A Resource Survey of River Energy and Low-Head Hydroelectric Power Potential in Oregon

by

Peter C. Klingeman

Water Resources Research Institute

Oregon State University

Corvallis, Oregon

WRRI-61

April 1979

A RESOURCE SURVEY OF RIVER ENERGY AND LOW-HEAD HYDROELECTRIC POWER POTENTIAL IN OREGON

By

Peter C. Klingeman
Principal Investigator

Oregon Water Resources Research Institute
Oregon State University
Corvallis, Oregon 97331

in cooperation with

State of Washington Water Research Center
Idaho Water Resources Research Institute
Montana University Joint Water Resources Research Center

This Project was Funded by the
United States Department of Energy
CONTRACT NO. EG-77-S-07-1691
Through The
Idaho Water Resources Research Institute

WRRI-61

April 1979

Water Resources
Research Institute

Oregon State University

Corvallis, Oregon 97331 (503) 754-4022

August 31, 1983

WRRI-61 ERRATA INFORMATION

Appendix 1

p. 0-1-110 Map is upside down but flow arrow is correct

p. 0-1-114 Map is upside down but flow arrow is correct

Appendix 5

p. 0-5-32 or p. 0-5-33 Doug Parrow (Oregon DOE) inquired about accuracy in June 1982 (no followup note in our files)

Appendix 17

p. 0-17-69, p. 0-17-70 } 1st reach was shortened to RM 5.4, to allow for N. Fork Chetco River, but elevation at end of reach was not adjusted accordingly. N. Fork Chetco River was omitted from analysis.

ABSTRACT

A systematic, statewide investigation of stream power and energy has been made for all reaches of Oregon streams not presently having dams but capable of producing 200 kw or more at least 50 percent of the time. From available precipitation data, topographic maps and stream gaging station records, hydrologic techniques were used to generate mean discharges, discharge patterns, flow-duration curves, stream power values and stream energy values for 7626 miles of rivers in Oregon, grouped into 1443 reaches. The information was developed to inventory the theoretical developable low-head hydro power potential for Oregon. Assumptions were made to use run-of-river conditions (rather than reservoir storage) and 100 percent efficiency in generating electrical energy from streamflow.

The resulting theoretical maximum developable low-head power and energy potential, respectively, are found to be about 2 GW and 15,000 GWh, for near-firm-power conditions of 95 percent-of-time exceedance, about 6 GW and 43,000 GWh for median flow conditions of 50 percent exceedance, and 11 GW and 61,000 GWh for near-mean flow conditions of 30 percent exceedance. Streams influenced by large precipitation in the Coastal and Cascade Ranges possess the greatest developable power and energy potential; Southeast Oregon streams have comparatively small potentials. Using practical but limited assessment criteria, preliminary feasibility analyses and screening were used to identify for near-future investigation 56 reaches out of the 1443 studied (39 of them in the Willamette Basin) that had relatively few constraints and had nearby energy marketing possibilities.

In comparison with other Pacific Northwest states and adjacent state's having some land in the Columbia River Basin, Oregon ranks second and possesses about one-fourth of the region's total developable low-head stream power and energy potential.

FOREWORD

The Water Resources Research Institute, located on the Oregon State University Campus, serves the State of Oregon. The Institute fosters, encourages and facilitates water resources research and education involving all aspects of the quality and quantity of water available for beneficial use. The Institute administers and coordinates statewide and regional programs of multidisciplinary research in water and related land resources. The Institute provides a necessary communications and coordination link between the agencies of local, state and federal government, as well as the private sector, and the broad research community at universities in the state on matters of water-related research. The Institute also coordinates the inter-disciplinary program of graduate education in water resources at Oregon State University.

It is Institute policy to make available the results of significant water-related research conducted in Oregon's universities and colleges. The Institute neither endorses nor rejects the findings of the authors of such research. It does recommend careful consideration of the accumulated facts by those concerned with the solution of water-related problems.

ACKNOWLEDGEMENTS

The assistance and sharing of ideas among members of the Idaho, Montana and Washington study teams and the sponsoring U.S. Department of Energy and its representatives is gratefully acknowledged for the benefits derived by the Oregon study team in this regional effort.

The contributions of the dozen members of the Oregon study team are most particularly appreciated. They devoted countless hours to the painstaking tasks involved in this project. In succession, Ronald C. Scheidt, William F. Galli and Nasser Talebbeydokhti served as project engineers, with Ron and Bill getting the project started before completing their work and studies at the university. During various phases of the project they were ably assisted by Judy A. Kelly, Carolyn J. Choquette, Milo N. Ullstad, Suzanne Townsen, Philip G. Newton, Ruthanne Rubenstein, James R. Hyneman, Alice Tulloch, and Henry W. Howe. The appendices to this report represent their collective effort, which is gratefully acknowledged.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. STUDY BACKGROUND AND PURPOSE

The University of Idaho Water Resources Research Institute entered into a contract with the U. S. Department of Energy in September, 1977, to make a study entitled "A Resource Survey of Low-Head Hydroelectric Potential -- Pacific Northwest Region". The University of Idaho Water Resources Research Institute in turn entered into subcontracts with the Water Resources Research Institutes in Oregon, Washington and Montana to do the portions of that study involving streams in their respective states.

The purpose of this study was to evaluate the low-head hydroelectric potential of the Pacific Northwest region. For purposes of this study, low-head hydroelectric power was defined as power produced from power sites with gross hydraulic heads ranging from 3 to 20 meters (m) and with resulting power plant sizes greater than 200 kilowatts (kW).

The study included all of the Columbia River Basin. It also included all other river basins in Idaho, Oregon and Washington. The study area is shown in Figure 1. The total area studied is approximately 292,000 square miles. The Oregon study team was responsible for evaluating the low-head hydroelectric potential of the State of Oregon, an area of approximately 97,000 square miles -- about one-third of the total study area.

The regional study was coordinated by the Idaho study team. The study was initiated in October 1977 by a one-day meeting of all state study teams with representatives of the U.S. Department of Energy to establish study methodologies and deal with the logistics of accomplishing the project objectives. A briefing meeting was held on the following day to discuss the study with interested state and federal agencies. Subsequently, study team coordination meetings were held quarterly to discuss study progress, problems encountered in applying methodologies, and tasks still to be completed. Additional briefing meetings and discussions with agencies and the public in general occurred throughout the study to provide information and to answer inquiries.

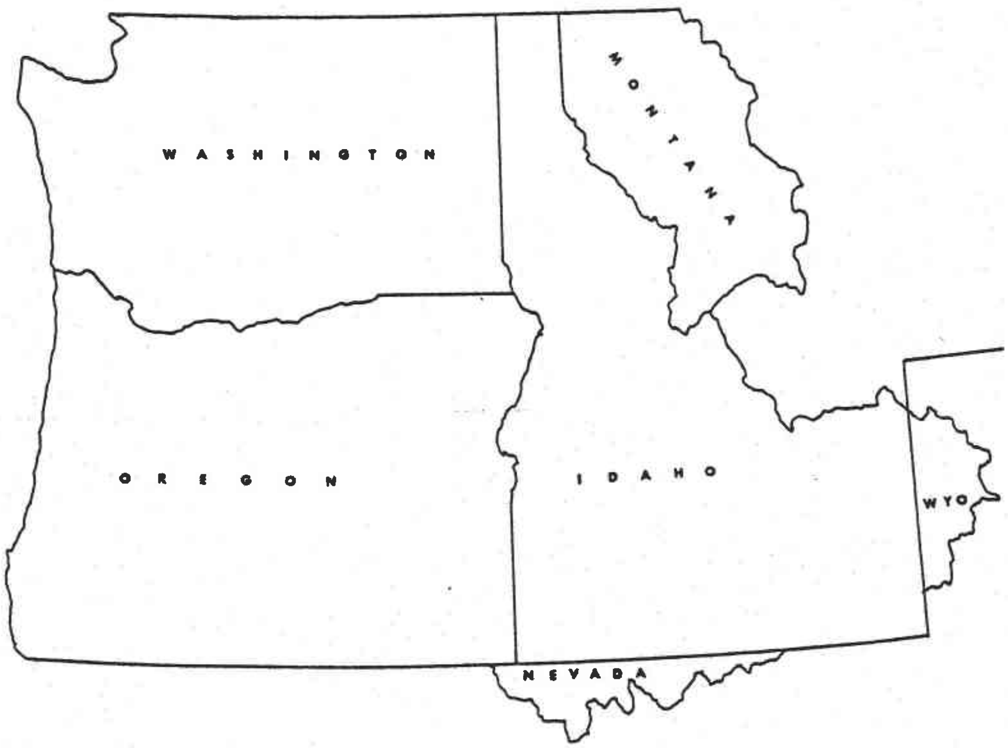

FIGURE 1. REGIONAL STUDY AREA

II. HYDROLOGIC AND ENERGY ANALYSIS TECHNIQUES

State River Basins

The 18 major drainage basins identified by the Oregon Water Resources Department (OWRD) were adopted as analytical units to provide evaluations useful for future river basin planning. These subdivisions of the state are shown in Figure 2. Each basin consists of one or more hydrologically homogeneous areas for which streamflow gaging station records could be correlated to develop runoff relations.

Use of Reaches

The initial study assignment was to define the low-head hydro potential by identifying all possible low-head hydroelectric sites. It was soon determined that this task was too formidable under the limitations of the available project time and budget. Therefore, the study approach followed was to define the power potential for consecutive reaches (lengths) of the streams. A reach is defined here as any length of stream with designated upstream and downstream boundaries such that average values taken over the reach give reasonable descriptions of the reach. Stream reaches were chosen so that major tributary streams would enter at the upstream or downstream end points of the reach rather than within the reach. Reaches did not include existing dams and reservoirs; instead, they terminated just upstream and downstream.

Reaches were assigned to all segments of streams that had flow capabilities of 36 cubic feet per second (cfs) -- about 1 cubic meter per second -- at least 50 percent of the time. This corresponds to the flow required to produce 200 kW at a 20 m head.

Synopsis of General Analytical Approach

The streamflow regime for each reach was determined by means of flow-duration curves. At locations where streamgaging stations existed, these curves were developed directly from data records. However, most reaches had no such stations and it was, therefore, necessary to generate synthetic flow-duration curves for them. An appropriate technique for doing this was developed, involving correlations among (1) precipitation data that had already been generalized to give isohyetal maps covering the entire state, (2) drainage areas that could be obtained for each reach from available maps, (3) average annual discharges available at gaging stations and

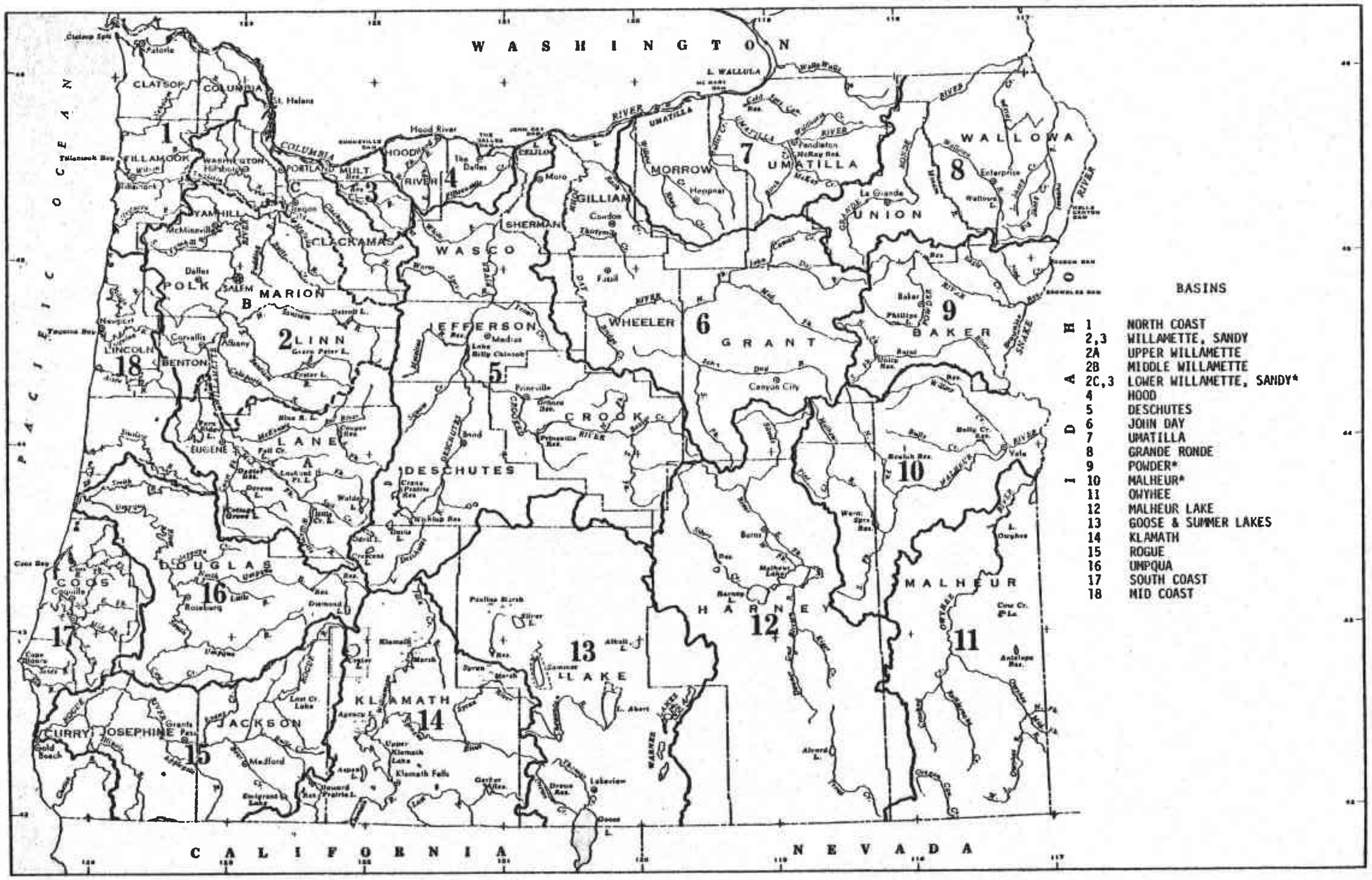

FIGURE 2. OREGON'S MAJOR DRAINAGE BASINS

adjustable to match the period of concurrent precipitation data, and (4) flow-duration curves at these gaging stations. Correlations using the first three parameters (precipitation, drainage area, and average annual discharge) at existing stations gave relations to predict average annual discharges at ungaged sites from precipitation and drainage area estimates. Correlations using the last two parameters (average annual discharge and flow-duration characteristics) gave additional relations so that the predicted average annual discharges at ungaged sites were converted into predicted flow-duration curve discharges.

The energy characteristics for each reach were determined by using five exceedance flows from the predicted flow-duration curves (flows that were exceeded 10, 30, 50, 80, and 95 percent of the time, based on long-term conditions). Each exceedance flow was used with the water power equation, which incorporates these flows with the available head in the reach. Power values were then converted to energy values by application of appropriate time intervals for power availability.

The plant load conditions for each reach were determined by comparing the energy outputs for the five exceedance flows under their predicted variable streamflow regimes with the energy output for the same flows if they instead were available without variation 100 percent of the time. The resulting ratios were called plant factors to distinguish them from other plant load terms commonly used.

Flow-Duration Approach

To describe the regime of flows available in a reach over time, a flow-duration curve approach was used. A typical flow-duration curve is shown in Figure 3.

The flow-duration curve is a cumulative frequency curve of discharges. The curve depicts the amounts of time that the flow rate of a stream can be expected to equal or exceed various specific flow values during some period. It combines in one curve the flow characteristics of a stream throughout its observed range of discharge, without regard to the sequence or frequency of occurrence of different discharges. The period used is normally one or more complete years of record. Mean daily streamflows are typically used in the development of the curve. Streamflow is depicted on the ordinate scale, which may be an arithmetic or logarithmic scale,