous single table picnic shelters, several double table picnic shelters, with barbecues; two restroom buildings; bicycle parking racks; vista points with paved parking lots; a 5.6 km (3.5-mile) rim trail; several interpretive signs; and a wading pool.

2.08 Debris Control. The debris transported into the reservoir consists of both drift (including whole trees, logs, stumps, roots, and other miscellaneous forest trash) and river bedload or sediment (composed of silt, sand, gravel, and small boulders). During high water, large pieces of submerged drift lodge against the intake structure. A lower debris basin, located on the right bank upstream from the lower boom, is used mainly as a holding area for drift collected by the work boats. The upper debris basin, also on the right bank, is upstream and is used as the main disposal area for all drift collected in the reservoir. Several thousand feet of sweep and sack booms are maintained in the two basins for collecting and storing drift intercepted by the stationary booms.

During high water, two power vessels are employed to collect the drift and tow it to storage positions over the debris basins. After the flood season, all floatable debris is collected and towed to the upper debris basin for disposal or beneficial uses.  Longer unsalvageable drift is cut to workable lengths by portable chain saws.  Salvageable drift for booms, fireplace wood, habitat logs, and other project use is removed and the remainder is ricked into piles and burned.  Debris will be removed from the intake structure trashracks by a land-based hydraulic excavator, with access at the 285.0 m and 292.6 m elevations (935- and 960-foot).  Debris removed from the trashracks will be disposed of in the upper debris basin.  River bedload or sediment deposited in the reservoir while the pool is high is eroded and passed through the outlets by the river flow when the pool is evacuated

## SECTION 3. HISTORY OF PROJECT

3.01 Authorization. Mud Mountain project was authorized as Mud Mountain Reservoir by the Flood Control Act of 22 June 1936, 74th Congress, 2d Session. The Flood Control Act of 1938 provided for operation and maintenance (O&M) of the project by the Corps and the Flood Control Act of 1944 authorized construction and O&M of recreational facilities.

3.02 Planning. The proposal for a flood control dam in the vicinity of Mud Mountain was initiated in 1933 by the Inter-County River Improvement Commission. This organization, created by King and Pierce Counties under an enabling act passed by the Washington State (State) Legislature in 1913, was charged with providing for the control of floodwaters of the Puyallup River and its tributaries. The investigations of the Commission included the making of a topographic survey of the proposed reservoir and of a geological report based on surface evidence later supplemented and confirmed by the drilling of seven diamond-drill holes. The District Engineer, CENWS, in his report on a review of House Document No. 154, 72nd Congress, 1st Session, a survey report on Puyallup River, Washington, with a view to control of its floods, recommended a dam of the same height and type as that proposed by the Commission but with structural details and regulating works as designed by CENWS. This review report formed the basis for the authorization of the project by the Congress.

3.03 Design. Based upon the earlier geological report, which pronounced the rock at the dam site to be a hard, unfissured andesite rising above elevation 387 m (1270 feet), an arch dam design was recommended by the Commission and accepted by CENWS. In the summer of 1936 it was decided that NWD should design the dam and appurtenant works. Many different types of dams were tentatively designed, analyzed, and discussed with a number of nationally known consulting engineers. Design in all cases proved very difficult because of the geological peculiarities of the site. Various structural alternatives were considered including an arch dam, straight gravity dam, gravity thrust dam, rock fill dam with earth core, and rolled fill dam. The Office, Chief of Engineers made the final decision for a rolled earth core dam with dumped quarry rock shell zones.

The discharge of water from the reservoir for normal low flow was designed to be through a 9-foot horseshoe tunnel with higher flows to be passed by a 23-foot circular tunnel. An overflow spillway was designed for the right abutment. The designs of the 23-foot tunnel and the spillway were studied by means of tests performed on 1-to-25 and 1-to-50 scale models respectively at the Bonneville Hydraulic Laboratory, Bonneville, Oregon. As a result of these tests, modifications were made to both designs.

3.04 Construction. In 1937 the Corps built a camp at the dam site to use during the detailed survey and exploration work and which then served to house the government inspection and supervisory force during construction. Before awarding a contract, the Corps also built more than 3.2 km (2 miles) of surfaced access road from the state highway to the dam site and cleared approximately 18.2 ha (45 acres) of heavily wooded land to expedite construction. On 21 July 1939, CENWS formally advertised for bids on construction of the project. Bids were opened on August 21 and the contract was awarded to the Guy F. Atkinson Company of San Francisco, California, on 25 August 1939.

River diversion through the 23-foot tunnel was accomplished on 1 September 1940 and the embankment was placed during the period March to December 1941. As a result of restrictions imposed on civil works construction because of World War II, work under the original contract was halted on 27 July 1942, with the project as originally designed complete with the major exceptions of the three steel penstocks, steel lining, and Howell-Bunger valves in the downstream end of the 23-foot tunnel, and the removal of the existing radial gate from the 9-foot tunnel, installation of a new radial gate and hydraulic operating mechanism with construction of a pump house to protect the mechanism. Construction was resumed in 1947 and installation of the penstocks, valves, and valve house was completed in 1948.

Sometime between 18 May and 30 June 1948, the original radial gate in the 9-foot tunnel was destroyed and washed downstream. The reason for the gate failure has never been fully established but is believed to have had its origin in inadequate venting and the effect of water flowing through the gate hoist shaft and dropping on the gate. A severe flood occurred in December 1946 in which the gatehouse was completely submerged with the gate at 2/3 opening. The situation was repeated in 1948, resulting in loss of the gate. A new radial gate was installed in 1953, together with an improved venting system extending above maximum pool. The gate hoist shaft was sealed against reservoir inflow and a modified entrance throat curvature provided for the 9-foot tunnel.

Major modifications to the project have been made based upon an evaluation under the CENWS Dam Safety Program. Design work for these changes was completed in the late 1980s. The principal construction work was completed during the period 1990 through 1995. These modifications consisted of:

a. Construction of a concrete cutoff wall in the dam core extending from elevation 378 m (1,240 feet) to 4.6 m (15 feet) into bedrock. From elevation 378 m (1,240 feet) to elevation 382 m (1,253 feet) a cast-in-place concrete wall was doweled and placed on top of the cutoff wall. This was filled over with soil and gravel to form the new top of dam at elevation 383 m (1,257 feet). Work was completed in 1990.

b. Raising the spillway chute walls 2.7 m (9 feet) vertically, parallel to the existing slope, to increase the discharge capacity to safely pass the spillway design flood. This work was completed in 1992.

c. Replacing the original 9-foot and 23-foot tunnel intake towers with a single intake tower containing an entrance to the 9-foot tunnel and dual entrances to the 23-foot tunnel. Vehicle access is provided at both the 292 m and 335 m (960 and 1,100 foot) elevations and pedestrian access across a bridge at elevation 384 m (1,260 feet). New tunnel sections were required to connect the new intakes with the existing tunnels. The Howell-Bunger valves were removed from the 23-foot tunnel exit, the exit structure modified, and a training wall erected to direct flow into the downstream channel. This work was completed in 1995.

The original fish ladder at the PSE diversion dam, approximately 8 km (5 miles) below the MMD, was reconstructed and adapted to form a temporary trap to collect anadromous fish during the construction period. The fish were then hauled by truck around the dam site and released back into the river. The original project design called for a fish trap to be located near the 9-foot tunnel outlet, from which the fish would be hauled over the dam on a tramway. Because of economic considerations and the objections of the State Department of Fisheries, this plan was abandoned in the early stages of construction. Construction of a new and permanent fish trap at the diversion dam was completed in February 1949.

3.05 Related Projects.

a. White River Project. This project, owned and operated by PSE, consists primarily of a diversion dam and headworks, a reservoir named Lake Tapps, and a hydropower facility known as the Dieringer Plant. Coordination between the Corps and PSE is required during the summer to protect downstream river users and during higher flood season flows for the management of lows carrying high sediment and bedloads and regulation that may be required to reinstall flashboards if washed out. A Memorandum of Agreement between the Corps and PSE is presented as exhibit 3-1.

(1). Diversion Dam. The diversion dam is located at RK 39 (RM 24.25) in the city of Buckley. It is a 3.3 m (11-foot) high structure consisting of a concrete and rock-filled crib structure 107.2 m by 1.2 m (352 feet long and 4 feet high), topped with 2.1 m (7-foot) high flashboards. These flashboards, some wooden and some steel, normally raise the forebay elevation to 204.5 m (671 feet). The concrete intake of the headworks include two stoney gates, each 3.9 m by 4.7 m (13 feet high by 15.5 feet wide) separated by a concrete pier. The headworks have a hydraulic capacity of about 56.6 $m^3/s$ (2,000 cfs) which is the existing water right. Most river flows which are in excess of the minimum flow release required to maintain a minimum mean daily flow of 3.6 $m^3/s$ (130 cfs) at the Muckleshoot Reservation, the diversion dam, but less than the hydraulic capacity, are diverted into Lake Tapps through a series of flumes, tunnels, canals, and five settling basins. River flows in excess of the hydraulic capacity pass over the diversion dam to continue down the White River. A general plan of PSE dam and diversion is shown on plate 3-1.

(2) Lake Tapps. Lake Tapps, the reservoir for the project, is approximately 7.2 km long by 4 km wide (4.5 miles by 2.5 miles). The lake originally consisted of several smaller natural lakes. By constructing earthen dikes totaling 4 km (2.5 miles) in length, the water level was raised 10.6 m (35 feet) above the original elevation creating a reservoir having a surface area of approximately 1,092 ha (2,700 acres) and an active storage capacity of approximately 5,758 ha-m (46,700 acre-feet) at normal maximum pool elevation of 165.5 m (543 feet). The normal minimum pool elevation is 156.9 m (515 feet).

(3). Dieringer Plant. A concrete lined tunnel 3.6 m (12 feet) in diameter and 866.2 m (2,842 feet) in length carries water from Lake Tapps to the forebay well. Three 2.4 meter (96-inch) diameter steel penstocks, each controlled by a 2.4 m (96-inch) diameter standard coffin sluice gate, direct water from the forebay well to the powerhouse below. The powerhouse, a concrete building 25.9 m by 68.5 m by 16.7 m (85 feet wide, 225 feet long, and 55 feet high), houses four reaction-type horizontal shaft turbines that operate at 360 RPM and four generating units with a total capacity of 82,600 kva. The powerhouse discharges water into a tailrace approximately 0.8 km (0.5 miles) in length which carries water to the White River at RK 5.7 (RM 3.6).

b. Levee System.. The State Legislature of 1913 passed an Act enabling the Commissioners of King and Pierce Counties to enter into an agreement for the improvement of Puyallup River and its tributaries for flood control. Responsibility for action was delegated to Inter-County, a commission composed of the boards of County Commissioners of King and Pierce Counties. The White and Puyallup River channels were straightened in many places between the city of Auburn (Auburn) and the city limits of the city of Tacoma (Tacoma), and levees and dikes were constructed to maintain a channel capacity of 707.5 $m^3/s$ (25,000 cfs) in the White River and 1,415 $m^3/s$ (50,000 cfs) in the Puyallup River. The channel capacity of the Puyallup River below the confluence with the White River continues to be approximately 1,415 $m^3/s$ (50,000 cfs). However, Inter-County has not been able to obtain hydraulic permits from the State to remove deposited bedload and sediments from the White River. The channel capacity has been reduced to the extent that the discharge from Mud Mountain Dam is now limited to 339.8 $m^3/s$ (12,000 cfs) unless higher discharge is required to efficiently utilize all available reservoir storage space for flood control.

c. Federal Project. A Corps project adopted 22 June 1936 provided a channel with a capacity of 1,415 $m^3/s$ (50,000 cfs) from the end of the Inter-County improvement to the East 11th Street bridge in Tacoma, see plate 3-2. The work consisted of straightening the channel, building levees, (revetting the channel and levees), and making all necessary bridge changes. The Corps maintains the project.

3.06 Modification of the Water Control Plan. The basic water control plan has remained unchanged since the project went in to operation except some restrictions on discharge during floods have been added to reduce flooding on the White River. Those restrictions are discussed in paragraph 7.04. The intensity of coordination with outside agencies has greatly increased over the years as the basin has experienced a dramatic increase in the level of development and concern for the environment has increased.

## SECTION 4. WATERSHED CHARACTERISTICS

4.01 General Characteristics. The Puyallup River and its tributaries drain approximately 2,517 square kilometers ($km^2$) (972 square miles) of the Puget Sound region. The Puyallup River basin is shown on plate 4-1. The Puyallup River flows northwestward about 41.8 km (26 miles) from its source, Tahoma and Puyallup Glaciers on Mount Rainier, to Kapowsin Creek, then turns and flows north for a little over 24 km (15 miles), then flows northwestward once again a little over 19.3 km (12 miles) to its mouth where it enters Commencement Bay in Tacoma. For the first 32 km (20 miles) the fall is rapid with an average slope in excess of 19 m (62.3 feet) per km (0.6 mile.) Glacial and stream erosion has rendered the upper portion of the basin of Puyallup River extremely rugged and irregular. About 1.6 km (1 mile) below the mouth of Mowich River at elevation 472.44 m (1550 feet), the Puyallup River enters a 14.4 km (9-mile) canyon cut through a hard, eruptive rock and drops approximately 283.4 m (930 feet). Below this canyon, the Puyallup River flows through a comparatively wide and open valley of alluvium with a gradually decreasing hydraulic gradient, receiving the waters of the Carbon River at RK 28.8 (RM 17.9) and those of the White River at RK 16.7 (RM 10.4). River profiles are shown on plate 4-1. The lower 4.2 km (2 2/3 miles) of the river are within the city limits of Tacoma. The extreme tidal range at the mouth is 5.9 m (19.5 feet), the highest tide of record being 4.5 m (15.0 feet) above mean lower low water or 2.4 m (8.1 feet) above mean sea level.

The principal tributary of the Puyallup River is White River (the first 13.3 km (8.3 miles) of the White River is known locally as the Stuck River), drainage area 1,279.4 $km^2$ (494 square miles). The White River rises in Emmons and Winthrop Glaciers and, with its tributaries, drains the whole northeast quadrant of Mount Rainier as well as a part of the western slope of the Cascade Range. The White flows generally northward to the point where it receives the waters of the Greenwater River, turns and flows westward about 37 km (23 miles) to Buckley, then makes a large north to south loop about 37 km (23 miles) in length around

Lake Tapps before discharging into the Puyallup River at Sumner. The upper White River, including the Greenwater River, drains very rugged steep slopes of Mount Rainier and the Cascades. The White, from the mouth of the Greenwater River to the project, occupies a comparatively wide valley with a river gradient of about 9 m (29 feet) per km (0.6 mile), and in the 46.6 km (29 miles) below the project the gradient is about 5.3 m (17 feet) per km (0.6 mile).

Prior to 1906 the waters of White River were discharged partly through Green and Duwamish Rivers into Elliott Bay at Seattle in King County, and partly through Stuck and Puyallup Rivers into Commencement Bay at Tacoma in Pierce County. During periods of low water, from two-thirds to three-fourths of the total volume of White River flowed into Green River at Auburn, the remainder flowing down Stuck River to Puyallup River. During high water periods, about half of the flow went into the Stuck and half into Green River. This condition existed until the flood of November 1906, which suddenly and with great destruction to the Stuck and Puyallup valleys, diverted the waters of the White to the Stuck channel, practically drying up the right-hand channel which joined the Green. In 1915 White River was permanently confined to its present channel by means of a diversion dam near Auburn which blocked the former channel to Green River. Hereinafter in the text, the term White River will include that portion of the channel known as Stuck River.

4.02 Topography. Elevations in the Puyallup River basin's range from sea level at Tacoma on the west to 4,392.4 m (14,411 feet) at the summit of Mt. Rainier on the southern boundary of the basin. The high elevations of Mt. Rainier and the extremely rugged topography in the vicinity of the mountain occur in only a small portion of the drainage area. A portion of the Cascade Mountain Range, with elevations reaching from 1,737 m to 2,011 m (5700 to 6600 feet) and the foothills constitute the upper or eastern portion of the basin. The northern boundary of the White River basin above Mud Mountain Dam ranges from 914 m to 1524 m (3000 to 5000 feet) in elevation. The lower, or western portion of the Puyallup

River basin is characterized by rolling timber-covered lowlands and flat river-bottom areas. Over 90 percent of the basin is below 1828 m (6000 feet) in elevation with variations as shown in table 4-1.

TABLE 4-1

**AREA ELEVATION DATA**

| | | Percent Area Below Listed Elevation | |
|---|---|---|---|
| Elevation | | White River at Mud Mountain Dam | Puyallup River at Puyallup |
| Meters | Feet | | |
| 2438 | 8000 | 98 | 98 |
| 1828 | 6000 | 91 | 94 |
| 1524 | 5000 | 77 | 85 |
| 1219 | 4000 | 54 | 72 |
| 914 | 3000 | 30 | 56 |
| 609 | 2000 | 10 | 40 |
| 304 | 1000 | 0 | 24 |

4.03 Geology and Soils.

a. Geology. During the glacial period the valleys of the Puyallup and its chief tributaries were occupied by Alpine-type glaciers from the summits of the mountain to the foothills where they merged with the mass of ice that then filled the Puget Sound Basin. These Alpine glaciers widened and deepened their valleys and left in their wake large quantities of debris that now make up the terraces and bars along the streams. A series of older volcanic rocks, mostly andesites and basalts, occur northwest of Mount Rainier. These show as erosion resisting dikes and flows with a rugged surface of sharp peaks and serrated ridges. Still farther to the northwest, from Fairfax to South Prairie, valuable coal measures occur in sandstone and shales that have been sharply upturned, although but little altered.

The outstanding geologic feature of the Puyallup River basin is Mount Rainier, a dormant volcano resting mainly upon a very irregular floor of granite, with minor quantities of other igneous rocks. The cone is made up largely of lava flows and broken rock expelled from the crater. The following pertinent excerpts are taken from the report "Volcanic Hazards Assessment For Mt. Rainier, Washington" compiled for the State Department of Emergency Services by Janet Cullen Tanaka, May 1983.

> At least 55 lahars have left deposits, from a few inches to over 100 feet deep, in the valleys that head on Mt. Rainier. The largest known of these is the Osceola mudflow that occurred about 5700 years ago (about 3700 BC). One of the world's largest, it covered an area of at least 323 $km^2$ (125 square miles), filling in an area that was once an arm of Puget Sound.
>
> The lahar that is used as a base for planning purposes, however, is the Electron mudflow that moved down the Puyallup Valley at least as far as the present town of Sumner about 600 years ago (about 1350-1400 AD). This mudflow apparently happened as a result of a steam explosion and/or earthquake during a period of dormancy rather than during an eruption.
>
> Most mudflows have been smaller than the Electron, but even these can bury roads, farms and hydroelectric facilities, as well as causing heavy siltation and debris-laden flooding for many miles downstream.
>
> Many lahars have originated at or near the Emmons Glacier.
>
> A large rockfall from Little Tahoma Peak in 1963 covered the valley head with debris as far as the White River Campground. In fact, it was the rapid deterioration of Emmons Glacier in 1969 that triggered the first serious concern about volcanic activity in the Cascade Range.

Throughout its history, Mt. Rainier has not been shown to produce large amounts of ash, compared to Mt. St. Helens and Glacier Peak. Although it is possible for a future eruption to be accompanied by a widespread ashfall like that of Mt. St. Helens in 1980, it is more likely that it will follow its typical pattern.

Very few lava flows have been erupted from Mt. Rainier in postglacial time. These have been small and confined to the summit and upper slopes. Lava from a flank eruption would only travel short distances and at no more than five miles an hour.

b. Soils. Agricultural lands in the valley have four general classifications: fine sandy loam, silt loam, Orting loam, and muck combined with peat. The fine sandy loam occurs usually as a comparative narrow strip bordering the present channel, having been deposited there during periods of overflow. The loose, incoherent structure of the soil and subsoil insures good natural drainage. The silt loam owes its origin to the deposition of fine sand, silt, and clay by the stream. The subsoil is usually a fine sand, this having been covered by the silt loam laid down by quieter waters. Orting loam is a sticky loam containing small amounts of gravel with occasional glacial boulders, the whole being of glacial origin left by retreating ice. Muck and peat represent accumulations of organic matter in various stages of decomposition, combined with silt and clay. When properly drained, these muck and peat areas produce profitably so that in the Puyallup valley overall, intensive farming methods have been especially successful in growing vegetables, berries, and small fruits. Oats, hay, and hops are staple crops. Pasturage is good and dairying is an important industry.

4.04 Sediment. The White River carries a heavier bed load and suspended sediment load than is normal for other Western Washington Rivers because of its glacial origin. The material that is characteristically carried downstream is silt, sand, gravel, and small boulders up to about two feet in diameter. The bulk of this material moves downstream during high flow conditions, although very fine suspended sediment, sometimes referred to as glacial flour, occurs primarily when glacier melt is highest in the summer. The reservoir is empty most of the year and the load carried by the river passes on through the 9-foot discharge tunnel. However, when a pool is maintained for maintenance or flood control, a considerable amount is deposited in the reservoir. When the reservoir is emptied, most of the deposited material passes out of the reservoir as the sides and bottom are steep. Some of the remaining deposits, usually fines, will be eroded by rain falling on the sides of the reservoir and discharged through the outlet tunnels.

Sedimentation ranges have been established in the reservoir with observations taken in 1951, 1962, 1964, 1969, 1974, 1978, and 1993. No recent sedimentation studies have been done. Because the reservoir is normally empty and outlets are at a low level, reservoir capacity loss due to sedimentation is minor based on visual inspection. Reservoir topography and the capacity vs. elevation and area vs. elevation relationships are shown on plate 4-2.

4.05 Climate.

a. General. The Puyallup River basin lies on the west side of the Cascade Range approximately 160 km (100 miles) east of the Pacific Ocean. Westerly air currents from the ocean prevail in these latitudes bringing the region considerable moisture, cool summers, and comparatively mild winters. Climate throughout the basin varies markedly due to topography, especially the imposing presence of Mount Rainier. Major storm activity occurs during the winter when the basin is subject to rather frequent, heavy frontal rains associated with cyclonic disturbances from the Pacific Ocean. During the summer months, weather is relatively warm and dry due to the decreased activity and northward displacement of the semi permanent Aleutian low and the increased moisture-bearing capacity of incoming marine air as it is warmed by passage over land. Climatological stations in and near the Puyallup River basin are shown on plate 4-3.

b. Temperatures. Mean annual temperatures in degrees Celsius ($^oC$) for stations in or near the basin vary from 11.2 (52.1 degrees Fahrenheit ($^oF$)) at Tacoma to 3.1 (37.6 $^oF$) at Rainier Paradise Ranger Station. Mean monthly temperatures vary from a January minimum of 4.3 $^oC$ (39.9 $^oF$) at Tacoma and -3.8$^oC$ (25.0 $^oF$) at Rainier Paradise Ranger Station to a July maximum of 18.2 $^oC$ (64.8 $^oF$) and 11.3$^oC$ (52.5 $^oF$) respectively for these stations. Extreme temperatures vary from 36.6 $^oC$ to –15 $^oC$ (98 $^oF$ to 5 $^oF$) at Tacoma and 35.5 $^oC$ to -28.8 $^oC$ (96 $^oF$ to –20 $^oF$) at the Ranger Station. The maximum temperature recorded in the basin was 37.7 $^oC$ (100 $^oF$) at Electron Headworks. Normal monthly temperatures for five representative stations in the basin are presented in metric and English units in tables 4-2.1 and 4-2.2 respectively.

c. Precipitation. In the Puyallup River basin precipitation is primarily a function of elevation and varies greatly over the basin. Normal annual precipitation ranges from about 939.8 mm (37 inches) near the mouth of the river to more than 3556 mm (140 inches) on Mount Rainier. The normal annual basin precipitation above the Puyallup River at Puyallup gaging station is 1574.8 mm (62 inches) and above Mud Mountain Dam is 1549.4 mm (61 inches). A normal annual isohyetal map is shown on plate 4-4. Approximately 75% of the annual amount falls during the 6-month period October through March. Mean monthly precipitation for stations in the basin varies from 17.78 mm (0.70 inches) for July at Tacoma to 258.3 mm (10.17 inches) for December at Electron Headworks. The maximum precipitation recorded for one month and for one day is 739.3 mm (29.11 inches) and 98.8 mm (3.89 inches) respectively at Rainier Carbon River Entrance in December 1933. Normal monthly precipitation values for seven representative stations in the basin are presented in metric and English units in tables 4-3.1 and 4-3.2 respectively.

TABLE 4-2.1

**NORMAL MONTHLY TEMPERATURE**

**DEGREES CELSIUS**

1961 to 1990

| STATIONS | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BUCKLEY 1NE | 3.8 | 5.7 | 7.1 | 9.2 | 12.4 | 15.3 | 17.5 | 17.8 | 15.1 | 10.6 | 6.4 | 3.7 | 10.4 |
| ELECTRON HEADWORKS | 1.0 | 2.9 | 4.1 | 6.7 | 10.3 | 13.1 | 15.6 | 15.1 | 12.6 | 8.3 | 4.1 | 2.2 | 8.0 |
| MUD MOUNTAIN DAM | 3.1 | 4.4 | 5.6 | 7.4 | 10.6 | 13.7 | 16.3 | 16.5 | 13.9 | 9.8 | 5.7 | 3.2 | 9.2 |
| PARKWAY 6S | -2.3 | -0.9 | -0.1 | 3.5 | 7.1 | 10.5 | 14.1 | 13.7 | 11.3 | 6.5 | 1.4 | -0.8 | 5.3 |
| PUYALLUP 2W EXP STA | 4.1 | 5.9 | 7.4 | 9.7 | 12.9 | 16.0 | 18.1 | 18.1 | 15.3 | 11.0 | 6.8 | 4.2 | 10.8 |
| RANIER PARADISE RNGR STATION | -3.9 | -2.3 | -2.2 | 0.4 | 4.3 | 7.2 | 11.4 | 14.2 | 9.1 | 4.9 | -0.1 | -2.6 | 3.2 |



TABLE 4-2.2

**NORMAL MONTHLY TEMPERATURE**

**DEGREES FAHRENHEIT**

1961 to 1990

| STATIONS | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BUCKLEY 1NE | 38.9 | 42.2 | 44.7 | 48.5 | 54.4 | 59.6 | 63.5 | 64.1 | 59.1 | 51.1 | 43.6 | 38.7 | 50.7 |
| ELECTRON HEADWORKS | 33.8 | 37.3 | 39.3 | 44.0 | 50.5 | 55.5 | 60.0 | 59.2 | 54.7 | 46.9 | 39.3 | 36.0 | 46.4 |
| MUD MOUNTAIN DAM | 37.5 | 40.0 | 42.0 | 45.4 | 51.0 | 56.7 | 61.4 | 61.7 | 57.1 | 49.7 | 42.3 | 37.8 | 48.5 |
| PARKWAY 6S | 27.8 | 30.3 | 31.9 | 38.3 | 44.7 | 50.9 | 57.4 | 56.6 | 52.3 | 43.7 | 34.5 | 30.5 | 41.6 |
| PUYALLUP 2W EXP STA | 39.4 | 42.6 | 45.4 | 49.4 | 55.3 | 60.8 | 64.5 | 64.6 | 59.6 | 51.8 | 44.2 | 39.5 | 51.5 |
| RANIER PARADISE RNGR STATION | 25.0 | 27.9 | 28.0 | 32.7 | 39.7 | 45.0 | 52.5 | 57.5 | 48.4 | 40.9 | 31.9 | 27.4 | 37.7 |

d. Snowfall. Snowfall amounts in the Puyallup River basin are dependent upon elevation and distance from the modifying influence of Puget Sound. Mean annual snowfall for stations in the basin varies from 279.4 mm (11 inches) at Tacoma to 4.8 meters (192 inches) at Parkway 6 S. At Paradise Ranger Station the mean annual snowfall is about 14.9 meters (590 inches); the greatest depth recorded is 9.3 meters (367 inches) and the greatest seasonal snowfall was 25.4 meters (1000 inches) during the winter of 1955-56. There is one Snowpack Telemetry (SNOTEL) site in the basin and one near the basin. Locations, elevations, and period of record are shown on plate 4-3.

e. Evaporation. Evaporation is measured at the Western Washington Research Experimental Station for the months April through November. Average evaporation at the station, Puyallup 2 W, is presented in table 4-4. Mud Mountain reservoir is empty except during periods of regulation for flood control and evaporation does not affect the project.

f. Wind. Winds in the basin of significant velocity are generally due to the pressure gradient resulting from the relative positions of the semi permanent high and low pressure cells, storm intensity, and topographic effects. Prevailing winds in the lower basin are from the south quadrant June through August. Moving up the river valleys above Orting and Buckley, the airflow is subject to a topographic "funneling" effect of the deeper valleys and to convergence around and over Mount Rainier. Occasionally cold continental air from eastern Washington will flow through Cascade Mountain passes creating cold east winds in the winter. In the winter season, winds will be in the range of 32 km to 48 km (20 to 30 miles) per hour during storms, and even higher on Mount Rainier.

g. Ice. The reservoir is empty except during flood control regulation periods, and flood-producing storms have temperatures above freezing, hence ice is not a problem on the reservoir.

TABLE 4-3.1

**NORMAL MONTHLY PRECIPITATION**

**MILLIMETERS**

| STATIONS | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BUCKLEY 1NE | 161 | 122 | 114 | 101 | 82 | 72 | 37 | 49 | 70 | 100 | 168 | 157 | 1233 |
| ELECTRON HEADWORKS | 248 | 180 | 155 | 132 | 99 | 89 | 35 | 52 | 88 | 166 | 224 | 258 | 1725 |
| GREENWATER | 205 | 151 | 130 | 113 | 82 | 77 | 26 | 42 | 87 | 155 | 209 | 227 | 1503 |
| MUD MOUNTAIN DAM | 181 | 131 | 128 | 125 | 109 | 95 | 48 | 63 | 85 | 115 | 192 | 176 | 1449 |
| PARKWAY 6S | 214 | 166 | 130 | 80 | 52 | 45 | 16 | 28 | 44 | 116 | 214 | 206 | 1310 |
| PUYALLUP 2W EXP. STA. | 172 | 113 | 99 | 71 | 50 | 50 | 22 | 33 | 49 | 83 | 152 | 157 | 1023 |
| RANIER CARBON R. ENTR. | 193 | 175 | 174 | 136 | 119 | 106 | 49 | 42 | 97 | 156 | 227 | 233 | 1706 |

TABLE 4-3.2

**NORMAL MONTHLY PRECIPITATION**

**INCHES**

| STATIONS | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | ANN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BUCKLEY 1NE | 6.34 | 4.79 | 4.47 | 3.99 | 3.23 | 2.82 | 1.46 | 1.92 | 2.77 | 3.93 | 6.62 | 6.20 | 48.54 |
| ELECTRON HEADWORKS | 9.77 | 7.07 | 6.11 | 5.18 | 3.90 | 3.50 | 1.37 | 2.03 | 3.46 | 6.54 | 8.80 | 10.17 | 67.90 |
| GREENWATER | 8.09 | 5.94 | 5.12 | 4.45 | 3.22 | 3.04 | 1.02 | 1.65 | 3.41 | 6.09 | 8.21 | 8.94 | 59.18 |
| MUD MOUNTAIN DAM | 7.13 | 5.16 | 5.05 | 4.91 | 4.28 | 3.73 | 1.89 | 2.48 | 3.36 | 4.54 | 7.55 | 6.93 | 57.04 |
| PARKWAY 6S | 8.43 | 6.53 | 5.11 | 3.16 | 2.05 | 1.79 | 0.62 | 1.09 | 1.73 | 4.56 | 8.41 | 8.11 | 51.59 |
| PUYALLUP 2W EXP. STA. | 6.79 | 4.46 | 3.90 | 2.80 | 1.98 | 1.97 | 0.88 | 1.30 | 1.93 | 3.28 | 5.99 | 6.18 | 40.26 |
| RANIER CARBON R. ENTR. | 7.60 | 6.88 | 6.84 | 5.36 | 4.67 | 4.19 | 1.93 | 1.65 | 3.81 | 6.13 | 8.95 | 9.18 | 67.18 |

TABLE 4-4

**PUYALLUP 2W EXP STA**

**AVERAGE MONTHLY EVAPORATION**

| MONTH | EVAPORATION | |
|---|---|---|
| | mm | inches |
| APR | 62.23 | 2.45 |
| MAY | 99.31 | 3.91 |
| JUNE | 119.13 | 4.69 |
| JULY | 143.76 | 5.66 |
| AUG | 117.60 | 4.63 |
| SEPT | 69.34 | 2.73 |
| OCT | 31.50 | 1.24 |
| NOV | 15.24 | 0.60 |

4.06 Storms. Flood producing storms occur chiefly during the winter season but are not uncommon in late fall or early spring. The sharp increase in frequency, duration, and severity of storms in late fall is a result of a southward displacement and renewed activity of the semi permanent Aleutian low-pressure system. Frequently, a series of waves develops along the polar front. As the waves move inland, the unstable, moist air masses are orographically lifted by the mountains. This results in general, often heavy, precipitation that increases with elevation. All general winter storms of the northwest are of this one basic type, having similar origins, air mass trajectories, and a moisture source in the Pacific Ocean. The storms of December 1933, January 1965, December 1977, January 1990, November 1990 and February 1996 produced the six floods that would have exceeded zero damage flow of 1415 $m^3/s$ (50,000 cfs) at the Puyallup River at Puyallup gage under natural conditions. Precipitation data from stations in operation during these storms is presented in metric and in English units in tables 4-5.1 and 4-5.2 respectively.

TABLE 4-5.1

**STORM PRECIPITATION**

**MILLIMETERS**

| STATION | 24-Hour | 48-Hour | 72-Hour | 96-Hour |
|---|---|---|---|---|
| | DECEMBER 1933 | | | |
| Buckley 1NE | 91.44 | 132.08 | 137.16 | 177.8 |
| Parkway 6S | 127 | 162.56 | 170.18 | 187.96 |
| Puyallup 2W Exp Sta | 86.36 | 111.76 | 121.92 | 124.46 |
| Rainier Carbon River Entrance | 137.16 | 162.56 | 175.26 | 187.96 |
| Rainier Paradise Ranger Station | 109.22 | 114.3 | 160.02 | 165.1 |
| Tacoma | 78.74 | 99.06 | 106.68 | 144.78 |
| | JANUARY 1965 | | | |
| Buckley 1NE | 69.85 | 101.6 | 116.84 | 148.082 |
| Electron Headworks | 87.63 | 120.65 | 195.58 | 213.36 |
| Greenwater | 105.41 | 165.1 | 210.82 | 242.824 |
| Mud Mountain Dam | 88.9 | 116.84 | 152.4 | 172.72 |
| Parkway 6S | 67.31 | 96.52 | 135.89 | 148.59 |
| Puyallup 2W Exp Sta | 33.02 | 44.45 | 66.04 | 83.82 |
| Rainier Paradise Ranger Station | 137.16 | 203.2 | 266.7 | 322.58 |
| Tacoma | 27.94 | 38.1 | 58.42 | 72.39 |
| | DECEMBER 1977 | | | |
| Buckley 1NE | 31.75 | 36.322 | 48.768 | 48.768 |
| Greenwater | 129.286 | 152.4 | 184.15 | 193.04 |
| Mud Mountain Dam | 31.75 | 39.37 | 50.8 | 50.8 |
| Puyallup 2W Exp Sta | 19.05 | 21.59 | 22.86 | 26.67 |
| Rainier Carbon River Entrance | 109.22 | 121.92 | 132.08 | 137.16 |
| Rainier Paradise Ranger Station | 197.104 | 257.556 | 294.386 | 304.8 |
| Tacoma | 11.43 | 18.796 | 18.796 | 18.796 |
| | JANUARY 1990 | | | |
| Buckley 1NE | 59.69 | 104.902 | 134.112 | 152.146 |
| Mud Mountain Dam | 90.17 | 143.51 | 168.91 | 170.18 |
| Puyallup 2W Exp Sta | 105.41 | 127 | 152.4 | 157.48 |
| Rainier Carbon River Entrance | 106.68 | 138.43 | 172.72 | 184.15 |
| Rainier Paradise Ranger Station | 106.68 | 167.64 | 210.82 | 222.25 |
| Tacoma | 92.964 | 114.3 | 149.098 | 162.052 |

| | | | | |
|---|---|---|---|---|
| | NOVEMBER 1990 | | | |
| Buckley 1NE | 64.77 | 90.17 | 100.33 | 104.14 |
| Greenwater | 66.04 | 83.82 | 96.52 | 109.22 |
| Mud Mountain Dam | 66.04 | 78.74 | 83.82 | 93.98 |
| Rainier Carbon River Entrance | 81.28 | 99.06 | 143.51 | Missing |
| Rainier Paradise Ranger Station | 182.88 | 215.9 | 226.06 | 347.98 |
| Tacoma | 96.52 | 107.95 | 116.84 | 131.318 |
| | FEBRUARY 1996 | | | |
| Buckley 1NE | 96.52 | 121.92 | 154.94 | 175.26 |
| Greenwater | 99.06 | 160.02 | 215.9 | 238.76 |
| Mud Mountain Dam | 96.52 | 124.46 | 160.02 | 180.34 |
| Rainier Carbon River Entrance | 93.98 | Missing | Missing | Missing |
| Rainier Paradise Ranger Station | 187.96 | 269.24 | 363.22 | 436.88 |
| Tacoma | 76.2 | 99.06 | 134.62 | 149.86 |

TABLE 4-5.2

**STORM PRECIPITATION**

**INCHES**

| STATION | 24-Hour | 48-Hour | 72-Hour | 96-Hour |
|---|---|---|---|---|
| | DECEMBER 1933 | | | |
| Buckley 1NE | 3.60 | 5.20 | 5.40 | 7.00 |
| Parkway 6S | 5.00 | 6.40 | 6.70 | 7.40 |
| Puyallup 2W Exp Sta | 3.40 | 4.40 | 4.80 | 4.90 |
| Rainier Carbon River Entranc | 5.40 | 6.40 | 6.90 | 7.40 |
| Rainier Paradise Ranger Station | 4.30 | 4.50 | 6.30 | 6.50 |
| Tacoma | 3.10 | 3.90 | 4.20 | 5.70 |
| | JANUARY 1965 | | | |
| Buckley 1NE | 2.75 | 4.00 | 4.60 | 5.83 |
| Electron Headworks | 3.45 | 4.75 | 7.70 | 8.40 |
| Greenwater | 4.15 | 6.50 | 8.30 | 9.56 |
| Mud Mountain Dam | 3.50 | 4.60 | 6.00 | 6.80 |
| Parkway 6S | 2.65 | 3.80 | 5.35 | 5.85 |
| Puyallup 2W Exp Sta | 1.30 | 1.75 | 2.60 | 3.30 |
| Rainier Paradise Ranger Station | 5.40 | 8.00 | 10.50 | 12.70 |
| Tacoma | 1.10 | 1.50 | 2.30 | 2.85 |

| | | | | |
|---|---|---|---|---|
| | DECEMBER 1977 | | | |
| Buckley 1NE | 1.25 | 1.43 | 1.92 | 1.92 |
| Greenwater | 5.09 | 6.00 | 7.25 | 7.60 |
| Mud Mountain Dam | 1.25 | 1.55 | 2.00 | 2.00 |
| Puyallup 2W Exp Sta | 0.75 | 0.85 | 0.90 | 1.05 |
| Rainier Carbon River Entrance | 4.30 | 4.80 | 5.20 | 5.40 |
| Rainier Paradise Ranger Station | 7.76 | 10.14 | 11.59 | 12.00 |
| Tacoma | 0.45 | 0.74 | 0.74 | 0.74 |
| | JANUARY 1990 | | | |
| Buckley 1NE | 2.35 | 4.13 | 5.28 | 5.99 |
| Mud Mountain Dam | 3.55 | 5.65 | 6.65 | 6.70 |
| Puyallup 2W Exp Sta | 4.15 | 5.00 | 6.00 | 6.20 |
| Rainier Carbon River Entrance | 4.20 | 5.45 | 6.80 | 7.25 |
| Ranier Paradise Ranger Station | 4.20 | 6.60 | 8.30 | 8.75 |
| Tacoma | 3.66 | 4.50 | 5.87 | 6.38 |
| | NOVEMBER 1990 | | | |
| Buckley 1NE | 2.55 | 3.55 | 3.95 | 4.10 |
| Greenwater | 2.60 | 3.30 | 3.80 | 4.30 |
| Mud Mountain Dam | 2.60 | 3.10 | 3.30 | 3.70 |
| Rainier Carbon River Entrance | 3.20 | 3.90 | 5.65 | M |
| Rainier Paradise Ranger Station | 7.20 | 8.50 | 8.90 | 13.70 |
| Tacoma | 3.80 | 4.25 | 4.60 | 5.17 |
| | FEBRUARY 1996 | | | |
| Buckley 1NE | 3.80 | 4.80 | 6.10 | 6.90 |
| Greenwater | 3.90 | 6.30 | 8.50 | 9.40 |
| Mud Mountain Dam | 3.80 | 4.90 | 6.30 | 7.10 |
| Rainier Carbon River Entrance | 3.70 | Missing | Missing | Missing |
| Rainier Paradise Ranger Station | 7.40 | 1o.60 | 14.30 | 17.20 |
| Tacoma | 3.00 | 3.90 | 5.30 | 5.90 |

4.07 Runoff Characteristics. The heaviest rainfall and, consequently, the highest runoff generally occur during the winter storm season from November through March. Frequent sharp peaks of short duration characterize runoff during this period. However, peaks may be separated by periods of relatively low flow when temperatures drop with the intrusion of a cold air mass and there is no precipitation or, if there is any, it falls mostly as snow. Intense winter rainstorms with warm winds and accompanying snowmelt cause the river to swell from relatively low flow to flood levels within 24 to 36 hours. Often two or three such rises will occur in rapid succession as series of severe storms pass through the basin. After a storm has passed, flows generally recede about as rapidly as they rose.

In April, heavy winter rains have abated, temperatures rise, and runoff is due mainly to snowmelt. Spring runoff is characterized by peaks which are generally smaller in magnitude than those occurring in the winter, but are of much longer duration. By the end of July, the snowpack over most of the basin is depleted and flows recede rapidly, reaching minimum flow during August. Rivers draining glaciers on Mount Rainier, such as the Puyallup and the White, maintain a higher base flow than those draining the Cascade Range.

The drainage area gaged by the upstream stations Puyallup river near Electron, Carbon River near Fairfax, White River at Greenwater, and Greenwater River at Greenwater totals 1195.5 $km^2$ (461.6 square miles) and the drainage area above the station Puyallup River at Puyallup (at Puyallup) is 2455 $km^2$ (948 square miles), an increase of 105 percent. The average annual runoff, however, increases only 66 percent reflecting the absence of orographic effects on precipitation and the continuing contribution from the glaciers on Mount Rainier to the upstream gages. The annual stream flow pattern for the Puyallup River basin is shown by the summary hydrographs for the stations White River near Buckley (Mud Mountain Reservoir outflow) and at Puyallup, plates 4-5 and 4-6 respectively, and the daily discharge hydrographs for the stations Puyallup River near Orting (near Orting), Carbon River near Fairfax (near Fairfax), near Buckley, and at Puyallup, plates 4-7, 4-8, 4-9 and 4-10 respectively.

The mean annual flow at Puyallup varied from 139.5 $m^3/s$ to 59.1 $m^3/s$ (4,927 cfs to 2,087 cfs) during the period of record from 1914 to 1992. Extremes of discharge recorded were a maximum of 1613 $m^3/s$ (57,000 cfs) in December 1933 and a minimum of 8.6 $m^3/s$ (306 cfs) in November 1955. The observed peak flow in February 1996 was 1322.5 $m^3/s$ (46,700 cfs) regulated, but the estimated peak under natural conditions is 2152.3 $m^3/s$ (76,000 cfs). The mean annual flow near Buckley varied from 59 $m^3/s$ to 25.6 $m^3/s$ (2088 cfs to 908 cfs) during the period of record from 1928 to November 1933 and 1938 to 1992. Extremes of discharge recorded were a maximum of 481.1 $m^3/s$ (17,000 cfs) in February 1932 and a minimum of no flow in 1958 and 1959. The peak discharge in December 1933 is estimated from flood marks to have been 792.4 $m^3/s$ (28,000 cfs). The estimated natural peak discharge for the February 1996 flood is 837.1 $m^3/s$ (29,560 cfs). Mean monthly flows for the stations near Orting, near Buckley, near Fairfax, and at Puyallup are listed in metric and in English units in table 4-6.1 and 4-6.2 respectively.

4.08 Channel and Floodway Characteristics. Inter-County constructed levees and improved the channel by enlargement and rectification of the Puyallup River from the confluence with the White River to the city limits of Tacoma to convey 1415 $m^3/s$ (50,000 cfs). The channel through Tacoma would carry no more than 849 $m^3/s$ (30,000 cfs). The Flood Control Act of June 22, 1936, authorized channel improvement, rectification, and levee construction on the lower Puyallup within the Tacoma city limits. The Corps completed the project in 1950 thus providing a channel that can carry 1415 $m^3/s$ (50,000 cfs) from the mouth of the White River to Commencement Bay. The Flood Control Act of 1938 authorized the Corps to maintain the federal project through the Tacoma city limits.

# Table 4-6.1

## MEAN MONTHLY STREAMFLOW DATA
## METRIC UNITS~$m^3$/sec

| Stream | Station Location | Period | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Puyallup | Near Orting | 1932-99 | 13.6 | 23.2 | 27.3 | 25.5 | 22.0 | 17.5 | 18.3 | 22.3 | 24.9 | 20.7 | 15.9 | 12.6 |
| Carbon | near Fairfax | 1911, 1929-77, 1992-99 | 8.8 | 14.1 | 15.3 | 13.4 | 10.9 | 8.7 | 10.6 | 15.8 | 18.4 | 13.9 | 9.1 | 6.9 |
| Puyallup | at Alderton | 1914-26, 1944-57 | 31.1 | 44.1 | 66.6 | 56.8 | 54.7 | 41.8 | 44.5 | 51.3 | 55.5 | 45.7 | 30.1 | 24.4 |
| White | near Buckley | 1929-33, 1939-99 | 20.6 | 38.8 | 48.2 | 45.5 | 43.2 | 37.1 | 44.8 | 60.2 | 65.3 | 42.1 | 25.3 | 19.0 |
| Puyallup | At Puyallup | 1914-99 | 55.5 | 95.2 | 124.9 | 121.4 | 110.5 | 91.6 | 96.0 | 111.9 | 125.8 | 89.4 | 59.4 | 47.8 |

# Table 4-6.2

## MEAN MONTHLY STREAMFLOW DATA
## CUBIC FEET PER SECOND

| Stream | Station Location | Period | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Puyallup | Near Orting | 1932-99 | 479 | 820 | 963 | 900 | 776 | 617 | 646 | 787 | 878 | 731 | 563 | 444 |
| Carbon | near Fairfax | 1911, 1929-77, 1992-99 | 310 | 497 | 542 | 472 | 384 | 308 | 374 | 558 | 651 | 490 | 321 | 245 |
| Puyallup | at Alderton | 1914-26, 1944-57 | 1099 | 1557 | 2353 | 2004 | 1933 | 1477 | 1570 | 1812 | 1961 | 1613 | 1062 | 860 |
| White | near Buckley | 1929-33, 1939-99 | 726 | 1369 | 1701 | 1608 | 1526 | 1311 | 1581 | 2127 | 2305 | 1485 | 893 | 672 |
| Puyallup | At Puyallup | 1914-99 | 1961 | 3360 | 4409 | 4287 | 3901 | 3234 | 3390 | 3953 | 4441 | 3158 | 2,096 | 1688 |

Table 4-6.2.doc

At the time of construction of the project, it was believed that the White River below the dam could carry 498.4 $m^3/s$ (17,600 cfs) without causing any damage because of the Inter-County improvements in the channel referred to in paragraph 3.05b. Because maintenance has been curtailed and there has been development at some points along the river, there are some reaches where damage might begin at flows as low as 169.8 $m^3/s$ (6,000 cfs). However, in February 1996 dam release was 382.3 $m^3/s$ (13,500 cfs) during the pool evacuation without major damage in the reach above the mouth of the White. Some specific areas threatened when discharges exceed 12,000 cfs are: residences in the Red Creek area, just downstream of the dam; Muckleshoot Tribe fish hatchery; Buckley Meadows subdivision; Sumner golf course; residences near intersection of 8th Street East and 138th Avenue East; and the Sumner sewage treatment plant.

4.09. Floods. Recorded flood peaks are available since the establishment of the gaging station at Puyallup in May 1914. The maximum flood discharge of record of 1613.1 $m^3/s$ (57,000 cfs) occurred in December 1933, followed 12 days later by a peak of 1301.8 $m^3/s$ (46,000 cfs). Floods in January 1965, December 1977, January 1990, November 1990 and February 1996 were controlled by the project to less than 1415 $m^3/s$ (50,000 cfs) at Puyallup but the estimated natural peaks would have been 1499.9 $m^3/s$, 1641.4 $m^3/s$, 1839.5 $m^3/s$, 1726.3 $m^3/s$ and 2152.1 $m^3/s$ (53,000, 58,000, 65,000, 61,000 and 76,000 cfs) respectively. A tabulation of flood peaks in excess of 849 $m^3/s$ (30,000 cfs), the channel capacity before completion of the federal project through Tacoma, is presented in metric and English units in tables 4-7.1 and 4-7.2, respectively. Frequency curves, representing maximum annual inflow and outflow and reservoir stage at Mud Mountain Dam are shown on plates 4-11, 4-12 and 4-13 respectively. Curves for local inflow for the area from below the dam to the Puyallup gage are shown on plate 4-14. Frequency curves for Puyallup River at Alderton and the natural and regulated condition at the Puyallup at Puyallup gage are found on plates 4-15 and 4-16 respectively.

# TABLE 4-7.1
# FLOOD PEAKS
# PUYALLUP RIVER AT PUYALLUP
# $M^3/S$

| Month | Year | Recorded Peak $m^3/s$ | Estimated Natural $m^3/s$ |
|---|---|---|---|
| Jun | 2001 | 200 | 215 |
| Nov | 1999 | 665 | 915 |
| Dec | 1998 | 677 | 930 |
| Oct | 1997 | 411 | unavailable |
| Jan | 1997 | 646 | 977 |
| Feb | 1996 | 1322 | 2,152 |
| Feb | 1991 | 894 | 1,041 |
| Nov | 1990 | 1186 | 1,726 |
| Jan | 1990 | 1268 | 1,840 |
| Nov | 1986 | 1240 | 1,344 |
| Feb | 1986 | 974 | 1,084 |
| Jan | 1984 | 1050 | 1,245 |
| Dec | 1977 | 1149 | 1,641 |
| Dec | 1975 | 942 | 1,189 |
| Jan | 1975 | 923 | 1,053 |
| Jan | 1974 | 889 | 1,067 |
| Jan | 1965 | 1174 | 1,500 |
| Nov | 1959 | 1007 | 1,358 |
| Dec | 1955 | 1064 | 1,344 |
| Dec | 1953 | 976 | 1,344 |

| Month | Year | Recorded Peak $m^3/s$ | Estimated Natural $m^3/s$ |
|---|---|---|---|
| Dec | 1946 | 957 | 1296 |
| Apr | 1938 | 959 | * |
| Oct | 1935 | 1118 | |
| Jan | 1934 | 877 | |
| Dec | 1933 | 1302 | |
| Dec | 1933 | 1613 | |
| Nov | 1932 | 1070 | |
| Feb | 1932 | 934 | |
| Jan | 1923 | 877 | |
| Dec | 1921 | 1007 | |
| Jan | 1919 | 1033 | |
| Dec | 1918 | 934 | |
| Dec | 1918 | 1146 | |
| Nov | 1906 | 1044 | ** |

* Regulation began in 1942
** Estimated historical peak

Table 4-7-1.doc

**TABLE 4-7.2**
**FLOOD PEAKS**
**PUYALLUP RIVER AT PUYALLUP**
**CFS**

| Month | Year | Recorded Peak cfs | Estimated Natural cfs |
|---|---|---|---|
| Jun | 2001 | 7080 | 7610 |
| Nov | 1999 | 23,500 | 32,300 |
| Dec | 1998 | 23,900 | 32,800 |
| Oct | 1997 | 14,500 | unavailable |
| Jan | 1997 | 22,800 | 28,200 |
| Feb | 1996 | 46,700 | 76,000 |
| Feb | 1991 | 31,600 | 36,800 |
| Nov | 1990 | 41,900 | 61,000 |
| Jan | 1990 | 44,800 | 65,000 |
| Nov | 1986 | 43,800 | 47,500 |
| Feb | 1986 | 34,400 | 38,300 |
| Jan | 1984 | 37,100 | 44,000 |
| Dec | 1977 | 40,600 | 58,000 |
| Dec | 1975 | 33,300 | 42,000 |
| Jan | 1975 | 32,600 | 37,200 |
| Jan | 1974 | 31,400 | 37,700 |
| Jan | 1965 | 41,500 | 53,000 |
| Nov | 1959 | 35,600 | 48,000 |
| Dec | 1955 | 37,600 | 47,500 |
| Dec | 1953 | 34,500 | 47,500 |

| Month | Year | Recorded Peak cfs | Estimated Natural cfs |
|---|---|---|---|
| Dec | 1946 | 33,800 | 45,800 |
| Apr | 1938 | 33,900 | * |
| Oct | 1935 | 39,500 | |
| Jan | 1934 | 31,000 | |
| Dec | 1933 | 46,000 | |
| Dec | 1933 | 57,000 | |
| Nov | 1932 | 37,800 | |
| Feb | 1932 | 33,000 | |
| Jan | 1923 | 31,000 | |
| Dec | 1921 | 35,600 | |
| Jan | 1919 | 36,500 | |
| Dec | 1918 | 33,000 | |
| Dec | 1918 | 40,500 | |
| Nov | 1906 | 36,900 | ** |

* Regulation began in 1942
** Estimated historical peak

Table 4-7-2.doc

4.10 Water Quality. The water quality of the Puyallup River from RK 1.6 to RK 50.8 (RM 1 to RM 31.6) and the White River from the mouth to Mud Mountain Dam are classified as Class A (excellent), and the Puyallup River above RK 50.8 (RM 31.6) and the White River above Mud Mountain Dam are classified as Class AA (extraordinary) by the State. Water quality of Class A "shall meet or exceed the requirements for all or substantially all uses" and of Class AA "shall markedly and uniformly exceed requirements for all or substantially all uses" as published in Chapter 173-201A WAC. Characteristic uses include, but are not limited to water supply, stock watering, fish, and shellfish reproduction, rearing and harvesting, wildlife habitat, and recreation.

4.11 Fish and Wildlife.

a. Fish. Anadromous fishes widely distributed in the Puyallup River basin are chinook, coho, pink, and chum salmon; steelhead and sea run cutthroat trout; and sea run Dolly Varden. Upstream migration of the various races and species overlap considerably with adults of one or more species entering the river system every month. In the White River, anadromous fish are trapped at the Buckley diversion and trucked to a fish dump approximately 8 km (5 miles) above Mud Mountain Dam. The State maintains and operates the Puyallup Salmon Hatchery on Voight Creek near Orting where fall chinook and coho are the principal salmon produced with nearly all fish planted in the basin. Two other state fish hatcheries, near Puyallup and at south Tacoma, rear anadromous and resident trout. A major percentage of the fish reared at the Puyallup facility and a minor percentage of those produced at south Tacoma are liberated in the Puyallup River basin. Rainbow and cutthroat trout are found in significant numbers. Brook trout, mountain whitefish, and Dolly Varden are also found in most of the streams in the basin. Suckers, squawfish, and other non-game species are also present. In the White River basin Chinook salmon and bull trout are listed as “threatened” under provisions of the Endangered Species Act. The Muckleshoot Tribe operates a fish hatchery on the right bank of the White River across the from the PSE diversion. The facility propagates White River spring Chinook. The hatchery draws about 2.5 cfs from the White River during the May through October period and a similar amount from groundwater wells the remainder of the year. A fish ladder for the hatchery joins the river just downstream of the PSE diversion.

b. Wildlife. Black-tailed deer, elk, bear, and mountain lion inhabit the foothill areas surrounding Mount Rainier and are seen less frequently in the project area. Deer are by far the most numerous and widespread of the big-game animals. Beavers, squirrels, chipmunks, coyotes, and similar mammals, as well as many forest rodents such as moles, mice, shrews, and others, live on adjacent lands. Game birds in the area include blue and ruffed grouse, bandtailed pigeons, and quail. Songbirds of numerous species and numbers are present. The bald eagle, listed as threatened under the Endangered Species Act, is present in small numbers in the White River basin

4.12 Downstream Structures. Information on downstream structures can be found in Section 3, paragraph 3.05.

4.13 Economic Data.

a. Population. The major portion of the Puyallup River basin is in Pierce County, with the White and Greenwater Rivers providing most of the boundary between King and Pierce Counties. The Puyallup River discharges into Commencement Bay in Tacoma, the principal industrial and commercial center of the basin. The population of the larger cities and towns in the basin, based on U.S. Census Bureau 2000 data, is given in table 4-8.

b. Agriculture. Agriculture land in the Puyallup River basin totals about 34,400 hectares (85,000 acres), of which about 8,903 ha (22,000 acres) are in productive farms. Products include hay, grain, poultry, berries, vegetables, nursery stock, bulbs, and dairy products. Berry farms in the vicinity of Sumner and Orting are among the most productive in the United States.

TABLE 4-8

**POPULATION (2000 census)**

| City | Population | City | Population |
|---|---|---|---|
| Tacoma | 193,556 | Sumner | 8,504 |
| Puyallup | 33,011 | Buckley | 4,145 |
| Enumclaw | 11, 116 | Orting | 3,760 |

c. Industry. Lumber mills, wood product factories, flour mills, and food canning plants, are located in Tacoma. Timber is harvested in the basin with much of it trucked to ports and shipped to other countries. Clay and sandstone are found in the basin and are used commercially for manufacturing pipe and building respectively. Hydroelectric power is a primary resource.

d. Flood Damages. No complete account of past flood losses is available. It has been estimated that the total damage from the floods of December 1917 and January 1919 was $400,000. The December 1933 flood was by far the most destructive flood in the history of the valley with damages estimated at $950,000. Since flood control regulation began at Mud Mountain Dam in 1942, no flows exceeding the 1415 $m^3/s$ (50,000 cfs) capacity of the channel below the mouth of the White River have occurred and no damages have been incurred in that reach. However, due to aggradation in the White River channel and encroachment in the flood plain, the White River can no longer carry the planned maximum discharge from Mud Mountain Dam of 498.4 $m^3/s$ (17,600 cfs) without some damage occurring. Project operations during the February 1996 flood of record resulted in $146.1 million in damages prevented, accounting for almost half of the total damages prevented during the 50 plus years of operation. Total damages prevented by Mud Mountain Dam through Fiscal Year 1999 are estimated at $308,152,000.

# SECTION 5. HYDROMETEOROLOGICAL DATA AND COMMUNICATIONS

5.01 Hydrometeorological Data Facilities. There are 23 active hydrometeorological (hydromet) stations in the Puyallup River basin. Plate 5-1 shows the location of these stations.

a. Meteorological Stations. For this manual, all weather stations, cooperative climatological stations and SNOTEL stations are considered meteorological stations. Eight such stations are currently active in the basin and are listed in table 5.1.

b. Streamgaging Stations. There are fifteen active streamgaging stations in the basin, which are listed in table 5.2. Thirteen stations are operated and maintained by the U.S. Geological Survey (USGS) with six stations funded fully by project funds transferred annually under the Cooperative Streamgaging Program (CSP). The Corps operates and maintains the reservoir and White River at Bridge Camp gages. The USGS is reimbursed under the CSP for publication of the reservoir data under the station name Mud Mountain Lake near Buckley, WA.

5.02 Project Hydromet Network. The Project automated network includes six streamgaging stations, two precipitation stations, and the project station (see tables 5-1 and 5-2, and plate 5-1). Each of these stations is tied via VHF and microwave into the hydromet data controllers located in the Project office and the Reservoir Control Center (RCC) in the CENWS Office. Each remote data station can be interrogated from the controllers either individually or in a group. Interrogation can be initiated manually at any time or automatically at preset intervals. The length of time intervals can be set according to need. Each remote data station is equipped with a real-time clock and can, without controller interrogation, automatically transmit data at preset intervals or whenever a predetermined criterion is met. All interrogated and remote self-initiated data transmissions received by the controllers are automatically relayed directly into the Columbia River Operational Hydromet Management System's Central Facility Data Controller for data processing by computer.

# TABLE 5.1
# METEOROLOGICAL STATIONS
## PRECIPITATION STATIONS

| Station | Weather Svc. Station Number | Hydromet Station Code | Elevation | | Period of Record | Operated and Maintained By | On Hydromet Network |
|---|---|---|---|---|---|---|---|
| | | | meters | feet | | | |
| Buckley 1 NE | 450945 | BUCW | 208.78 | 685 | 1913- | Puget Sound Energy | No |
| McMillan Reservoir | 455224 | MMLW | 176.47 | 579 | 1941- | Tacoma Water Dept. | No |
| Mud Mountain Dam | 455704 | ENUW | 398.67 | 1308 | 1939- | Seattle District | Yes |
| Puyallup 2W Exp Sta | 456803 | PLXW | 30.48 | 100 | 1914- | W WA Resch Ext Ctr | No |
| Carbon R Nr Fairfax | None | FFXW | 366.30 | 1202 | 1992- | Seattle District | Yes |
| Tacoma 1 | 458278 | TACW | 33.22 | 109 | 1878- | Tacoma Public Works | No |



## SNOTEL SITES

| Station | National Resource Conservation Service (NRCS) Sta. Number | Hydromet Station Code | Elevation | | Period of Record | Operated and Maintained By | On Hydromet Network |
|---|---|---|---|---|---|---|---|
| | | | meters | feet | | | |
| Morse Lake | 21c17f | MRSW | 1645.92 | 5400 | 1956- | NRCS | No |
| Corral Pass | 21b13f | COPW | 1828.8 | 6000 | 1940- | NRCS | No |

# TABLE 5-2
# STREAMGAGING STATIONS

| Station | USGS Station Number | Hydromet Station Code | Drainage Area | | Period of Record | On Hydromet Network |
|---|---|---|---|---|---|---|
| | | | $km^2$ | Sq. miles | | |
| Puyallup River near Electron | 12092000 | ELEW | 240.87 | 93 | 1908-33; 44-49; 57- | No |
| Puyallup River near Orting | 12093500 | ORTW | 445.48 | 172 | 1931- | Yes |
| Puyallup River at Puyallup | 12101500 | PUYW | 2455.32 | 948 | 1914 | Yes |
| South Prairie Creek At South Prairie | 12095000 | SPEW | 207.2 | 80 | 1949-71; 87- | No |
| Mud Mountain Lake near Buckley | 12098000 | MMD | 1036 | 400 | 1943 | Yes |
| White River near Buckley | 12098500 | MMDW | 1038.59 | 401 | 1928-33; 38- | Yes |
| White River Canal at Buckley | 12099000 | WRCW | * | * | 1913-38; 81- | No |
| Boise Creek at Buckley | 12099600 | BOSW | 38.85 | 15 | 1977- | No |
| White River at Buckley | 12100000 | BUKW | 1105.93 | 427 | 1910-11; 77- | No |
| White River near Auburn | 12100496 | WABW | 1201.76 | 464 | 1987-89; 90- | No |
| Lake Tapps near Sumner | 12101000 | TAP | * | * | 1911- | No |
| Lake Tapps Diversion at Dieringer | 12101100 | LTDW | * | * | 1958- | No |
| Greenwater River at Greenwater | 12097500 | GEEW | 191.66 | 74 | 1929-77; 80- | No |
| Carbon River near Fairfax | 12094000 | FFXW | 204.61 | 79 | 1910-12; 29-78; 91- | Yes |
| White R at Bridge Camp Abv MMD | COE Only | MMAW | 854.70 | 330 | 2002- | Yes |

* Part of the diversion system supplying water to Dieringer Power Plant

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5.03 Communications Network. The CENWS office and the Project are linked via commercial telephone for voice communications. A five-channel VHF voice system is available for communication between the Project and CENWS office or Corps vehicles equipped with two-way radio equipment. Cellular telephones are available both at the Project and in the District Office.

5.04 Maintenance. Maintenance and repair of any of the sensing equipment that is part of the hydromet network is the responsibility of the HHS. Maintenance and repair of the communications and data transmission system is the responsibility of Project Support of Operations Division.

5.05 Project Reporting Instructions.

a. Effective communications are essential to the safe and efficient operation of Mud Mountain project. The preceding paragraphs describe hydrometeorological data collected and physical facilities available for transmission of information. This data and information provide the basis for implementation of the Water Control Plan as specified in Section 7, the Water Control Plan.

b. General instruction for recording reservoir regulation activities and hydrometeorological information are provided in paragraphs 7.05, a and b.

c. Special coordination for weekend and non-standard operation and flood control is described in paragraphs 7.05, c and d.

d. Coordination with Puget Sound Energy's diversion facility located downstream of MMD project is especially sensitive and critical. Guidance for this coordination is specified in Exhibit 3-1.

e. Exhibit 7-1 is a list of agencies and individuals that are often involved in operation of the project and information for contacting them.

5.06 Warnings and Emergency Operating Procedures. Paragraph 7.05, e provides guidance on responsibilities for reporting and responding to unusual and emergency situations and supplements guidance provided elsewhere in Section 7 and other Sections of the manual.

## SECTION 6. FORECASTING

6.01 General. Streamflow forecasts are used for flood control regulation in the White/Puyallup River Basins. Forecasts of weather and streamflow conditions for the White River at Mud Mountain Dam, South Prairie Creek at South Prairie, the Carbon River near Fairfax, the Puyallup River near Orting, and the Puyallup River at Puyallup are made by the National Weather Service (NWS) River Forecast Center (RFC). The RFC uses the River Forecast Systems (RFS) model for predicting streamflow throughout the Pacific Northwest. These RFS model forecasts are useful for estimating the natural river flows in the White/Puyallup basins during high flow periods. When local weather conditions on the White River basin are contrary to regional patterns, RFC forecasts can be inappropriate for predicting inflow to Mud Mountain Dam. For this reason, a customized inflow forecast is prepared by the CENWS for the White River above Mud Mountain Dam using a quantitative precipitation forecast (QPF) by the district meteorologist.

6.02 Flood Forecasts.

a. Requirements. Flood forecasts for the White/Puyallup Rivers are necessary to allow adequate time for Project regulation to be effective in reducing flood flows in the lower valley as observed at the control station, USGS gage number 12101500, Puyallup River at Puyallup. The primary purpose of Mud Mountain Dam is to control the flow of the Puyallup River as measured at the Puyallup control point to 1415 $m^3/s$ (50,000 cfs). To compensate for the uncertainty associated with the rainfall/runoff forecasting process and the flow from the unregulated portion of the basin, a target flow of 1273.5 $m^3/s$ (45,000 cfs) at the Puyallup gage is used. Travel time between the dam and Puyallup is approximately 6 hours during high flows. Therefore, forecasts must be developed expeditiously so that regulation at the dam can be implemented to reduce the natural flood peak downstream. Flood forecasts by the RFC for the White, Carbon and Puyallup Rivers are used in conjunction with the CENWS forecast for the White River to formulate an effective reservoir regulation plan.

b. Methods. The RFC RFS model combines the Anderson Snow Model with the Sacramento Soil Moisture Accounting Model to predict total runoff. A unit hydrograph is used to distribute the runoff over time in 6-hour increments. The RFS model also includes a Streamflow Synthesis and Reservoir Regulation (SSARR) reservoir operation model. With the inclusion of real time reservoir operations and one of several channel routing methods, the model is capable of producing a realistic forecast for the control point, Puyallup River at Puyallup.
Runoff forecasting for inflow to Mud Mountain Dam can also be done using the HEC-1 flood runoff model developed by the Hydrologic Engineering Center and customized to apply to the Puyallup basin by CENWS. Runoff values are computed at hourly intervals using both forecasted and observed precipitation, snow water equivalent, and temperature data. Due to the limited network of stream gages and weather stations in the White/Puyallup Basin, the HEC-1 model of the upper White River Basin is modeled as a single watershed. Default unit hydrograph parameters, loss coefficients, and snowmelt parameters have been calibrated from past storm events. Considerable hydrologic judgment must be applied when adjusting model parameters due to the uncertain nature of the rainfall/runoff process.

The customized inflow forecast created by the district meteorologist is on an hourly basis rather than the standard 6-hour increments to not only present a more detailed description of the rainfall intensity and duration, but also to create the hourly QPF required by HEC-1 and a flood routing spreadsheet program. Atmospheric pressure, air temperature, humidity, wind speed, and wind direction data from a radiosonde launched from Quillayute, Washington, along with other supplemental data such as the strength and orientation of the polar jet stream, are entered into a proprietary computer spreadsheet program. The program output consists of an hourly precipitation and temperature forecast for a 72-hour period for seven locations in Western Washington including Mud Mountain Dam.

A flood routing spreadsheet program aids regulators in determining the quantity and timing of project releases to obtain the desired control flow at Puyallup. The spreadsheet (on Microsoft EXCEL) is linked to the HEC-1 model output. It reveals the resulting reservoir level associated with possible project releases. When using the spreadsheet program in a predictive mode, the regulator enters trial discharges from the dam, and predicted local inflows to obtain the desired 45,000 cfs target flows at Puyallup. A fixed travel time of 6 hours from the dam to Puyallup is assumed. Predicted local inflow is based on the RFC's RFS model runs for the Carbon and Puyallup Rivers, and sound hydrologic judgment.

Current streamflow forecasting procedures will be updated and replaced as the District's database expands and the Corps' next generation software is made available.

# SECTION 7. WATER CONTROL PLAN

7.01 General Objectives. Mud Mountain Dam is a single purpose project regulated primarily to prevent flood damages in the Puyallup River valley below the mouth of the White River. The reservoir is empty except during periods of actual flood regulation or during periods when a pool is required for debris removal or project maintenance.

7.02 Operating Constraints.

a. General. The maximum capacity of the modified 9-foot tunnel is approximately 127 $m^3$/s to 141 $m^3$/s (4500 - 5000 cfs), about the same as existed with the original intake. The maximum possible capacity of the 23-foot tunnel is approximately 608 $m^3$/s (21,500 cfs), significantly greater than existed with the original tunnel. Because of this additional discharge capacity, extreme diligence must be exercised to ensure that total MMD outflow from combined operation of both the 9- and 23-foot tunnels does not exceed the authorized release of 498 $m^3$/s (17,600 cfs). Except in cases of extreme emergency, i.e., save the dam conditions, MMD is to be regulated to a maximum total release of 498.08 $m^3$/s (17,600 cfs).

b. 9-Foot Tunnel.

(1) Control gate (R3) should be in the 100 percent open position at all times unless regulation is needed for flood control or maintenance.

(2) Control gate is not to be operated at less than 100 percent open to regulate tunnel discharge in the 56.6 $m^3$/s to 141.5 $m^3$/s (2000 - 5000 cfs) range to prevent potential gate-to-tunnel control shift problems. Control gate is not to be operated at less than 10 percent open regardless of pool elevation because of the potential for blockage of the gate opening by debris.

(3) Rating curves for the 9-foot tunnel are found on charts 2-2 and 2-3.

c. 23-Foot Tunnel.

(1) Control gates (R1 and R2) will normally be set at 80 percent open and remain at that position unless a different setting is required for water control regulation or maintenance.

(2) Control gates are to be limited to a maximum opening of 90 percent when pool elevation exceeds 320 m (1050 feet) except in cases of extreme emergency, i.e., save the dam conditions, when gates may be opened to 100 percent.

(3) Control gates are not to be positioned in the greater than 90 percent to less than 100 percent open range regardless of pool elevation. If gate openings larger than 90 percent are required, the gate(s) are to be opened 100 percent.

(4) Control gates are not to be operated to pass water at less than 10 percent open regardless of pool elevation because of the potential for blockage of the gate opening by debris. To the extent possible, avoid long term operation of the gates at gate openings less than those shown in table 7-1 to minimize potential cavitation conditions.

**TABLE 7-1**

**MINIMUM GATE OPENINGS**

**23-FOOT TUNNEL GATES**

| Pool Elevation (Meters) | Pool Elevation (feet) | Minimum Gate Opening (%) |
|---|---|---|
| < 289.56 | < 950 | 10 |
| 289.57-304.80 | 950.1-1000 | 15 |
| 304.81-312.42 | 1000.1-1025 | 20 |
| 312.43-320.04 | 1025.1-1050 | 25 |
| 320.05-327.66 | 1050.1-1075 | 30 |
| 327.67-342.90 | 1075.1-1125 | 35 |
| 342.91-350.52 | 1125.1-1150 | 40 |
| 350.53-358.14 | 1150.1-1175 | 45 |
| > 358.14 | > 1175 | 50 |

(5) Control gates should generally be operated to obtain approximately equal discharges through the two openings. Difference in discharge between the two entrances of more than 30 percent should be avoided when possible.

(6) Rating curves for the 23-foot tunnel are found on charts 2-4, 2-5, 2-6 and 2-7.

7.03 Ramp Rate Criteria.

a. General. Ramp rate limits are intended to reduce stranding of fish and apply as follows:

(1) When flow is being reduced by operation of gates. The limits do not apply to river fluctuations that occur downstream with no gate changes.

(2) When discharge is less than 28.3 $m^3/s$ (1000 cfs).

(3) Limits do not apply to operations required during flood emergencies.

(4) Rate-of-rise limit is 0.3 m/hr (1 ft/hr) except during flood emergencies

**TABLE 7-2**

**DOWN RAMPING LIMITS**

| | **Daylight Hours (1 hour before sunrise to 1 hour after sunset)** | | **Night Time Hours (1 hour after sunset to 1 hour before sunrise)** | |
|---|---|---|---|---|
| | **in/hr** | **cm/hr** | **in/hr** | **cm/hr** |
| **February 16-June 15** | **0** | **0** | **2** | **5** |
| | | | | |
| **June 16-October 31** | **1** | **2.5** | **1** | **2.5** |
| | | | | |
| **November 1-February 15** | **2** | **5** | **2** | **5** |

7.04 Flood Control Regulation.

a. General. During the winter flood control season, 1 October - 31 March, the reservoir will be empty with MMD on free flow to provide approximately 13,069 ha-m (106,000 acre-feet) of storage for use in regulating floods. The primary flood control objective is damage prevention on the lower Puyallup River. A secondary objective is to reduce damage in the White River reach between the dam and the mouth of the White by limiting dam discharge to 339.8 $m^3/s$ (12,000 cfs) when feasible.

b. White River Discharge Limits. Dam discharge will be increased on the rising side of the flood hydrograph to preserve storage for Lower Puyallup River flood control up to a limit of 339.8 $m^3/s$ (12,000 cfs). During floods, discharge will be reduced as necessary to provide flood control on the Lower Puyallup River except during large floods discharge will be increased according to the requirements of the Discharge Regulation Schedule, Chart 7-1, to best utilize remaining reservoir storage.

c. Lower Puyallup River Flood Control. Although the channel capacity in the lower Puyallup is 1415 $m^3$/s (50,000 cfs), the control flow at Puyallup is established at 1273.5 $m^3$/s (45,000 cfs) to provide a factor of safety against errors in forecasting. When the flow at Puyallup is forecast to exceed 1273.5 $m^3$/s (45,000 cfs) in 8 hours, the discharge from MMD will be regulated to hold the discharge at the Lower Puyallup control flow as long as feasible considering that inflow below dam and the contribution from the upper Puyallup River may exceed the control flow. Because MMD controls only 42 percent of the total drainage area at Puyallup, not all potential floods can be held below the non-damaging discharge even if there is no discharge from the dam. Also, MMD discharge will be increased if necessary to make best use of remaining reservoir storage as specified in paragraph b. above. During flood control regulation, if the reservoir fills to the spillway crest, elevation 370.33 m (1215 feet), a reduction will be made in the sluice discharge, if any is occurring, equal to the increase in spillway discharge until the sluices are closed to make use of surcharge storage. Chart 2-1 is a spillway rating curve.

d. Evacuation of storage. Evacuation of storage shall begin after forecasts indicate a continuing falling trend in the flow at Puyallup and a discharge below 1,273.5 $m^3$/s (45,000 cfs) for two consecutive hours. Releases from the dam will be scheduled to maintain a 1,273.5 $m^3$/s (45,000 cfs) discharge at Puyallup until project discharge reaches 339.8 $m^3$/s (12,000 cfs). Discharge may be increase to as high as 498 $m^3$/s (17,600 cfs) if forecasts indicate that expedited evacuation is required to provide for control of an expected subsequent flood. At any time during the evacuation period storage will be resumed for flood control if the discharge at Puyallup is again forecast to exceed 1,273.5 $m^3$/s (45,000 cfs) in 8 hours.

e. Flood Debris Management. Typically, large amounts of floating debris accumulate in the reservoir during flood events. If weather forecasts indicate that subsequent flood events are not imminent, reservoir evacuation may be temporarily suspended when drawdown reaches approximately elevation 1050 to allow for collection and disposal of debris.

7.05 Standing Instructions to Dam Tenders.

a. General. The project shall normally be attended on a 5-day-week basis from Monday through Friday, 8 hours per day. MMD personnel will man the project continuously during a declared flood alert or periods of flood control regulation, including evacuation. A list of project and HHS personnel to be contacted in emergency situations is reviewed and disseminated each year (see exhibit 7-1). Dam tenders will implement only reservoir regulation instructions received directly from HHS unless communication is interrupted, in which case regulation will be in accordance with emergency regulation procedures, paragraph 7.05c. All instructions pertaining to reservoir regulation will be implemented as expeditiously as possible and recorded, along with physical data, personnel involved, contacts made, etc., in the Mud Mountain Dam Operating Log book.

b. Normal Operating Procedures. Collecting, recording, and reporting data are routine functions required at all Corps projects. Each normal workday at 0800 hours, MMD personnel will collect the maximum, minimum, and current temperature, snowfall and snow depth, and precipitation in the manual gage, and record the data. This data will also be reported to HHS during a morning telephone call together with data from the gages on Boise Creek near Buckley, the flume flow and spill at the PSE diversion dam, any gate changes made since the last report, and the temperature and turbidity of the reservoir inflow and outflow from the day before. The data may be cumulative for one day or for up to a four-day period depending upon weekends and holidays.

c. Weekend and Special Coordination. Prior to a weekend or holiday, during periods of construction at the project, when gate operations are required after normal duty hours or in any situation or when any unusual situation exists which may require non-routine gate operation, the assigned MMD gate operator will contact the HHS regulator for coordination. Coordination will include but not be limited to:

(a) Initial gate settings.

(b) Weather forecast.

(c) Contact procedures for telephones, pagers, computers etc.

(d) Information pertinent to any expected unusual operations or events.

d. Flood Operations.

(1) In flood situations when communication with major hydromet stations is lost, dam tenders may be required to go to the station to observe streamflow and/or weather data at-site and transmit this information to the dam by portable radio or cell phone.

(2) The project shall be attended by at least two persons during flood alerts and/or flood control regulation as required for monitoring of the reservoir and the weather, and regulation of the discharge. The dam tender will immediately notify HHS if either of the following conditions should occur:

(a) Rainfall in excess of 5 cm (2 inches) during any consecutive 3-hour period or 7.6 cm (3 inches) during any consecutive 24-hour period.

(b) Computed reservoir inflow approaches 283 $m^3/s$ (10,000 cfs) or is rapidly rising to this level.

e. Emergency Operating Procedures. It is impossible to anticipate every unusual flood, power, or physical feature emergency or combination of events that may require special attention. If an emergency develops requiring immediate action to protect human life or prevent damage to the project, the dam tender will take action and then immediately contact HHS. Should an emergency develop or appear to be imminent which will affect reservoir regulation functions, the dam tender will promptly contact HHS, report on the existing conditions, and request instructions.

7.06 Fish and Wildlife. MMD is a single purpose flood control project which passes all inflow, except during times of flood or maintenance, and does not store water during low flow periods. As such, special minimum instream flow releases have not been set for MMD. Special maintenance operations will continue to pass inflow when possible or maintain 5.66 $m^3/s$ (200 cfs) below the dam. Special impoundments for maintenance or conditions in which the project cannot pass inflow will be coordinated with the Environmental Resources Section (ERS) and avoided during the March-July fish out migration period whenever practicable. Ramping rate criteria is specified in paragraph 7.03 and is established primarily to minimize adverse impact on fish. PSE is required to release sufficient water at its diversion dam to produce a continuous flow in the White River of at least 3.67 m3/s (130 cfs) at the boundary of the Muckleshoot Reservation, approximately RK 25.2 (RM 15.7), unless it is precluded from doing so because of releases from MMD, concerns for public health and safety, or agreement between the Tribe and PSE that a lower flow is necessary for fisheries studies or maintenance/construction activities at the diversion facility.

Dam configuration and operations have been designed to provide safe passage of downstream migrant fish, both fingerlings and adult fish. Of the three radial gates now used in operating MMD, the radial gate controlling the 9-foot tunnel is the primary means of regulating downstream flow. During periods of normal operation (non-flood), this gate is operated fully open while the 23-foot tunnel radial gates are open at 80%. Both gates provide safe passage for out migrating salmonoids.

Operation of a debris removal bypass tunnel that enters into the 9-foot tunnel will be restricted to specific conditions according to the Dam Safety Assurance Program Supplemental Environmental Assessment 3, dated 21 September 1995.

Constraints to be observed are:

a. Coordinate timing and duration of debris bypass operation with ERS.

b. Limit operations to daytime hours.

c. Confine operation only to debris removal.

d. Limit operation of bypass tunnel to flows less than 28.3 $m^3/s$ (1000 cfs).

e. Monitor and clear obstructing debris within debris bypass.

During extended periods of maintenance on the 9-foot tunnel, sediment deposition occurs upstream of the radial gate. Extended maintenance and the discharge of sediment deposition occurring as a result of this maintenance will be coordinated with ERS.

# SECTION 8. EFFECTS OF WATER CONTROL PLAN

8.01 General. MMD is a single purpose flood control project. The effects of project operation are discussed in the following paragraphs.

8.02 Flood Control.

a. Spillway Design Flood (SDF).

(1) History. The SDF for design of initial project construction was developed in 1938 with peak inflow of 4248.0 $m^3/s$ (150,000 cfs) and outflow of 3936.5 $m^3/s$ (139,000 cfs). The SDF inflow is equivalent to the probable maximum flood. Several reviews were conducted during the period between 1938 and 1985; however, none of the revised SDFs were officially adopted. A site specific probable maximum precipitation (PMP) analysis, completed in 1985, was performed by the Hydrometeorological Branch of the National Weather Service incidental to a major redesign of project features for dam safety assurance.

(2) The 1986 SDF. A new SDF was developed in 1986. The 1986 SDF adds a snowmelt component to the 1985 PMP and applies it to a basin runoff and reservoir routing model. This results in a peak inflow of 7136.6 $m^3/s$ (252,000 cfs) and outflow of 6938.4 $m^3/s$ (245,000 cfs). The 1986 SDF was utilized in design of features later constructed as a part of the Dam Safety Assurance project. Development of the SDF is summarized on plate 8-1. Results of routing the SDF through the reservoir are shown on plate 8-1, page 2. Additional details on development of the project PMP and SDF can be found in General Design Memorandum 26, dated July 1986.

b. Standard Project Flood (SPF). No SPF has been developed for the Puyallup basin.

c. Project Design Flood (PDF). Definition of the PDF for Mud Mountain project is complicated by uncertainties associated with hydrologic data available at the time the project was designed in the mid-1930s and by major changes in the design of the project between authorization in 1936 and award of the construction contract in 1939.

Early design documents consistently reference the level of protection to be provided by the proposed project to the December 1933 flood, the largest flood of record at the time. Estimated hydrographs at the dam site and Puyallup for the 1933 flood are shown on plate 8-2. However, no discharge measurements were made at the project site and at several other key locations in the basin during that flood. Also, some of the discharge estimates for the flood were revised after the hydrologic input to the authorizing document was completed.

The authorizing document anticipates that dam will be a concrete arch structure with 20,978.0 ha-m (170,000 acre-feet) of storage available below spillway crest elevation 381.0 m (1250 feet). Initial studies concluded that this project would control a flood 50 per cent greater than the 1933 flood to 1416.0 $m^3/s$ (50,000 cfs) at Puyallup. The design of the dam evolved during the final design process to the earth core, rock fill structure that was built with spillway crest at elevation 381.0 m (1215 feet) and 13,080.4 ha-m (106,000 acre-feet) of storage.

In the early 1940s studies were done to define the hypothetical flood hydrograph which could be controlled to 1416.0 $m^3/s$ (50,000 cfs) at Puyallup by the as-built project. See Exhibit, 1-2, 72. The December 1933 flood was again used as a pattern. The conclusion was that the project could control a flood approximately 1.4 times the volume of the 1933 flood. Hypothetical unregulated and regulated hydrographs for that flood are shown on plate 8-3. These flood hydrographs, have historically been referred to as the "project design flood" even though they were not the basis for the design of the project. In 1992 McGrane performed some studies (see exhibit 1-2, 73) which question some of the assumptions and characteristics associated with the floods shown on plate 8-3; however, the revised McGrane hydrographs have not been officially adopted.

d. <u>Flood of Record, February 1996</u>. The February 1996 flood occurred when a moist tropical airmass, transported on a strong jet stream with origins near Hawaii, arrived in the Northwest. The storm was preceded by prolonged cold weather that froze much of the ground, followed by a significant snowpack. The cold spell lasted until

February 5 when the Arctic air supply was cut off. Warm temperatures arrived and, combined with heavy precipitation, began melting the snowpack. One unusual feature of the storm was its duration; it lasted five days, two more than typical flood-producing storms. Runoff from the Puyallup River basin set new peak flow records at some of the gage sites. Inflows to Mud Mountain Dam peaked at 837.1 $m^3/s$ (29,560 cfs), while the discharge was shut off completely for nearly eight hours to protect downstream towns and cities. Eighty-four percent of the flood control storage was used bringing the pool level to a new record of 364.6 m (1196.1 feet), 5.8 m (19 feet) below the ungated spillway crest. Still, due to the high flows from the unregulated portion of the basin, the water reached the top of the levee in Puyallup. The Puyallup River reached a stage of 9.0-m (29.8 feet), which corresponds to a discharge of 1,322.5 $m^3/s$ (46,700 cfs). Without Mud Mountain Dam, the discharge at Puyallup would have reached approximately 2,152.3 $m^3/s$ (76,000 cfs), which would make the peak a 1.5% chance exceedence flood. This event is a new flood of record for some gages in the Puyallup River Basin. Hydrographs are shown on plates 8-4.

8.03 Recreation. The reservoir is not used for recreational activities. The Corps maintains vista points and picnic grounds near the top of the canyon rim and a fisherman access area along the lower debris basin road. Only foot traffic is permitted in the vicinity of the dam for fishermen, hikers, and sightseers. Stretches of the lower White River are used for swimming and other recreational activities during the summer. The Corps and PSE coordinate changes in river flow to provide a factor of safety for river users.

8.04 Water Quality. Water quality above and below the dam is greatly affected by the steep profile of the White River with elevation ranging from 4,392.4 m (14,411 feet) at the summit of Mt. Ranier to 274.3 m (900 feet) at the dam site. Because of the exceptionally steep profile and the relatively high discharge rates experienced during winter floods and spring snowmelt, the stream carries exceptionally high volume of bed load and suspended solids. Because the reservoir is kept empty except during operation for flood control and during special operations, most of the bed load and suspended solids pass through the dam and on downstream. During the summer period much of the streamflow originates from glacial melt on Mt. Ranier. Glacial melt introduces very fine-grained suspended sediment, commonly referred to as glacial flour, in to the water giving it a milky appearance.

After flood control operations and other special operations where water is temporarily stored, the reservoir is emptied as expeditiously as is feasible without major fluctuation in project outflow. This allows accumulation of sediment in the reservoir to pass through the dam at the highest feasible flow rate and results in the best possible distribution of material in the channel downstream.

Project personnel normally measure project inflow and outflow water temperature and turbidity daily except on weekends and holidays. The measurements are made at the fish trap site downstream of the dam and at the fish dump site upstream of the reservoir.

See additional information on water quality in paragraph 4.10.

8.05 Fish and Wildlife. The migration and rearing of fish in the White River during spring, summer, and fall are enhanced or sustained by the configuration and operations of the project. Since 1949 adult migrants have been trapped at the facility located at the PSE diversion dam near the city of Buckley and transported around the dam by truck. Normally the reservoir is empty and the dam passes inflow. This enhances rearing conditions between the dam and the PSE diversion because flow through side channels, water temperature, and sediment movement more nearly approximate natural conditions. Special operation of MMD to assist Puget Sound Energy in replacement of their diversion dam has resulted in fish kills. Because MMD is normally operated as a run-of-the-river project with no reservoir, the facility's effect of wildlife is insignificant.

8.06 Frequencies. The effect of Mud Mountain project on flood peaks at the dam and at the control station at Puyallup is shown on plates 4-11 through 4-16.

## SECTION 9. ORGANIZATION AND COORDINATION FOR RESERVOIR REGULATION

9.01 General Objective. Mud Mountain project is operated to regulate flood flows in the lower reaches of the Puyallup River basin and is the only flood control project in the basin. Much of the lower reach is levied and several pumping installations are in place to pump interior runoff which ponds landward of the levees. A number of agencies are involved in data collection and providing information to be evaluated in reservoir regulation. exhibit 9-1 is Telephone Notification List for Emergency Events.

9.02 U.S. Army Corps of Engineers. Congressional authorizations delegate responsibility to the Corps to operate projects under its jurisdiction for all authorized purposes. The Corps is responsible for regulation and for all continuing studies that will ensure the maximum sustained public benefit from MMD project operation. Headquarters, United States Army, CE approved a RCC for the NWD in May 1968 and delegated responsibility for reservoir regulation activities in the NWD area to the Division Engineer. The Division Engineer delegated responsibility for regulation of MMD to CENWS in the RCC Guidance Memorandum (exhibit 1-1), dated January 1972. Reservoir regulation is a function of Engineering Division in accordance with EM 1110-2-3600 and direct responsibility on all matters concerning regulation of water with regard to timing, quantity, and quality is assigned to HHS. Project operation and maintenance activities are assigned to Operations Division and the physical operation of project facilities to effect the regulation directed by HHS and the performance of maintenance is the responsibility of the Project Engineer. A CENWS organization chart is shown as exhibit 9-2.

9.03 Interagency Coordination. There are a number of agencies that collect data and/or provide information that is useful or essential to the efficient and effective regulation at the project. In addition, information is provided to some individuals and agencies that have an interest or requirement related to project operations.

a. U.S. Geological Survey. The USGS has a water resources division that collects and processes water quantity and/or quality records for 13 stations in the Puyallup River basin. These stations are listed in table 5-2 and are shown on plate 4-1. Six of these stations are funded totally by the Corps through the CSP. In addition to their regular periodic streamflow measurements to maintain current stage-discharge relationships, the USGS will, upon request from the Corps, make special measurements if a shift in a rating table is suspected. The USGS also operates a northwest water resources data center that publishes streamflow, storage, and water quality data obtained from the data collection system. Administrative and maintenance services are provided by the Tacoma, Washington office, telephone 253-428-3600.

b. National Weather Service. The NWS operates 5 stations that provide data used in planning and scheduling regulation at MMD project. The National Meteorological Center of the NWS issues QPFs twice daily in the form of national maps showing isohyetal lines of expected precipitation of ¼, ½, 1, 2, 3 inches, etc. These QPFs are for successive periods of 6, 6, 12, and 24 hours, the first period beginning 12 hours after the data time. These QPFs are of necessity generalized and not specific enough for direct application to the relatively small subareas of the Puyallup River basin, but do alert the Corps to potential flood threats. The NWS Forecast Office, Seattle, issues QPFs that are site specific for the Seattle-Tacoma Airport and for Stampede Pass. The QPFs are made daily during the flood season and provide precipitation amounts by 6-hour increments for the first 48 hours after forecast time and a 24-hour amount for the third day. These QPFs are used as indicators only because of the potential for wide variations in precipitation distribution depending upon storm track, topographic influences, storm type, etc. The telephone number for the Forecast Office is 206-527-6095. The NWS River Forecast Center (RFC) in Portland, Oregon, is officially charged with the preparation of flood forecasts and the dissemination of flood warnings to the public. These forecasts are made available to the Corps as discussed in paragraph 6.02. The telephone number for the RFC is 503-326-7291.

c. U.S. Fish and Wildlife Service (USFWS). USFWS is the Federal agency primarily responsible for ensuring, at the Federal level, the conservation and management of the nation's wild birds, mammals, and sport fishes, both for their recreational and their economic values. The regional office is located at Portland, Oregon. Included in the major program areas of the FWS are: technical assistance to Federal, State, and private organizations in the development and administration of sport fishing and wildlife management programs; administration and operation of a national system of fish hatcheries engaged in the propagation and distribution of sport fish; and cooperation with other Federal and non-Federal agencies. FWS coordinates with agencies involved with water resource projects to determine the effects of such projects on fish and wildlife resources and recommends measures for the protection and improvement of these resources.

d. Washington State Department of Fish and Wildlife (WSFW). The WSFW has the authority for regulation of fish and wildlife in the Puyallup River basin. This agency collects data and makes studies to evaluate the effects of the project, exchanges information with the Corps, and makes recommendations on potentially beneficial changes in project regulation. Except in cases of emergency requiring prompt action, WSFW should be contacted in advance of any unusual regulation of discharge at the project to obtain advice on scheduling which might reduce any potential adverse impact on the fishery.

e. Washington State Department of Ecology (DOE). The DOE is the responsible agency for assigning water rights for both groundwater and surface water in the Puyallup River basin. PSE has a water permit to divert up to 56.6 $m^3/s$ (2,000 cfs) from the flow of the White River at its diversion facility 8.59 RK (5.34 RM) downstream of the project. DOE has approved a number of small irrigation and domestic permits from time to time.

The DOE is the agency responsible for the instream resources protection program in accordance with Chapter 173-500 WAC (Water Resources Management Program). Chapter 173-510 WAC applies specifically to all waters within the Puyallup River basin, the provisions of which apply, as a matter of state law, to future water right authorizations issued pursuant to the State's water rights codes. The purpose of this chapter is to retain perennial rivers, streams, and lakes in the basin with instream flows and levels necessary for the preservation and protection of wildlife, fish, scenic, aesthetic, and other environmental values, recreational, and navigational values, and to preserve water quality. A copy of Chapter 173-510 WAC is presented as exhibit 9-3. Of special interest to reservoir regulation at MMD project is paragraph -030 and -070(1).

The DOE is also responsible for the water quality criteria in the State and for a surveillance and enforcement program. The Federal Clean Water Act of 1977 requires that State Water Quality Standards be reviewed periodically and that agencies and the public be allowed to participate in the review.

f. Muckleshoot and Puyallup Indian Tribes. These tribes have fishery treaty rights on the White/Puyallup system under treaties with the U.S. Government. Executive Order 13084 and Corps Indian Policy require coordination and consultation with the tribes regarding possible impacts to treaty rights.

g. Puget Sound Energy. PSE operates the White River project, a hydroelectric power facility, using water from the White River discharged from the MMD. PSE will be advised whenever a change in MMD discharge might have a significant effect on PSE's diversion facility.

h. King County. Coordination with King and Pierce Counties is required because part of the White River basin is in each county. As shown on Plate 2-1, the county boundary generally follows to the channel of the Greenwater River downstream until the Greenwater joins the White. The boundary then follows the channel of the White all the way to a point near Auburn. A short stretch of the White River is entirely in King County in the area near Auburn; however soon after the stream turns southward it enters Pierce County; thereafter, it is wholly in Pierce County downstream to the confluence with the Puyallup River.

King County receives information from the Corps HHS during flood events regarding flow releases and expected operations which is then provided to floodplain residents through the King County flood warning system. The National Weather Service provides forecast information to the media. HHS assures that information relating to MMD operation is provided to King County and other interested stakeholders.

i. Pierce County. As described in paragraph 9.03, h, above, part of the White River basin lies in Pierce County. HHS assures that appropriate information relating to MMD operation is made available to Pierce County.

Pierce County has accepted administrative responsibility for Inter-County; therefore, is the initial point of contact for issues pertinent to that organization.

# TABLE 2-1 MUD MOUNTAIN RESERVOIR CONTENTS IN ACRE-FEET

| Elev~Ft | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 895 | 0 | 0.2 | 0.4 | 0.6 | 0.8 | 1 | 1.2 | 1.4 | 1.6 | 1.8 |
| 896 | 2 | 2.3 | 2.6 | 2.9 | 3.2 | 3.5 | 3.8 | 4.1 | 4.4 | 4.7 |
| 897 | 5 | 5.3 | 5.6 | 5.9 | 6.2 | 6.5 | 6.8 | 7.1 | 7.4 | 7.7 |
| 898 | 8 | 8.3 | 8.6 | 8.9 | 9.2 | 9.5 | 9.8 | 10.1 | 10.4 | 10.7 |
| 899 | 11 | 11.3 | 11.6 | 11.9 | 12.2 | 12.5 | 12.8 | 13.1 | 13.4 | 13.7 |
| 900 | 14 | 14.3 | 14.6 | 14.9 | 15.2 | 15.5 | 15.8 | 16.1 | 16.4 | 16.7 |
| 901 | 17 | 17.3 | 17.6 | 17.9 | 18.2 | 18.5 | 18.8 | 19.1 | 19.4 | 19.7 |
| 902 | 20 | 20.3 | 20.6 | 20.9 | 21.2 | 21.5 | 21.8 | 22.1 | 22.4 | 22.7 |
| 903 | 23 | 23.4 | 23.8 | 24.2 | 24.6 | 25 | 25.4 | 25.8 | 26.2 | 26.6 |
| 904 | 27 | 27.4 | 27.8 | 28.2 | 28.6 | 29 | 29.4 | 29.8 | 30.2 | 30.6 |
| 905 | 31 | 31.4 | 31.8 | 32.2 | 32.6 | 33 | 33.4 | 33.8 | 34.2 | 34.6 |
| 906 | 35 | 35.4 | 35.8 | 36.2 | 36.6 | 37 | 37.4 | 37.8 | 38.2 | 38.6 |
| 907 | 39 | 39.4 | 39.8 | 40.2 | 40.6 | 41 | 41.4 | 41.8 | 42.2 | 42.6 |
| 908 | 43 | 43.4 | 43.8 | 44.2 | 44.6 | 45 | 45.4 | 45.8 | 46.2 | 46.6 |
| 909 | 47 | 47.5 | 48 | 48.5 | 49 | 49.5 | 50 | 50.5 | 51 | 51.5 |
| 910 | 52 | 52.5 | 53 | 53.5 | 54 | 54.5 | 55 | 55.5 | 56 | 56.5 |
| 911 | 57 | 57.5 | 58 | 58.5 | 59 | 59.5 | 60 | 60.5 | 61 | 61.5 |
| 912 | 62 | 62.5 | 63 | 63.5 | 64 | 64.5 | 65 | 65.5 | 66 | 66.5 |
| 913 | 67 | 67.5 | 68 | 68.5 | 69 | 69.5 | 70 | 70.5 | 71 | 71.5 |
| 914 | 72 | 72.5 | 73 | 73.5 | 74 | 74.5 | 75 | 75.5 | 76 | 76.5 |
| 915 | 77 | 77.6 | 78.2 | 78.8 | 79.4 | 80 | 80.6 | 81.2 | 81.8 | 82.4 |
| 916 | 83 | 83.6 | 84.2 | 84.8 | 85.4 | 86 | 86.6 | 87.2 | 87.8 | 88.4 |
| 917 | 89 | 89.6 | 90.2 | 90.8 | 91.4 | 92 | 92.6 | 93.2 | 93.8 | 94.4 |
| 918 | 95 | 95.6 | 96.2 | 96.8 | 97.4 | 98 | 98.6 | 99.2 | 99.8 | 100.4 |
| 919 | 101 | 102 | 102 | 103 | 103 | 104 | 105 | 105 | 106 | 106 |
| 920 | 107 | 108 | 108 | 109 | 109 | 110 | 111 | 111 | 112 | 112 |
| 921 | 113 | 114 | 114 | 115 | 116 | 117 | 117 | 118 | 119 | 119 |
| 922 | 120 | 121 | 121 | 122 | 123 | 124 | 124 | 125 | 126 | 126 |

# TABLE 2-1 MUD MOUNTAIN RESERVOIR CONTENTS IN ACRE-FEET

| Elev~Ft | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 923 | 127 | 128 | 128 | 129 | 130 | 131 | 131 | 132 | 133 | 133 |
| 924 | 134 | 135 | 135 | 136 | 137 | 138 | 138 | 139 | 140 | 140 |
| 925 | 141 | 142 | 143 | 143 | 144 | 145 | 146 | 147 | 147 | 148 |
| 926 | 149 | 150 | 151 | 152 | 153 | 154 | 154 | 155 | 156 | 157 |
| 927 | 158 | 159 | 160 | 161 | 162 | 163 | 164 | 165 | 166 | 167 |
| 928 | 168 | 169 | 169 | 170 | 170 | 171 | 172 | 172 | 173 | 173 |
| 929 | 174 | 176 | 177 | 179 | 181 | 183 | 184 | 186 | 188 | 189 |
| 930 | 191 | 192 | 194 | 195 | 196 | 198 | 199 | 200 | 201 | 203 |
| 931 | 204 | 205 | 207 | 208 | 210 | 211 | 212 | 214 | 215 | 217 |
| 932 | 218 | 220 | 221 | 223 | 224 | 226 | 227 | 229 | 230 | 232 |
| 933 | 233 | 235 | 236 | 238 | 239 | 241 | 243 | 244 | 246 | 247 |
| 934 | 249 | 251 | 253 | 255 | 257 | 259 | 260 | 262 | 264 | 266 |
| 935 | 268 | 270 | 271 | 273 | 274 | 276 | 278 | 279 | 281 | 282 |
| 936 | 284 | 286 | 288 | 290 | 292 | 294 | 295 | 297 | 299 | 301 |
| 937 | 303 | 305 | 307 | 309 | 311 | 313 | 315 | 317 | 319 | 321 |
| 938 | 323 | 325 | 327 | 329 | 331 | 334 | 336 | 338 | 340 | 342 |
| 939 | 344 | 346 | 348 | 351 | 353 | 355 | 357 | 359 | 362 | 364 |
| 940 | 366 | 368 | 371 | 373 | 375 | 378 | 380 | 382 | 384 | 387 |
| 941 | 389 | 391 | 394 | 396 | 399 | 401 | 403 | 406 | 408 | 411 |
| 942 | 413 | 416 | 418 | 421 | 423 | 426 | 428 | 431 | 433 | 436 |
| 943 | 438 | 441 | 443 | 446 | 448 | 451 | 454 | 456 | 459 | 461 |
| 944 | 464 | 467 | 469 | 472 | 475 | 478 | 480 | 483 | 486 | 488 |
| 945 | 491 | 494 | 497 | 499 | 502 | 505 | 508 | 511 | 513 | 516 |
| 946 | 519 | 522 | 525 | 528 | 531 | 534 | 536 | 539 | 542 | 545 |
| 947 | 548 | 551 | 554 | 557 | 560 | 563 | 566 | 569 | 572 | 575 |
| 948 | 578 | 581 | 584 | 587 | 590 | 594 | 597 | 600 | 603 | 606 |
| 949 | 609 | 612 | 615 | 619 | 622 | 625 | 628 | 631 | 635 | 638 |
| 950 | 641 | 644 | 648 | 651 | 654 | 658 | 661 | 664 | 667 | 671 |

# TABLE 2-1 MUD MOUNTAIN RESERVOIR CONTENTS IN ACRE-FEET

| Elev~Ft | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 951 | 674 | 677 | 681 | 684 | 688 | 691 | 694 | 698 | 701 | 705 |
| 952 | 708 | 712 | 715 | 719 | 722 | 726 | 729 | 733 | 736 | 740 |
| 953 | 743 | 747 | 750 | 754 | 757 | 761 | 765 | 768 | 772 | 775 |
| 954 | 779 | 783 | 787 | 790 | 794 | 798 | 802 | 806 | 809 | 813 |
| 955 | 817 | 821 | 825 | 829 | 833 | 837 | 840 | 844 | 848 | 852 |
| 956 | 856 | 860 | 864 | 868 | 872 | 876 | 880 | 884 | 888 | 892 |
| 957 | 896 | 900 | 904 | 908 | 912 | 917 | 921 | 925 | 929 | 933 |
| 958 | 937 | 941 | 945 | 950 | 954 | 958 | 962 | 966 | 971 | 975 |
| 959 | 979 | 983 | 988 | 992 | 997 | 1001 | 1005 | 1010 | 1014 | 1019 |
| 960 | 1023 | 1030 | 1036 | 1043 | 1049 | 1056 | 1062 | 1069 | 1075 | 1082 |
| 961 | 1088 | 1091 | 1093 | 1096 | 1098 | 1101 | 1104 | 1106 | 1109 | 1111 |
| 962 | 1114 | 1119 | 1123 | 1128 | 1133 | 1138 | 1142 | 1147 | 1152 | 1156 |
| 963 | 1161 | 1166 | 1171 | 1175 | 1180 | 1185 | 1190 | 1195 | 1199 | 1204 |
| 964 | 1209 | 1214 | 1219 | 1224 | 1229 | 1234 | 1238 | 1243 | 1248 | 1253 |
| 965 | 1258 | 1263 | 1268 | 1273 | 1278 | 1283 | 1288 | 1293 | 1298 | 1303 |
| 966 | 1308 | 1313 | 1318 | 1324 | 1329 | 1334 | 1339 | 1344 | 1350 | 1355 |
| 967 | 1360 | 1365 | 1371 | 1376 | 1381 | 1387 | 1392 | 1397 | 1402 | 1408 |
| 968 | 1413 | 1418 | 1424 | 1429 | 1435 | 1440 | 1445 | 1451 | 1456 | 1462 |
| 969 | 1467 | 1473 | 1478 | 1484 | 1489 | 1495 | 1500 | 1506 | 1511 | 1517 |
| 970 | 1522 | 1528 | 1533 | 1539 | 1544 | 1550 | 1556 | 1561 | 1567 | 1572 |
| 971 | 1578 | 1584 | 1590 | 1595 | 1601 | 1607 | 1613 | 1619 | 1624 | 1630 |
| 972 | 1636 | 1642 | 1648 | 1654 | 1660 | 1666 | 1671 | 1677 | 1683 | 1689 |
| 973 | 1695 | 1701 | 1707 | 1713 | 1719 | 1725 | 1731 | 1737 | 1743 | 1749 |
| 974 | 1755 | 1761 | 1767 | 1773 | 1779 | 1786 | 1792 | 1798 | 1804 | 1810 |
| 975 | 1816 | 1822 | 1829 | 1835 | 1841 | 1848 | 1854 | 1860 | 1866 | 1873 |
| 976 | 1879 | 1885 | 1892 | 1898 | 1905 | 1911 | 1917 | 1924 | 1930 | 1937 |
| 977 | 1943 | 1950 | 1956 | 1963 | 1969 | 1976 | 1983 | 1989 | 1996 | 2002 |
| 978 | 2009 | 2016 | 2022 | 2029 | 2036 | 2043 | 2049 | 2056 | 2063 | 2069 |

# TABLE 2-1  MUD MOUNTAIN RESERVOIR CONTENTS IN ACRE-FEET

| Elev~Ft | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 979 | 2076 | 2083 | 2090 | 2097 | 2104 | 2111 | 2117 | 2124 | 2131 | 2138 |
| 980 | 2145 | 2152 | 2159 | 2166 | 2173 | 2180 | 2187 | 2194 | 2201 | 2208 |
| 981 | 2215 | 2222 | 2229 | 2237 | 2244 | 2251 | 2258 | 2265 | 2273 | 2280 |
| 982 | 2287 | 2294 | 2302 | 2309 | 2316 | 2324 | 2331 | 2338 | 2345 | 2353 |
| 983 | 2360 | 2368 | 2375 | 2383 | 2390 | 2398 | 2405 | 2413 | 2420 | 2428 |
| 984 | 2435 | 2443 | 2450 | 2458 | 2465 | 2473 | 2481 | 2488 | 2496 | 2503 |
| 985 | 2511 | 2519 | 2527 | 2534 | 2542 | 2550 | 2558 | 2566 | 2573 | 2581 |
| 986 | 2589 | 2597 | 2605 | 2613 | 2621 | 2629 | 2636 | 2644 | 2652 | 2660 |
| 987 | 2668 | 2676 | 2684 | 2692 | 2700 | 2708 | 2716 | 2724 | 2732 | 2740 |
| 988 | 2748 | 2756 | 2764 | 2773 | 2781 | 2789 | 2797 | 2805 | 2814 | 2822 |
| 989 | 2830 | 2838 | 2847 | 2855 | 2863 | 2872 | 2880 | 2888 | 2896 | 2905 |
| 990 | 2913 | 2922 | 2930 | 2939 | 2947 | 2956 | 2964 | 2973 | 2981 | 2990 |
| 991 | 2998 | 3007 | 3015 | 3024 | 3032 | 3041 | 3050 | 3058 | 3067 | 3075 |
| 992 | 3084 | 3093 | 3102 | 3110 | 3119 | 3128 | 3137 | 3146 | 3154 | 3163 |
| 993 | 3172 | 3181 | 3190 | 3199 | 3208 | 3217 | 3225 | 3234 | 3243 | 3252 |
| 994 | 3261 | 3270 | 3279 | 3288 | 3297 | 3307 | 3316 | 3325 | 3334 | 3343 |
| 995 | 3352 | 3361 | 3370 | 3380 | 3389 | 3398 | 3407 | 3416 | 3426 | 3435 |
| 996 | 3444 | 3453 | 3463 | 3472 | 3482 | 3491 | 3500 | 3510 | 3519 | 3529 |
| 997 | 3538 | 3548 | 3557 | 3567 | 3576 | 3586 | 3595 | 3605 | 3614 | 3624 |
| 998 | 3633 | 3643 | 3652 | 3662 | 3672 | 3682 | 3691 | 3701 | 3711 | 3720 |
| 999 | 3730 | 3740 | 3750 | 3759 | 3769 | 3779 | 3789 | 3799 | 3808 | 3818 |
| 1000 | 3828 | 3838 | 3848 | 3858 | 3868 | 3878 | 3888 | 3898 | 3908 | 3918 |
| 1001 | 3928 | 3938 | 3948 | 3959 | 3969 | 3979 | 3989 | 3999 | 4010 | 4020 |
| 1002 | 4030 | 4040 | 4051 | 4061 | 4072 | 4082 | 4092 | 4103 | 4113 | 4124 |
| 1003 | 4134 | 4145 | 4155 | 4166 | 4177 | 4188 | 4198 | 4209 | 4220 | 4230 |
| 1004 | 4241 | 4252 | 4263 | 4274 | 4285 | 4296 | 4306 | 4317 | 4328 | 4339 |
| 1005 | 4350 | 4361 | 4372 | 4383 | 4394 | 4406 | 4417 | 4428 | 4439 | 4450 |
| 1006 | 4461 | 4472 | 4484 | 4495 | 4507 | 4518 | 4529 | 4541 | 4552 | 4564 |

# TABLE 2-1 MUD MOUNTAIN RESERVOIR CONTENTS IN ACRE-FEET

| Elev~Ft | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| **1007** | 4575 | 4587 | 4598 | 4610 | 4621 | 4633 | 4645 | 4656 | 4668 | 4679 |
| **1008** | 4691 | 4703 | 4715 | 4726 | 4738 | 4750 | 4762 | 4774 | 4785 | 4797 |
| **1009** | 4809 | 4821 | 4833 | 4845 | 4857 | 4869 | 4881 | 4893 | 4905 | 4917 |
| **1010** | 4929 | 4941 | 4953 | 4966 | 4978 | 4990 | 5002 | 5014 | 5027 | 5039 |
| **1011** | 5051 | 5064 | 5076 | 5089 | 5101 | 5114 | 5126 | 5139 | 5151 | 5164 |
| **1012** | 5176 | 5189 | 5201 | 5214 | 5227 | 5240 | 5252 | 5265 | 5278 | 5290 |
| **1013** | 5303 | 5316 | 5329 | 5342 | 5355 | 5368 | 5380 | 5393 | 5406 | 5419 |
| **1014** | 5432 | 5445 | 5458 | 5472 | 5485 | 5498 | 5511 | 5524 | 5538 | 5551 |
| **1015** | 5564 | 5577 | 5591 | 5604 | 5618 | 5631 | 5644 | 5658 | 5671 | 5685 |
| **1016** | 5698 | 5712 | 5725 | 5739 | 5752 | 5766 | 5780 | 5793 | 5807 | 5820 |
| **1017** | 5834 | 5848 | 5862 | 5875 | 5889 | 5903 | 5917 | 5931 | 5944 | 5958 |
| **1018** | 5972 | 5986 | 6000 | 6014 | 6028 | 6042 | 6056 | 6070 | 6084 | 6098 |
| **1019** | 6112 | 6126 | 6141 | 6155 | 6169 | 6184 | 6198 | 6212 | 6226 | 6241 |
| **1020** | 6255 | 6270 | 6284 | 6299 | 6313 | 6328 | 6342 | 6357 | 6371 | 6386 |
| **1021** | 6400 | 6415 | 6429 | 6444 | 6459 | 6474 | 6488 | 6503 | 6518 | 6532 |
| **1022** | 6547 | 6562 | 6577 | 6592 | 6607 | 6622 | 6637 | 6652 | 6667 | 6682 |
| **1023** | 6697 | 6712 | 6727 | 6743 | 6758 | 6773 | 6788 | 6803 | 6819 | 6834 |
| **1024** | 6849 | 6864 | 6880 | 6895 | 6911 | 6926 | 6941 | 6957 | 6972 | 6988 |
| **1026** | 7160 | 7176 | 7192 | 7208 | 7224 | 7240 | 7256 | 7272 | 7288 | 7304 |
| **1027** | 7320 | 7336 | 7353 | 7369 | 7385 | 7402 | 7418 | 7434 | 7450 | 7467 |
| **1028** | 7483 | 7500 | 7516 | 7533 | 7549 | 7566 | 7583 | 7599 | 7616 | 7632 |
| **1029** | 7649 | 7666 | 7683 | 7700 | 7717 | 7734 | 7750 | 7767 | 7784 | 7801 |
| **1030** | 7818 | 7835 | 7852 | 7870 | 7887 | 7904 | 7921 | 7938 | 7956 | 7973 |
| **1031** | 7990 | 8008 | 8025 | 8043 | 8060 | 8078 | 8096 | 8113 | 8131 | 8148 |
| **1032** | 8166 | 8184 | 8202 | 8220 | 8238 | 8256 | 8273 | 8291 | 8309 | 8327 |
| **1033** | 8345 | 8363 | 8381 | 8400 | 8418 | 8436 | 8454 | 8472 | 8491 | 8509 |
| **1034** | 8527 | 8546 | 8564 | 8583 | 8601 | 8620 | 8638 | 8657 | 8675 | 8694 |
| **1035** | 8712 | 8731 | 8750 | 8768 | 8787 | 8806 | 8825 | 8844 | 8862 | 8881 |

# TABLE 2-1 MUD MOUNTAIN RESERVOIR CONTENTS IN ACRE-FEET

| Elev~Ft | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1036 | 8900 | 8919 | 8938 | 8957 | 8976 | 8996 | 9015 | 9034 | 9053 | 9072 |
| 1037 | 9091 | 9110 | 9130 | 9149 | 9169 | 9188 | 9207 | 9227 | 9246 | 9266 |
| 1038 | 9285 | 9305 | 9324 | 9344 | 9364 | 9384 | 9403 | 9423 | 9443 | 9462 |
| 1039 | 9482 | 9502 | 9522 | 9542 | 9562 | 9582 | 9602 | 9622 | 9642 | 9662 |
| 1040 | 9682 | 9702 | 9723 | 9743 | 9763 | 9784 | 9804 | 9824 | 9844 | 9865 |
| 1041 | 9885 | 9906 | 9926 | 9947 | 9967 | 9988 | 10009 | 10029 | 10050 | 10070 |
| 1042 | 10091 | 10112 | 10133 | 10154 | 10175 | 10196 | 10216 | 10237 | 10258 | 10279 |
| 1043 | 10300 | 10321 | 10342 | 10364 | 10385 | 10406 | 10427 | 10448 | 10470 | 10491 |
| 1044 | 10512 | 10534 | 10555 | 10577 | 10598 | 10620 | 10642 | 10663 | 10685 | 10706 |
| 1045 | 10728 | 10750 | 10772 | 10794 | 10816 | 10838 | 10859 | 10881 | 10903 | 10925 |
| 1046 | 10947 | 10969 | 10991 | 11014 | 11036 | 11058 | 11080 | 11102 | 11125 | 11147 |
| 1047 | 11169 | 11192 | 11214 | 11237 | 11259 | 11282 | 11304 | 11327 | 11349 | 11372 |
| 1048 | 11394 | 11417 | 11440 | 11462 | 11485 | 11508 | 11531 | 11554 | 11576 | 11599 |
| 1049 | 11622 | 11645 | 11668 | 11691 | 11714 | 11738 | 11761 | 11784 | 11807 | 11830 |
| 1050 | 11853 | 11877 | 11900 | 11924 | 11947 | 11971 | 11994 | 12018 | 12041 | 12065 |
| 1051 | 12088 | 12112 | 12136 | 12160 | 12184 | 12208 | 12231 | 12255 | 12279 | 12303 |
| 1052 | 12327 | 12351 | 12376 | 12400 | 12425 | 12449 | 12473 | 12498 | 12522 | 12547 |
| 1053 | 12571 | 12596 | 12621 | 12645 | 12670 | 12695 | 12720 | 12745 | 12769 | 12794 |
| 1054 | 12819 | 12844 | 12869 | 12895 | 12920 | 12945 | 12970 | 12995 | 13021 | 13046 |
| 1055 | 13071 | 13097 | 13122 | 13148 | 13174 | 13200 | 13225 | 13251 | 13277 | 13302 |
| 1056 | 13328 | 13354 | 13380 | 13406 | 13432 | 13459 | 13485 | 13511 | 13537 | 13563 |
| 1057 | 13589 | 13616 | 13642 | 13669 | 13695 | 13722 | 13749 | 13775 | 13802 | 13828 |
| 1058 | 13855 | 13882 | 13909 | 13936 | 13963 | 13990 | 14017 | 14044 | 14071 | 14098 |
| 1059 | 14125 | 14152 | 14180 | 14207 | 14235 | 14262 | 14289 | 14317 | 14344 | 14372 |
| 1060 | 14399 | 14427 | 14455 | 14483 | 14511 | 14539 | 14566 | 14594 | 14622 | 14650 |
| 1061 | 14678 | 14706 | 14735 | 14763 | 14791 | 14820 | 14848 | 14876 | 14904 | 14933 |
| 1062 | 14961 | 14990 | 15019 | 15047 | 15076 | 15105 | 15134 | 15163 | 15191 | 15220 |
| 1063 | 15249 | 15278 | 15307 | 15337 | 15366 | 15395 | 15424 | 15453 | 15483 | 15512 |

# TABLE 2-1 MUD MOUNTAIN RESERVOIR CONTENTS IN ACRE-FEET

| Elev~Ft | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| **1064** | 15541 | 15571 | 15600 | 15630 | 15659 | 15689 | 15719 | 15748 | 15778 | 15807 |
| **1065** | 15837 | 15867 | 15897 | 15927 | 15957 | 15988 | 16018 | 16048 | 16078 | 16108 |
| **1066** | 16138 | 16169 | 16199 | 16230 | 16260 | 16291 | 16321 | 16352 | 16382 | 16413 |
| **1067** | 16443 | 16474 | 16505 | 16536 | 16567 | 16598 | 16628 | 16659 | 16690 | 16721 |
| **1068** | 16752 | 16783 | 16815 | 16846 | 16878 | 16909 | 16940 | 16972 | 17003 | 17035 |
| **1069** | 17066 | 17098 | 17130 | 17161 | 17193 | 17225 | 17257 | 17289 | 17320 | 17352 |
| **1070** | 17384 | 17416 | 17448 | 17481 | 17513 | 17545 | 17577 | 17609 | 17642 | 17674 |
| **1071** | 17706 | 17739 | 17771 | 17804 | 17837 | 17870 | 17902 | 17935 | 17968 | 18000 |
| **1072** | 18033 | 18066 | 18099 | 18132 | 18165 | 18199 | 18232 | 18265 | 18298 | 18331 |
| **1073** | 18364 | 18398 | 18431 | 18465 | 18498 | 18532 | 18566 | 18599 | 18633 | 18666 |
| **1074** | 18700 | 18734 | 18768 | 18802 | 18836 | 18870 | 18904 | 18938 | 18972 | 19006 |
| **1075** | 19040 | 19074 | 19109 | 19143 | 19178 | 19212 | 19246 | 19281 | 19315 | 19350 |
| **1076** | 19384 | 19419 | 19454 | 19489 | 19524 | 19559 | 19593 | 19628 | 19663 | 19698 |
| **1077** | 19733 | 19768 | 19804 | 19839 | 19874 | 19910 | 19945 | 19980 | 20015 | 20051 |
| **1078** | 20086 | 20122 | 20158 | 20193 | 20229 | 20265 | 20301 | 20337 | 20372 | 20408 |
| **1079** | 20444 | 20480 | 20517 | 20553 | 20589 | 20626 | 20662 | 20698 | 20734 | 20771 |
| **1080** | 20807 | 20844 | 20881 | 20917 | 20954 | 20991 | 21028 | 21065 | 21101 | 21138 |
| **1081** | 21175 | 21212 | 21249 | 21287 | 21324 | 21361 | 21398 | 21435 | 21473 | 21510 |
| **1082** | 21547 | 21585 | 21622 | 21660 | 21698 | 21736 | 21773 | 21811 | 21849 | 21886 |
| **1083** | 21924 | 21962 | 22000 | 22039 | 22077 | 22115 | 22153 | 22191 | 22230 | 22268 |
| **1084** | 22306 | 22345 | 22383 | 22422 | 22460 | 22499 | 22538 | 22576 | 22615 | 22653 |
| **1085** | 22692 | 22731 | 22770 | 22809 | 22848 | 22888 | 22927 | 22966 | 23005 | 23044 |
| **1086** | 23083 | 23123 | 23162 | 23202 | 23241 | 23281 | 23321 | 23360 | 23400 | 23439 |
| **1087** | 23479 | 23519 | 23559 | 23599 | 23639 | 23679 | 23719 | 23759 | 23799 | 23839 |
| **1088** | 23879 | 23920 | 23960 | 24001 | 24041 | 24082 | 24122 | 24163 | 24203 | 24244 |
| **1089** | 24284 | 24325 | 24366 | 24407 | 24448 | 24489 | 24530 | 24571 | 24612 | 24653 |
| **1090** | 24694 | 24736 | 24777 | 24819 | 24860 | 24902 | 24943 | 24985 | 25026 | 25068 |
| **1091** | 25109 | 25151 | 25193 | 25235 | 25277 | 25319 | 25360 | 25402 | 25444 | 25486 |

# TABLE 2-1 MUD MOUNTAIN RESERVOIR CONTENTS IN ACRE-FEET

| Elev~Ft | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| **1092** | 25528 | 25570 | 25613 | 25655 | 25698 | 25740 | 25782 | 25825 | 25867 | 25910 |
| **1093** | 25952 | 25995 | 26038 | 26081 | 26124 | 26167 | 26209 | 26252 | 26295 | 26338 |
| **1094** | 26381 | 26424 | 26468 | 26511 | 26554 | 26598 | 26641 | 26684 | 26727 | 26771 |
| **1095** | 26814 | 26858 | 26902 | 26945 | 26989 | 27033 | 27077 | 27121 | 27164 | 27208 |
| **1096** | 27252 | 27296 | 27341 | 27385 | 27429 | 27474 | 27518 | 27562 | 27606 | 27651 |
| **1097** | 27695 | 27740 | 27785 | 27829 | 27874 | 27919 | 27964 | 28009 | 28053 | 28098 |
| **1098** | 28143 | 28188 | 28233 | 28279 | 28324 | 28369 | 28414 | 28459 | 28505 | 28550 |
| **1099** | 28595 | 28641 | 28686 | 28732 | 28778 | 28824 | 28869 | 28915 | 28961 | 29006 |
| **1100** | 29052 | 29098 | 29144 | 29190 | 29236 | 29282 | 29328 | 29374 | 29420 | 29466 |
| **1101** | 29512 | 29558 | 29605 | 29651 | 29697 | 29744 | 29790 | 29836 | 29882 | 29929 |
| **1102** | 29975 | 30022 | 30068 | 30115 | 30161 | 30208 | 30255 | 30301 | 30348 | 30394 |
| **1103** | 30441 | 30488 | 30535 | 30582 | 30629 | 30676 | 30722 | 30769 | 30816 | 30863 |
| **1104** | 30910 | 30957 | 31004 | 31052 | 31099 | 31146 | 31193 | 31240 | 31288 | 31335 |
| **1105** | 31382 | 31430 | 31477 | 31525 | 31572 | 31620 | 31667 | 31715 | 31762 | 31810 |
| **1106** | 31857 | 31905 | 31953 | 32000 | 32048 | 32096 | 32144 | 32192 | 32239 | 32287 |
| **1107** | 32335 | 32383 | 32431 | 32479 | 32527 | 32575 | 32623 | 32671 | 32719 | 32767 |
| **1108** | 32815 | 32863 | 32912 | 32960 | 33008 | 33057 | 33105 | 33153 | 33201 | 33250 |
| **1109** | 33298 | 33347 | 33395 | 33444 | 33492 | 33541 | 33590 | 33638 | 33687 | 33735 |
| **1110** | 33784 | 33833 | 33882 | 33931 | 33980 | 34029 | 34077 | 34126 | 34175 | 34224 |
| **1111** | 34273 | 34322 | 34371 | 34421 | 34470 | 34519 | 34568 | 34617 | 34667 | 34716 |
| **1112** | 34765 | 34815 | 34864 | 34914 | 34963 | 35013 | 35062 | 35112 | 35161 | 35211 |
| **1113** | 35260 | 35310 | 35360 | 35409 | 35459 | 35509 | 35559 | 35609 | 35658 | 35708 |
| **1114** | 35758 | 35808 | 35858 | 35908 | 35958 | 36009 | 36059 | 36109 | 36159 | 36209 |
| **1115** | 36259 | 36309 | 36360 | 36410 | 36461 | 36511 | 36561 | 36612 | 36662 | 36713 |
| **1116** | 36763 | 36814 | 36864 | 36915 | 36966 | 37017 | 37067 | 37118 | 37169 | 37219 |
| **1117** | 37270 | 37316 | 37362 | 37408 | 37454 | 37500 | 37546 | 37592 | 37638 | 37684 |
| **1118** | 37730 | 37786 | 37842 | 37899 | 37955 | 38011 | 38067 | 38123 | 38180 | 38236 |
| **1119** | 38292 | 38344 | 38395 | 38447 | 38498 | 38550 | 38601 | 38653 | 38704 | 38756 |

# TABLE 2-1 MUD MOUNTAIN RESERVOIR CONTENTS IN ACRE-FEET

| Elev~Ft | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1120 | 38807 | 38859 | 38911 | 38962 | 39014 | 39066 | 39118 | 39170 | 39221 | 39273 |
| 1121 | 39325 | 39377 | 39429 | 39481 | 39533 | 39586 | 39638 | 39690 | 39742 | 39794 |
| 1122 | 39846 | 39898 | 39951 | 40003 | 40056 | 40108 | 40160 | 40213 | 40265 | 40318 |
| 1123 | 40370 | 40423 | 40475 | 40528 | 40581 | 40634 | 40686 | 40739 | 40792 | 40844 |
| 1124 | 40897 | 40950 | 41003 | 41056 | 41109 | 41162 | 41215 | 41268 | 41321 | 41374 |
| 1125 | 41427 | 41480 | 41534 | 41587 | 41640 | 41694 | 41747 | 41800 | 41853 | 41907 |
| 1126 | 41960 | 42014 | 42067 | 42121 | 42175 | 42229 | 42282 | 42336 | 42390 | 42443 |
| 1127 | 42497 | 42551 | 42605 | 42659 | 42713 | 42767 | 42821 | 42875 | 42929 | 42983 |
| 1128 | 43037 | 43085 | 43134 | 43182 | 43231 | 43279 | 43327 | 43376 | 43424 | 43473 |
| 1129 | 43521 | 43582 | 43643 | 43703 | 43764 | 43825 | 43886 | 43947 | 44007 | 44068 |
| 1130 | 44129 | 44184 | 44239 | 44295 | 44350 | 44405 | 44460 | 44515 | 44571 | 44626 |
| 1131 | 44681 | 44737 | 44792 | 44848 | 44903 | 44959 | 45014 | 45070 | 45125 | 45181 |
| 1132 | 45236 | 45292 | 45348 | 45404 | 45460 | 45516 | 45571 | 45627 | 45683 | 45739 |
| 1133 | 45795 | 45851 | 45908 | 45964 | 46020 | 46077 | 46133 | 46189 | 46245 | 46302 |
| 1134 | 46358 | 46415 | 46471 | 46528 | 46584 | 46641 | 46698 | 46754 | 46811 | 46867 |
| 1135 | 46924 | 46981 | 47038 | 47095 | 47152 | 47209 | 47266 | 47323 | 47380 | 47437 |
| 1136 | 47494 | 47551 | 47609 | 47666 | 47724 | 47781 | 47838 | 47896 | 47953 | 48011 |
| 1137 | 48068 | 48126 | 48184 | 48241 | 48299 | 48357 | 48415 | 48473 | 48530 | 48588 |
| 1138 | 48646 | 48704 | 48762 | 48820 | 48878 | 48937 | 48995 | 49053 | 49111 | 49169 |
| 1139 | 49227 | 49286 | 49344 | 49403 | 49461 | 49520 | 49578 | 49637 | 49695 | 49754 |
| 1140 | 49812 | 49871 | 49930 | 49989 | 50048 | 50107 | 50165 | 50224 | 50283 | 50342 |
| 1141 | 50401 | 50460 | 50519 | 50579 | 50638 | 50697 | 50756 | 50815 | 50875 | 50934 |
| 1142 | 50993 | 51053 | 51112 | 51172 | 51231 | 51291 | 51351 | 51410 | 51470 | 51529 |
| 1143 | 51589 | 51649 | 51709 | 51769 | 51829 | 51889 | 51949 | 52009 | 52069 | 52129 |
| 1144 | 52189 | 52249 | 52310 | 52370 | 52430 | 52491 | 52551 | 52611 | 52671 | 52732 |
| 1145 | 52792 | 52853 | 52913 | 52974 | 53035 | 53096 | 53156 | 53217 | 53278 | 53338 |
| 1146 | 53399 | 53460 | 53521 | 53582 | 53643 | 53705 | 53766 | 53827 | 53888 | 53949 |
| 1147 | 54010 | 54072 | 54133 | 54195 | 54256 | 54318 | 54379 | 54441 | 54502 | 54564 |

# TABLE 2-1 MUD MOUNTAIN RESERVOIR CONTENTS IN ACRE-FEET

| Elev~Ft | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| **1148** | 54625 | 54687 | 54749 | 54810 | 54872 | 54934 | 54996 | 55058 | 55119 | 55181 |
| **1149** | 55243 | 55307 | 55371 | 55436 | 55500 | 55564 | 55628 | 55692 | 55757 | 55821 |
| **1150** | 55885 | 55946 | 56006 | 56067 | 56127 | 56188 | 56249 | 56309 | 56370 | 56430 |
| **1151** | 56491 | 56554 | 56617 | 56680 | 56743 | 56806 | 56869 | 56932 | 56995 | 57058 |
| **1152** | 57121 | 57184 | 57248 | 57311 | 57375 | 57438 | 57501 | 57565 | 57628 | 57692 |
| **1153** | 57755 | 57819 | 57883 | 57946 | 58010 | 58074 | 58138 | 58202 | 58265 | 58329 |
| **1154** | 58393 | 58457 | 58521 | 58586 | 58650 | 58714 | 58778 | 58842 | 58907 | 58971 |
| **1155** | 59035 | 59100 | 59164 | 59229 | 59293 | 59358 | 59423 | 59487 | 59552 | 59616 |
| **1156** | 59681 | 59746 | 59811 | 59876 | 59941 | 60006 | 60071 | 60136 | 60201 | 60266 |
| **1157** | 60331 | 60396 | 60462 | 60527 | 60593 | 60658 | 60723 | 60789 | 60854 | 60920 |
| **1158** | 60985 | 61051 | 61117 | 61182 | 61248 | 61314 | 61380 | 61446 | 61511 | 61577 |
| **1159** | 61643 | 61709 | 61775 | 61842 | 61908 | 61974 | 62040 | 62106 | 62173 | 62239 |
| **1160** | 62305 | 62372 | 62438 | 62505 | 62571 | 62638 | 62705 | 62771 | 62838 | 62904 |
| **1161** | 62971 | 63038 | 63105 | 63172 | 63239 | 63306 | 63373 | 63440 | 63507 | 63574 |
| **1162** | 63641 | 63708 | 63776 | 63843 | 63911 | 63978 | 64045 | 64113 | 64180 | 64248 |
| **1163** | 64315 | 64383 | 64451 | 64519 | 64587 | 64655 | 64722 | 64790 | 64858 | 64926 |
| **1164** | 64994 | 65062 | 65131 | 65199 | 65267 | 65336 | 65404 | 65472 | 65540 | 65609 |
| **1165** | 65677 | 65746 | 65814 | 65883 | 65952 | 66021 | 66089 | 66158 | 66227 | 66295 |
| **1166** | 66364 | 66433 | 66502 | 66571 | 66640 | 66710 | 66779 | 66848 | 66917 | 66986 |
| **1167** | 67055 | 67125 | 67194 | 67264 | 67333 | 67403 | 67472 | 67542 | 67611 | 67681 |
| **1168** | 67750 | 67820 | 67890 | 67960 | 68030 | 68100 | 68169 | 68239 | 68309 | 68379 |
| **1169** | 68449 | 68519 | 68590 | 68660 | 68730 | 68801 | 68871 | 68941 | 69011 | 69082 |
| **1170** | 69152 | 69223 | 69293 | 69364 | 69435 | 69506 | 69576 | 69647 | 69718 | 69788 |
| **1171** | 69859 | 69930 | 70001 | 70072 | 70143 | 70215 | 70286 | 70357 | 70428 | 70499 |
| **1172** | 70570 | 70642 | 70713 | 70785 | 70856 | 70928 | 70999 | 71071 | 71142 | 71214 |
| **1173** | 71285 | 71357 | 71429 | 71501 | 71573 | 71645 | 71716 | 71788 | 71860 | 71932 |
| **1174** | 72004 | 72076 | 72149 | 72221 | 72293 | 72366 | 72438 | 72510 | 72582 | 72655 |
| **1175** | 72727 | 72800 | 72873 | 72945 | 73018 | 73091 | 73164 | 73237 | 73309 | 73382 |

# TABLE 2-1 MUD MOUNTAIN RESERVOIR CONTENTS IN ACRE-FEET

| Elev~Ft | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1176 | 73455 | 73528 | 73602 | 73675 | 73748 | 73822 | 73895 | 73968 | 74041 | 74115 |
| 1177 | 74188 | 74262 | 74336 | 74410 | 74484 | 74558 | 74631 | 74705 | 74779 | 74853 |
| 1178 | 74927 | 75001 | 75076 | 75150 | 75225 | 75299 | 75373 | 75448 | 75522 | 75597 |
| 1179 | 75671 | 75746 | 75821 | 75896 | 75971 | 76046 | 76121 | 76196 | 76271 | 76346 |
| 1180 | 76421 | 76497 | 76572 | 76648 | 76723 | 76799 | 76874 | 76950 | 77025 | 77101 |
| 1181 | 77176 | 77252 | 77328 | 77404 | 77480 | 77557 | 77633 | 77709 | 77785 | 77861 |
| 1182 | 77937 | 78014 | 78090 | 78167 | 78243 | 78320 | 78397 | 78473 | 78550 | 78626 |
| 1183 | 78703 | 78780 | 78857 | 78935 | 79012 | 79089 | 79166 | 79243 | 79321 | 79398 |
| 1184 | 79475 | 79553 | 79630 | 79708 | 79786 | 79864 | 79941 | 80019 | 80097 | 80174 |
| 1185 | 80252 | 80330 | 80409 | 80487 | 80565 | 80644 | 80722 | 80800 | 80878 | 80957 |
| 1186 | 81035 | 81114 | 81193 | 81271 | 81350 | 81429 | 81508 | 81587 | 81665 | 81744 |
| 1187 | 81823 | 81902 | 81982 | 82061 | 82141 | 82220 | 82299 | 82379 | 82458 | 82538 |
| 1188 | 82617 | 82697 | 82777 | 82857 | 82937 | 83017 | 83096 | 83176 | 83256 | 83336 |
| 1189 | 83416 | 83496 | 83577 | 83657 | 83738 | 83818 | 83898 | 83979 | 84059 | 84140 |
| 1190 | 84220 | 84301 | 84382 | 84463 | 84544 | 84625 | 84706 | 84787 | 84868 | 84949 |
| 1191 | 85030 | 85112 | 85193 | 85275 | 85356 | 85438 | 85519 | 85601 | 85682 | 85764 |
| 1192 | 85845 | 85927 | 86009 | 86091 | 86173 | 86256 | 86338 | 86420 | 86502 | 86584 |
| 1193 | 86666 | 86749 | 86831 | 86914 | 86996 | 87079 | 87162 | 87244 | 87327 | 87409 |
| 1194 | 87492 | 87575 | 87658 | 87742 | 87825 | 87908 | 87991 | 88074 | 88158 | 88241 |
| 1195 | 88324 | 88408 | 88491 | 88575 | 88659 | 88743 | 88826 | 88910 | 88994 | 89077 |
| 1196 | 89161 | 89245 | 89330 | 89414 | 89498 | 89583 | 89667 | 89751 | 89835 | 89920 |
| 1197 | 90004 | 90089 | 90174 | 90258 | 90343 | 90428 | 90513 | 90598 | 90682 | 90767 |
| 1198 | 90852 | 90937 | 91023 | 91108 | 91194 | 91279 | 91364 | 91450 | 91535 | 91621 |
| 1199 | 91706 | 91792 | 91878 | 91964 | 92050 | 92136 | 92221 | 92307 | 92393 | 92479 |
| 1200 | 92565 | 92652 | 92738 | 92825 | 92911 | 92998 | 93084 | 93171 | 93257 | 93344 |
| 1201 | 93430 | 93517 | 93604 | 93692 | 93779 | 93866 | 93953 | 94040 | 94128 | 94215 |
| 1202 | 94302 | 94390 | 94478 | 94566 | 94654 | 94742 | 94829 | 94917 | 95005 | 95093 |
| 1203 | 95181 | 95270 | 95358 | 95447 | 95535 | 95624 | 95713 | 95801 | 95890 | 95978 |

# TABLE 2-1 MUD MOUNTAIN RESERVOIR CONTENTS IN ACRE-FEET

| Elev~Ft | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| **1204** | 96067 | 96156 | 96246 | 96335 | 96424 | 96514 | 96603 | 96692 | 96781 | 96871 |
| **1205** | 96960 | 97050 | 97140 | 97230 | 97320 | 97410 | 97500 | 97590 | 97680 | 97770 |
| **1206** | 97860 | 97951 | 98041 | 98132 | 98223 | 98314 | 98404 | 98495 | 98586 | 98676 |
| **1207** | 98767 | 98798 | 98830 | 98861 | 98893 | 98924 | 98955 | 98987 | 99018 | 99050 |
| **1208** | 99081 | 99233 | 99385 | 99537 | 99689 | 99842 | 99994 | 100146 | 100298 | 100450 |
| **1209** | 100602 | 100695 | 100788 | 100880 | 100973 | 101066 | 101159 | 101252 | 101344 | 101437 |
| **1210** | 101530 | 101624 | 101717 | 101811 | 101904 | 101998 | 102091 | 102185 | 102278 | 102372 |
| **1211** | 102465 | 102559 | 102653 | 102748 | 102842 | 102936 | 103030 | 103124 | 103219 | 103313 |
| **1212** | 103407 | 103502 | 103597 | 103692 | 103787 | 103882 | 103976 | 104071 | 104166 | 104261 |
| **1213** | 104356 | 104452 | 104547 | 104643 | 104738 | 104834 | 104930 | 105025 | 105121 | 105216 |
| **1214** | 105312 | 105408 | 105505 | 105601 | 105697 | 105794 | 105890 | 105986 | 106082 | 106179 |
| **1215** | 106275 | 106372 | 106469 | 106566 | 106663 | 106760 | 106857 | 106954 | 107051 | 107148 |
| **1216** | 107245 | 107343 | 107440 | 107538 | 107636 | 107734 | 107831 | 107929 | 108027 | 108124 |
| **1217** | 108222 | 108320 | 108419 | 108517 | 108616 | 108714 | 108812 | 108911 | 109009 | 109108 |
| **1218** | 109206 | 109305 | 109404 | 109503 | 109602 | 109702 | 109801 | 109900 | 109999 | 110098 |
| **1219** | 110197 | 110297 | 110397 | 110496 | 110596 | 110696 | 110796 | 110896 | 110995 | 111095 |
| **1220** | 111195 | 111296 | 111396 | 111497 | 111597 | 111698 | 111798 | 111899 | 111999 | 112100 |
| **1221** | 112200 | 112301 | 112402 | 112504 | 112605 | 112706 | 112807 | 112908 | 113010 | 113111 |
| **1222** | 113212 | 113314 | 113416 | 113518 | 113620 | 113722 | 113823 | 113925 | 114027 | 114129 |
| **1223** | 114231 | 114334 | 114436 | 114539 | 114641 | 114744 | 114847 | 114949 | 115052 | 115154 |
| **1224** | 115257 | 115360 | 115464 | 115567 | 115670 | 115774 | 115877 | 115980 | 116083 | 116187 |
| **1225** | 116290 | 116394 | 116498 | 116602 | 116706 | 116810 | 116914 | 117018 | 117122 | 117226 |
| **1226** | 117330 | 117435 | 117540 | 117645 | 117750 | 117855 | 117959 | 118064 | 118169 | 118274 |
| **1227** | 118379 | 118485 | 118591 | 118696 | 118802 | 118908 | 119014 | 119120 | 119225 | 119331 |
| **1228** | 119437 | 119544 | 119650 | 119757 | 119864 | 119971 | 120077 | 120184 | 120291 | 120397 |
| **1229** | 120504 | 120612 | 120719 | 120827 | 120934 | 121042 | 121150 | 121257 | 121365 | 121472 |
| **1230** | 121580 | 121689 | 121797 | 121906 | 122014 | 122123 | 122231 | 122340 | 122448 | 122557 |
| **1231** | 122665 | 122774 | 122884 | 122993 | 123103 | 123212 | 123321 | 123431 | 123540 | 123650 |

## TABLE 2-1 MUD MOUNTAIN RESERVOIR CONTENTS IN ACRE-FEET

| Elev~Ft | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| **1232** | 123759 | 123869 | 123980 | 124090 | 124200 | 124311 | 124421 | 124531 | 124641 | 124752 |
| **1233** | 124862 | 124973 | 125084 | 125196 | 125307 | 125418 | 125529 | 125640 | 125752 | 125863 |
| **1234** | 125974 | 126086 | 126198 | 126310 | 126422 | 126535 | 126647 | 126759 | 126871 | 126983 |
| **1235** | 127095 | 127208 | 127321 | 127434 | 127547 | 127660 | 127773 | 127886 | 127999 | 128112 |
| **1236** | 128225 | 128339 | 128453 | 128567 | 128681 | 128795 | 128908 | 129022 | 129136 | 129250 |
| **1237** | 129364 | 129479 | 129593 | 129708 | 129823 | 129938 | 130052 | 130167 | 130282 | 130396 |
| **1238** | 130511 | 130627 | 130742 | 130858 | 130973 | 131089 | 131205 | 131320 | 131436 | 131551 |
| **1239** | 131667 | 131784 | 131900 | 132017 | 132133 | 132250 | 132367 | 132483 | 132600 | 132716 |
| **1240** | 132833 | 132951 | 133068 | 133186 | 133304 | 133422 | 133539 | 133657 | 133775 | 133892 |
| **1241** | 134010 | 134128 | 134246 | 134364 | 134482 | 134600 | 134717 | 134835 | 134953 | 135071 |
| **1242** | 135189 | 135309 | 135428 | 135548 | 135668 | 135788 | 135907 | 136027 | 136147 | 136266 |
| **1243** | 136386 | 136506 | 136625 | 136745 | 136864 | 136984 | 137104 | 137223 | 137343 | 137462 |
| **1244** | 137582 | 137704 | 137825 | 137947 | 138068 | 138190 | 138311 | 138433 | 138554 | 138676 |
| **1245** | 138797 | 138918 | 139040 | 139161 | 139283 | 139404 | 139525 | 139647 | 139768 | 139890 |
| **1246** | 140011 | 140134 | 140258 | 140381 | 140504 | 140628 | 140751 | 140874 | 140997 | 141121 |
| **1247** | 141244 | 141367 | 141490 | 141614 | 141737 | 141860 | 141983 | 142106 | 142230 | 142353 |
| **1248** | 142476 | 142601 | 142726 | 142851 | 142976 | 143101 | 143226 | 143351 | 143476 | 143601 |
| **1249** | 143726 | 143851 | 143976 | 144101 | 144226 | 144352 | 144477 | 144602 | 144727 | 144852 |
| **1250** | 144977 | 145104 | 145231 | 145358 | 145485 | 145612 | 145738 | 145865 | 145992 | 146119 |
| **1251** | 146246 | 146373 | 146500 | 146626 | 146753 | 146880 | 147007 | 147134 | 147260 | 147387 |
| **1252** | 147514 | 147638 | 147763 | 147887 | 148011 | 148136 | 148260 | 148384 | 148508 | 148633 |
| **1253** | 148757 | 148881 | 149006 | 149130 | 149254 | 149379 | 149503 | 149627 | 149751 | 149876 |
| **1254** | 150000 | 150128 | 150255 | 150383 | 150510 | 150638 | 150765 | 150893 | 151020 | 151148 |
| **1255** | 151275 | 151403 | 151530 | 151658 | 151785 | 151913 | 152040 | 152168 | 152295 | 152423 |
| **1256** | 152550 | 152673 | 152795 | 152918 | 153040 | 153163 | 153285 | 153408 | 153530 | 153653 |
| **1257** | 153775 | 153898 | 154020 | 154143 | 154265 | 154388 | 154510 | 154633 | 154755 | 154878 |
| **1258** | 155000 | | | | | | | | | |

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# TABLE 2-2 MUD MOUNTAIN RESERVOIR CONTENTS IN HECTARE-METERS

| Elev~M | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| **273** | 0.1727 | 0.2911 | 0.4096 | 0.5280 | 0.6464 | 0.7648 | 0.8833 | 1.0017 | 1.1201 | 1.2385 |
| **274** | 1.3570 | 1.4791 | 1.6012 | 1.7233 | 1.8455 | 1.9676 | 2.0897 | 2.2118 | 2.3340 | 2.4561 |
| **275** | 2.5782 | 2.7324 | 2.8866 | 3.0408 | 3.1950 | 3.3492 | 3.5034 | 3.6576 | 3.8118 | 3.9660 |
| **276** | 4.1202 | 4.2781 | 4.4360 | 4.5939 | 4.7518 | 4.9097 | 5.0676 | 5.2255 | 5.3834 | 5.5413 |
| **277** | 5.6992 | 5.9003 | 6.1014 | 6.3025 | 6.5035 | 6.7046 | 6.9057 | 7.1068 | 7.3078 | 7.5089 |
| **278** | 7.7100 | 7.9185 | 8.1270 | 8.3354 | 8.5439 | 8.7524 | 8.9609 | 9.1693 | 9.3778 | 9.5863 |
| **279** | 9.795 | 10.039 | 10.283 | 10.528 | 10.772 | 11.016 | 11.260 | 11.505 | 11.749 | 11.993 |
| **280** | 12.237 | 12.494 | 12.750 | 13.007 | 13.264 | 13.520 | 13.777 | 14.033 | 14.290 | 14.547 |
| **281** | 14.803 | 15.087 | 15.371 | 15.654 | 15.938 | 16.222 | 16.506 | 16.789 | 17.073 | 17.357 |
| **282** | 17.640 | 17.986 | 18.331 | 18.677 | 19.022 | 19.368 | 19.713 | 20.058 | 20.404 | 20.749 |
| **283** | 21.095 | 21.637 | 22.180 | 22.723 | 23.266 | 23.808 | 24.351 | 24.894 | 25.437 | 25.980 |
| **284** | 26.522 | 27.201 | 27.879 | 28.558 | 29.236 | 29.915 | 30.593 | 31.272 | 31.950 | 32.629 |
| **285** | 33.307 | 34.060 | 34.812 | 35.565 | 36.317 | 37.070 | 37.822 | 38.575 | 39.327 | 40.080 |
| **286** | 40.832 | 41.720 | 42.609 | 43.497 | 44.385 | 45.273 | 46.161 | 47.050 | 47.938 | 48.826 |
| **287** | 49.714 | 50.763 | 51.811 | 52.860 | 53.908 | 54.957 | 56.005 | 57.054 | 58.103 | 59.151 |
| **288** | 60.200 | 61.384 | 62.568 | 63.752 | 64.937 | 66.121 | 67.305 | 68.489 | 69.674 | 70.858 |
| **289** | 72.042 | 73.362 | 74.682 | 76.002 | 77.322 | 78.642 | 79.962 | 81.282 | 82.602 | 83.922 |
| **290** | 85.242 | 86.697 | 88.153 | 89.609 | 91.064 | 92.520 | 93.976 | 95.431 | 96.887 | 98.343 |
| **291** | 99.80 | 101.43 | 103.05 | 104.68 | 106.31 | 107.94 | 109.57 | 111.20 | 112.83 | 114.45 |
| **292** | 116.08 | 117.99 | 119.91 | 121.82 | 123.73 | 125.64 | 127.55 | 129.47 | 131.38 | 133.29 |
| **293** | 135.20 | 136.95 | 138.71 | 140.46 | 142.21 | 143.96 | 145.71 | 147.46 | 149.22 | 150.97 |
| **294** | 152.72 | 154.82 | 156.91 | 159.01 | 161.11 | 163.21 | 165.30 | 167.40 | 169.50 | 171.59 |
| **295** | 173.69 | 175.94 | 178.18 | 180.43 | 182.67 | 184.92 | 187.16 | 189.41 | 191.65 | 193.90 |
| **296** | 196.14 | 198.56 | 200.98 | 203.40 | 205.81 | 208.23 | 210.65 | 213.07 | 215.49 | 217.90 |
| **297** | 220.32 | 222.83 | 225.33 | 227.83 | 230.34 | 232.84 | 235.35 | 237.85 | 240.35 | 242.86 |
| **298** | 245.36 | 248.15 | 250.94 | 253.73 | 256.51 | 259.30 | 262.09 | 264.88 | 267.67 | 270.45 |
| **299** | 273.24 | 276.24 | 279.24 | 282.24 | 285.23 | 288.23 | 291.23 | 294.23 | 297.22 | 300.22 |
| **300** | 303.22 | 306.40 | 309.58 | 312.77 | 315.95 | 319.13 | 322.32 | 325.50 | 328.68 | 331.86 |
| **301** | 335.05 | 338.43 | 341.81 | 345.19 | 348.57 | 351.95 | 355.33 | 358.71 | 362.09 | 365.47 |

# TABLE 2-2 MUD MOUNTAIN RESERVOIR CONTENTS IN HECTARE-METERS

| Elev~M | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---:|---:|---:|---:|---:|---:|---:|---:|---:|---:|---:|
| **302** | 368.85 | 372.30 | 375.75 | 379.21 | 382.66 | 386.12 | 389.57 | 393.02 | 396.48 | 399.93 |
| **303** | 403.39 | 407.16 | 410.94 | 414.71 | 418.49 | 422.26 | 426.04 | 429.81 | 433.59 | 437.36 |
| **304** | 441.14 | 445.11 | 449.08 | 453.05 | 457.02 | 461.00 | 464.97 | 468.94 | 472.91 | 476.89 |
| **305** | 480.86 | 485.09 | 489.32 | 493.55 | 497.78 | 502.01 | 506.24 | 510.48 | 514.71 | 518.94 |
| **306** | 523.17 | 527.72 | 532.27 | 536.83 | 541.38 | 545.93 | 550.48 | 555.03 | 559.59 | 564.14 |
| **307** | 568.69 | 573.38 | 578.06 | 582.75 | 587.44 | 592.13 | 596.82 | 601.50 | 606.19 | 610.88 |
| **308** | 615.57 | 620.70 | 625.83 | 630.96 | 636.09 | 641.23 | 646.36 | 651.49 | 656.62 | 661.75 |
| **309** | 666.88 | 672.34 | 677.79 | 683.24 | 688.69 | 694.15 | 699.60 | 705.05 | 710.50 | 715.96 |
| **310** | 721.41 | 727.15 | 732.88 | 738.62 | 744.35 | 750.09 | 755.83 | 761.56 | 767.30 | 773.04 |
| **311** | 778.77 | 784.82 | 790.86 | 796.91 | 802.95 | 808.99 | 815.04 | 821.08 | 827.13 | 833.17 |
| **312** | 839.22 | 845.60 | 851.97 | 858.35 | 864.73 | 871.11 | 877.48 | 883.86 | 890.24 | 896.62 |
| **313** | 903.00 | 909.56 | 916.12 | 922.68 | 929.25 | 935.81 | 942.37 | 948.93 | 955.50 | 962.06 |
| **314** | 968.62 | 975.83 | 983.03 | 990.24 | 997.44 | 1004.64 | 1011.85 | 1019.05 | 1026.26 | 1033.46 |
| **315** | 1040.66 | 1048.28 | 1055.89 | 1063.50 | 1071.11 | 1078.72 | 1086.33 | 1093.94 | 1101.56 | 1109.17 |
| **316** | 1116.78 | 1124.78 | 1132.79 | 1140.80 | 1148.80 | 1156.81 | 1164.81 | 1172.82 | 1180.83 | 1188.83 |
| **317** | 1196.84 | 1205.26 | 1213.69 | 1222.12 | 1230.54 | 1238.97 | 1247.39 | 1255.82 | 1264.24 | 1272.67 |
| **318** | 1281.09 | 1289.67 | 1298.24 | 1306.81 | 1315.39 | 1323.96 | 1332.53 | 1341.11 | 1349.68 | 1358.26 |
| **319** | 1366.83 | 1376.08 | 1385.33 | 1394.58 | 1403.84 | 1413.09 | 1422.34 | 1431.59 | 1440.84 | 1450.10 |
| **320** | 1459.35 | 1469.11 | 1478.86 | 1488.62 | 1498.38 | 1508.14 | 1517.90 | 1527.65 | 1537.41 | 1547.17 |
| **321** | 1556.93 | 1567.26 | 1577.60 | 1587.94 | 1598.28 | 1608.61 | 1618.95 | 1629.29 | 1639.63 | 1649.96 |
| **322** | 1660.30 | 1671.22 | 1682.14 | 1693.05 | 1703.97 | 1714.89 | 1725.81 | 1736.72 | 1747.64 | 1758.56 |
| **323** | 1769.48 | 1780.64 | 1791.80 | 1802.97 | 1814.13 | 1825.30 | 1836.46 | 1847.62 | 1858.79 | 1869.95 |
| **324** | 1881.12 | 1893.22 | 1905.32 | 1917.42 | 1929.52 | 1941.62 | 1953.73 | 1965.83 | 1977.93 | 1990.03 |
| **325** | 2002.13 | 2014.80 | 2027.47 | 2040.14 | 2052.81 | 2065.48 | 2078.15 | 2090.82 | 2103.49 | 2116.15 |
| **326** | 2128.82 | 2142.07 | 2155.32 | 2168.57 | 2181.82 | 2195.07 | 2208.32 | 2221.57 | 2234.81 | 2248.06 |
| **327** | 2261.31 | 2275.17 | 2289.02 | 2302.87 | 2316.73 | 2330.58 | 2344.43 | 2358.29 | 2372.14 | 2385.99 |
| **328** | 2399.85 | 2413.85 | 2427.85 | 2441.85 | 2455.85 | 2469.85 | 2483.85 | 2497.85 | 2511.86 | 2525.86 |
| **329** | 2539.86 | 2554.93 | 2570.01 | 2585.08 | 2600.16 | 2615.23 | 2630.31 | 2645.38 | 2660.46 | 2675.53 |
| **330** | 2690.60 | 2706.30 | 2721.99 | 2737.68 | 2753.37 | 2769.06 | 2784.75 | 2800.44 | 2816.14 | 2831.83 |

# TABLE 2-2 MUD MOUNTAIN RESERVOIR CONTENTS IN HECTARE-METERS

| Elev~M | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 331 | 2847.52 | 2863.85 | 2880.18 | 2896.52 | 2912.85 | 2929.18 | 2945.52 | 2961.85 | 2978.18 | 2994.51 |
| 332 | 3010.85 | 3027.81 | 3044.77 | 3061.73 | 3078.70 | 3095.66 | 3112.62 | 3129.58 | 3146.54 | 3163.51 |
| 333 | 3180.47 | 3198.06 | 3215.65 | 3233.24 | 3250.83 | 3268.42 | 3286.01 | 3303.61 | 3321.20 | 3338.79 |
| 334 | 3356.38 | 3374.06 | 3391.73 | 3409.41 | 3427.09 | 3444.77 | 3462.44 | 3480.12 | 3497.80 | 3515.48 |
| 335 | 3533.15 | 3551.90 | 3570.66 | 3589.41 | 3608.16 | 3626.91 | 3645.66 | 3664.41 | 3683.16 | 3701.91 |
| 336 | 3720.66 | 3739.83 | 3759.00 | 3778.17 | 3797.34 | 3816.51 | 3835.68 | 3854.85 | 3874.02 | 3893.19 |
| 337 | 3912.36 | 3931.89 | 3951.42 | 3970.95 | 3990.47 | 4010.00 | 4029.53 | 4049.06 | 4068.59 | 4088.11 |
| 338 | 4107.64 | 4127.58 | 4147.51 | 4167.45 | 4187.38 | 4207.32 | 4227.25 | 4247.19 | 4267.12 | 4287.06 |
| 339 | 4306.99 | 4326.69 | 4346.39 | 4366.09 | 4385.79 | 4405.49 | 4425.19 | 4444.90 | 4464.60 | 4484.30 |
| 340 | 4504.00 | 4524.59 | 4545.17 | 4565.76 | 4586.35 | 4606.94 | 4627.53 | 4648.12 | 4668.71 | 4689.30 |
| 341 | 4709.88 | 4731.08 | 4752.27 | 4773.46 | 4794.66 | 4815.85 | 4837.04 | 4858.24 | 4879.43 | 4900.62 |
| 342 | 4921.82 | 4943.31 | 4964.80 | 4986.29 | 5007.77 | 5029.26 | 5050.75 | 5072.24 | 5093.73 | 5115.22 |
| 343 | 5136.71 | 5158.13 | 5179.54 | 5200.96 | 5222.37 | 5243.79 | 5265.20 | 5286.62 | 5308.03 | 5329.45 |
| 344 | 5350.86 | 5373.13 | 5395.40 | 5417.66 | 5439.93 | 5462.20 | 5484.46 | 5506.73 | 5529.00 | 5551.26 |
| 345 | 5573.53 | 5596.44 | 5619.34 | 5642.25 | 5665.16 | 5688.07 | 5710.98 | 5733.88 | 5756.79 | 5779.70 |
| 346 | 5802.61 | 5826.03 | 5849.46 | 5872.89 | 5896.31 | 5919.74 | 5943.16 | 5966.59 | 5990.02 | 6013.44 |
| 347 | 6036.87 | 6060.78 | 6084.68 | 6108.59 | 6132.50 | 6156.40 | 6180.31 | 6204.22 | 6228.13 | 6252.03 |
| 348 | 6275.94 | 6300.34 | 6324.74 | 6349.14 | 6373.54 | 6397.94 | 6422.34 | 6446.74 | 6471.14 | 6495.55 |
| 349 | 6519.95 | 6544.85 | 6569.76 | 6594.67 | 6619.57 | 6644.48 | 6669.38 | 6694.29 | 6719.20 | 6744.10 |
| 350 | 6769.01 | 6793.64 | 6818.28 | 6842.91 | 6867.55 | 6892.18 | 6916.82 | 6941.45 | 6966.09 | 6990.72 |
| 351 | 7015.36 | 7041.29 | 7067.22 | 7093.15 | 7119.08 | 7145.01 | 7170.94 | 7196.87 | 7222.80 | 7248.73 |
| 352 | 7274.66 | 7301.14 | 7327.61 | 7354.08 | 7380.55 | 7407.03 | 7433.50 | 7459.97 | 7486.45 | 7512.92 |
| 353 | 7539.39 | 7566.40 | 7593.40 | 7620.40 | 7647.41 | 7674.41 | 7701.41 | 7728.42 | 7755.42 | 7782.42 |
| 354 | 7809.43 | 7836.99 | 7864.55 | 7892.10 | 7919.66 | 7947.22 | 7974.78 | 8002.34 | 8029.90 | 8057.46 |
| 355 | 8085.01 | 8112.28 | 8139.54 | 8166.80 | 8194.06 | 8221.33 | 8248.59 | 8275.85 | 8303.11 | 8330.38 |
| 356 | 8357.64 | 8386.28 | 8414.93 | 8443.57 | 8472.22 | 8500.86 | 8529.51 | 8558.15 | 8586.79 | 8615.44 |
| 357 | 8644.08 | 8673.27 | 8702.46 | 8731.64 | 8760.83 | 8790.02 | 8819.20 | 8848.39 | 8877.58 | 8906.76 |
| 358 | 8935.95 | 8965.74 | 8995.53 | 9025.33 | 9055.12 | 9084.91 | 9114.70 | 9144.49 | 9174.28 | 9204.07 |
| 359 | 9233.87 | 9264.40 | 9294.93 | 9325.46 | 9355.99 | 9386.52 | 9417.06 | 9447.59 | 9478.12 | 9508.65 |

# TABLE 2-2 MUD MOUNTAIN RESERVOIR CONTENTS IN HECTARE-METERS

| Elev~M | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 360 | 9539.18 | 9569.50 | 9599.83 | 9630.15 | 9660.47 | 9690.79 | 9721.11 | 9751.44 | 9781.76 | 9812.08 |
| 361 | 9842.40 | 9874.39 | 9906.38 | 9938.36 | 9970.35 | 10002.34 | 10034.32 | 10066.31 | 10098.30 | 10130.29 |
| 362 | 10162.27 | 10194.98 | 10227.68 | 10260.38 | 10293.08 | 10325.79 | 10358.49 | 10391.19 | 10423.90 | 10456.60 |
| 363 | 10489.30 | 10522.76 | 10556.21 | 10589.67 | 10623.12 | 10656.58 | 10690.03 | 10723.49 | 10756.94 | 10790.40 |
| 364 | 10823.85 | 10858.04 | 10892.22 | 10926.40 | 10960.59 | 10994.77 | 11028.95 | 11063.13 | 11097.32 | 11131.50 |
| 365 | 11165.68 | 11199.53 | 11233.38 | 11267.23 | 11301.08 | 11334.93 | 11368.78 | 11402.63 | 11436.48 | 11470.33 |
| 366 | 11504.18 | 11539.95 | 11575.71 | 11611.47 | 11647.23 | 11682.99 | 11718.76 | 11754.52 | 11790.28 | 11826.04 |
| 367 | 11861.80 | 11895.57 | 11929.33 | 11963.10 | 11996.86 | 12030.62 | 12064.39 | 12098.15 | 12131.91 | 12165.68 |
| 368 | 12199.44 | 12240.05 | 12280.66 | 12321.27 | 12361.88 | 12402.49 | 12443.10 | 12483.71 | 12524.32 | 12564.93 |
| 369 | 12605.54 | 12644.12 | 12682.69 | 12721.27 | 12759.84 | 12798.41 | 12836.99 | 12875.56 | 12914.14 | 12952.71 |
| 370 | 12991.29 | 13030.83 | 13070.36 | 13109.90 | 13149.44 | 13188.97 | 13228.51 | 13268.05 | 13307.58 | 13347.12 |
| 371 | 13386.66 | 13425.90 | 13465.14 | 13504.38 | 13543.62 | 13582.86 | 13622.10 | 13661.34 | 13700.58 | 13739.82 |
| 372 | 13779.07 | 13820.44 | 13861.82 | 13903.19 | 13944.57 | 13985.94 | 14027.31 | 14068.69 | 14110.06 | 14151.44 |
| 373 | 14192.81 | 14235.16 | 14277.51 | 14319.86 | 14362.21 | 14404.56 | 14446.91 | 14489.26 | 14531.61 | 14573.96 |
| 374 | 14616.31 | 14659.84 | 14703.38 | 14746.91 | 14790.44 | 14833.98 | 14877.51 | 14921.05 | 14964.58 | 15008.11 |
| 375 | 15051.65 | 15096.38 | 15141.11 | 15185.84 | 15230.57 | 15275.30 | 15320.03 | 15364.76 | 15409.49 | 15454.22 |
| 376 | 15498.95 | 15543.48 | 15588.02 | 15632.55 | 15677.08 | 15721.62 | 15766.15 | 15810.68 | 15855.21 | 15899.75 |
| 377 | 15944.28 | 15991.42 | 16038.55 | 16085.69 | 16132.82 | 16179.96 | 16227.10 | 16274.23 | 16321.37 | 16368.50 |
| 378 | 16415.64 | | | | | | | | | |
| | | | | | | | | | | |

MMDCapaMetric.doc

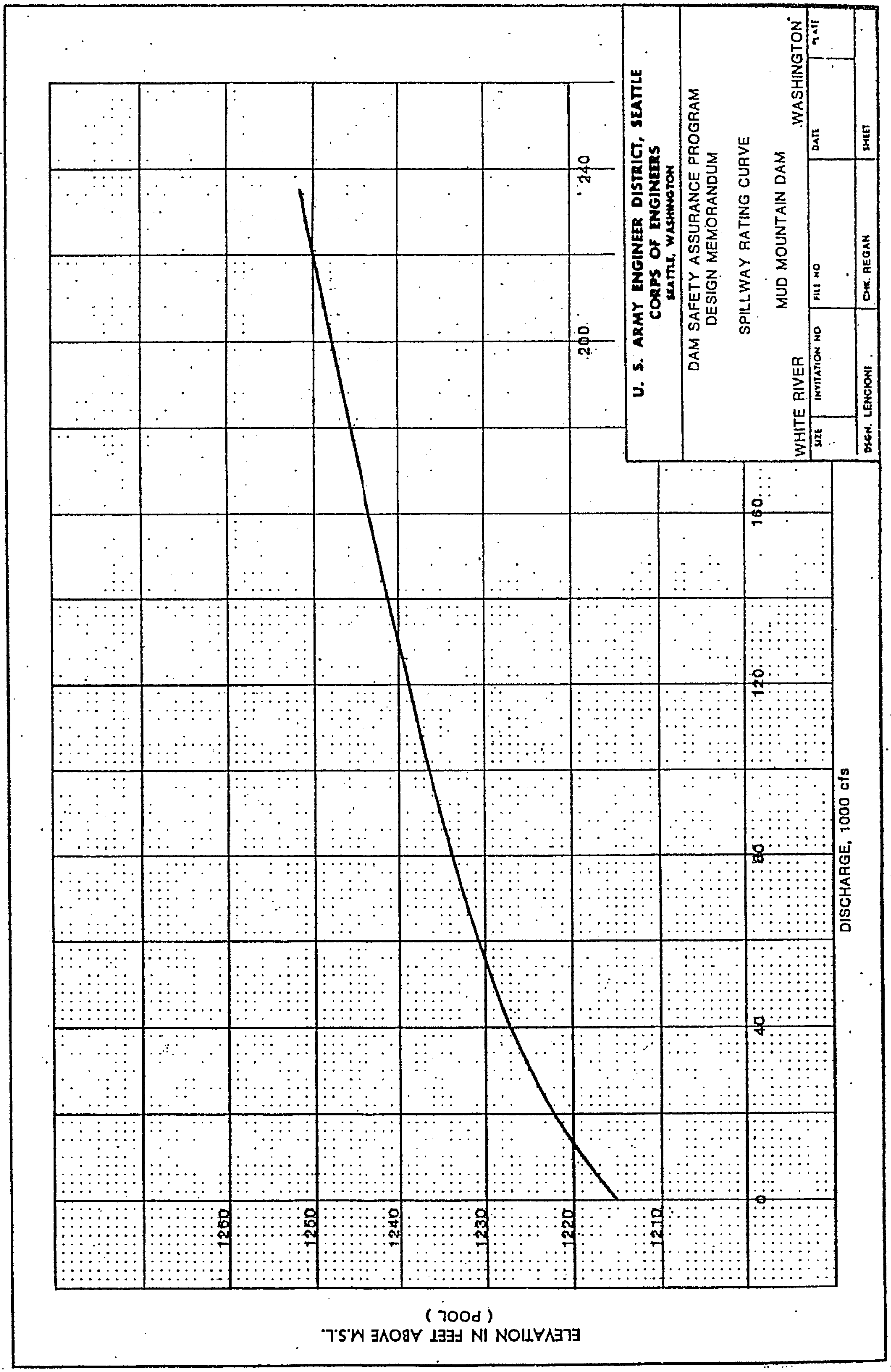
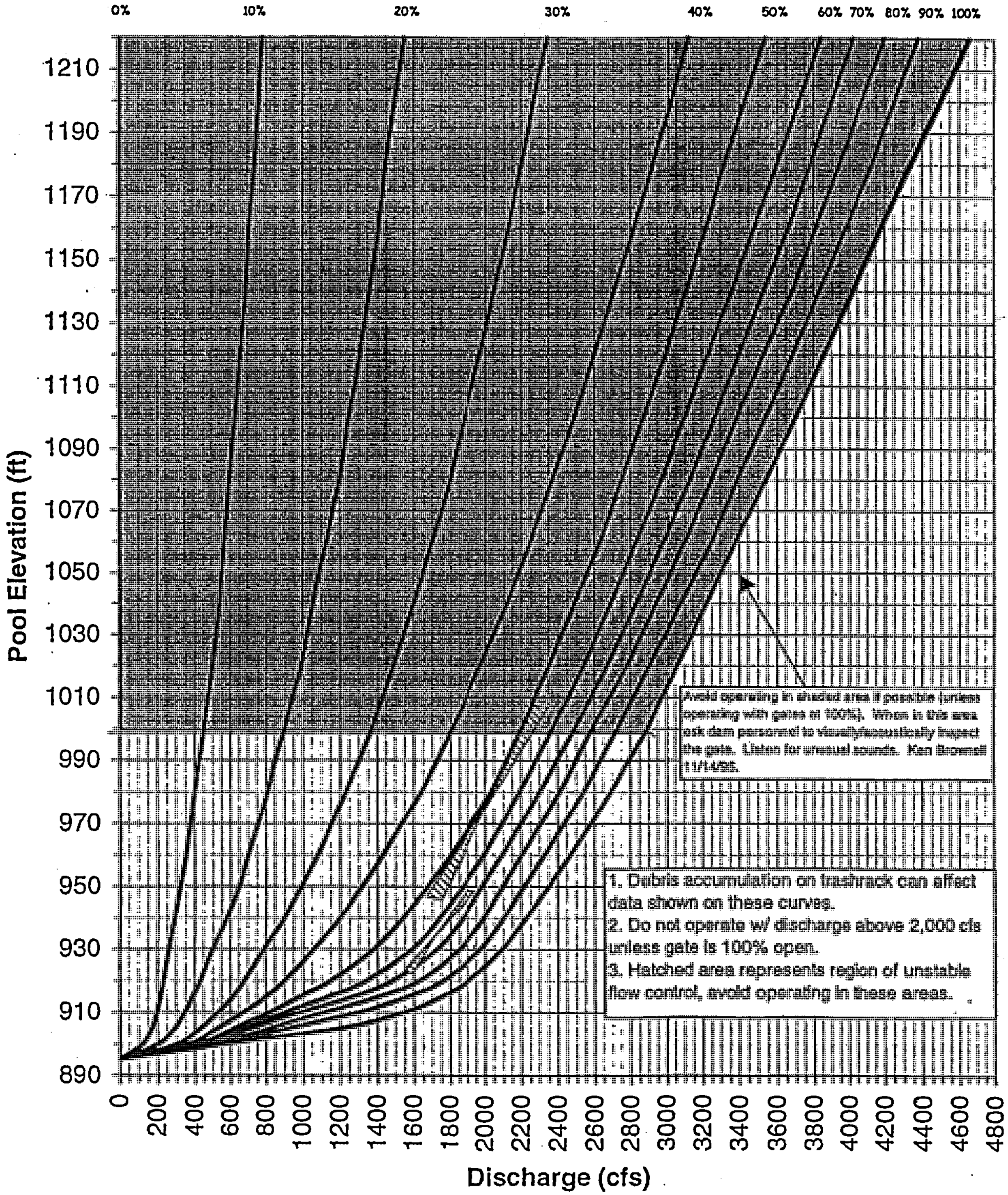

U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON
DAM SAFETY ASSURANCE PROGRAM
DESIGN MEMORANDUM
SPILLWAY RATING CURVE
MUD MOUNTAIN DAM
WHITE RIVER
WASHINGTON
SIZE
INVITATION NO
FILE NO
DATE
PLATE
DSGN. LENCIONI
CHK. REGAN
SHEET
0
40
80
120
160
200
240
DISCHARGE, 1000 cfs
1210
1220
1230
1240
1250
1260
ELEVATION IN FEET ABOVE M.S.L.
( POOL )



CHART 2-1

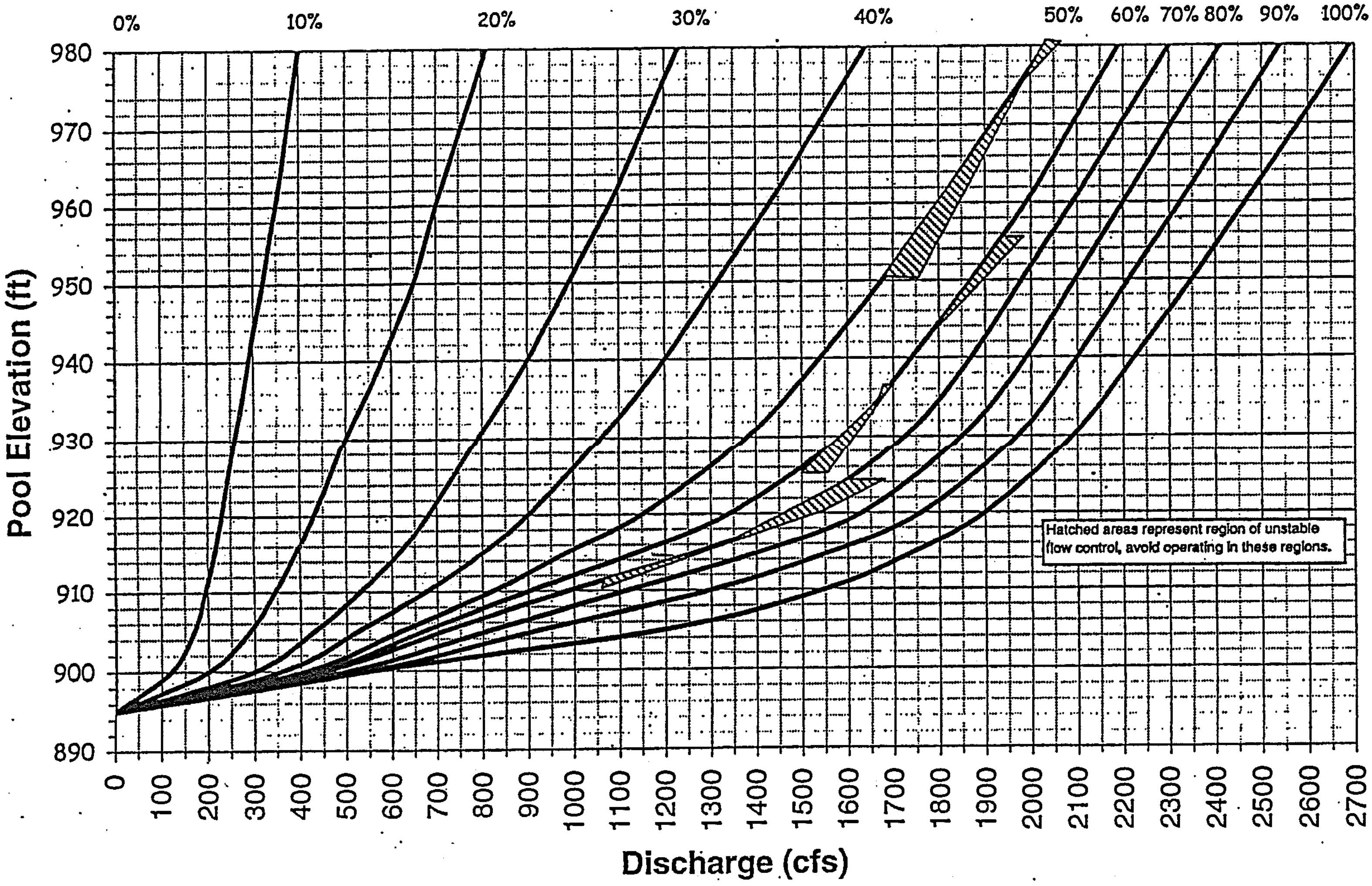
# RATING CURVE
# 9 FOOT TUNNEL (GATE R-3)
# MUD MOUNTAIN DAM




1998 Rating table combined the 1995 table with observed measurements (David van Rijn).

| | R3 | R3 | R3 | R3 | R3 | R3 | R3 | R3 | R3 | R3 | R3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| POOL | | | FLOW IN CUBIC FEET PER SECOND (CFS) | | | | | | | | |
| ELEVATION | 0% | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% |
| 895 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 900 | 0 | 120 | 200 | 300 | 360 | 410 | 435 | 450 | 500 | 545 | 550 |
| 905 | 0 | 170 | 290 | 430 | 525 | 620 | 670 | 715 | 815 | 923 | 1200 |
| 910 | 0 | 195 | 345 | 530 | 675 | 820 | 900 | 985 | 1115 | 1300 | 1550 |
| 915 | 0 | 215 | 390 | 615 | 800 | 985 | 1140 | 1270 | 1410 | 1570 | 1750 |
| 920 | 0 | 230 | 430 | 680 | 900 | 1150 | 1340 | 1485 | 1630 | 1760 | 1900 |
| 925 | 0 | 245 | 465 | 735 | 980 | 1265 | 1465 | 1605 | 1740 | 1865 | 1995 |
| 930 | 0 | 260 | 500 | 790 | 1060 | 1380 | 1590 | 1725 | 1850 | 1970 | 2090 |
| 935 | 0 | 275 | 540 | 845 | 1130 | 1460 | 1665 | 1798 | 1920 | 2035 | 2158 |
| 940 | 0 | 290 | 580 | 900 | 1200 | 1540 | 1740 | 1870 | 1990 | 2100 | 2225 |
| 950 | 0 | 320 | 650 | 990 | 1315 | 1675 | 1870 | 1980 | 2095 | 2213 | 2350 |
| 960 | 0 | 350 | 700 | 1080 | 1430 | 1800 | 1990 | 2090 | 2200 | 2325 | 2465 |
| 970 | 0 | 375 | 755 | 1155 | 1535 | 1915 | 2090 | 2195 | 2305 | 2433 | 2580 |
| 980 | 0 | 400 | 810 | 1230 | 1640 | 2030 | 2190 | 2300 | 2410 | 2540 | 2690 |
| 990 | 0 | 425 | 850 | 1300 | 1725 | 2115 | 2280 | 2395 | 2498 | 2633 | 2790 |
| 1000 | 0 | 450 | 900 | 1370 | 1810 | 2200 | 2370 | 2490 | 2585 | 2725 | 2890 |
| 1010 | 0 | 475 | 945 | 1430 | 1890 | 2275 | 2455 | 2580 | 2683 | 2813 | 2970 |
| 1020 | 0 | 500 | 990 | 1490 | 1970 | 2350 | 2540 | 2670 | 2780 | 2900 | 3060 |
| 1030 | 0 | 520 | 1025 | 1545 | 2045 | 2420 | 2615 | 2750 | 2860 | 2990 | 3140 |
| 1040 | 0 | 540 | 1060 | 1600 | 2120 | 2490 | 2690 | 2830 | 2940 | 3080 | 3220 |
| 1050 | 0 | 555 | 1090 | 1650 | 2185 | 2560 | 2760 | 2905 | 3020 | 3165 | 3300 |
| 1060 | 0 | 570 | 1130 | 1700 | 2250 | 2630 | 2830 | 2980 | 3100 | 3250 | 3380 |
| 1070 | 0 | 585 | 1165 | 1750 | 2310 | 2690 | 2900 | 3055 | 3175 | 3320 | 3460 |
| 1080 | 0 | 600 | 1200 | 1800 | 2370 | 2750 | 2970 | 3130 | 3250 | 3390 | 3540 |
| 1090 | 0 | 615 | 1225 | 1840 | 2430 | 2810 | 3035 | 3200 | 3320 | 3465 | 3620 |
| 1100 | 0 | 630 | 1250 | 1880 | 2490 | 2870 | 3100 | 3270 | 3390 | 3540 | 3700 |
| 1110 | 0 | 645 | 1285 | 1925 | 2545 | 2930 | 3165 | 3335 | 3460 | 3613 | 3780 |
| 1120 | 0 | 660 | 1310 | 1970 | 2600 | 2990 | 3230 | 3400 | 3530 | 3685 | 3860 |
| 1130 | 0 | 675 | 1335 | 2010 | 2655 | 3050 | 3295 | 3465 | 3605 | 3758 | 3940 |
| 1140 | 0 | 690 | 1360 | 2050 | 2710 | 3110 | 3360 | 3530 | 3680 | 3830 | 4020 |
| 1150 | 0 | 700 | 1385 | 2090 | 2765 | 3165 | 3420 | 3595 | 3745 | 3905 | 4100 |
| 1160 | 0 | 710 | 1410 | 2130 | 2820 | 3220 | 3480 | 3660 | 3810 | 3980 | 4180 |
| 1170 | 0 | 725 | 1430 | 2165 | 2870 | 3270 | 3540 | 3720 | 3878 | 4053 | 4260 |
| 1180 | 0 | 740 | 1450 | 2200 | 2920 | 3320 | 3600 | 3780 | 3945 | 4125 | 4340 |
| 1190 | 0 | 750 | 1475 | 2235 | 2970 | 3375 | 3660 | 3840 | 4008 | 4188 | 4420 |
| 1200 | 0 | 760 | 1500 | 2270 | 3020 | 3430 | 3720 | 3900 | 4070 | 4250 | 4500 |
| 1210 | 0 | 770 | 1525 | 2305 | 3070 | 3485 | 3780 | 3960 | 4133 | 4313 | 4580 |
| 1220 | 0 | 780 | 1550 | 2340 | 3120 | 3540 | 3840 | 4020 | 4195 | 4375 | 4660 |

# LOW HEAD RATING CURVE
# 9 FOOT TUNNEL (GATE R-3)
# MUD MOUNTAIN DAM

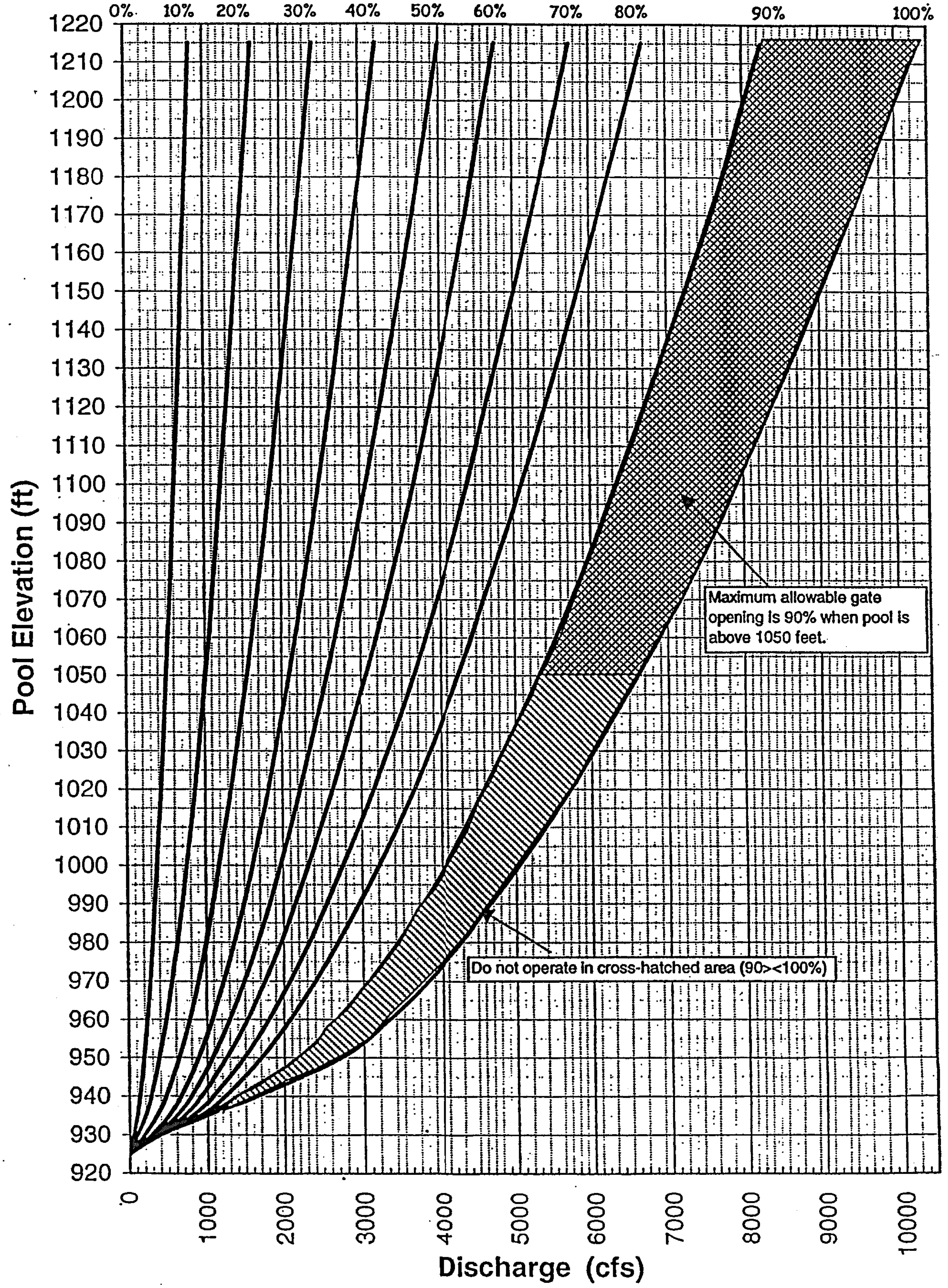



1998 Rating table combined the 1995 table with observed measurements (David van Rijn)

RATING CURVE

# 23 FOOT TUNNEL (GATE R-1)

MUD MOUNTAIN DAM

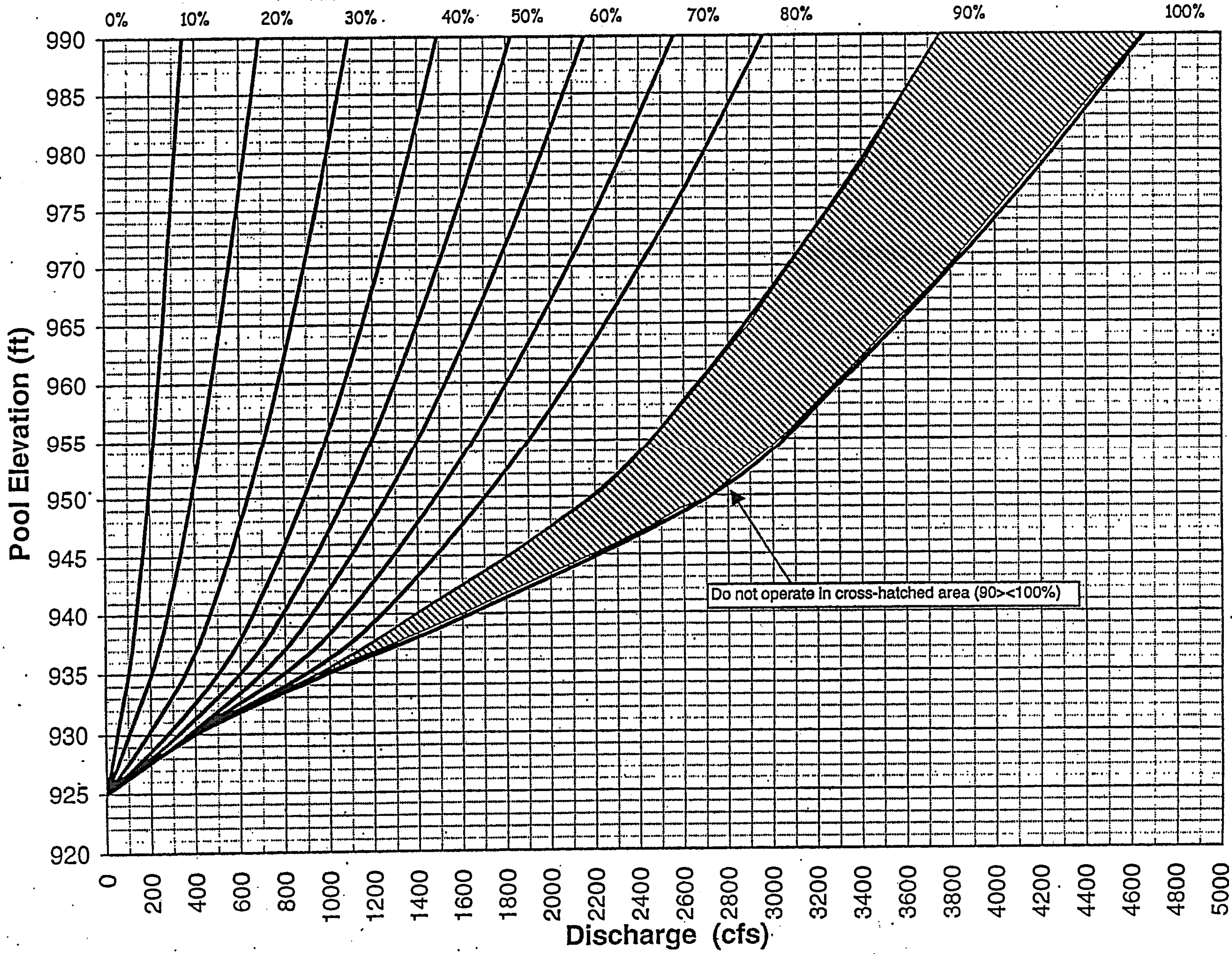



1998 Rating table combined the 1995 table with observed measurements (David van Rij

Mud Mountain Rating Table (1998)

| POOL ELEVATION | R1 0% | R1 10% | R1 20% | R1 30% | R1 40% | R1 50% | R1 60% | R1 70% | R1 80% | R1 90% | R1 100% |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | FLOW IN CUBIC FEET PER SECOND (CFS) | | | | | | | | |
| 895 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 900 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 905 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 910 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 915 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 920 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 925 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 930 | 0 | 51 | 103 | 189 | 274 | 323 | 371 | 380 | 390 | 395 | 400 |
| 935 | 0 | 102 | 204 | 354 | 504 | 601 | 698 | 799 | 900 | 960 | 1000 |
| 940 | 0 | 138 | 275 | 466 | 658 | 789 | 921 | 1079 | 1237 | 1400 | 1640 |
| 950 | 0 | 193 | 386 | 638 | 889 | 1074 | 1259 | 1482 | 1706 | 2190 | 2725 |
| 960 | 0 | 238 | 476 | 774 | 1072 | 1300 | 1529 | 1805 | 2081 | 2674 | 3314 |
| 970 | 0 | 277 | 555 | 891 | 1228 | 1494 | 1760 | 2083 | 2406 | 3074 | 3813 |
| 980 | 0 | 313 | 625 | 996 | 1367 | 1666 | 1966 | 2331 | 2695 | 3430 | 4258 |
| 990 | 0 | 345 | 690 | 1091 | 1492 | 1823 | 2154 | 2557 | 2960 | 3754 | 4662 |
| 1000 | 0 | 376 | 751 | 1180 | 1608 | 1968 | 2328 | 2767 | 3205 | 4054 | 5036 |
| 1010 | 0 | 404 | 808 | 1262 | 1716 | 2103 | 2490 | 2963 | 3435 | 4334 | 5386 |
| 1020 | 0 | 431 | 862 | 1340 | 1818 | 2231 | 2644 | 3148 | 3653 | 4598 | 5716 |
| 1030 | 0 | 457 | 913 | 1414 | 1914 | 2352 | 2789 | 3324 | 3859 | 4848 | 6029 |
| 1040 | 0 | 481 | 963 | 1484 | 2006 | 2467 | 2928 | 3492 | 4056 | 5086 | 6327 |
| 1050 | 0 | 505 | 1010 | 1552 | 2094 | 2577 | 3061 | 3653 | 4246 | 5315 | 6613 |
| 1060 | 0 | 528 | 1056 | 1617 | 2178 | 2683 | 3189 | 3809 | 4428 | 5535 | 6888 |
| 1070 | 0 | 550 | 1100 | 1680 | 2259 | 2786 | 3312 | 3958 | 4604 | 5746 | 7153 |
| 1080 | 0 | 572 | 1143 | 1740 | 2337 | 2884 | 3432 | 4103 | 4774 | 5951 | 7409 |
| 1090 | 0 | 592 | 1185 | 1799 | 2413 | 2980 | 3547 | 4243 | 4939 | 6149 | 7657 |
| 1100 | 0 | 613 | 1226 | 1856 | 2486 | 3073 | 3659 | 4379 | 5099 | 6341 | 7898 |
| 1110 | 0 | 633 | 1265 | 1911 | 2558 | 3163 | 3768 | 4512 | 5255 | 6528 | 8132 |
| 1120 | 0 | 652 | 1304 | 1965 | 2627 | 3251 | 3875 | 4641 | 5407 | 6710 | 8360 |
| 1130 | 0 | 671 | 1342 | 2018 | 2695 | 3336 | 3978 | 4767 | 5556 | 6887 | 8582 |
| 1140 | 0 | 689 | 1379 | 2070 | 2761 | 3420 | 4079 | 4890 | 5701 | 7060 | 8799 |
| 1150 | 0 | 707 | 1415 | 2120 | 2825 | 3502 | 4178 | 5010 | 5843 | 7230 | 9011 |
| 1160 | 0 | 725 | 1450 | 2169 | 2888 | 3582 | 4275 | 5128 | 5981 | 7395 | 9219 |
| 1170 | 0 | 743 | 1485 | 2217 | 2950 | 3660 | 4370 | 5244 | 6118 | 7558 | 9422 |
| 1180 | 0 | 760 | 1519 | 2265 | 3010 | 3736 | 4463 | 5357 | 6251 | 7717 | 9621 |
| 1190 | 0 | 777 | 1553 | 2311 | 3069 | 3812 | 4554 | 5468 | 6382 | 7872 | 9817 |
| 1200 | 0 | 793 | 1586 | 2357 | 3127 | 3885 | 4644 | 5577 | 6511 | 8025 | 10009 |
| 1215 | 0 | 817 | 1635 | 2424 | 3213 | 3994 | 4775 | 5738 | 6700 | 8250 | 10290 |

LOW HEAD RATING CURVE **23 FOOT TUNNEL (GATE R1)** MUD MOUNTAIN DAM




1998 Rating table combined the 1995 table with observed measurements (David van Rijn).

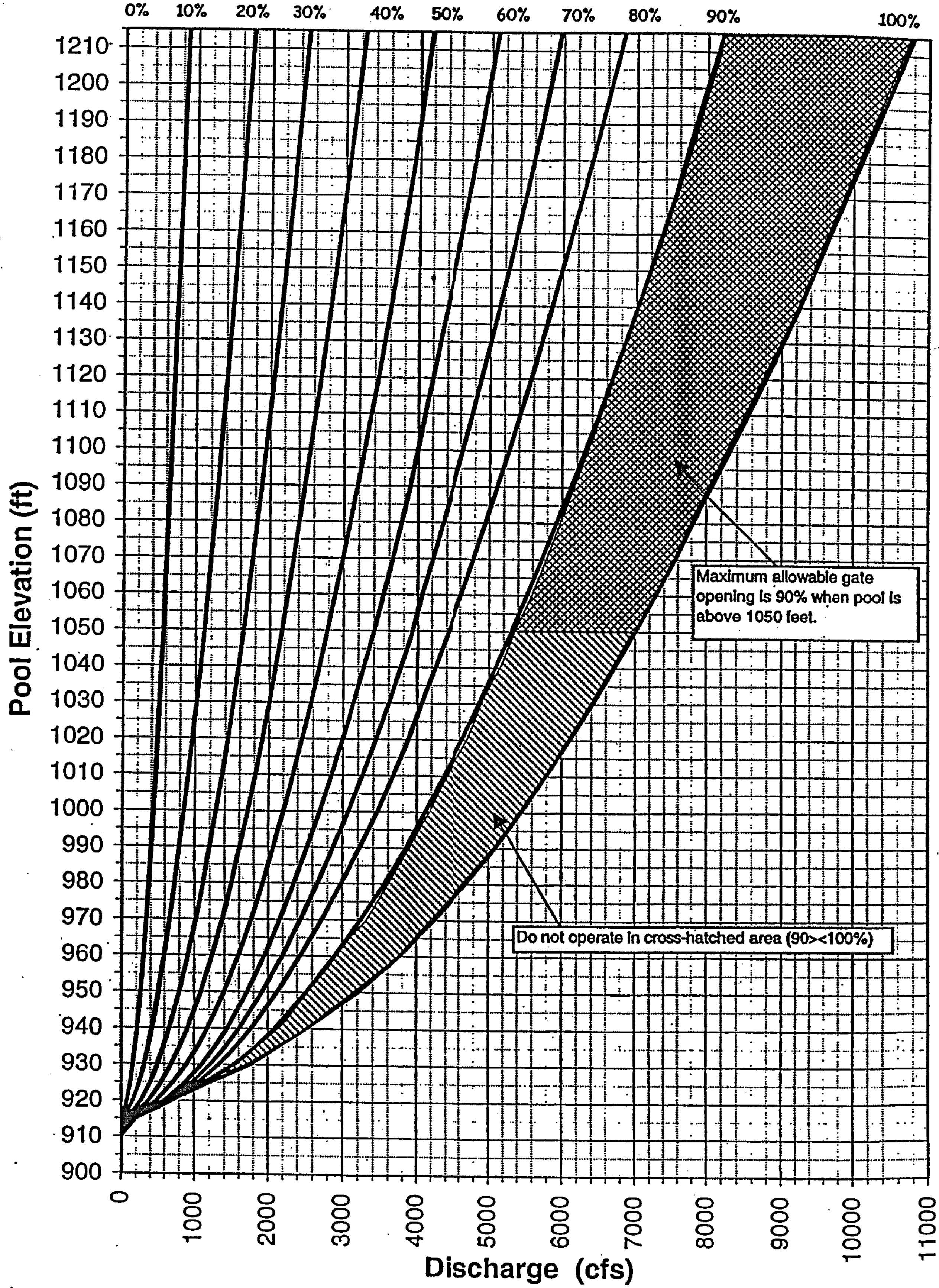
C2-7

CHART 2-5

RATING CURVE

# 23 FOOT TUNNEL (GATE R-2)

MUD MOUNTAIN DAM




1998 Rating table combined 1995 table with observed measurements (David van Rijn).



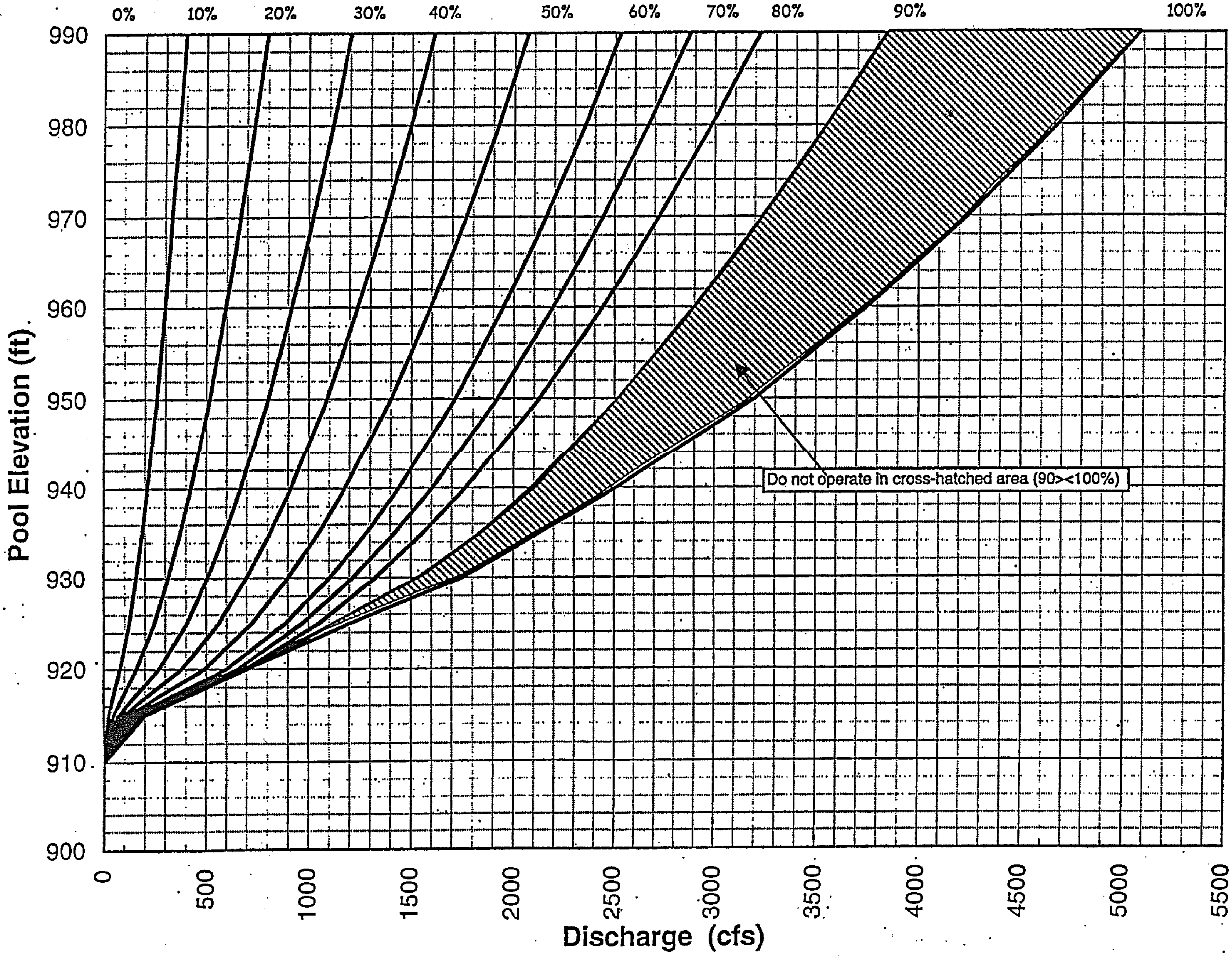
CHART 2-6

Mud Mountain Rating Table (1998)

| | R2 | R2 | R2 | R2 | R2 | R2 | R2 | R2 | R2 | R2 | R2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| POOL | | | FLOW IN CUBIC FEET PER SECOND (CFS) | | | | | | | | |
| | | | | | | | | | | | |
| ELEVATION | 0% | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% |
| 895 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 900 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 905 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 910 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 915 | 0 | 24 | 48 | 71 | 95 | 119 | 143 | 166 | 190 | 196 | 200 |
| 920 | 0 | 79 | 158 | 268 | 378 | 489 | 600 | 655 | 691 | 696 | 700 |
| 925 | 0 | 123 | 246 | 403 | 561 | 724 | 887 | 969 | 1051 | 1125 | 1200 |
| 930 | 0 | 157 | 314 | 506 | 698 | 900 | 1103 | 1214 | 1326 | 1538 | 1750 |
| 935 | 0 | 186 | 372 | 592 | 813 | 1048 | 1283 | 1421 | 1559 | 1843 | 2130 |
| 940 | 0 | 212 | 424 | 668 | 913 | 1177 | 1441 | 1603 | 1765 | 2090 | 2510 |
| 950 | 0 | 257 | 515 | 801 | 1088 | 1401 | 1714 | 1920 | 2126 | 2522 | 3200 |
| 960 | 0 | 297 | 595 | 917 | 1238 | 1594 | 1949 | 2195 | 2441 | 2900 | 3750 |
| 970 | 0 | 334 | 667 | 1020 | 1373 | 1766 | 2159 | 2441 | 2724 | 3240 | 4240 |
| 980 | 0 | 367 | 734 | 1115 | 1496 | 1923 | 2351 | 2667 | 2983 | 3553 | 4680 |
| 990 | 0 | 398 | 797 | 1203 | 1609 | 2069 | 2528 | 2877 | 3225 | 3845 | 5081 |
| 1000 | 0 | 428 | 856 | 1286 | 1716 | 2205 | 2694 | 3073 | 3452 | 4118 | 5440 |
| 1010 | 0 | 456 | 912 | 1364 | 1816 | 2333 | 2850 | 3259 | 3667 | 4378 | 5781 |
| 1020 | 0 | 482 | 965 | 1438 | 1911 | 2455 | 2999 | 3435 | 3872 | 4625 | 6105 |
| 1030 | 0 | 508 | 1016 | 1509 | 2002 | 2571 | 3140 | 3604 | 4068 | 4862 | 6415 |
| 1040 | 0 | 533 | 1065 | 1577 | 2089 | 2682 | 3275 | 3765 | 4256 | 5089 | 6713 |
| 1050 | 0 | 557 | 1113 | 1643 | 2172 | 2789 | 3405 | 3921 | 4437 | 5308 | 7000 |
| 1060 | 0 | 580 | 1159 | 1706 | 2253 | 2891 | 3530 | 4071 | 4612 | 5520 | 7277 |
| 1070 | 0 | 602 | 1204 | 1767 | 2330 | 2991 | 3651 | 4216 | 4782 | 5725 | 7546 |
| 1080 | 0 | 624 | 1247 | 1827 | 2406 | 3087 | 3768 | 4357 | 4946 | 5925 | 7807 |
| 1090 | 0 | 645 | 1290 | 1884 | 2479 | 3180 | 3882 | 4494 | 5106 | 6119 | 8061 |
| 1100 | 0 | 665 | 1331 | 1940 | 2550 | 3271 | 3992 | 4627 | 5262 | 6307 | 8308 |
| 1110 | 0 | 686 | 1371 | 1995 | 2619 | 3359 | 4100 | 4757 | 5414 | 6492 | 8549 |
| 1120 | 0 | 705 | 1411 | 2049 | 2686 | 3446 | 4205 | 4883 | 5562 | 6672 | 8784 |
| 1130 | 0 | 725 | 1449 | 2101 | 2752 | 3530 | 4307 | 5007 | 5707 | 6848 | 9014 |
| 1140 | 0 | 744 | 1487 | 2152 | 2817 | 3612 | 4407 | 5128 | 5849 | 7020 | 9239 |
| 1150 | 0 | 762 | 1524 | 2202 | 2879 | 3692 | 4504 | 5246 | 5988 | 7189 | 9460 |
| 1160 | 0 | 780 | 1561 | 2251 | 2941 | 3771 | 4600 | 5362 | 6124 | 7354 | 9676 |
| 1170 | 0 | 798 | 1596 | 2299 | 3001 | 3848 | 4694 | 5476 | 6258 | 7517 | 9889 |
| 1180 | 0 | 816 | 1631 | 2346 | 3061 | 3923 | 4786 | 5588 | 6390 | 7677 | 10097 |
| 1190 | 0 | 833 | 1666 | 2392 | 3119 | 3997 | 4876 | 5697 | 6519 | 7833 | 10302 |
| 1200 | 0 | 850 | 1700 | 2438 | 3176 | 4070 | 4964 | 5805 | 6646 | 7988 | 10504 |
| 1215 | 0 | 875 | 1750 | 2505 | 3260 | 4177 | 5094 | 5963 | 6832 | 8215 | 10800 |

ATTACHMENT 1 TO
CHART 2-6

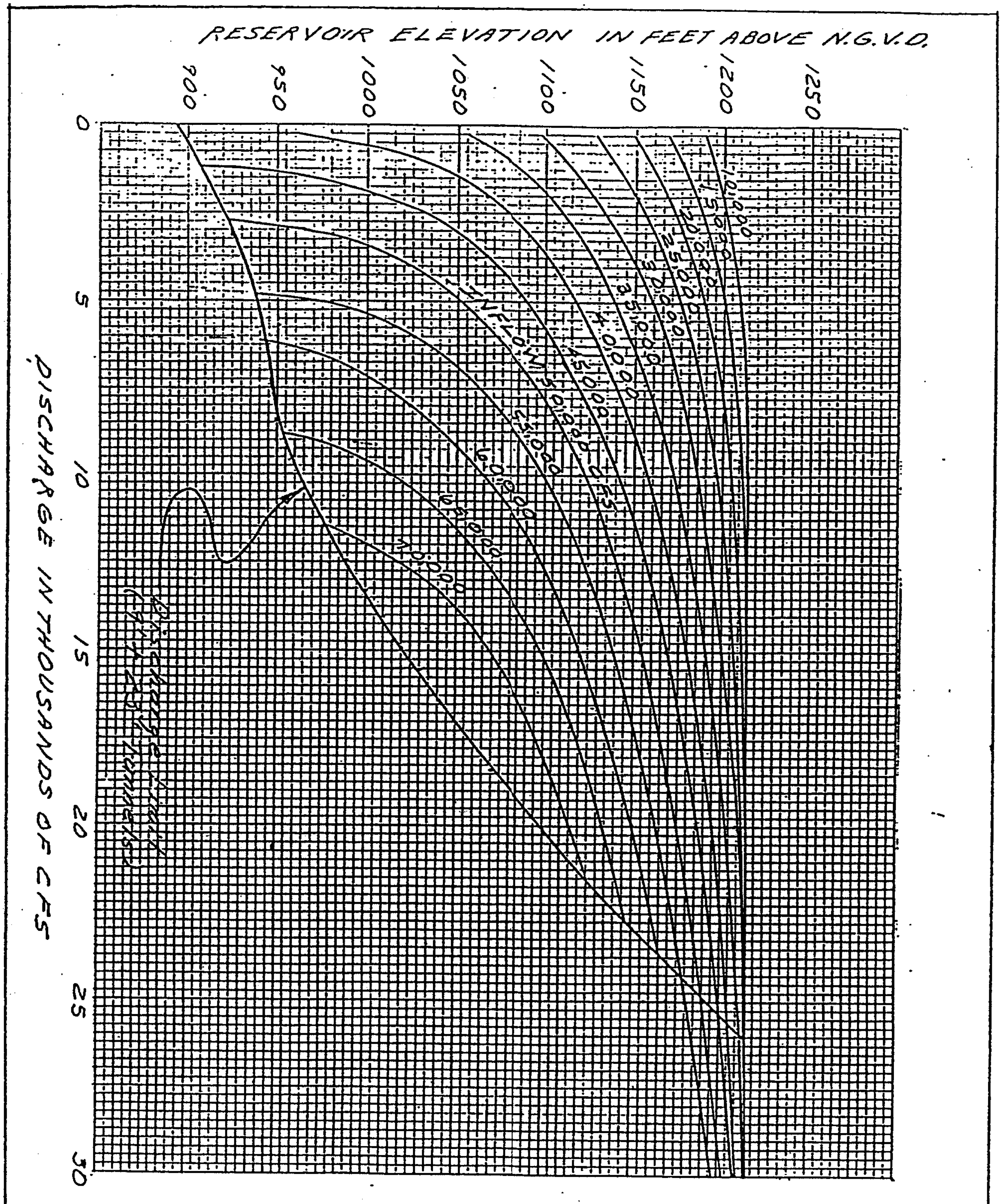
## LOW HEAD RATING CURVE 23 FOOT TUNNEL (GATE R2) MUD MOUNTAIN DAM




1998 Rating table combined the 1995 table with observed measurements (David van Rijn).

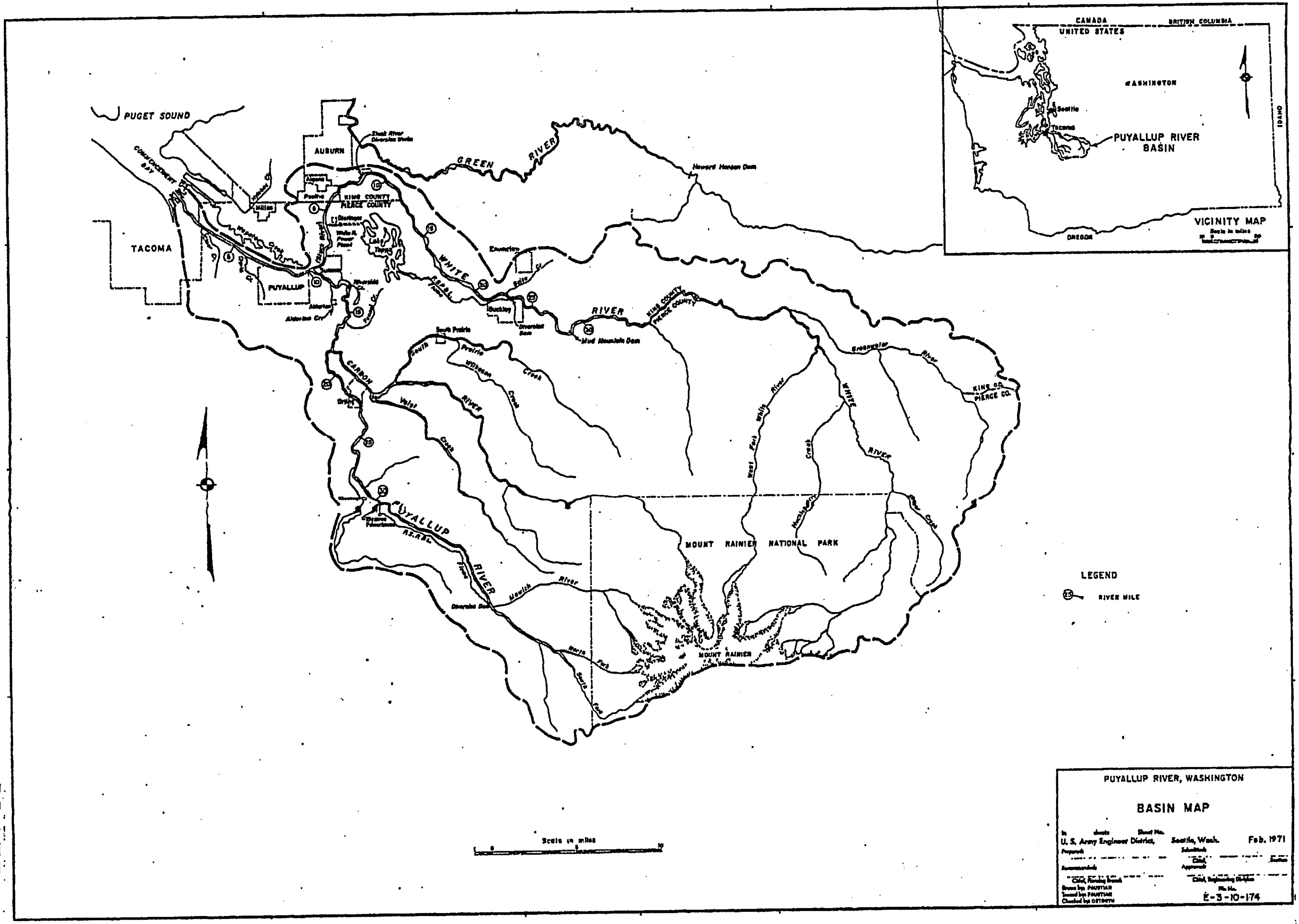
C2-10

CHART 2-7




. **<u>White River Discharge Limits.</u>** **Dam discharge will be increased on the rising side of the flood hydrograph to preserve storage for Lower Puyallup River flood control up to a limit of 339.8 m$^3$/s (12,000 cfs). During floods, discharge will be reduced as necessary to provide flood control on the Lower Puyallup River except during large floods discharge will be increased according to the requirements of the Discharge Regulation Schedule, Chart 7-1, to best utilize remaining reservoir storage.**

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON
MUD MOUNTAIN DAM
DISCHARGE REGULATION SCHEDULE
12 AUG 90



PUGET SOUND
COMMENCEMENT BAY
TACOMA
PUYALLUP
AUBURN
KING COUNTY
PIERCE COUNTY
GREEN RIVER
Howard Hanson Dam
WHITE RIVER
Enumclaw
Buckley
Mud Mountain Dam
Lake Tapps
South Prairie
South Prairie Creek
Wilkeson Creek
CARBON RIVER
Voight Creek
PUYALLUP RIVER
Mowich River
North Fork
South Fork
West Fork White River
Huckleberry Creek
Greenwater River
KING CO.
PIERCE CO.
MOUNT RAINIER NATIONAL PARK
MOUNT RAINIER
LEGEND
RIVER MILE
Scale in miles
CANADA
BRITISH COLUMBIA
UNITED STATES
WASHINGTON
Seattle
Tacoma
PUYALLUP RIVER BASIN
IDAHO
OREGON
VICINITY MAP
PUYALLUP RIVER, WASHINGTON
BASIN MAP
U. S. Army Engineer District, Seattle, Wash.
Feb. 1971
E-3-10-174


P2-1

PLATE 2-1

REDACTED CONTENT

REDACTED CONTENT

P2-4

REDACTED CONTENT

PLATE 2-4
SHEET 1

P2-5

REDACTED CONTENT

PLATE 2-4
SHEET 2

REDACTED CONTENT

P2-7

REDACTED CONTENT

PLATE 2-6

REDACTED CONTENT

REDACTED CONTENT

P2-10

REDACTED CONTENT

PLATE 2-9

P2-11

**REDACTED CONTENT**

PLATE 2-10

P2-12

PLATE 2-11

**REDACTED CONTENT**

PLATE 2-12

REDACTED CONTENT

P3-1

REDACTED CONTENT

PLATE 3-1

REDACTED CONTENT

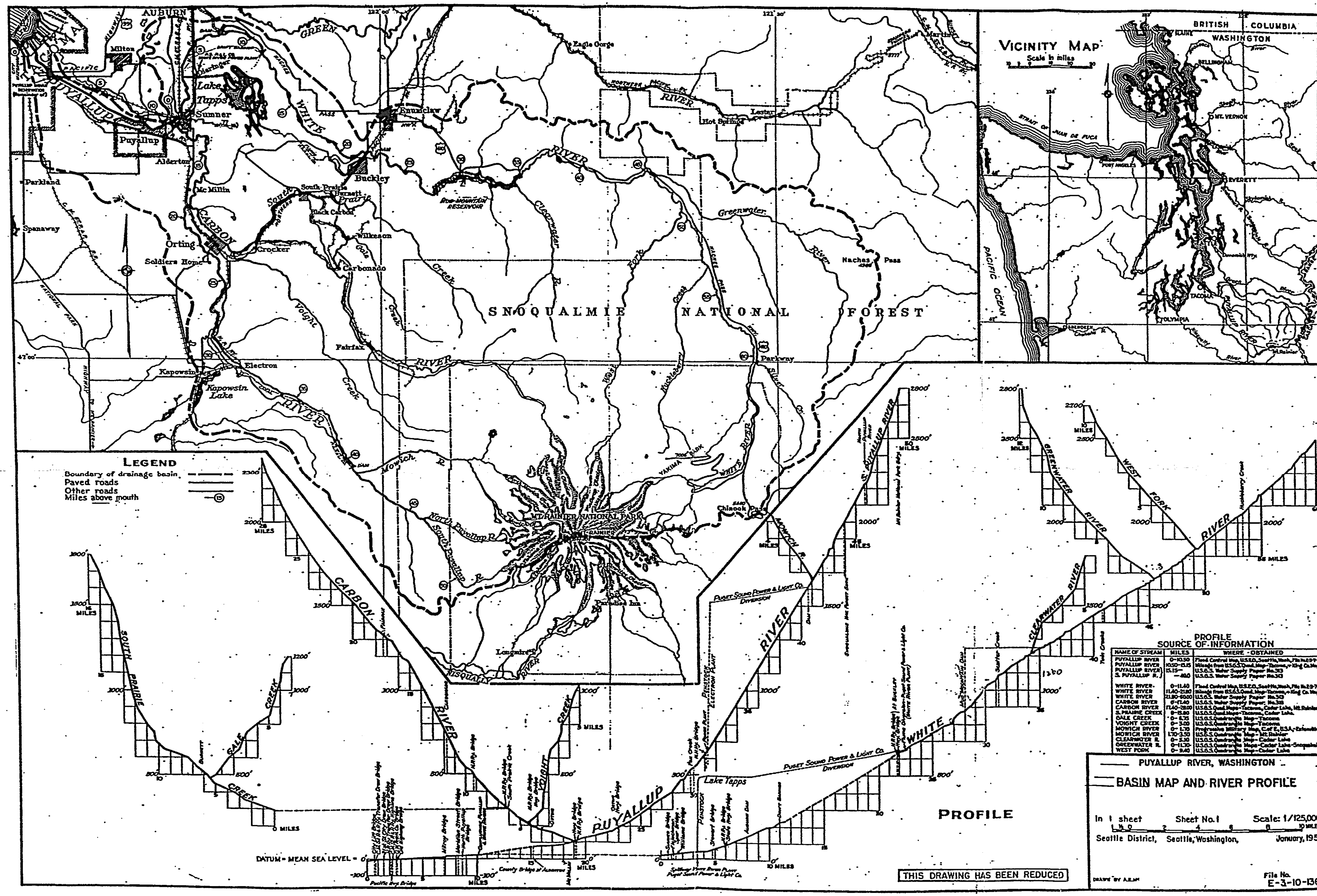
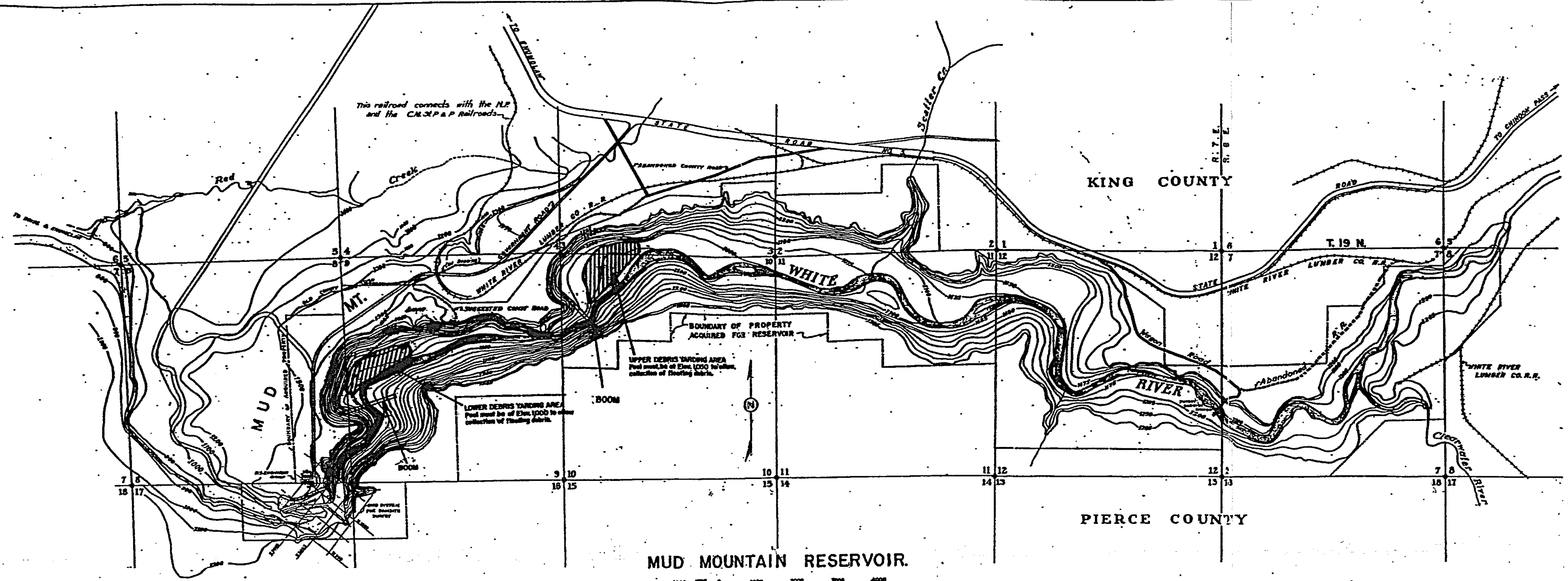

VICINITY MAP
BRITISH COLUMBIA
WASHINGTON
PACIFIC OCEAN
STRAIT OF JUAN DE FUCA
BELLINGHAM
MT. VERNON
EVERETT
TACOMA
OLYMPIA
AUBURN
Milton
Lake Tapps
Sumner
Puyallup
Alderton
Parkland
Spanaway
McMillin
Orting
Soldiers Home
Crocker
South Prairie
Burnett
Black Carbon
Wilkeson
Carbonado
Enumclaw
Buckley
Fairfax
Electron
Kapowsin
Kapowsin Lake
Eagle Gorge
Lester
Hot Springs
Greenwater
Naches Pass
Parkway
Chinook Pass
Paradise Inn
Longmire
MT. RAINIER NATIONAL PARK
SNOQUALMIE NATIONAL FOREST
PUYALLUP
CARBON
WHITE RIVER
GREEN RIVER
Clearwater R.
West Fork
Greenwater River
Mowich R.
North Puyallup R.
South Puyallup R.
NISQUALLY RIVER
MUD MOUNTAIN RESERVOIR
LEGEND
Boundary of drainage basin
Paved roads
Other roads
Miles above mouth
PROFILE
DATUM = MEAN SEA LEVEL = 0'
THIS DRAWING HAS BEEN REDUCED
PROFILE
SOURCE OF INFORMATION
NAME OF STREAM | MILES | WHERE - OBTAINED
PUYALLUP RIVER | 0-10.50 | Flood Control Map, U.S.E.D., Seattle, Wash., File No. E-3-7-18
PUYALLUP RIVER | 10.50-15.15 | Mileage from U.S.G.S. Quad. Map-Tacoma, & King Co. Map.
PUYALLUP RIVER | 15.15- | U.S.G.S. Water Supply Paper No. 313
S. PUYALLUP R. | -40.0 | U.S.G.S. Water Supply Paper No. 313
WHITE RIVER | 0-11.40 | Flood Control Map, U.S.E.D., Seattle, Wash., File No. E-3-7-18
WHITE RIVER | 11.40-21.80 | Mileage from U.S.G.S. Quad. Map-Tacoma, & King Co. Map
WHITE RIVER | 21.80-60.00 | U.S.G.S. Water Supply Paper No. 313
CARBON RIVER | 0-17.40 | U.S.G.S. Water Supply Paper No. 313
CARBON RIVER | 17.40-28.00 | U.S.G.S. Quad. Maps-Tacoma, Cedar Lake, Mt. Rainier
S. PRAIRIE CREEK | 0-15.80 | U.S.G.S. Quad. Maps-Tacoma, Cedar Lake.
GALE CREEK | 0-6.75 | U.S.G.S. Quadrangle Map-Tacoma
VOIGHT CREEK | 0-5.00 | U.S.G.S. Quadrangle Map-Tacoma
MOWICH RIVER | 0-1.70 | Progressive Military Map, C. of E., U.S.A.-Enumclaw
MOWICH RIVER | 1.70-3.50 | U.S.G.S. Quadrangle Map-Mt. Rainier
CLEARWATER R. | 0-5.10 | U.S.G.S. Quadrangle Map-Cedar Lake
GREENWATER R. | 0-11.70 | U.S.G.S. Quadrangle Maps-Cedar Lake-Snoqualmie
WEST FORK | 0-9.40 | U.S.G.S. Quadrangle Map-Cedar Lake
PUYALLUP RIVER, WASHINGTON
BASIN MAP AND RIVER PROFILE
In 1 sheet
Sheet No. 1
Scale: 1/125,000
Seattle District, Seattle, Washington,
January, 1954
File No.
E-3-10-136

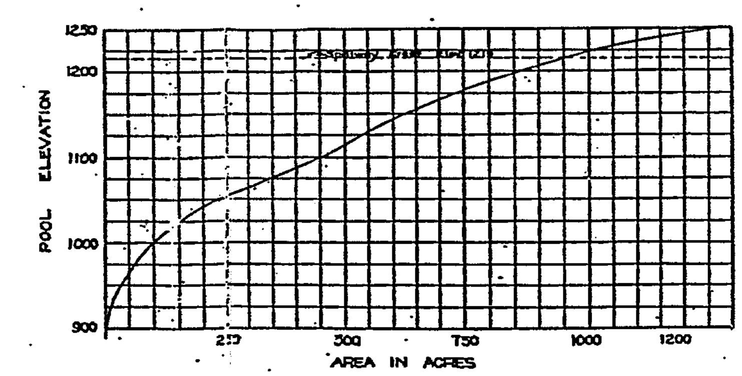


PLATE 4-1

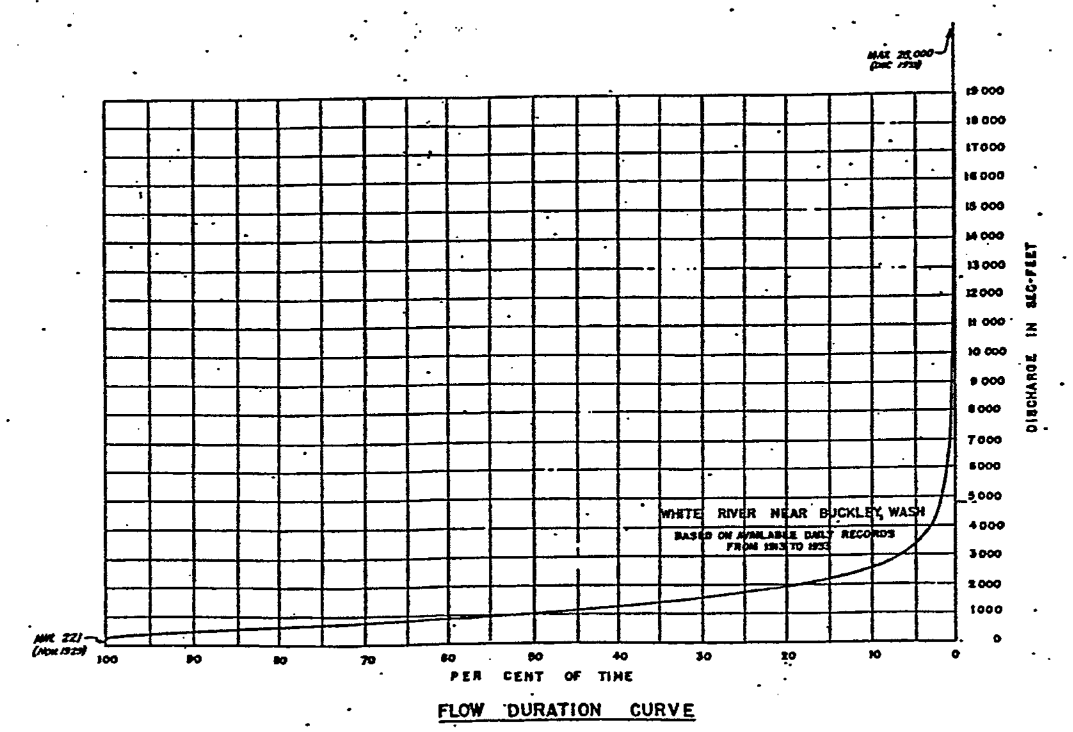



## MUD MOUNTAIN RESERVOIR.

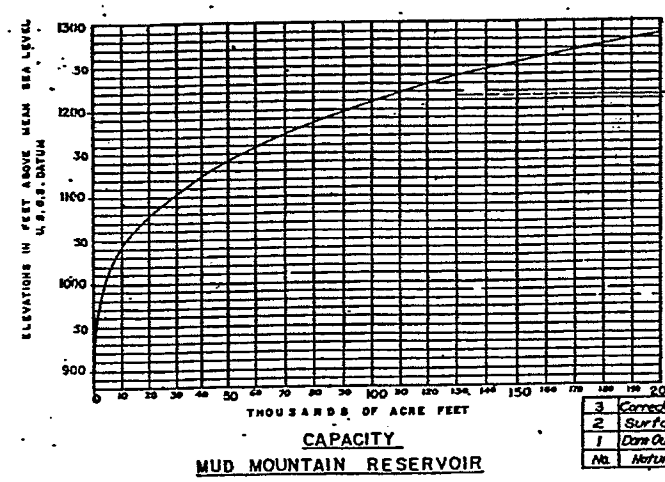
Scale in feet
Contour interval 25 feet
Elevations refer to Mean Sea Level
(U.S.G.S. Datum)




SURFACE AREA
MUD MOUNTAIN RESERVOIR




FLOW DURATION CURVE




CAPACITY
MUD MOUNTAIN RESERVOIR

PUYALLUP RIVER FLOOD CONTROL PROJECT

MUD MOUNTAIN DAM

WHITE RIVER, WASHINGTON.

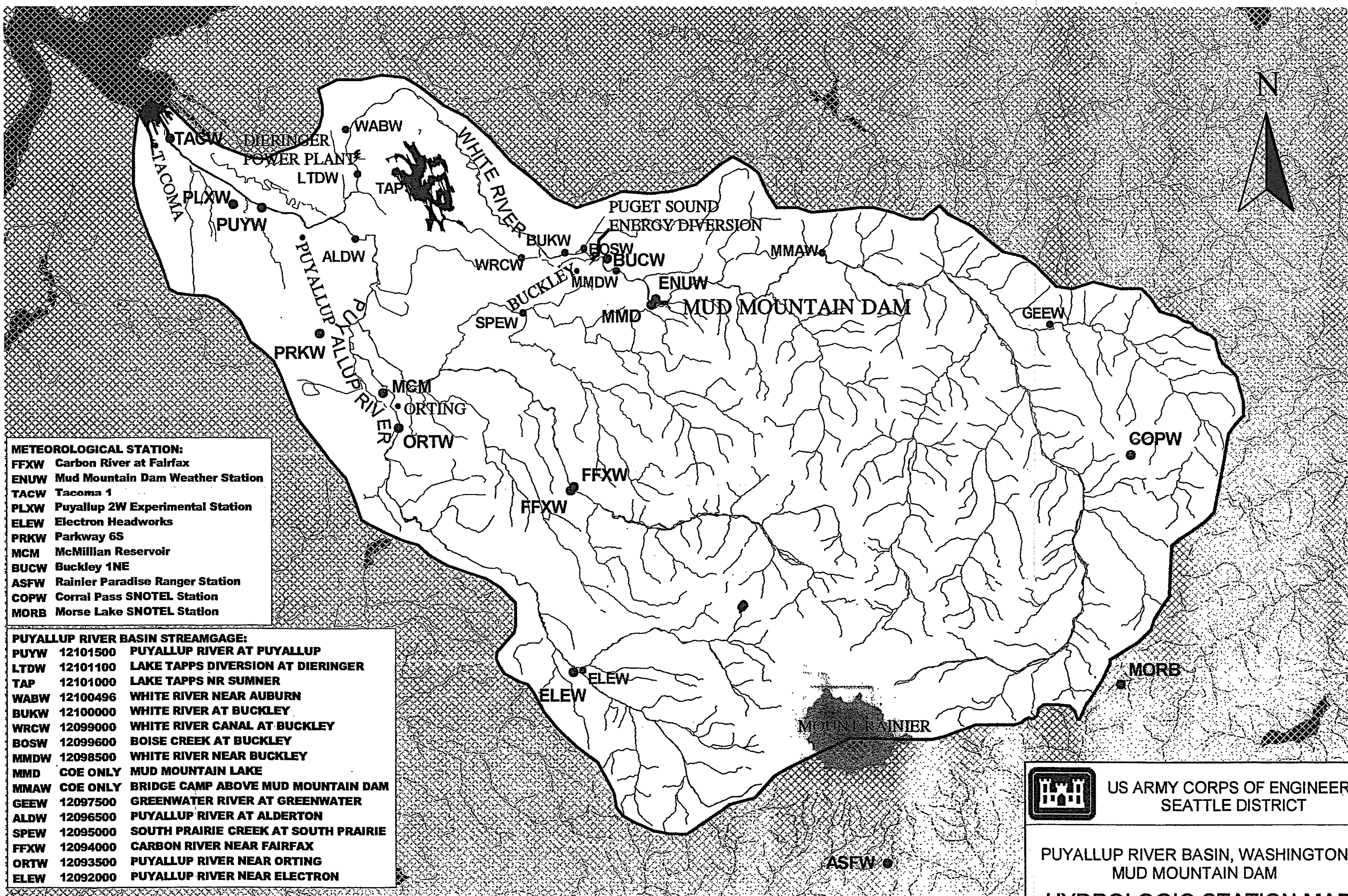
RESERVOIR CONTOUR MAP

| No. | Nature of Revision | By | App. | Date |
|---|---|---|---|---|
| 3 | Corrected Capacity & Area Curve | | | |
| 2 | Surface Area Curve | C.L.C. | | |
| 1 | Dam Outline & Spillway Berm | J.W.G. | | |

U.S. ENGINEER OFFICE
NORTH PACIFIC DIVISION
PORTLAND, OREGON.
JULY 1, 1939.



PLATE 4-2




**METEOROLOGICAL STATION:**

| | |
|---|---|
| FFXW | Carbon River at Fairfax |
| ENUW | Mud Mountain Dam Weather Station |
| TACW | Tacoma 1 |
| PLXW | Puyallup 2W Experimental Station |
| ELEW | Electron Headworks |
| PRKW | Parkway 6S |
| MCM | McMillian Reservoir |
| BUCW | Buckley 1NE |
| ASFW | Rainier Paradise Ranger Station |
| COPW | Corral Pass SNOTEL Station |
| MORB | Morse Lake SNOTEL Station |

**PUYALLUP RIVER BASIN STREAMGAGE:**

| | | |
|---|---|---|
| PUYW | 12101500 | PUYALLUP RIVER AT PUYALLUP |
| LTDW | 12101100 | LAKE TAPPS DIVERSION AT DIERINGER |
| TAP | 12101000 | LAKE TAPPS NR SUMNER |
| WABW | 12100496 | WHITE RIVER NEAR AUBURN |
| BUKW | 12100000 | WHITE RIVER AT BUCKLEY |
| WRCW | 12099000 | WHITE RIVER CANAL AT BUCKLEY |
| BOSW | 12099600 | BOISE CREEK AT BUCKLEY |
| MMDW | 12098500 | WHITE RIVER NEAR BUCKLEY |
| MMD | COE ONLY | MUD MOUNTAIN LAKE |
| MMAW | COE ONLY | BRIDGE CAMP ABOVE MUD MOUNTAIN DAM |
| GEEW | 12097500 | GREENWATER RIVER AT GREENWATER |
| ALDW | 12096500 | PUYALLUP RIVER AT ALDERTON |
| SPEW | 12095000 | SOUTH PRAIRIE CREEK AT SOUTH PRAIRIE |
| FFXW | 12094000 | CARBON RIVER NEAR FAIRFAX |
| ORTW | 12093500 | PUYALLUP RIVER NEAR ORTING |
| ELEW | 12092000 | PUYALLUP RIVER NEAR ELECTRON |

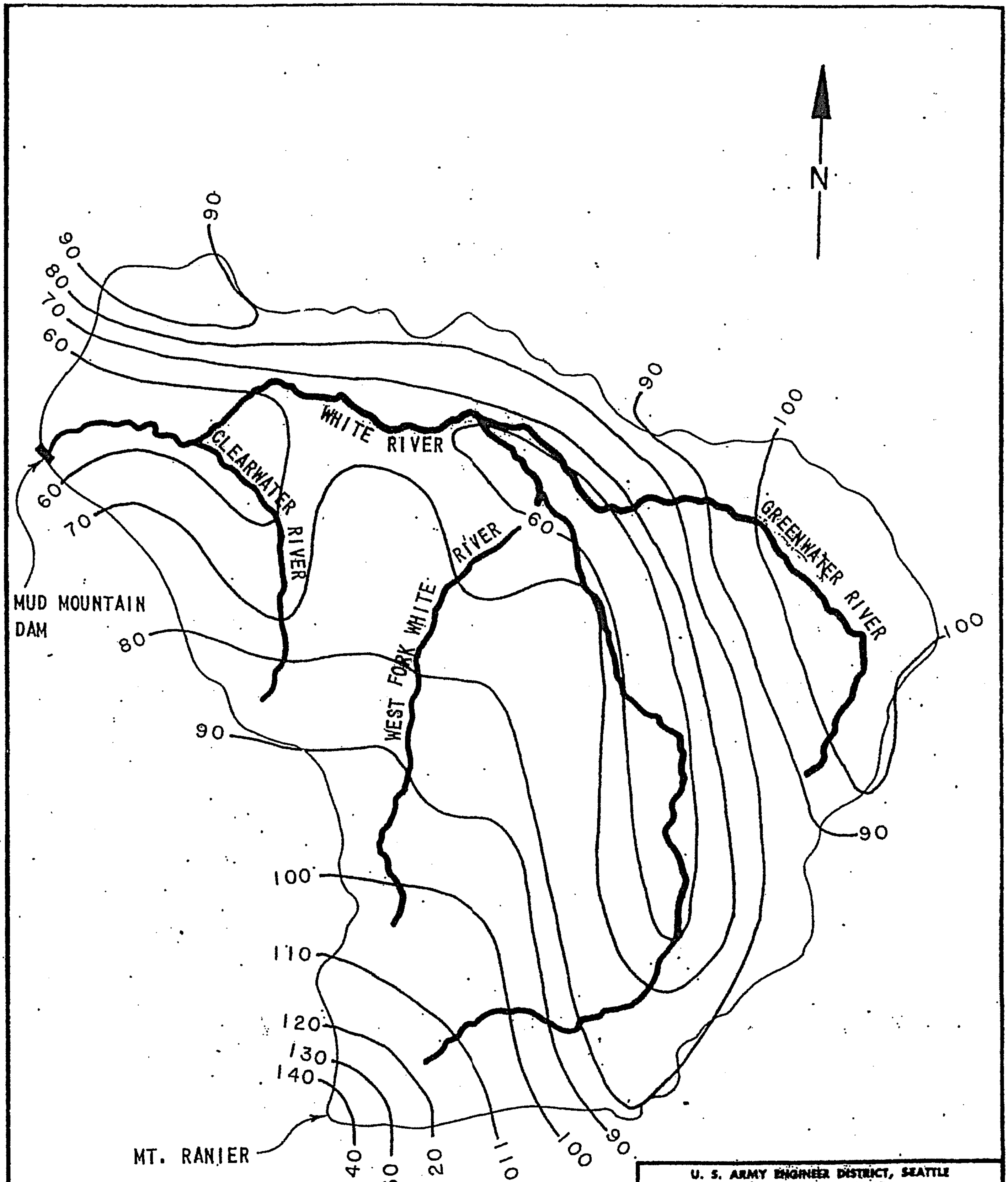
US ARMY CORPS OF ENGINEERS
SEATTLE DISTRICT

PUYALLUP RIVER BASIN, WASHINGTON
MUD MOUNTAIN DAM

## HYDROLOGIC STATION MAP

Drawn by: Kate Steff
Approved by: Larry Merkle

Date: 13 January 2003
PLATE 4-3

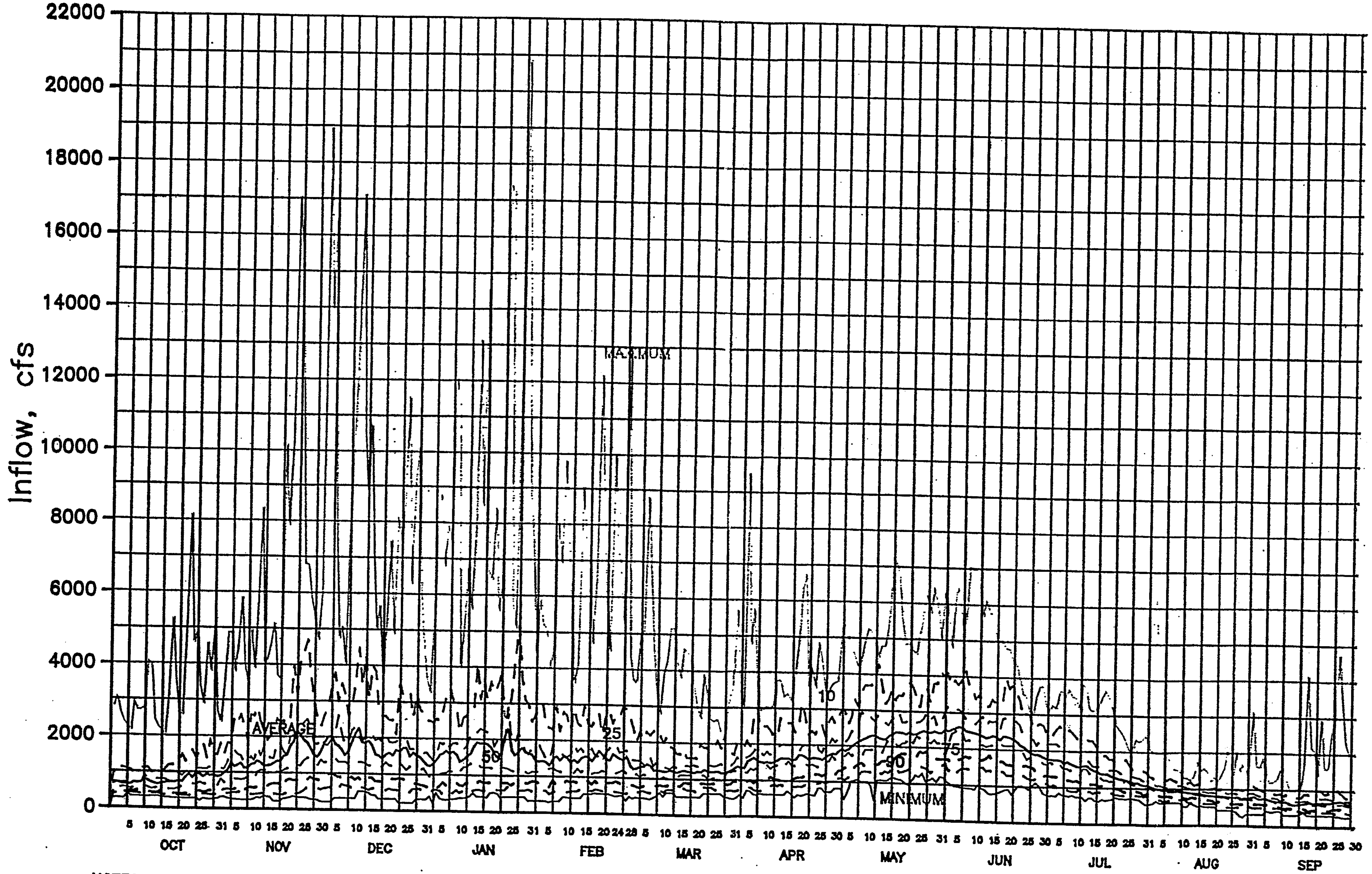



U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

DRAINAGE BASIN
NORMAL ANNUAL PRECIPITATION
(INCHES)

WHITE RIVER MUD MOUNTAIN DAM WASHINGTON

| SIZE | INVITATION NO. | FILE NO. | DATE | PLATE |
|---|---|---|---|---|
| A | | | 85 MAR | |
| DSGN. JANGAARD | CHK. MERKLE | | SHEET | |

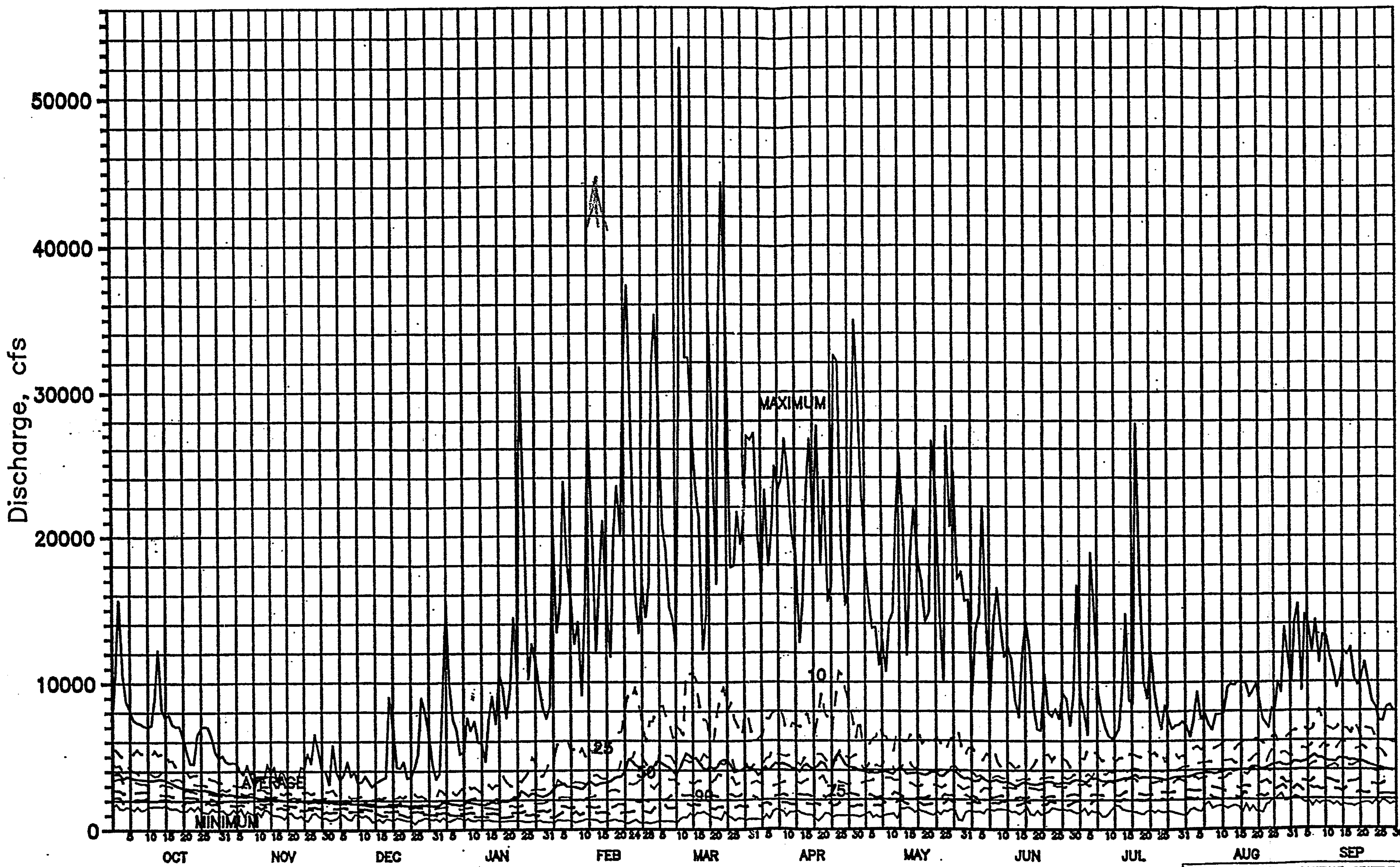



NOTES:
1. All inflows are observed 0800 daily inflows.
2. Period of record was 50 years 1944 through 1993.
3. Inflow represents a drainage area of 402 square miles.

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

WHITE RIVER, WASHINGTON
MUD MOUNTAIN DAM RESERVOIR
SUMMARY HYDROGRAPH

| Developed | Checked | Date |
|---|---|---|
| K.SCATTARELLA | G.SINGLETON | 5 JANUARY 95 |

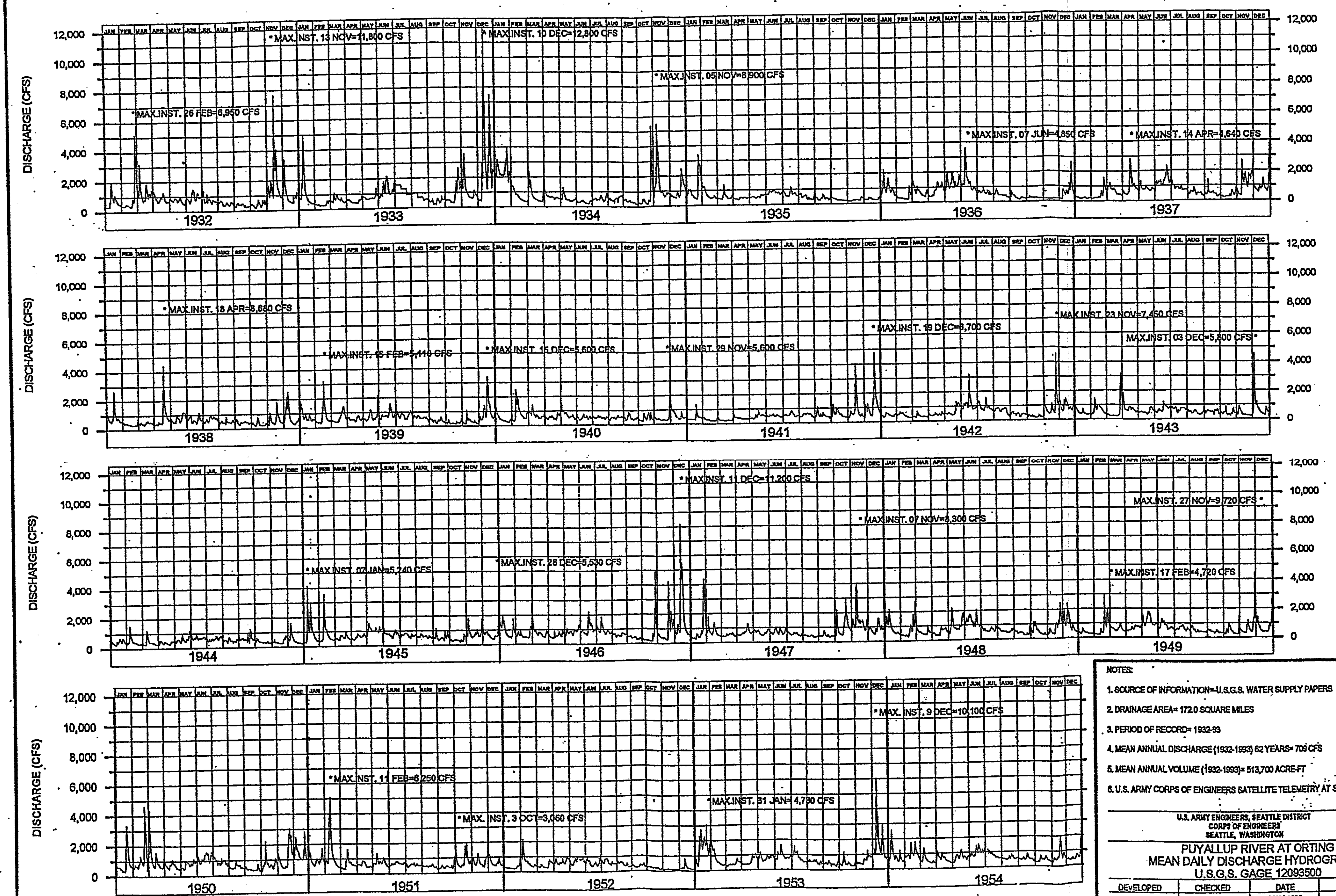



NOTES: 1. All discharge values are mean daily discharges in cfs.
2. Period of record was 79 years, 1915 through 1993.
3. Discharges represent a drainage area of 948 square miles.

U.S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

PUYALLUP, WASHINGTON
PUYALLUP RIVER
SUMMARY HYDROGRAPH

| Developed | Checked | Date |
|---|---|---|
| K.SCATTARELLA | G.SINGLETON | 6 JANUARY 95 |



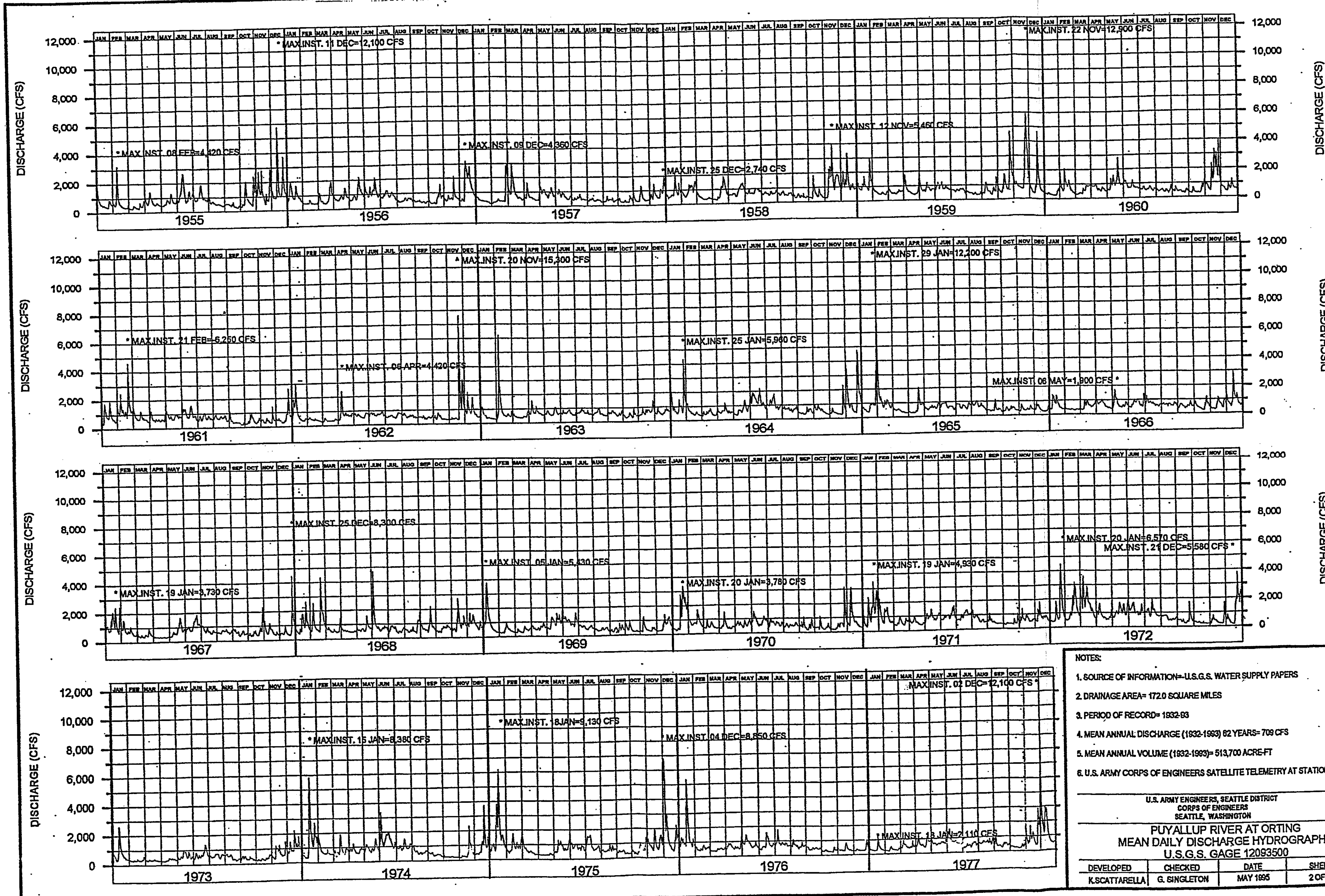

NOTES:

1. SOURCE OF INFORMATION=U.S.G.S. WATER SUPPLY PAPERS
2. DRAINAGE AREA= 172.0 SQUARE MILES
3. PERIOD OF RECORD= 1932-93
4. MEAN ANNUAL DISCHARGE (1932-1993) 62 YEARS= 709 CFS
5. MEAN ANNUAL VOLUME (1932-1993)= 513,700 ACRE-FT
6. U.S. ARMY CORPS OF ENGINEERS SATELLITE TELEMETRY AT STATION.

U.S. ARMY ENGINEERS, SEATTLE DISTRICT
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

PUYALLUP RIVER AT ORTING
MEAN DAILY DISCHARGE HYDROGRAPHS
U.S.G.S. GAGE 12093500

| DEVELOPED | CHECKED | DATE | SHEET |
|---|---|---|---|
| K.SCATTARELLA | G. SINGLETON | MAY 1995 | 1 OF 3 |




NOTES:

1. SOURCE OF INFORMATION=U.S.G.S. WATER SUPPLY PAPERS
2. DRAINAGE AREA= 172.0 SQUARE MILES
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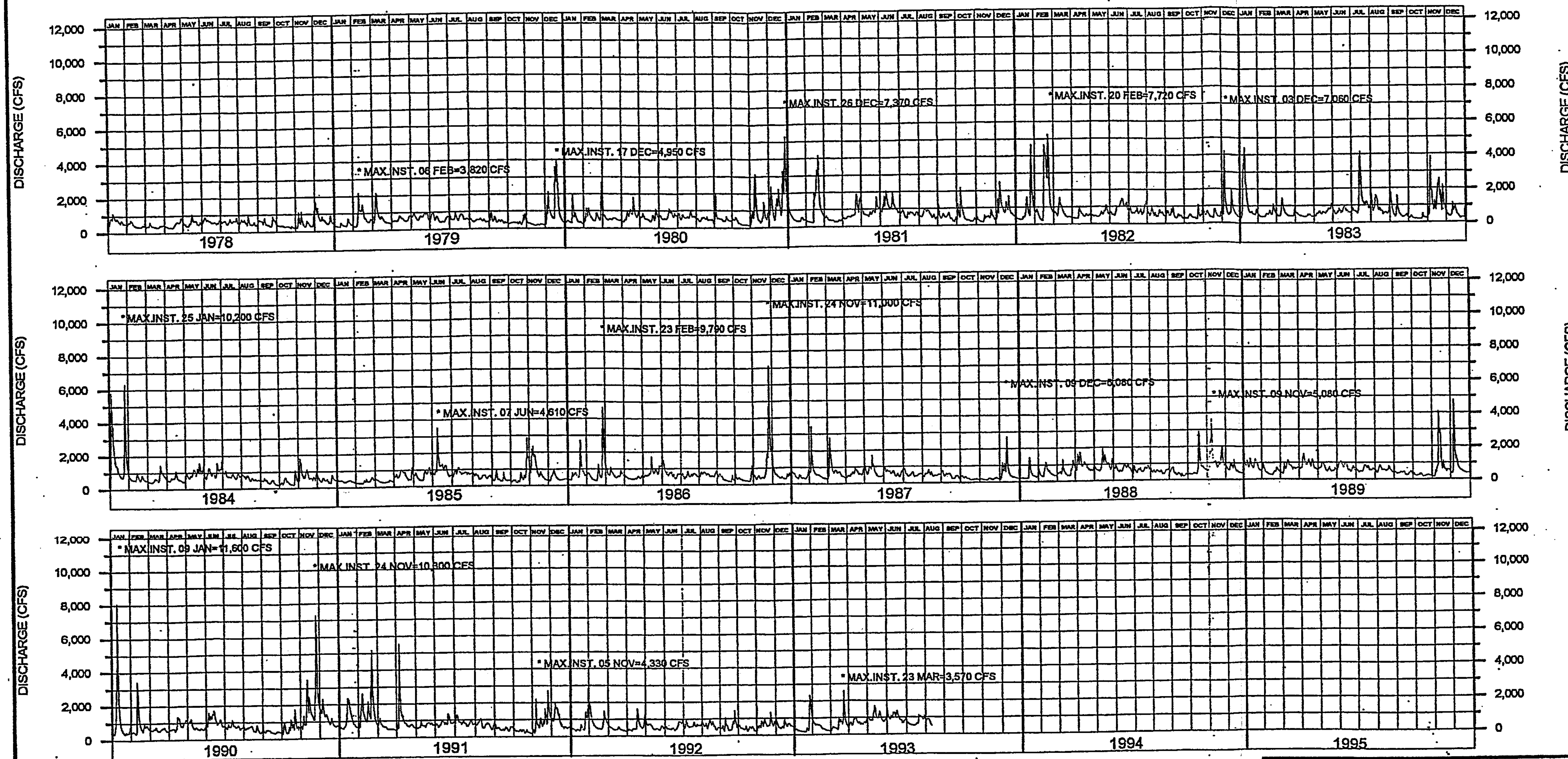
U.S. ARMY ENGINEERS, SEATTLE DISTRICT
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

PUYALLUP RIVER AT ORTING
MEAN DAILY DISCHARGE HYDROGRAPHS
U.S.G.S. GAGE 12093500

| DEVELOPED | CHECKED | DATE | SHEET |
|---|---|---|---|
| K.SCATTARELLA | G. SINGLETON | MAY 1995 | 2 OF 3 |



PLATE 4-7



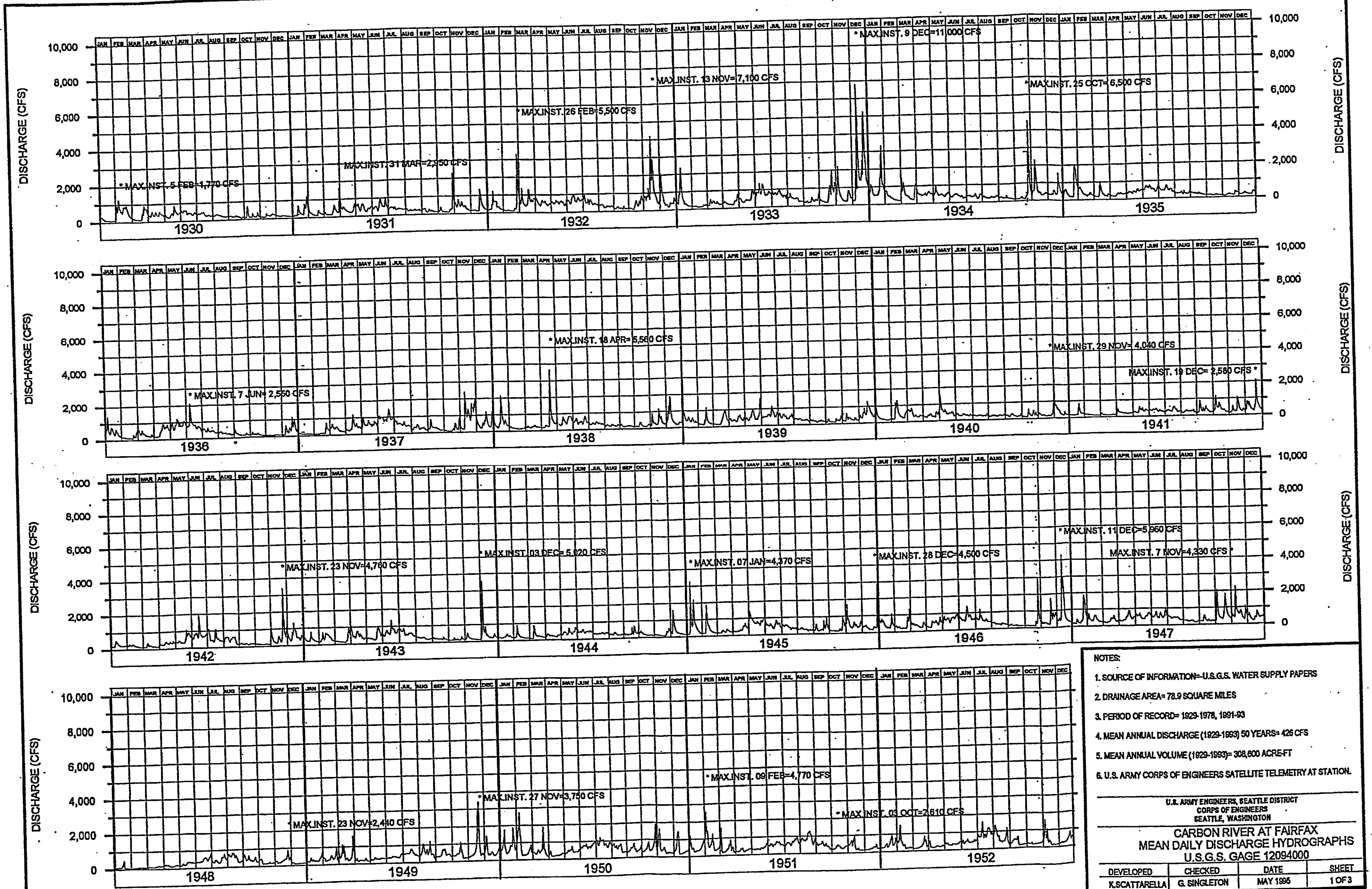

NOTES:

1. SOURCE OF INFORMATION=U.S.G.S. WATER SUPPLY PAPERS
2. DRAINAGE AREA= 172.0 SQUARE MILES
3. PERIOD OF RECORD= 1932-93
4. MEAN ANNUAL DISCHARGE (1932-1993) 62 YEARS= 709 CFS
5. MEAN ANNUAL VOLUME (1932-1993)= 513,700 ACRE-FT
6. U.S. ARMY CORPS OF ENGINEERS SATELLITE TELEMETRY AT STATION.

U.S. ARMY ENGINEERS, SEATTLE DISTRICT
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

PUYALLUP RIVER AT ORTING
MEAN DAILY DISCHARGE HYDROGRAPHS
U.S.G.S. GAGE 12093500

| DEVELOPED | CHECKED | DATE | SHEET |
|---|---|---|---|
| K.SCATTARELLA | G. SINGLETON | MAY 1995 | 3 OF 3 |



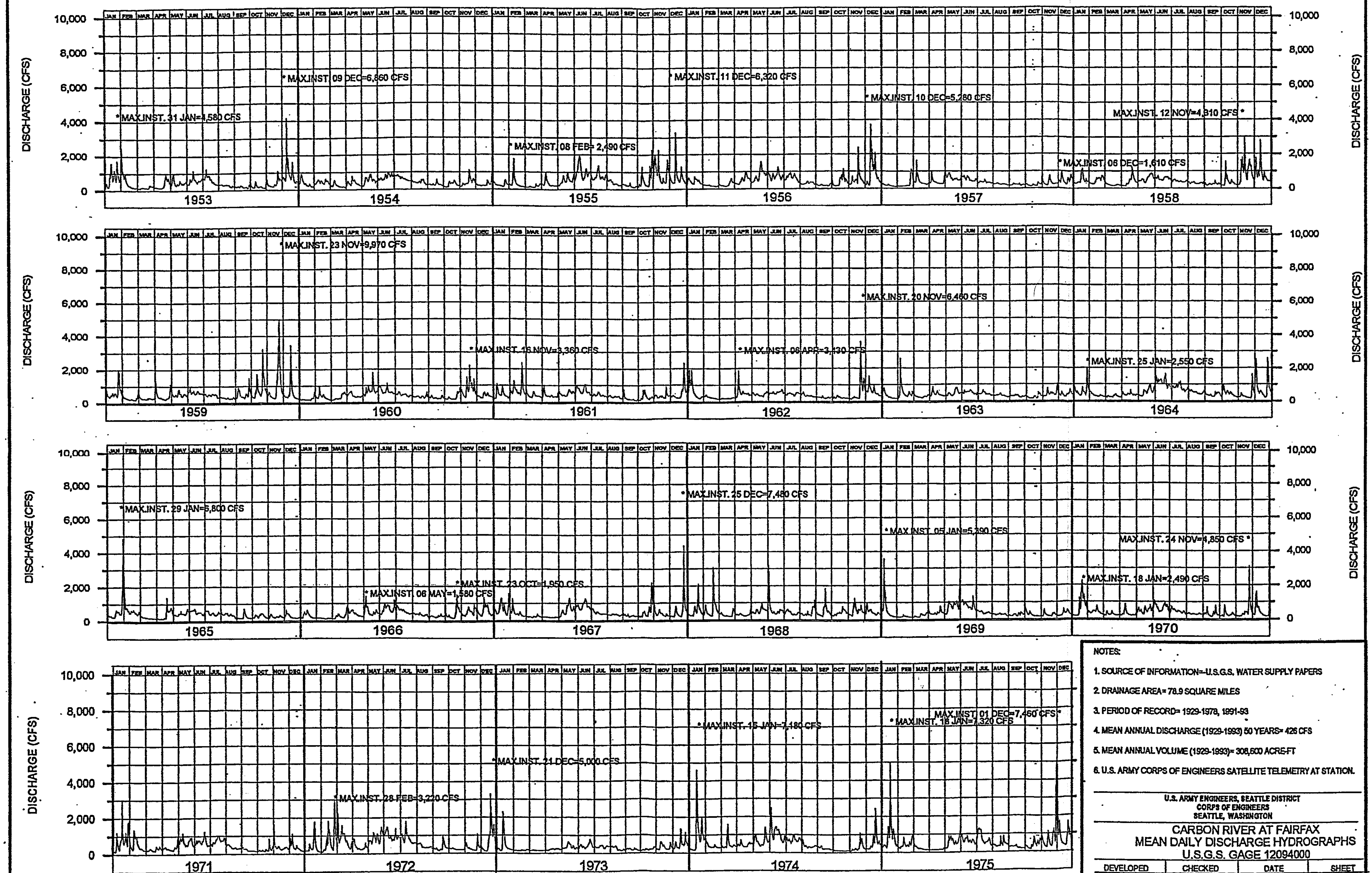

NOTES:

1. SOURCE OF INFORMATION=-U.S.G.S. WATER SUPPLY PAPERS
2. DRAINAGE AREA= 78.9 SQUARE MILES
3. PERIOD OF RECORD= 1929-1978, 1991-93
4. MEAN ANNUAL DISCHARGE (1929-1993) 50 YEARS= 426 CFS
5. MEAN ANNUAL VOLUME (1929-1993)= 308,600 ACRE-FT
6. U.S. ARMY CORPS OF ENGINEERS SATELLITE TELEMETRY AT STATION.

U.S. ARMY ENGINEERS, SEATTLE DISTRICT
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

CARBON RIVER AT FAIRFAX
MEAN DAILY DISCHARGE HYDROGRAPHS
U.S.G.S. GAGE 12094000

| DEVELOPED | CHECKED | DATE | SHEET |
|---|---|---|---|
| K.SCATTARELLA | G. SINGLETON | MAY 1995 | 1 OF 3 |




NOTES:

1. SOURCE OF INFORMATION--U.S.G.S. WATER SUPPLY PAPERS
2. DRAINAGE AREA= 78.9 SQUARE MILES
3. PERIOD OF RECORD= 1929-1978, 1991-93
4. MEAN ANNUAL DISCHARGE (1929-1993) 50 YEARS= 426 CFS
5. MEAN ANNUAL VOLUME (1929-1993)= 308,600 ACRE-FT
6. U.S. ARMY CORPS OF ENGINEERS SATELLITE TELEMETRY AT STATION.

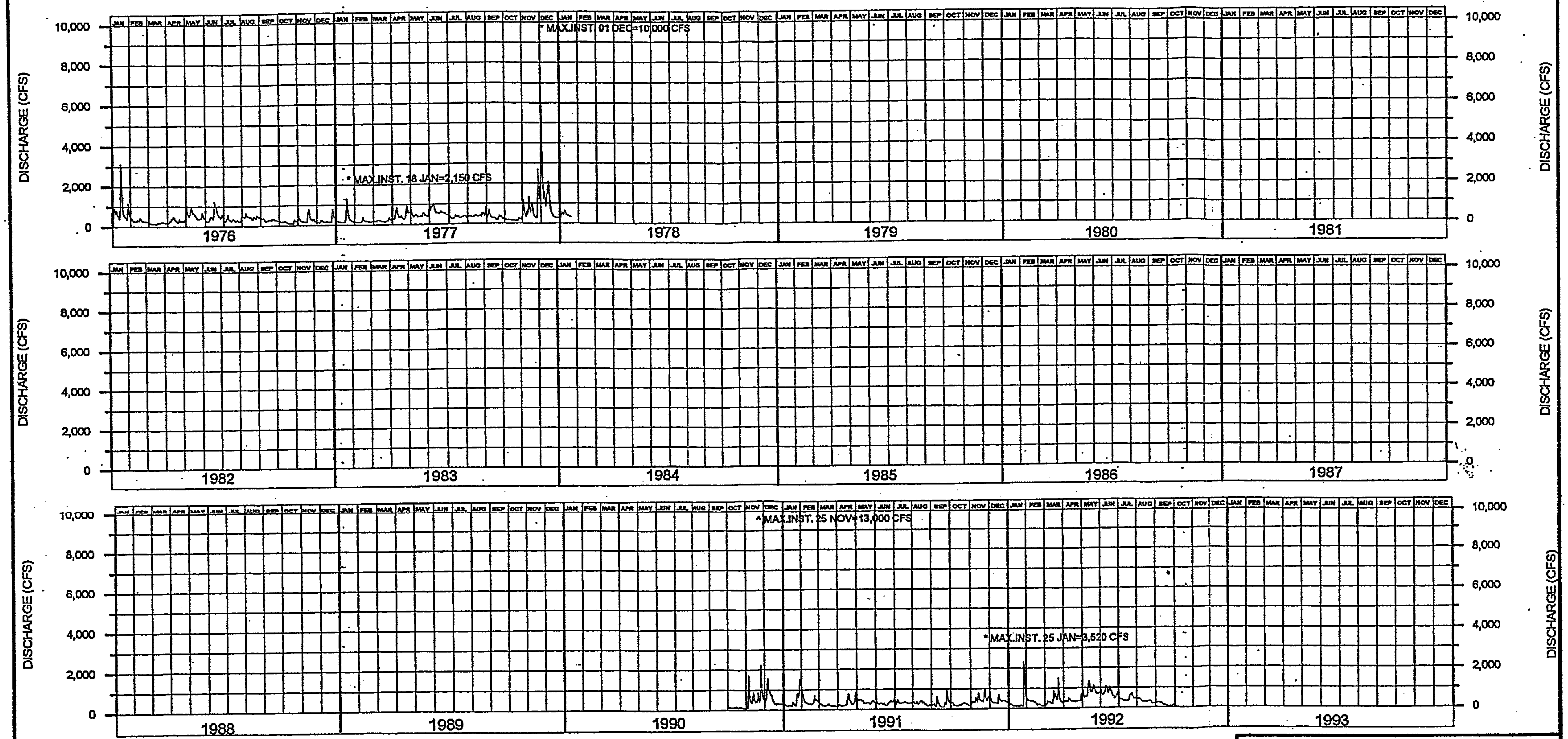
U.S. ARMY ENGINEERS, SEATTLE DISTRICT
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

CARBON RIVER AT FAIRFAX
MEAN DAILY DISCHARGE HYDROGRAPHS
U.S.G.S. GAGE 12094000

| DEVELOPED | CHECKED | DATE | SHEET |
|---|---|---|---|
| K.SCATTARELLA | G. SINGLETON | MAY 1995 | 2 OF 3 |



PLATE 4-8



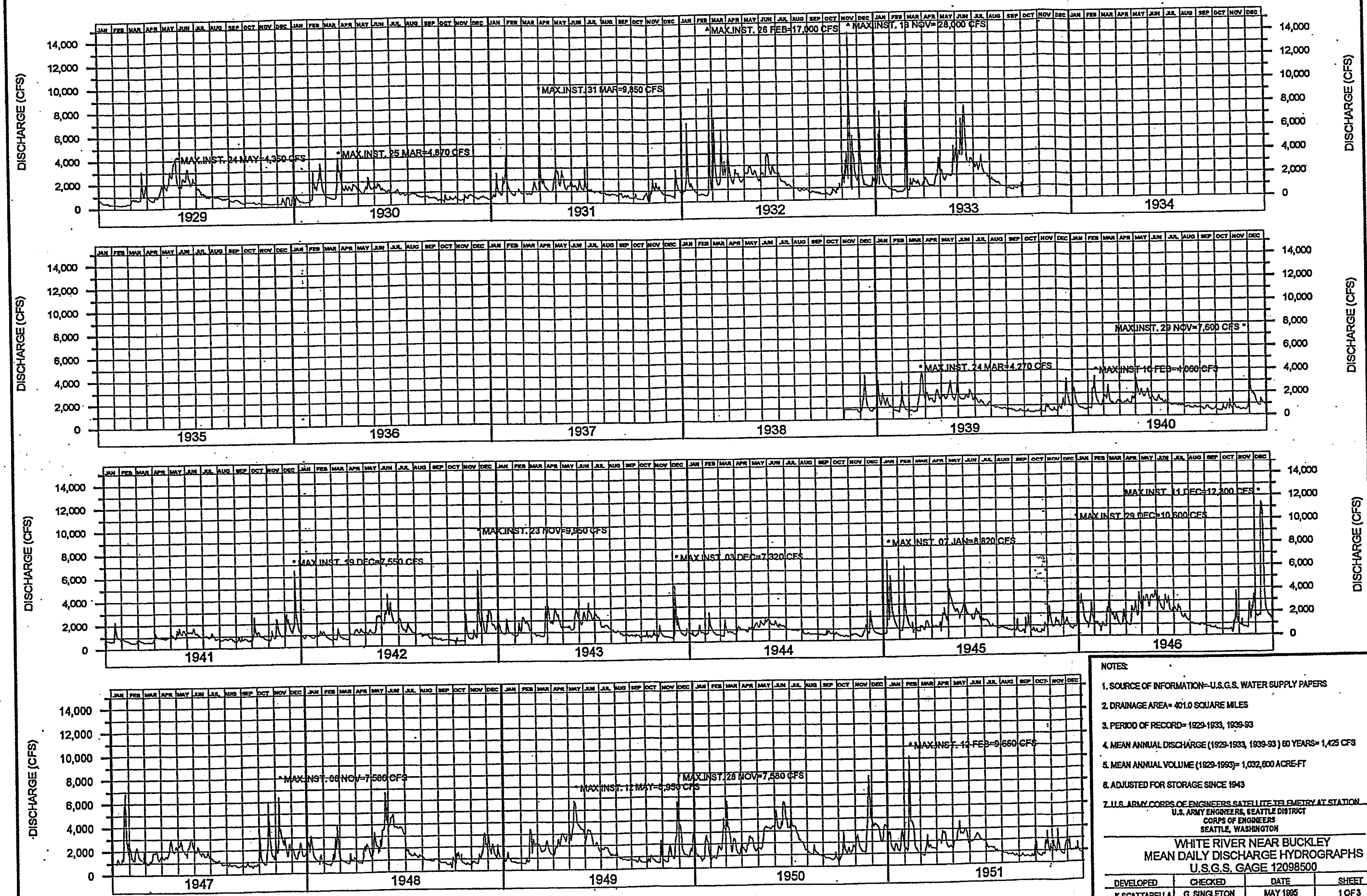

NOTES:

1. SOURCE OF INFORMATION=U.S.G.S. WATER SUPPLY PAPERS
2. DRAINAGE AREA= 78.9 SQUARE MILES
3. PERIOD OF RECORD= 1929-1978, 1991-93
4. MEAN ANNUAL DISCHARGE (1929-1993) 50 YEARS= 426 CFS
5. MEAN ANNUAL VOLUME (1929-1993)= 308,600 ACRE-FT
6. U.S. ARMY CORPS OF ENGINEERS SATELLITE TELEMETRY AT STATION.

U.S. ARMY ENGINEERS, SEATTLE DISTRICT
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

CARBON RIVER AT FAIRFAX
MEAN DAILY DISCHARGE HYDROGRAPHS
U.S.G.S. GAGE 12094000

| DEVELOPED | CHECKED | DATE | SHEET |
|---|---|---|---|
| K.SCATTARELLA | G. SINGLETON | MAY 1995 | 3 OF 3 |




NOTES:

1. SOURCE OF INFORMATION=U.S.G.S. WATER SUPPLY PAPERS

2. DRAINAGE AREA= 401.0 SQUARE MILES

3. PERIOD OF RECORD= 1929-1933, 1939-93

4. MEAN ANNUAL DISCHARGE (1929-1933, 1939-93) 60 YEARS= 1,425 CFS

5. MEAN ANNUAL VOLUME (1929-1993)= 1,032,600 ACRE-FT

6. ADJUSTED FOR STORAGE SINCE 1943

7. U.S. ARMY CORPS OF ENGINEERS SATELLITE TELEMETRY AT STATION

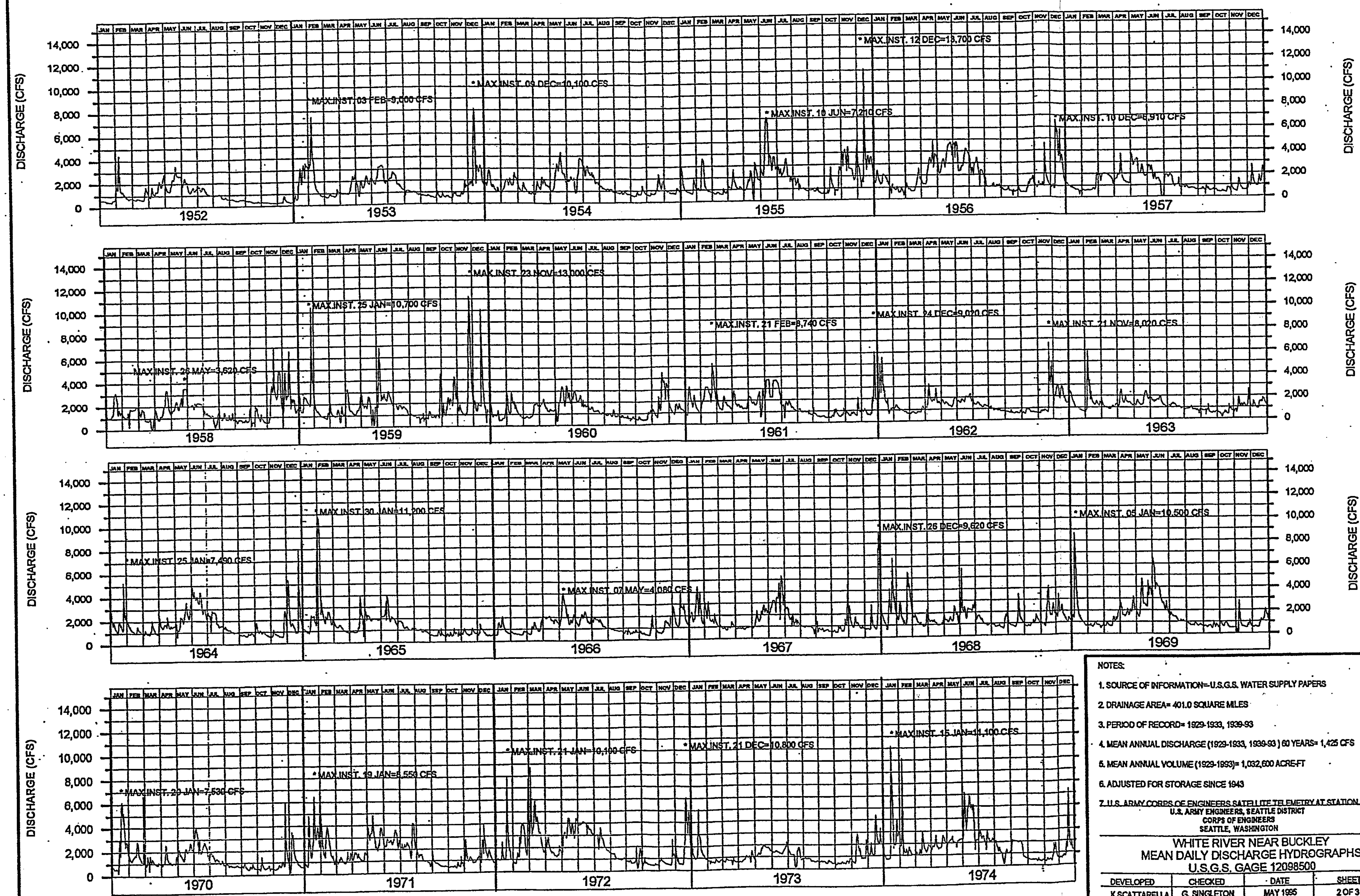
U.S. ARMY ENGINEERS, SEATTLE DISTRICT
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

WHITE RIVER NEAR BUCKLEY
MEAN DAILY DISCHARGE HYDROGRAPHS
U.S.G.S. GAGE 12098500

| DEVELOPED | CHECKED | DATE | SHEET |
|---|---|---|---|
| K.SCATTARELLA | G. SINGLETON | MAY 1995 | 1 OF 3 |



PLATE 4-9




NOTES:

1. SOURCE OF INFORMATION=-U.S.G.S. WATER SUPPLY PAPERS

2. DRAINAGE AREA= 401.0 SQUARE MILES

3. PERIOD OF RECORD= 1929-1933, 1939-93

4. MEAN ANNUAL DISCHARGE (1929-1933, 1939-93 ) 60 YEARS= 1,425 CFS

5. MEAN ANNUAL VOLUME (1929-1993)= 1,032,600 ACRE-FT

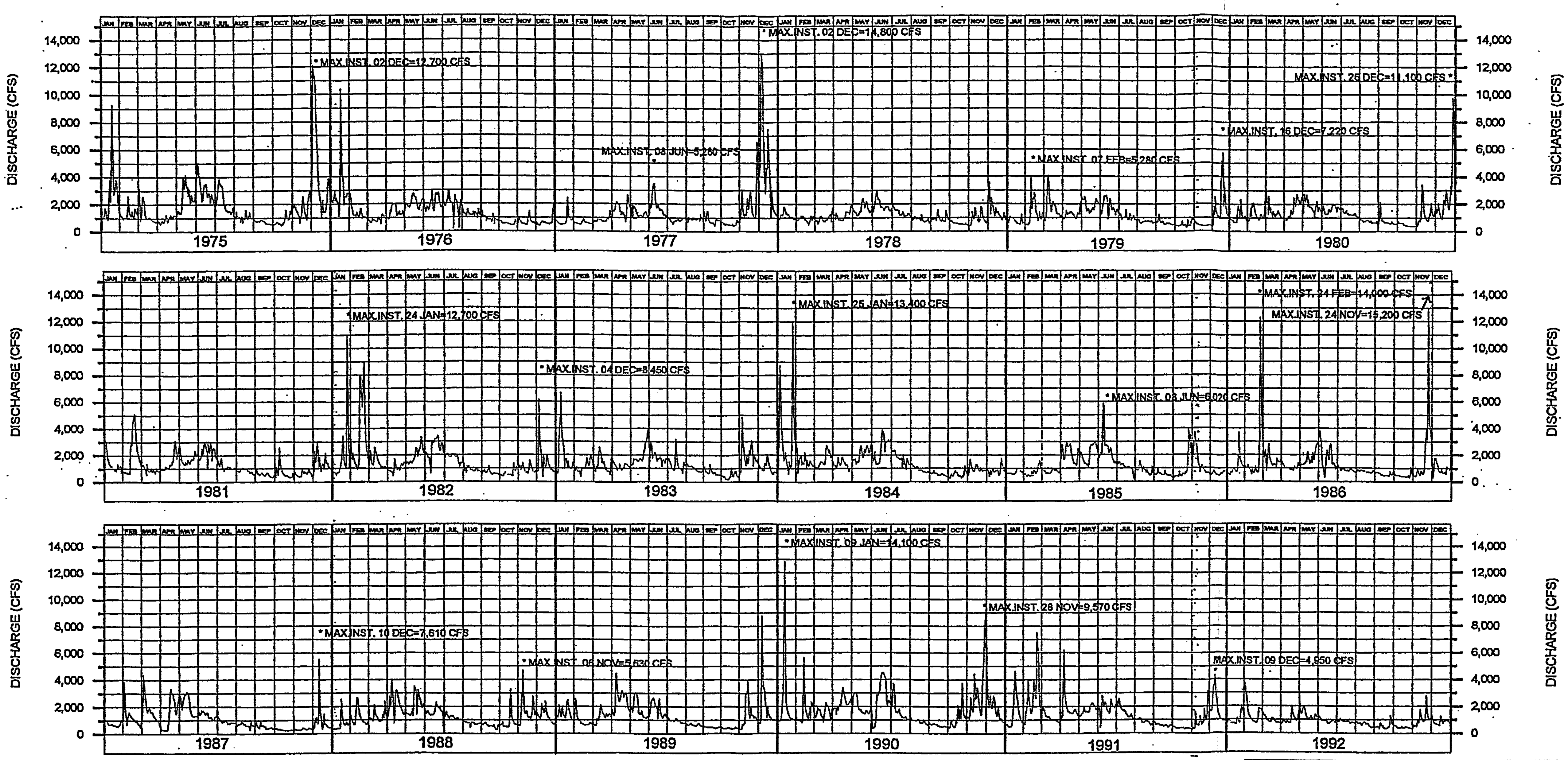
6. ADJUSTED FOR STORAGE SINCE 1943

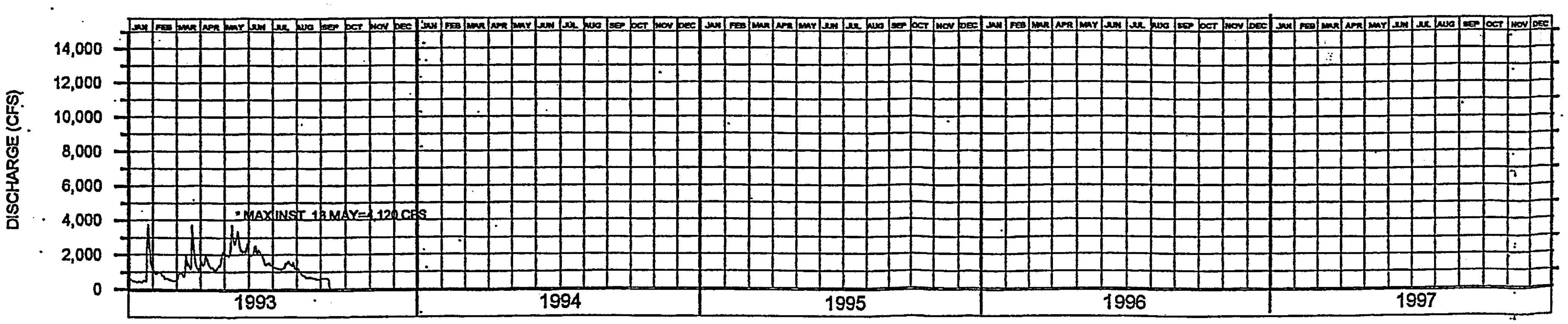
7. U.S. ARMY CORPS OF ENGINEERS SATELLITE TELEMETRY AT STATION

U.S. ARMY ENGINEERS, SEATTLE DISTRICT
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

WHITE RIVER NEAR BUCKLEY
MEAN DAILY DISCHARGE HYDROGRAPHS
U.S.G.S. GAGE 12098500

| DEVELOPED | CHECKED | DATE | SHEET |
|---|---|---|---|
| K.SCATTARELLA | G. SINGLETON | MAY 1995 | 2 OF 3 |




NOTES:

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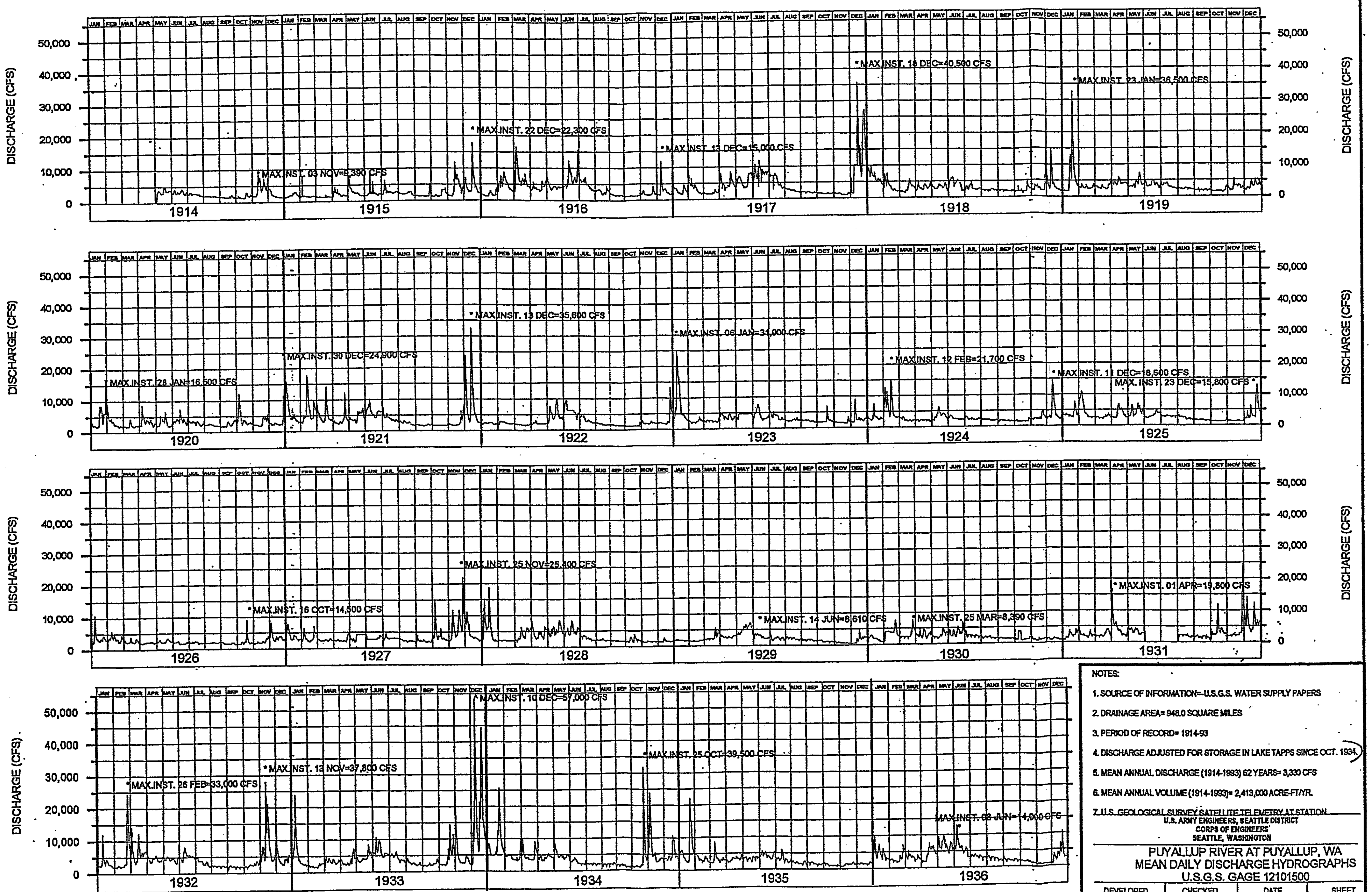
U.S. ARMY ENGINEERS, SEATTLE DISTRICT
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

WHITE RIVER NEAR BUCKLEY
MEAN DAILY DISCHARGE HYDROGRAPHS
U.S.G.S. GAGE 12098500

| DEVELOPED | CHECKED | DATE | SHEET |
|---|---|---|---|
| K.SCATTARELLA | G. SINGLETON | MAY 1995 | 3 OF 3 |



PLATE 4-9




NOTES:

1. SOURCE OF INFORMATION=-U.S.G.S. WATER SUPPLY PAPERS
2. DRAINAGE AREA= 948.0 SQUARE MILES
3. PERIOD OF RECORD= 1914-93
4. DISCHARGE ADJUSTED FOR STORAGE IN LAKE TAPPS SINCE OCT. 1934.
5. MEAN ANNUAL DISCHARGE (1914-1993) 62 YEARS= 3,330 CFS
6. MEAN ANNUAL VOLUME (1914-1993)= 2,413,000 ACRE-FT/YR.
7. U.S. GEOLOGICAL SURVEY SATELLITE TELEMETRY AT STATION

U.S. ARMY ENGINEERS, SEATTLE DISTRICT
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

PUYALLUP RIVER AT PUYALLUP, WA
MEAN DAILY DISCHARGE HYDROGRAPHS
U.S.G.S. GAGE 12101500

| DEVELOPED | CHECKED | DATE | SHEET |
| --- | --- | --- | --- |
| K.SCATTARELLA | G. SINGLETON | MAY 1995 | 1 OF 4 |


NOTES:

1. SOURCE OF INFORMATION=-U.S.G.S. WATER SUPPLY PAPERS
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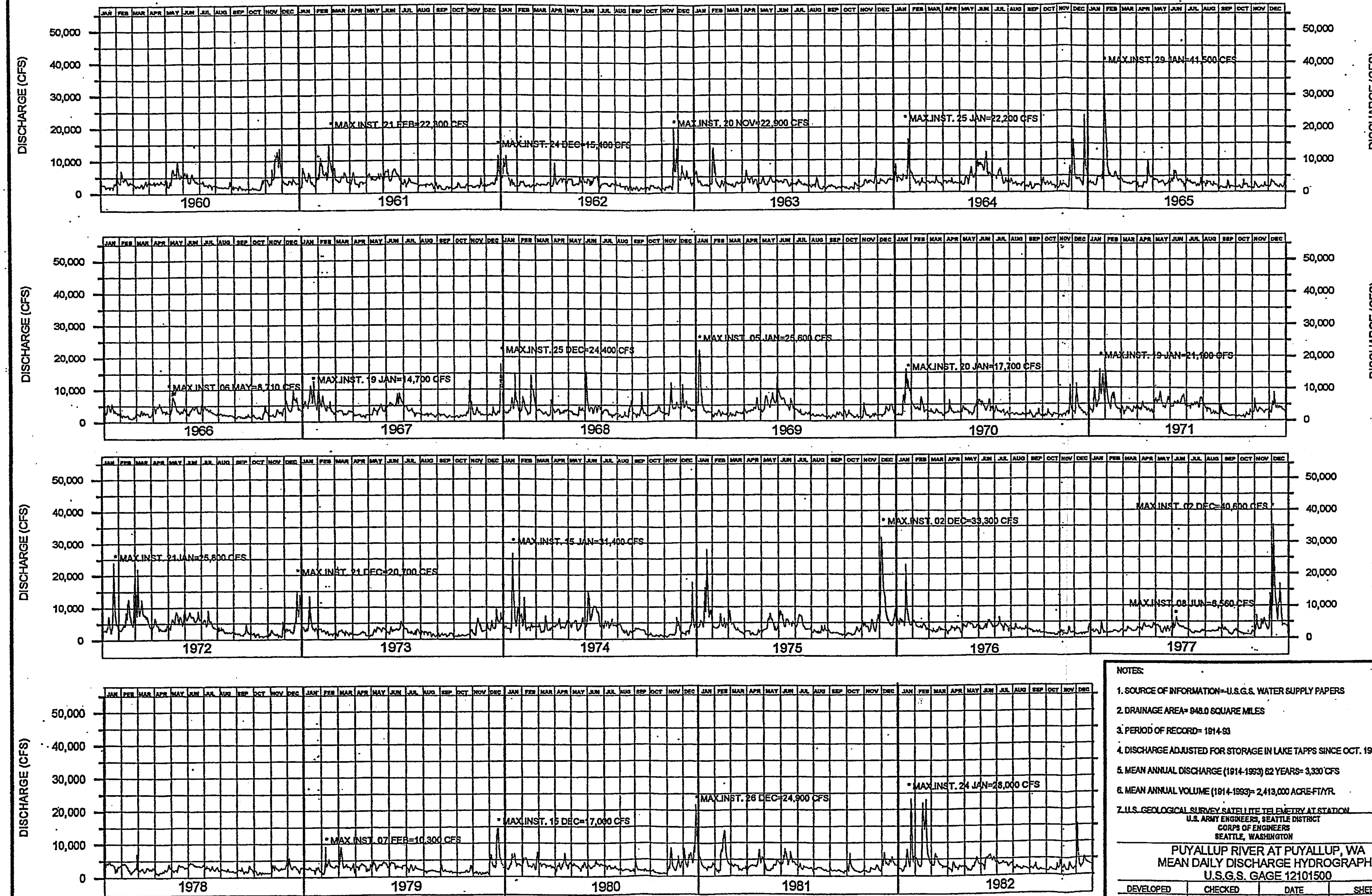
U.S. ARMY ENGINEERS, SEATTLE DISTRICT
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

PUYALLUP RIVER AT PUYALLUP, WA
MEAN DAILY DISCHARGE HYDROGRAPHS
U.S.G.S. GAGE 12101500

| DEVELOPED | CHECKED | DATE | SHEET |
|---|---|---|---|
| K.SCATTARELLA | G. SINGLETON | MAY 1995 | 2 OF 4 |




NOTES:

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3. PERIOD OF RECORD= 1914-93
4. DISCHARGE ADJUSTED FOR STORAGE IN LAKE TAPPS SINCE OCT. 1934
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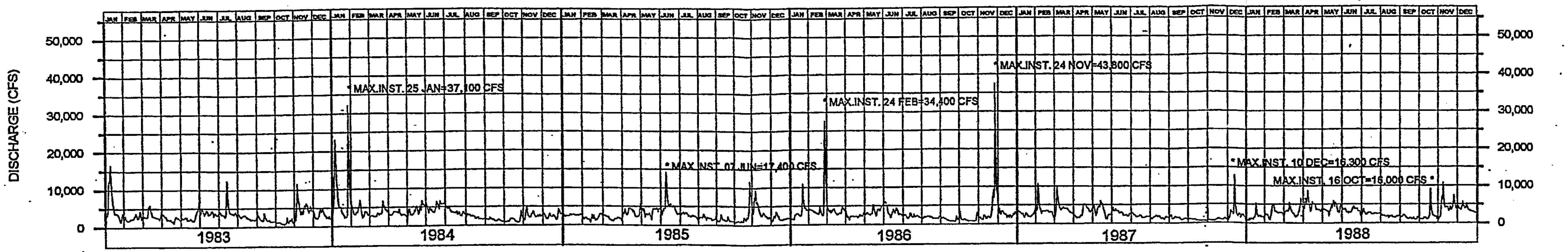
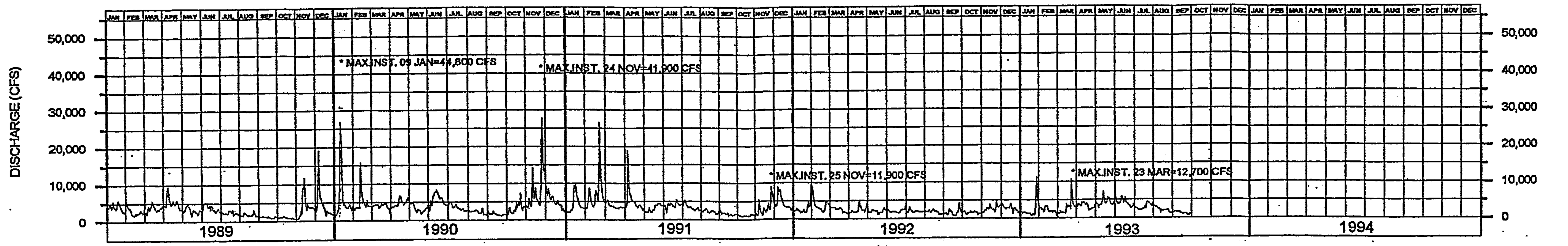
U.S. ARMY ENGINEERS, SEATTLE DISTRICT
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

PUYALLUP RIVER AT PUYALLUP, WA
MEAN DAILY DISCHARGE HYDROGRAPHS
U.S.G.S. GAGE 12101500

| DEVELOPED | CHECKED | DATE | SHEET |
|---|---|---|---|
| K.SCATTARELLA | G. SINGLETON | MAY 1995 | 3 OF 4 |




NOTES:

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7. U.S. GEOLOGICAL SURVEY SATELLITE TELEMETRY AT STATION

U.S. ARMY ENGINEERS, SEATTLE DISTRICT
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

PUYALLUP RIVER AT PUYALLUP, WA
MEAN DAILY DISCHARGE HYDROGRAPHS
U.S.G.S. GAGE 12101500

| DEVELOPED | CHECKED | DATE | SHEET |
|---|---|---|---|
| K.SCATTARELLA | G. SINGLETON | MAY 1995 | 4 3 OF 4 |

P4-20

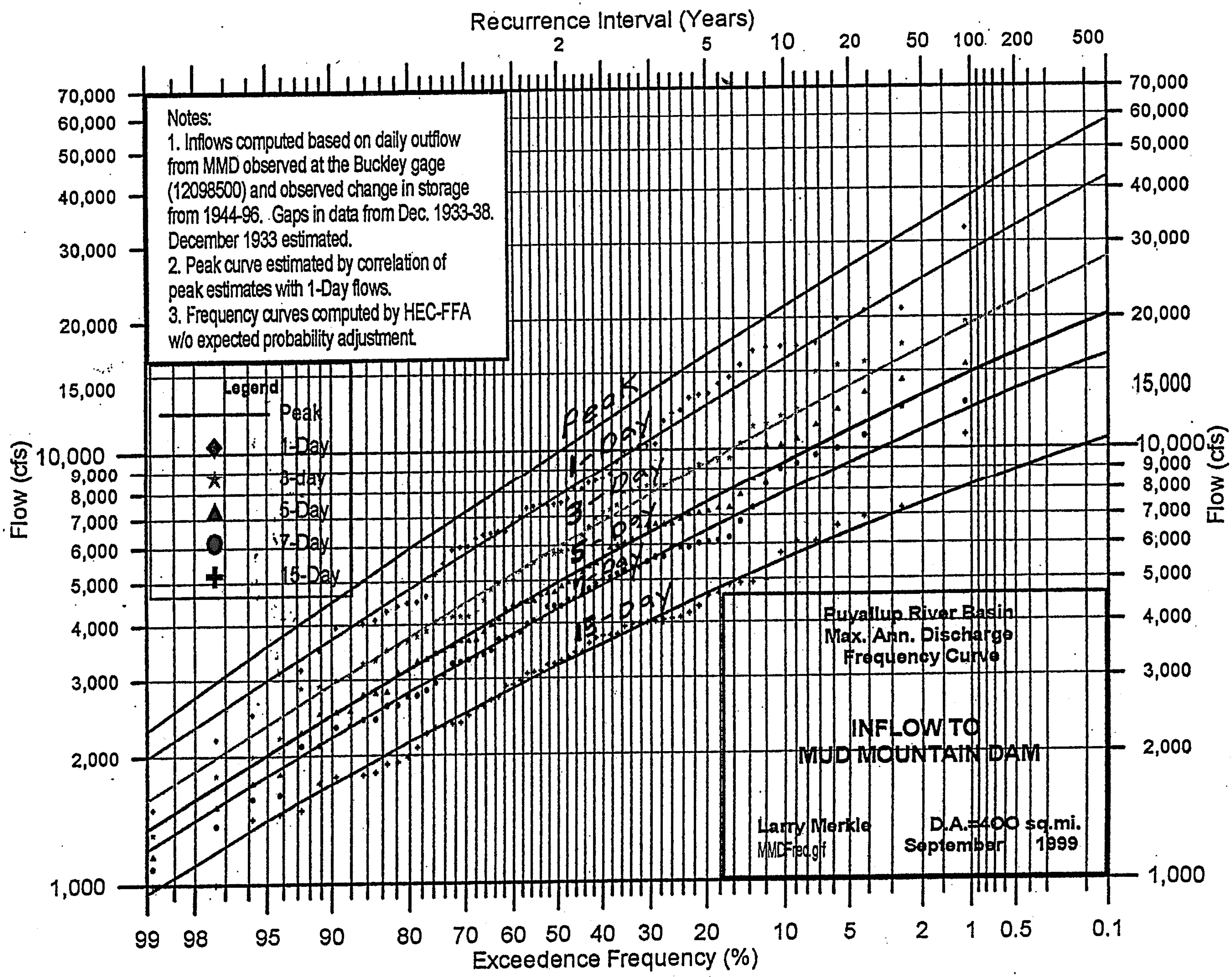
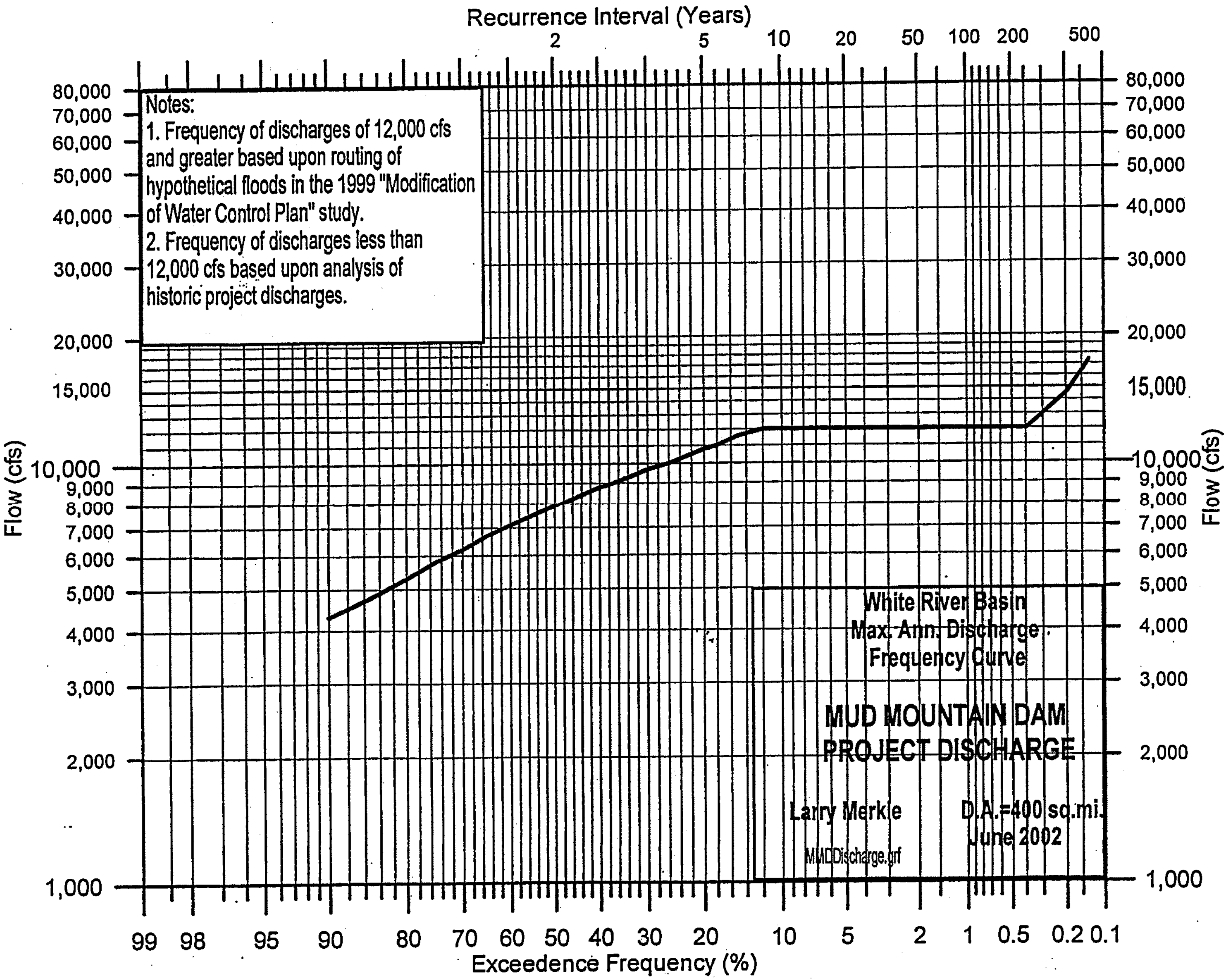
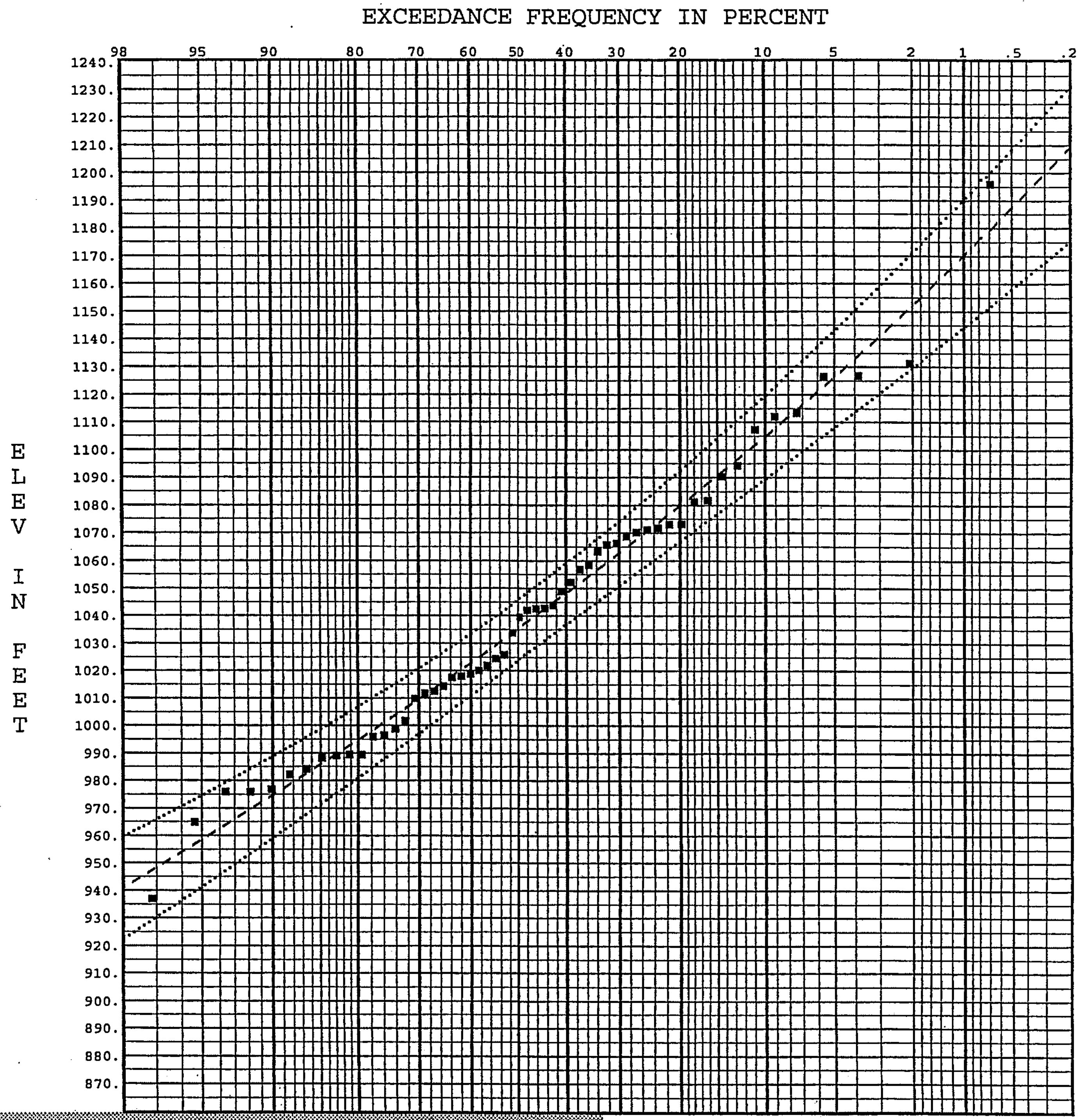



PLATE 4-11


Recurrence Interval (Years)
2
5
10
20
50
100
200
500
Notes:
1. Frequency of discharges of 12,000 cfs and greater based upon routing of hypothetical floods in the 1999 "Modification of Water Control Plan" study.
2. Frequency of discharges less than 12,000 cfs based upon analysis of historic project discharges.
80,000
70,000
60,000
50,000
40,000
30,000
20,000
15,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
Flow (cfs)
White River Basin
Max. Ann. Discharge
Frequency Curve
MUD MOUNTAIN DAM
PROJECT DISCHARGE
Larry Merkle
D.A.=400 sq.mi.
June 2002
MMDDischarge.grf
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
Exceedence Frequency (%)




--- ELEV Frequency (with Exp. Prob.)
■ Median Plotting Positions
........ 5% and 95% Confidence Limits

FREQUENCY STATISTICS
NO TRANSFORM OF ELEV, FEET

| | | NUMBER OF EVENTS | |
|---|---|---|---|
| MEAN | 1037.87 | HISTORIC EVENTS | 0 |
| STANDARD DEV | 49.85 | HIGH OUTLIERS | 1 |
| SKEW | .2980 | LOW OUTLIERS | 0 |
| REGIONAL SKEW | .1000 | ZERO OR MISSING | 0 |
| ADOPTED SKEW | .3000 | SYSTEMATIC EVENTS | 57 |
| | | HISTORIC PERIOD(1900-2000) | 101 |

MUD MOUNTAIN LAKE STAGES
Max. Annual Stage-Frequency
Exist. Condition Observations
Merkle 21 JUNE 2002

BASIN AREA = 400.0 SQ MI
WATER YEARS IN RECORD
1944-2000

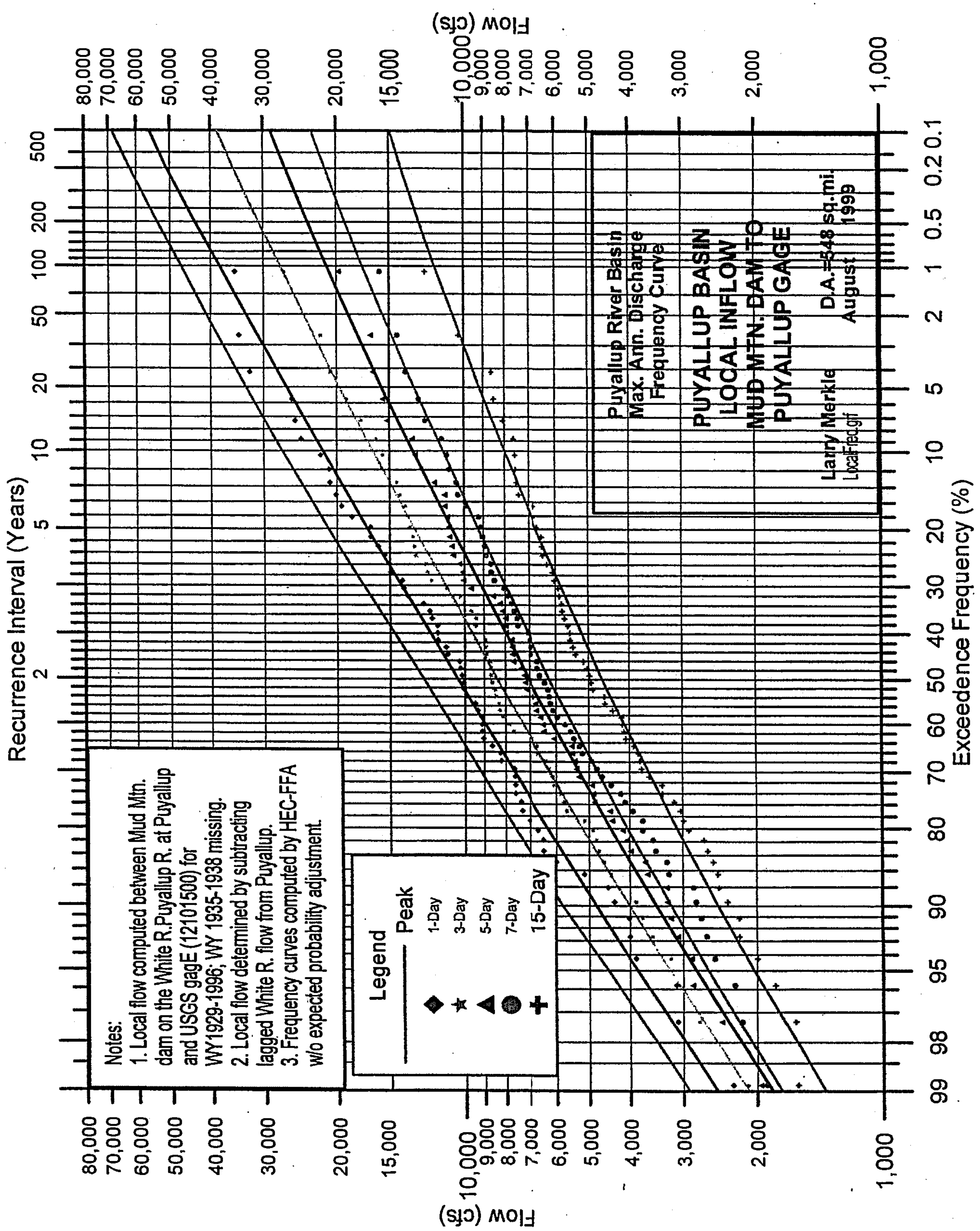
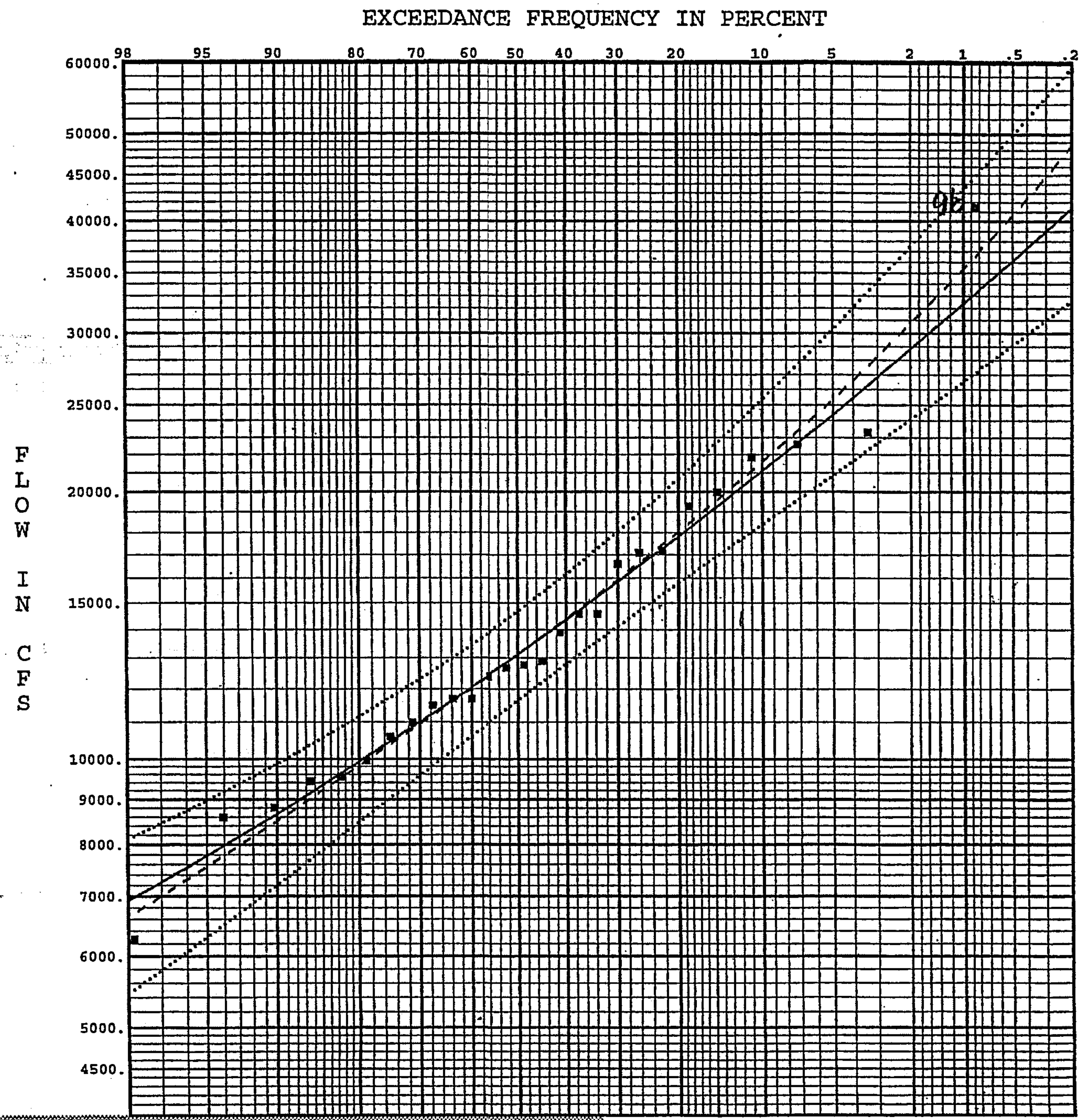

Recurrence Interval (Years)
Exceedence Frequency (%)
Flow (cfs)
Puyallup River Basin
Max. Ann. Discharge
Frequency Curve
PUYALLUP BASIN
LOCAL INFLOW
MUD MTN. DAM TO
PUYALLUP GAGE
Larry Merkle
LocalFreq.gif
D.A.=548 sq.mi.
August 1999
Notes:
1. Local flow computed between Mud Mtn. dam on the White R.Puyallup R. at Puyallup and USGS gagE (12101500) for WY1929-1996; WY 1935-1938 missing.
2. Local flow determined by subtracting lagged White R. flow from Puyallup.
3. Frequency curves computed by HEC-FFA w/o expected probability adjustment.
Legend
Peak
1-Day
3-Day
5-Day
7-Day
15-Day



PLATE 4-14




—— FLOW Frequency (without Exp. Prob.)
- - - FLOW Frequency (with Exp. Prob.)
■ Median Plotting Positions
....... 5% and 95% Confidence Limits

FREQUENCY STATISTICS
LOG TRANSFORM OF FLOW, CFS

| | | NUMBER OF EVENTS | |
|---|---|---|---|
| MEAN | 4.1261 | HISTORIC EVENTS | 1 |
| STANDARD DEV | .1512 | HIGH OUTLIERS | 0 |
| SKEW | .3200 | LOW OUTLIERS | 0 |
| REGIONAL SKEW | .0000 | ZERO OR MISSING | 0 |
| ADOPTED SKEW | .3000 | SYSTEMATIC EVENTS | 26 |
| | | HISTORIC PERIOD (1916-1996) | 81 |

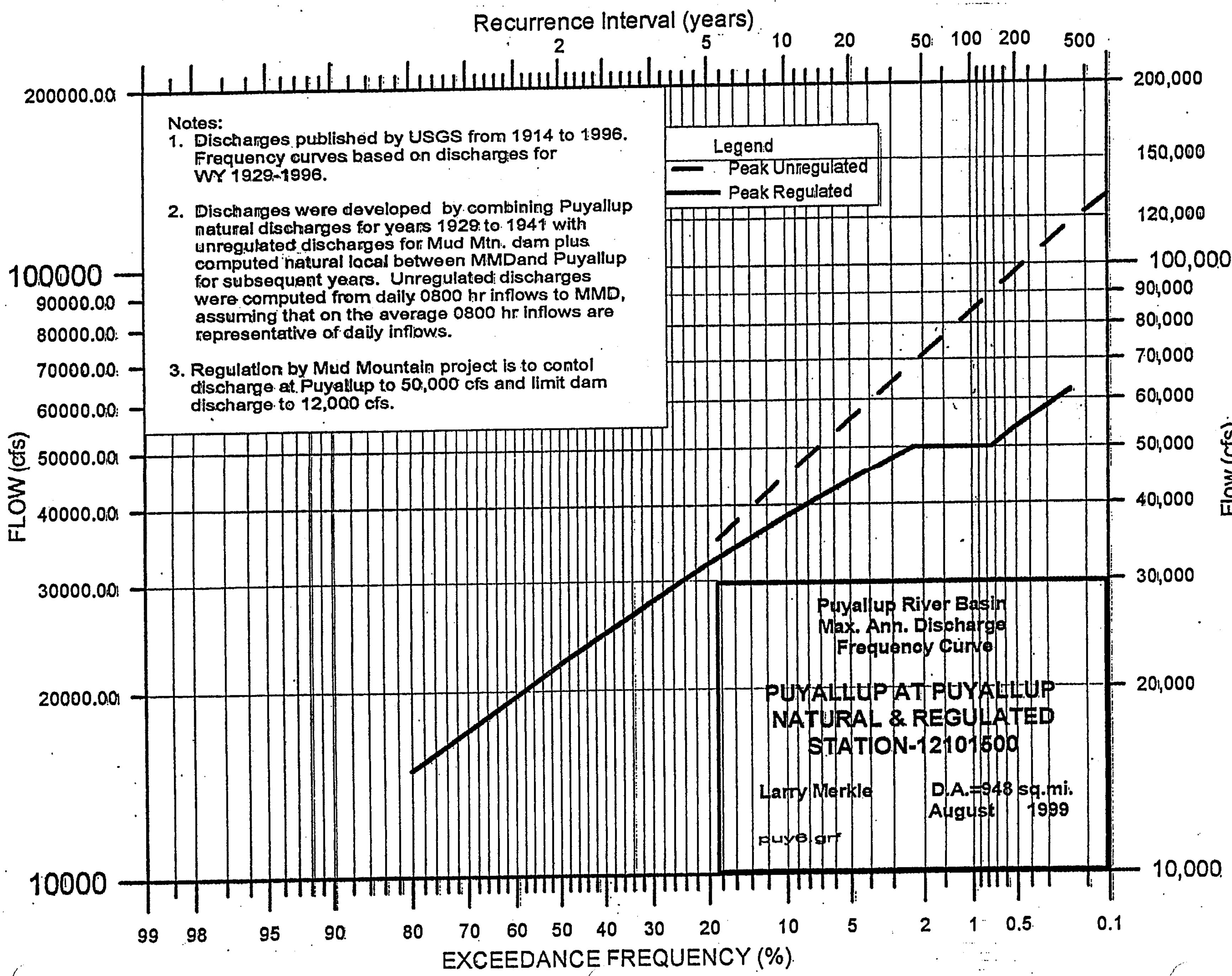
PUYALLUP RIVER AT ALDERTON
USGS GAGE 12096500
Max. Ann. Discharge-Frequency

D. HARVEY JAN 1999

BASIN AREA= 438 SQ MI
WATER YEARS IN RECORD
1916-1927, 1944-1957, 1996



PLATE 4-15


Recurrence Interval (years)
2
5
10
20
50
100
200
500
200000.00
100000
90000.00
80000.00
70000.00
60000.00
50000.00
40000.00
30000.00
20000.00
10000
FLOW (cfs)
200,000
150,000
120,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
Flow (cfs)
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.1
EXCEEDANCE FREQUENCY (%)
Notes:
1. Discharges published by USGS from 1914 to 1996. Frequency curves based on discharges for WY 1929-1996.
2. Discharges were developed by combining Puyallup natural discharges for years 1929 to 1941 with unregulated discharges for Mud Mtn. dam plus computed natural local between MMDand Puyallup for subsequent years. Unregulated discharges were computed from daily 0800 hr inflows to MMD, assuming that on the average 0800 hr inflows are representative of daily inflows.
3. Regulation by Mud Mountain project is to contol discharge at Puyallup to 50,000 cfs and limit dam discharge to 12,000 cfs.
Legend
Peak Unregulated
Peak Regulated
Puyallup River Basin
Max. Ann. Discharge
Frequency Curve
PUYALLUP AT PUYALLUP
NATURAL & REGULATED
STATION-12101500
Larry Merkle
D.A.=948 sq.mi.
August 1999
puy6.grf

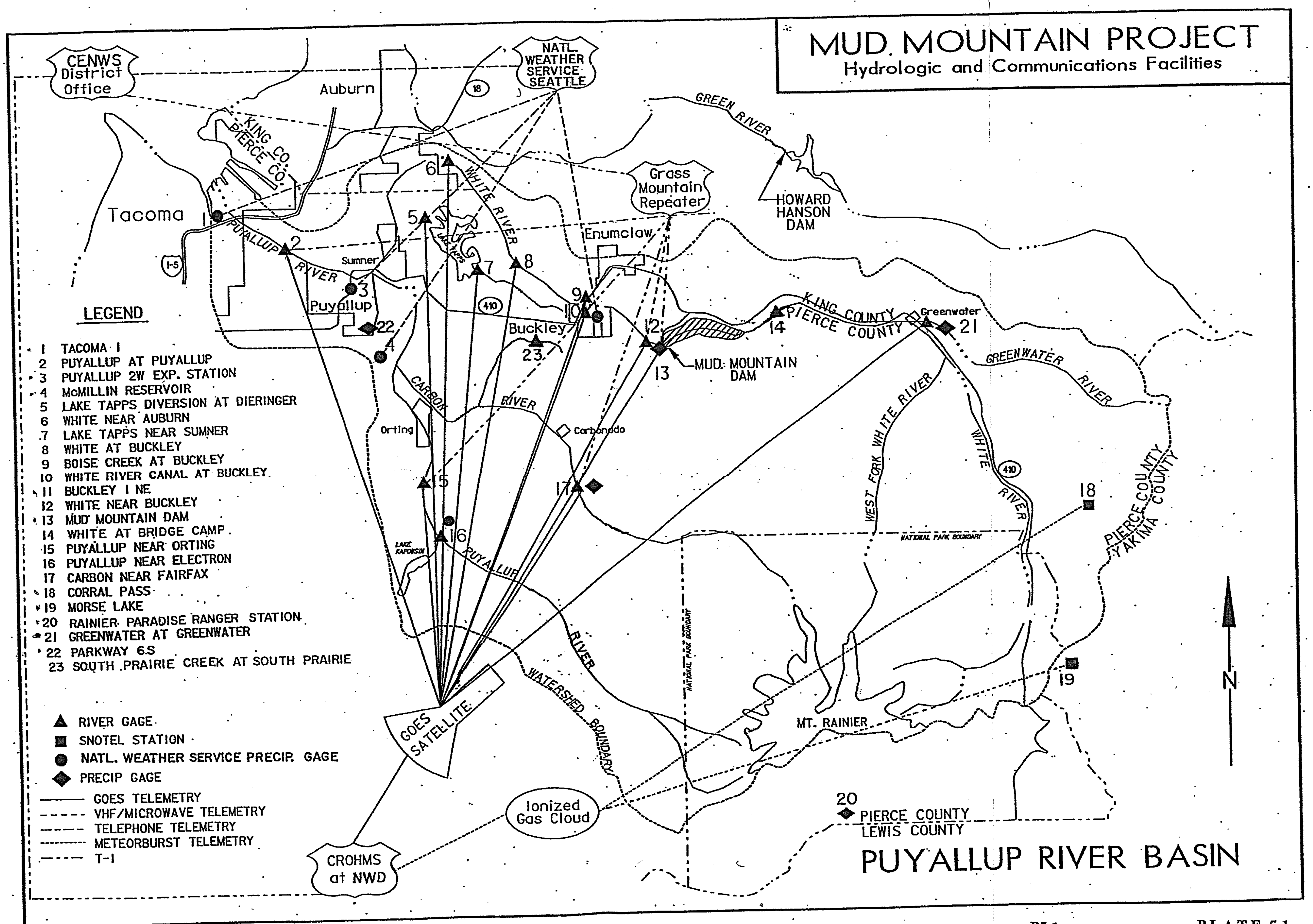
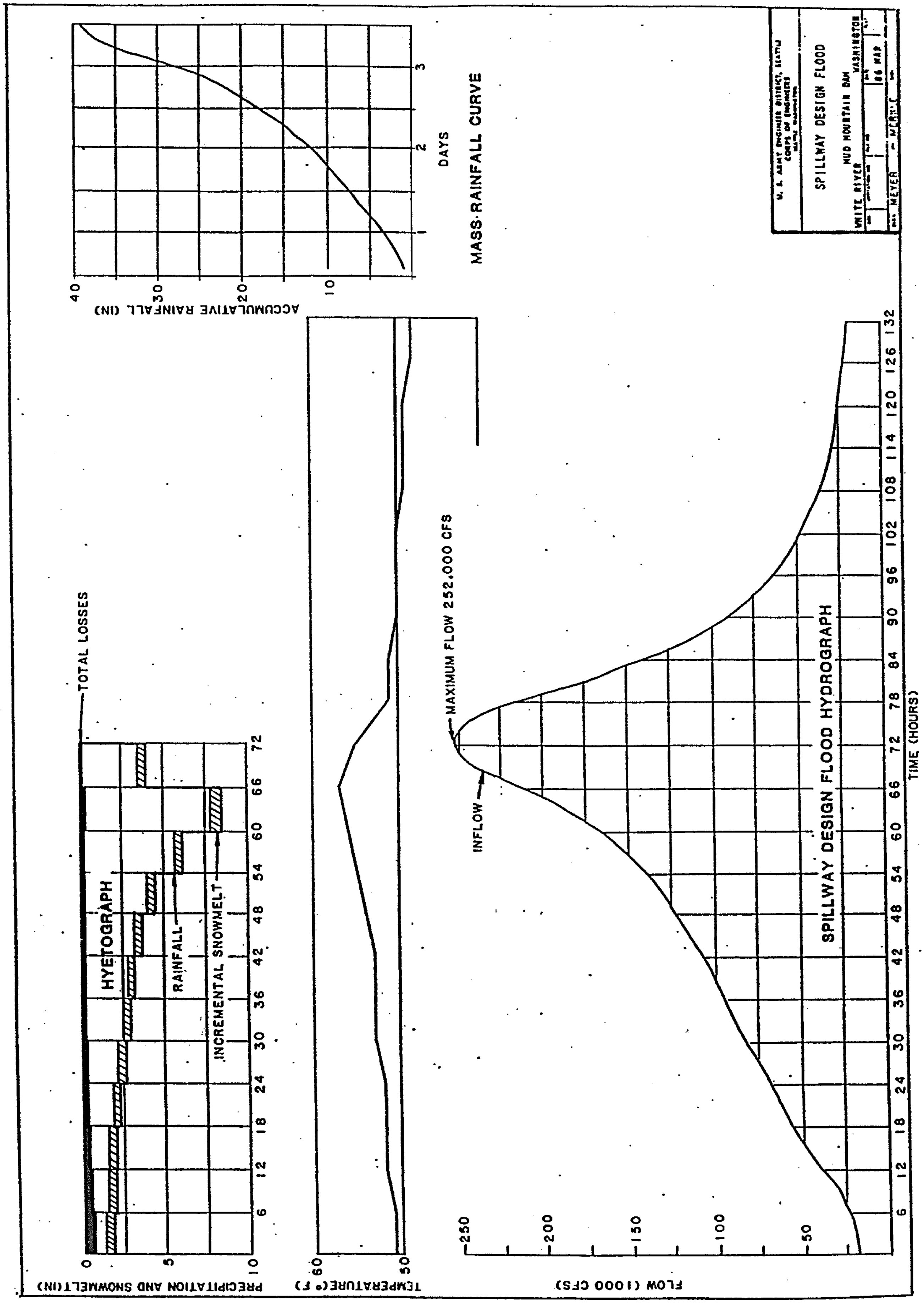
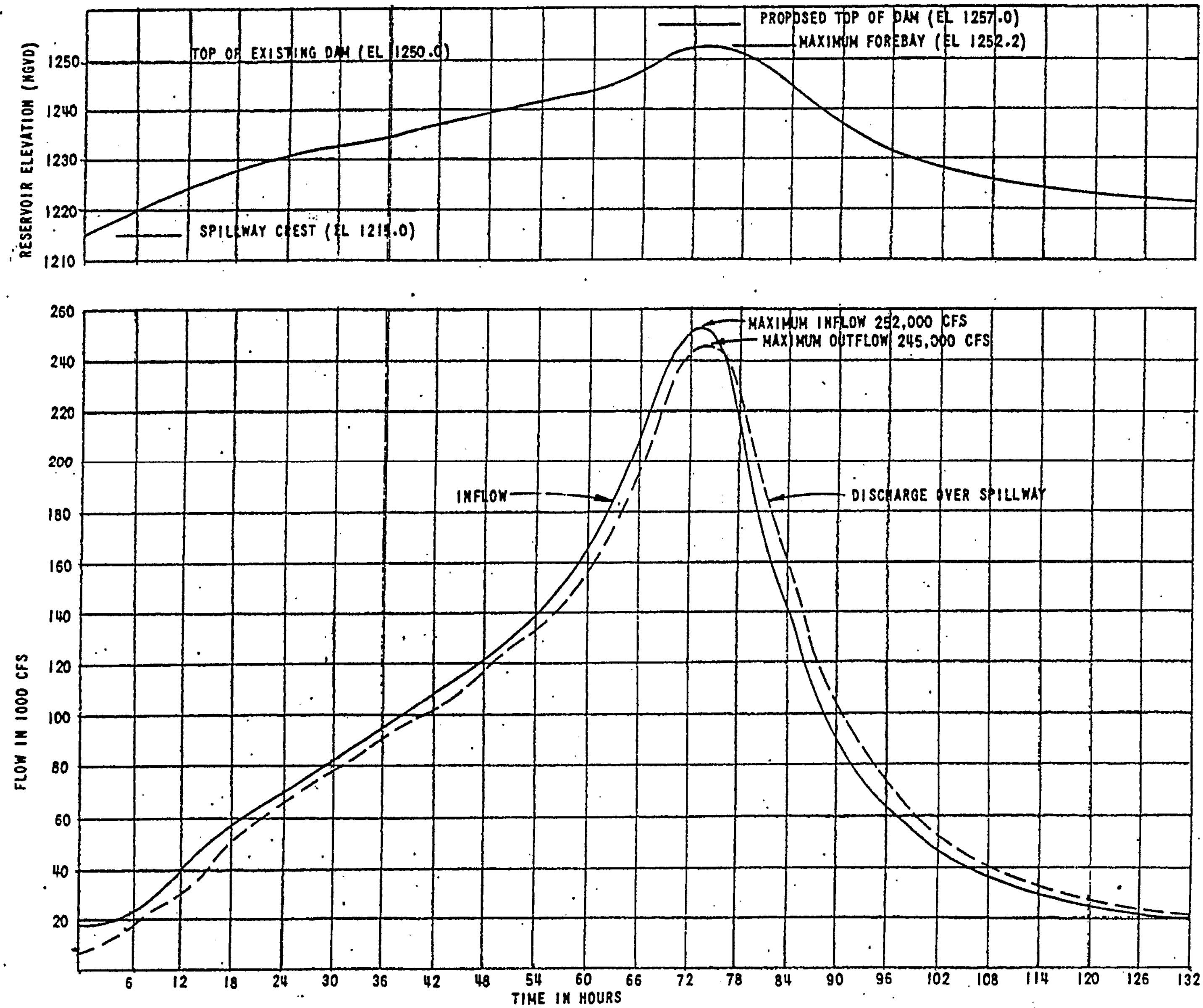

MUD MOUNTAIN PROJECT
Hydrologic and Communications Facilities
PUYALLUP RIVER BASIN
CENWS District Office
NATL. WEATHER SERVICE SEATTLE
Grass Mountain Repeater
HOWARD HANSON DAM
MUD MOUNTAIN DAM
GOES SATELLITE
Ionized Gas Cloud
CROHMS at NWD
Tacoma
Auburn
Sumner
Puyallup
Orting
Buckley
Enumclaw
Carbonado
Greenwater
MT. RAINIER
KING CO.
PIERCE CO.
KING COUNTY
PIERCE COUNTY
PIERCE COUNTY
YAKIMA COUNTY
PIERCE COUNTY
LEWIS COUNTY
GREEN RIVER
WHITE RIVER
PUYALLUP RIVER
CARBON RIVER
GREENWATER RIVER
WEST FORK WHITE RIVER
PUYALLUP RIVER
WATERSHED BOUNDARY
NATIONAL PARK BOUNDARY
N
LEGEND
1 TACOMA 1
2 PUYALLUP AT PUYALLUP
3 PUYALLUP 2W EXP. STATION
4 McMILLIN RESERVOIR
5 LAKE TAPPS DIVERSION AT DIERINGER
6 WHITE NEAR AUBURN
7 LAKE TAPPS NEAR SUMNER
8 WHITE AT BUCKLEY
9 BOISE CREEK AT BUCKLEY
10 WHITE RIVER CANAL AT BUCKLEY
11 BUCKLEY 1 NE
12 WHITE NEAR BUCKLEY
13 MUD MOUNTAIN DAM
14 WHITE AT BRIDGE CAMP
15 PUYALLUP NEAR ORTING
16 PUYALLUP NEAR ELECTRON
17 CARBON NEAR FAIRFAX
18 CORRAL PASS
19 MORSE LAKE
20 RAINIER PARADISE RANGER STATION
21 GREENWATER AT GREENWATER
22 PARKWAY 6S
23 SOUTH PRAIRIE CREEK AT SOUTH PRAIRIE
RIVER GAGE
SNOTEL STATION
NATL. WEATHER SERVICE PRECIP. GAGE
PRECIP GAGE
GOES TELEMETRY
VHF/MICROWAVE TELEMETRY
TELEPHONE TELEMETRY
METEORBURST TELEMETRY
T-1



PLATE 5-1


HYETOGRAPH
TOTAL LOSSES
RAINFALL
INCREMENTAL SNOWMELT
PRECIPITATION AND SNOWMELT (IN)
TEMPERATURE (° F)
MASS-RAINFALL CURVE
DAYS
ACCUMULATIVE RAINFALL (IN)
SPILLWAY DESIGN FLOOD HYDROGRAPH
MAXIMUM FLOW 252,000 CFS
INFLOW
FLOW (1000 CFS)
TIME (HOURS)
SPILLWAY DESIGN FLOOD
MUD MOUNTAIN DAM
WHITE RIVER
WASHINGTON
MEYER




NOTES:

1. RESERVOIR CONTENTS AT START OF FLOOD ASSUMED TO BE AT SPILLWAY CREST AS A RESULT OF AN EARLIER FLOOD.

2. SPILLWAY AND OUTLETS MODIFIED AS RECOMMENDED FOR DAM SAFETY ASSURANCE.

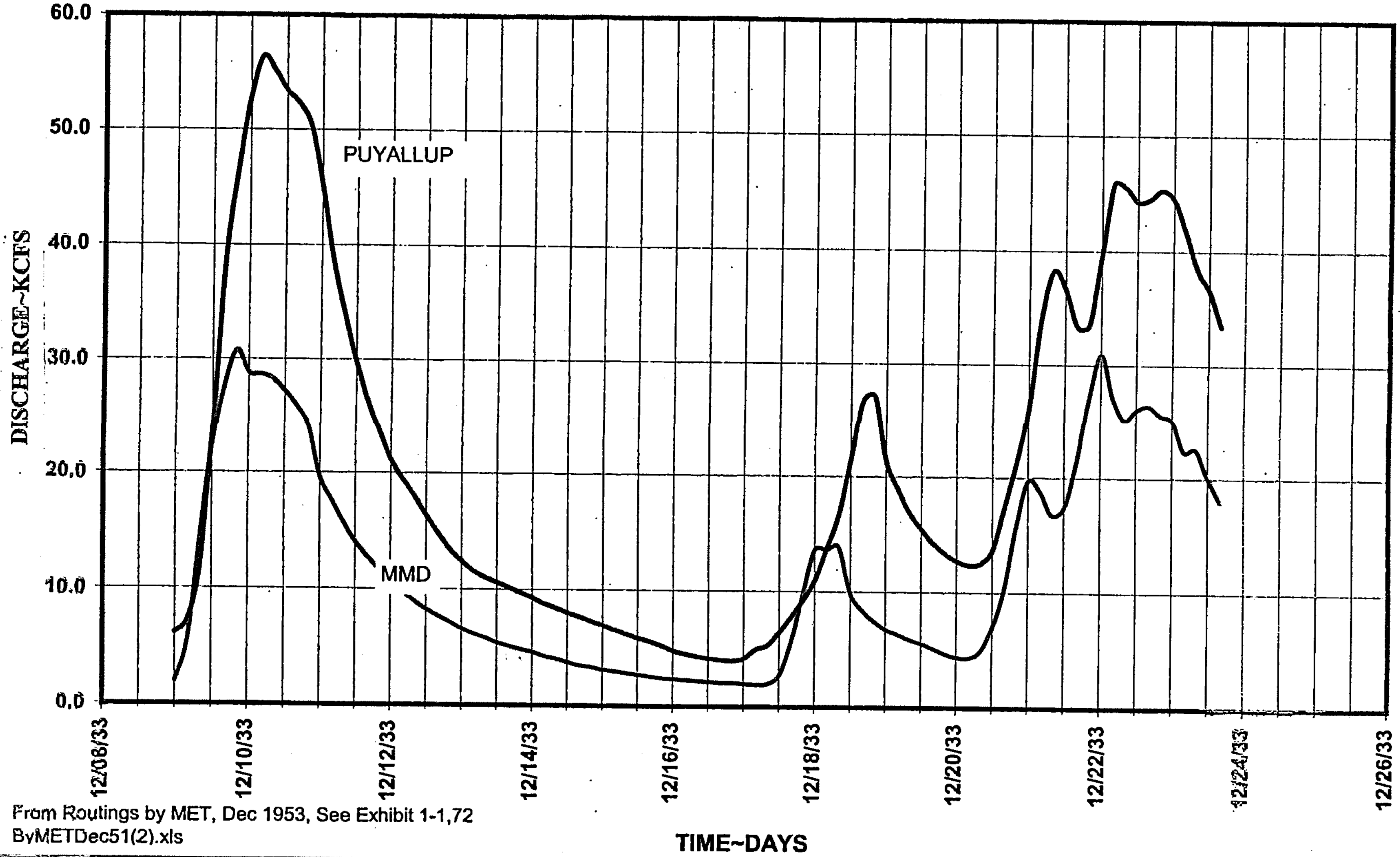
3. NINE FOOT AND 23 FOOT TUNNEL GATES OPEN 25% EXCEPT INOPERATIVE FOR DISCHARGES GREATER THAN 90,000 CFS DUE TO BACKWATER EFFECTS.

4. SPILLWAY CAPACITY NOT RESTRICTED BY DEBRIS.

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

ROUTING OF SPILLWAY
DESIGN FLOOD
MUD MOUNTAIN DAM
WHITE RIVER WASHINGTON
86 MAR
MEYER MERKLE

## DECEMBER 1933 NATURAL DISCHARGES




From Routings by MET, Dec 1953, See Exhibit 1-1,72
ByMETDec51(2).xls

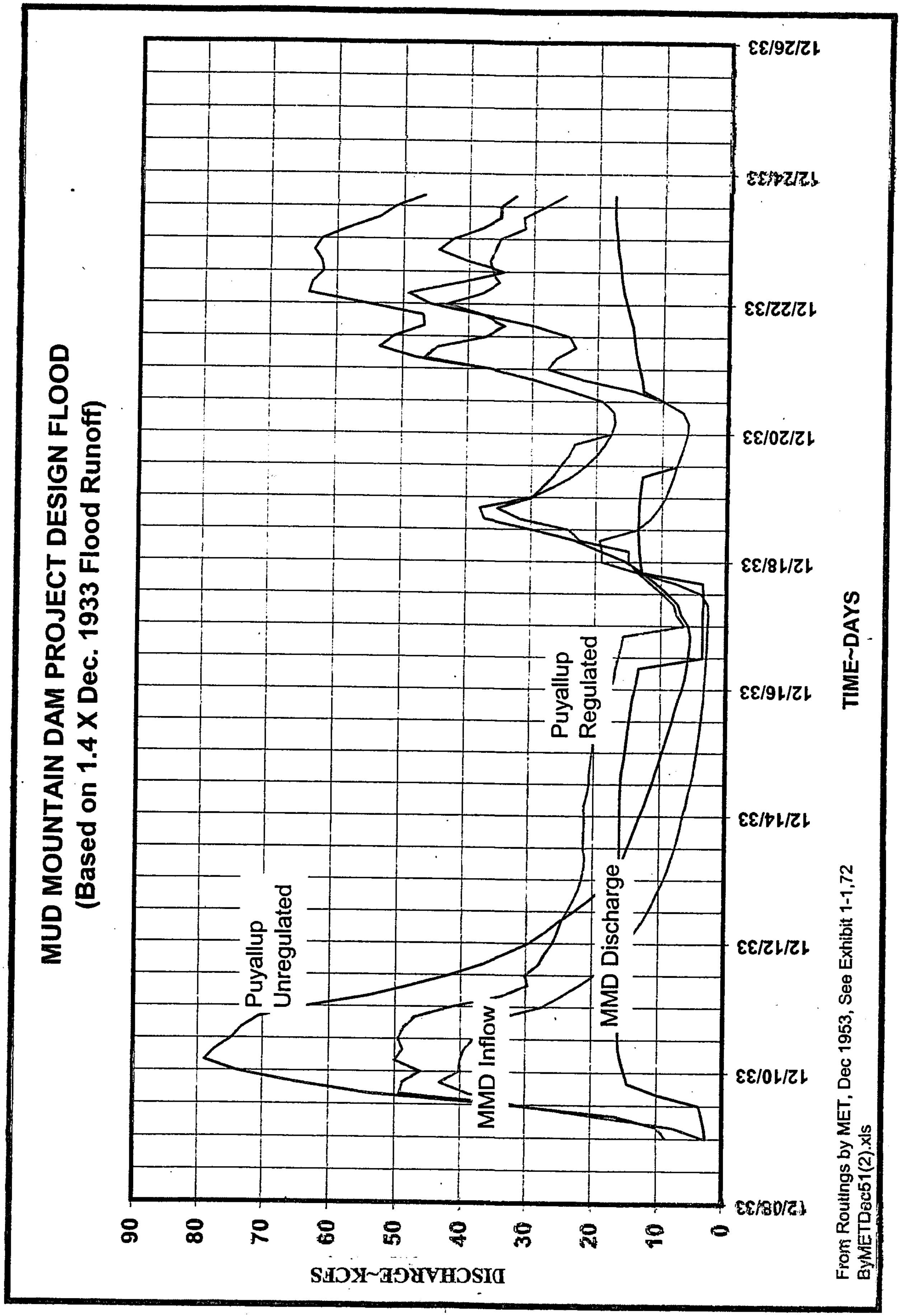
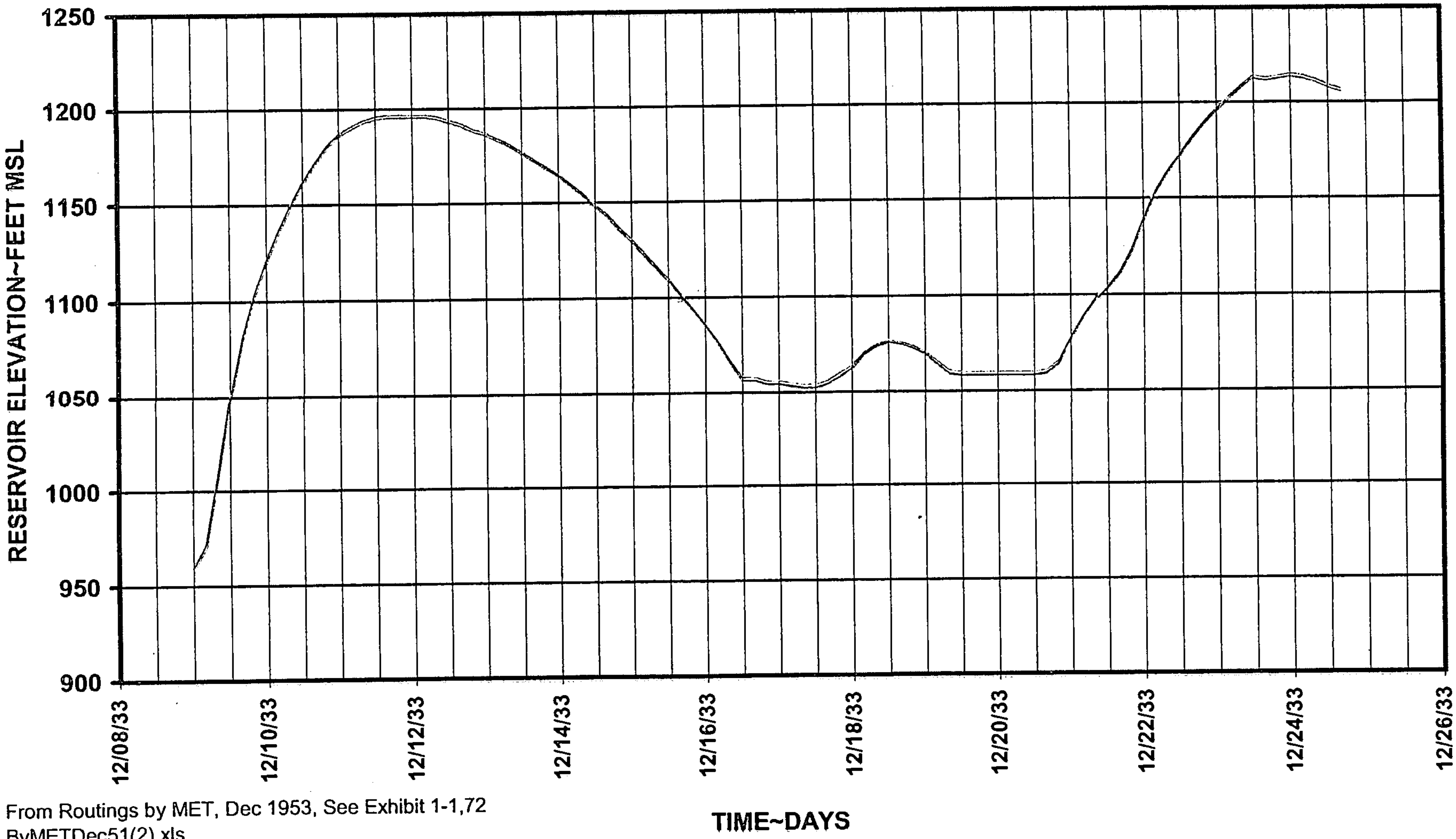





PLATE 8-3, SHEET 1/2

## MUD MOUNTAIN DAM PROJECT DESIGN FLOOD
(Based on 1.4X Dec 1933 Flood Runoff)




From Routings by MET, Dec 1953, See Exhibit 1-1,72
ByMETDec51(2).xls

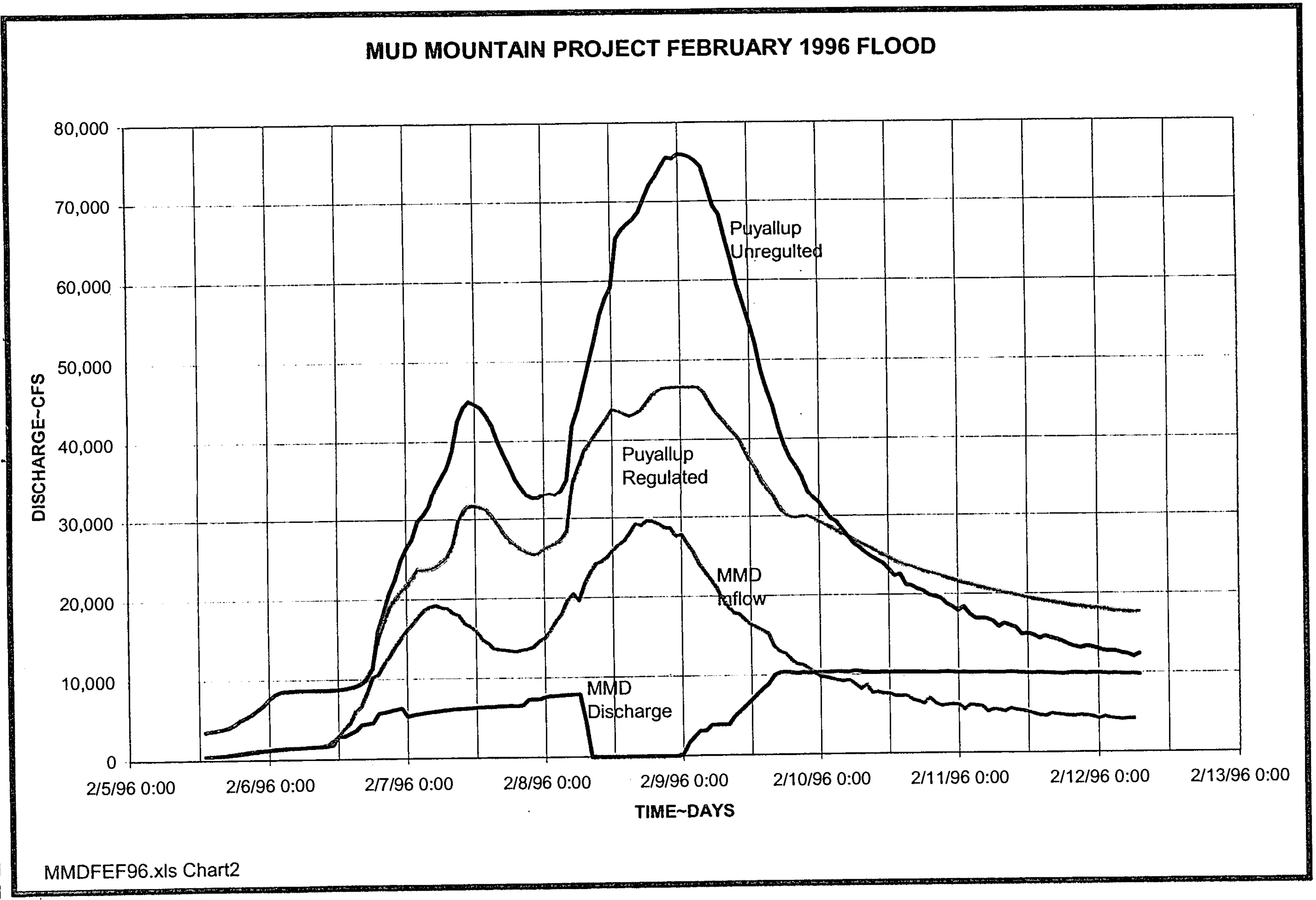
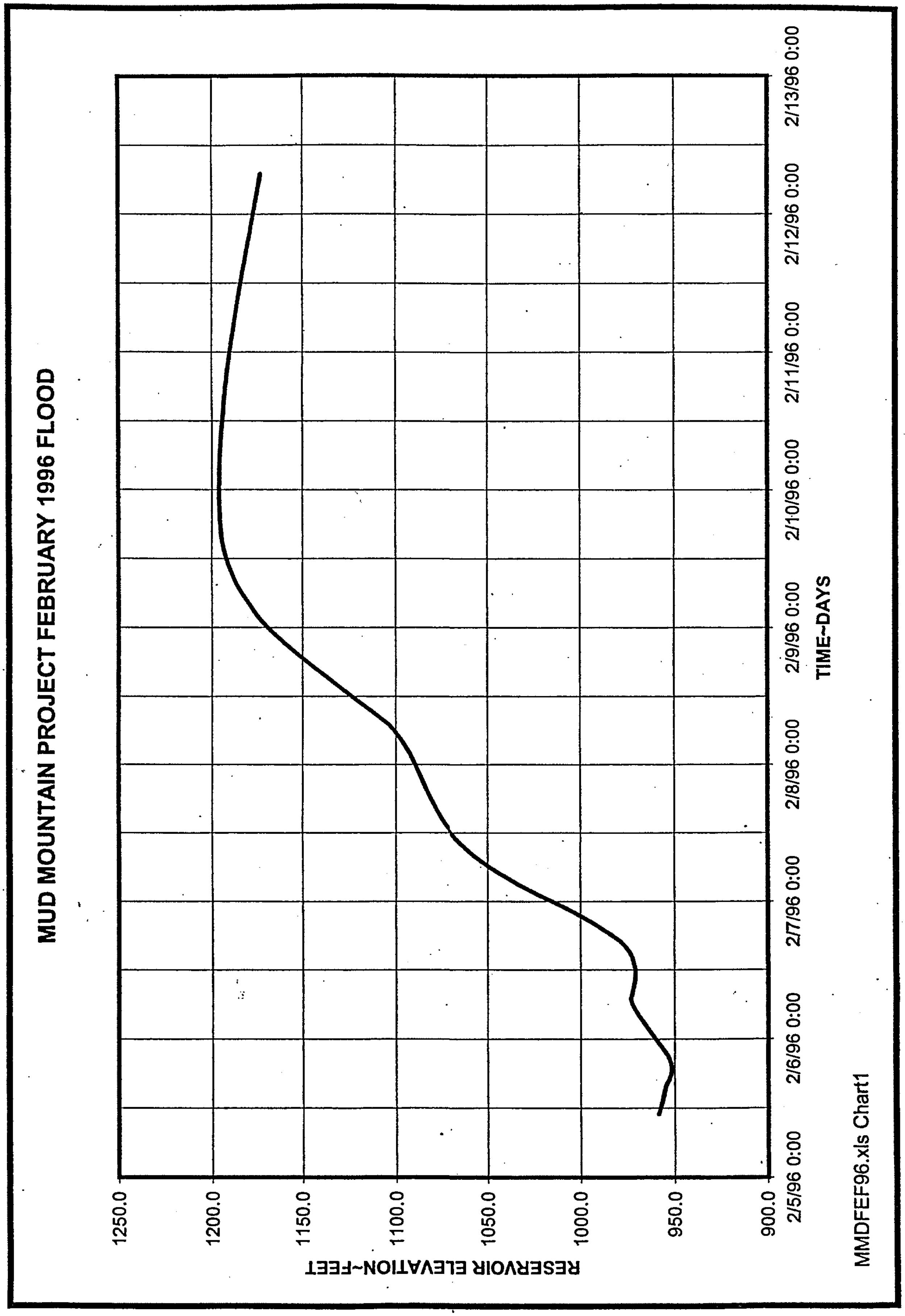





PLATE 8-4, SHEET 1/2


MUD MOUNTAIN PROJECT FEBRUARY 1996 FLOOD
RESERVOIR ELEVATION~FEET
1250.0
1200.0
1150.0
1100.0
1050.0
1000.0
950.0
900.0
2/5/96 0:00
2/6/96 0:00
2/7/96 0:00
2/8/96 0:00
2/9/96 0:00
2/10/96 0:00
2/11/96 0:00
2/12/96 0:00
2/13/96 0:00
TIME~DAYS
MMDFEF96.xls Chart1

DEPARTMENT OF THE ARMY
NORTH PACIFIC DIVISION, CORPS OF ENGINEERS
P. O. Box 2870
Portland, Oregon 97208-2870

CENPD-EN-WM
Regulation
Number 1165-2-2

2 January 1990

Water Resource Policies and Authorities
WATER MANAGEMENT RESPONSIBILITIES

1. PURPOSE. This regulation pertains to the management of the Columbia River reservoir system through the regulation and operation of Corps of Engineers dams and those owned by other agencies. The purpose of this regulation is to clarify the organizational structure of and define specific responsibilities for the Division, districts, and project offices engaged in this activity. It also defines the Water Management Board and associated procedures for Division-district interface on water management activities.

2. APPLICABILITY. This regulation is applicable to Engineering and Operations elements in Headquarters North Pacific Division (HQNPD), and in Portland, Seattle, and Walla Walla Districts (including Planning Division in CENPW).

3. REQUIRED PUBLICATIONS.

a. ER 1110-2-240 (Water Control Management). Cited in paragraph 5a, 6b, 11b, 12 and 13.

b. ER 1110-2-241 (Use of Storage Allocated for Flood Control and Navigation at Non-Corps Projects). Cited in paragraph 5a.

c. ER 1110-2-249 (Management of Water Control Data Systems). Cited in paragraph 12a.

d. ER 1110-2-1400 (Reservoir Control Centers). Cited in paragraph 4.

e. EM 1110-2-3600 (Management of Water Control Systems). Cited in paragraph 5a.

f. Columbia River Master Water Control Manual. Cited in paragraph 5c.

g. CENPD Master Plan for Water Control Data Systems. Cited in paragraph 11.

*Supersedes NPDR 1165-2-2, 10 January 1967

4. <u>BACKGROUND AND DEFINITIONS</u>.

a. Water control management of dams and reservoirs in North Pacific Division (NPD) is the responsibility of both district and division offices. In the Columbia River basin, which encompasses three district jurisdictions, a need exists for centralized management of reservoir regulation activities, since the system of reservoirs requires unified coordination and operation. Accordingly, a system management organization, now the Water Management Branch, was established in 1968 in the HQNPD. The duties and responsibilities of the Branch, which includes a Reservoir Control Center, are defined by ER 1110-2-1400. District offices also remain involved with the Columbia basin reservoirs, but in a secondary capacity. In certain geographic areas that are independent from the Columbia River basin, however, district offices assume primary regulation responsibilities. Jurisdiction for district/division responsibilities for each major project within the NPD boundaries have been defined and are shown in Appendix A. Responsibilities have generally been assigned to the district office in which the project exists unless the project is connected electrically and/or hydraulically to the Columbia system.

b. Certain key terms used in this regulation are defined in Appendix B. Some of these terms are used very explicitly in defining the responsibilities covered by this regulation.

5. <u>WATER MANAGEMENT POLICIES, GUIDANCE</u>.

a. <u>General Policies and Guidance</u>. Corps of Engineers' projects will be regulated to conform with basic provisions in authorizing documents and water management policies and criteria. Corps of Engineers' policies with regard to water management are contained in ER 1110-2-240 and ER 1110-2-241. Technical guidance in carrying out reservoir regulation is contained in EM 1110-2-3600.

b. <u>Project Regulation Guidance</u>. Project water control plans have been developed to define and describe regulation procedures for each Corps project and for non-Corps projects for which the Corps has primary regulation responsibility. These are usually contained in the project water control manuals.

c. <u>Policies and Guidance for System Management</u>. The Master Water Control Manual for the Columbia River (reference 3f) contains policy and guidance for regulating the dams and reservoirs in the Columbia basin to fulfill integrated system objectives. Since the projects in the Columbia system are interrelated, regulation for individual projects must be coordinated with objectives for the system as a whole. Project obligations to meet system objectives are broadly defined in authorizing documents, with specific requirements contained in contractual agreements which are described in the CENPD Master Water Control Manual (reference 3f).

6. DIVISION OFFICE ORGANIZATION AND RESPONSIBILITIES.

a. Organization. The organizational chart for those elements in the HQNPD associated with water management is shown in Appendix C. Also shown are the other agencies with which coordination is required. Water management activities are carried out by the Water Management Branch in Engineering Division. The Branch is organized into three sections which carry out the various responsibilities relating to the water management mission described below. These are also summarized on the organizational chart.

b. Responsibilities. HQNPD is responsible for:

(1) Preparing the annual operating plan for the Columbia system in accordance with Pacific Northwest Coordination Contract and Columbia River Treaty, including performing system regulation studies and coordination as shown in Appendix A.

(2) Preparing the annual operating plan for the Willamette basin.

(3) Primary regulation of the Columbia reservoir system, including coordination with BPA, USBR, district offices, fishery agencies, electrical utilities, etc.; performing back-up analyses; and issuing instructions to projects. Also performing secondary regulation for other projects as necessary. See specified projects in Appendix A.

(4) Implementing the Columbia River Treaty in accordance with Treaty documents, through the Treaty Operating Committee and Hydrometeorological Committee, including performing required studies as well as daily regulation activities.

(5) Representing the Corps of Engineers on the Coordination Contract Committee and NWPP Operating Committee, for water management responsibilities.

(6) Developing, coordinating, planning and implementing the juvenile fish passage plan and water budget plan on the Columbia and Snake Rivers.

(7) Coordinating water supply forecasts with NWRFC, BPA and other agencies, overseeing forecast integrity, and preparing forecasting procedures for projects listed in Appendix A.

(8) Performing system flood control, power, water quality, and conservation storage studies to improve regulation procedures or analyze problem areas for projects for which water control plan responsibilities exist.

(9) Maintaining and implementing the CROHMS System, including the central computer facility hardware and software (in conjunction with CENPD-IM). Includes maintenance of communications facilities such as the CBT

network and the GOES system; coordination of remote stations; and the processing of real-time data.

(10) Performing public information/involvement activities in accordance with annual plans.

(11) Participating in activities associated with the Water Management Board.

(12) Assuming necessary dam safety responsibilities relating to reservoir regulation and flood warning and notification, including conducting and participating in emergency action plan exercises.

(13) Preparing and maintaining master water control manuals for the Columbia and Willamette River basins and portions of other water control manuals for projects designated in Appendix A.

(14) Implementing water quality programs required for mainstem Columbia and Snake River projects.

(15) Preparing the Columbia River Treaty and Columbia River Water Management Group Annual Reports, and special after-action reports such as post-flood reports, as defined in Appendix A.

(16) Performing oversight and approval of district Water Control Data System (WCDS) development as required by ER 1110-2-240.

(17) Performing oversight and approval of District water control plans and manuals as required by ER 1110-2-240.

(18) Performing oversight of district reservoir regulation activities.

7. DISTRICT OFFICE ORGANIZATION AND RESPONSIBILITIES.

a. Organization. Appendix C contains separate organizational charts for those parts of the organizations associated with water management. This activity resides as a section within the Districts' Hydrology and Hydraulics branches.

b. Jurisdiction. Projects and responsibilities that fall within the jurisdiction of each District Office are shown in Appendix A.

c. Responsibilities. District Offices will be responsible for:

(1) Maintaining and updating as necessary the water control plan for projects shown in Appendix A, including making studies and coordinating with other agencies as appropriate.

(2) Primary and secondary regulation of those projects specified in Appendix A, including the necessary coordination and back-up analyses.

(3) Preparing and updating water control manuals or projects specified in Appendix A.

(4) Performing flood control and conservation storage studies to improve regulation procedures or analyze problem areas for projects for which water control plan responsibility exists (Appendix A).

(5) Operating and maintaining designated Water Control Data Systems, including data controllers and remote stations.

(6) Developing and implementing water supply and streamflow forecasting procedures for those projects listed in Appendix A.

(7) Preparing special after-action reports such as post-flood reports for projects shown in Appendix A.

(8) Participating in activities associated with the Water Management Board.

(9) Assuming necessary dam safety responsibilities.

(10) Performing public information activities in accordance with annual plans.

(11) Conducting and participating in emergency action plan exercises.

(12) Water quality studies and activities for tributary and coastal streams.

(13) Collecting snow cover data from aerial flights and satellite imagery for use in spring flood forecasting (CENPS and CENPW).

8. PROJECT OFFICE ORGANIZATION AND RESPONSIBILITIES.

a. Organization and Coordination. Project offices are within the purview of CENPD Construction-Operations Division, with Operations organizations in district offices providing oversight to project engineers and staff. Interface with water management personnel in district or division offices occurs in the project regulation process. In routine regulation situations this is normally accomplished by direct contact between district or division reservoir regulation personnel and project personnel. In unusual situations, district or division managers may be brought into the communication line. For Columbia Basin projects, the NPD Reservoir Control Center communicates directly with project personnel, unless otherwise agreed or if special circumstances arise that would be of significance to the District (e.g., regulation that would be sensitive to local communities, or a change in operating plans).

b. Responsibilities. Project offices will be responsible for the following actions, with regard to water management.

(1) Carrying out instructions from Division/District water control managers.

(2) Reporting project status and hydromet data as required.

(3) Coordinating with water control managers regarding O&M activities that will affect project regulation.

(4) Carrying out responsibilities with regard to dam safety.

(5) Carrying out public information activities with regard to project regulation.

9. WATER MANAGEMENT BOARD. The Water Management Board is composed of district (excluding CENPA) and HQNPD representatives who consult with the Chief, CENPD-EN, on water management of the Columbia River reservoir system by CENPD-EN-WM. The purpose of the Board is to provide consultation on this Division-wide activity, to assist in resolving differences between division and district offices on setting policy, and to keep district offices better informed on the management of the Columbia River. The Board is an independent consultative body, reporting to the Chief, CENPD-EN and assisting him by presenting a perspective on the management of the Columbia River that reflects points of view of district offices and CENPD-CO. The Board receives overall direction from the Chief, CENPD-EN.

a. Composition. The HQNPD will be represented by the Chief, CENPD-EN and by the Chief, CENPD-CO-O or their representatives. Each District Office will be represented by the District Commander or his representative. These will be designated in writing to the Chief, CENPD-EN. Each office may have additional supporting staff to assist in the Board's activities, but there will be only one official spokesperson for each of the five organizations represented.

b. Board Chair. The Board meetings will be chaired by the Chief, CENPD-EN.

c. Meetings. The Board will have a formal meeting at least once a year, generally in the month of January or February. This time-frame is desirable because it provides the best opportunity to address matters pertaining to the current operational outlook, the development of the next year's Operating Plan, and the O&M budget submittal. Additional meetings may be requested by Board members and set by the Chief, CENPD-EN.

d. Responsibilities. The Board will address both routine items as listed below, and special issue topics requested by Board members or by Chief, CENPD-EN. Routine items are to include:

(1) The Corps' input to the Annual Operating Plan prepared by the Pacific Northwest Coordination Agreement Contract Committee.

(2) Requests for changes by board members to the current year's operating plan and actual system regulation, as driven by current water supply forecasts and operating requirements.

(3) The annual public information program.

(4) Water Management Branch's staffing expenditures, and budget, including staffing, budget, and expenditures for operating and maintaining the NPD CROHMS computer facility.

(5) CENPD-EN-WM (and other participants as appropriate) will prepare the necessary information to address agenda topics. Technical information will be distributed to Board members at least one week prior to the meeting.

e. Procedures. Prior to the scheduled Board meeting, the following will be implemented. For special Board meetings, similar procedures will be followed as appropriate.

(1) Chief, CENPD-EN will set the date of the meeting.

(2) Chief, CENPD-EN will solicit issue papers from Board members, which will be considered as agenda topics for the meeting. Additionally, the Chief, CENPD-EN will circulate to Board members his desires for agenda topics. The meeting agenda will be set by the Chief, CENPD-EN at least one month prior to the meeting/date.

(3) CENPD-EN-WM will provide an update of financial, budgetary, and staffing information to Board members at least two weeks prior to the meeting date.

(4) CENPD-EN-WM will provide the annual power operating plan and summary of the supporting refill study data for the current operating year two months before the meeting.

(5) CENPD-EN-WM (and other participants as appropriate) will prepare the necessary information to address agenda topics. Technical information will be distributed to Board members at least one week prior to the meeting.

f. Documentation. Minutes of Board meetings, along with any formal correspondence relating to the Board, will constitute the record of the Board's activities and actions. HQNPD will be responsible for recording, preparing, and distributing the minutes of the Board's meetings.

g. Resolution of Issues. Where there are unresolved issues, the Chief, CENPD-EN will submit a copy of the minutes along with his plan to address these issues to the Division Commander and the Board members.

10. PUBLIC INFORMATION. A reservoir regulation outlook will be developed by CENPD-EN-WM each year in January, reflecting Corps of Engineers obligations to the system, the first water supply forecasts for runoff in the northwest, projected reservoir regulation, and other factors. The reservoir regulation outlook is to address in particular the potential impacts of reservoir regulation on local users of the projects, such as reservoir and downstream river users. This outlook will be reviewed by the Water Management Board at its January/February meeting and a plan will be established with agreed-upon procedures for informing and involving the public regarding the regulation of reservoirs for the forthcoming winter-spring-summer period. In years having especially low or high runoff, or if other circumstances are expected to result in unusual project regulation, the board may recommend special public meetings. Otherwise routine procedures to inform the public would suffice. The Districts have the lead responsibility for public information, including gathering input from the public disseminating information, and organizing public meetings. Technical assistance will be provided by CENPD-EN-WM as necessary.

11. WATER CONTROL PLANS AND MANUALS.

a. Responsibilities. District offices have the responsibility for preparing and maintaining project water control plans and manuals, and HQNPD is responsible for reviewing and approving those manuals. In the case of several projects on the mainstem of the Columbia River which involve extensive system-wide coordination, HQNPD will also be involved in the preparation and maintenance of the plans and manuals. Appendix A indicates the Division/District responsibilities by project. HQNPD will also be responsible for preparing and maintaining two master water control manuals, for the Willamette and Columbia River basins.

b. Requirements. The following requirements and procedures apply to project water control manuals, with the objective of maintaining the most important parts of the manuals (including the water control plan) in an accurate and up-to-date status while utilizing a minimum of personnel resources.

(1) The water control plan for the project is to be current and accurate.

(2) The water control manual will be considered functional and officially acceptable if it contains at least an up-to-date plan. Preferably, it would also contain other chapters that are of a technical nature. It need not contain other chapters with general information to be a functional manual.

(3) Water control manuals will be updated such that the more important parts are given a higher priority.

(4) The manual will be contained in a loose-leaf binder with cover sheets at the front that indicate status of the chapters in the manual.

(5) District offices will prepare their annual status report to HQNPD in accordance with ER 1110-2-240. A division-wide report will be submitted to HQUSACE.

12. WATER CONTROL DATA SYSTEMS.

a. Responsibilities. General responsibilities as defined in ER 1110-2-240 and ER 1110-2-249 are for district offices to develop and maintain Water Control Data Systems, while HQNPD maintains approval authority for systems and networks through the submittal of the Master Plan for Water Control Data Systems and its annual updates. Because of the necessity of having a centralized data collection and processing system for the management of the Columbia River, the HQNPD has developed the Columbia River Operational Hydromet and Management System (CROHMS) in conjunction with district offices and other federal agencies. The maintenance of CROHMS, along with the Columbia Basin Telecommunications (CBT) system requires that the Division be involved with data collection at some projects. Appendix A defines specific areas of responsibility for each project.

b. Requirements and Procedures. ER 1110-2-240 gives specific requirements for submittal and updating of district and Division WCDS mater plans.

13. AFTER-ACTION REPORTING.

a. Routine Reports. ER 1110-2-240 requires that a Division report on water management activities be submitted to HQUSACE annually. For NPD, HQUSACE has permitted the Columbia River Water Management Group Annual Report to fulfill this requirement. This report is prepared by HQNPD at the end of each water year, with input requested from district offices. Another routine water management report prepared by HQNPD that may require district input is the Columbia River Treaty Annual Report.

* b. Special after-action reports. After the occurrence of large floods and other unusual events such as natural disasters, an after-action report may be required. General guidance on responsibilities for these are shown in Appendix A. *

FOR THE COMMANDER:

CLIFTON P. JACKSON, JR.
Executive Assistant

3 Appendices
App A - District/Division Water Management Responsibilities
App B - Definitions and Acronyms
App C - Division/District Organizations for Water Management

Distribution:
A and B

| PROJECT | OWNER | AUTHORITY | PRIMARY REGULATION | SECONDARY REGULATION | WATER CNTRL PLAN. | WAT SUPL FORECAST | STREAMFLOW FORECAST | WATER CNTRL DATA SYSTEM | WATER CNTRL MANUAL | AFTER-ACTION REPORTING |
|---|---|---|---|---|---|---|---|---|---|---|
| ....... UPPER COLUMBIA ........ | | | | | | | | | | |
| Mica | BCH | Treaty | NPD | | NPD | NWS* | NWS | NPD* | | NPD |
| Revelstoke | BCH | Power Coord | NPD | | NPD | NWS* | NWS | NPD* | | NPD |
| Hugh Keenleyside | BCH | Treaty | NPD | | NPD | NWS* | NWS | NPD* | | NPD |
| LIBBY | CE | Congress. | NPD | NPS | NPD/NPS | NPD/NWS | NWS | NPS/NPD* | NPS | NPD |
| Duncan | BCH | Treaty | NPD | | NPD | NWS* | NWS | NPD* | | NPD |
| Corra Linn | W KOOT P&L | Power Coord | NPD | | NPD | NWS | NWS | NPD* | | NPD |
| Kootenay Projects | BCH/W KOOT | Power Coord | NPD | | NPD | NWS | NWS | NPD* | | NPD |
| Hungry Horse | USBR | Section 7 | NPD | NPS | NPD | NWS* | NWS | NPD* | NPS/NPD* | NPD |
| Kerr | MONT P&L | FERC License | NPD | NPS | NPD | NWS | NWS | NPD* | | NPD |
| Thompson Falls | MONT P&L | Power Coord | NPD | | NPD | NWS | NWS | NPD* | | NPD |
| Noxon Rapids | WASH WP | Power Coord | NPD | | NPD | NWS | NWS | NPD* | | NPD |
| Cabinet Gorge | WASH WP | Power Coord | NPD | | NPD | NWS | NWS | NPD* | | NPD |
| ALBENI FALLS | CE | Congress. | NPD | NPS | NPD | NWS | NWS | NPD | NPS/NPD | NPD |
| Box Canyon | PEND PUD | Power Coord | NPD | | NPD | NWS | NWS | NPD* | | NPD |
| Boundry | SEATTLE CL | Power Coord | NPD | | NPD | NWS | NWS | NPD* | | NPD |
| Seven Mile | BCH | Power Coord | NPD | | NPD | NWS | NWS | NPD* | | NPD |
| Waneta | W KOOT P&L | Power Coord | NPD | | NPD | NWS | NWS | NPD* | | NPD |
| Spokane Projects | WASH WP | Power Coord | NPD | | NPD | NWS | NWS | NPD* | | NPD |
| Grand Coulee | USBR | Section 7 | NPD | | NPD | NWS | NWS | NPD* | NPD*/NPS | NPD |
| .......MID-COLUMBIA ....... | | | | | | | | | | |
| CHIEF JOSEPH | CE | Congress. | NPD | NPS | NPD | NWS | NWS | NPD | NPS/NPD | NPD |
| Wells | DOUGLAS PUD | FERC License | NPD | NPS | NPD | NWS | NWS | NPD* | NPS/NPD* | NPD |
| Rocky Reach | CHELAN PUD | FERC License | NPD | | NPD | NWS | NWS | NPD* | NPS/NPD* | NPD |
| Rock Island | CHELAN PUD | FERC License | NPD | | NPD | NWS | NWS | NPD* | NPS/NPD* | NPD |
| Wanapum | GRANT PUD | FERC License | NPD | | NPD | NWS | NWS | NPD* | NPS/NPD* | NPD |
| Priest Rapids | GRANT PUD | FERC License | NPD | | NPD | NWS | NWS | NPD* | NPS/NPD* | NPD |
| Yakima Projects | USBR | | NPD | NPS | NPD | NWS | NWS | NPD* | | NPS/NPD |
| ....... LOWER COLUMBIA ....... | | | | | | | | | | |
| HILL CREEK | CE | Congress. | NPW | | NPW | | | NPW | NPW | NPW |
| MCNARY | CE | Congress. | NPD | NPW | NPW | NWS | NWS | NPD | NPW | NPD |
| WILLOW CREEK | CE | Congress. | NPP | | NPP | | NWS | NPP | NPP | NPP |
| JOHN DAY | CE | Congress. | NPD | NPP | NPD/NPP | NWS | NWS | NPD | NPP | NPD |
| Prineville | USBR | Section 7 | NPP | | NPP | NWS | | NPP | NPP | NPP |
| Ochoco | USBR | Section 7 | NPP | | NPP | NWS | | NPP | NPP | NPP |
| THE DALLES | CE | Congress. | NPD | NPP | NPP | NWS | NWS | NPD | NPP | NPD |
| BONNEVILLE | CE | Congress. | NPD | NPP | NPP | NWS | NWS | NPD | NPP | NPD |
| Swift #1 & #2 | PP&L/COWLITZ | FERC License | NPD | NPP | NPD/NPP | | NWS | NPP | NPP* | NPP |
| Yale V | PP&L | FERC License | NPD | NPP | NPD/NPP | | NWS | NPP | NPP* | NPP |
| Mossyrock/ Mayfield | TACOMA CL | FERC License | NPD | NPP | NPD/NPP | | NWS | NPP | NPP/NPD* | NPP |

DISTRICT/DIVISION WATER MANAGEMENT RESPONSIBILITIES

APPENDIX A
NPDR 1165-2-2
DISTRICT/DIVISION WATER MANAGEMENT RESPONSIBILITIES

| PROJECT | OWNER | AUTHORITY | PRIMARY REGULATION | SECONDARY REGULATION | WATER CNTRL PLAN | WAT SUPL FORECAST | STREAMFLOW FORECAST | WATER CNTRL DATA SYSTEM | WATER CNTRL MANUAL | AFTER-ACTION REPORTING |
|---|---|---|---|---|---|---|---|---|---|---|
| ....... WILLAMETTE ....... | | | | | | | | | | |
| HILLS CREEK | CE | Congress. | NPD | NPP | NPP/NPD | NPP | NWS/NPD | NPP | NPP | NPP/NPD |
| LOOKOUT POINT | CE | Congress. | NPD | NPP | NPP/NPD | NPP | NWS/NPD | NPP | NPP | NPP/NPD |
| DEXTER | CE | Congress. | NPD | NPP | NPP/NPD | | NWS/NPD | NPP | NPP | NPP/NPD |
| FALL CREEK | CE | Congress. | NPD | NPP | NPP/NPD | | NWS/NPD | NPP | NPP | NPP/NPD |
| COTTAGE GROVE | CE | Congress. | NPD | NPP | NPP/NPD | | NWS/NPD | NPP | NPP | NPP/NPD |
| DORENA | CE | Congress. | NPD | NPP | NPP/NPD | | NWS/NPD | NPP | NPP | NPP/NPD |
| COUGAR | CE | Congress. | NPD | NPP | NPP/NPD | | NWS/NPD | NPP | NPP | NPP/NPD |
| BLUE RIVER | CE | Congress. | NPD | NPP | NPP/NPD | NPP | NWS/NPD | NPP | NPP | NPP/NPD |
| FERN RIDGE | CE | Congress. | NPD | NPP | NPP/NPD | | NWS/NPD | NPP | NPP | NPP/NPD |
| GREEN PETER | CE | Congress. | NPD | NPP | NPP/NPD | NPP | NWS/NPD | NPP | NPP | NPP/NPD |
| FOSTER | CE | Congress. | NPD | NPD | NPP/NPD | | NWS/NPD | NPP | NPP | NPP/NPD |
| DETROIT | CE | Congress. | NPD | NPP | NPP/NPD | NPP | NWS/NPD | NPP | NPP | NPP/NPD |
| BIG CLIFF | CE | Congress. | NPD | NPP | NPP/NPD | | NWS/NPD | NPP | NPP | NPP/NPD |
| Scoggins | USBR | Section 7 | NPP | NPD | NPP | | NWS | | | |
| ....... UPPER SNAKE ....... | | | | | | | | | | |
| Jackson Lake | USBR | Section 7 | NPW | NPD | NPW | NWS/NPW* | NWS | NPW/NPD* | NPW* | NPW |
| Palisades | USBR | Section 7 | NPW | NPD | NPW | NWS/NPW* | NWS | NPW/NPD* | NPW* | NPW |
| Ririe | USBR | Section 7 | NPW | NPD | NPW | NWS* | NWS | NPW/NPD* | NPW* | NPW |
| American Falls | USBR | | | NPW | NPW | NWS* | NWS | NPW/NPD* | | NPW |
| Little Wood | USBR | Section 7 | NPW | | NPW | NWS* | NWS | NPW/NPD* | | NPW |
| Owyhee | USBR | | | NPW | NPW | NWS* | NWS | NPW/NPD* | | NPW |
| Anderson Ranch | USBR | Section 7 | NPW | NPD | NPW | NWS/NPW* | NWS | NPW* | NPW* | NPW |
| Arrowrock | USBR | Section 7 | NPW | NPD | NPW | NWS/NPW* | NWS | NPW* | NPW* | NPW |
| LUCKY PEAK | CE | Congress. | NPW | NPD | NPW | NWS/NPW* | NWS | NPW* | NPW | NPW |
| Warm Springs | USBR | Section 7 | NPW | | NPW | NWS* | NWS | NPW* | NPW* | NPW |
| Agency Valley | USBR | Section 7 | NPW | | NPW | NWS* | NWS | NPW* | NPW* | NPW |
| Bully Creek | USBR | Section 7 | NPW | | NPW | NWS* | NWS | NPW* | NPW* | NPW |
| Cascade | USBR | | | NPW | NPW | NWS* | NWS | NPW* | NPW* | NPW |
| Deadwood | USBR | | | NPW | NPW | NWS* | NWS | NPW* | NPW* | NPW |
| Mason | USBR | Section 7 | NPW | | NPW | NWS* | NWS | NPW* | NPW* | NPW |
| .......MID, LOWER SNAKE ....... | | | | | | | | | | |
| Brownlee | IDAHO POW | FERC License | NPD | NPD/NPW | NPD | NWS | NWS | NPD* | NPW/NPD* | NPD/NPW |
| Oxbow | IDAHO POW | FERC License | NPW | NPD/NPW | NPD | NWS | NWS | NPD* | NPW/NPP* | NPD/NPW |
| Hells Canyon | IDAHO POW | FERC License | NPD | NPD/NPW | NPD | NWS | NWS | NPD* | NPW/NPD* | NPD/NPW |
| DWORSHAK | CE | Congress. | NPD | NPW | NPD/NPW | NPW/NPD | NWS | NPW | NPW | NPD/NPW |
| LOWER GRANITE | CE | Congress. | NPD | NPW | NPD | NWS | NWS | NPW | NPW | NPD/NPW |
| LITTLE GOOSE | CE | Congress. | NPD | NPW | NPD | NWS | NWS | NPD | NPW | NPD/NPW |
| LOWER MONUMENTAL | CE | Congress. | NPD | NPW | NPD | NWS | NWS | NPD | NPW | NPD/NPW |
| ICE HARBOR | CE | Congress. | NPD | NPW | NPD | NWS | NWS | NPD | NPW | NPD/NPW |

:NDIX A
« 1165-2-2.

DISTRICT/DIVISION WATER MANAGEMENT RESPONSIBILITIES

| PROJECT | OWNER | AUTHORITY | PRIMARY REGULATION | SECONDARY REGULATION | WATER CNTRL PLAN | WAT SUPL FORECAST | STREAMFLOW FORECAST | WATER CNTRL DATA SYSTEM | WATER CNTRL MANUAL | AFTER-ACTION REPORTING |
|---|---|---|---|---|---|---|---|---|---|---|
| .......PUGET SOUND ....... | | | | | | | | | | |
| Ross/Diablo | SEATTLE CL | FERC License | NPS | | NPS | | NWS | NPS* | NPS* | NPS |
| Upper/Lower Baker | PUGET P&L | FERC License | NPS | | NPS | | NWS | NPS* | NPS* | NPS |
| LAKE WASHINGTON | CE | Congress. | NPS | | NPS | | NWS | NPS | NPS | NPS |
| HOWARD A HANSON | CE | Congress. | NPS | | NPS | NPS | NPS/NWS | NPS | NPS | NPS |
| MUD MOUNTAIN | CE | Congress. | NPS | | NPS | | NPS/NWS | NPS | NPS | NPS |
| WYNOOCHEE | CE | Congress. | NPS | | NPS | NPS | NPS/NWS | NPS | NPS | NPS |
| .......COASTAL ....... | | | | | | | | | | |
| Galesville | DOUGLAS COUNTY | Section 7 | NPP | | NPP | | NWS | NPP* | NPP* | NPP |
| LOST CREEK | CE | Congress. | NPP | NPD | NPP | NPP | NWS/NPP | NPP | NPP | NPP |
| ELK CREEK | CE | Congress. | NPP | NPD | NPP | | NWS/NPP | NPP | NPP | NPP |
| Emigrant | USBR | Congress. | NPP | NPP | NPP | | | | | |
| APPLEGATE | CE | Congress. | NPP | NPD | NPP | NPP | NWS/NPP | NPP | NPP | NPP |

NOTES

1. Corps of Engineers projects are listed in capital letters

2. Asterisks (*) indicate that coordination with another agency is required in carrying out the responsibility. This notation was not used for the regulation function, since interagency coordination is assumed to be inherent in the process.

3. When joint responsibilities are shown, the office with lead responsibility is shown first.

4. Headings: "Primary Regulation" - prime responsibility for day-to-day regulation of the project, or coordination required to regulate the project as a part of a system.

   "Secondary Regulation" - periodic regulation responsibilities along with continuous monitoring of the project's operation.

   "Water Control Plan" - development and updating of the project's Water Control Plan. This may be for either the project's Water Control Manual or for coordinated system operation.

   "Water Supply Forecast" - development and updating of water supply forecast procedure for the project.

   "Streamflow Forecast" - Development, updating and implementation of streamflow forecasting procedure for project.

   "Water Control Data System" - Development, maintenance, and implementation of project's WCDS.

   "Water Control Manual" - Development and updating of project's Water Control Manual.

   "After-Action Reporting" - Routine or special reports such as post-flood reports.

APPENDIX B
DEFINITIONS AND ACRONYMS

Primary Regulation. For the purposes of this regulation the term primary regulation is meant to indicate the lead regulation responsibility for a project. This involves frequent monitoring of the project, the issuing of operating instructions, and personal contact with project operators. It also involves the necessary analysis required to make regulating decisions.

Secondary Regulation. For purposes of this regulation the term "secondary regulation" means the responsibility to maintain surveillance of their project's regulation to provide information to others and to participate in periodic coordination that may be necessary.

Regulation/Operation. The term "regulation" as applied to water management means the activity of regulating reservoirs, including receiving information and data on reservoir status, making analysis and decisions, coordinating with affected parties/agencies, and issuing instructions to dam operators. In this NPDR the term "regulation" is kept distinct from "operation" which refers to the actions by field personnel of maintaining and physically operating equipment at projects.

Water Control Data Systems (WCDS). A system of gages, telemetry, and computer processors that collects hydrometeorological data from remote sites and sends it to computer controllers for processing and use by water control managers.

Water Control Manual. A manual used as reference for regulating a reservoir project or system of projects. It contains a Water Control Plan, a specific plan of regulation for that project.

BPA Bonneville Power Administration

CBT Columbia Basin Telecommunications Network. A data communication network within CROHMS.

CROHMS The Columbia River Operational Hydromet and Management System, the name given to the Water Control Data System for the Columbia River.

GOES Geostationary Operational Environmental Satellite. A hydromet data collection system within CROHMS.

NWPP Northwest Power Pool.

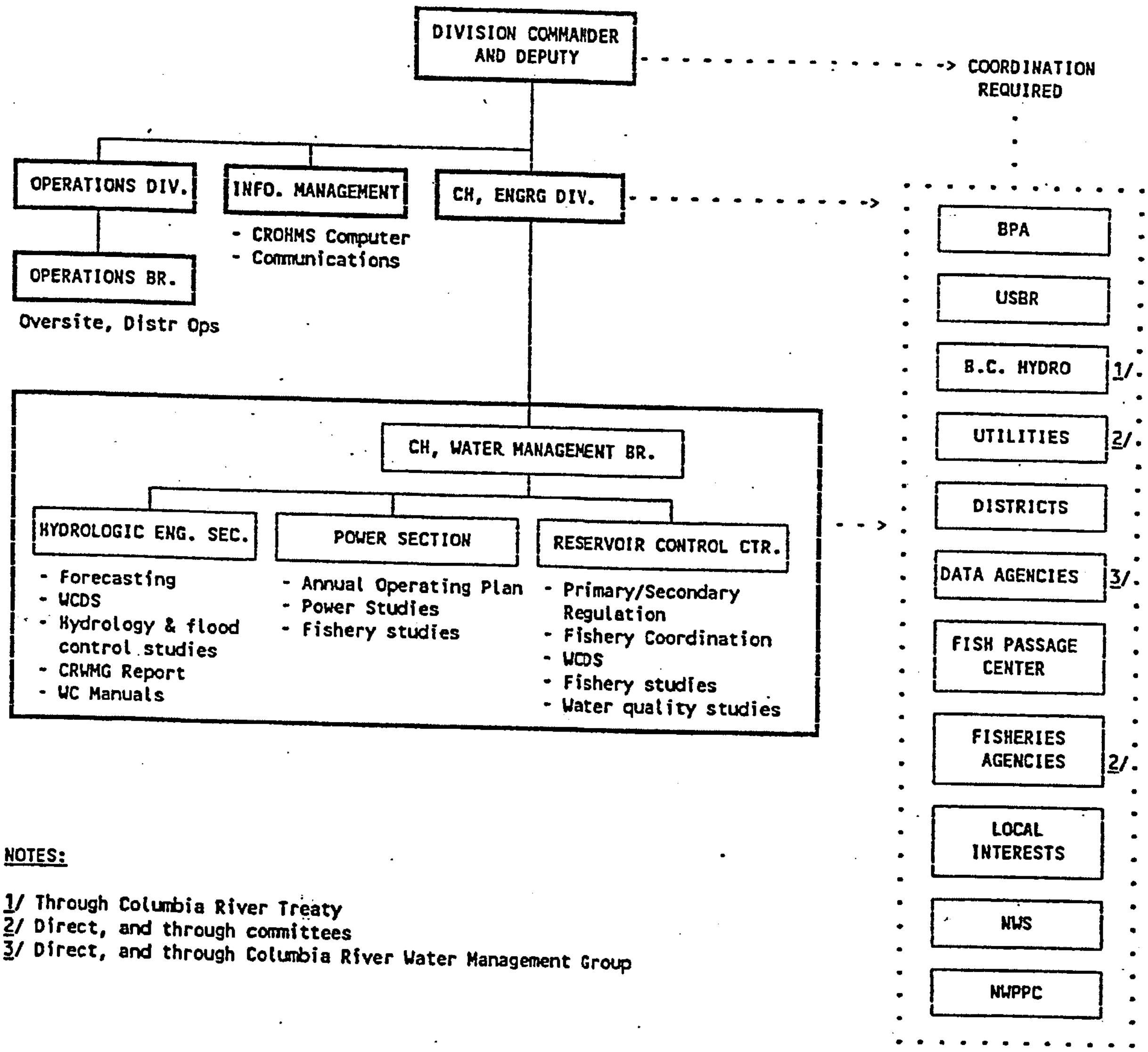
NWRFC Northwest River Foreast Center, National Weather Service.

USBR Bureau of Reclamation

APPENDIX C

DIVISION/DISTRICT ORGANIZATION FOR WATER MANAGEMENT

DIVISION OFFICE




NOTES:

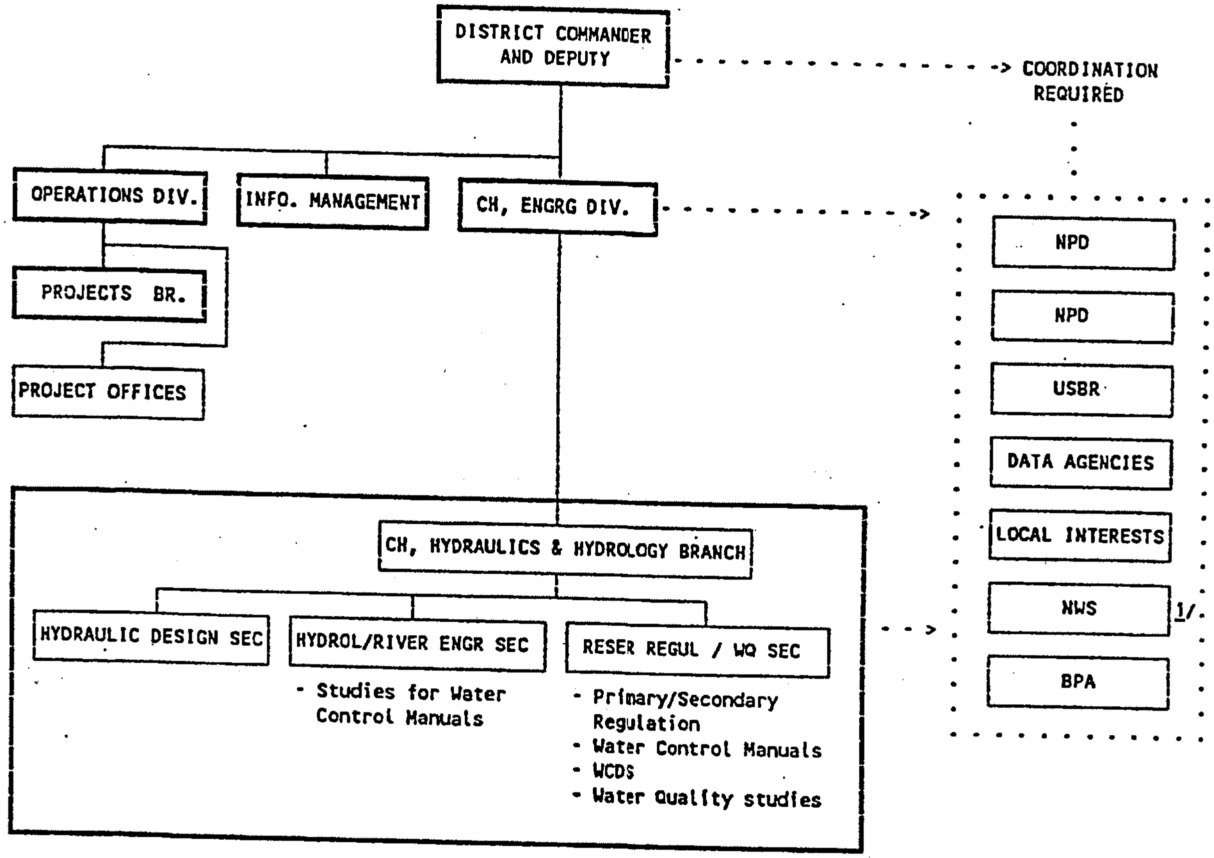
1/ Through Columbia River Treaty
2/ Direct, and through committees
3/ Direct, and through Columbia River Water Management Group

EXHIBIT 1-1

APPENDIX C (CONTINUED)

DIVISION/DISTRICT ORGANIZATION FOR WATER MANAGEMENT

PORTLAND DISTRICT OFFICE



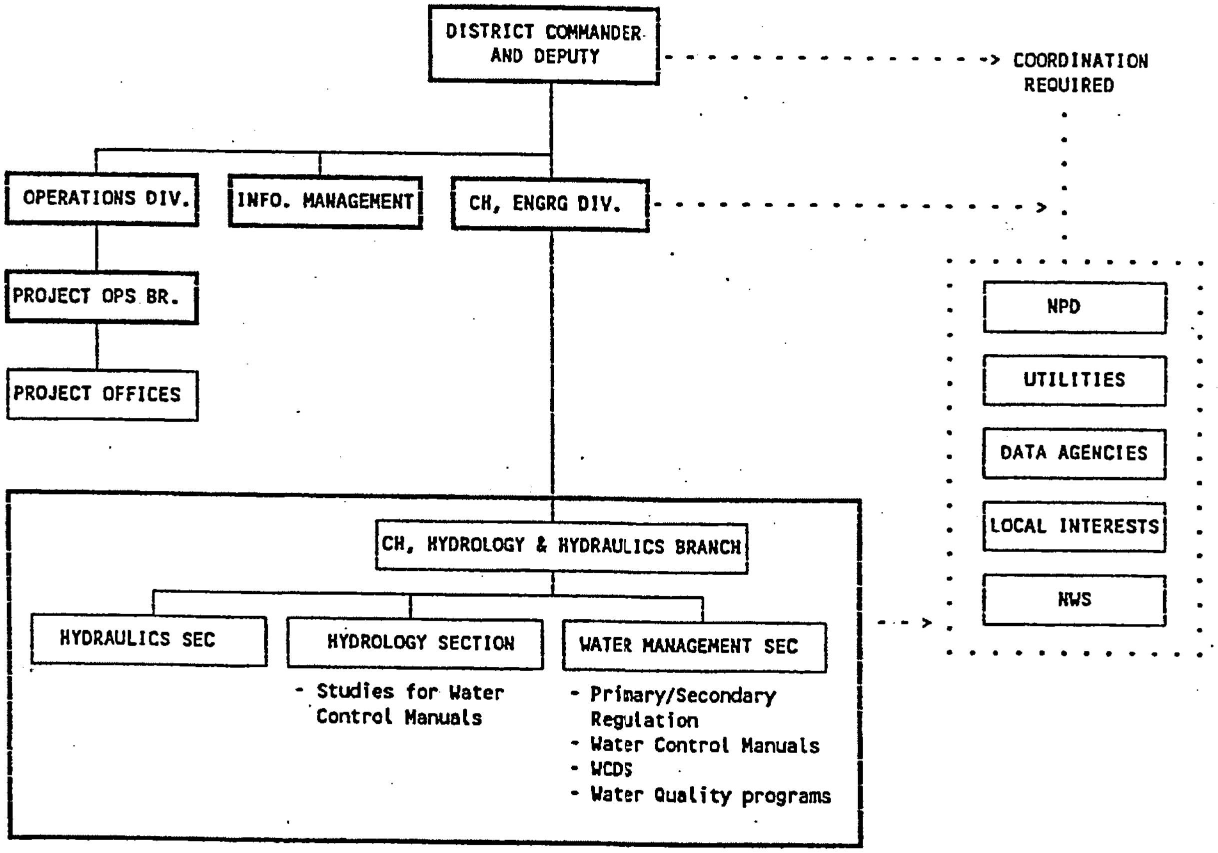

NOTES:

1/ Coordination at Lost Creek

APPENDIX C (CONTINUED)

DIVISION/DISTRICT ORGANIZATION FOR WATER MANAGEMENT

SEATTLE DISTRICT OFFICE



APPENDIX C (CONTINUED)

DIVISION/DISTRICT ORGANIZATION FOR WATER MANAGEMENT

WALLA WALLA DISTRICT OFFICE

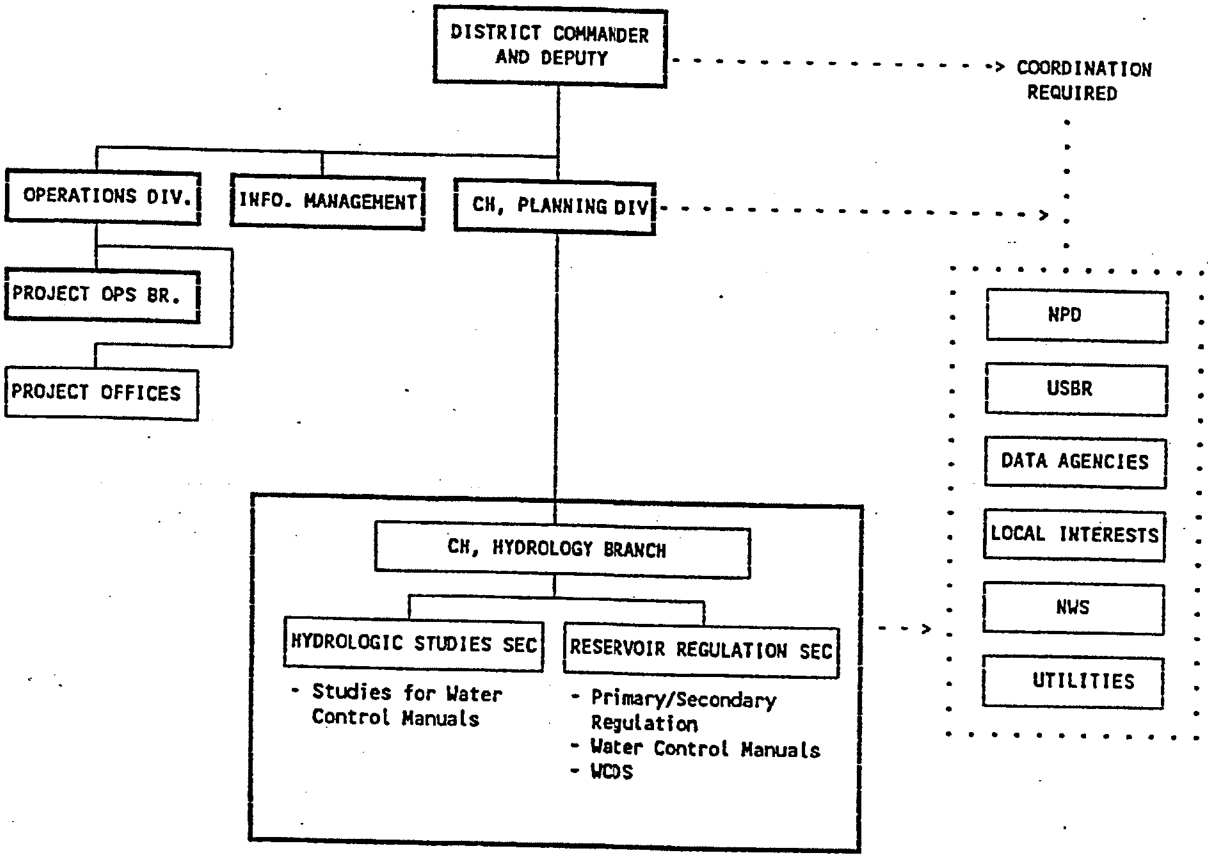



EXHIBIT 1-1

MUD MOUNTAIN DAM
REPORTS AND REFERENCES

| Item | Subject | Date |
|---|---|---|
| 1. | Construction Plans | — |
| 2. | Geological Report, Edwin T. Hodge | 18 July 1938 |
| 3. | Analysis of Design, Mud Mountain Dam | 03 December 1938 |
| 4. | Design of Mud Mountain Dam and Appurtenances | 30 December 1938 |
| 5. | Report on Soil Tests for Mud Mountain Dam | 11 May 1939 |
| 6. | TM 164-1, WES, Results of Soil Test on Materials from Proposed Mud Mountain Dam | 20 December 1939 |
| 7. | Contract Specifications for the Dam | 1939 |
| 8. | Test Fill Report for Mud Mountain Dam | — |
| 9. | Bonneville Hydraulic Laboratory, Model Study of the Spillway for Mud Mountain Dam | 1942 |
| 10. | WES Bulletin No. 14, Permeability Characteristics of Mud Mountain Imprevious Clay Materials | 20 February 1942 |
| 11. | Foundation Report | 21 March 1942 |
| 12. | Bonneville Hydraulic Laboratory, Model Study of the 23-Foot Outlet Tunnel for Mud Mountain Dam | 15 July 1942 |
| 13. | Prototype Testing | January 1945 |
| 14. | Agenda for Consulting Board Meeting | 28-29 July 1945 |
| 15. | Analysis of Design—Embankment Design | 1946 |
| 16. | Analysis of Design—Design Other Than Embankment | 1946 |
| 17. | Analysis of Design—Original 9-Foot Gate, Modified 9-Foot Gate and Cable Way | 1946 |
| 18. | Master Recreation Plan | 1946 |

| Item | Subject | Date |
| --- | --- | --- |
| 19. | Real Estate, Preliminary Planning Report—Civil Project—Tracts 14 and 15 | 04 March 1948 |
| 20. | Supplement to Agenda for Consulting Board Meeting | 28-29 July 1948 |
| 21. | Proceedings of Consulting Board Meeting | 28-29 July 1948 |
| 22. | Real Estate, Preliminary Planning Report—Civil Project—Easements for Radio Reporting Network, Puyallup River Basin, Mud Mountain Dam | 04 May 1949 |
| 23. | Proposed Improvements—Right Bank | January 1950 |
| 24. | Proposed Revisions—Outlet Works | January 1950 |
| 25. | Real Estate Supplement to Preliminary Planning Report—Easements for Radio Reporting Network, Puyallup River Basin, Mud Mountain Dam | 13 February 1950 |
| 26. | Real Estate Supplement to Supplement dated 13 February 1950 (same title) | 06 March 1952 |
| 27. | Reservoir Regulation Manual | August 1954 |
| 28. | Real Estate Planning Report—Civil Project—Mud Mountain Dam, Piezometer Stations | 26 August 1954 |
| 29. | Real Estate—Design Memorandum No. 1—Access Road and Bridge | 11 February 1958 |
| 30. | Design Memorandum (unnumbered)—Improved Access Upstream and Downstream Outlet Works Structures | December 1960 |
| 31. | Design Memorandum Supplement No. 1—Improved Access to Upstream and Downstream Outlet Works Structures | December 1962 |
| 32. | Design Memorandum No. 1B—Reservoir Management and Public Use Development (Master Plan) | March 1964 |

| Item | Subject | Date |
|---|---|---|
| 33. | Report of Earthquake Damage | 1965 |
| 34. | Periodic Inspection and Continued Evaluation Report—Inspection of: | 20 July 1967 |
| 35. | Design Memorandum No. 1B Revised Master Plan | December 1968 |
| 36. | Periodic Inspection and Continuing Evaluation Report—Inspection of: | 29 April 1969 |
| 37. | Periodic Inspection and Continuing Evaluation Report No. 3—Inspection of: | 07 October 1971 |
| 38. | Environmental Impact Statement—Mud Mountain Dam and Reservoir, White River, Washington | April 1972 |
| 39. | Cableway Replacement Planning Report | May 1973 |
| 40. | Periodic Inspection and Continuing Evaluation Report No. 4—Inspection of: | 23 May 1973 |
| 41. | Feasibility of Forest Management Determination Report | December 1973 |
| 42. | Mud Mountain Dam, Interpretive Concept Plan | April 1974 |
| 43. | USGS Water Resources Investigation 78-113 Sediment Transportation by the White River into Mud Mountain Reservoir | June 1974-June 1976 |
| 44. | Design Memorandum No. 20B—The Mud Mountain Dam Master Plans, Phase III | September 1974 |
| 45. | Periodic Inspection and Continuing Evaluation Report No. 5—Inspection of: | 22 April 1975 |
| 46. | Design Memorandum No. 1C—Mud Mountain Master Plan | April 1976 |
| 47. | Design Memorandum No. 2—Visitors Center | May 1976 |
| 48. | Design Memorandum No. 3—Water Treatment Plant | September 1976 |

| Item | Subject | Date |
| --- | --- | --- |
| 49. | Real Estate—Design Memorandum No. 8—Revised Guide Taking Line | September 1976 |
| 50. | Means of Improving the Capability and Quality of the Water System—Harstad Accounts, Inc. | March 1977 |
| 51. | Periodic Inspection Report No. 6—Inspection of: | April 1977 |
| 52. | Design Memorandum No. 4—Stabilizing Right Downstream Bank | September 1977 |
| 53. | Design Memorandum No. 5—Construction of Road on Upstream Face of Dam | September 1977 |
| 54. | Design Memorandum No. 6—Stop Log Hoist for 9-Foot Tunnel | September 1978 |
| 55. | Report on Right Rim Reservoir Leakage | December 1978 |
| 56. | Design Memorandum No. 7—Rehabilitation of Apron Structure for 9-Foot Tunnel | August 1979 |
| 57. | Supplement No. 1 to Design Memorandum 1C—Landscaping and Parking Improvements | October 1979 |
| 58. | Design Memorandum No. 12—Supplement No. 9, Rockfill Dam, Spillway Outlet Works and Related Project Facilities | — |
| 59. | Operational and Maintenance Manual | June 1981 |
| 60. | Emergency Preparedness Brief with Dam Break Flood Inundation Maps | April 1982 |
| 61. | Periodic Inspection Report No. 7—Inspection of: | 05 May 1982 |
| 62. | Effect of Mud Mountain Dam Regulation on Sediment Movement in the White River, Northwest Hydraulic Consultants, Inc. | July 1983 |
| 63. | Design Memorandum No. 25—Earthquake Analysis of Mud Mountain Dam | September 1983 |
| 64. | Reconnaissance Report for Mud Mountain Dam, Dam Safety Assurance Program | April 1984 |

| Item | Subject | Date |
| --- | --- | --- |
| 65. | Preliminary Reconnaissance report on Seepage Studies at Mud Mountain Dam | 20 August 1985 |
| 66. | Reconnaissance Report on Seepage Control, Mud Mountain Dam | 13 December 1985 |
| 67. | Real Estate--Design Memorandum No. 27--Contractor Staging Area Dam Safety Assurance Program, Mud Mountain Dam | January 1986 |
| 68. | General Design Memorandum No. 26. --Dam Safety Assurance Program, Mud Mountain Dam | July 1986 |
| 69. | Supplement No. 1 to General Design Memorandum No. 26--Mud Mountain Dam Seepage Control Measures | November 1986 |
| 70. | Feature Design Memorandum No. 28--Intake Tower, Mud Mountain Dam | 1988 |
| 71. | Letter Supplement No. 1 to Real Estate Design Memorandum No. 27, Access Road And Bridge | June 1987 |
| 72. | Hydrology & Hydraulics Section File, 11-2-240a, Mud Mountain Dam O&M, Flood Routing--Standard Project Flood | December 1951 |
| 73. | Hydrology & Hydraulics Section File, 11-2-240a, Mud Mountain Dam O&M, Project Design Flood (PDF) Review by McGrane | April 1992 |

**REDACTED CONTENT**

**REDACTED CONTENT**

**REDACTED CONTENT**

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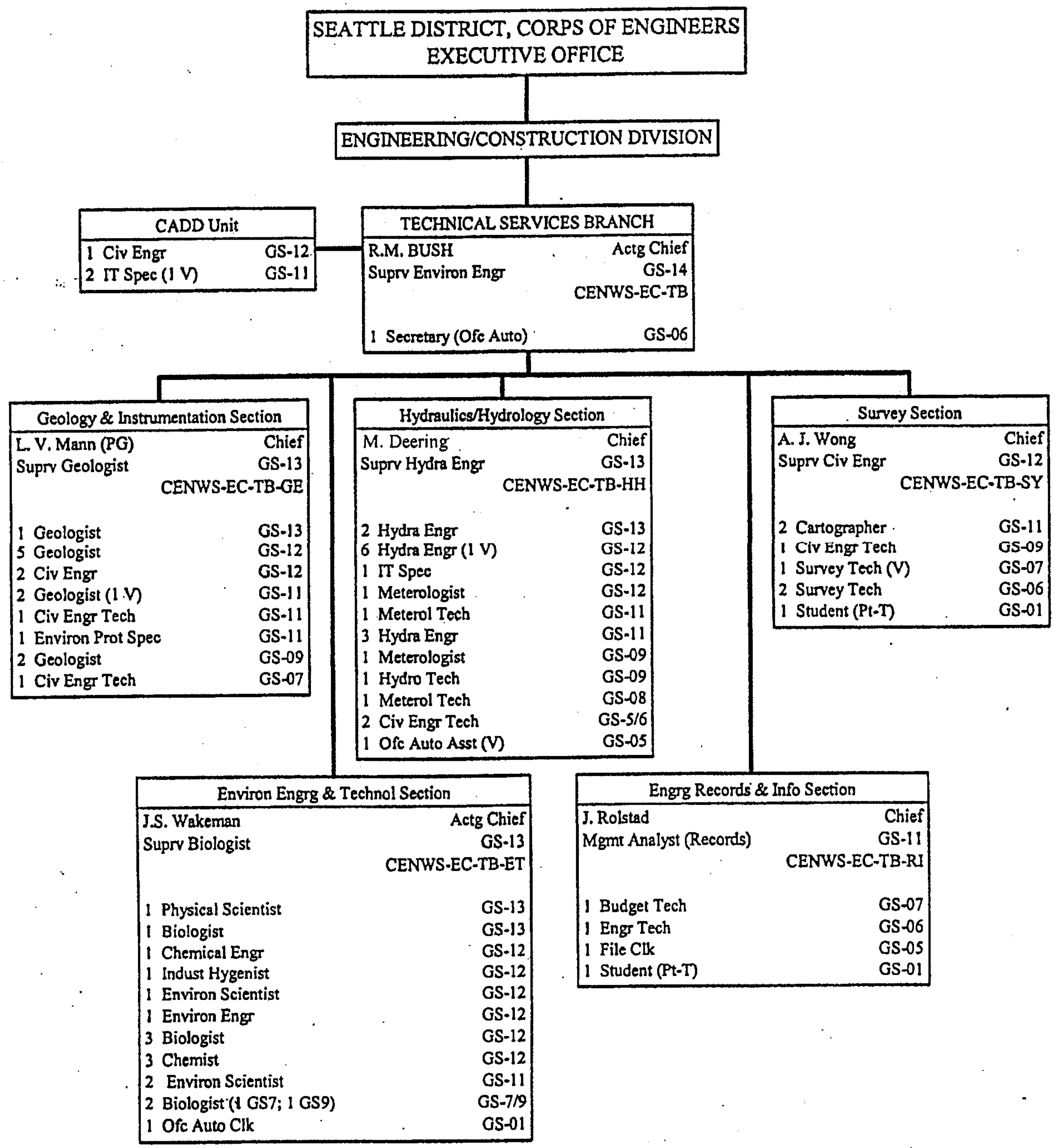
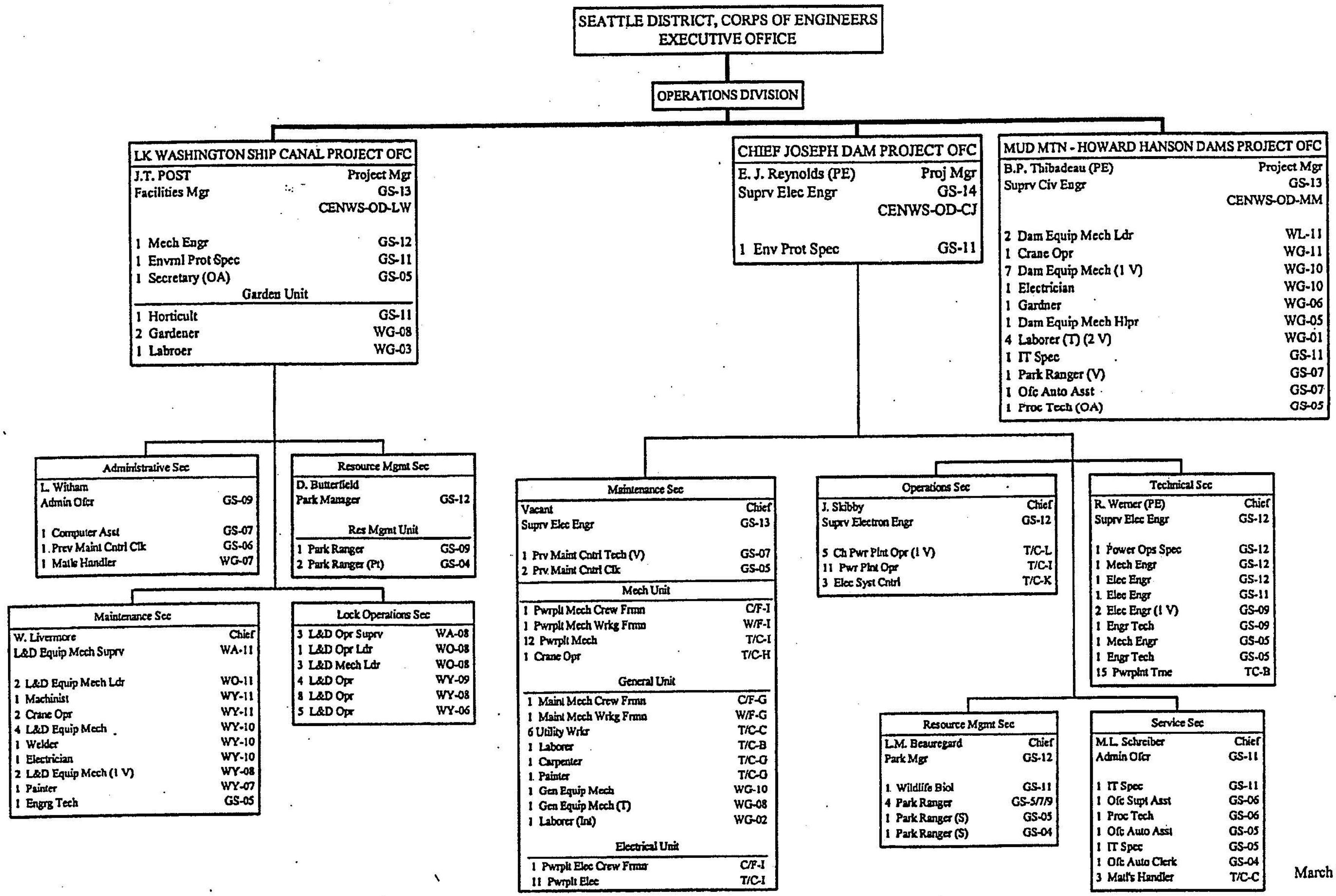
REDACTED CONTENT

**REDACTED CONTENT**

REDACTED CONTENT


SEATTLE DISTRICT, CORPS OF ENGINEERS
EXECUTIVE OFFICE
ENGINEERING/CONSTRUCTION DIVISION
TECHNICAL SERVICES BRANCH
R.M. BUSH Actg Chief
Suprv Environ Engr GS-14
CENWS-EC-TB
1 Secretary (Ofc Auto) GS-06
CADD Unit
1 Civ Engr GS-12
2 IT Spec (1 V) GS-11
Geology & Instrumentation Section
L. V. Mann (PG) Chief
Suprv Geologist GS-13
CENWS-EC-TB-GE
1 Geologist GS-13
5 Geologist GS-12
2 Civ Engr GS-12
2 Geologist (1 V) GS-11
1 Civ Engr Tech GS-11
1 Environ Prot Spec GS-11
2 Geologist GS-09
1 Civ Engr Tech GS-07
Hydraulics/Hydrology Section
M. Deering Chief
Suprv Hydra Engr GS-13
CENWS-EC-TB-HH
2 Hydra Engr GS-13
6 Hydra Engr (1 V) GS-12
1 IT Spec GS-12
1 Meterologist GS-12
1 Meterol Tech GS-11
3 Hydra Engr GS-11
1 Meterologist GS-09
1 Hydro Tech GS-09
1 Meterol Tech GS-08
2 Civ Engr Tech GS-5/6
1 Ofc Auto Asst (V) GS-05
Survey Section
A. J. Wong Chief
Suprv Civ Engr GS-12
CENWS-EC-TB-SY
2 Cartographer GS-11
1 Civ Engr Tech GS-09
1 Survey Tech (V) GS-07
2 Survey Tech GS-06
1 Student (Pt-T) GS-01
Environ Engrg & Technol Section
J.S. Wakeman Actg Chief
Suprv Biologist GS-13
CENWS-EC-TB-ET
1 Physical Scientist GS-13
1 Biologist GS-13
1 Chemical Engr GS-12
1 Indust Hygenist GS-12
1 Environ Scientist GS-12
1 Environ Engr GS-12
3 Biologist GS-12
3 Chemist GS-12
2 Environ Scientist GS-11
2 Biologist (1 GS7; 1 GS9) GS-7/9
1 Ofc Auto Clk GS-01
Engrg Records & Info Section
J. Rolstad Chief
Mgmt Analyst (Records) GS-11
CENWS-EC-TB-RI
1 Budget Tech GS-07
1 Engr Tech GS-06
1 File Clk GS-05
1 Student (Pt-T) GS-01

March 02


SEATTLE DISTRICT, CORPS OF ENGINEERS
EXECUTIVE OFFICE
OPERATIONS DIVISION
LK WASHINGTON SHIP CANAL PROJECT OFC
J.T. POST Project Mgr
Facilities Mgr GS-13
CENWS-OD-LW
1 Mech Engr GS-12
1 Envml Prot Spec GS-11
1 Secretary (OA) GS-05
Garden Unit
1 Horticult GS-11
2 Gardener WG-08
1 Labroer WG-03
Administrative Sec
L. Witham
Admin Ofcr GS-09
1 Computer Asst GS-07
1 Prev Maint Cntrl Clk GS-06
1 Matls Handler WG-07
Resource Mgmt Sec
D. Butterfield
Park Manager GS-12
Res Mgmt Unit
1 Park Ranger GS-09
2 Park Ranger (Pt) GS-04
Maintenance Sec
W. Livermore Chief
L&D Equip Mech Suprv WA-11
2 L&D Equip Mech Ldr WO-11
1 Machinist WY-11
2 Crane Opr WY-11
4 L&D Equip Mech WY-10
1 Welder WY-10
1 Electrician WY-10
2 L&D Equip Mech (1 V) WY-08
1 Painter WY-07
1 Engrg Tech GS-05
Lock Operations Sec
3 L&D Opr Suprv WA-08
1 L&D Opr Ldr WO-08
3 L&D Mech Ldr WO-08
4 L&D Opr WY-09
8 L&D Opr WY-08
5 L&D Opr WY-06
CHIEF JOSEPH DAM PROJECT OFC
E. J. Reynolds (PE) Proj Mgr
Suprv Elec Engr GS-14
CENWS-OD-CJ
1 Env Prot Spec GS-11
Maintenance Sec
Vacant Chief
Suprv Elec Engr GS-13
1 Prv Maint Cntrl Tech (V) GS-07
2 Prv Maint Cntrl Clk GS-05
Mech Unit
1 Pwrplt Mech Crew Frmn C/F-I
1 Pwrplt Mech Wrkg Frmn W/F-I
12 Pwrplt Mech T/C-I
1 Crane Opr T/C-H
General Unit
1 Maint Mech Crew Frmn C/F-G
1 Maint Mech Wrkg Frmn W/F-G
6 Utility Wrkr T/C-C
1 Laborer T/C-B
1 Carpenter T/C-G
1 Painter T/C-G
1 Gen Equip Mech WG-10
1 Gen Equip Mech (T) WG-08
1 Laborer (Int) WG-02
Electrical Unit
1 Pwrplt Elec Crew Frmn C/F-I
11 Pwrplt Elec T/C-I
Operations Sec
J. Skibby Chief
Suprv Electron Engr GS-12
5 Ch Pwr Plnt Opr (1 V) T/C-L
11 Pwr Plnt Opr T/C-I
3 Elec Syst Cntrl T/C-K
Technical Sec
R. Werner (PE) Chief
Suprv Elec Engr GS-12
1 Power Ops Spec GS-12
1 Mech Engr GS-12
1 Elec Engr GS-12
1 Elec Engr GS-11
2 Elec Engr (1 V) GS-09
1 Engr Tech GS-09
1 Mech Engr GS-05
1 Engr Tech GS-05
15 Pwrplnt Trne TC-B
Resource Mgmt Sec
L.M. Beauregard Chief
Park Mgr GS-12
1 Wildlife Biol GS-11
4 Park Ranger GS-5/7/9
1 Park Ranger (S) GS-05
1 Park Ranger (S) GS-04
Service Sec
M.L. Schreiber Chief
Admin Ofcr GS-11
1 IT Spec GS-11
1 Ofc Supt Asst GS-06
1 Proc Tech GS-06
1 Ofc Auto Asst GS-05
1 IT Spec GS-05
1 Ofc Auto Clerk GS-04
3 Matl's Handler T/C-C
MUD MTN - HOWARD HANSON DAMS PROJECT OFC
B.P. Thibadeau (PE) Project Mgr
Suprv Civ Engr GS-13
CENWS-OD-MM
2 Dam Equip Mech Ldr WL-11
1 Crane Opr WG-11
7 Dam Equip Mech (1 V) WG-10
1 Electrician WG-10
1 Gardner WG-06
1 Dam Equip Mech Hlpr WG-05
4 Laborer (T) (2 V) WG-01
1 IT Spec GS-11
1 Park Ranger (V) GS-07
1 Ofc Auto Asst GS-07
1 Proc Tech (OA) GS-05

March 02

# Chapter 173–510 WAC
# INSTREAM RESOURCES PROTECTION PROGRAM—PUYALLUP RIVER BASIN, WATER RESOURCE INVENTORY AREA (WRIA) 10



**WAC 173–510–010 General provision.** These rules apply to waters within the Puyallup River basin, WRIA 10, as defined in WAC 173–500–040. This chapter is promulgated pursuant to chapter 90.54 RCW (Water Resources Act of 1971), chapter 90.22 RCW (minimum water flows and levels), and in accordance with chapter 173–500 WAC (water resources management program). [Statutory Authority: Chapters 90.22 and 90.54 RCW. 80–04–047 (Order DE 79–31), § 173–510–010, filed 3/21/80.]

**WAC 173–510–020 Purpose.** The purpose of this chapter is to retain perennial rivers, streams, and lakes in the Puyallup River basin with instream flows and levels necessary to provide protection for wildlife, fish, scenic–aesthetic, environmental values, recreation, navigation, and to preserve high water quality standards. [Statutory Authority: Chapters 90.22 and 90.54 RCW. 80–04–047 (Order DE 79–31), § 173–510–020, filed 3/21/80.]

**WAC 173–510–030 Establishment of instream flows.** (1) Stream management units and associated control stations are established as follows:

Stream Management Unit Information

| Control Station No. Stream Management Unit Name | Control Station by River Mile and Section, Township, and Range | Affected Stream Reach(es) |
|---|---|---|
| 12–0965.00 Upper Puyallup River | 12.2 25–20–4E | Confluence with Puyallup River to the headwaters including all tributaries |
| 12–0957.00 Carbon River | 0.1 13–19–4E | From the confluence with the White River to the headwaters including all tributaries, excluding the Carbon River. |
| 12 1015.00 Lower Puyallup River | 6.6 20-20N-R4E | From the influence of mean annual high tide at low base flow levels to the confluence with the White River including all tributaries and excluding the White River. |

(2) Instream flows are established for the stream management units in WAC 173–510–030(1) as follows:

Instream Flows in the Puyallup River Basin

(in cubic feet per second)

| Month | Day | 12–0965.00 Puyallup River (At Alderton) | 12–1015.00 Puyallup River | 12–0957.00 Carbon River |
|---|---|---|---|---|
| Jan | 1 | 700 | 1400 | 600 |
| | 15 | 700 | 1400 | 550 |
| Feb | 1 | 750 | 1400 | 550 |
| | 15 | 800 | 1500 | 550 |
| Mar | 1 | 800 | 1600 | 550 |
| | 15 | 850 | 1700 | 550 |
| Apr | 1 | 900 | 1800 | 600 |
| | 15 | 950 | 1900 | 700 |
| May | 1 | 950 | 2000 | 900 |
| | 15 | 1000 | 2000 | 900 |
| Jun | 1 | 1050 | 2000 | 600 |
| | 15 | 1050 | 2000 | 500 |
| Jul | 1 | 1050 | 2000 | 450 |
| | 15 | 1050 | 1750 | 400 |
| Aug | 1 | 900 | 1500 | 350 |
| | 15 | 800 | 1300 | 350 |
| Sep | 1 | 600 | 1150 | 350 |
| | 15 | 500 | 1000 | 350 |
| Oct | 1 | 500 | 1000 | 350 |
| | 15 | 500 | 1000 | 550 |
| Nov | 1 | 600 | 1000 | 550 |
| | 15 | 700 | 1100 | 600 |
| Dec | 1 | 700 | 1200 | 700 |
| | 15 | 700 | 1300 | 700 |

(3) Instream flow hydrographs, as represented in the document entitled "Puyallup River basin instream resource protection program," shall be used for definition of instream flows on those days not specifically identified in WAC 173–510–030(2).

(4) All consumptive water rights hereafter established shall be expressly subject to instream flows established in WAC 173–510–030(1) through (3).

(5) At such time as the department of fisheries and/or department of wildlife and the department of ecology shall agree that additional stream management units should be identified other than those specified in WAC 173–510–030(1), the department of ecology shall identify additional control stations and management

units on streams and tributaries within the basin and ...l further protect instream flows where possible for ...e stations as provided in chapters 90.22 and 90.54 ...W. [Statutory Authority: Chapters 43.21B, 43.27A, 90.22 and 90.54 RCW. 88-13-037 (Order 88-11), § 173-510-030, filed 6/9/88. Statutory Authority: Chapters 90.22 and 90.54 RCW. 80-04-047 (Order DE 79-31), § 173-510-030, filed 3/21/80.]

**WAC 173-510-040 Surface water source limitations to further consumptive appropriations.** (1) The department of ecology, having determined unlimited consumptive appropriations would harmfully impact instream values, adopts instream flows as follows confirming surface water source limitations previously established administratively under the authority of chapter 90.03 RCW and RCW 75.20.050.

**Low Flow Limitations**

| Stream Number<br>Stream Name<br>Section, Township, Range of<br>Stream Mouth or Lake Outlet | Limitation |
|---|---|
| 10.0594<br>Unnamed stream, tributary to<br>Puyallup R...<br>NE1/4S... 6, T.18N, R.5E | No diversion when flow falls to 0.10 cfs. |
| 10.0415<br>Unnamed stream, (Taylor Creek)<br>tributary of Carbon River<br>NW1/4SW1/4, Sec. 33, T.19N., R.5E | No diversion when flow falls to 1.0 cfs. |
| 10.0402<br>...med stream, (Van Ogle Creek)<br>...y to Puyallup River<br>...SE1/4, Sec. 30, T.20N, R.5E | No diversion when discharge into the Puyallup River drops to 1.0 cfs. |
| Unnamed stream, (Canyon Creek)<br>tributary to Puyallup River<br>SE1/4NE1/4, Sec. 24, T. 20N, R.3E | No diversion when flow falls to 1.0 cfs. |

(2) The following stream and lake closures are adopted confirming surface water source limitations previously established administratively under the authority of chapter 90.03 RCW and RCW 75.20.050.

**Existing Surface Water Closures**

| Stream Number<br>Stream Name<br>Section, Township, Range | Date of Closure | Period of Closure |
|---|---|---|
| 10.0414<br>Voight Creek, tributary to Carbon River<br>NW1/4SW1/4, Sec. 33, T.19N., R.5E | 2/26/75 | All year |
| 10.0589<br>Unnamed stream (Lawrence Creek),<br>tributary to Puyallup River<br>NW1/4NE1/4, Sec. 25, T.19N, R.4E | 2/26/75 | All year |
| Unnamed springs, tributary to<br>Puyallup River<br>SE1/4NE1/4, Sec. 35, T.20N, R.4E | 12/14/64 | All year |
| 10. 0006 Hylebos Creek<br>Hylebos Creek, drains into<br>Commencement Bay and Puget Sound<br>NW1/4NE1/4, Sec. 27, T.21N, R.3E | 4/26/76 | All year |
| 10.0406<br>Fennel Creek, tributary to Puyallup River<br>SE1/4SE1/4, Sec. 6, T.19N, R.5E | 2/26/75 | All year |
| ...ke<br>...T.21N, R.4E | 8/19/47 | All year |

(3) The department, having determined that further consumptive appropriations would harmfully impact instream values, closes the following streams and lakes in WRIA 10 to further consumptive appropriations.

**New Surface Water Closures**

| Stream Number<br>Stream or Lake Name<br>Section, Township, Range of<br>Stream Mouth or Lake Outlet | Period of Closure |
|---|---|
| 10.0429<br>South Prairie Creek and all tributaries, tributary to Carbon River<br>SW1/4SE1/4, Sec. 27, T.19N, R.5E | All year |
| 10.0027<br>Clarks Creek and all tributaries, tributary to Puyallup River<br>NE1/4NE1/4, Sec. 19, T.20N, R.4E | All year |
| 10.0600<br>Kapowsin Creek and all tributaries, tributary to Puyallup River<br>SW1/4SW1/4, Sec. 20, T.18N, R.5E | All year |
| 10.0031 -.0197<br>White River and all tributaries<br>SW1/4SE1/4, Sec 23, T.20N, R.4E | All year |
| Kapowsin Lake<br>SE1/4NE1/4, Sec. 5, T.17N., R.5E | All year |
| 10.0603 -.0607<br>Ohop Creek and all tributaries source of Kapowsin Lake<br>SE1/4NW1/4, Sec. 18, T.17N., R.3E | All year |
| 10.0022<br>Clear Creek and all tributaries, tributary to Puyallup River<br>NW1/4SW1/4, Sec. 11, T.20N., R.3E | All year |
| 10.0410<br>Canyon Falls Creek and all tributaries, tributary to Puyallup River<br>Sec. 7, T.19N., R.5E | All year |
| 10.0596<br>Fiske Creek and all tributaries, tributary to Puyallup River<br>SW1/4SW1/4, Sec. 17, T.18N., R.5E | All year |
| 10.0006<br>Hylebos Creek and all tributaries, tributary to Commencement Bay<br>NW1/4NE1/4, Sec. 27, T.21N., R.3E | All year |
| 10.0620<br>Le Dout Creek and all tributaries, tributary to Puyallup River<br>NW1/4NW1/4, Sec. 28, T.17N., R.6E | All year |
| 10.0622<br>Niesson Creek and all tributaries, tributary to Puyallup River<br>NE1/4SE1/4, Sec. 33, T.17N., R.6E | All year |
| 10.0017<br>Wapato Creek and all tributaries, tributary to Commencement Bay<br>NW1/4SW1/4, Sec. 27, T.21N., R.3E | All year |
| 10.0035<br>Unnamed Stream (Strawberry Creek), (Salmon Creek) and all tributaries, tributary to White River<br>NE1/4SE1/4, Sec. 13, T.20N., R.4E | All year |
| 10.0621<br>Kellogg Creek and all tributaries, tributary to Puyallup River<br>SE1/4SW1/4, Sec. 28, T.17N., R.6E | All year |

[Statutory Authority: Chapters 90.22 and 90.54 RCW. 80-04-047 (Order DE 79-31), § 173-510-040, filed 3/21/80.]

EXHIBIT 9-3

WAC 173-510-050 **Ground water.** In future permitting actions relating to ground water withdrawals, particularly from shallow aquifers, a determination shall be made as to whether the proposed withdrawal will have a direct, and measurable, impact on stream flows in streams for which closures and instream flows have been adopted (WAC 173-510-040). If the determination affirms such interrelationship, the provisions of WAC 173-510-040 shall apply. [Statutory Authority: Chapters 90.22 and 90.54 RCW. 80-04-047 (Order DE 79-31), § 173-510-050, filed 3/21/80.]

WAC 173-510-060 **Lakes.** In future permitting actions relating to withdrawal of lake waters, lakes and ponds shall be retained substantially in their natural condition. Withdrawals of water which would conflict therewith shall be authorized only in those situations where it is clear that overriding considerations of the public interest will be served. [Statutory Authority: Chapters 90.22 and 90.54 RCW. 80-04-047 (Order DE 79-31), § 173-510-060, filed 3/21/80.]

WAC 173-510-070 **Exemptions.** (1) Nothing in this chapter shall affect water rights, riparian, appropriative, or otherwise existing on the effective date of this chapter, nor shall it affect existing rights relating to the operation of any navigation, hydroelectric, or water storage reservoir or related facilities.

(2) Domestic in-house use for a single residence and watering shall be exempt except that use related to ...ts. [Statutory Authority: Chapters 90.22 and 90.54 RCW. 80-04-047 (Order DE 79-31), § 173-510-070, filed 3/21/80.]

WAC 173-510-080 **Future rights.** No rights to divert or store public surface waters of the Puyallup WRIA 10 shall hereafter be granted which shall conflict with the purpose of this chapter as stated in WAC 173-510-02 [WAC 173-510-020]. [Statutory Authority: Chapters 90.22 and 90.54 RCW. 80-04-047 (Order DE 79-31), § 173-510-080, filed 3/21/80.]

WAC 173-510-090 **Enforcement.** In enforcement of this chapter, the department of ecology may impose such sanctions as appropriate under authorities vested in it, including but not limited to the issuance of regulatory orders under RCW 43.27A.190 and civil penalties under RCW 90.03.600. [Statutory Authority: Chapters 43-.21B, 43.27A, 90.22 and 90.54 RCW. 88-13-037 (Order 88-11), § 173-510-090, filed 6/9/88. Statutory Authority: Chapters 90.22 and 90.54 RCW. 80-04-047 (Order DE 79-31), § 173-510-090, filed 3/21/80.]

WAC 173-510-095 **Appeals.** All final written decisions of the department of ecology pertaining to permits, regulatory orders, and related decisions made pursuant ...'s chapter shall be subject to review by the pollution ...l hearings board in accordance with chapter 43-...B RCW. [Statutory Authority: Chapters 43.21B, 43-.27A, 90.22 and 90.54 RCW. 88-13-037 (Order 88-11), § 173-510-095, filed 6/9/88.]

WAC 173-510-100 **Regulation review.** The department of ecology shall initiate a review of the rules established in this chapter whenever new information, changing conditions, or statutory modifications make it necessary to consider revisions. [Statutory Authority: Chapters 43.21B, 43.27A, 90.22 and 90.54 RCW. 88-13-037 (Order 88-11), § 173-510-100, filed 6/9/88. Statutory Authority: Chapters 90.22 and 90.54 RCW. 80-04-047 (Order DE 79-31), § 173-510-100, filed 3/21/80.]

EXHIBIT 9-3