The Biennial Report

OF THE

Board of Geological Survey

OF THE

State of Washington

FOR THE TERM 1913-1915

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1915

LETTER OF TRANSMITTAL.

To the Legislature of the State of Washington:

The Board of Geological Survey transmits herewith its biennial report for the term 1913-15, as required by statute.

Respectfully submitted,

ERNEST LISTER, *President;*
LOUIS F. HART,
EDWARD MEATH, *Secretary;*
E. A. BRYAN.

Olympia, December 15, 1914.

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BIENNIAL REPORT OF THE BOARD OF GEOLOGICAL SURVEY

GENERAL PURPOSES OF SURVEYS.

TOPOGRAPHICAL SURVEYS.

The Topographical Map.—A topographical map is designed to represent the form and slope of the surface of the land and the elevation of all points above sea level. The positions of streams, lakes and ponds, public and private roads, towns and railroads, are shown in their correct relative positions. The map indicates boundaries of counties and the position of section lines wherever there have been land surveys. In the making of the necessary surveys for such maps permanent marks, consisting of iron posts, copper bolts or tablets, are set at frequent intervals to mark the exact elevation above sea level to serve as datum points for further spirit level work, for engineering investigation, and for such public works as canals, water supply, railway and other public or private surveys.

The topographical map is made with such accuracy and in such detail that it is useful to almost every citizen. In a new state that is inviting immigration, the map is valuable in order to show the location of desirable farm lands and the general character of the country. From it the positions of streams and lakes may be seen and the possibilities of these for purposes of water power or irrigation may be largely determined. The topographical map facilitates the construction of railroads and wagon roads, since upon it available routes and grades may be laid out without the preliminary surveys ordinarily necessary for improvements of this kind. In our public schools such a map is indispensable in that it places before the children truthful maps of our commonwealth, instead of those that are glaringly inaccurate.

In the making of topographical maps the areas selected for survey are defined by lines of latitude and longitude and are called quadrangles. Each quadrangle, and the topographic

map which represents its features, is designated by the name of the most prominent place or topographic feature included within it. The scale generally used in map construction is about two miles to the inch, and on this scale the area embraced in a quadrangle is about eight hundred square miles. In Washington the topographic map when completed will comprise, in round numbers, ninety sheets, complete and fractional, of which about thirty-two have already been surveyed.

HYDROGRAPHICAL SURVEYS.

Hydrographical surveys furnish a basis of determining the water resources of the state. They are essential to indicate the supply of water suitable for domestic and industrial purposes, for comprehensive development of power and irrigation projects, for navigation and flood prevention, and for wise and equitable sanitary regulation. The water supply is of more importance to the life and pursuits of the people than any other natural resource, as the health and economic development of every community are directly dependent upon the character and volume of the available supply.

Our water resources are unlike the other mineral resources in that they are continually existent. Our coal beds and mineral lodes are exhausted when mined and placed upon the market, but the water supply is constantly renewed. Therefore, failure to put water into beneficial use is an economic loss, for the energy and utility does not serve the needs of civilization effectively prior to hydraulic development.

Hydrographical surveys cover two fields of investigation, the surface supply and the underground supply. The surface supply furnishes by far the greatest volume of water and is readily accessible in the various rivers and creeks. Gaging stations are maintained along the principal streams of the state for determining the daily flow throughout a series of years. Daily records are published and are used extensively in designing hydraulic works of all kinds. Probably the greatest ultimate benefit derived from the streams in the state will be brought about by hydroelectric development. Washington ranks first

among the states in the union in respect to the estimated water-power possibilities. These possibilities are being investigated in connection with obtaining records of daily flow. River profiles or level lines along the principal power streams are also being run to determine the fall, storage capacity of prospective reservoir sites, and other data. An analysis of the data obtained in respect to flow, fall storage, capacity, etc., is being made in a series of reports on the water powers of the Cascade range. The power analyses are being based on the best information obtainable and will greatly encourage the development of hydroelectric projects.

Investigation of underground water supplies is equally as important as in the case of surface waters. This work includes a determination of the areas that are underlaid by water-bearing strata, of the depths at which these strata occur, and of the amount and quality of water that may be obtained. A knowledge of the existence of water-bearing strata is very necessary, not alone for the purpose of irrigation, but in some parts of Washington settlement is well-nigh impossible because not even enough water for domestic purposes has as yet been obtained.

GEOLOGICAL SURVEYS.

Geological surveys have been organized in nearly all the states of the Union, and in some of the older states they have been continuously active for over fifty years. In most states they are regular departments of the state government, and receive definite financial support in the way given to every other bureau or department. They are usually in charge of a board of three or five men, who direct the work of the survey, and who are responsible for its management.

The general purpose of a geological survey is to disclose and make known the mineral resources of a state. Under such heading would naturally come the metalliferous deposits, coal fields, iron ores, building stones, soils, clay beds, road materials, water power, and kindred subjects. The field work of a survey consists in mapping accurately the locations of all such valuable products as those just mentioned, and determining the areal

extent and quantity of each. The office work consists of careful tests and analyses of all samples collected in the field, and the preparation of reports which describe fully the mineral resources under investigation. The reports and maps when published are valuable alike to the citizens of the state and to outside capitalists and investors. Surveys examine and test those minerals, ores and rocks that are but little known and determine whether or not they are of economic value. They also suggest ways of preventing wastes in mining operations, and assist in all ways to conserve the natural resources. Surveys are potent factors in making available valuable information regarding the mineral resources of the state, which knowledge may be utilized by the poorest citizen as well as the wealthiest corporation.

PRINCIPAL FEATURES OF STATE LAWS PROVIDING FOR SURVEYS.

The law establishing a state geological survey was passed by the legislature at the session of 1901. As set forth in the various sections of the law, the principal objects of the measure are as follows: An examination of the economic products of the state, such as gold, silver, copper, lead, and iron ores, as well as building stones, clays, coal, and all mineral substances of value; an examination of the soils, road-building material, water supplies, artesian wells, water power, etc.; an examination of the physical features of the state with reference to their practical bearing upon the occupations of the people; the preparation of special geographic and economic maps to illustrate the resources of the state; and the publication from time to time of the results of the work of the survey in reports and bulletins, and the dissemination of these among the people.

At the session of 1903 the legislature amended the above law, by providing for cooperative work between the federal and the state bureaus engaged in geological survey work. The amendment authorized the state board of geological survey to make provisions for topographic, geologic, and hydrographic surveys of the state, in cooperation with the United States Geologi-

cal Survey, in such manner as would be of the greatest benefit to the agricultural, industrial and geological requirements of the state. The amendment carried a proviso that the Director of the United States Geological Survey should agree to expend on the part of the United States upon such surveys a sum equal to that expended by the state.

At the session of the legislature for 1909 the work of the state geological survey was provided for by a law having these provisions:

SECTION 1. In order to complete the topographical map of the State of Washington, and for the purpose of making more extensive stream measurements, and otherwise investigating and determining the water supply of the state, there is hereby appropriated the sum of thirty thousand dollars ($30,000), for cooperation with those branches of the United States Geological Survey engaged in this work. This appropriation, however, shall be contingent upon, and not become available unless the United States government apportion an equal amount to be expended for similar purposes within the state. The board of geological survey is hereby authorized and directed to enter into such agreements with the director of the United States Geological Survey as will insure that the said surveys and investigations be carried on in the most economical manner, and that the maps and data be available for the use of the public as quickly as possible.

SEC. 2. In order to enable the board of geological survey to carry on investigations authorized by law, there is hereby appropriated the sum of twenty thousand dollars ($20,000) for the use of said board in the geological and other investigations provided for in chapter 165 of the Session Laws of the State of Washington for 1901, and as amended in chapter 157 of the Session Laws of 1903.

SEC. 3. In order to carry out the purposes of this act, all persons employed hereunder are authorized to enter and cross all lands within the state: *Provided*, That in so doing no damage is done to private property.

SEC. 4. The sum of fifty thousand dollars ($50,000) herein appropriated for the purposes specified in this act shall be available in the following manner: One-half during the first twelve months after this act takes effect, and the unexpended balance during the second twelve months after this act takes effect.

At the session of the legislature for 1913 the work of the Geological Survey was provided for in the general appropriation bill, wherein $35,000.00 were appropriated for topographic and

hydrographic surveys (conditioned upon a similar sum being expended by the United States Geological Survey), and $20,000.00 were appropriated for geological surveys.

REPORT FOR 1913-15.

ORGANIZATION.

At the call of the Governor, the State Board of Geological Survey met at Olympia on April 2, 1913, with all the members present as follows: Governor Lister, Lieut. Governor Hart, State Treasurer Meath, President Kane of the State University, and President Bryan of the State College. Henry Landes was re-elected State Geologist for the ensuing term of four years Governor Lister was authorized to sign the necessary agreements with the Director of the United States Geological Survey, arranging for cooperative work in topography and hydrography, as provided by law. The work for the biennium was outlined, and the State Geologist directed to carry on the different investigations and surveys that are described below.

TOPOGRAPHICAL SURVEYS.

The accompanying progress map indicates the location of the quadrangles surveyed during this biennium, as well as from 1909 to 1913. In selecting quadrangles for survey it has been the policy of the board to choose those areas where the demand for the maps is very great and where they are most likely to be used to advantage.

In the field season of 1913 the Wenatchee quadrangle was completed. This was the last of several areas to be surveyed in Central Washington where irrigation is practised and where detailed maps are very necessary for various lines of engineering work. In addition, the Wenatchee quadrangle completed the series involved in the problem of the reclamation of Quincy Valley.

The Hoquiam and Ocosta quadrangles, to be later engraved together, under the name of the Grays Harbor Special Map, were completed during the season of 1913. The maps are now being engraved and are about ready for distribution.

The Chehalis quadrangle, embracing over 800 square miles in the vicinity of Chehalis and Centralia, was topographically surveyed during the seasons of 1913 and 1914. The necessary office work is now being done and this map will be out of the engraver's hands within the next few months. A large portion of the northern part of this quadrangle is embraced within the coal fields of Lewis and Thurston counties and the detailed map will make it easier to work out the geology of the coal basins.

The Mitchell and Haven quadrangles, both 15-minute sheets, are located on opposite sides of Columbia River, between Beverly and Hanford. This area was surveyed in the seasons of 1913 and 1914 and the office work is now being done preparatory to engraving the map. As in other portions of arid Washington the detailed topographic work was done here in order to make it easier to carry out whatever irrigation projects are necessary for the reclamation of the desert.

The Pasco quadrangle, embracing an area of between 800 and 900 square miles, was surveyed in the summer of 1914. It includes the lowlands lying along Columbia River where irrigation must be employed if agriculture is successfully carried on. The topographic map is necessary in laying out any comprehensive scheme of irrigation.

The Arlington quadrangle, embracing a portion of the eastern part of Klickitat county, was surveyed in the field season of 1913. The southern half of the quadrangle lies across the river in Oregon and it takes its name from the town of Arlington. This region is one also wherein irrigation will be desirable for successful farming and the topographic map has been made as an assistance to that end.

Copies of all engraved topographic maps may be purchased of the United States Geological Survey, Washington, D. C., at ten cents each.

HYDROGRAPHICAL SURVEYS.

The water resources of the state have been investigated jointly by the federal and state surveys, each party contributing equal sums for the work. In addition to this work the federal

survey expends about $2,500 a year for investigations in the Indian reserves, which is paid by the United States Indian Service. The chief object has been to obtain accurate information regarding the amount of water that could be depended upon for irrigation and for power purposes. All of the water that can be secured by storage that is tributary to arid Washington will soon be needed for irrigation. The rapid industrial development of Western Washington demands the continued utilization of the available water power. The detailed investigations have been along two lines, viz., establishment and maintenance of gaging stations, and a series of reports summarizing the power possibilities of the Cascade range.

Gaging Stations.—As shown on the progress map, gaging stations are in operation upon all of the principal streams of the state. Measurements of flow are frequently made, and daily records of the height of the water on substantially set gages are kept by local observers. The measurements and gage heights make possible an estimate of the average amount of water flowing each day during the year. The water contributed by any stream varies considerably from day to day, season to season, and year to year, so that records for a series of years are necessary for properly designing hydraulic works. The records are particularly important during low water periods which occur on some streams in the early fall and on others in mid-winter. The gage heights, measurements, and estimates of daily flow are published annually by the United States Geological Survey in water supply papers as indicated in the list of publications given at the end of this report. The data published for each gaging station may be seen in the sample given below for Spokane river at Spokane for the year ending September 30, 1914. There are 94 gaging stations in operation within the state at the close of the biennium.

SPOKANE RIVER AT SPOKANE, WASHINGTON.

Location.—In Sec. 9, T. 25 N., R. 43 E., W. M., about 1½ miles northeast of the business center of the city of Spokane, about 4 miles above Latah creek, one-half mile above Mission

Avenue bridge, and 500 feet above auxiliary steam plant of Washington Water Power Company. Elevation, low water, 1,870 feet.

Records Available.—October 25, 1896, to September 30, 1914.

Drainage Area.—4,000 quare miles.

Gage.—Inclined staff on right side of river anchored to concrete footings.

Channel.—Permanent except during high stages.

Winter Flow.—Not affected by ice formation.

Diversion.—A small proportion of the low water flow diverted for irrigation purposes at Post Falls, Idaho, by Spokane Valley Land & Water Company.

Regulation.—Considerable storage is utilized in Coeur d'Alene Lake by Washington Water Power Company to increase the flow during low water periods.

Accuracy.—Excellent.

Cooperation.—Washington Water Power Company.

DISCHARGE MEASUREMENTS OF SPOKANE RIVER AT SPOKANE, WASH., DURING THE YEAR ENDING SEPTEMBER 30, 1914.

Date	Hydrographer	Gage Height	Discharge
1913		Feet	Sec.-ft.
October 28.....	F. B. Storey.....	71.08	4,330
October 29.....	F. B. Storey.....	71.08	4,320
1914			
June 3.....	Parker and Brown.....	73.10	8,230
August 19.....	Parker and Hoyt.....	69.10	1,880
September 28..	C. O. Brown.....	68.93	1,660

DAILY GAGE HEIGHT, IN FEET, OF SPOKANE RIVER AT SPOKANE, WASH., FOR THE YEAR ENDING SEPTEMBER 30, 1914.
(E. Freeman, Observer.)

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1....	69.0	71.0	71.0	69.5	70.8	72.4	74.2	76.8	72.7	69.4	69.1	68.8
2....	69.1	71.4	70.9	69.4	71.6	72.4	73.7	76.7	72.6	69.5	69.1	69.0
3....	69.1	69.9	70.9	69.5	72.0	72.6	70.4	76.7	73.1	69.4	69.2	69.5
4....	69.2	69.8	70.8	69.4	72.3	72.6	72.6	76.7	73.1	69.4	69.2	68.9
5....	69.2	69.8	70.6	69.4	71.9	72.8	73.5	76.6	73.0	69.5	69.2	69.2
6....	69.2	70.9	70.6	69.4	72.1	72.8	73.8	76.6	73.0	69.7	69.2	68.8
7....	69.2	71.4	70.4	69.4	72.1	72.7	74.8	76.5	73.0	69.5	69.2	68.8
8....	69.2	71.4	70.3	69.4	72.0	72.8	75.5	76.4	72.9	69.4	69.2	69.4
9....	69.6	71.3	69.8	69.4	72.0	72.8	76.1	76.3	72.8	69.4	69.2	69.1
10....	69.5	71.2	69.8	69.4	72.0	72.9	76.4	76.3	72.8	69.4	69.2	69.0
11....	69.5	70.6	69.8	69.4	71.6	73.2	76.6	76.3	72.6	69.4	69.2	69.0
12....	69.5	69.6	69.8	69.4	71.9	73.4	76.7	76.3	72.6	69.4	69.2	69.1
13....	69.6	69.6	69.8	69.6	71.8	73.5	76.8	76.2	72.6	69.5	69.2	68.9
14....	69.6	71.1	69.8	69.6	71.7	73.6	76.8	76.2	72.5	69.6	69.1	69.0
15....	69.6	71.1	69.8	69.5	71.6	73.6	76.9	76.2	72.4	69.6	69.1	68.9
16....	69.6	71.0	69.6	69.5	71.6	74.0	77.1	76.2	70.5	69.4	69.1	69.1
17....	69.6	71.0	69.6	69.6	71.4	74.2	77.3	76.2	70.3	69.3	69.1	68.9
18....	69.6	69.6	69.6	69.6	71.4	74.3	77.5	76.2	70.1	69.3	69.1	68.9
19....	69.6	69.6	69.6	69.5	71.2	74.4	77.6	76.2	70.0	69.3	69.1	68.8
20....	69.6	69.6	69.6	69.5	71.2	74.8	77.5	76.1	69.8	69.3	69.8	68.8
21....	69.6	69.6	69.6	69.5	71.2	75.0	77.4	75.9	69.8	69.3	69.1	68.9
22....	69.6	70.5	69.6	69.5	71.2	75.2	77.4	75.8	69.7	69.2	69.1	69.0
23....	69.6	70.7	69.6	71.4	71.2	75.2	77.4	75.7	69.6	69.2	69.0	69.0
24....	69.6	70.7	69.6	71.5	71.4	75.2	77.4	75.6	69.4	69.1	69.1	68.9
25....	69.6	70.7	69.4	71.6	71.6	75.2	77.4	75.5	69.5	69.1	69.1	68.9
26....	69.6	70.7	69.4	71.6	71.8	75.2	77.5	75.4	69.5	69.1	69.1	69.0
27....	69.6	70.7	69.5	71.6	72.0	75.0	77.4	75.3	69.5	69.1	69.1	68.8
28....	71.0	70.7	69.4	71.6	72.2	74.9	77.3	75.1	69.5	69.1	69.1	68.9
29....	71.1	71.0	69.4	72.6	.....	74.6	77.2	74.4	69.5	69.1	68.9	68.9
30....	71.0	71.0	69.4	69.8	.....	74.5	77.0	74.3	69.5	69.1	69.0	68.9
31....	71.0	.....	69.5	70.7	.....	74.4	.....	73.6	.....	69.1	69.0	.....

NOTE.—Add 1,800 feet to gage heights to obtain mean sea level elevations.

DAILY DISCHARGE IN SECOND-FEET OF SPOKANE RIVER AT SPOKANE, WASH., FOR THE YEAR ENDING SEPTEMBER 30, 1914.

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1....	1,700	4,210	4,210	2,250	3,920	6,680	10,500	17,200	7,270	2,140	1,810	1,500
2....	1,810	4,860	4,060	2,140	5,200	6,680	9,400	17,000	7,070	2,250	1,810	1,700
3....	1,810	2,710	4,060	2,250	5,920	7,070	3,360	17,000	8,090	2,140	1,920	2,250
4....	1,920	2,590	3,920	2,140	6,490	7,070	7,070	17,000	8,090	2,140	1,920	1,600
5....	1,920	2,590	3,640	2,140	5,740	7,470	8,960	16,700	7,880	2,250	1,920	1,920
6....	1,920	4,060	3,640	2,140	6,110	7,470	9,620	16,700	7,880	2,470	1,920	1,500
7....	1,920	4,860	3,360	2,140	6,110	7,270	12,000	16,400	7,880	2,250	1,920	1,500
8....	1,920	4,860	3,220	2,140	5,920	7,470	13,800	16,100	7,670	2,140	1,920	2,140
9....	2,360	4,690	2,590	2,140	5,920	7,470	15,300	15,800	7,470	2,140	1,920	1,810
10....	2,250	4,530	2,590	2,140	5,920	7,670	16,100	15,800	7,470	2,140	1,920	1,700
11....	2,250	3,640	2,590	2,140	5,200	8,300	16,700	15,800	7,070	2,140	1,920	1,700
12....	2,250	2,360	2,590	2,140	5,740	8,740	17,000	15,800	7,070	2,140	1,920	1,810
13....	2,360	2,360	2,590	2,360	5,560	8,960	17,200	15,600	7,070	2,250	1,920	1,600
14....	2,360	4,370	2,590	2,360	5,380	9,180	17,200	15,600	6,870	2,360	1,810	1,700
15....	2,360	4,370	2,590	2,250	5,200	9,180	17,500	15,600	6,680	2,360	1,810	1,600
16....	2,360	4,210	2,360	2,250	5,200	10,100	18,100	15,600	3,500	2,140	1,810	1,810
17....	2,360	4,210	2,360	2,360	4,860	10,500	18,700	15,600	3,220	2,030	1,810	1,600
18....	2,360	2,360	2,360	2,360	4,860	10,800	19,300	15,600	2,960	2,030	1,810	1,600
19....	2,360	2,360	2,360	2,250	4,530	11,000	19,600	15,600	2,830	2,030	1,810	1,500
20....	2,360	2,360	2,360	2,250	4,530	12,000	19,300	15,300	2,590	2,030	2,590	1,500
21....	2,360	2,360	2,360	2,250	4,530	12,500	19,000	14,800	2,590	2,030	1,810	1,600
22....	2,360	3,500	2,360	2,250	4,530	13,000	19,000	14,500	2,470	1,920	1,810	1,700
23....	2,360	3,780	2,360	4,860	4,530	13,000	19,000	14,200	2,360	1,920	1,700	1,700
24....	2,360	3,780	2,360	5,030	4,860	13,000	19,000	14,000	2,140	1,810	1,810	1,600
25....	2,360	3,780	2,140	5,200	5,200	13,000	19,000	13,800	2,250	1,810	1,810	1,600
26....	2,360	3,780	2,140	5,200	5,560	13,000	19,300	13,500	2,250	1,810	1,810	1,700
27....	2,360	3,780	2,250	5,200	5,920	12,500	19,000	13,200	2,250	1,810	1,810	1,500
28....	4,210	3,780	2,140	5,200	6,300	12,200	18,700	12,800	2,250	1,810	1,810	1,600
29....	4,310	4,210	2,140	7,070	.....	11,500	18,400	11,000	2,250	1,810	1,600	1,600
30....	4,210	4,210	2,140	2,590	.....	11,300	17,800	10,800	2,250	1,810	1,700	1,600
31....	4,210	.....	2,250	3,780	.....	11,000	.....	9,180	.....	1,810	1,700	.....

MONTHLY DISCHARGE OF SPOKANE RIVER AT SPOKANE, WASH., FOR THE YEAR ENDING SEPTEMBER 30, 1914.

MONTH	DISCHARGE IN SECOND-FEET			Total Run-off in Acre-feet	Accuracy
	Maximum	Minimum	Mean		
October	4,370	1,700	2,470	152,000	A
November	4,860	2,360	3,650	218,000	A
December	4,210	2,140	2,730	168,000	A
January	7,070	2,140	3,000	184,000	A
February	6,490	3,920	5,350	297,000	A
March	13,000	6,680	9,910	609,000	A
April	19,600	3,360	15,800	940,000	A
May	17,200	9,180	15,000	922,000	A
June	8,090	2,140	4,990	297,000	A
July	2,470	1,810	2,060	127,000	A
August	2,590	1,600	1,860	114,000	A
September	2,250	1,500	1,670	99,400	A
The year	19,600	1,500	5,700	4,130,000	.....

Cascade Power Reports.—During the past six years an investigation of the power possibilities has been in progress. The work has been hampered to considerable extent due to lack of sufficient base data for making accurate estimates and the urgency of continuing the stream flow observations. The records of flow obtained at the gaging stations indicate the water supply available, and surveys have been run along the portions of the larger streams which have sufficient fall for economical power development. Reservoir sites which appear to offer favorable storage opportunities for increasing the low water flow have also been surveyed, and a large mass of other information bearing upon the feasibility of hydroelectric projects collected.

The scheme followed in analyzing the power resources of the Cascades consists of assembling the estimates for a group of streams within a relatively small section of the range. It is proposed to publish the estimates in a series of seven reports published by the United States Geological Survey as water supply papers. The areas to be covered in the seven units are shown on the progress map attached.

The first report is Water Supply Paper 253 and is entitled "Water Powers of the Cascade Range, Part 1, Southern Washington." The power possibilities of Klickitat, White Salmon, Little White Salmon, Lewis and Toutle rivers are summarized.

The second report is Water Supply Paper 313 and is entitled "Water Powers of the Cascade Range, Part II." The power possibilities of Cowlitz, Nisqually, Puyallup, White, Cedar, and Green rivers are summarized. This report also includes a discussion of the hydroelectric market conditions in the Puget Sound region.

The third report is Water Supply Paper 369 and is entitled "Water Powers of the Cascade Range, Part III, Yakima Basin." The summaries were more difficult to compile than for any of the series on account of the necessity of taking into consideration the ultimate use of stored water for irrigation in the Yakima Valley.

All of the field data have been collected for the fourth and fifth units of the series, and considerable work has been done toward compiling the summaries, but the manuscript is not prepared for publication.

Practically all of the surveys have been completed for the sixth unit and most of the field reconnaissance has been finished. The establishment of gaging stations within the area covered by the seventh unit has been effected, and it is proposed to undertake the necessary surveys during the coming summer.

GEOLOGICAL SURVEYS.

Mineral Resources.—The State Geological Survey, since 1911, has cooperated with the United States Geological Survey in the collection of statistics regarding the mineral production of Washington. It is a matter of great importance to the state that such statistics be secured covering accurately the entire mineral output, because of the bearing this must have upon the establishment of industrial enterprises. The accompanying table gives a summary of the principal mineral products of Washington for the ten-year period from 1904 to 1913, inclusive. While the production is already large, and constantly growing, it is capable of a very much greater extension when the economic minerals are investigated and made better known.

The statistics covering the mineral resources of the state are now published annually. The report for 1912, known as "Bulletin 11," gave a description of the principal localities where different mineral products are obtained, with a list of producers and a statement covering the output. This bulletin was accompanied by an outline map of the state wherein, by a system of symbols and colors, all varieties of mineral products were shown in the localities where they were obtained.

MINERAL PRODUCTION OF WASHINGTON FROM 1904 TO 1913, INCLUSIVE.*

NON-METALLIC PRODUCTS	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913
Coal	$5,120,931	$5,141,258	$5,908,434	$7,679,801	$6,690,412	$9,158,999	$9,764,465	$8,174,170	$8,042,871	$9,243,137
Clay products	1,200,919	1,175,032	1,499,884	1,921,934	2,104,289	3,000,486	3,023,854	2,861,758	2,388,870	2,370,226
Portland cement	.....	.....	.....	† 214,500	† 396,000	767,195	1,031,704	1,496,807	2,012,785	2,853,260
Granite	442,508	681,730	459,975	562,352	870,944	742,878	642,992	1,345,551	809,201	140,279
Trap rock ‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	‡ 632,915
Sandstone	88,185	124,910	169,500	295,585	464,587	335,470	438,581	301,843	344,476	560,468
Limestone	71,857	52,470	49,192	62,317	31,660	38,269	36,186	32,478	20,370	62,913
Marble	23,098	60,000	59,985	.....	.....	.....	.....	.....	.....	.....
Lime	216,454	160,985	347,924	238,568	228,353	282,628	267,735	228,933	234,832	219,163
Mineral waters	10,508	10,101	10,800	10,820	13,650	15,958	12,571	14,654	17,542	18,834
Sand and gravel	.....	.....	144,725	179,800	261,531	423,425	481,569	319,760	345,289	385,886
Totals	$7,174,460	$7,406,486	$8,650,419	$11,165,677	$11,061,426	$14,825,308	$15,699,657	$14,775,954	$14,216,236	$16,507,081
METALLIC PRODUCTS										
Gold	$304,640	$405,078	$221,648	$262,300	$253,700	$362,051	$788,145	$847,677	$680,964	$695,275
Silver	89,831	75,727	30,738	55,400	46,400	41,334	110,886	129,204	254,326	200,068
Copper	43,786	16,958	45,360	24,453	21,411	33,167	11,038	39,776	179,192	147,883
Lead	69,937	28,437	52,787	29,786	32,844	12,414	58,180	38,186	5,732	8,909
Totals	$508,196	$526,200	$350,533	$371,939	$354,355	$448,966	$968,249	$1,056,017	$1,120,214	$1,053,135
Grand totals	$7,682,656	$7,932,686	$9,000,952	$11,537,616	$11,415,781	$15,274,274	$16,667,906	$15,631,971	$15,336,450	$17,560,216

* Compiled from Mineral Resources U. S. Geological Survey.

† Approximate production.

‡ Heretofore included in granite totals.

Surveys of Coal Fields.—In former years coal surveys have been made in King, Pierce and Kittitas counties. In each instance the work has been carried on with great thoroughness and the plan has been to make the surveys in such detail that they would not need to be repeated for many years.

It has been the plan to publish ample descriptive matter describing the results of the field examinations. Maps are made which show accurately (1) the boundaries of the developed fields, (2) the limits of the probable workable fields, (3) the locations of the fields where coal outcrops occur but where the coal is not believed to be commercially valuable, and (4) those localities underlaid by formations other than coal measures and where coal is an impossibility.

The report on King county has been published as Bulletin 3 of the State Geological Survey reports. The reports on Pierce and Kittitas counties have been published as Bulletins 10 and 9, respectively. The maps were prepared a number of months in advance of the descriptive matter in order that they might be of the greatest assistance to the county assessors and other persons desiring to use them.

The field work has been nearly completed for a report on the coal fields of Whatcom County. The region embraced by these coal fields is so difficult of access that considerable expense is involved in making surveys. For this reason the work proceeds slowly and another field season will be required for its completion.

The field work for a report upon the coal fields of Thurston, Lewis and Cowlitz counties is nearly finished. Accurate maps are being made, showing the exact locations of the workable coal beds of this section. Samples have been collected from all of the mines and careful analyses have already been made. This is a lignite field containing a heavy tonnage of coal and one which in time will be of considerable value to the state.

Investigation of Materials for Portland Cement.—The investigation of crude materials for cement making, which was carried on for several seasons, has been completed and the re-

port printed and distributed. Cement of excellent quality is now being made at four centers in the state and as the demand for this product increases other factories will no doubt be constructed. The report embraces not only those localities where ample limestone deposits are found, but also the smaller bodies where the limestone may be utilized for the manufacture of quick lime, for fertilizer, for use as a flux, or for any other purpose.

Reports on Metal Mining Districts.—In past years reports have been made upon the principal metal mining districts of the state, such as those at Republic, Myers Creek, Oroville, Blewett and Index. In response to an urgent request from the mining men from the Covada district, this area in Ferry county was investigated in the summer of 1913. In this region there was a contest between the mining interests and the Indian allotments. For the benefit of the men who had spent much time and money in developing their mining claims the field work was done and a bulletin published giving the results obtained.

In the season of 1914 a party was engaged in an investigation of the geology and ore deposits of the mining areas in Stevens and Pend Oreille counties. The field work has been completed and the manuscript is now being prepared for the printer covering the results of this inquiry.

Soil Surveys.—Extensive soil surveys have been made under a cooperative arrangement with the Bureau of Soils, United States Department of Agriculture. Under this plan the latter bureau agreed to assume the major portion of the expense of the field work, and all the expense of printing the reports. In these surveys the various kinds of soil are studied with care, and they are classified into types based upon origin, texture, depth, agricultural value and topography. Maps are prepared in colors, showing the character of the soils which occur in every locality embraced by the surveys. All the factors that have a bearing upon the utility of the soils, such as topography, drainage, climate, etc., are investigated and the conclusions set forth in detail in the reports.

The earlier soil surveys were carried on mostly in Western Washington and have had to do with the logged-off lands. As a result of the surveys a land classification map was prepared in colors, showing the extent of the logged-off lands, the areas still covered by virgin forests, the tracts which had been developed agriculturally, and the swamp or marsh lands. The lands surveyed were further classified into different groups, and these were shown on the land classification map by means of symbols. Some of the principal groups were as follows: Lands adapted to general farming and justifying immediate agricultural development; lands which were capable of being developed agriculturally and are adapted to intensive farming, fruit growing and pasturage; lands which could be utilized for orchards and pasturage, but not well adapted to farming; non-agricultural lands, suitable for reforestation only; and areas of forests, unclassified.

The principal demands in the last two years have been for soil surveys in the agricultural areas in Eastern Washington. During the field season of 1913 all of Stevens County was surveyed. A report upon this work has been prepared for the printer and it will soon be ready for distribution. The field season of 1914 was employed in making a similar soil survey of Franklin county. In this county particular attention was paid to the quality and character of the soils embraced within the Palouse project and other portions of the county where irrigation is possible and where it must be practiced before the region can be reclaimed. It seems desirable to carry on the future soil surveys in those regions where irrigation must be followed in order to know what problems are presented by the character of the soils themselves.

Geology of Western Counties.—For several field seasons work has been done by small parties on the bed rock formations of those counties of Washington which are located to the westward of the foothills of the Cascade Mountains. The formations of this extensive area are largely sedimentary in character and embrace mainly sandstones and shales. While the economic value

of these rocks is limited, there has been considerable inquiry in regard to the possibility of gas and oil. The entire area is so large and the cost of doing field work so great in the inaccessible parts of the country that the work has progressed with great slowness on account of the small amount of funds available. As a result of persistent field work and careful office work a report of several hundred pages is now ready for the printer. The maps have already been engraved and are ready for use. They indicate the structure of the formations, the dip and strike of the beds and in a general way indicate the best places for prospecting for gas and oil. The possible occurrence of these economic products at the different localities of the extensive area are thoroughly discussed. It is believed that this report will be of great service in determining whether or not gas and oil occur in commercial quantities in Western Washington.

Report on the Glaciation of the Puget Sound Region.—Immediately prior to this biennium a report was published on the glacial geology of the country around Puget Sound. This bulletin was received with a great deal of interest and in the present biennium it has been found advisable to assume the small expense of continuing the area to the south and west of Puget Sound. A bulletin is now ready for the printer which makes practically complete a description of the glacial geology of all of Western Washington beyond the foothills of the Cascades.

New Base Map of the State.—In cooperation with the United States Geological Survey, each party assuming one-half of the expense, a new base map of the state has been prepared on a scale of eight miles to the inch. This has been printed in two colors and is the most accurate map of Washington which has been made. It is already in considerable demand by our citizens who need a map of this character.

Office Work.—The office work of the Geological Survey becomes increasingly heavy from year to year. Constant inquiries come to the office in regard to the mineral resources of every corner of the state. Prospective settlers and others are very desirous of accurate information regarding the climatic and soil

conditions of those regions in which they may plan to make their homes. Manufacturers are desirous before coming to Washington of knowing the nature of the fuel supply and the variety of crude materials of a mineral character which may be obtained for manufacturing purposes. On the whole the work of the State Geological Survey is carried on at a minimum of expense because a very large part of the work, especially the office work, is done by men who do not receive any compensation for that purpose out of the funds of the Survey.

FINANCIAL STATEMENT.

TOPOGRAPHICAL AND HYDROGRAPHICAL SURVEYS.

U. S. Geological Survey:		
Allotment for cooperation 1913-15		$35,000 00
Expenditures to December 1, 1914		29,027 05
Balance on December 1, 1914		$5,972 95
State Geological Survey:		
Appropriation for 1913-15		$35,000 00
Expenditures to December 1, 1914		29,389 50
Balance on December 1, 1914		$5,610 50

GEOLOGICAL SURVEYS.

State Geological Survey:		
Appropriation for 1913-15		$20,000 00
Expenditures to December 1, 1914:		
Printing of reports	$3,588 53	
Coal Surveys:		
Pierce County	837 05	
Kittitas County	247 45	
Whatcom County	2,116 47	
Investigation of cement materials	105 00	
Soil surveys	2,065 29	
Investigations for oil	729 57	
Surveys of metal mining districts	1,107 59	
Report on geology of Puget Sound region	557 55	
Investigation of mineral resources	483 35	
Investigation of diatomaceous earth	60 00	
Clerical work	1,512 50	
Draftsmen	1,706 32	
Instruments and filing cabinets	46 95	
Office supplies, express charges and incidentals	630 46	
Traveling and field expenses of State Geologist	723 80	
Per diem paid State Geologist	525 00	
Expenses of Board of Geological Survey	73 65	
Total	$17,116 53	
Balance on December 1, 1914		$2,883 47
U. S. Department of Agriculture, Bureau of Soils:		
Expenditures for field-work in cooperation, soil surveys		$4,508 34

RECOMMENDATIONS.

APPROPRIATIONS REQUESTED.

For topographical and hydrographical surveys (conditioned upon a similar sum being expended in the state by the United States Geological Survey)	$35,000
For Geological Surveys	20,000

TOPOGRAPHICAL SURVEYS.

The principal demand for topographical surveys comes from the arid regions of the state where the land may be reclaimed only by irrigation and where topographic maps are almost indispensable in engineering work of this nature. After consultation with the officers of the United States Geological Survey it is recommended that for the next biennium the major portion of the topographical work be done in Kittitas, Yakima, Benton, Franklin and Walla Walla counties.

In the past six years level lines or profiles have been run along all the streams of the Eastern Cascades and along all the streams of the Western Cascades south of the Skagit River. This has been done as a necessary part of the problem of determining with accuracy the total hydroelectric power of the rivers of the Cascade Mountains. With our usual appropriation it will be possible within the coming biennium to run profiles along the Skagit and Nooksack rivers, with their tributaries, and thus complete the data for water power reports on the entire Cascade Mountains.

HYDROGRAPHICAL SURVEYS.

As indicated on the progress map accompanying this report, gaging stations are maintained on a large number of the rivers where information is very necessary as to the total amount of water available for municipal supplies, irrigation and power. The gaging records are of the greatest value only when they are kept continuously for a series of years. It is recommended that the usual appropriation for this work be made so that cooperation with the Federal government may be continued.

GEOLOGICAL SURVEYS.

The sum of twenty thousand dollars, the same amount as appropriated by the legislatures of 1909, 1911 and 1913, is requested for geological surveys, in order that certain lines of work now under way may be completed and some new work may be begun.

Printing.—Several bulletins or reports are now about ready for printing. In some instances the field work for these reports has extended over several years and it is desirable that the bulletins be printed at the earliest moment. The Geological Survey does not have any special appropriation for printing, as is true of practically all of the other bureaus of the state government, but its entire printing bill must be paid out of its appropriation for maintenance. As a rule the most valuable part of a report is embraced in the maps. This is especially true in a state as new as Washington where reliable base maps are difficult to obtain. It has been the purpose of the Survey to prepare its maps with very great care and this has involved considerable expense.

Surveys of Coal Fields.—One more field season will be necessary in order to secure the remaining information for reports on the coal fields of Whatcom, Thurston, Lewis and Cowlitz counties. When these reports are made all of the known fields of the state that are of any commerical value will have had reports made upon them in great detail. In all the coal surveys the boundaries are followed with great care so that the exact areas underlaid by seams of workable coal are accurately determined.

Soil Surveys.—Soil surveys should be continued in those portions of the state where irrigation problems are of primary importance. Not only is it necessary to have these surveys where irrigation is proposed, but where irrigation has been carried on for some years, in order that the various soil problems may be solved. In all soil surveys cooperation is afforded with the United States Bureau of Soils, the Federal bureau usually as-

suming about three-fourths of the expense of the field work besides all the cost of printing.

Surveys of Metal Mining Districts.—In addition to the detailed surveys already made of the best known districts, there are many requests for reconnoissance surveys of the scattered mining sections, whereby the varieties of bed-rock, the important minerals, and the character of the ore deposits may be determined and described. It is also hoped that in this connection samples from low grade ore bodies may be secured and tests made to ascertain the best treatment to employ in separating out the metals.

For the next biennium surveys of the mining districts in Ferry, Okanogan and Chelan counties should be made. Such surveys are of very great service to the mining men who are giving their time and money to the development of one of the state's resources. It is of great value to the promoter, as well as the investor and to the state at large that the truth in regard to the quality and quantity of the ore bodies should be made known.

Report on Clay Deposits.—One of the most important mineral products of the state is clay. Factories for the manufacture of clay products are located in many section of the state. There is a great deal of inquiry in regard to the location and extent of high grade clays, those suitable for the manufacture of the more expensive wares. As the state grows in population and wealth the demand for pottery products will be greatly increased. There is a necessity at this time for a complete field report upon the formations of the state which yield clays of economic value. Maps should be prepared which show the extent of the clay deposits of different types and kinds.

Topographical Map.—There is a great deal of inquiry for a map which will show by a system of contours or by a series of tints the elevations of various portions of the state. By utilizing the base map which has already been prepared and compiling the data regarding elevations throughout the state it will be possible to prepare a map which will give the informa-

tion most needed. Such a map should be printed in colors, the black referring to the culture, the blue giving the water bodies, and a series of brown shades or tints which will give the variations in elevation from sea level to the tops of the highest mountains.

Geological Map.—With the base map now available it is desirable that the boundaries of the different geological formations should be entered thereon and a complete geological map of the state prepared as clearly as possible. This has been very generally done by other states and Washington is one of the last to prepare such a map. It is of very great value to all persons who have to deal with that phase of applied geology concerned with the development of any of our mineral resources. The cost of preparation of such a map is not excessive and the value to citizens generally would repay the cost many fold.

Report on Mineral Industries.—Any information bearing upon the production of different minerals in different counties and other portions of the state is always in much demand. It seems necessary to keep this information in such form that it may be given out regularly and revised as often as desirable. At least once a year reports and maps should be issued which set forth the localities where different mineral products may be obtained, along with the names of all producers and accurate statistics in regard to the output of each particular mineral concerned. Such information is very greatly desired by manufacturers and all others who have occasion to use in any way whatsoever those minerals that are of economic importance.

PUBLICATIONS

OF THE

WASHINGTON GEOLOGICAL SURVEY.

Volume 1.—Annual Report for 1901. Part 1, Creation of the State Geological Survey, and An Outline of the Geology of Washington, by Henry Landes; part 2, The Metalliferous Resources of Washington, Except Iron, by Henry Landes, William S. Thyng, D. A. Lyon and Milnor Roberts; part 3, The Non-Metalliferous Resources of Washington, Except Coal, by Henry Landes; part 4, The Iron Ores of Washington, by S. Shedd, and the Coal Deposits of Washington, by Henry Landes; part 5, The Water Resources of Washington, by H. G. Byers, C. A. Ruddy and R. E. Heine; part 6, Bibliography of the Literature Referring to the Geology of Washington, by Ralph Arnold. Out of print.

Volume 2.—Annual Report for 1902. Part 1, The Building and Ornamental Stones of Washington, by S. Shedd; part 2, The Coal Deposits of Washington, by Henry Landes and C. A. Ruddy. Postage 20 cents. Address, State Librarian, Olympia, Washington.

Bulletin 1.—Geology and Ore Deposits of Republic Mining District, by Joseph B. Umpleby. Bound in cloth; price, 35 cents. Address State Librarian, Olympia, Washington.

Bulletin 2.—The Road Materials of Washington, by Henry Landes. Bound in cloth; price, 60 cents. Address, State Librarian, Olympia, Washington.

Bulletin 3.—The Coal Fields of King County, by Geo. W. Evans. Bound in cloth; price, 75 cents. Address, State Librarian, Olympia, Washington.

Bulletin 4.—The Cement Materials of Washington, by S. Shedd. Bound in cloth; price, 75 cents. Paper cover; price, 40 cents. Address, State Librarian, Olympia, Washington.

Bulletin 5.—Geology and Ore Deposits of the Myers Creek and Oroville-Nighthawk Districts, by Joseph B. Umpleby. Bound in cloth; price, 50 cents. Address, State Librarian, Olympia, Washington.

Bulletin 6.—Geology and Ore Deposits of the Blewett Mining District, by Charles E. Weaver. Bound in cloth; price, 50 cents. Address, State Librarian, Olympia, Washington.

Bulletin 7.—Geology and Ore Deposits of the Index Mining District, by Charles E. Weaver. Bound in cloth; price, 50 cents. Address, State Librarian, Olympia, Washington.

Bulletin 8.—Glaciation of the Puget Sound Region, by J. Harlen Bretz. Bound in cloth; price, 60 cents. Paper cover; price, 35 cents. Address, State Librarian, Olympia, Washington.

Bulletin 9.—The Coal Fields of Kittitas County, by E. J. Saunders. Bound in cloth; price, 60 cents. Paper cover; price, 40 cents. Address, State Librarian, Olympia, Washington.

Bulletin 10.—The Coal Fields of Pierce County, by Joseph Daniels. Bound in cloth; price, 60 cents. Paper cover; price, 40 cents. Address, State Librarian, Olympia, Washington.

Bulletin 11.—The Mineral Resources of Washington, with Statistics for 1912, by Henry Landes. Paper cover; price, 25 cents. Address, State Librarian, Olympia, Washington.

Bulletin 12.—Bibliography of Washington Geology and Geography, by Gretchen O'Donnell. Paper cover; price, 25 cents. Address, State Librarian, Olympia, Washington.

Bulletin 13.—The Tertiary Formations of Western Washington, by Charles E. Weaver. In preparation.

Bulletin 14.—The Quincy Valley Irrigation Project, by Henry Landes, A. W. Mangum, H. K. Benson, E. J. Saunders, and Joseph Jacobs. Paper cover; price, 20 cents. Address, State Librarian, Olympia, Washington.

Bulletin 15.—A Preliminary Report on the Tertiary Paleontology of Western Washington, by Chas. E. Weaver. Paper cover; price, 20 cents. Address, State Librarian, Olympia, Washington.

Bulletin 16.—Geology and Ore Deposits of the Covada Mining District, by Charles E. Weaver. Paper cover; price, 25 cents. Address, State Librarian, Olympia, Washington.

Bulletin 17.—The Mineral Resources of Washington, with Statistics for 1913, by Henry Landes. In preparation.

Bulletin 18.—The Coal Fields of Lewis, Thurston and Cowlitz Counties, by Harold E. Culver. In preparation.

Bulletin 19.—Ore Deposits of the Principal Mining Districts of Stevens and Pend Oreille Counties, by Charles E. Weaver. In preparation.

PUBLICATIONS OF THE U. S. GEOLOGICAL SURVEY, IN CO-OPERATION WITH THE WASHINGTON GEOLOGICAL SURVEY.

(For copies of these publications address the Director U. S. Geological Survey, Washington, D. C.)

Topographic Maps of the Following Quadrangles: Mount Vernon, Quincy, Winchester, Moses Lake, Beverly, Red Rock, Cedar Lake, Arlington, Wenatchee, Malaga, Mitchell, Haven, Chehalis, Hoquiam, Ocosta, Pasco. Price, 10 cents each.

POWER REPORTS.

Water-Supply Paper No. 253: Water Powers of the Cascade Range, Part I, Southern Washington.

Water-Supply Paper No. 313: Water Powers of the Cascade Range, Part II, Puget Sound Region.

Water-Supply Paper No. 369: Water Powers of the Cascade Range, Part III, Yakima Basin.

Water-Supply Paper No. —: Water Powers of the Cascade Range, Part IV. In preparation.

RIVER PROFILES.

Water-Supply Paper No. 346: Profile Surveys of Clark Fork of Columbia River.

Water-Supply Paper No. 366: Profile Surveys of Snoqualmie, Sultan, and Skykomish rivers.

Water-Supply Paper No. 368: Profile Surveys of Wenatchee River and tributaries.

ANNUAL STREAM-FLOW REPORTS.

Water-Supply Paper No. 272: Surface Water Supply of the United States, North Pacific Coast, 1909.

Water-Supply Paper No. 292: Surface Water Supply of the United States, North Pacific Coast, 1910.

Water-Supply Paper No. 312: Surface Water Supply of the United States, North Pacific Coast, 1911.

Water-Supply Paper No. 332: Surface Water Supply of the United States, North Pacific Coast, 1912. At Government Printing Office.

Water-Supply Paper No. 362: Surface Water Supply of the United States, North Pacific Coast, 1913. In preparation.

QUALITATIVE REPORT.

(Principally in co-operation with State Board of Health.)

Water-Supply Paper No. 339: Quality of the Surface Waters of Washington.

PUBLICATIONS OF THE U. S. DEPARTMENT OF AGRICULTURE, BUREAU OF SOILS, IN CO-OPERATION WITH THE WASHINGTON GEOLOGICAL SURVEY.

(For copies of these publications address one of the members of congress from Washington.)

Reconnoissance Soil Survey of the Eastern Part of the Puget Sound Basin.

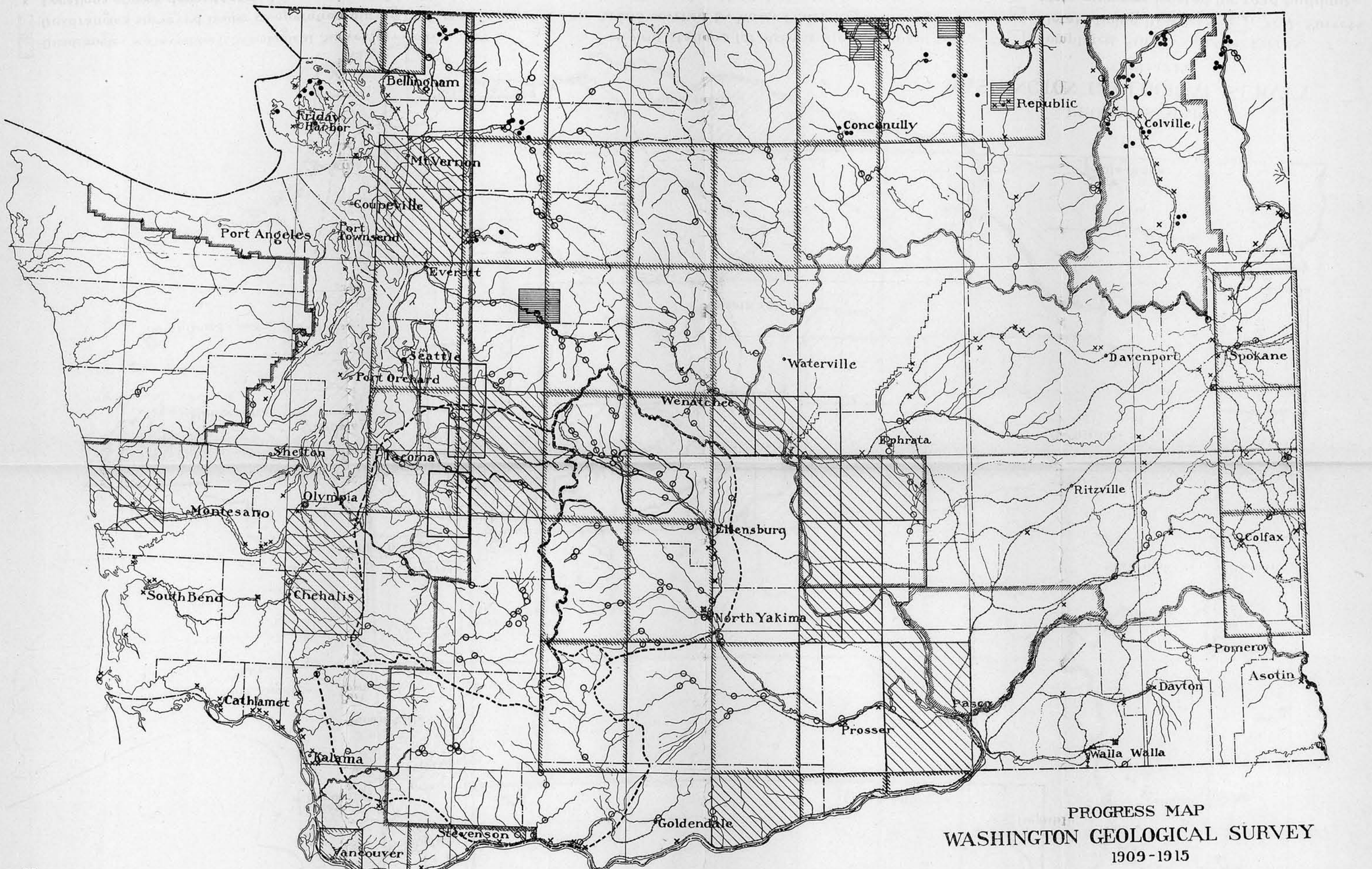
Reconnoissance Soil Survey of the Western and Southern Parts of the Puget Sound Basin.

Reconnoissance Soil Survey of Southwestern Washington.

Reconnoissance Soil Survey of the Quincy Area.

Reconnoissance Soil Survey of Stevens County.

Reconnoissance Soil Survey of Franklin County. In preparation.



PROGRESS MAP
WASHINGTON GEOLOGICAL SURVEY
1909-1915

Quadrangles surveyed by U.S. Geological Survey previous to 1909.
Quadrangles surveyed under co-operation during 1909-13.
× Locations of rock deposits tested for use in road building.
o Gauging stations for stream measurements.
--- Areas covered by Water Power Reports.
• Locations of materials tested for making cement.
Completed Surveys of Coal Fields.
Metal Mining Districts. Soil Surveys.
State quarries located for road building.

TOPOGRAPHY

U.S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH
DIRECTOR

STATE OF WASHINGTON
M.E. HAY, GOVERNOR
HENRY LANDES, STATE GEOLOGIST

WASHINGTON
(GRANT COUNTY)
RED ROCK QUADRANGLE

R.B. Marshall, Chief Geographer.
T.G. Gerdine, Geographer in charge.
Topography by A.O. Burkland, H.L. McDonald, C.F. Eberly, and R.M. LaFollette.
Control by C.H. Semper and R.B. Robertson.
Surveyed in 1909.

SURVEYED IN COOPERATION WITH THE STATE OF WASHINGTON.

McDonald
E
LaF
Burkland

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 25 feet.
Datum is mean sea level.

TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1909.

Edition of Jan. 1911.

RED ROCK

DESCRIPTION OF THE TOPOGRAPHIC MAP OF THE UNITED STATES

The United States Geological Survey is making a topographic map of the United States. This work has been in progress since 1882, and more than one-third of the area of the country, excluding outlying possessions, has been mapped. The mapped areas are widely scattered, nearly every State being represented, as shown on the progress maps accompanying each annual report of the Director.

This great map is being published in atlas sheets of convenient size, which are bounded by parallels and meridians. The four-cornered division of land corresponding to an atlas sheet is called a *quadrangle*. The sheets are of approximately the same size: the paper dimensions are 20 by 16½ inches; the map occupies about 17½ inches of height and 11½ to 16 inches of width, the latter varying with latitude. Three scales, however, are employed. The largest scale is 1:62500, or very nearly one mile to one inch; i. e., one linear mile on the ground is represented by one linear inch on the map. This scale is used for the thickly settled or industrially important parts of the country. For the greater part of the country an intermediate scale of 1:125000, or about two miles to one inch, is employed. A third and still smaller scale of 1:250000, or about four miles to one inch, has been used in the desert regions of the far West. A few special maps on larger scales are made of limited areas in mining districts. The sheets on the largest scale cover 15′ of latitude by 15′ of longitude; those on the intermediate scale, 30′ of latitude by 30′ of longitude; and those on the smallest scale, 1° of latitude by 1° of longitude.

The features shown on this map may, for convenience, be classed in three groups: (1) *water*, including seas, lakes, ponds, rivers and other streams, canals, swamps, etc.; (2) *relief*, including mountains, hills, valleys, cliffs, etc.; (3) *culture*, i. e., works of man, such as towns, cities, roads, railroads, boundaries, etc. The conventional signs used for these features are grouped below. Variations appear in some maps of earlier dates.

All water features are shown in *blue*, the smaller streams and canals in full blue lines, and the larger streams, lakes, and the sea by blue water-lining. Certain streams, however, which flow during only a part of the year, their beds being dry at other times, are shown, not by full lines, but by lines of dots and dashes. Ponds which are dry during a part of the year are shown by oblique parallel lines. Salt-water marshes are shown by horizontal ruling interspersed with tufts of blue, and fresh-water marshes and swamps by blue tufts with broken horizontal lines.

Relief is shown by contour lines in *brown*. Each contour passes through points which have the same altitude. One who follows a contour on the ground will go neither uphill nor downhill, but on a level. By the use of contours not only are the shapes of the plains, hills and mountains shown, but also the elevations. The line of the seacoast itself is a contour line, the datum or zero of elevation being mean sea level. The contour line at, say, 20 feet above sea level is the line that would be the seacoast if the sea were to rise or the land to sink 20 feet. Such a line runs back into the valleys and forward around the points of hills and spurs. On a gentle slope this contour line is far from the present coast line, while on a steep slope it is near it. Thus a succession of these contour lines far apart on the map indicates a gentle slope; if close together, a steep slope; and if the contours run together in one line, as if each were vertically under the one above it, they indicate a cliff. In many parts of the country are depressions or hollows with no outlets. The contours of course surround these, just as they surround hills. Those small hollows known as sinks are usually indicated by hachures, or short dashes, on the inside of the curve. The contour interval, or the vertical distance in feet between one contour and the next, is stated at the bottom of each map. This interval varies according to the character of the area mapped; in a flat country it may be as small as 5 feet; in a mountainous region it may be 200 feet. Certain contours, usually every fifth one, are accompanied by figures stating elevation above sea level. The heights of many definite points, such as road corners, railroad crossings, railroad stations, summits, water surfaces, triangulation stations, and bench marks, are also given. The figures in each case are placed close to the point to which they apply, and express the elevation to the nearest foot only. The *exact* elevations of bench marks and their descriptions, as well as the descriptions and geodetic coordinates of triangulation stations, are published in the annual reports and bulletins of the Survey. The publications pertaining to specified localities may be had on application.

The works of man are shown in *black*, in which color all lettering also is printed. Boundaries, such as State, county, city, land-grant, reservation, etc., are shown by broken lines of different kinds and weights. Houses are shown by small black squares which in the densely built portions of cities and towns merge into blocks. Roads are shown by fine double lines (full for the better roads, dotted for the inferior ones), trails by single dotted lines, and railroads by full black lines with cross lines. Other cultural features are represented by conventions which are easily understood.

The sheets composing the topographic atlas are designated by the name of a principal town or of some prominent natural feature within the quadrangle and the names of adjoining published sheets are printed on the margins. They are sold at five cents each when fewer than 100 copies are purchased, but when ordered in lots of 100 or more copies, whether of the same or of different sheets, the price is three cents each.

The topographic map is the base on which the facts of geology and the mineral resources of a quadrangle are represented. The topographic and geologic maps of a quadrangle are finally bound together, accompanied by a description of the district, to form a folio of the Geologic Atlas of the United States. The folios are sold at twenty-five cents each, excepting that such as are unusually comprehensive are priced accordingly.

Applications for the separate topographic maps or for folios of the Geologic Atlas should be accompanied by cash—the exact amount—or by post-office money order, and should be addressed to—

THE DIRECTOR,

United States Geological Survey,

Washington, D. C.

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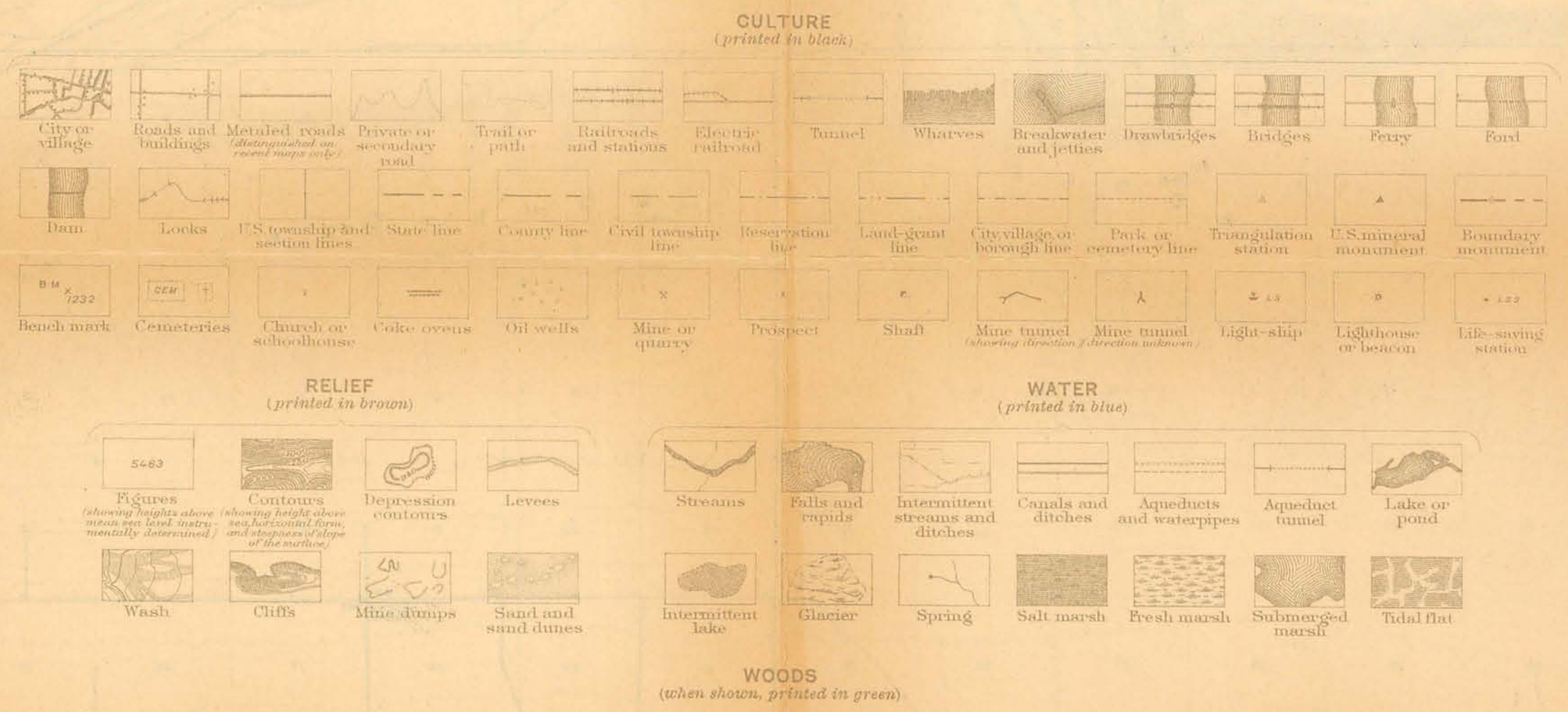
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