

UNITED STATES  
DEPARTMENT OF THE INTERIOR  
GEOLOGICAL SURVEY  
WATER RESOURCES DIVISION

A LIST OF REFERENCES ON THE  
OCCURRENCE, AVAILABILITY, AND CHARACTER OF GROUND WATER  
IN THE MISSOURI RIVER BASIN

Compiled by  
Eldon A. Busch

FOR USE OF PERSONNEL OF THE  
UNITED STATES GEOLOGICAL SURVEY  
ENGAGED IN GROUND-WATER INVESTIGATIONS  
IN THE MISSOURI RIVER BASIN

July 1950

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INTRODUCTION

This compilation of ground-water references was prepared as an aid to the field men engaged in ground-water investigations in the Missouri River Basin. It is thought that an acquaintance with the available literature on the area in which a field man is working may on occasion not only save him the effort of duplicating work that has already been done in his area but that he will find the reports of other workers on the same problem both informative and challenging.

It is suggested that each field man make every effort to obtain copies of the literature on his area from nearby sources before he calls on his superior for help in obtaining copies of the desired references.

It is not presumed that this bibliography is complete. In order that it may be improved upon at a later date, the field man is requested to enter on the blank pages at the end of the listed references all other references he may discover from time to time. Then, if the demand for a revision of the bibliography is sufficiently great, these added references can be inserted in the appropriate places. Suggestions as to an improved arrangement of the material will be welcomed by the Missouri Basin Ground-Water Headquarters Office.

Papers Relating to Specific Areas Within the State

United States Geological Survey Bulletins

The Boulder, Colo., oil field, by N. M. Fenneman. U. S. Geol. Survey Bull. 213, pp. 322-332, 1903.

Describes the geology, structure, and stratigraphy of the area. Includes a brief discussion of subsurface water in connection with oil accumulation (p. 325). In isolated cases, deep water-bearing strata have been encountered, and the water is salty in places.

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Geology of the Boulder district, Colo., by N. M. Fenneman. U. S. Geol. Survey Bull. 265, 101 pp., 5 pls., 1905.

Describes the geology of a rectangular area 16 miles north and south by 9 miles east and west, in the southwestern part of which is situated the city of Boulder. Discusses briefly (pp. 67-69) the flowing wells and water-bearing formations, including the Dakota sandstone. Contains a geologic map of the area.

Geology and oil and gas prospects of northeastern Colo., by K. F. Mather, James Gilluly and R. G. Lusk. U. S. Geol. Survey Bull. 796 b, pp. 65-124, pls., 14-18, 1928.

Well logs show the occurrence of water (pp. 118-124, pl. 18). Includes geologic map and section of part of northeast Colorado, structure-contour map of Fort Collins-Wellington oil field, and graphic well logs.

Other United States Geological Survey Publications

Geology of the Denver Basin in Colorado by S. F. Emmons, Whitman Cross and G. N. Eldridge. U. S. Geol. Survey Mon. 27, 556 pp., 31 pls., 1896.

Contains a discussion of water in the Pleistocene deposits (pp. 272, 273) and a section on artesian wells (pp. 401-465). Discusses the history of artesian-water developments in Colorado, the water-bearing horizons, the artesian structure, the quantity of artesian water, and the yield and decrease in yield of flowing wells. Includes three analyses of well waters and maps showing the geology of the region and the original area of artesian flow.

Irrigation near Greeley, Colo., by David Boyd. U. S. Geol. Survey Water-Supply Paper 9, 90 pp., 21 pls., 1897.

Describes the water supplies, irrigation developments, and agricultural practices in the valley of the Cache La Poudre River, a tributary of the South Platte. Discusses the legislative and judicial control of the water supplies, (including ground water), the source and disposal of ground water, and the use of ground water, the effects of alkali water on soil, pumping of ground water and artesian wells.

Economic geology of the Georgetown quadrangle (together with the Empire district), Colo. by J. E. Spurr and G. H. Garrey, with general geology by S. H. Ball. U. S. Geol. Survey Prof. Paper 63, 422 pp., 87 pls., 1908.

Discusses the hot springs at Idaho Springs and Glenwood (pp. 27, 163-168) and gives analyses of 6 spring waters at Idaho Springs (p. 164).

Progress report on the ground-water resources of the lower South Platte River Valley between Hardin, Colo., and Paxton, Nebr., by L. J. Bjorklund and J. A. Tavelli, with a section on the chemical quality of the ground water, by Herbert A. Swenson. U. S. Geol. Survey, Missouri Basin Studies, mimeographed report, Feb. 1949.

#### Publications by Other Federal Agencies

Soil survey of the Greeley area, Colo. by J. G. Holmes and N. P. Neill, Field operations of the Bur. Soils. U. S. Dept. Agr. pp. 951-993, 1 map, 1 fig., 1904.

Discusses the physiography and geology of the region. Includes a detailed description of soils and a short paragraph on water supply for irrigation.

Irrigation in northern Colorado, (Cache La Poudre River), by R. G. Hemphill. Dept. of Agr. Bull. 1026, 85 pp., 1922.

Colorado State College of Agricultural and Mechanical Arts,  
Agricultural Experiment Station Bulletins

Seepage and return waters from irrigation (Cache La Poudre and South Platte Rivers), by L. G. Carpenter. State Coll. Agr. and Mech. Arts Agr. Exp. Station Bull. 33, pp. 95-96, 1898.

Return of seepage waters to the South Platte River in Colorado, by R. L. Parshall, State Coll. Agr. and Mech. Arts Agr. Exp. Station Bull. 279, pp. 1-72, 1922.

Use of ground water for irrigation in the South Platte Valley of Colorado, by W. E. Code, State Coll. Agr. and Mech. Arts Agr. Exp. Station Bull. 483, 44 pp., 1 pl., 17 figs., Sept., 1943.

Discusses the extent and importance of ground-water use, ground-water inventories, and general conditions in specific areas. Includes hydrographs and a map showing irrigation districts.

Publications by Other State Agencies

Ground waters of parts of Elbert, El Paso, and Lincoln Counties, Colo., by R. C. Coffin. Colorado Geol. Survey Bull. 26, pp. 3-8, 1921.

Colorado Science Society Proceedings

The artesian wells of Denver; a report by a special committee of the Colorado Sci. Soc. published by the society, 41 pp., Denver, 1884, R. T. Cross and others.

Geologic relation of artesian wells in Denver by C. W. Cross. Colorado Sci. Soc. Proc. 1, pp. 77-83, 1885.

Data concerning the Denver wells, by F. F. Chisolm, Colorado Sci. Soc. Proc. 1, pp. 83-98, 1885.



Chemistry of the Denver artesian wells, by Regis Chauvenit, pp. 98, 101, Colorado Sci. Soc. Proc. 1, 1885.

General information concerning Denver artesian wells and others, Colorado Sci. Soc. Proc. 1, pp. 102-108, 1885.

Notes upon the artesian wells of Denver, C. G. Slack. Colorado Sci. Soc. Proc. 2, pp. 56-60, 1887.

The Denver artesian basin, by R. T. Hill Colorado Sci. Soc. Proc. 4, p. 6, 1891.

The sanitary chemical character of some of the artesian waters of Denver, by W. C. Strong. Colorado Sci. Soc. Proc. 5, pp. 17-23, 1898 (separate edition, 9 pp., 1894).

#### Other Journal Articles

Increased water supply for Golden, Colo. Eng. News, p. 610, June 27, 1891.

Pumping and return flow in the South Platte River Valley, by W. E. Code, Through the Leaves, vol. 26, (3) pp. 87-89, May 1938.

Water supply increased by infiltration galleries (East Park and Douglas Co.) by A. A. Wieland, Water Works and Sewerage, vol. 76 (1), pp. 1-2, Jan. 1931.

#### Papers of a General Nature or Relating to the Entire State

#### Publications by Federal Agencies

A report on the preliminary investigation to determine the proper location of artesian wells within the area of the 97th Meridian of longitude and east of the foothills of the Rocky Mountains. U. S. 51st Cong., 1st sess., S. Ex. Doc. 222, 1890.

Water resources of the State of Colorado, by A. L. Fellows, U. S. Geol. Survey Water-Supply Paper 74, 151 pp., 1902.

Seepage and drainage are discussed in some detail in regard to surface water sources for irrigation in the South Platte division of Colorado. Drainage areas and discharge measurements are computed in part. The absorption of rainfall in various types of rocks is also discussed.

Irrigation in Colorado, by C. W. Beach and P. J. Preston. U. S. Dept. Agr. Bur. Chem. and Soils Bull. 218, 48 pp., 1910.

Colorado State College of Agricultural and Mechanical Arts,  
Agricultural Experiment Station Annual Reports

Water analyses by D. O'Brien. State Coll. Agr. and Mech. Arts, Agr. Exp. Sta. 1st Ann. Rept., p. 151, 1888.

Irrigation Engineering, by L. G. Carpenter. State Coll. Agr. and Mech. Arts, Agr. Exp. Sta. 4th Ann. Rept., pp. 45-57, 1891.

Irrigation Engineering, by L. G. Carpenter. State Coll. Agr. and Mech. Arts, Agr. Exp. Sta. 11th Ann. Rept., pp. 176-198, 1898.

Seepage gains and losses, by L. G. Carpenter, State Coll. Agr. and Mech. Arts, Agr. Exp. Sta. 13th Ann. Rept., pp. 135-140, 1900.

Colorado State College of Agricultural and Mechanical Arts,  
Agricultural Experiment Station Bulletins

Artesian wells of Colorado and their relation to irrigation by L. G. Carpenter, State Coll. Agr. and Mech. Arts, Agr. Exp. Sta. Bull. 16, 28 pp., July, 1891.

Loss from canals from filtration or seepage, by L. G. Carpenter. State Coll. Agr. and Mech. Arts, Agr. Exp. Sta. Bull. 48, 1898.



A soil study, part 4. The ground water, by W. P. Headden. State Coll. Agr. and Mech. Arts, Agr. Exp. Sta. Bull. 72, p. 47.

Seepage and return waters, by L. G. Carpenter. State Coll. Agr. and Mech. Arts, Agr. Exp. Sta. Bull. 180, part 1, 70 pp., part 2, 48 pp., part 3, 146 pp., 1911.

Alkalies in Colorado, by W. P. Headden. State Coll. Agr. and Mech. Arts, Agr. Exp. Sta. Bull. 239, 1918.

Cost of pumping for irrigation in Colorado, by W. E. Code. State Coll. Agr. and Mech. Arts, Agr. Exp. Sta. Bull. 387, Mar., 1932.

Cost of pumping for irrigation in Colorado, with basic data, by W. E. Code. State Coll. Agr. and Mech. Arts, Agr. Exp. Sta. Bull. 388, Mar., 1932.

The construction of irrigation wells in Colorado, by W. E. Code. State Coll. Agr. and Mech. Arts, Agr. Exp. Sta. Bull. 415, 1935.

Seepage losses from irrigation channels, by C. Rohwer and O. V. P. Stout. State Coll. Agr. and Mech. Arts Exp. Sta., Tech. Bull. 38, 100 pp., 39 figs., 10 tables, Mar., 1948.

Discusses ground water in relation to seepage problems from irrigation channels. Includes seepage measurements and ground-water profiles. Also technical drawings and discussions.

#### Publications by Other State Agencies

Municipal water supplies of Colorado, by C. C. Williams. Univ. of Colorado Bull., Sept., 1912.

Mineral waters of Colorado, by R. D. George, Colorado State Survey Bull. 11, 474 pp., 40 figs., 2 pls., 1920.

Public water supplies in Colorado, Colorado State Board of Health, Division of Sanitary Eng., Dec., 1926. (Map).

#### Journal Articles

Artesian wells in Colorado, by E. L. Berthoud, Kansas City Rev., vol. 4, pp. 536-540, 1881.

Colorado ground-water investigations by A. C. Stiefel, Engineer's Bull., vol. 30, no. 12, p. 6, 21, 1 fig., Dec., 1946.

Papers Relating to Specific Areas Within the State

## Iowa State Geological Survey Publications

Geology of Keokuk, Mohasha, Van Buren and Montgomery Counties, Ia., by H. F. Bain, C. H. Gordon and E. H. Lonsdale. Iowa Geol. Survey 4, pp. 252, 308-309, 377, 449, 1895.

Describes the geology and physiography of each of the counties with a brief section on water supply. Includes geologic maps and surface deposit maps.

Geology of Washington, Woodbury, Jones and Appanoose Counties, Ia., by S. Calvin and H. F. Bain. Iowa Geol. Survey 5, pp. 111, 171-172, 298, 1896.

Describes the geology and physiography of each county and includes a brief section on water supply. Includes geologic maps and surface deposit maps.

Geology of Dallas, Buchanan, Delaware, and Plymouth Counties, Ia., by S. Calvin, H. F. Bain and A. G. Leonard. Iowa Geol. Survey 8, pp. 115, 189-191, 252-253, and 365, 1898.

Describes the geology and physiography of each of the counties and includes a brief section on water supply. Includes geologic maps and surface deposit maps.

Geology of Story, Hardin, Osceola, Dickinson, and Worth Counties, Ia., by S. W. Beyer, T. H. Macbride, I. A. Williams. Iowa Geol. Survey 10, pp. 227, 229, 303-305 and 376, 1900.

Contains a brief discussion of water supplies of each of the counties. Describes the geology and topography of the counties. Includes maps showing superficial deposits.

Geology of Page, Clay, O'Brien, Marion, Louisa and Pottawattomie Counties, Ia., by S. Calvin, T. H. Macbride, B. L. Miller, and J. Udden. Iowa Geol. Survey 11, pp. 125, 193-194, 273, 454-456, 495., 1901.

Describes the geology and physiography of each of the counties with a brief section on water supply. Includes geologic maps and maps showing surface deposits.

Geology of Mitchell, Monroe, Chickasaw, Howard, Kossuth, Hancock, Winnebago, Tama, Mills, and Fremont Counties, Ia., by S. Calvin, S. W. Beyer, T. E. Young, T. H. Macbride, T. E. Savage, and J. Udden. Iowa Geol. Survey 13, pp. 78-79, 108, 180, 253, 290-291, 335-337, 420, 1903.

Describes the geology, topography, drainage, stratigraphy and water supply of each of the counties. Contains geologic and superficial deposit maps.

Geology of Black Hawk, Sac, Ida, Bremer, Jackson and Franklin Counties, Ia., by M. F. Arey, T. H. Macbride, W. H. Norton, T. E. Savage, and L. E. Williams. Iowa Geol. Survey 16, pp. 394-395, 450-452, 505-507, 547-548, 648, 1906.

Describes the topography, drainage, stratigraphy and water supply of each of the counties. Includes superficial deposit maps and geologic maps.

Geology of Hamilton, Wright, Harrison, Monroe, Iowa, and Poweshiek Counties, Ia., by T. H. Macbride and S. W. Stocky. Iowa Geol. Survey 20, pp. 153, 185, 255-267, 417-418, 1910.

Describes the geology and physiography of each of the counties and contains a brief section on water supply.

Geology of Crawford County, Ia., by J. H. Lees. Iowa Geol. Survey 22, pp. 346-357, 1927.

Geology of Taylor, Ringgold, Clarke, and Cass Counties, Ia., by M. F. Arey and J. F. Tilton. Iowa Geol. Survey 27, pp. 60-61, 98-100, 150-162, 254-57, 1916.

Describes the topography, drainage, stratigraphy and water resources of each of the counties. Includes topographic geologic and superficial deposit maps.

#### Publications by Other State Agencies

A summary of hydrologic data, Ralston Creek watershed, 1924-1935, by F. T. Maris and Ed. Soucek. Univ. Iowa Studies in Eng. Bull. 9, 1936.

## Journal Articles

Section of a deep well at Emmettsberg, Ia., by N. H. Winchell, Minnesota Acad. Sci. Bull. vol. 1, pp. 347-390, 1880.

The Glenwood well, by S. Dean. Iowa Civil Eng. and Surv. Soc. Proc. 7, pp. 33-39, 1895.

An unusual well record in northwestern Iowa by J. H. Lees. Iowa Acad Sci. Proc. 30, pp. 445-450, 1924.

Discusses the well log of the Holstein well. This log indicates that the Cambrian is almost entirely shale, that the Huronian beds are much thinner than expected and that the bottom 30 feet of the well, 2010 to 2040 feet, is Archean granite.

Ground-water conditions of the Dakota sandstone in northwestern Iowa, by T. W. Robinson. Abstract in Econ. Geology, vol. 34, no. 8, p. 940, Dec., 1939.

Water in the Dakota sandstone in northwestern Iowa occurs under artesian conditions, but the head is nowhere sufficient to produce natural flow from wells at the land surface. A contour map of the piezometric surface of the water in the formation shows the general direction of movement to be southward, but a prominent ground-water divide begins about 60 miles east of the Iowa-South Dakota state line and extends about 100 miles southward from the Minnesota-Iowa state line. Some decline of artesian head has occurred locally in heavily pumped areas.

Papers of a General Nature or Relating to the Entire State

## United States Geological Survey Publications

Underground waters of Iowa, by W. H. Norton. U. S. Geol. Survey Water-Supply Paper 114, pp. 220-225, 1905.

Contains a brief report on ground water in Iowa. Discusses water in the driftless area and water in the drift. Includes a generalized geologic section and an artesian water map.

Underground-water resources of Iowa, by W. H. Norton, W. S. Hendrixson, H. E. Simpson, O. E. Meinzer, and others. U. S. Geol. Survey Water-Supply Paper 293, 994 pp., 18 pls., 1912.

Describes the topography, climate and geology of the state, the occurrence of water in the various geologic formations. The artesian phenomena and the yield of artesian wells, the chemical composition of the ground waters, the municipal, domestic and industrial water supplies, and methods of drilling wells. Includes maps showing the glacial and rock geology, structure contours on water-bearing formations, head of artesian water, and quality of ground water. Also includes numerous geologic sections showing depths to the principal water-bearing formations.

#### Iowa State Geological Survey Publications

Chemical analyses of Water, 2nd Ann. Rept. of the State Geologist, by G. Henrichs. Iowa State Geol. Survey, pp. 235-238, 1869.

Springs of Iowa, by C. A. White. Report of the Geological Survey of Iowa, vol. 1, pp. 78-80, 1870.

General description of artesian wells in Iowa, by C. A. White. Report of the Geological Survey of Iowa, vol. 2, pp. 331-333, 1870.

Salt springs of Iowa, by C. A. White. Report of the Geological Survey of Iowa, vol. 2, pp. 334-336, 1870.

Artesian wells and spring water, by R. Emery. Report of the Geological Survey of Iowa, vol. 2, pp. 354-357, 1870.

Artesian wells of Iowa, by W. H. Norton. Iowa Geol. Survey 6, pp. 115-428, figs. 29-44, pls. 5-24, 1897.

Discusses the theory of artesian wells, artesian conditions, records of wells, chemical analyses of artesian waters, and artesian water as a public supply. Contains a geologic map, geologic cross sections and well records.

Underground-water resources of Iowa, by W. H. Norton, Iowa Geol. Survey 21, pp. 29-1214, 1912.

An exhaustive study of the ground-water resources of the state.

Well water recessions in Iowa, by J. H. Lees. Iowa Geol. Survey, vol. 23, pp. 375-400, 4 figs. (includes maps), 1928.

Deep wells of Iowa (a supplementary report), by W. H. Norton. Iowa Geol. Survey, vol. 33, pp. 9-374, map, 1928.

A discussion of state-wide deep wells. Contains well logs and analyses of at least 400 wells.

#### Publications by Other State Agencies

Preliminary paper on artesian wells in Iowa, by R. E. Call. Iowa Weather and Crop Service, Monthly Review, vol. 2, no. 4, pp. 1-6, 1891.

Chemistry of Iowa artesian waters, by R. E. Call. Iowa Weather and Crop Service, Monthly Review, vol. 3, no. 2, Feb. 1892.

Iowa artesian wells, by R. E. Call. Iowa Weather and Crop Service, Monthly Review, vol. 3, no. 3, pp. 1-5, March 1892.

Artesian wells in Iowa, by S. Calvin. Iowa Board of State Institutions, Bull. 4, pp. 402-408, 1902.

Water resources of Iowa; a report of progress. Iowa State Planning Board, Water Res. Div. pp. 167-235, Sept. 1934.

#### Iowa Academy of Science Proceedings

Artesian wells in Iowa, by R. E. Call, Iowa Acad. Sci. Proc. 1, part 2, pp. 57-65, 1892.

Sanitary analyses of some Iowa deep-well waters, by J. B. Weems. Iowa Acad. Sci. Proc. 9, pp. 63-70, 1902.

Discusses the analyses of deep well water and the concentration of solids. Contains a table of wells showing the results of sanitary analysis.

Some features of Iowa ground waters, part 1, by W. S. Hendrixson. Iowa Acad. of Sci. Proc. 14, pp. 187-199, 1907. (See 16th Proc. for part 2);

Discusses the general features of ground water in Iowa. Includes notes on analyses of water and tables showing the amount of dissolved solids in ground water from different strata.

Some Iowa waters, by N. Knight. Iowa Acad. of Sci. Proc. 15, pp. 109-110, 1908.

Contains a brief discussion of water from Springville water supply, a spring at the Palisades and the Lisbon water supply. Contains tables showing the total solids in each water in parts per million.

Some features of Iowa ground waters, part 2, by W. S. Hendrixson. Iowa Acad. of Sci. Proc. 16, pp. 135-142, 1909. (See 14th Proc. for part 1).

A continuation of the previous paper (Proc. 14). Discusses the possibility of obtaining water from deeper sources, and the use of hard water.

The conservation of underground waters, by J. H. Lees. Iowa Acad. of Sci. Proc. 27, pp. 187-196, 1920.

Contains a general discussion of the conservation of ground water. Discusses the relation of rock strata to ground water, and the general effect of agriculture on ground water.

Water problems in Iowa, by A. C. Trowbridge. Iowa Acad of Sci. Proc. 45, pp. 43-51, Apr. 1938.

Discusses the origin and conservation of water in a general manner. Discusses the water problems of Iowa briefly and offers some general statements on solutions of these problems.



## American Water Works Association Journal

Shallow wells of Iowa, by H. V. Pederson. Am. Water Works Assoc. Jour. vol. 15, pp. 70-72, Jan. 1925.

Well water recession in Iowa, by J. H. Lees. Am. Water Works Assoc. Jour. vol. 18, pp. 314-317, Sept. 1927.

The effects of drought on public water supplies in Iowa, by A. H. Wieters. Am. Water Works Assoc. Jour. vol. 27, pp. 154-163, Feb. 1935.

## Other Journal Articles

Artesian wells in Iowa, by Prof. Loverett, Sanitary Eng., Oct. 1, 1887.

Artesian wells in Iowa, by R. E. Call. Science, vol. 19, pp. 310-311, 1892.

Artesian wells of Iowa, by W. H. Norton. Iowa Civil Engineers and Surveyors Soc. Proc. 10, pp. 98-101, 1898.

Well water recession in Iowa, by J. H. Lees. Public Works, vol. 58, p. 413, Nov. 1927.

Deep wells in Iowa, by H. F. Blomquist. American City, vol. 39, (2), pp. 127-128, Aug. 1928.

Ground-water work of the Iowa Geol. Survey. Assoc. Am. State Geologists Jour., vol. 8, no. 1, pp. 12-19, Jan. 1, 1937.

Methods used in ground-water investigations in Iowa (abstract). Geol. Soc. America, Bull., vol. 58, no. 12, part 2, p. 1274, Dec. 1947.

Drainage in western Iowa, by J. G. Melliush. Illinois Soc. of Engineers and Surveyors, Ann. Rept. 20, pp. 57-65.

Papers Relating to Specific Areas Within the State

## United States Geological Survey Publications

Ground-water levels in observation wells on eight experimental areas of the Soil Conservation Service, by R. M. Leggette and others. U. S. Geol. Survey mimeographed rept., 8 pp., July 10, 1936.

Gives data on water levels in wells in experimental area near Mankato, Kans.

Ground-water data collected during 1947 in the Wilson Unit of the Missouri River Basin in Lincoln County, Kans., by V. C. Fishel and D. W. Berry. Manuscript release. 3 pp., 1 fig., July 1947.

Discusses briefly the geology of the area. Contains water-level measurements in 16 wells and a map showing location of wells and test holes.

Ground-water data collected in the Almena Unit of the Missouri River Basin in Norton and Phillips Counties, Kans., by V. C. Fishel and D. W. Berry. Manuscript release. 3 pp., 1 fig., July 1947.

Discusses observation wells and test drilling. Contains a table of water-level measurements in 14 wells and a map showing location of wells and test holes.

Ground-water data collected during 1946 and 1947 in the Kanopolis Unit of the Missouri River Basin in Ellsworth, McPherson and Saline Counties, Kans., by V. C. Fishel and D. W. Berry. Manuscript release. 4 pp., 1 fig., July 1947.

Discusses briefly the geology of the area. Contains water-level measurements in 15 observation wells and logs of 38 test holes. Includes a map showing location of wells and test holes.

Ground-water data collected during 1946 and 1947 in the Glen Elder Unit of the Missouri River Basin in Mitchell County, Kans., by V. C. Fishel and D. W. Berry. Manuscript release. 3 pp., 1 fig., July 1947.

Discusses briefly the geology of the area. Contains water-level measurements in 12 wells, records of wells and 9 logs of test holes. Includes a map showing location of wells and test holes.

Ground-water data collected during 1946 and 1947 in the Webster Unit of the Missouri River Basin in Osborne County, Kans., by V. C. Fishel and D. W. Berry. Manuscript release. 3 pp., 1 fig., July 1947.

Contains a brief discussion of the geology of the area. Includes a table of water-level measurements in 9 wells, a table of well records and a map showing the location of wells and test holes.

Ground-water data collected during 1946 and 1947 in the Cedar Bluff Unit of the Missouri River Basin in Ellis County, Kans., by V. C. Fishel and D. W. Berry. Manuscript release. 4 pp., 1 fig., July 1947.

Contains a brief statement on the geology of the area and the progress made in collecting well data. Contains a table of water-level measurements in 14 wells, logs of 2 test holes, a table of well records, a map showing areas where ground-water data are being collected and a map showing well locations.

Ground-water data collected in Kansas on the Almena, Bostwick, Cedar Bluff, Glen Elder, Kanopolis, Webster, and Wilson Units in the Missouri River Basin (to Dec. 31, 1947) by D. W. Berry. U. S. Geol. Survey, Missouri Basin Studies, mimeographed report, Sept. 1948.

Ground-water data collected in the Missouri River Basin Units in Kansas during 1948, by D. W. Berry. U. S. Geol. Survey, Missouri Basin Studies, mimeographed report, Nov. 1949.

## Kansas State Geological Survey Bulletins

Ground water, the geology of Cloud and Republic Counties, Kans., by M. E. Wing. Kansas State Geol. Survey. Bull. 15, p. 46, 1930.

Describes the geography, topography and geologic formations of the area. Contains a section on ground-water supplies from river gravels, sheet water from the uplands and slopes, Tertiary gravels and the Dakota sandstone. Includes geologic maps and structure contour maps.

Ground water, the geology of Mitchell and Osborne Counties, Kans., by K. K. Landes. Kansas State Geol. Survey Bull. 16, p. 49, 1930.

A brief paragraph on ground water giving a general discussion on obtaining water supply and chemical character of the water.

Geology of Wallace County, Kans., by M. K. Elias. Kansas State Geol. Survey Bull. 18, p. 221, April, 1931.

Describes the geography and geology of the area. Discusses underground water by townships. Includes a geologic map, columnar sections and a subsurface contour map.

Ground water in the McPherson district, Kans., by S. W. Lohman, Kansas Geol. Survey Bull. 27, pp. 63-66, 2 figs., includes piezometric map, June 25, 1940.

This discussion treats only of the occurrence of ground water in the unconsolidated Tertiary and Quaternary beds. The unconsolidated deposits comprise the Emma Creek formation of Pliocene age, the McPherson formation (restricted) of Pleistocene age, Pleistocene loess, and Pleistocene and Recent alluvium and dunes. Contains geologic sections of water-bearing alluvial deposits and a map of the water table.

Ground water in the Scott district, Scott and Finney Counties, Kans., by H. A. Waite. Kansas Geol. Survey Bull. 27, pp. 73-74, June 25, 1940.

A brief discussion of ground water in the Scott district. Water is obtained in the shallow basin at 20 to 90 feet from the Ogallala formation. Information on yield from the Ogallala formation is given.

Ground-water conditions in the vicinity of Lawrence, Kans., by S. W. Lohman. Kansas Geol. Survey Bull. 38, part 2, pp. 17-64, 2 pls., June 23, 1941.

Presents the results of a detailed investigation of the ground-water conditions in and near Lawrence, with particular reference to the possibility of replacing the present municipal surface-water supply with a suitable supply of ground water. Includes a map showing water-table contours. Also contains analyses of 34 water wells and test borings and records and logs of wells and borings.

Reconnaissance of ground-water resources in Atchison County, Kans., by J. C. Frye. Kansas Geol. Survey Bull. 38, part 9, pp. 237-260, 3 pls., 1941.

A short discussion of the character of the Pennsylvanian, Tertiary(?), and Quaternary rocks, and water supplies in them.

The geology of Riley and Geary Counties, Kans., by John M. Jewett. Kansas State Geol. Survey Bull. 39, 164 pp., 17 pls., 2 figs., 6 tables, Dec. 1941.

Discusses the geography, stratigraphy, structural and economic geology of the area. Gives a brief section on water resources. Contains stratigraphic sections, an areal geology map, and logs of test holes.

Ground water in the oil-field areas of Ellis and Russell Counties, Kans., by J. C. Frye and J. J. Brazil. Kansas Geol. Survey Bull. 50, 104 pp., 2 pls., Dec. 1943.

Describes the deposits of Cretaceous, Tertiary, and Quaternary age which cover the area. States that water in some of the Cretaceous sandstones is highly mineralized but that water in the Dakota sandstone (Cretaceous) and younger formations is satisfactory for most uses. The depth to water ranges from about 5 feet in the main stream valleys to more than 150 feet in some upland wells that obtain water from Dakota sandstone.

Geology and ground-water resources of Thomas County, Kans., by J. C. Frye, with analyses by E. O. Holmes. Kansas Geol. Survey Bull. 59, 111 pp., 6 pls., 13 figs., Dec. 1945.

A detailed report on Thomas County, with discussion of several water-bearing formations, data on quantity of water, and well records.

Geology and ground-water resources of Scott County, Kans., by H. A. Waite. Kansas Geol. Survey Bull. 66, 216 pp. 16 pls, 16 figs., July 1947.

Describes the geography, geology and ground-water resources of Scott County. Includes a map showing the rock formations that crop out, a map showing depth to water level, chemical analyses of water and logs of wells and test holes.

Ground-water resources of the Kansas City, Kans., area by V. C. Fishel with analyses by H. A. Stoltenberg. Kansas State Geol. Survey Bull. 71, 107 pp., 3 pls., 12 figs., 9 tables, Feb. 1948.

Discusses the geography, geology in relation to the ground water, source, occurrence, and movement of the ground water, permeability of the water-bearing materials, yield of wells, chemical character of the ground water and utilization of ground water. Includes records and logs of wells and test holes. Also a map showing the location of wells and test holes, and cross-sections.

Ground-water resources of Republic and northern Cloud Counties, Kans., by V. C. Fishel. Kansas State Geol. Survey Bull. 73, 194 pp., 12 pls., 6 figs., 1948.

Describes the geography, geology and ground-water resources of Republic and northern Cloud Counties. Discusses ground-water recharge and discharge. Includes records of chemical analyses, an areal geology map, a bedrock contour map, profile sections, a water-table contour map and well and test hole data.

Ground-water supplies at Hays, Victoria, Walker, Gorham and Russell, Kans., with special reference to future needs, by B. F. Latta. Kansas State Geol. Survey Bull. 76, part 6,, 196 pp., 8 figs., 1948.

Discusses the geology and ground-water conditions of towns in Ellis and Russell Counties in north-central Kansas. Includes small maps showing the geology and water tables of the area, cross sections of Big Creek Valley, and well and test hole logs.

Geology and ground-water resources of Norton County and north-western Phillips County, Kans., by John C. Frye and A. R. Leonard. Kansas State Geol. Survey Bull. 81, 144 pp., 10 pls., 1949.

Ground-water conditions in the Smoky Hill Valley in Saline, Dickinson and Geary Counties, Kans., by B. F. Latta. Kansas State Geol. Survey Bull. 84, 152 pp., 6 pls, 1949.

Memorandum in regard to prospecting for supplemental ground-water supply for the City of Russell, Kans., by T. G. McLaughlin, Manuscript release.

Geology of Rawlins and Decatur Counties with special reference to water resources, by M. K. Elias, Kansas Geol. Survey Min. Res. Circ. 13. (Kansas Univ. Bull., vol. 38, no. 13), 25 pp., 2 pls., 2 figs., July 1, 1937.

States the main features of known geologic conditions, especially those related to water supplies. Discusses the stratigraphy, water resources and utilization of water resources. Includes a geologic section through deep wells, profiles of Rawlins and Decatur Counties and topographic maps of both counties.

Preliminary report on ground-water resources of the shallow-water basin in Scott and Finney Counties, Kans., Kansas Geol. Survey Circ. 5, 7 pp., 3 figs, Oct. 1, 1939.

#### Publications by Other State Agencies

The geology of underground water in western Kansas, by E. Haworth: McPherson and vicinity, by C. S. Presser and J. W. Beede. Kansas State Board of Irrigation Survey and Experiment Rept. 1895-1896, pp. 49-114, maps, 1897.

Prospecting for a softer water supply for the Kansas State Penitentiary, Lansing, Kans., by S. W. Lohman and Alexander Mitchell. Kansas State Board of Health, 17 pp., 1 map (Mimeographed), July 1940.

Describes present supply from four wells of large diameter in alluvium and the pumping equipment. Gives data on nine test wells. Recommends either more complete treatment of present supply to reduce hardness or the use of water from Missouri River.



## Kansas Academy of Science Transactions

The water of the Fort Scott artesian well, by E. N. S. Bailey and E. W. Walter. Kansas Acad. Sci. Trans., vol. 9, pp. 96-98, 1883-84.

Gives a general description of the artesian well and includes a drill record, analyses of water, and constituents of the water in grains per gallon.

The deep well at Madison, Kans, by F. W. Bushong. Kansas Acad. Sci. Trans., vol. 16, pp. 67-70, (1897-1898).

Gives a brief description of the location of the well and shows a section and log of the well.

Lowering of the ground-water table, by W. A. Cook. Kansas Acad. Sci. Trans., vol. 26, pp. 84-86, 1913.

Gives a brief discussion on lowering of the water table in Kansas.

Water resources of Johnson County during the drought of 1934, by J. M. Jewett and C. C. Williams, Kansas Acad. Sci. Trans., vol. 38, pp. 191-198, 11 figs., 1935.

Describes the topography and areal geology of the area. Discusses the effect of the drought on the water table in 1934, the character of the water-bearing formations and water associated with valley fill and glacial deposits. Includes geologic cross section.

Fluctuations of the water table in the glaciated part of Kansas, by W. H. Schoewe, Kansas Acad. Sci. Trans., vol. 38, pp. 201-204, 1935.

Discusses the water supply during the drought of 1934 in the glaciated part of Kansas. Contains a log of a flood-plain well and one of an upland well. Includes a summary of the fluctuations of the water table in flood-plain and upland well in the glaciated part of Kansas.

Shallow aquifers in eastern Kansas, by J. M. Jewett, Kansas Acad. Sci. Trans., vol. 24, p. 339, 1939.



Chemical analyses of some oil-well waters of Russell, Ellis, and Trego Counties, Kans., by E. Runyon and R. Rankin. Kansas Acad. Sci. Trans., vol. 43, pp. 235-241, 1940.

This investigation has shown that waters can be identified by chemical analyses. Contains tables of analyses of waters from several formations in the area.

Ground-water resources of Kansas, by V. C. Fishel, Kansas Acad. Sci. Trans., vol. 50, no. 2, pp. 105-114, 3 figs., Sept. 1947.

This investigation was made to determine the quantity and quality of water available from the underlying water-bearing formations, to develop criteria for choosing favorable locations for drilling and digging wells, to determine possibility of increasing yields, and to determine the quantity and quality of water obtainable from each aquifer. Contains maps showing the shape and slope of the water table and depth-to-water level below land surface.

#### Other Journal Articles

Artesian well at Russell, Kans., by J. D. Parker. Kansas City Rev. 8, p. 65, 1884.

Geology and ground-water resources of the "Equus" area in south-central Kansas, by S. W. Lohman and J. C. Frye. Econ. Geol., vol. 35, no. 7, pp. 839-866, Nov. 1940; abstract in Econ. Geol., vol. 34, no. 8, pp. 942-943, Dec. 1939.

Describes the location and testing of a new water supply for Wichita, and the remapping of the "Equus beds." Hydrologic studies included drilling 100 test wells and driving 60 others, collection of water samples for analyses, mapping of the water table, and measurements of ground-water recharge. Includes a map showing the geology and contours on the water table.

Factors producing a 9-year decline in ground-water levels in Scott County, Kans., by H. A. Waite. Am. Geophys. Union Trans., pp. 772-775, Aug. 1941.

Gives data on the ground-water level in an area where there was a notable decline during 1932-40. Discusses the relation of pumping and of precipitation to this decline. Contains map showing contours on water table.

Papers of a General Nature or Relating to the Entire State

## United States Geological Survey Publications

Quality of the water supplies of Kansas, by H. N. Parker, with a preliminary report on stream pollution by mine waters in southeastern Kansas by H. S. Bailey. U. S. Geol. Survey Water-Supply Paper 273, 375 pp., pl., 1911.

Describes the geology, ground water, and artesian basins of the State. Discusses the significance of mineral constituents and classification of water. Gives details concerning quality of ground water by counties and surface water by drainage basins. Contains numerous assays and analyses of surface and ground waters. Includes a geologic map of the State.

Ground-water levels in Kansas in 1940, by S. W. Lohman. U. S. Geol. Survey Mimeographed Rept., 1 p., April 28, 1941.

Ground-water levels in Kansas during the period October to December 1941, by S. W. Lohman. U. S. Geol. Survey Mimeographed Rept., Feb. 11, 1942.

A summary of changes in ground water levels in 18 principal areas of ground-water development in the State. See also Water-Supply Paper 938.

## Kansas Geological Survey Publications

Mineral waters, by E. H. S. Bailey. Kansas Geol. Survey, vol. 7, 343 pp., 38 pls., 1902.

Gives a general discussion of mineral waters as to sources, uses, classification and analyses. Includes a map showing location of springs and wells. Contains a section on mineral waters classified as to group by analyses.

Underground resources of Kansas, by R. C. Moore and K. K. Landes. Kansas Geol. Survey Bull. 13, pp. 138-144, Nov. 1927.

Contains a brief discussion of the sources, quality and quantity of ground water in Kansas. The quality and quantity of ground water and its depth below the surface are largely controlled by geologic conditions. The deposits of sand and gravel of Tertiary and Pleistocene age carry the largest quantities of water and therefore are the main source of water supply. Contains a map showing the areas covered by Tertiary rocks and a reconnaissance map showing the structure of the Dakota sandstone.

Ground-water resources of Kansas. Kansas Geol. Survey Bull. 27, 112 pp., 34 pls., June 25, 1940.

The main part of the report treats of the geologic conditions affecting the occurrence of ground water and describes the several water-bearing formations of the State. A small map shows the ground-water provinces of the State.

Ground-water supplies in Kansas available for national defense industries, by S. W. Lohman, J. C. Frye, H. A. Waite, V. C. Fishel, T. G. McLaughlin, B. F. Latta and G. E. Abernathy. Kansas Geol. Survey Bull. 41, pt. 2, pp. 21-68, Apr. 14, 1942.

"This report calls timely attention to the availability in many parts of Kansas of large supplies of water from wells or from streams for use by national defense agencies. It also summarizes the quality of water from wells in different parts of the State with reference to suitability for industrial use." Contains list of references to publications on geology and water resources in Kansas.

Kansas mineral resources for wartime industries; water resources, by J. C. Frye, J. M. Jewett, and others. Kansas Geol. Survey Bull. 41, pt. 3, pp. 117-179, May 9, 1942.

"Industrial ground-water supplies in excess of 5 million gallons a day can be obtained at many places in Kansas, and at certain selected localities supplies in excess of 20 million gallons a day are available."

## Publications by Other State Agencies

Semi-arid Kansas, by S. W. Williston. Kansas Univ. Quart. 3, pp. 209-216, Map, 1895.

Report of Kansas Board of Irrigation, Survey and Experiment 1895-1896, pp. 49-114, 1897.

Underground waters of Kansas; special areas described by G. I. Adams. Kansas Board of Irrigation Survey Report, 1895-1896, pp. 104-114, map, 1897.

State Board of Health of Kansas, 2nd Bienn. Rept. on the 19th and 20th Ann. Rept. from Jan. 1, 1903 to Dec. 31, 1904. 182 pp., 1905.

Special report on well waters in Kansas, by E. Haworth. Kansas Univ. Bull. 1, 103 pp., 1913.

Discusses the rate of flow of ground water, porosity of surface materials, water conditions in areas covered by glacial drift, water-bearing conditions of the Tertiary area of western Kansas, prospecting for shallow ground water and ground water within stratified rocks. Contains a geologic map, a reconnaissance hydrographic map of western Kansas, and geologic cross sections of the McPherson "Equis" beds.

Water supplies of Kansas, pt. 1, Ground-water supplies, by C. A. Haskins and C. C. Young. Univ. Kansas Eng. Exper. Sta., Bull. 5. 187 pp. Apr. 1915.

Water, its use and control in Kansas. Kansas State Planning Board, 28 pp., Oct. 1936.

Includes section on ground water supplies which furnish water for four-fifths of the population of Kansas; in eastern Kansas, the water-level in 1934 was ten feet lower than that of 20 years ago; in western Kansas, the water-levels are apparently unaffected; both shallow "mantle-rock" wells and deep "bed-rock" wells are used; abandoned river-channels furnish abundant supplies of shallow water; some ground water has high fluoride content.

Water resources of Kansas, Kansas State Planning Board, Kansas Legislative Council Research Dept. Pub. 66, 8 pp., Nov. 1937.

## Journal Articles

Methods used in ground-water investigations in Kansas, by V. C. Fishel. (abstract). Geol. Soc. Am. Bull., vol. 58, no. 12, pt. 2, p. 1273, Dec. 1947.

Artesian wells in Kansas and the cause of their flow, by R. Hay. Am. Geol. 5, pp. 296-301, 1890.

Discusses the causes of artesian flow in Kansas and classifies the pressures as hydrostatic, gas, and rock. Gives general description of some wells falling into these classes.

MISSOURIPapers Relating to Specific Areas Within the State

## United States Geological Survey Publications

Spring system of the Decaturville dome, Camden County, Mo., by E. M. Shepard. U. S. Geol. Survey Water-Supply Paper 110, pp. 113-125, 1905.

This report confirms the opinion of the author that some relation exists between the granite mass and the system of great springs and sinks that surround the area. This report discusses numerous springs and artesian wells in the area. Includes a sketch map of the area showing springs and sinks and ideal cross-sections. Also a record of water analyses.

Leavenworth-Smithville folio, by H. Hinds and F. C. Greene. U. S. Geol. Survey Geologic Atlas (No. 206), 1917.

Describes the geology, stratigraphy and geography of the area. Includes a section on water resources. Contains maps showing topography and areal geology.

Ground-water levels in observation wells on eight experimental areas of the Soil Conservation Service, by R. M. Leggette and others. U. S. Geol. Survey mimeographed rept., 8 pp., July 10, 1936.

Gives data on water levels in wells in experimental area near Tarkio, Mo.

## Missouri Geological Survey Bulletins

The mineral waters of Saline County, Mo., by A. E. Woodward. Missouri Geol. Survey Bull. 1, pp. 45-59, 1890.

The mineral waters of Henry, St. Clair, Johnson and Benton Counties, Mo., by A. E. Woodward. Missouri Geol. Survey Bull. 3, pp. 85-101, 1890.

Contains a description of the important springs and wells of the 4 counties, with the results of analyses of their waters.

A report on Greene County, Mo., by E. M. Shepard. Missouri Geol. Survey Bull. 7, pp. 13-237, 1898.

Missouri Bureau of Geology and Mines Publications



Geology of Miller County, Mo., by S. H. Ball and A. F. Smith. Missouri Bur. of Geology and Mines, 2d Ser. vol. 1, 1903.

Describes the geology of the area and contains a brief section on water supply. Discusses springs and wells. Contains a geologic map and a map showing well location. Includes cross sections and columnar sections.

Geology of Moniteau County, Mo., by F. B. Van Horn. Missouri Bur. of Geology and Mines, 2d Ser., vol. 3, 1905.

Describes the geology of the area and includes a brief section on water supply (pp. 99-100). Includes a geologic map, a map showing well location and columnar sections.

The geology of Morgan County, Mo., by C. F. Marbut. Missouri Bur. of Geology and Mines, 2d Ser., vol. 7, 1907.

Geology of Rolla quadrangle, by W. Lee. Missouri Bur. of Geology and Mines, 2d Ser., vol. 12, 1913.

Geology of Jackson County, Mo., by W. E. McCort. Missouri Bur. of Geology and Mines, 2d Ser., vol. 14, 158 pp., 19 pls., 1917.

Describes the geography, topography and geology of the area. Contains a brief section on underground waters. Discusses briefly springs, shallow wells, and deep wells. Contains analyses of spring water and deep-well water. Also 2 well records. Includes a geologic map of Jackson County.

The geology of Vernon County, Mo., by F. C. Greene and W. F. Pond. Missouri Bur. of Geology and Mines, 2d Ser., vol. 19, 1926.

#### Missouri Geological Survey and Water Resources Publications

Underground waters in St. Louis County, and City of St. Louis, Mo., by C. D. Gleason. Missouri Geol. Survey and Water Resources, Appendix 5, 58th Bienn. Rept., 24 pp., 5 pls., 1 fig., 1935.

A preliminary and generalized summary of the underground water resources in this area. Discusses the stratigraphy, structure, water-producing formations, and the chemical composition of well waters. Includes a geologic and water map of the area, cross sections, composite stratigraphic section and a graph showing the chemical composition of well waters.

The geology of northwestern Missouri, by H. S. McQueen and F. C. Greene. Missouri Geol. Survey and Water Resources. Vol. 25, 217 pp., 7 pls., 11 figs, 3 tables, 1938.

A preliminary guide to the geology of northwestern Missouri and includes data pertaining to the surface and subsurface stratigraphy of the area. Includes analyses of waters, well logs, and geologic, structure and thickness maps.

Recent drilling in northwestern Missouri, by F. C. Greene. Missouri Geol. Survey and Water Resources, Rept. Inv. No. 1, 153 pp., 14 figs., 1945.

Discusses the structure and stratigraphy of the area and chemical composition of ground waters. The bulk of the report consists of well logs and water analyses. Includes structure maps, thickness maps and total dissolved solids maps.

#### Publications By Other State Agencies

Ebb and flow springs in the Ozarks, by J. Bridge. Missouri Univ. School of Mines and Metallurgy Bull., Tech. Ser. 7, vol. 1, 6 figs., 3 pls., Nov. 1923.

Subterranean stream piracy in the Ozarks, by C. L. Oake and J. Bridge. Missouri School of Mines, 1924.



## Bradley Geological Field Station of Drury College Bulletins

The Springfield water supply: Description of springs and geology of the district, by E. J. Park and Kate Lyman. Bradley Geol. Field Sta. Drury Coll. Bull., vol. 1, pt. 2, pp. 45-49, 1905.

Chemical analysis of the water of Fulbright Springs, Mo., by Kate Lyman. Bradley Geol. Field Sta. of Drury Coll. Bull., vol. 1, pt. 2, pp. 49-50, 1905.

Sanitary analysis of water of Fulbright Springs, Mo., by Etta Little. Bradley Geol. Field Sta. of Drury Coll. Bull., vol. 1, pt. 2, pp. 50-52, 1905.

Geology of the Hahatonka district, Camden County, Mo., by G. H. Scherer. Bradley Geol. Field Sta. of Drury Coll. Bull., vol. 1, pt. 2, pp. 58-67, 1905.

Hahatonka, Mo., by Berta Ross. Bradley Geol. Field Sta. of Drury Coll. Bull., vol. 1, pt. 2, pp. 68-71, 1905.

The Hannibal formation in Greene County, Mo., by E. J. Park and Kate Lyman. Bradley Geol. Field Sta. of Drury Coll. Bull., vol. 1, pt. 2, pp. 79-90, 1905.

The Graydon sandstone and its mineral waters, by E. N. Babcock. Bradley Geol. Field Sta. of Drury Coll. Bull., vol. 1, pt. 2, pp. 22-31, 1904.

## Publications By Other Agencies

Excelsior Springs. Passenger Dept. of Wabash Railroad, St. Louis, Mo., 1889.

## Journal Articles and Miscellaneous Publications

Belcher's artesian well in St. Louis, Mo., by Charles W. Stevens. Am. Jour. Sci., p. 133, 1853.



Well at the Insane Asylum, St. Louis County, Mo., by G. C. Broadhead, St. Louis Acad. of Sci. Trans., vol. 3, p. 216, 1878.

Influence of stratigraphy on the emergence of springs as illustrated in the Ozark Uplift, by T. C. Hopkins. Am. Geol. vol. 14, pp. 365-368, 1894.

Briefly discusses the occurrence of springs in the Ozark Uplift and the influence of different beds on the emergence of springs.

Analysis of Sweet Spring water, Saline County, Mo. Kansas City Rev. Sci. and Ind., vol. 1, p. 186.

The famous Eldorado Springs, by W. Wisham. Bazoo Print, Sedalia, Mo., 48 pp.

Eldorado Springs, Cedar County, Mo., by P. Schweitzer, Sedalia, Mo., 30 pp.

Blue Lick Springs, Eldorado, Mo., by L. D. Burch, Marshall, Mo., 32 pp.

#### Papers of a General Nature or Relating to the Entire State

##### United States Geological Survey Publications

Contributions to the hydrology of eastern United States. Section on Missouri by E. M. Shepard, U. S. Geol. Survey Water-Supply Paper 102, pp. 389-440, 1903.

Contains records of 105 wells and 112 springs and analyses of 13 well waters and 34 spring waters. Includes discussion on water supply of Livingstone County, by R. Hawkins.

Underground waters of eastern United States. Section on Missouri, by E. M. Shepard. U. S. Geol. Survey Water-Supply Paper 114, pp. 209-219, 1905.

Includes sketch map of the geology and ground-water conditions of the state.

Underground waters of Missouri, their geology and utilization, by E. M. Shepard. U. S. Geol. Survey Water-Supply Paper 195, 224 pp., 6 pls., 1907.

Describes the topography and geology of the State and discusses the water supplies by districts and counties; gives statistics of city water supplies, analyses of water, and many well sections and records; includes a map of the State, showing the locations of flowing and non-flowing deep wells.

#### Missouri Bureau of Geology and Mines Publications

Preliminary report on the structural and economic geology of Missouri by J. A. Gallaher. Missouri Bur. of Geology and Mines, 1st Ser., vol. 5 (13), 1900.

Water resources of Missouri, by H. C. Beckman. Missouri Bur. of Geology and Mines, 2nd Ser., vol. 20, 424 pp., 12 pls., 1927.

Describes the springs (p. 341) of the State, including discharge measurements. Contains the description and location of the major springs. Most of the text is on surface water.

The large springs of Missouri, by H. C. Beckman and N. S. Hinchey. Missouri Geol. Survey and Water Resources 2d Ser., vol. 29, 141 pp., 18 pls., 1944.

Describes the size and rank, sources and the location of springs. Discusses the geology, flow characteristics and quality of spring water. Includes measurements of flow in individual springs. Also includes a map of Missouri showing location and relative size of the large springs.

Ground water in agriculture: 1, Ground water in Missouri, by K. E. Anderson and J. G. Grohskopf. Missouri Geol. Survey and Water Res. Inf. Circ. 2, 7 pp., 1 fig., index map, 7 tables, 1946.

#### Publications By Other State Agencies

Mineral springs of Missouri, by G. C. Broadhead. Missouri State Board Agr. Sec. Rept., no. 2, pp. 99-102, 1867.

Contributions from the laboratory of the State University, by P. Schweitzer. Ann. Rept. pp. 160-169, 1874.

Contributions from the laboratory of the State University, by P. Schweitzer. Ann. Rept., pp. 155-193, 1875.

Report on the mineral waters of Missouri, by P. Schweitzer. Missouri Geol. Survey 1st Ser., vol. 3, 1892.

(Includes a bibliography of about 200 titles of publications on mineral waters from 1500-1883).

A systematic description and the results of analyses of the mineral waters of the State are given. Breaks down the waters into muriatic, alkaline, sulphatic, chalybeate, and sulphur divisions. Includes a geologic map showing the locations of the different characteristic waters.

Artesian water in Missouri, by A. W. McCoy. Missouri Univ. Bull. Eng. Exper. Sta. Survey 4, no. 3, 73 pp., 1913.

#### Journal Articles

Water-supply conditions in Missouri, by G. W. Putnam. Am. Water Works Assoc., vol. 15 (3), pp. 279-287, Mar. 1926.

Some methods of tracing sources of well contamination in Missouri (abstract) by K. E. Anderson. Geol. Soc. Am. Bull., vol. 58, no. 12, pt. 2, p. 1, 271, Dec. 1947.

#### MONTANA

##### Papers Relating to Specific Areas Within the State

##### United States Geological Survey Water-Supply Papers

Geology and water resources of the Great Falls region, Mont., by C. A. Fisher. U. S. Geol. Survey Water-Supply Paper 221, 89 pp., 7 pls., 1909.

Describes the geography and geology, and the surface waters, ground waters and artesian conditions in an area comprising parts of Cascade, Teton, Fergus, Chouteau, and Lewis and Clark Counties. Discusses municipal water supplies, the chemical character of the water, water power, irrigation and agriculture; gives analyses of water; includes map showing the geology and locations of artesian wells.

The water resources of Butte, Mont., by O. E. Meinzer. U. S. Geol. Survey Water-Supply Paper 345-g pp. 79-125, pls. 7-8, 1917.

Describes the physiography of the Butte area and the geology of the bedrock and valley fill. Discusses occurrence, quantity and quality of water in bedrock and valley fill, artesian pressure, water table, and irrigation. Includes a map showing water resources and tabulated chemical analyses and well records.

Ground water in Musselshell and Golden Valley Counties, Mont., by A. J. Ellis and O. E. Meinzer. U. S. Geol. Survey Water-Supply Paper 518, vi, 92 pp., 5 pls., 1924.

Describes the physiography, water-bearing properties of rock formations, effect of geologic structure on water supply, artesian conditions, and quality of water with reference to geologic horizon and depth. Includes descriptions of ground-water conditions by townships, water analyses and a geologic map of the area.

Geology and ground-water resources of Townsend Valley, Mont., by J. T. Pardee, U. S. Geol. Survey Water-Supply Paper 539, iv, 61 pp., 2 pls., 1925.

Includes parts of Lewis and Clark and Broadwater Counties, Mont. Describes the geology, physiography, and ground-water conditions with reference to public water supplies, water table, quality of water and artesian conditions. Includes water analyses, well records and a geologic map.

Water power and irrigation in the Madison River Basin, Mont., by J. F. Deeds and W. N. White, U. S. Geol. Survey Water-Supply Paper 560-a, pp. 1-30, 1925.

Describes the geography, physiography, geology and water supply of the area. Contains monthly precipitation records and monthly discharge records of the Madison River. Discusses irrigation and water power development. Includes a small map showing irrigated land and proposed canal construction.

Water power and irrigation in the Jefferson River Basin, Mont., by J. F. Deeds and W. N. White. U. S. Geol. Survey Water-Supply Paper 580-b, pp. 41-116, 1927.

Discusses the water supply, storage, reservoirs and undeveloped storage sites. Special effort was made to obtain information regarding present and potential development of power and irrigation. Includes monthly discharge records of streams in the Jefferson River Basin and a map showing irrigated land.

Ground water in Yellowstone and Treasure Counties, Mont., by G. M. Hall and C. S. Howard. U. S. Geol. Survey Water-Supply Paper 599, vi, 118 pp., 7 pls., 1929.

Describes the physiography and geology of part of south-central Montana and gives the water-bearing properties of each geologic formation. Discusses the relation of structure to ground water, gives methods of obtaining water, and describes public water supplies and their quality. Includes a geologic map, analyses of water and a discussion of ground-water conditions by townships.

Geology and ground-water resources of central and southern Rosebud County, Mont., by B. C. Renick, with chemical analyses of the water, by H. B. Riffenburg. U. S. Geol. Survey Water-Supply Paper 600, 140 pp., 12 pls., 1929.

Discusses the stratigraphic relations, character and thickness, and water-bearing properties of Upper Cretaceous and Tertiary formations. Also makes reference to the water-bearing properties of the alluvium and Pleistocene terraces. Includes a geologic map, chemical analyses of waters and a discussion of ground-water conditions by townships.

#### United States Geological Survey Bulletins

A report of work done in the Washington laboratory during the fiscal year 1883-84, by F. W. Clarke and T. W. Chatard. U. S. Geol. Survey Bull. 9, 40 pp., 1884.

Contains analyses of water samples from Livingston Warm Springs, Warm Springs, Emigrant Gulch Springs, Helena Hot Springs, and Mill Creek Cold Springs in Montana.

Geology of the Castle Mountain mining district, Mont., by W. H. Weed and L. V. Pirsson. U. S. Geol. Survey Bull. 139, pp. 104, 1896.

Describes the topography and structural and geological history of the area. Contains a brief section on mineral waters with 2 chemical analyses.

The Bull Mountain Coal Fields, Musselshell and Yellowstone Counties, Mont., by L. H. Woolsey, R. W. Richards, and C. T. Lupton. U. S. Geol. Survey Bull. 647, 218 pp., 36 pls., 1917.

Gives detailed data regarding water supplies. Describes the geology and geography of the area and includes maps showing topography and economic geology by townships.

Geology and oil and gas prospects of the Lake Basin field, Mont., by E. T. Hancock. U. S. Geol. Survey Bull. 691-d, pp. 101-147, pls. 16-23, 1918.

Briefly describes streams and springs in the area (p. 105). Well logs and other records mention occurrence of water (pp. 143-145).. Includes a map showing structure on the base of the Eagle sandstone.

Geology and oil and gas prospects of the Huntley field, Mont., by E. T. Hancock. U. S. Geol. Survey Bull. 711-g, pp. 105-148, pls. 14-18, 1919.

Logs of four wells give depths at which water was encountered (pp. 142-143). Mentions several wells yielding water and traces of oil (p. 144). Includes a geologic map showing structure on the base of the Eagle sandstone.

Oil and gas prospects in and near the Crow Indian Reservation, Mont., by W. T. Thom, Jr. U. S. Geol. Survey Bull. 736-b, pp. 35-53, pl. 7, 1923.

States that wells penetrating the Sundance formation will probably encounter two or three water-bearing sandstones (p.40). Mentions water supply available for drilling in the different areas and notes that both surface water and shallow ground water are scarce. Reports water in the Cloverly and Tensleep formations in Black Gulch dome area (p. 51). Includes map of part of the area showing structure on the top of the Cloverly formation.

Geology of the Tullock Creek coal field, Rosebud and Big Horn Counties, Mont., by G. S. Rogers and Wallace Lee. U. S. Geol. Survey Bull. 749, vi, 181 pp., 6 pls., 1923.

Describes the occurrence of springs in the region and states that water is probably obtainable from shallow wells in most of the coulees (p. 8). Includes geologic map structure contour map, and stratigraphic and structure sections.

Geology and possible oil and gas resources of the faulted area south of the Bearpaw Mountains, Mont., by Frank Reeves. U. S. Geol. Survey Bull. 751-c, pp. 71-114, pls. 10-14, 1925.

Gives records of four wells that were drilled for oil in the area, with data on the water-bearing strata (pp. 103-106). Discusses the role of ground water in oil accumulation and gives two analyses of water from one of the wells (pp. 107-111). Describes the water resources of the area, stating that there are many springs along fault planes but little shallow ground water except in gravel terraces (p. 113). Includes a geologic map.

The Scobey lignite field, Valley, Daniels and Sheridan Counties, Mont., by A. J. Collier. U. S. Geol. Survey Bull. 751-e, pp. 157-230, pls. 21-29, 1925.

Some springs issue at the contact of glacial drift and bedrock. Shallow wells obtain water in gravel. Wells in underlying rock yield water that often carries sulfur and iron (pp. 161, 162). Includes geologic map and structure and columnar sections.

The Ekalaka lignite field, southeastern Montana, by C. M. Bauer. U. S. Geol. Survey Bull. 751-f, pp. 231-267, pls. 30-34, 1925.

States that the Dakota and Lakota sandstones are potential sources of artesian water and that the Fox Hills sandstone carries water in that part of the area which it underlies (p. 248). Includes a geologic map and columnar sections.

The geology of Ingomar anticline, Treasure and Rosebud Counties, Mont., by K. C. Heald. U. S. Geol. Survey Bull. 786-a, pp. 1-37, pls. 1-2, 1927.

States that springs and wells furnish the only permanent supply of water, the best being in the Judith River and Claggett formations at depths down to 1,500 feet (pp. 5, 6). The Dakota sandstone in the anticline commonly carries water but is dry in some places (p. 22). Includes a geologic map showing structure on top of the Judith River formation.

The northwest extension of the Sheridan coal field, Big Horn and Rosebud Counties, Mont., by A. A. Baker. U. S. Geol. Survey Bull. 806-b, pp. 15-67, pls. 6-29, 1928.

Describes streams, springs, and general ground-water conditions in the area (pp. 20-22). Log of a well gives depths to water-bearing beds (p. 64).

Thrust faulting and oil possibilities in the plains adjacent to the Highwood Mountains, Mont., by Frank Reeves. U. S. Geol. Survey Bull. 806-e, pp. 155-195, pl. 44, 1929.

Mentions "water in several sands" (p. 181) and various water-bearing sands in logs of 6 wells (pp. 186-190). Includes a geologic map showing structure on top of the Kootenai formation and structure sections.



The Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Mont., by C. E. Dobbin. U. S. Geol. Survey Bull. 812-a, pp. 1-55, pls. 1-10, 1929.

Describes springs from the Lance and Fort Union formations (pp. 5,6). States that domestic water supplies are obtained chiefly from dug wells or from drilled wells penetrating sandstone overlying the Rosebud coal bed.

The Kevin-Sunburst oil field and other possibilities of oil and gas in the Sweetgrass arch, Mont., by A. J. Collier. U. S. Geol. Survey Bull. 812-b, pp. 57-189, pls. 11-18, 1930.

Mentions well and spring water from the Virgelle sandstone (Cretaceous) (p. 61). States that the large areas covered by the Colorado shale have no potable water supply. Some of the well data (pp. 88-92) and tabulated well records (pp. 94-168) mention the occurrence of water. Many of the "dry holes" yield salt water or sulfur water. Describes water associated with the oil (pp. 179, 180). Gives analyses of six water samples (pl. 18). Includes maps of Sweetgrass arch and the Kevin-Sunburst field showing the structure on the Madison limestone, and graphic well logs.

Geology and mineral resources of parts of Carbon, Big Horn, Yellowstone and Stillwater Counties, Mont., by R. S. Knappes and G. F. Moulton. U. S. Geol. Survey Bull. 822-a, pp. 1-70, pls. 1-5, 1931.

Describes briefly the water supply of the area (p. 71). Both alluvial material and sandstone below stream level yield water to wells; some wells flow. Describes circulation of ground water and notes that data on some wells report the occurrence of water (pp. 57-63). A section on ground water contains a description of several wells and springs and two analyses of water from deep wells (pp. 67-70). Includes a geologic map showing structure on top of the Graybull sandstone member of the Cloverly formation.

The Ashland coal field, Rosebud, Powder River, and Custer Counties, Mont., by N. W. Bass. U. S. Geol. Survey Bull. 831-b, pp. 19-105, pls. 3-37, 1932.

Briefly describes ground-water resources of the area (p. 26). Many springs of potable water come from coal beds. Potable well water is obtainable in most parts of the area, and flowing artesian water is found in the Tongue River and Otter Creek Valleys. Where springs yield alkaline water from Lebo shale, potable water may be obtained by drilling to the Lance formation. Contains geologic map showing outcrops of coal beds, and columnar sections.

Geology of Big Horn County and the Crow Indian Reservation, Mont., with special reference to the water, coal, oil, and gas resources, by W. T. Thom, Jr., G. M. Hall, C. H. Wegimann, and G. F. Moulton. U. S. Geol. Survey Bull. 856, vii, 200 pp., 15 pls., 1935.

Describes briefly the ground-water investigations made in Montana from 1915 to 1921 (pp. 8, 9). Treats of drainage and surface-water irrigation (pp. 19-24). Logs of gas and oil wells mention the occurrence of water (pp. 104-124). Discusses water-bearing properties of the rock formation, relation of rock structure to water supply, artesian conditions, water supply, methods of obtaining ground water supplies, storage of surface water, storage of ice, and quality of water in Big Horn County. Includes analyses of 36 water samples. Gives detailed descriptions of water supplies by townships (pp. 156-196). Includes a geologic map showing the structure on top of the Cloverly formation, structure section, detailed structure-contour maps of parts of the area, and columnar sections and graphic well logs.

The Rosebud coal field, Rosebud and Custer Counties, Mont., by W. G. Pierce. U. S. Geol. Survey Bull. 847-b, pp. 1-iv, 43-120, pls. 5-21, 1936.

Discusses surface-water and ground-water supplies and gives data on springs and flowing artesian wells in the area (pp. 45-51). Includes a geologic map showing outcrops of coal beds, a generalized structure-contour map, and structure and columnar sections.

The Richey-Lambert coal field, Richland and Dawson Counties, Mont., by F. S. Parker. U. S. Geol. Survey Bull. 847-c, pp. 1-iv, 121-174, pls. 22-27, 1936.

Briefly describes the surface-water and ground-water supplies of the area in a section on drainage and water supply, including comments on the quality of water from different formations (pp. 126, 127). Includes a geologic map showing outcrops of coal beds, a generalized structure coal map and columnar sections.

Geology and mineral resources of north-central Chouteau, western Hill, and eastern Liberty Counties, Mont., by W. G. Pierce and C. B. Hunt. U. S. Geol. Survey Bull. 847-f, pp. 1-iv, 225-270, pls. 36-43, 1937.

Describes briefly water resources of the area. "The two formations that yield the greatest amount of water are the Judith River formation and the Eagle sandstone" (p. 264). Includes a geologic map showing the structure on top of the Eagle sandstone, columnar sections and graphic well logs.

The coal resources of McCone County, Mont., by A. J. Collier and M. M. Knechtel. U. S. Geol. Survey Bull. 905, vii, 80 pp., 16 pls., 1939.

"Most of the water for domestic use is obtained from shallow dug wells near the creeks, from drilled wells a few feet to 200 or 300 feet deep, and from springs near the outcrops of coal beds."

The Mizpah coal field, Custer County, Mont., by F. S. Parker and D. A. Andrews. U. S. Geol. Survey Bull. 906-c, pp. 1-iv, 85-133, pls. 16-40, 1940.

"Water for domestic supply is obtained from wells and springs. Along the Powder River flowing wells 100 to 300 feet in depth penetrate sandy layers of the sandstone member of the Lance formation and furnish plentiful supplies of potable water. Along Mizpah Creek wells of equal depth do not flow, but the water rises within a short distance from the surface" (p. 91).

#### Other United States Geological Survey Publications

Reconnaissance on Musselshell River, Mont., by S. B. Robbins. U. S. Geol. Survey 2d Ann. Rept., Reclamation Service, pp. 252-254, 1904.

Ground water in the Missouri Valley near Townsend, Broadwater County, Mont., by J. T. Pardee. U. S. Geol. Survey Mimeographed Report, 6 pp., Jan. 25, 1922.

Gives the results of an investigation made in 1921. Ground water is abundant in the valley bottoms at about 20 feet and on the bench lands at depths of 100 to 300 feet. Conditions are in general unfavorable for artesian water. Describes local conditions in the several parts of the area, with notes on quality of water. See also Water-Supply Paper 539.

Report on geologic reconnaissance of the Clark Foot-Kootenai River development plan, Lincoln and Sanders Counties, Mont., by C. E. Erdmann. U. S. Geol. Survey, 80 pp., 14 pls., includes index and geologic maps, June 1945.

Progress report, ground-water hydrology, Lower Marias irrigation project, Mont., by F. A. Swenson, with a section on the chemical quality of the water, by H. A. Swenson. U. S. Geol. Survey, Missouri Basin Studies, typewritten manuscript, 86 pp., 1 pl., 5 figs., 1947.

Discusses the geology, water-bearing formations, fluctuations in water level, and areas of possible waterlogging with irrigation. Contains hydrographs, precipitation records, a stratigraphic column and table showing mineral constituents of the water. Also a map showing geology and well locations.

Progress report on the ground-water hydrology of the Medicine Lake-Grenora area, Missouri-Souris irrigation project, Montana and North Dakota, by Robert C. Vorhis. U. S. Geol. Survey, Missouri Basin Studies, mimeographed report, 88 pp., 4 pls., 1 fig., 1949.

Geology and ground-water resources of the Helena Valley, Mont., by H. W. Lorenz and F. A. Swenson, with a section on the mineral quality of the water by Herbert A. Swenson. U. S. Geol. Survey, Missouri Basin Studies, mimeographed report, 93 pp., 4 pls., 11 figs., 1949.

#### Montana Bureau of Mines and Geology Miscellaneous Contributions

Artesian wells as a source of water for the Winnett irrigation project, Mont., by E. S. Perry. Montana Bur. of Mines and Geology Misc. Contr. 1, 5 pp. 4 pls., Mar. 1932.

Shallow wells near Terry, Mont., as a source of irrigation water, by E. S. Perry, Montana Bur. of Mines and Geology, Misc. Contr. 3, 7 pp. (mimeographed) 1 pl., May 1932.

Artesian wells as a source of water for municipal supply at Fort Benton, Mont. Montana Bur. of Mines and Geology. Misc. Contr. 4, 7 pp., 1 pl., Dec. 1932.

Shallow wells as a source of irrigation water in Frenchtown and Camas Prairie Valleys, Mont., by E. S. Perry. Montana Bur. of Mines and Geology Misc. Contr. 5, 8 pp., 2 pls., Feb. 1933.

## Montana Bureau of Mines and Geology Memoirs

Ground water in eastern and central Montana, by E. S. Perry. Montana Bur. of Mines and Geology Mem. 2, 59 pp., 10 pls., Feb. 1931.

Ground-water resources of Judith Basin, Mont., by E. S. Perry, Montana Bur. of Mines and Geology Mem. 7, 30 pp., 3 pls., includes maps, 1932.

Discusses the geologic formations, their capacity as water-carriers and the relationship of their outcrops to catchment and intake areas on the flanks of the mountain uplifts. States the approximate depth the driller should reach the various water-bearing horizons. Includes a geologic map and sections of the basin. Also chemical analyses of water.

Geology and artesian water resources along Missouri and Milk Rivers in northeastern Montana, by E. S. Perry. Montana Bur. of Mines and Geology, Mem. 11, 34 pp. 1 pl., 15 figs., 5 tables, Dec. 1934.

Describes the stratigraphy of the Missouri and Milk River Valleys, the geologic structure, water-bearing sandstones, and chemical composition of the artesian water. Discusses the pressures and volume of flow of artesian waters. Includes a map showing distribution of characteristic types of water occurring in the Judith River formation, a map showing drainage modifications, generalized sections, a table of chemical analyses and a table of typical drilled wells.

Physiography and ground-water supply in Big Hole Basin, Mont., by E. S. Perry, Montana Bur. of Mines and Geology Mem. 12, 18 pp., 2 figs., 3 pls., includes geol. map, June 1934.

A reconnaissance study of the physiography and water supply of the area. Discusses the bedrock formations and valley fill. Describes the shallow and deep ground waters and their composition. Includes a generalized cross-section showing terraces and fills, a geologic map, and a map showing the relation of the Big Hole river to ancient valleys.

Geology and ground-water resources of southeastern Montana, by E. S. Perry, Montana Bur. of Mines and Geology Mem. 14, 67 pp., 3 pls., 27 figs., Dec. 1935.

## Journal Articles

Giant Springs of Great Falls, Mont., by C. A. Fisher, Geol. Soc. Am. Bull. 19, pp. 339-346, 1908.

Discusses the geologic relations, amount of flow, utilization, composition and source of the springs at Great Falls. Includes a map showing the pre-glacial channel of the Missouri River and the source of Giant Springs.

Some geochemical relations of ground water and associated natural gas in the Lance formation, Mont., by B. C. Renick, Jour. Geol., vol. 32, no. 8, pp. 668-684, 3 figs. Nov. Dec. 1924.

Describes the geology of the artesian basin along the valley of the Yellowstone River below Forsyth. Gives analyses of artesian water from 10 gas-bearing wells. Discusses the chemical character of the waters and of the gases that they contain. These gases contain more than 30 percent of nitrogen and unimportant amounts of helium. Methane reduces sulfate in the water to hydrogen sulfide, forming carbonate and bicarbonate.

Ground water in eastern and central Montana, by E. S. Perry. Northwest Sci. vol. 4, no. 4, pp. 96-100, Dec. 1930.

Papers of a General Nature or Relating to the Entire State

United States Geological Survey Publications

Water analyses from the laboratory of the U. S. Geol. Survey, tabulated by F. W. Clarks, U. S. Geol. Survey Water-Supply Paper 364, 44 pp., 1914.

Contains miscellaneous water analyses of Montana.

Base change in ground water by silicates as illustrated in Montana, by B. C. Renick. U. S. Geol. Survey Water-Supply Paper 520-d, pp. 53-72, pls. 3-5, 1925.

Discusses the natural softening of water that takes place in the Lance and Fort Union formations in Rosebud County, Mont. Includes water analyses and petrographic descriptions of the water-bearing formations.



## Publications by Other Federal Agencies

Report on the geological character of certain section of the State of Montana, showing the possibility of imbibition of water which would be available for artesian purposes, by C. C. Morton, U. S. 52d Cong. 1st sess., Sen. Doc. 41, pt. 2, pp. 78-83, map, 1892.

## Publications By State Agencies

Possibilities of ground-water supply for certain towns and cities of Montana, by E. S. Perry. Montana Bur. of Mines and Geology Misc. Contr. 2, 49 pp. 70 figs., 2 pls., Jan. 1933.

Possibilities of ground-water supply of certain towns and cities of Montana, by E. S. Perry, Montana School of Mines, Butte, 1933.

Some geological aspects of Montana water conservation projects, by P. A. Schofer, Missouri School of Mines, Glückauf, vol. 1, no. 5, pp. 2, 4, 30, June 1936.

Some chemical characteristics of public water supplies in Montana. Montana State Board of Health, Special Bull. 44, Dec. 1932.

## Journal Articles

Oil-field waters of the Montana plains, by J. G. Crawford. Am. Assoc. Petrol. Geol. Bull., vol. 26, no. 8, pp. 1317-1374, Aug. 1942.

Presents and discusses tabular and graphic analyses of waters from the oil-producing and gas-producing zones of Montana. The analyses indicate that all these waters have been considerably modified by the infiltration of meteoric water.



Papers Relating to Specific Areas Within the State

## United States Geological Survey Water-Supply Papers

Underground waters of a portion of southeastern Nebraska, by N. H. Darton. U. S. Geol. Survey Water-Supply Paper 12, 56 pp., 12 pls., 1898.

Covers an area that includes Lancaster, Seward, York, Fillmore, Hamilton, Clay, Hall, Adams, Buffalo, Kearney, and Phelps Counties and parts of Saline, Gosper, and Dawson Counties. Describes the physiography, geology, and ground waters of the area and discusses briefly the prospects for obtaining water from deep-seated formations.

Geology and water resources of the Patrick and Goshen Hole quadrangles, in eastern Wyoming and western Nebraska, by G. I. Adams. U. S. Geol. Survey Water-Supply Paper 70, 50 pp., 11 pls., 1902.

Describes the geology and contains some information on springs and wells in these quadrangles. Discusses water supply and irrigation and includes a geologic map, a map showing land under irrigation, and a map showing constructed and proposed canals along the North Platte River.

The underflow of the South Platte Valley, by C. S. Slichter and H. C. Wolff. U. S. Geol. Survey Water-Supply Paper 184, 42 pp., 1906.

Describes investigations of velocity, direction, and quantity of underflow at Ogalalla, Nebr., gives chemical analysis of the water, and discusses disadvantages of underflow canals or infiltration ditches. Describes also investigations at North Platte, Nebr., and gives suggestions for the construction of small pumping plants.

Geology and water resources of a portion of the Missouri River Valley in northeastern Nebraska, by G. E. Condra. U. S. Geol. Survey Water-Supply Paper 215, 59 pp., 11 pls., 1908.

Describes the geology, streams, springs, and shallow and artesian wells in Boyd, Knox, Cedar, Dixon, and Dakota Counties and in a part of Holt County; includes maps showing geology and artesian-water conditions.

Geology and ground-water resources of the Republican River Valley and adjacent areas, Nebr., by G. E. Condra. U. S. Geol. Survey Water-Supply Paper 216, 71 pp., 13 pls., 1907.

Describes the geography, geology, surface and ground waters in Dundy, Hitchcock, Redwillow, Furnas, Harlan, Franklin, Webster, Nuckolls, Thayer, and Jefferson Counties; includes a geologic map; contains information on "blowing wells."

Ground water for irrigation in Lodgepole Valley, Wyoming-Nebraska, by O. E. Meinzer. U. S. Geol. Survey Water-Supply Paper 425-b, pp. 37-69, pls. 4-6, 1918.

Describes the physiography and geology of Lodgepole Valley and adjacent region and the water in the alluvial gravel and in the Tertiary and Cretaceous formations; discusses irrigation with ground water; contains maps showing the geology and the depths to the water table. Gives well data and analyses.

The Thiem method for determining permeability of water-bearing materials and its application to the determination of specific yield, results of investigations in the Platte River Valley, Nebr., by L. K. Wenzel. U. S. Geol. Survey Water-Supply Paper 679, pp. 1-57, pls. 1-6, 1935.

Describes pumping tests in the Platte River Valley, Nebr. and the comparison of the results with the theoretical data of Thiem's formulae.

Geology and ground-water resources of south-central Nebraska, with special reference to the Platte River Valley between Chapman and Gothenburg, by A. L. Lugin and L. K. Wenzel. U. S. Geol. Survey Water-Supply Paper 779, 242 pp., 16 pls., 1938.

Discusses the available supply of ground water in south-central Nebraska, the origin and discharge of the ground water and the relation of the geologic and ground-water conditions in the Platte River Valley to conditions occurring under the plains to the south. Includes a water table contour map, well location map, hydrographs, profile sections and well records.

Local overdevelopment of ground-water supplies, with special reference to conditions at Grand Island, Nebr., by L. K. Wenzel. U. S. Geol. Survey Water Supply Paper 836-e, pp. 233-281, pls. 16-21, 1940.

Discusses the history of the Grand Island public water supply, geologic conditions and hydrologic properties of the Pleistocene sand and gravel. Includes logs of wells and test holes, records of wells pumped for irrigation, a map showing contours on the water table, profiles of the water table and water-level measurements.

Ground water in Keith County, Nebr., by L. K. Wenzel and H. A. Waite. U. S. Geol. Survey Water-Supply Paper 848, 68 pp., 8 pls., 1941.

Discusses the Ogallala and other Tertiary formations, the accumulation of loess derived from them, and their water-bearing properties. Also refers to movement, storage, discharge and recharge of ground water. Includes a map showing contours on the water table, well records, test hole logs and profile sections.

Geology and ground-water resources of Box Butte County, Nebr., by R. C. Cady and O. J. Scherer. U. S. Geol. Survey Water-Supply Paper 969, 120 pp., 9 pls., 1945.

Gives a detailed description of the Miocene and Pliocene formations, the Quaternary alluvial fill, and their water-bearing character. Discusses discharge and recharge of ground water. Includes records of test holes and wells, a geologic map, a water table contour map, profile sections and hydrographs.

Geology and ground-water resources of Scottsbluff County, Nebr., by L. K. Wenzel, H. A. Waite, and R. C. Cady. U. S. Geol. Survey Water-Supply Paper 943, 155 pp., 12 pls., 1946.

Discusses the Cretaceous and Tertiary formations, alluvial deposits of Quaternary age, and their water-bearing properties. Special reference is made to the Pleistocene terraces and their sands and gravels. Also discusses recharge, discharge, seepage and irrigation. Includes a geologic and a topographic map, profile sections and logs of test holes and wells.

## Other United States Geological Survey Publications

Preliminary report on the geology and water resources of Nebraska west of the 103rd meridian, by N. H. Darton. U. S. Geol. Survey 19th Ann. Rept. (1897-98), pt. 4, Hydrography, 814 pp., 118 pls., 1898, pp. 727-785, pls. 74-118.

Describes the general geology of Nebraska, and the topography, geology, and water horizons of the area covered by the report. Gives information on springs, streams, irrigation, climate, and timber, and of elevations of various points. Includes a general geologic map of Nebraska and more detailed maps of the portion of the State west of the 103rd meridian, showing the geology and the ground-water conditions.

Notes on the ground-water supply at Kearney, Nebr. U. S. Geol. Survey 21st Ann. Rept. (1899-1900), pt. IV, Hydrography, pp. 216, 217, 1909.

Discusses the effect of the Platte River water-level fluctuations on neighboring wells. Temperature and wind direction seems to effect the water level in the area. A map showing the location of wells and a profile of the water table may be found in U. S. Geol. Survey Water-Supply and Irrigation Paper 12, (p. 30, 40).

Preliminary report on the geology and water resources of Nebraska west of the 103rd meridian, by N. H. Darton. U. S. Geol. Survey Prof. Paper 17, 69 pp., 43 pls., 1903.

Discusses the topography, geology, underground waters, streams and irrigation. Includes a geologic map, ground-water map, topographic map and numerous sections.

Oelrichs folio, by N. H. Darton. U. S. Geol. Survey Geol. Atlas (no. 85), 1902.

Discusses the geography, geology, and stratigraphy of the area. Includes maps showing topography, areal geology, artesian water and structure sections. Also columnar sections.

Edgemont folio, by N. H. Darton and W. S. T. Smith. U. S. Geol. Survey Geol. Atlas (no. 108), 1904.

Discusses the geography, geology and structure of the region. Contains a section on water supply. Includes maps showing topography, areal geology, artesian water, structure sections. Also columnar sections.

Four-year decline in the ground-water level in the Platte River Valley in central Nebraska caused by subnormal precipitation, by L. K. Wenzel. U. S. Geol. Survey Mimeographed Rept., 2 pp., 2 pls., April 1, 1935.

The water level declined 1 to 8 feet from October 1930 to October 1934, the decline being greatest where the water table lies deepest. During the period the deficiency of precipitation amounted to about 1,400,000 acre-feet, and the net loss of ground water was about 400,000 acre-feet. The records indicate that recharge in normal years will restore the water levels to their normal position. See also Water-Supply Paper 779.

Ground-water resources of south-central Nebraska, with special reference to the Platte River Valley between Chapman and Gothenburg, by A. L. Lugin and L. K. Wenzel. U. S. Geol. Survey Mimeographed Rept. 2 pp., Sept. 16, 1935.

Nearly all water supplies of the area are from wells. It is estimated that the pumpage for municipal, irrigation, and other uses is about 30,000 acre-feet a year and that about 56,000 acre-feet a year percolates southward under the upland and reappears in the tributaries of the Republican and Blue Rivers. With the return of normal years of precipitation there will be restoration of the ground-water supply. See also Water-Supply Paper 779.

Ground-water resources of Box Butte County, Nebr., by R. C. Cady and O. J. Scherer. U. S. Geol. Survey Mimeographed Rept., Jan. 6, 1942.

Most of the ground water pumped comes from formations of Miocene and Pliocene age. Although these formations consist of fine-grained sand and sandstone, they yield large quantities of water to wells. Their productiveness is due to the great thickness of the saturated beds and to the fact that their sands are well assorted and contain very little silt and clay. See also Water-Supply Paper 969.

Ground-water resources of Scottsbluff County, Nebr., by H. A. Waite, L. K. Wenzel, and R. C. Cady. U. S. Geol. Survey Mimeographed Rept. 1 p., Jan. 6, 1942.

The estimated annual discharge of ground water by wells is about 8,000 acre-feet; the loss due to evaporation and transpiration by plants in the lowlands is about 100,000 acre-feet; and about 325,000 acre-feet of ground water percolates to streams that carry it out of the county. See also Water-Supply Paper 943.

Investigations of ground-water levels in the Platte River Valley, Nebr., by A. L. Lugin and L. K. Wenzel. U. S. Geol. Survey Mimeographed Rept., 2 pp., Feb. 28, 1943.

A summary of the studies that have been made, including test drilling, pumping tests, measurements of water level, and collection of well data. See also Water-Supply Paper 779.

Progress report on the ground-water hydrology of the Republican and Frenchman River Valleys in Nebraska, by H. A. Waite and others, with a section on the chemical quality of the ground water, by H. A. Swenson. U. S. Geol. Survey Circ. 19, 83 pp., 1 pl., 4 figs., 10 tables, Aug. 1948.

Discusses the geology and ground-water conditions of the area. Contains water-level measurements, well records and results of chemical analyses of ground waters. Includes hydrographs and a map showing location of observation wells and contours on the water table.

Progress report on the ground-water hydrology of the Lower Platte River Valley, Nebr., by H. A. Waite, with a section on the chemical quality of the ground water, by H. A. Swenson. U. S. Geol. Survey Circ. 20, 211 pp., 9 pls., 14 figs., 13 tables., Jan. 1949.

Discusses the geologic formations and their water-bearing properties. Contains water-level measurements, hydrographs, and maps showing changes of water level, locations of observation wells and water-table contours. Also geologic sections, well records, test hole logs, and results of chemical analyses.

#### Nebraska Water Resources Survey Water-Supply Papers

Ground-water in the Republican River Basin in Nebraska, pt. 1, Nuckolls, Webster, Franklin and Harlan Counties, by H. A. Waite, E. C. Reed, and D. S. Jones, Jr. Nebraska Water Resources Survey Water-Supply Paper 1, Lincoln, Nebr., 43 pp., 8 figs., Oct. 1944.

Gives a short discussion of the geology and ground-water conditions in each county and logs of 243 test holes. Includes maps showing location of test holes and data on the water-bearing formations.



Ground-water in the Republican River Basin in Nebraska, part 2, Furnas County, by H. A. Waite, E. C. Reed, and D. S. Jones, Jr. Nebraska Water Resources Survey Water-Supply Paper 1, Lincoln, Nebr. 32 pp., 2 figs., Feb. 1945.

Gives a brief description of the geology of Furnas County and its relation to the occurrence of ground water. Contains a map showing the location of test holes, contours on top of the Cretaceous bedrock, and the approximate thickness of the water-bearing sand and gravel in the valley of the Republican River and its principal tributaries. Presents the logs of about 130 test holes.

Ground water in the Republican River Basin in Nebraska, pt. 3, Red Willow and Frontier Counties, by H. A. Waite, E. C. Reed, and D. S. Jones Jr. Nebraska Water Resources Survey Water-Supply Paper 1, Lincoln, Nebr., 35 pp., 2 pls., Aug. 1945.

Describes the geology and ground-water conditions in each county. Presents the logs of 151 test holes in Red Willow County and 15 in Frontier County. Includes maps showing location of test holes and data on the water-bearing beds.

Ground-water survey of the area north of O'Neill, Holt County, Nebr., by E. C. Reed. Nebraska Water Resources Survey Water-Supply Paper 2, Lincoln, Nebr., 26 pp., 12 figs., Dec. 1945.

Gives results of a study of the possibilities of pump irrigation in an area of about 70 square miles situated north and northwest of O'Neill. Includes records of 13 test holes 39 to 84 feet deep and descriptions of the geology, topography, drainage, soils, and ground water. Concludes that pump irrigation may be economically feasible on a small scale in a limited part of the area.

Ground-water levels in the Lower Platte River Valley, Nebr., by H. A. Waite. Nebraska Water Resources Survey Water-Supply Paper 3, May 1948.

A comprehensive report on the ground-water levels in the lower Platte Valley. Includes hydrographs and maps showing net changes in ground-water levels from December 1930 to December 1946.

#### Publications By Other State Agencies

Pump irrigation at North Platte Experimental Substation, by H. E. Weakly, Univ. of Nebraska Agr. Exper. Sta. Bull. 301 pp. 1-12, 1936.



Correlation of formations in the Midland Forster well, near Fremont, Nebr., by E. C. Reed, Nebraska Geol. Survey Paper 13, 20 pp., 4 figs., Dec. 1938.

Describes the drilling operations and correlation of the samples. Contains a complete log of the well. Includes a section on ground water and the different water horizons. Contains water analyses of the St. Peter sandstone at 3 different levels.

Deep wells at Lincoln, Nebr., by G. E. Condra and E. C. Reed, Nebraska Geol. Survey Paper 15, 25 pp., 2 figs., includes index map, July 1939.

Describes the 7 deep wells in the vicinity of Lincoln. The information gathered from various sources is sufficient for logging and correlation of three of the wells and for the general description of the others. Discusses the origin of salt water and salt water horizons. Includes a profile section and correlation tables.

Irrigation work on the North Platte River, by B. P. Flemming. Univ. of Wyoming Agr. Exp. Sta. Bull. 66, 24 pp.

Unpublished geologic and ground-water data on Adams, Clay, Fillmore, Franklin, Hamilton, Jefferson, Kearney, Nuckolls, Polk, Saline, Seward, Thayer, Webster and York Counties, Nebr., by E. C. Reed, Univ. of Nebr., Conservation and Survey Division.

Consists of maps showing type of land, water-table contours, depth to water, and thickness of water saturated sand and gravel. Also contains geologic sections based on test drilling.

#### Journal Articles

The test well in the Carboniferous formations at Brownsville, Nebr., by L. C. Hicks, Am. Jour. of Sci. 3rd ser., vol. 29, p. 156, 1885.

Notes on mineral water from Odell, Nebr., by Rosa Bouton. Nebraska Acad. of Sci. Proc. No. 3, p. 12, 1891.

The driven well system of Schuyler, Nebr., by F. L. Burrell. Eng. News, Sept. 1, 1892.

Water works improvements at Kearney, Nebr., by E. L. Furgeson. Eng. News Record, vol. 94 (22), pp. 884-885, May 28, 1925.

Ground-water hydrology and Pleistocene geology of the Platte River Valley and adjacent areas in Nebraska, by A. L. Luginbuhl. Am. Geophys. Union Trans. 12, pp. 224-226, June 1931.

A preliminary report on the occurrence and quantity of ground water in the Platte River Valley area.

Methods of ground-water investigation in the middle portion of the Platte Valley, Nebr., by H. P. Burleigh. Nebraska Irrigation Assoc. Proc. 1932.

The ground waters and lakes of the Sand Hill Region, Nebr., by G. E. Condra. Nebraska Irrigation Assoc. Proc. 1932.

Pumping and return flow in the South Platte Valley, by W. E. Code. Through the Leaves vol. 26 (3), p. 87, May 1938.

"The results of this study indicate that although pumping may have had some effect in reducing the amount of return flow, the greater effect, by far has been caused by diminished stream flow."

Preparing land for irrigation and methods of applying water (Scott County, Nebr.), Irrigation Age, vol. 21, pp. 24-26.

How land is prepared for irrigation and water applied for crops (Scott County, Nebr.). Irrigation, vol. 4, no. 2, pp. 3-5.

Underground water investigation in central Nebraska, by H. A. Waite. Compass, vol. 11, no. 5, pp. 98-99.

#### Papers of a General Nature or Relating to the Entire State

##### United States Geological Survey Water Supply Papers

Reclamation and water storage in Nebraska, by O. V. P. Stout. U. S. Geol. Survey Water-Supply Paper 93, pp. 276-284, 1904.

A brief discussion of the reclamation and water storage problem in Nebraska. Wyoming offers reservoir sites for storage of water for use in Nebraska.

Studies of relations of rainfall and runoff in the U. S. by W. C. Hoyt and others. U. S. Geol. Survey Water-Supply Paper 772, 301 pp., 1936.

Contains data on ground-water runoff (pp. 245-247) and on ground-water levels in the Platte River Valley in Nebraska (pp. 269-273). Contains a list of 193 references to relations between rainfall and runoff, and related subject, including several publications dealing with ground water.

Drought of 1936, with discussion on the significance of drought in relation to climate, by J. C. Hoyt. U. S. Geol. Survey Water-Supply Paper 820, iv, 62 pp., 2 pls., 1938.

Discusses the effects of the drought on ground water supplies (pp. 11-13) and gives data on the fluctuation of the water level in an observation well in Hall County, Nebr.

#### Publications By Other Federal Agencies

Agriculture by irrigation in western United States: Artesian wells of Nebraska, by F. H. Newell. Dept. of Commerce, Bur. of Census, 11th Census, p. 272, 1890.

Report on artesian waters in Nebraska, by C. W. Irish. 51st Cong., (2nd sess.) S. Ex. Doc. 53, pt. 1.

Progress report of artesian and underflow investigation, by E. S. Nettleton. 51st Cong., (2nd sess.) S. Ex. Doc. 53, pt. 2, pp. 3-12.

A report on irrigation and cultivation of the land thereby, with physical data, conditions, and progress within the United States for 1891, by R. J. Hinton. 52nd Cong. (1st sess.) S. Ex. Doc. 41, pt. 1, Irrigation in Nebraska, pp. 292-294, Water Works pumping from ground water p. 448, 1892.

Artesian and underflow investigation. Final report of the Chief Engineer. E. S. Nettleton 1892. 52nd Cong. (1st sess.) S. Ex. Doc. 41, pt. 2, Underground Water Surveys, pp. 19-29, Underflow and irrigation problems in Nebraska and Kansas, pp. 30-34, 1893.

Report of progress of the Division of Hydrography for the year 1895, by F. H. Newell. Data on seepage and evaporation, Nebr. and Kans. United States Geol. Survey Bull. 140, pp. 347-350, 1896.

Discusses data on the increase of flow in Frenchman River from underground sources. Discusses seepage measurements at Kearney, Nebr., and evaporation and seepage from a small lake at the Nebr. State Industrial School. Contains a short paragraph on the seepage at Goodland, Kans. Includes tables of seepage measurements.

#### Nebraska State Geological Survey Publications

Deep wells of Nebraska, by G. E. Condra and others, Nebraska State Geol. Survey Bull. 2nd ser., no. 4, 228 pp., 1931.

Contains logs of wells 1,000 feet or more in depth. Includes a table showing the location and depth of wells.

Ground-water level survey in Nebraska, by H. A. Waite. Nebraska Geol. Survey Paper 7, Lincoln, Nebr., 14 pp., 1935.

Describes the selection of observation wells and methods of recording the data. Gives summary of water-level records in the Platte River Valley, October 1930 to October 1934. Includes a map showing the location of observation wells.

The Pleistocene geology of Nebraska, by A. L. Lugin. Nebraska State Geol. Survey Bull. 2d series, no. 10, pp. 201-210, 1935.

In more than half the state water supplies are obtained from Pleistocene aquifers. However, water supplies of the Sand Hills are drawn from Pleistocene and Tertiary formations. Discusses ground water in relation to Pleistocene deposits. Includes profile section.

Water-bearing formations of Nebraska, by G. E. Condra and E. C. Reed. Nebraska Geol. Survey Paper 10, 24 pp., 3 pls., geol. maps, 11 figs., 1936.

This paper is a review of the water horizons of the State. Much of the ground water of the state occurs in the mantle rock which is the unconsolidated surface deposits, such as alluvium, dunesand, loess, glacial drift and glacio-fluvial sand and gravels. Contains maps showing the bedrock, ground-water regions and mantle rock formations of the state. Includes generalized cross-sections.

## University of Nebraska Division of Conservation and Survey Bulletins

The conservation of Nebraska water resources, by G. E. Condra. Univ. Nebraska Div. of Cons. and Survey Bull. no. 3, 19 pp., Oct. 8, 1930.

Contains a general discussion of all phases of water conservation in the State.

The relation of drought to water use in Nebraska, by G. E. Condra. Univ. Nebraska Div. Cons. and Survey Bull. no. 6, 1934.

Contains a general discussion of the relation of drought to water use. Briefly discusses ground-water movement and water-table levels. Includes sections.

Conservation of land and water resources of Nebraska, by G. E. Condra. Univ. of Nebraska Div. of Cons. and Survey Bull. no. 14, Dec. 1936.

Contains a general outline of water and land conservation. Includes brief sections on irrigation, water storage and Sand Hills waters.

Drought, its effects and measures of control in Nebraska, by G. E. Condra. Univ. of Nebraska, Div. of Cons. and Survey Bull. 25, 43 pp., April 1944.

Discusses the nature of drought, climatological data, drought in relation to soil, surface, and ground water. Contains brief statements on irrigation and storage. Includes profile sections.

## University of Nebraska Agricultural Experiment Station Publications

Irrigation in Nebraska, by L. E. Hicks, Univ. of Nebraska Agr. Exp. Sta. Bull. no. 1, 1887.

Water supply in Nebraska, by O.V.P. Stout. Univ. Nebraska Agr. Exp. Sta. Bull. no. 41, pp. 153-172, 1895.

The storage and use of soil moisture. Univ. Nebraska Agr. Exp. Sta. Bull. no. 5, 1914.

Pump irrigation in Nebraska, by E. E. Brackett and O. C. Syogren. Univ. Nebraska Agr. Exp. Sta. Circ. no. 2, pp. 1-28, 1917.

Pump irrigation results, by H. E. Weakly. Univ. Nebraska Agr. Exp. Sta. Bull. no. 227, June 1928.

Pump irrigation and water table studies, by H. E. Weakly, Univ. Nebraska Agr. Exp. Sta. Bull. 271, 14 pp, 1932.

Pump irrigation investigation in Nebraska, by E. E. Brackett and E. B. Lewis. Univ. Nebraska Agr. Exp. Sta. Bull. 282, 33 pp., 1933.

Agricultural engineering investigations, by the Nebraska station. Ann. Rept. of the Univ. Nebraska Agr. Exp. Sta., pp. 5-7, 34, 1935.

#### Publications by Other State Agencies

The problem of our soils and soil moisture, by E. H. Barbour. Ann. Rept. of the Nebraska State Bd. Agr., 1896.

Moisture as an element of soil fertility, by E. H. Barbour. Ann. Rept. of the Nebraska State Bd. of Agr., 1897.

Some methods of lifting water in Nebraska. Ann. Rept. of the Nebraska State Bd. of Agr., 1899.

The deep and shallow wells of Nebraska, by E. H. and Carrie A. Barbour. 1901 Ann. Rept. of the Nebraska State Bd. of Agr.

Water resources of Nebraska, Nebraska State Planning Bd. 695 pp., Dec. 1936.

A comprehensive study of Nebraska's water resources made for the purpose of formulating recommendations concerning their development. Contains maps showing geology, ground-water regions, location of observation wells and precipitation. Includes graphs and hydrographs.

Ground-water papers in Biennial reports of the State Engineer, 1890-1939. Bur. of Irrigation, Water Power, and Drainage.

Ground water by O. E. Meinzer. Nebraska State Soil Cons. 3rd Conference of District Supervisors Proc., Lincoln, Nebr., pp. 39-42, Jan. 8, 1942.

Physical survey of water resources, Surface and Ground. Records at State W.P.A. Administration Office and Nebraska Planning Board Office. O. P. No. 465-81-3-155. Works Progress Administration.

### Journal Articles

Some typical well sections in Nebraska, by L. E. Hicks. Am. Assoc. Adv. of Sci. Proc., vol. 35, p. 217, 1887.

A statewide program of periodic measurements of ground-water levels in Nebraska, by L. K. Wenzel, Am. Geophys. Union Trans, pt. 2, pp. 495-498, August 1935.

Describes the program for ground-water level measurements in about 350 wells in Nebraska. Gives correlation of water-level fluctuations, with precipitation in the Platte River Valley in central Nebraska.

Symposium on fluctuations of ground water: The recovery of ground-water levels in Nebraska in 1935, by L. K. Wenzel. Am. Geophys. Union. Trans. no. 17, pt. 2, pp. 370-371, July 1936.

Gives average fluctuations and net changes in water level in groups of wells segregated according to different depths to water level below the land surface.

Ground-water recharge in areas of deep water table in the Great Plains, by R. C. Cady. Am. Geophys. Union. Trans. pl. 2, pp. 570-574, July 1940.

A summary of studies in western Nebraska, based chiefly on observations of water levels in wells. Includes water-table contour map of Keith County and a map of Box Butte County showing contours and gradients of the water table.



Papers Relating to Specific Areas Within the State

## United States Geological Survey Water-Supply Papers

The artesian-water supply of the Dakota sandstone in North Dakota, with special reference to the Edgeley quadrangle, by O. E. Meinzer and H. A. Hard. U. S. Geol. Survey Water-Supply Paper 520-e, pp. 73-95, pls. 6-7, 1925.

Discusses early artesian drilling, decline in artesian head and shrinkage of area of artesian flow, decline in yield of wells, rate of recharge, the removal of water from the Dakota sandstone and compression of the formation, and the conservation program of North Dakota. Includes well records and analyses of water.

Water supply of the Dakota sandstone in the Ellendale-Jamestown area, North Dakota, by L. K. Wenzel and H. H. Sand. U. S. Geol. Survey Water-Supply Paper 889-a, pp. 1-iv, 1-81, pls. 1-3, 1942.

Describes the development of flowing artesian wells in the area and the decline in head caused by the great draft on the supply. The report gives tabulated data on 375 wells and 33 analyses of water samples. Contains map showing fluoride content of the ground water and map showing location of artesian wells, and the original western limit of artesian flow and the limit in 1915, 1923, and 1938.

## United States Geological Survey Bulletins

The moraines of the Missouri Coteau and their attendant deposits, by J. E. Todd. U. S. Geol. Survey Bull. 144, 71 pp., 1896.

Discusses the morainal features of North and South Dakota between the Missouri and James Rivers. Contains well log information on wells drilled in the different moraines. Includes a map showing the location of morainal margins in the area.

The Nesson anticline, Williams County, N. Dak., by A. J. Collier. U. S. Geol. Survey Bull. 691-g, pp. 211-217, pl. 26, 1918.

Notes on two wells mention artesian water in the Dakota sandstone (pp. 216, 217). Includes structure contour map and structure section.

Lignite in the western part of the Fort Berthold Indian Reservation south of the Missouri River, N. Dak., by C. M. Bauer and F. A. Herald. U. S. Geol. Survey Bull. 726-d, pp. 109-172, pls. 13-19, 1922.

Gives brief descriptions of springs along streams and of the quality of water from springs.

Geology and lignite resources of the Marmarth field, southwestern North Dakota, by C. J. Hares, U. S. Geol. Survey Bull. 775, vi, 110 pp., 14 pls., 1928.

There are numerous springs in the area, but their water is mostly of poor quality. Wells also furnish water of poor quality. A few flowing artesian wells in the area probably obtain water from the Fox Hills sandstone (pp. 10-11). Some of the township descriptions contain mention of the water supply (pp. 58-104). Includes a geologic map showing outcrops of lignite beds, and columnar sections.

Geology and water resources of the Edgeley and La Moure quadrangles, N. Dak., by H. A. Hard. U. S. Geol. Survey Bull. 801, v, 90 pp., 5 pls., 1929.

Discusses springs of the area (p. 21), and a section on water resources describes the occurrence of ground water in the glacial drift, Pierre and Benton formations, and especially in the Dakota sandstone (pp. 44-56). A section on artesian conditions and prospects gives the history of well drilling and describes original head and area of artesian flow, decline in head, shrinkage in area of artesian flow, increase in hydraulic gradient, and decline in yield of flowing wells from 1886 to 1923 (pp. 57-74). Gives data on specific capacities and total discharge of artesian wells, rate of recharge of Dakota sandstone, withdrawal of water from storage, compression of sandstone, and quality, temperature, and occurrence of natural gas in water of the Dakota sandstone (pp. 74-78). Tabulated well data give location, depth, and other information on the principal artesian wells in and near Edgeley quadrangle. Includes geologic maps and maps showing thickness of glacial drift and artesian water conditions.

Geology and coal resources of the Minot region, N. Dak., by D. A. Andrews. U. S. Geol. Survey Bull. 906-b, pp. i-iv, 43-84, pls. 11-15, 1939.

Discusses artesian water in the Des Lacs area (pp. 80, 81). Shows the approximate extent of the flowing-well area and the location of many other water wells, in which the approximate depth to water is indicated by the altitude of the coal beds (p. 11). See also Water-Supply Paper 598.

## Other United States Geological Survey Publications

Jamestown-Tower folio, by D. E. Willard and H. S. Williams. U. S. Geol. Survey Geol. Atlas (no. 168), 1909.

Discusses the geology and stratigraphy of the area. Includes a section on ground-water supplies, uses, and quality. Contains maps showing topography, areal geology, and artesian water. Also a table of representative artesian wells in the area.

Bismarck folio, by A. G. Leonard, U. S. Geol. Survey Geol. Atlas (no. 181), 1912.

Discusses the geology, stratigraphy, and topography of the area. Includes a section on water supply. Includes maps showing topography and areal geology.

A report of an investigation of ground-water supplies and dam sites in the James and Sheyenne River Basins of North and South Dakota, by A. N. Sayre, U. S. Geol. Survey unpublished report to the Chief of Engineers, War Dept., June 1933.

The relation of ground-water levels to temperatures and precipitation at Harvey, N. Dak., by A. N. Sayre. U. S. Geol. Survey Mimeographed Rept. 2 pp., June 10, 1935.

Gives data on water level in a well of the city water supply system in which the level is low in the spring season and rises to maximum height in early summer. The water-level fluctuations also show a marked relation to the seasonal temperature. Includes diagram showing fluctuation in water level in the well from January 1927 to May 1935.

Progress report on the ground-water hydrology of the lower Missouri-Souris area, N. Dak., by G. A. Waring and G. A. LaRocque, Jr. U. S. Geol. Survey, Missouri Basin Studies, Mimeographed report, 560 pp., 13 pls., 5 figs., 1949.

Discusses the geology, ground-water conditions and hydrology of the area. Contains a map showing location of wells and principal ground-water subdivisions. Includes hydrographs and precipitation records. Well records under separate cover.

Progress report on the ground-water hydrology of the Medicine Lake-Grenora area, Missouri-Souris irrigation project, Mont. and N. Dak. by Robert C. Vorhis. U. S. Geol. Survey, Missouri Basin Studies, Mimeographed report, 88 pp., 4 pls., 1 fig., 1949.

Ground-water hydrology of the Heart River irrigation project and the Dickinson area, N. Dak., by P. C. Tychsen, with a section on the mineral quality of water of the Heart River project, by H. A. Swenson. U. S. Geological Survey Circular 34, 1950.

Discusses the geology and hydrology of the area. Describes the water-bearing formations and discusses the fluctuation of the water level. Contains the results of water analyses and a map of the Dickinson area showing areas of less mineralized ground water.

#### North Dakota Geological Survey Ground-Water Studies

Ground water in the Fessenden area, Wells County, N. Dak., by Leonard Filaseta, North Dakota Geol. Survey Ground Water Studies no. 1, 22 pp., 3 figs., Mar. 1946.

Discusses the water-bearing properties of the Cretaceous formations, glacial drift and associated deposits, sand and gravel at the base of the drift, sand lenses within the drift, outwash material and stream alluvium. Also describes the water table and present ground-water development. Includes logs of 14 test holes, a map showing location of wells and graphic features, and graphic logs of test holes.

Ground water at Dickinson, N. Dak., by T. G. McLaughlin, with a section on geology, by Arthur LeRoy Greenlee. North Dakota Geol. Survey Ground-water Studies no. 3, 31 pp., 5 pls., includes index map, Oct., 1946.

This investigation had as its purpose the defining of the area of influence of the existing wells and the determination of the capacity of the aquifer to transmit additional quantities of water. The transmissibility of the aquifer is low and approximately 80 feet of the aquifer has been permanently unwatered. Describes the geology and physical properties of the water-bearing materials. Includes results of pumping tests, well logs and well schedules.

Ground water near Buxton, Trail County, N. Dak., by P. E. Dennis. North Dakota Geol. Survey. Ground-water Studies no. 5, 29 pp., 4 figs., Jan. 1947.

A progress report on the geology and ground-water resources of Trail County. The purpose of the report is to determine the occurrence, movement, discharge and recharge of the ground water and the quantity and quality of such water. Discusses the water-bearing formations, artesian and shallow wells, and the quality of the water. Includes analyses of waters, well records and logs, a map showing the geology and hydrology of the area and cross-sections.

Ground water in the deposits of ancient Lake Dakota, Dickey County, N. Dak., by W. C. Rasmussen. North Dakota Geol. Survey Ground-Water Studies no. 4, 87 pp., 5 pls., 10 figs., Mar. 1947.

This report relates to the occurrence of ground water in the sand deposits beneath the plain south of Oakes, N. Dak. (the site of glacial Lake Dakota), and the availability of the water for agricultural, industrial, military, and other uses. The water is highly mineralized and, though suitable for stock, it is unsatisfactory for domestic use or for irrigation. Contains the results of pumping tests, analyses of water and sediments, and logs of test holes. Includes maps showing topography, geology, depth to water, and water table contours. Also includes graphs and cross-sections.

Geology and ground-water conditions at Minot, N. Dak., by P. D. Akin. North Dakota Geol. Survey Ground-Water Studies no. 6, 99 pp., 12 figs., Aug. 1947.

The purpose of this report was to determine the ground-water resources of the area and especially the hydrologic and hydraulic characteristics of the sand and gravel aquifer from which the City of Minot obtains its water supply and to predict the quantity of water that can be produced from the aquifer without ultimate overdevelopment. Includes a map showing the geology and well and test-hole locations. Also graphic logs and water-level measurements.

Ground water in the Aneta area, Nelson County, N. Dak., by P. E. Dennis. North Dakota Geol. Survey Ground-Water Studies no. 7, 23 pp., Oct. 1947.

Discusses the recharge of outwash gravels and the source of the water. The till of the Fergus Falls-Leaf Hills recessional moraine is virtually non-waterbearing as is also the Pierre shale. The general movement of the ground water in the aquifer is down the slopes of the Coulee into deeper gravels at its bottom. Discharge from the glacial outwash aquifer may be of the magnitude of about a million gallons a day. The discharge is chiefly by evaporation and transpiration. All the ground waters in the area are highly mineralized but those of the outwash aquifer contain the smallest amounts of dissolved minerals. Includes a map showing the geologic and hydrologic features and generalized cross-sections.

Ground water in the Sharon area, Steele County, N. Dak., by P. E. Dennis. North Dakota Geol. Survey Ground-Water Studies no. 8, 29 pp., 3 figs., Dec. 1947.

The area is in the east-central part of the Drift Prairie on the east margin of the Fergus Falls-Leaf Hills recessional moraine. The till of the moraine is virtually non-waterbearing as is also the Cretaceous shale bedrock. A channel 1 mile east of Sharon is cut in



till and contains no water-bearing sand and gravel. Gravel is exposed at the surface of an outwash plain about 4 miles west of Sharon. The ground-water body in this gravel receives considerable annual recharge from precipitation upon its permeable surface and perennial springs discharge from it. Includes analyses of water, well records and logs, a map of Sharon showing hydrologic features, and generalized cross-sections based on test holes.

Ground water in the Hope area, Steele County, N. Dak., by P. E. Dennis. North Dakota State Water Cons. Comm. and North Dakota Geol. Survey Ground-Water Studies no. 9, 30 pp., 2 figs., Apr. 1948.

Describes the geology and hydrology of the rock materials and their water-bearing characteristics. Discusses storage, recharge, movement, and discharge of water in the outwash gravels. Contains sections on quality of water and water-level measurements. Includes a map of the area showing geologic and hydrologic features, generalized cross-sections based on test holes, water analyses, well records and well logs.

Ground water in the Zeeland area, North Dakota, by Wilson M. Laird, with chapters on pumping tests and quality of water, by P. D. Akin. North Dakota Geol. Survey Ground-Water Studies 12, 35 pp., 8 figs., Oct. 1948. (Mimeographed).

Contains information on the quality and quantity of water in the shallow aquifer of limited extent 2 miles west of Zeeland. The results of pumping tests on a single well in the aquifer indicate a transmissibility of about 9,000 gallons per day per foot and a storage coefficient of about 0.19. Includes a geologic sketch map, water-table contour map, and graphs showing water level in observation well during pumping and recovery. Also chemical analyses of 2 ground waters and logs of test holes.

Ground water in the Wimbledon area, Barnes and Stutsman Counties, N. Dak. North Dakota Geol. Survey Ground-Water Studies. (In process).

#### Miscellaneous Publications

Water resources of the Devil's Lake region, N. Dak., by E. J. Babcock. North Dakota Geol. Survey Bienn. Rept. 2, pp. 208-250, map, 1902.

This paper deals with the surface and shallow-water supplies of the Devil's Lake drainage basin in a preliminary manner. Special attention is given to the possible application of large quantities of water obtainable from shallow-water reservoirs of this region. All underground water supplies depend largely for their source, character

and permanency upon the surrounding topography and geological features. Considerable space is given to a discussion of the topography and geologic conditions. Includes a map of the Devil's Lake drainage basin.

The water supply of the Tower quadrangle, N. Dak., by H. V. Hibbard, North Dakota Agr. Coll. Survey, Bienn. Rept. 2, pp. 152-157, 1904.

Report on geology and ground water of Williams, Burke, Mountrail, and Divide Counties, N. Dak., by A. Alpha. Univ. of North Dakota. M. S. dissertation, typewritten, 1935.

Geology, geography, physical and water resources of the James River Basin. Works Progress Administration O. P. No. 465-73-3-161, State Ser. No. 20330. Records at State W.P.A. Administrator's office or North Dakota State Planning Board.

Water resources, Souris-Devil's Lake Drainage area, N. Dak. Works Progress Administration O.P. No. 465-73-3-62. State Ser. No. 20331. Records at State W.P.A. Administrator's office or North Dakota State Planning Board.

Ground-water supply provides present and future needs of Minot, N. Dak., by H. E. Simpson. Water Works Eng., vol. 85 (11), pp. 386-389, June 1, 1932.



Papers of a General Nature or Relating to the Entire State

## United States Geological Survey Publications

Preliminary report on artesian waters of a portion of the Dakotas, by N. H. Darton. U. S. Geol. Survey 17th Ann. Rept. (1895-1896), pt. 2, pp. 603-694, 1896.

The lignite of North Dakota and its relation to irrigation, by F. A. Wilder, U. S. Geol. Survey Water-Supply Paper 117, 59 pp., 1905.

Discusses the lignite deposits in respect to fuel and value, water properties and irrigation. Discusses various river flats in connection with lignite. Gives the (1905) irrigation status.

Geology and ground-water resources of North Dakota, by H. E. Simpson, with a discussion of chemical character of the water, by H. B. Riffenburg. U. S. Geol. Survey Water-Supply Paper 598, v, 312 pp., 3 pls., 1929.

Discusses the physiography, climate, and occurrence of ground water in the various geological formations of North Dakota. Describes the ground-water provinces of the State and artesian water, with special reference to the Dakota sandstone. Includes county reports, a map showing areas of artesian flow, and a chapter on quality of the ground water.

Ground-water levels decline slightly in North Dakota, in 1938, by L. K. Wenzel. U. S. Geol. Survey Mimeographed Rept., 6 pp., 2 pls., Feb. 7, 1939.

Gives a summary of the changes of water level in 77 observation wells throughout the State and data on the observation-well program in cooperation with the North Dakota Geol. Survey. Includes map showing location of wells. See also Water-Supply Paper 845.

Artesian water conservation in North Dakota has beneficial effects, by L. K. Wenzel. U. S. Geol. Survey Mimeographed Rept. 2 pp., Feb. 5, 1941.

Summary of artesian water development in the State from the Dakota sandstone.

Ground-water levels rise in North Dakota, by W. C. Rasmussen. U. S. Geol. Survey Mimeographed Rept., 1 p., Jan. 29, 1942.

A summary of changes in the water level in 22 observation wells from September 1937 to November 1941. See also Water-Supply Papers 845, 886, 908, 938.

## Publications by Other Federal Agencies

Report of artesian water conditions of the Dakotas, by G. E. Culver. U. S. 51st Congress, 1st sess., Sen. Ex. Doc. 222, pp. 56-63, 1890.

Report on artesian wells in North Dakota, by F. S. Underhill, U. S. 51st Congress, 1st sess. Sen. Ex. Doc. 222 pp. 105-109, 1890.

Irrigation in North Dakota, by T. R. Atkinson. U. S. Dept. of Agr. Office of Exp. Sta. Bull. 219, 39 pp., 1909.

## North Dakota Geological Survey Publications

The conservation of artesian water, by H. E. Simpson, North Dakota Geol. Survey Bull. 5, 22 pp., 1 fig. 1926.

Discusses the principals and purpose of conservation as applied to artesian water. Describes the Dakota artesian system.

A method of water prospecting, by H. F. Simpson (3d bienn. rept. of the State water geologist, pp. 9-16). North Dakota Geol. Survey Bull. 6, 17 pp., 1927.

Discusses the water supply at Harvey, North Dakota, with remarks on early supplies, ground-water surveys, test drilling, developing the supply and methods of water prospecting.

The ground water of North Dakota, by H. E. Simpson, North Dakota Geol. Survey Bull. 7, 26 pp., 2 figs, 1 pl., 1932.

Discusses the occurrence and classification of ground water. Describes the topographic climatic and geologic conditions of the area. Discusses the unconsolidated deposits and bedrock formations in relation to ground water. Includes a map showing physiographic regions of North Dakota and a map showing precipitation.

Methods of reducing the flow of artesian wells by H. E. Simpson. North Dakota Geol. Survey Bull. 3, Revised 1932.

A general discussion of the use of reducers, plugs and valves in reducing artesian flow.

Artesian water conditions, by H. E. Simpson. North Dakota Geol. Survey Bull. 2, 1923, revised edition, 10 pp., 1935.

A general discussion of artesian water conditions and conservation practices in North Dakota.

The artesian waters of North Dakota, by H. E. Simpson, North Dakota Geol. Survey Bull. 8, pp. 1-31, 13 figs., includes index map, 1935.

Discusses the types of artesian systems found in the State, describes the artesian areas, discusses the yields, uses and methods of conservation of the artesian waters. Includes a map of North Dakota showing original areas of artesian flow, diagrammatic sections showing different artesian conditions, and sections of the Dakota artesian basin.

The fluoride content of North Dakota ground water as related to the occurrence and distribution of mottled enamel, by G. A. Abbott. North Dakota Geol. Survey Bull. 9, 15 pp., 1 fig., index map, 1937.

Discusses the occurrence of fluoride in the ground water of North Dakota. Gives a general discussion on effects of fluoride waters and possible removal methods. Includes a map showing the fluoride area and contains a table of representative fluoride-bearing waters.

Change in ground-water levels, by H. E. Simpson, North Dakota Geol. Survey Bull. 10, 23 pp., 2 figs., maps, 1937.

Discusses changes in ground-water and surface-water levels as affected by the droughts. Includes a summary table of the water levels by counties and a map showing change in ground-water levels and a map showing decline in ground-water levels over a period of years in Middle Missouri River Basin.

Maps and graphs prepared for the Water Resources Committee, North Dakota State Planning Board, by F. W. Voedisch, North Dakota Geol. Survey Circ 3, 52 pp., 32 figs., includes index and geol. maps, 1937.

The municipal ground-water supplies of North Dakota, by G. A. Abbott and F. W. Voedisch, North Dakota Geol. Survey Bull. 11, 99 pp., 2 pls., includes index map, 13 figs., 1938.

Discusses the ground water and municipal water supply of the state. Discusses the source, character and quantity of the ground water. Includes graphs showing the percent composition of typical water from the various water horizons. Also tables of analyses and a generalized section showing the principal water-bearing horizons.

The municipal ground-water supplies of North Dakota, by G. A. Abbott and F. W. Voedisch, North Dakota Geol. Survey Bull. 11, 99 pp. 2 pls., includes index map, 13 figs., 1938.

Discusses the ground water and municipal water supply of the state. Discusses the source, character and quantity of the ground water. Includes graphs showing the percent composition of typical water from the various water horizons. Also tables of analyses and a generalized section showing the principal water-bearing horizons.

Selected deep well records, by Wilson M. Laird. North Dakota Geol. Survey Bull. 12, 31 pp., 1941.

Describes the samples taken from 11 wells in different counties of the state. These well records are taken from wells which penetrate through the Dakota sandstone.

A reconnaissance of possible well irrigation areas in North Dakota, by W. C. Rasmussen, North Dakota Geol. Survey Bull. 20, 6 pp., Grand Forks, N. Dak., 1945.

Describes potential areas in North Dakota where ground water may be adequate to permit well irrigation and recommends the Oakes area for immediate investigation. Contains outline map of North Dakota showing the Pleistocene geology.

#### North Dakota State Planning Board Publications

Water conservation and development in North Dakota, by F. W. Voedisch, North Dakota State Planning Board Circ. 2, 15 pp., May 15, 1935.

Water conservation and development in North Dakota: Urban water supplies. North Dakota State Planning Board Circ. 2-A., Dec. 2, 1935.

2d progress report to the National Resources Board. North Dakota State Planning Board, pp. 131-146, 177-183, 142, 150, June 15, 1935.

Third progress report to the National Resources Board, by I. Lavine, North Dakota State Planning Board, pp. 349-352, Dec. 15, 1935.

A preliminary report on water conservation and utilization; Water Resources Committee report to Federal consultant. North Dakota State Planning Board, 131 pp., 28 pls., includes geologic maps, Apr. 10, 1935.

A report on the surface and ground-water resources of North Dakota, including water analyses. Serious depletion of stream flow and ground-water levels has taken place in many parts of the State. Discusses geology with relation to ground-water supplies. Wells are divided into those drawing from "mantle deposits," including glacial drift, and those drawing from artesian aquifers.

Water resources of slope drainage. Works Progress Administration, O.P. No. 465-73-3-163, State Ser. No. 20332. Records at State W.P.A. Administrator's office or North Dakota State Planning Board.

Survey of well schedules from County assessors and agents. Works Progress Administration O.P. No. 665-73-348. State Ser. No. 30117. Records at State W.P.A. Administrators office or North Dakota State Planning Board.

Analyses, plan for improving water supply for towns and communities, record of well logs, loss of artesian pressure, measured water levels. Works Progress Administration O.P. No. 665-73-3-48. State Ser. No. 85038. Records at State W.P.A. Administrator's office or North Dakota State Planning Board.

#### Publications by Other State Agencies

The water supply of North Dakota, by D. E. Willard. North Dakota Agr. Coll. Survey, 2d Bienn. Rept., pp. 144-152 (1904).

Notes on the wells of a portion of the Dakota artesian basin, by D. E. Willard. North Dakota Agr. Coll., 3d Bienn. Rept., pp. 44-46 (1906).

Water of North Dakota, by A. E. McCoy. Univ. of North Dakota, 1924.

What becomes of rainfall in North Dakota, by E. E. Chandler. North Dakota Univ. Quart. Jour., vol. 15, no. 2, p. 110, 1925.

The principles of conservation as applied to artesian waters (North Dakota) by H. E. Simpson. North Dakota Univ. Quart. Jour., vol. 15, no. 4, pp. 287-297, May 1925.

Fourth biennial report of the State water geologist (North Dakota), by H. E. Simpson, 7 pp., (mimeographed) 1929.

Fifth biennial report of the State water geologist (North Dakota) by H. E. Simpson, 6 pp. (mimeographed) 1931.

Water for domestic purposes in North Dakota, by E. F. Ladd. North Dakota Agr. Exper. Sta. Bull., 66. pp. 557-571.

### Journal Articles

Artesian wells of North Dakota, by G. H. Eldridge. Comptes Rendus. International Geol. Cong. V, Washington, D. C., 1891, p. 318, 1893.

Artesian wells in North and South Dakota, by W. Upham. Minnesota Acad. Nat. Sci., Bull. 3, pp. 370-379, 1901.

The underground water supply, by D. E. Willard. North Dakota Farmers Inst. Ann. Rept., 1903.

The waters of North Dakota, by A. E. McCoy. Am. Water Works Assoc. Jour., vol. 11, (2), 458-466, 1924.

Artesian water supply of the Dakota sandstone, Pan-Am. Geol., vol. 43 (5), June 1925.

Ground water supply, by H. E. Simpson. Water Works Eng., vol. 58 (11), pp. 686-689, June 1, 1932.

Artesian water beds revealed in North Dakota. Eng. News-Record, vol. 115 (8), 281 pp., Aug. 22, 1935.

North Dakota water facts. Water Works Eng., vol. 90 (3), p. 162, Feb. 1937.

Changes in ground-water levels in North Dakota, by H. E. Simpson. Am. State Geol. Assoc. Jour., vol. 9, (2), p. 14, Aug. 15, 1938.



Papers Relating to Specific Areas Within the State

## United States Geological Survey Water-Supply Papers

Geology and water resources of a portion of southeastern South Dakota, by J. E. Todd. U. S. Geol. Survey Water-Supply Paper 34, 34 pp., 10 pls., 1900.

Covers a rectangular area that includes parts of Turner, Hutchinson, Bonhomme, Yankton and Clay Counties. Describes the geology and the surface and ground waters with special reference to the artesian water in the Dakota sandstone. Contains a geologic map and maps showing depths to bedrock, depths to the water at the base of the till, and depths to artesian water.

Geology and water resources of part of the James River Valley, S. Dak., by J. E. Todd and C. M. Hill. U. S. Geol. Survey Water-Supply Paper 90, 41 pp., 23 pls., 1904.

Describes the geology, surface waters, and artesian and other ground waters of a rectangular area comprising Davison, Hanson, Sanborn, Beadle, and Miner Counties and parts of Kingsbury, Jerauld, Aurora and McCook Counties. Includes a geologic map of the area and maps showing areas of artesian flow, depths to Dakota sandstone, head of artesian water, depths to bedrock, and depths to water at the base of the till.

Artesian waters in the vicinity of the Black Hills, S. Dak., by N. H. Darton. U. S. Geol. Survey Water-Supply Paper 428, 64 pp., 13 pls., 1918.

Describes the geology and artesian-water conditions in areas covered in previous reports but in the light of additional data. Discusses the artesian prospects of the Dakota, Minnelusa, and Deadwood sandstones. Contains a map showing the geology and the depths to the water-bearing sandstones.

Problems of the soft-water supply of the Dakota sandstone, with special reference to the conditions at Canton, S. Dak., by O. E. Meinzer. U. S. Geol. Survey Water-Supply Paper 597-c, pp. 147-170, pl. 20, 1929.

Describes the geology of water-bearing formations at Canton, S. Dak., with special reference to quality of water obtained from horizons in the Dakota sandstone. Includes water analysis and well records.



## United States Geological Survey Bulletins

The moraines of the Missouri Coteau and their attendant deposits, by J. E. Todd, U. S. Geol. Survey Bull. 144, 71 pp., 1896.

Discusses the morainal features of North and South Dakota between the Missouri and James Rivers. Contains well log information on wells drilled in the different moraines. Includes a map showing the location of morainal margins in the area.

Geology of the Standing Rock and Cheyenne River Indian Reservations, N. and S. Dak., by W. R. Calvert, A. L. Beekly, V. H. Barnett and M. A. Pishel. U. S. Geol. Survey Bull. 575, 49 pp., 18 pls., 1914.

Covers an area west of the Missouri River, north of the Cheyenne River, and south of the Cannonball River, and extending westward to the 102d meridian. Describes the geology and contains a geologic map of the area. Includes a brief discussion of the water in the Dakota and Fox Hills sandstones and in other formations (pp. 24-25).

The lignite field of northwestern South Dakota, by D. E. Winchester, C. J. Hares, E. R. Lloyd, and E. M. Parks. U. S. Geol. Survey Bull. 627, 169 pp., 11 pls., 1916.

Describes the geology and contains maps of Harding and Perkins Counties. Describes the drainage and water supply and contains some data on deep wells not given in Water-Supply Paper 227.

## United States Geological Survey Atlas Folios

Oelrichs folio, by N. H. Darton. U. S. Geol. Survey Geol. Atlas (no. 85).

Discusses the geography, geology, and stratigraphy of the area. Includes maps showing topography, areal geology, artesian water and structure sections. Also columnar sections.

Olivet folio, by J. E. Todd. U. S. Geol. Survey Geol. Atlas (no. 96), 1903.

Describes the geography and geology of the area. Contains a section on underground waters, wells and artesian flow. Includes maps showing topography, areal geology and artesian water.

Parker folio, by J. E. Todd. U. S. Geol. Survey Geol. Atlas (No. 97), 1903.

Describes the geology and geography of the area. Contains a section on water, surface and subterranean. Includes maps showing topography, areal geology and artesian water.

Mitchell folio, by J. E. Todd. U. S. Geol. Survey Geol. Atlas (No. 99), 1903.

Describes the geology and geography of the area. Contains a section on surface and underground waters. Includes maps showing topography, areal geology, and artesian water.

Alexandria folio, by J. E. Todd and C. M. Hall, U. S. Geol. Survey Geol. Atlas (No. 100), 1903.

Describes the geology and geography of the area. Contains a section on surface and underground waters. Includes maps showing the topography, areal geology, and artesian water.

Newcastle folio, by N. H. Darton. U. S. Geol. Survey Geol. Atlas (No. 107), 1904.

Discusses the geology, geography, stratigraphy and water supply of the area. Includes maps showing the topography, areal and economic geology, artesian water and structure sections. Also columnar sections.

Edgemont folio, by N. H. Darton and W.S.T. Smith. U. S. Geol. Survey Geol. Atlas (No. 108), 1904.

Discusses the geography, geology and structure of the area. Contains a section on water supply. Includes maps showing topography, areal geology, artesian water and structure sections. Also columnar sections.

Huron folio, by J. E. Todd. U. S. Geol. Survey Geol. Atlas (No. 113), 1904.

Describes the geology and geography of the area. Contains a section on water resources, surface and underground. Includes maps showing topography, areal geology and artesian water.

De Smet folio, by J. E. Todd and C. M. Hall. U. S. Geol. Survey Geol. Atlas (No. 114), 1904.

Describes the geology and geography of the area. Contains a section on water resources. Includes maps showing topography, areal geology and artesian water.

Sundance folio, by N. H. Darton. U. S. Geol. Survey Geol. Atlas (No. 127), 1905.

Discusses the geology, geography, and stratigraphy of the area. Includes maps showing topography, areal and economic geology, artesian water and structure sections. Also columnar sections.

Aladdin folio, by N. H. Darton and C. C. O'Hara. U. S. Geol. Survey Geol. Atlas (No. 128), 1905.

Discusses the geography, geology and stratigraphy of the area. Includes maps showing topography, areal geology, artesian water, and structure sections. Also columnar sections.

Elk Point folio, by J. E. Todd. U. S. Geol. Survey Geol. Atlas (No. 156), 1908.

Discusses the topography, geology, geography and stratigraphy of the area. Includes maps showing topography, areal geology and artesian water.

Belle Fourche folio, by N. H. Darton and C. C. O'Hara. U. S. Geol. Survey Geol. Atlas (No. 164), 1909.

Describes the geography and geology of the area. Contains a section on water supply and underground water. Discusses the water-bearing formations and deep wells. Includes maps showing topography, areal geology, structure sections, and artesian water. Also a columnar section.

Aberdeen-Redfield folio, by J. E. Todd. U. S. Geol. Survey Geol. Atlas (No. 165), 1909.

Describes the geography and geology of the area. Contains a section on underground waters, wells and artesian flow. Includes topographic, areal geology and artesian water maps. Also a table showing artesian pressures in wells in the area.

Newell folio, by N. H. Darton. U. S. Geol. Survey Geol. Atlas (No. 209), 1919.

Describes the geology and geography of the area. Contains a section on water resources. Includes maps showing topography, areal geology and artesian water.

Central Black Hills folio, by N. H. Darton and Sidney Paige. U. S. Geol. Survey Geol. Atlas (No. 219), 1925.

Describes the geology and geography of the area. Contains a section on water resources. Includes maps showing topography, areal geology, artesian water, and structure sections. Also columnar sections.

#### Other United States Geological Survey Publications

Preliminary report on artesian waters of a portion of the Dakotas, by N. H. Darton, U. S. Geol. Survey 17th ann. rept. (1895-1896) pt. 2, pp. 603-694, pls. 69-107, 1897.

Covers the part of South Dakota lying east of the 101st meridian and the part of North Dakota lying east of the 101st meridian and south of the 47th parallel. Gives an outline of the geologic relations. Describes the water horizons and the extent of the artesian waters, gives detailed information by counties concerning wells and prospects for obtaining wells, discusses the origin, quantity, head, and quality of the artesian waters and their use for developing power, gives data by counties regarding irrigation with artesian water and directions as to the construction and management of artesian wells. Includes maps showing the areas of artesian flow supplied from the Dakota sandstone and from glacial drift, respectively, the height to which the artesian water will rise, the depth to the principal artesian horizon of the Dakota sandstone, and contours of the surface of the bedrock.

New development in well boring and irrigation in eastern South Dakota, by N. H. Darton. U. S. Geol. Survey 18th ann. rept. (1896-1897), Pt. 4, pp. 561-616, pls. 38-47, 1898.

Describes the progress that was made in 1896 in drilling wells and in irrigating with artesian waters in Aurora, Beadle, Bonhomme, Brule, Buffalo, Charles Mix, Davison, Douglas, Hanson, Hutchinson, Jerauld, Sanborn, Spink, and Yankton Counties, and in areas west of the Missouri River. Discusses the temperature, pressure, and flow of the artesian waters, the extent of the artesian basin, and the position of the bedrock. Gives analyses of waters from the Missouri River and from artesian wells in the Sanborn basin. Includes maps showing the rate of increase of temperature in wells with depth, contours of the bedrock surface, and flow of wells.

Preliminary description of the geology and water resources of the southern half of the Black Hills and adjoining regions in South Dakota and Wyoming, by N. H. Darton, U. S. Geol. Survey 21st ann. rept. (1899-1900) Pt. 4, pp. 489-599, pls. 58-112, 1901.

Covers an area comprising about 5,500 square miles in southwestern South Dakota and the adjoining portion of Wyoming. Describes the topography, geology, water horizons, wells, surface waters, irrigation, soil mineral resources, climate, and the timber of the area. Includes maps showing the geology, the depths to the Dakota sandstone, and other ground-water conditions.

Geology and water resources of the northern portion of the Black Hills and adjoining regions in South Dakota and Wyoming, by N. H. Darton. U. S. Geol. Survey Prof. Paper 65, 105 pp., 24 pls., 1909.

Describes the geology of the sedimentary rocks and discusses their mineral resources, including their water supplies. Contains information concerning the timber, climate, and surface waters available for irrigation and stockraising. Includes maps showing the geology, outcrops of and depths to principal water-bearing formations, and areas of artesian flow.

Geology and ground-water hydrology of the Angostura irrigation project, S. Dak., by Robert T. Littleton, with a section on the mineral quality of waters, by Herbert A. Swenson. U. S. Geol. Survey, Circular 54, 96 pp., 2 pls., 12 figs., 1949.

Progress report on the geology and ground-water hydrology of part of the Oahe unit, James River Division, S. Dak., by Gerald A. Waring and W. H. Bush. U. S. Geol. Survey, Missouri Basin Studies, Mimeographed report, 1949.

#### Publications by Other Federal Agencies

Report on the geology and resources of the Black Hills of Dakota, by H. Newton and W. P. Jenney. U. S. Geog. and Geol. Survey Rocky Mtns. (Powell), 560 pp., 1880.

Investigation of ground-water supplies and dam sites in the James and Sheyenne River Basins, N. and S. Dak., by A. N. Sayre, in War Dept. Corps of Engineers, Water Supply and Sewage Disposal 1935, pp. 90-104, 1936.

Prepared for the Federal Emergency Administration of Public Works. Discusses the geology with relation to ground-water supplies and supplies of 15 cities and towns and gives data on 7 dam sites. Describes rural supplies from the Dakota sandstone, Niobrara and Benton formations, and glacial deposits. Contains a record of water levels, logs of wells, and analyses of surface water and ground water.

Report on an investigation of water losses in streams flowing east out of the Black Hills, S. Dak., by C. B. Brown. Sediment Section, Office of Research, Soil Conservation Service. Spec. Rept. 8. 45 pp., 2 maps, 7 figs., Oct. 1944.

Discusses the effect of stream sealing on artesian and ground-water supplies in the area. Includes a columnar section and a cross-section of the east side of the Black Hills.

#### South Dakota Geological Survey Reports of Investigation

Water supplies and geology of Lake Kampeska, S. Dak., by E. P. Rothrock. South Dakota Geol. Survey, Rept. Inv. 17, Dec. 1933.

Discusses the water supply of Lake Kampeska as to source of water and outlet. Contains a discussion of the geology with special reference to glacial drift. Contains an index map showing the location of the lake, a map showing water levels, graphs showing fluctuations of lake level and a geologic map and a map showing contours on top of the clay at the bottom of the Big Sioux spillway.

Water supplies at Fort Thompson, S. Dak., by E. P. Rothrock, South Dakota Geol. Survey Rept. Inv. 18, 9 pp., 4 pls., Feb. 1934.

Discusses the Missouri River and its underflow, deep wells and terrace gravels as sources of water in the area. Contains logs of wells and analyses of water from deep wells. Includes diagram of Ft. Thompson geology and a map of the Missouri Valley at Ft. Thompson.

A shallow water supply for Huron, S. Dak., by E. P. Rothrock, South Dakota Geol. Survey Rept. Inv. 24, 9 pp., 12 pls., Jan. 1935.

Discusses deep well supplies of artesian water and water from chalk formations, glacial supplies and development of water sands. Includes a map showing the location of earth resistance stations, shallow and deep wells and test holes. Contains graphs of resistivity curves and a map showing contours on the bedrock surface.



Geology and water resources of Day County, S. Dak., by E. P. Rothrock, South Dakota Geol. Survey Rept. Inv. 25, 42 pp., 12 pls., Nov. 1935.

Describes the topography and geology of the area. Discusses the water supply of lakes, shallow wells, glacial sands and contact sands, and artesian conditions. Contains a geologic map, geologic sections, and maps showing sand and gravel deposits and moraines. Also maps showing artesian head.

Artesian conditions in west-central South Dakota, by E. P. Rothrock and T. W. Robinson. South Dakota Geol. Survey Rept. Inv. 26, 93 pp. 1936.

Treats of the geology (p. 1-34) and the hydrology (pp. 35-93), with a discussion of the area by counties. Contains a map showing contours on top of the Dakota sandstone and a map showing head of artesian water in the Dakota sandstone. Contains analyses of 17 samples of well water.

Ground-water fluctuations in eastern South Dakota, by E. P. Rothrock and Dorothy Ullery, South Dakota Geol. Survey Rept. Inv. 30, 29 pp., 2 pls., 28 figs., Nov. 1938.

Discusses the fluctuations of ground water level in eastern South Dakota. Periodic measurements were made of 16 wells and the information plotted on hydrographs and recorded in tables (pp. 18-29).

Stratigraphy and structure of the Chamberlain, S. Dak., section of the Missouri River Valley, by M. E. Wing and J. P. Gries. South Dakota State Geol. Survey. Rept. Inv. 39, pp. i-viii Appendix. Apr. 1941.

Well records of the Chamberlain city well and correlation are given. Also includes records of 4 other wells.

A hydrologic study of the White River Valley, by E. P. Rothrock. South Dakota State Geol. Survey. Rept. Inv. 41, 32 pp., 1 map, Feb. 1942.

This report determines the feasibility of pump irrigation in the White River Valley. The depth of the valley fill and amount of water it contains was measured to determine the amount of possible recharge. Describes the geology and porosity and water content of the fill. Includes chemical analyses of the water and mechanical analyses of samples from test holes. Also an index map showing locations of resistivity profiles.

Ground-water resources of the Sioux Falls area, S. Dak.; Part 1, Description, Part 2, tables; Geology by E. P. Rothrock, Hydrology by E. G. Otton. South Dakota Geol. Survey, Rept. Inv. 56, 111 pp., 15 pls., includes index and geologic maps, 9 tables, Mar. 1947.



Discusses the geology and hydrology of the area. The investigations were conducted to determine the total amount of water the ground-water reservoir could retain, the volume of water which could be used from the ground-water reservoir in times of drouth when no recharge is available, the source from which water for recharging the reservoir is derived, the amount which enters under normal conditions and dry conditions, and the maximum perennial supply that can be developed by inducing recharge and making full use of the storage capacity of the ground-water reservoir. Includes geologic maps, water table contour maps, geologic sections, hydrographs, and maps showing well location.

Ground-water fluctuations in eastern South Dakota, by E. E. Caddes. South Dakota Geol. Survey, Rept. Inv. 59, 50 pp., 15 figs., includes maps, Sept. 1947.

#### Publications by Other State Agencies

The geology of Grant County, S. Dak., by E. P. Rothrock. South Dakota State Geol. Survey Bull. 20, 40 pp., June 1934.

Logs of some deep wells in western South Dakota, by E. P. Rothrock. South Dakota State Geol. Survey Bull. 4, 44 pp., 1936.

Preliminary report on the water resources of South Dakota. S. Dak. Water Resources Committee.

- Vol. 1.
1. Big Sioux River Drainage Basin, 87 pp., 1937.
  2. James River Drainage Basin, 71 pp., Feb. 20, 1937.
  3. Bad River Drainage Basin, 33 pp., March 15, 1937.
  4. Sheyenne River Drainage Basin, April 6, 1937.
  5. Moreau River Drainage Basin, April 16, 1937.
  6. Vermillion River Drainage Basin, April 21, 1937.
  7. White River Drainage Basin, May 1, 1937.
  8. Missouri River Drainage Basin, May 15, 1937.
  9. Grand River Drainage Basin, May 15, 1937.
  10. Keya Paha Panco Drainage Basin, May 15, 1937.
  11. Little Missouri Drainage Basin, May 15, 1937.
  12. Minnesota Drainage Basin, May 15, 1937.

## Journal Articles

Notes on the water supply in the Black Hills of South Dakota and vicinity, by E. H. Richards. Massachusetts Inst. Technology: Soc. Arts Techn. Quart., Dec. 1903.

Improvements to the water supply of Winner, S. Dak., by G. T. Prince, Am. Water Works Assoc. Jour. 15, (5), pp. 546-548, May 1926.

New water supply of Sioux Falls, by F. G. Gordon. Water Works and Sewerage. Vol. 76, (12), pp. 525-526, Dec. 1929.

Some observations on thermal springs of the southeastern Black Hills of South Dakota, by P. M. Work. Iowa Acad. of Sci. Proc., Vol. 41, pp. 203-208, 1934.

Briefly discusses the geology, structure, source of water, and source of heat and gives a general description of the springs.

Symposium on fluctuations of ground water: Decline of artesian head in west-central South Dakota, by T. W. Robinson, Am. Geophys. Union Trans. 17, Part 2, pp. 363-366, 1936.

The Dakota sandstone is the principal source of artesian water supply in west-central South Dakota. Since the early developments there has been pronounced decline of the static water level. The greatest decline has taken place along the Missouri River and averaged 15 feet a year at Chamberlain during 1891-1911. There was a decline in head of about 100 feet from 1900-1915. The paper includes a map showing the artesian water head.

Some geological observations on the central part of the Rosebud Indian Reservation, S. Dak., by A. B. Reagen. Am. Geol., Vol. 36, pp. 229-243.

Gives a general description of the Rosebud reservation with brief sections on water, springs and irrigation. Contains sections and a geologic map.

## Miscellaneous Articles

Report on water supply and improvements for Huron, S. Dak., Black and Veatch, Engineers, Kansas City, Kans.

Papers of a General Nature or Relating to the Entire State

## United States Geological Survey Publications

Geology and underground water of South Dakota, by N. H. Darton. U. S. Geol. Survey Water-Supply Paper 227, 156 pp., 15 pls., 1909.

Describes the geology and water horizons of the State, and discusses, by counties, the deep wells and well prospects. Gives note on the construction and management of artesian wells. Includes maps showing the geology and artesian conditions.

Salt-water problems and methods of investigation. U. S. Geol. Survey Mimeographed Rept., May 1941.

Salt-water problems in Iowa and South Dakota, by T. W. Robinson, 2 pp.

## South Dakota Agricultural College Experiment Station Bulletins

The artesian waters of South Dakota, by J. H. Shepard. South Dakota Agr. Coll. Exper. Sta., Bull. 41, 76 pp. (1895).

The shallow artesian wells of South Dakota, by J. H. Shepard. South Dakota Agr. Coll. Exper. Sta., Bull. 49, 24 pp., (1896).

The artesian waters of South Dakota, by J. H. Shepard, South Dakota Agr. Coll. Exper. Sta. Bull. 81, pp. 43-62.

Irrigation in the artesian basin of South Dakota, by A. B. Crane, South Dakota Agr. Coll. Exper. Sta. Bull. 148, pp. 29-44, 1904.

Irrigation in South Dakota, by S. H. Lee. South Dakota Agr. Coll. Exper. Sta. Bull. 210, 60 pp., 1909.

## South Dakota State Planning Board Publications

Water resources of South Dakota. South Dakota State Planning Board. 69 pp., June 1, 1935.

Artesian well control. South Dakota State Planning Board, 26 pp. (Mimeographed). Sept. 16, 1935.

Committee reports and recommendations. South Dakota State Planning Board, pp. 4-5, 28-33, Oct. 1936.

Artesian well flow in South Dakota, South Dakota State Planning Board, 138 pp., illustrations, Jan. 1937.

Artesian well flow in South Dakota, South Dakota State Planning Board, 136 pp., 150 illus., (mimeographed) 1938.

W.P.A. report featuring the waste of artesian water in the State; general geology, yearly increase in number of wells drilled, decline of artesian flow, quality of water and methods of conservation are considered; gives location of wells and percentage of wells which have ceased flowing in each of 44 counties.

Survey of water resources with recommendations for improvement and conservation. Works Progress Administration O.P. No. 465-74-3-257. State serial No. 20381. Records at State W.P.A. Administrator's office or South Dakota State Planning Board.

## Publications by Other State Agencies

The first and second biennial reports on the geology of South Dakota, with accompanying papers, 1893-96, by J. E. Todd. South Dakota Geol. Survey Bull. 2, 130 pp., Vermillion, S. Dak., 1898.

Additional well borings in South Dakota, by C. L. Baker. South Dakota Geol. Survey. Rept. Inv. 61. 40 pp., 2 maps, April 1948.

A supplement to Report of Investigations 57. The report was made from a study of the cuttings of most of the deep wells which have been drilled in recent years, and contains the logs of all the important oil tests and some deep water wells drilled west of the 100th meridian. Includes maps showing location of borings in south-western and eastern South Dakota. Contains well logs and chemical analyses of waters.

Public water supplies of South Dakota, by W. W. Towne. South Dakota Public Health Bulletin, Spec. no. 1932.

Progress report of the South Dakota consultants to the National Resources Board, April 1, 1935. Also reports of June 15, 1935, Dec. 15, 1935, and June 1936.

Artesian well flow in South Dakota. Agr. Resources Comm. Rept. 142 pp., Jan. 1937.

#### Journal Articles

The South Dakota artesian basin, by W. S. Hall. Science 22, pp. 29-30 (1893).

The South Dakota artesian basin, by F. F. D. Coffin. Irrigation Age, Vol. 10 (2), pp. 71-73, 1896.

Geothermal data from deep artesian wells in the Dakotas, by N. H. Darton. Am. Jour. Sci. 4th ser. vol. 5, no. 27, pp. 161-168, Mar. 1898.

Gives data on temperature of the water from 46 wells, a map showing rate of increase of temperature with depth, and a contour map of the bedrock surface.

The geology of the artesian basin in South Dakota, by D. S. McCaslin. Minnesota Acad. of Nat. Sci. Bull. 3, pp. 380-388 (1901).

Artesian wells of South Dakota, by J. E. Todd. Irrigation Age. Vol. 17 (1), pp. 12-15, 1902.

The origin of artesian pressure, by W. L. Russell, Soc. of Econ. Geol., Econ. Geol., vol. 23, pp. 132-155, 1928.

This report is based on data collected by the author for the South Dakota Geol. Survey. It discusses the general stratigraphic and structural relations, the age of the water-bearing sandstones, the origin and theory of artesian pressure and the future of supply of artesian water of the Dakota artesian basin. Includes a map showing the area in South Dakota underlain by hot salty water with gas pressure.

Hard water characteristics of South Dakota supplies, by W. W. Towne, Water Works Eng., Vol. 82, (26), pp. 1827-1831, Dec. 18, 1929.

South Dakota water supplies, by W. W. Towne. Am. Water Works Assoc. Jour. 23, (7) pp. 1041, 1931.

Effect of recent drought on South Dakota public water supplies, by E. G. Fiala. Am. Water Works Assoc. Jour. 27, (2) pp. 145-153, Feb. 1935.

The relation of the drought of 1934 to ground-water supplies in the James and Sheyenne River Basins in North and South Dakota, by A. N. Sayre, Am. Geophys. Union Trans. 17. No. 2, pp. 366-370, July 1936.

The chief sources of ground water in the area are the Dakota sandstone and glacial sand and gravel. The drought had no effect on water supplies from the sandstone and only minor effect in the supplies of large inglacial reservoirs except where excessive water was pumped. The smaller ground-water reservoirs were seriously depleted but have recovered.

## WYOMING

### Papers Relating to Specific Areas Within the State

#### United States Geological Survey Water-Supply Papers

Geology and water resources of the Patrick and Goshen Hole Quadrangles in eastern Wyoming and western Nebraska, by G. I. Adams. U. S. Geol. Survey Water-Supply Paper 70, 50 pp., 1902.

Describes the geology and contains some information on springs and wells in these quadrangles.

Ground water for irrigation in Lodgepole Valley, Wyo. and Nebr., by O. E. Meinzer. U. S. Geol. Survey Water-Supply Paper 425-b, pp. 37-69, 1919.

Describes the physiography and geology of Lodgepole Valley and adjacent region and the water in the alluvial gravel and in the Tertiary and Cretaceous formations; discusses irrigation with ground water; gives well data and analyses of water samples from 20 wells and 2 samples from Lodgepole Creek; contains maps showing the geology and the depths to the water table; also includes data on the cost of pumping for irrigation in western Nebraska, by H. C. Diesem, U. S. Dept. of Agri.

## United States Geological Survey Bulletins

Analyses of waters of the Yellowstone National Park, with an account of the method of analysis employed, by F. A. Gooch and J. E. Whitfield. U. S. Geol. Survey Bull. 47, 84 pp., 1888.

Describes methods used in analyzing natural waters and contains analyses of 43 geyser, spring and surface waters in Yellowstone National Park.

Coal and oil in southern Uinta County, Wyo., by A. C. Veatch. U. S. Geol. Survey Bull. 285-f, pp. 331-353, pls. 10-12, 1906.

Describes the geology of an area that occupies Tps. 12 to 23 N., Rs. 115 to 121 W., inclusive; in Uinta County, Wyo. Contains a geologic map and a brief statement in regard to artesian conditions and prospects (p. 353). This area is covered more fully in Prof. Paper 56.

Geology and mineral resources of the Laramie Basin, Wyo., (a preliminary report), by N. H. Darton and C. E. Siebenthal. U. S. Geol. Survey Bull. 364, 81 pp., 8 pls., 1909.

Describes the geology and contains a geologic map. Includes a section on ground water (pp. 67-78), in which are given well data and 6 water analyses. A part of the area is covered by the Laramie-Sherman folio, U. S. Geol. Survey Geol. Atlas (No. 173), which also contains information on ground water.

The Powder River oil field, Wyo., by C. H. Wegemann. U. S. Geol. Survey Bull. 471-a, pp. 56-75, 1912.

Describes the geology and contains a geologic map of a quadrangular area which includes Tps. 40-42 N., R. 81 W., and portions of adjoining townships. Contains brief notes on water supplies, including water-bearing formations (pp. 58, 59).

Geology and geography of a portion of Lincoln County, Wyo., by A. R. Schultz. U. S. Geol. Survey Bull. 543, 141 pp., 11 pls., 1914.

Describes the geology and contains a geologic map of an area in the central part of Lincoln County, between Green River and the Salt Creek Range (Tps. 22-29 N., Rs. 113-117 W.). Includes a brief discussion of ground water and artesian prospects. (pp. 134, 135).



Oil and gas near Basin, Big Horn County, Wyo., by C. T. Lupton. U. S. Geol. Survey Bull. 621-1, pp. 157-190, pl. 17, 1916.

Describes the geology and contains a geologic map of parts of Tps. 50-52 N., Rs. 92 and 93 W. Includes a brief description of the water supplies and the water-bearing sand with a table giving percentages of oil and gas wells that obtain water in each of these sand strata (pp. 164-166). It also includes well records that contain some data in regard to water (pp. 186-189).

Anticlines in central Wyoming, by C. J. Hares. U. S. Geol. Survey Bull. 641-i, pp. 223-280, pl. 23, 1917.

Covers nearly 5,000 square miles in Natrona and Fremont Counties, west of Casper and southeast of Lander. Contains (pp. 235-236) a brief discussion of the water supply, including statements regarding various hot springs, springs of large size, sulfur springs, and other mineral springs, also a statement regarding water-bearing formations and artesian prospects. Includes a geologic map.

Anticlines in the southern part of the Big Horn Basin, Wyo., a preliminary report on the occurrence of oil, by D. F. Hewett and C. T. Lupton. U. S. Geol. Survey Bull. 656, 192 pp., 32 pls., 1917.

Covers a large region in northwestern Wyoming, west of the Big Horn Mountains. Gives detailed data regarding surface waters, springs, wells and ground-water prospects in the numerous anticlinal areas described in the report. See pages 15, 16, 56-188. Includes a geologic map and section.

The Salt Creek oil field, Wyo., by C. H. Wegemann. U. S. Geol. Survey Bull. 670, 52 pp., 7 pls., 1917.

Describes briefly the water supply of the area (pp. 11, 12), water sands in the Steele shale (pp. 20, 33, 34), and water in the oil sands with analyses of 9 water samples (pp. 42-45). Includes a map showing the structure on top of the Wall Creek and Shannon sands.

Oil in the Warm Springs and Hamilton Dunes, near Thermopolis, Wyo., by A. J. Collier. U. S. Geol. Survey Bull. 711-d, pp. 61-73, pls. 7-10, 1920.

Mentions travertine deposits from hot springs (p. 62). Two wells near Hamilton dune showed no water, oil, or gas (p. 63). Reports hot water in wells on anticline near Thermopolis, in vicinity of hot springs (p. 73). Includes structure-contour maps, structure sections, and graphic well logs.

Gas in the Big Sand draw anticline, Fremont County, Wyo., by A. J. Collier  
U. S. Geol. Survey Bull. 711-e, pp. 75-83, pl. 11, 1919.

Gives log of a well showing brackish water at 200 and 315 feet  
(p. 78). Includes a geologic map and structure section.

Anticlines near Maverick Springs, Fremont County Wyo., by A. J. Collier,  
U. S. Geol. Survey Bull. 711-h, pp. 149-171, pls. 19-21, 1919.

Reports mineral springs on the west side of the Big Dune (p. 163).  
Nearly all deep wells obtain water, which usually flows at the surface:  
there are several water-bearing strata in some wells. In most wells  
the water is mineralized, but in some it is reported to be fresh.  
Describes several wells that yield water. Includes a topographic map  
showing the structure on top of the Park City formation and structure  
sections.

The Mule Creek oil field, Wyo., by E. T. Hancock. U. S. Geol. Survey  
Bull. 716-c, pp. 35-53, pl. 7, 1921.

Log of a well shows water in the Dakota sandstone at 1,160-1,269  
feet (p. 52).

The Lance Creek oil and gas field, Niobrara County, Wyo., by E. T. Hancock,  
U. S. Geol. Survey Bull. 716-e, pp. 91-122, pls. 10-13, 1921.

States that water may be obtained in most of the stream beds of  
the region by shallow drilling, although streams themselves are dry  
most of the year (p. 94). Includes a geologic structure-contour map.

The Osage oil field, Weston County, Wyo., by A. J. Collier. U. S. Geol.  
Survey Bull. 736-d, pp. 77-110, pls. 10-14, 1923.

Mentions several wells drilled for water supply (p. 74). Gives  
numerous references to occurrence of water in wells drilled for oil.  
Contains a paragraph dealing with artesian wells in the Dakota and  
Lakota sandstones (p. 96). Tabulated well records give data on the  
water-bearing sands (pp. 107-110). Includes a structure contour map  
and structure sections.

The Gillette coal field, northeastern Wyoming, by C. E. Dobbins and V. H.  
Barnett, and the Minturn district and the northwestern part of the Gillette  
field, by W. T. Thom. Jr., U. S. Geol. Survey Bull. 796-a, pp. 1-64, pls.  
1-13, 1928.

States that most domestic water supplies of the area are from  
dug or drilled wells and from springs issuing from coal beds. Water  
under artesian pressure is probably obtainable from the Fox Hills  
sandstone or the lower part of the Lance formation (p. 5). Includes  
geologic maps of parts of the area.

Geology and oil and gas possibilities of the Bell Springs district, Carbon County, Wyo., by C. E. Dobbin, H. W. Hoots, and C. H. Dane. U. S. Geol. Survey Bull. 796-d, pp. 171-202, pls. 23-27, 1928.

States that numerous springs occur in the bluffs east of Separation Flats, especially near Bell Springs (pp. 172, 173). Well records mention the occurrence of water in some wells drilled for oil (pp. 193-195). Includes a geologic map showing the structure on top of the Cloverly formation in surrounding area and graphic well logs.

Geology and coal and oil resources of the Hanna and Carbon Basins, Carbon County, Wyo., by C. E. Dobbin, C. F. Bowen, and H. W. Hoots. U. S. Geol. Survey Bull. 804, vi, 88 pp., 27 pls., 1929.

Mentions the presence of water in several wells penetrating the upper part of the Cloverly formation (pp. 85, 86). Includes a geologic map showing outcrops of coal beds, structure sections, columnar sections, and graphic well logs.

The Pumpkin Buttes coal field, Wyo., by C. H. Wegemann, R. W. Howell, and C. E. Dobbin. U. S. Geol. Survey Bull. 806-a, v, 195 pp., 44 pls., 1929.

States that "springs issuing from sandstone and coal beds occur at many places in the field; the largest are the perennial Hot Springs" (p. 3).

Geology of the Rock Creek oil field and adjacent areas, Carbon and Albany Counties, Wyo., by C. E. Dobbin, H. W. Hoots, C. H. Dane, and E. T. Hancock. U. S. Geol. Survey Bull. 806-d, pp. 131-153, pls. 36-43, 1929.

Data on test wells mention water in the Cloverly formation (p. 49) and in the Wall Creek (?) sand (pp. 150-151).

#### United States Geological Survey Professional Papers

The copper deposits of the Encampment district, Wyo., by A. C. Spencer. U. S. Geol. Survey Prof. Paper 25, 107 pp., 1904.

Discusses ground water on pages 44-45. A lower as well as upper limit of the water seems to be present.

Geology of the Bighorn Mountains, by N. H. Darton. U. S. Geol. Survey Prof. Paper 51, 129 pp., 47 pls., 1906.

Describes the geology of the region in detail and contains a brief discussion (pp. 119, 120) of the probable depths and water-bearing conditions of the principal sandstones. Includes a geologic map.

Geology and water resources of the Bighorn Basin, Wyo., by C. A. Fisher. U. S. Geol. Survey Prof. Paper 53, 72 pp., 16 pls., 1907.

Describes the geography, geology, water-bearing formations, irrigation developments, mineral waters and other mineral resources of the basin. Includes a geologic map.

Geology and water resources of the northern portion of the Black Hills and adjoining regions in South Dakota and Wyoming, by N. H. Darton. U. S. Geol. Survey Prof. Paper 65, 105 pp., 1909.

Describes the geology of the sedimentary rocks and discusses their mineral resources; including their water supplies. Contains information concerning the timber, climate and surface waters available for irrigation and stock raising. Includes maps showing the geology, outcrops of and depth to principal water-bearing formations, and areas of artesian flow.

Geology and oil and coal resources of the Oregon Basin, Mectetse, and Grass Creek Basin quadrangles, Wyo., by D. F. Hewett, U. S. Geol. Survey Prof. Paper 145, iv, 107 pp., 32 pls., 1926.

Describes springs and wells in the area (pp. 9, 10) and discusses relations of water to gas and oil (pp. 81, 82).

The significance of geologic conditions in the Naval Petroleum Reserve No. 3, Wyo., by W. T. Thom., Jr. and E. M. Spieker, with a section on the waters of the Salt Creek-Teapot Dome uplift, by Herman Stabler. U. S. Geol. Survey Prof. Paper 163, v, 64 pp., 30 pls., 1931.

Describes the character and distribution of waters in Teapot and Salt Creek oil fields (pp. 21-23). Discusses the quality of the ground waters from the several formations and shows analyses graphically (pp. 39-54).

## United States Geological Survey Atlas Folios

New Castle folio, by N. H. Darton. U. S. Geol. Survey Geol. Atlas (No. 107), 1904.

Discusses the geology, geography, stratigraphy and water supply of the area. Includes maps showing the topography, areal and economic geology, artesian water, and structure sections. Also columnar sections.

Sundance folio, by N. H. Darton. U. S. Geol. Survey Geol. Atlas (No. 127), 1905.

Discusses the geology, geography, and stratigraphy of the area. Includes maps showing topography, areal and economic geology, artesian water, and structure sections. Also columnar sections.

Aladdin folio, by N. H. Darton and C. C. O'Hara. U. S. Geol. Survey Geol. Atlas, (No. 128), 1905.

Discusses the geography, geology, and stratigraphy of the area. Includes maps showing topography, areal geology, artesian water, and structure sections. Also columnar sections.

Bald Mountain - Dayton folio, by N. H. Darton and R. D. Salisbury. U. S. Geol. Survey Geol. Atlas (No. 141), 1906.

Discusses the geology, stratigraphy and water supply of the area. Includes maps showing topography, areal and economic geology, and structure sections. Also columnar sections.

## Publications by Other Federal Agencies

Report upon the reconnaissance of northwestern Wyoming made in the summer of 1873, by W. A. Jones. 43d Congress (1st sess.), H. Ex. Doc. 285, 210 pp., 1874.

Geology of the Wind River District, by O. St. John. U. S. Geol. Survey 12th Ann. Rept. (1878) pt. 1, p. 267, 1883.

Preliminary description of the geology and water resources of the southern half of the Black Hills and adjoining regions in South Dakota and Wyoming, by N. H. Darton. U. S. Geol. Survey 21st Ann. Rept., pt. 4-b, pp. 489-599. (1899-1900)

Covers an area comprising about 5,000 square miles in southwestern South Dakota and the adjoining portion of Wyoming. Describes the topography, geology, water horizons, wells, surface waters, irrigation, soil, mineral resources, climate and timber of the area. Includes maps showing the geology, the depths to the Dakota sandstone, and other ground-water conditions.

Geology of the Yellowstone National Park, pt. I. General Geology; (unpublished), pt. II. Descriptive Geology, by A. Hague, J. P. Iddings, W. H. Weed, C. D. Wolcott, G. H. Girty, T. W. Stanton, and F. H. Knowlton. U. S. Geol. Survey Mon. 32, 893 pp., 1899.

Investigations in northern Wyoming, by J. Ahern. 2d Ann. Rept. Recl. Bur. (1902-1903), pp. 515-528, (1904).

The geology of the Owl Creek Mountains, Wyo., by N. H. Darton. 59th Congress (1st sess.) S. Ex. Doc. 219, p. 39, 1906.

Report on irrigation by recovery of ground water in the Egbert-Pine Bluffs area, Wyo., by H. P. Burleigh and E. C. Gwillim. Bur. Agr. Econ. Div. Land Econ., Apr. 14, 1938.

Preliminary report, ground-water hydrology of the Owl Creek irrigation project, Hot Springs County, Wyo., by R. T. Littleton, with a section on the quality of ground water, by H. A. Swenson. Manuscript release, 62 pp., 2 pls., 4 figs., Aug. 1947.

Discusses the geology and ground water of the area in detail. Contains a section on quality of water, a table of well records and a table of water-level measurements. Includes a map showing the geology and well locations, hydrographs, precipitation records and a chart showing the mineral constituents present in the ground water.

#### Publications by State Agencies

Seepage investigations in the valley of the Laramie River, by B. P. Fleming. Wyoming Exper. Sta. Bull. 61, 32 pp., 3 figs, 1905.

Irrigation work on the North Platte River, by B. P. Fleming. Wyoming Exper. Sta. Bull. 66, 24 pp. (1905).

Progress report on experiments in supplemental irrigation with small water supplies at Cheyenne and New Castle, Wyo. Bur. Agr. Econ., Office Exper. Sta. Circ. 92, 1910.



Underground water resources of Chugwater Creek, Laramie River and North Laramie River Valleys, Wyo., by A. R. Edwards. Wyoming Geol. Survey Bull. 32, 32 pp. 3 pls., 3 figs., Nov. 1941.

This report discusses the ground-water resources of an area of 1,050 square miles in the southern half of Platte County and the extreme northwestern part of Laramie County, southeastern Wyoming. Describes the topography and drainage, structure, stratigraphy, precipitation, surface and ground water, the occurrence and quality of the ground water, artesian conditions and ground water recharge from streams and irrigation. Includes 3 maps showing hydrography, geology and depth to water table. Includes a table of well data.

### Journal Articles

The hot springs at Thermopolis, Wyo., by N. H. Darton. Jour. Geology, vol. 14, no. 3, pp. 194-200, April-May 1906.

Several large hot springs issue from the "red beds" of the Chugwater formation on the crest of a small anticline. The total discharge is more than 1,000 gallons a minute and the maximum temperature 135° F. The analyses given show total dissolved solids of 129.82 grains per gallon. Describes the extensive hot-spring deposits and discusses the source of the water. Heat may be due to the depth from which the water rises, or it may be due to deep-seated igneous rocks in the vicinity, which have not yet cooled.

Temperatures in some springs and geysers in Yellowstone National Park, by C. E. Van Ostrand. Jour. Geology, vol 32, no. 3, pp. 194-225, 5 figs. April-May 1924.

Presents evidence concerning temperatures of hot spring, taken from temperature tests of 154 flowing wells, 8 mines and 49 non-flowing wells, located chiefly in lava-bearing areas. The behavior of the springs and geysers are explained on the basis of convection currents and artesian flow of water.

Water analyses in oil production and some analyses from Poison Spider, Wyo., by E. M. Parks. Am. Assoc. Petrol. Geol. Bull., vol. 9, no. 6, pp. 927-946, 3 figs., Sept. 1925.

Discusses the use of water analyses in determining the source of oil-field waters. Contains the results of 19 water analyses which show that waters can be distinguished by analyses. The geochemical relations between oil and water are briefly reviewed.

Analyses of waters of the Salt Creek field applied to underground problems, by J. S. Ross and E. A. Swedenborg. Am. Inst. Min. Met. Eng. Tech. Pub. no. 157, 17 pp., 3 figs., Dec. 1928.

Geology of the Alcova Dam and Reservoir Site, North Platte River, Natrona County, Wyo., by W. H. Bradley. Econ. Geology vol. 30 (2), pp. 147-169, Mar.-Apr. 1935.

Discusses the significance of artesian flow and the effect of the dam on increasing the artesian pressure and flow. Contains a section on hot spring waters and their solution effect on the different formations. Includes a geologic map, a table showing the exposed formations and cross-sections.

Water storage problem is solved by City of Cheyenne, Wyo., by Z. E. Levison. Western Const. News vol. 2, (6) pp. 173-175, June 1936.

#### Papers of a General Nature or Relating to the Entire State

#### United States Geological Survey Publications

Notes on some artesian borings along the line of the Union Pacific Railroad in Wyoming Territory, by F. W. Hayden. U. S. Geol. Survey Terr. Bull. 3, pp. 181-185 (1877).

Sodium sulphate, its sources and uses, by R. C. Wells. U. S. Geol. Survey Bull. 717, iv, 43 pp., 1923.

Notes fresh-water springs occurring near sodium sulfate deposits in Wyoming (p. 29).

Water levels and artesian pressure in observation wells in the U. S. in 1942. Part 5, Northwestern States, by O. E. Meinzer, L. K. Wenzel, and others. U. S. Geol. Survey Water-Supply Paper 948, iv, 194 pp., 1944.

#### Publications by Other Federal Agencies

Tabulation of wells reported in Wyoming; location, elevation, depth, cost, pressure, and variations in flow. 51st Congress (1st sess.) S. Ex. Doc. 222. pp. 339, 359, 376 and 382, 1890.

A report on irrigation and the cultivation of the soil thereby, with physical data, conditions, and progress within the U. S. for 1891, by R. J. Hinton, pp. 276-287, 52d Congress. (1st sess.) S. Ex. Doc. 41, Part 1, 1892.

Irrigation in Wyoming, by C. T. Johnston. Bur. Agr. Econ., Office Exper. Sta. Bull. 205, 60 pp., 1909.

#### Publications by State Agencies

The artesian wells of southern Wyoming, their history and relation to irrigation, by J. D. Conley. Univ. Wyoming Agr. Exper. Sta. Bull. 20, 1894.

A preliminary report on the artesian basins of Wyoming, by W. C. Knight. Wyoming Univ. Exper. Sta. Bull. 45, pp. 107-251, illustrations, map (1900).

The mineral hot springs of Wyoming, by A. B. Bartlett. Wyoming Geologist's office Bull. no. 16, 15 pp., 5 figs., May 6, 1926.

Discusses some of the larger mineral springs of Wyoming, including chemical analyses of the waters. Notes that springs come to the surface through outcrops of the Chugwater formation of Triassic Age.

Cooperative ground-water investigations in Wyoming, by F. C. Foley, T. W. Robinson, A. M. Morgan, and J. B. Graham. Wyoming State Engineer. 26th Bienn. Rept. 1941-1942, Cheyenne, Wyo., pp. 41-49, 1942.

A preliminary report on investigations in the Egbert-Pine Bluffs area, the Cheyenne area, and the Laramie area. Each investigation includes a study of the geology, the recharge and discharge of ground water and the gradient and direction of its flow, estimates of the quantity of ground water in storage, the limits of safe development of areas that are yielding water to wells, and a discussion of areas favorable for new production of ground water.

Cooperating ground-water investigations in Wyoming, by A. M. Morgan. Wyoming State Engineer's, 27th Bienn. Rept. 1943-44, Cheyenne, Wyo., pp. 43-49, Oct. 1944.

Contains brief description of the principal aquifers and data on ground-water levels in the Egbert-Pine Bluff area, Carpenter area, Cheyenne area, and Laramie area.

Cooperative ground-water investigations in Wyoming, by D. A. Warner. Wyoming State Engineer's 28th Bienn. Rept., 1945-46, pp. 103-110 (1946?).

### Journal Articles

Analyses of Wyoming oil field waters, by E. L. Estabrook. Am. Assoc. Petrol. Geol. vol. 9, no. 2, pp. 235-246, 3 figs., Mar. - Apr. 1925.

Discusses the different characters of water in association with oil and gas. Discusses the change in constituents of the waters according to circulation and association with and through oil strata.

A remarkable intermittent spring (Wyoming) by N. D. Stearns. Mid-Pacific Mag., vol. 45, no. 3, pp. 217-218, Mar. 1933.

Hydrothermal activity in Yellowstone and other parts of Wyoming, by A. H. Kemp, (abstract): Texas Acad. Sci. Trans. and Proc. 1934-35, vol. 19, p. 30, 1936.

Oil field waters of Wyoming and their relations to geologic formations, by J. G. Crawford. Am. Assoc. Petrol. Geol. vol. 24, no. 7, pp. 1214-1329, July 1940.

Tabular and graphic analyses of water from oil and gas-producing zones of Wyoming are presented and discussed. Contains graphic well logs and results of chemical analyses.

Ground-water control through legislation, by N. B. Bennett, Jr., discussion by F. C. Foley. Wyoming Eng. Soc. 23d Ann. Conv. Proc., Cheyenne, Wyo., pp. 28-31, Jan. 23-24, 1942.

United States Geological Survey Water-Supply Papers

Irrigation practice on the Great Plains, by E. B. Cowgill. U. S. Geol. Survey Water-Supply Paper 5, 39 pp., 12 pls., 1897.

Contains directions for constructing reservoirs for pumped well water (pp. 14-19).

Preliminary list of deep borings in the U. S., pt. I (Ala. - Mont.), by N. H. Darton, U. S. Geol. Survey Water-Supply Paper 57, 1902.

Contains data on wells 400 feet in depth or more. References to logs or records of the wells, or extended descriptions of them, are given in footnotes, and after the list of wells in each State there is an additional list of principal publications relating to deep borings in that State. This paper covers Colorado, Iowa, Kansas, and Montana.

Preliminary list of deep borings in the United States, pt. 2 (Nebr. - Wyo.), by N. H. Darton. U. S. Geol. Survey Water-Supply Paper 61, pp. 66-67, 1902.

Contains tabular data in regard to wells and other borings more than 400 feet deep. Gives information as to the depths, diameter, and yields of the wells, the head, temperature and quality of the water, and purposes for which the boring was done. Covers Nebraska, North and South Dakota and Wyoming.

Western hydrology, by N. H. Darton, U. S. Geol. Survey Water-Supply Paper 93, pp. 117-120, 1904.

Contains a discussion of the work of the division of hydrology in the western section.

Preliminary list of deep borings in the U. S. (2nd edition with additions) by N. H. Darton, U. S. Geol. Survey Water-Supply Paper 149, 175 pp., 1905.

Gives location, depth, diameter, yield, water level, and other available information concerning wells 400 feet or more in depth; includes all wells in Water-Supply Papers 57 and 61, contains some data in regard to every State in the U. S. arranged alphabetically by States and counties. Mentions principal publications relating to deep borings.

Underground-water papers, 1910, by M. L. Fuller, F. G. Clapp, G. C. Matson, Samuel Sanford and H. C. Wolff. U. S. Geol. Survey Water-Supply Paper 258, 123 pp., 2 pls., 1911.

This report discusses a number of peculiarities affecting the economic values of wells and the occurrence of water in certain special classes of rocks of widespread occurrence. Contains the scientific results of general investigations of the occurrence, availability, quality and other features of water found over extensive areas.

Water analyses from the laboratory of the U. S. Geol. Survey, tabulated by F. W. Clarke. U. S. Geol. Survey Water-Supply Paper 364, 40 pp. 1914.

Contains 203 miscellaneous analyses of waters from rivers, lakes, wells, springs, and mines, which were made at various times in the chemical laboratory of the U. S. Geol. Survey. It contains analyses of the water from the following States: Colorado, Iowa, Missouri, Montana and Wyoming.

Chemical character of ground waters of the Northern Great Plains, by H. B. Riffenburg. U. S. Geol. Survey Water-Supply Paper 560-b., pp. 31-52, 1925.

Describes the general geology of the region; the general character of the ground water; the changes that take place through base exchange, absorption of base and acid, and reduction of sulfate. Discusses the character of water from the several geologic formations of the region and gives typical analyses of water from the principal formations.

Large springs in the U. S., by O. E. Meinzer. U. S. Geol. Survey Water-Supply Paper 557, 1927.

Discusses the distribution and character of large springs and gives a proposed classification with respect to size. Describes in detail the large springs from each part of the U. S. as to origin, size, fluctuations of discharge, relation to rock structure, and character of the water. Includes maps of several areas showing the relation of springs to geologic structure.

Water levels and artesian pressure in observation wells in the U. S. in 1935, by O. E. Meinzer and L. K. Wenzel. U. S. Geol. Survey Water-Supply Paper 777, 1936.

A group of papers prepared by members of the U. S. Geological Survey. This is the first of a series of annual reports on the fluctuation of the ground-water levels and artesian pressure in the U. S.



Thermal springs in the U. S., by N. D. Stearns, H. T. Stearns, and G. A. Waring. U. S. Geol. Survey Water-Supply Paper 679-b, pp. i-iv, 59-206, pls. 7-16, 1937.

Discusses the geologic problems relating to thermal springs, and their occurrence by physiographic divisions. Includes annotated bibliography and tabulated lists by States of 1,059 spring localities. Contains State index maps showing location of the thermal springs and a map of the U. S. showing their distribution.

Water levels and artesian pressures in observation wells in the U. S. in 1936, by O. E. Meinzer and L. K. Wenzel. U. S. Geol. Survey Water-Supply Paper 817, 1937.

Includes nearly all the periodic measurements by the U. S. Geological Survey and cooperating agencies in Nebraska and in eight areas of the Soil Conservation Service and complete records for selected wells in other states.

Water levels and artesian pressure in observation wells in the U. S. by O. E. Meinzer and L. K. Wenzel. U. S. Geol. Survey Water-Supply Paper 840, 1937.

Water level in the middle part of the U. S. generally showed a decline. Annual changes in water level correspond in general to departures from normal annual precipitation.

Iowa and Missouri, Tarkio Creek area, by V. C. Fishel, G. A. LaRocque, and G. N. Mesnier.

Nebraska, by L. K. Wenzel.

North Dakota, by L. K. Wenzel and F. W. Voedisch.

South Dakota, City of Huron, by A. N. Sayre.

Water levels and artesian pressure in observation wells in the U. S. in 1936, prepared under the direction of O. E. Meinzer and L. K. Wenzel. U. S. Geol. Survey Water-Supply Paper 845, iv, 724 pp., 1939.

Contains information on measurements in observation wells in the following states: Iowa, Missouri, Kansas, Montana, Nebraska, North Dakota and South Dakota.

Water levels and artesian pressure in observation wells in the U. S. in 1939, by O. E. Meinzer, L. K. Wenzel and others. U. S. Geol. Survey Water-Supply Paper 886, v, 933 pp., 1940 (1941).

Contains information on measurements in observation wells in the following states: Iowa, Missouri, Kansas, Montana, Nebraska, North Dakota and South Dakota.

Water supply of the Dakota sandstone, by L. K. Wenzel and H. H. Sand.  
U. S. Geol. Survey Water-Supply Paper 889-a, pp. i-iv, 1-81, pls. 1-3, 1942.

Describes the development of flowing artesian wells in the area and the decline in head caused by the great draft on the supply. This decline has been partly controlled since 1921 by legislation restricting the flow of wells to beneficial use.

Water levels and artesian pressure in observation wells in the U. S. in 1940, part 3. North-central States, by O. E. Meinzer, L. K. Wenzel and others.  
U. S. Geol. Survey Water-Supply Paper 908, iv, 288 pp., 1942.

Covers the states of North Dakota, South Dakota, Nebraska, Kansas, Iowa and Missouri.

Water levels and artesian pressure in observation wells in the U. S. in 1941, part 3, North-central States, by O. E. Meinzer, L. K. Wenzel and others.  
U. S. Geol. Survey Water-Supply Paper 938, iv, 232 pp., 1943.

Covers the states of North Dakota, South Dakota, Nebraska, Kansas, Iowa, and Missouri.

Water levels and artesian pressure in observation wells in the U. S. in 1942, part 3, North-central States, by O. E. Meinzer, L. K. Wenzel and others.  
U. S. Geol. Survey Water-Supply Paper 946, v, 278 pp., 1944.

Covers the states of Iowa, Kansas, Missouri, Nebraska, North Dakota and South Dakota.

Water levels and artesian pressure in observation wells in the U. S. in 1943, part 3. North-central States, by O. E. Meinzer, L. K. Wenzel and others.  
U. S. Geol. Survey Water-Supply Paper 988, iv, 352 pp., 1946.

Covers the states of Iowa, Kansas, Missouri, North Dakota, Nebraska, and South Dakota.

Water levels and artesian pressure in observation wells in the U. S. in 1943, by O. E. Meinzer and L. K. Wenzel. U. S. Geol. Survey Water-Supply Paper 990, 1946.

Covers the states of Colorado, Montana and Wyoming.

Water levels and artesian pressure in observation wells in the United States in 1944, by A. N. Sayre and others. U. S. Geol. Survey Water-Supply Paper 1018, 1947.

Covers states of Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota.

Water levels and artesian pressure in observation wells in the United States in 1945, prepared under the direction of C. G. Paulsen. U. S. Geol. Survey Water-Supply Paper 1025, 1948.

Covers the states of Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota and South Dakota.

Water levels and artesian pressure in observation wells in the United States in 1945, prepared under the direction of C. G. Paulsen. U. S. Geol. Survey Water-Supply Paper 1029, 1948.

Covers states of Colorado, Idaho, and Wyoming.

Water levels and artesian pressure in observation wells in the United States in 1946, prepared under the direction of C. G. Paulsen. U. S. Geol. Survey Water-Supply Paper 1073, 1949.

Covers states of Iowa, Kansas, Minnesota, Missouri, Nebraska, and North Dakota.

#### United States Geological Survey Bulletins

Lists and analyses of the mineral springs of the U. S. (a preliminary study) by A. C. Peale. U. S. Geol. Survey Bull. 32, 1886.

Contains a list of mineral springs in Colorado, Iowa, Kansas, Missouri, Montana, Nebraska, North Dakota, South Dakota, and Wyoming with chemical analyses.

Report of progress of the division of hydrography for the calendar years 1893 and 1894, by F. W. Newell. U. S. Geol. Survey Bull. 131, 126 pp., 1895.

Contains records of wells collected by Robert Hay in Nebraska, Colorado and Kansas (pp. 92-126). Gives a general description of wells, depth of well and depth of water.

Lignites of the Middle and Upper Missouri River Valley, by E. F. Burchard. U. S. Geol. Survey Bull. 225, pp. 276-288, 1903.

Discusses the occurrence of lignite in northeastern Nebraska, South Dakota, and North Dakota. Mentions briefly water in connection with the sinking of mine shafts.

Record of deep well drilling for 1904, by M. L. Fuller, E. F. Lines, and A. C. Veatch. U. S. Geol. Survey Bull. 264, 106 pp., 1905.

Discusses the importance of accurate well records to drillers, to owners of oil, gas and water wells, and to geologists. Describes methods of work. Gives tabulated records of wells in 39 States and Territories, and detailed records of wells in Colorado, Iowa, Kansas, and Missouri.

Record of deep well drilling for 1905, by M. L. Fuller and S. Sanford. U. S. Geol. Survey Bull. 298, 299 pp., 1906.

Gives an account of progress in the collection of well records and samples. Contains tabulated records of wells in 48 states and territories, and detailed records of wells in Colorado, Iowa, Kansas, Minnesota, Missouri, Montana, and South Dakota.

Geology of the Standing Rock and Cheyenne River Indian Reservations, North and South Dakota, by W. R. Calvert, A. L. Beekly, V. H. Barnett, and M. A. Pishel. U. S. Geol. Survey Bull. 575, 49 pp., 8 pls., 1914.

Covers an area lying west of the Missouri River, north of the Cheyenne River and south of the Cannonball River and extending westward to the 102d meridian. Describes the geology and contains a geologic map of the area. Includes a brief discussion of the water in the Dakota and Fox Hills sandstones and in other formations (pp. 24-25).

The enrichment of ore deposits, by W. H. Emmons, U. S. Geol. Survey Bull. 625, 530 pp., 7 pls., 1917.

This paper is a revision of Bulletin 529 with a somewhat enlarged scope.

The structure of parts of the Central Great Plains, by N. H. Darton. U. S. Geol. Survey Bull. 691-a, pp. 1-26, 1918.

Contains a number of well records, most of which show the occurrence of water, including deep borings in Colorado, Kansas, Nebraska, South Dakota, and Wyoming. Includes a preliminary map of the central Great Plains showing the structure of the Dakota sandstone, several structure maps of small areas, and a number of well sections and generalized structure areas.

Salt resources of the U. S., by W. C. Phalen, U. S. Geol. Survey Bull. 669, 284 pp., 17 pls., 1919.

Discusses the geology and occurrence of salt deposits in the United States, by States. Contains numerous logs of test wells and other wells drilled into salt-bearing formations. Includes several geologic maps.

The data of geochemistry (fifth edition) by F. W. Clarke. U. S. Geol. Survey Bull. 770, 841 pp., 1924.

Earlier editions were published as Bulletins 330, 491, 616, and 695. Gives estimates of the total quantity of underground water in the earth's crust (p. 35). Contains a discussion of the statement and interpretation of water analyses (pp. 64-68) and a short discussion of springs (pp. 68-69). A chapter on mineral wells and springs (pp. 181-217), the definition and classification of mineral waters (including typical analyses), changes in composition of water and reactions with adjacent material, chemical deposits from water, vadose and juvenile waters, and the relation of thermal springs to volcanism.

#### United States Geological Survey Annual Reports

Preliminary report of the geological survey of Montana and portions of adjacent territories, by F. V. Hayden, U. S. Geol. Survey, 5th Ann. Rept. 538 pp., maps, 1872.

Explorations in Colorado, Utah, and Wyoming, by A. C. Peale. U. S. Geol. Survey 6th Ann. Rept. (1872) pt. 1, (Geysers: pp. 138-140, 144-158). 1873.

Thermal springs: pp. 121-125, 128-130, 135-143, 176-178.

Report on the Snake River Division by F. H. Bradley (Geysers: pp. 234-242, 244-247).

Artesian irrigation on the Great Plains. U. S. Geol. Survey 11th Ann. Rept. (1889-1890) Pt. 2, pp. 260-278, 1891.

Limitations imposed by quantity, head, and cost are discussed concerning artesian irrigation. Irrigation by means of artesian wells in various counties is described. Records are given of wells in Kansas, Minnesota, Montana, Nebraska, and North and South Dakota.

Natural mineral waters of the United States, by A. C. Peale. U. S. Geol. Survey 14th Ann. Rept. (1892-1893) Pt. 2, pp. 49-88, pls. 3-4, 1894.

Discusses the history, origin, flow, classification, and geographic distribution of mineral and thermal springs, the chemical composition and analyses of spring waters, and the utilization of mineral waters. Gives a list of American mineral spring resorts.

The public lands and their water supply, by F. H. Newell. U. S. Geol. Survey 16th Ann. Rept., pt. 2 (e), pp. 457-533, pls., 1895.

Describes the public lands and the streams, wells, and reservoirs as sources of water supply; contains a brief but comprehensive and farsighted discussion of the ground-water resources of the West (pp. 499-502); includes brief notes on ground water in Colorado, Kansas, Nebraska, and North and South Dakota.

Water resources of a portion of the Great Plains, by R. Hay. U. S. Geol. Survey 16th Ann. Rept. (1894-95), pt. 2, (f) pp. 535-588, 1896.

Describes an indefinite area that lies on both sides of the east boundary of Colorado and extends from the vicinity of Smoky Hill River northward to the North Platte, thus comprising parts of Colorado, Nebraska, and Kansas. Discusses the lakes, streams and springs of the area, the underflow of the river bottoms, and the water-bearing strata beneath the higher lands, the source, quantity and rate of percolation of ground water, the wells in the valleys and on the upland, the unsuccessful wells, artesian conditions, "blowing" wells and the temperatures of the well waters. Describes briefly the topography and geology of the region and utilization of the water supply.



The High Plains and their utilization, by W. D. Johnson. U. S. Geol. Survey 21st Ann. Rept. (1899-1900) pt. 4 (c), pp. 601-741, pls. 113-156, 1901.

Describes the area lying in an irregular belt about midway across the long eastward slope of the Great Plains and including parts of Wyoming, Nebraska, Colorado and Kansas. Gives a comprehensive description of the physiographic features and Tertiary deposits of the region and a critical discussion of their interpretation. Discusses precipitation, climate, and the use of streams and storm waters for irrigation. Describes the artesian conditions, with special reference to the Meade artesian basin, and explains the principles of artesian and other ground waters. Concluded in the 22d Ann. Rept. part 4.

The High Plains and their utilization, (concluded) by W. D. Johnson. U. S. Geol. Survey 22d Annual Report (1900-1901), IV c. pp. 631-669, 1902.

This is the concluding part of the paper on the High Plains and their utilization begun in the 21st Annual Report, part 4. It discusses the occurrence of water, consolidated and unconsolidated formations, the origin and level of the ground water of the High Plains, the utilization of ground water for stock raising and irrigation, and methods of constructing wells.

#### Other United States Geological Survey Publications

Preliminary report on the geology and underground water resources of the central Great Plains, by N. H. Darton, U. S. Geol. Survey Prof. Paper 32, 433 pp., 1905.

Covers South Dakota, Nebraska, central and western Kansas, eastern Colorado and eastern Wyoming. Describes the geography, geology, and water horizons; gives deep-well data and well prospects by counties; also describes other mineral resources. Includes maps showing the geology, location of deep wells, structure of the Dakota sandstone, depths to this sandstone, head of artesian water, and areas of artesian flow.

Aladdin folio, (Wyo., S. Dak., Mont.) by N. H. Darton and C. C. O'Hara. U. S. Geol. Survey Geol. Atlas (no. 128), 1905.

Discusses the geography, geology and stratigraphy of the area, Includes maps showing topography, areal geology, artesian water, and structure sections. Also columnar sections.

Elk Point folio, (S. Dak., Nebr., Ia.) by J. E. Todd. U. S. Geol. Survey Geol. Atlas (no. 156), 1908.

Discusses the topography, geology, geography and stratigraphy of the area. Includes maps showing topography, areal geology, and artesian water.

Soft water in the Dakota sandstone, by O. E. Meinzer. U. S. Geol. Survey Mimeographed Rept., 3 pp., May 25, 1929.

Gives data on the quality of water from the Dakota sandstone, in different wells. See also Water-Supply Paper 597-c.

#### Publications by Other Federal Agencies

Artesian wells upon the Great Plains, by C. A. White, S. Aughey, and Horace Beach. Dept. Agr. Misc. Pub., 37 pp., 1882.

Irrigation in the U. S., by R. J. Hinton. U. S. 49th Congress (2d sess.) S. Misc. Doc. 15, pp. 46, 108-109, 1887.

A report on the preliminary investigations to determine the proper location of artesian wells within the area of the 97th meridian of longitude and east of the foothills of the Rocky Mountains. U. S. 51st Congress (1st sess.) S. Ex. Doc. 222, 1890.

Irrigation in the U. S. Progress report for 1890, by R. J. Hinton. U. S. 51st Congress (2d Sess.) S. Ex. Doc. 53, pt. 1, pp. 36-38, 1891.

A report on irrigation and cultivation of the soil thereby with physical data, conditions and progress within the U. S. for 1891, by R. J. Hinton. U. S. 52d Congress (1st sess.) S. Ex. Doc. 41, pt. 1, 1892.

Artesian and underflow investigation Final report of the Chief Engineer, E. S. Nettleton. Underground water surveys. U. S. 52d Congress (1st sess.) S. Ex. Doc. 41, pt. 2, pp. 19-29, 1892.

Final geological reports of the artesian and underflow investigations between the 97th meridian and the foothills of the Rocky Mountains.

Underflow and sheet waters, irrigable lands and geologic structure of Nebraska with its effect upon water supply, by L. E. Hicks, pp. 167-190. 52d Congress (1st sess.) S. Ex. Doc. 41, pt. 3, 1894.

The underwaters of the Great Plains, by J. W. Gregory, Final report of the Mid Plains Division of the artesian and underflow investigation between the 97th meridian and the foothills of the Rocky Mountains, pp. 5-55. 52d Congress (1st sess.) S. Ex. Doc. 41, pt. 4, 1894.

Peview of irrigation work for the year 1904. R. P. Teale. U. S. Dept. of Agric. Bur. Chem. and Soils, Bull. 158, 1905.

Pumping plants in Colorado, Nebraska, and Kansas, by O. V. P. Stout. U. S. Dept. of Agric. Bur of Chem. and Soils, Bull. 158, 1905.

Possibilities of shelterbelt planning in the Plains Region; Section 14, Ground-water conditions of the shelterbelt zone, by G. A. Condra. U. S. Dept. of Agr., Forest Service, pp. 175-196, 1935.

Status of information on ground waters in North Dakota, South Dakota, and Minnesota, by E. P. Rothrock and others. Nat. Resources Planning Board, Report of Subcommittee on underground waters, Omaha, Nebraska, 69 pp., 9 pls., 1940.

Geological, geographical, physical and water resources Survey of Missouri River Main Stem. Works Progress Administration. O. P. No. 465-73-3-160. State Ser. No. 20329. Records at State W. P. A. Administrator's office or North Dakota State Planning Board.

Geographical Report: Population, Industries, Communications, Irrigation and Artesian Wells. Mon. 1, War Dept. pp. 172-210.

#### Journal Articles

Underground waters of the Arid Region, by R. T. Hill. Eng. Mag. pp. 653-660, Aug. 1892.

Underground waters of the Arid Region, by R. T. Hill. Eclectic Mag. New Ser. vol. 5. pp. 653-660, Aug. 1892.

Artesian water in the Arid Region, by R. T. Hill, Pop. Sci. Monthly, vol. 42, pp. 599-611, 1893.

Pump irrigation on the Great Plains, by H. V. Hinckley, Eclectic Mag., April 1896.

The hydraulic gradient of the main artesian basin of the northwest (abstract), by J. E. Todd. Am. Geol. 18, pp. 219-220 (1896). Sci., new ser. 4, p. 385 (1896).

Contains a brief statement on the comparison between the decrease in artesian pressure and hydraulic gradient of streams. It was suggested that actual irregularities of the pressure gradient may result from a complex arrangement of the water-bearing stratum.

Pump irrigation in the west, by H. Morrison. Yale Univ. Sci. Monthly, Feb. 1898.

Artesian irrigation. Sci. Am., vol. 79, p. 58, July 23, 1898.

Some problems of the Dakota artesian system, by J. E. Todd. Sci., new ser. 14, p. 794, 1901.

A few remarkable artesian wells and the uses to which they are put, by E. H. Barbour. Sci. Am., July 13, 1901.

A study of the deep wells in the southern part of the Great Plains Region, by C. A. Long. Univ. of Oklahoma, thesis, 57 pp., 1905.

Artesian water supply of the Dakota sandstone, by O. E. Meinzer, Pan-Am. Geol. vol. 43 (5), June 1925.

Abstract of a paper presented at the annual meeting of the American Association for the Advancement of Science, December 1924. The Dakota sandstone forms the most remarkable artesian basin in the U. S. with respect to its great extent, the long distance through which the water must percolate from the outcrops of the formation, and especially the tremendous pressure under which the water in the sandstone was originally held by its thick and continuous cover of impermeable shales. The decline in pressure and flow, after the drilling of more than 16,000 wells has been great. See also Water-Supply Paper 520-e.

Problem of soft water in the Dakota sandstone, by O. E. Meinzer. *Howell Driller's News*, Minneapolis, Minn., vol. 8, no. 8, pp. 1-3, Aug. 1929, no. 9, pp. 1, 3, 5, and 8, Sept. 1929, no. 10, pp. 1, 6, 7-9, Oct. 1929.

Describes the extent and water-bearing characteristics of the Dakota sandstone. In general the upper strata contain soft water and the lower strata contain hard water. Soft water is obtained near Canton, S. Dak., in wells 300 to 500 feet deep sunk to upper strata of the sandstone. The water rises under artesian pressure 200 feet or more above the depth at which it is struck. The city of Canton obtains its supply of 150,000 gallons a day from several wells in the sandstone. Discusses the chemical character of the water and also the physical character of the water-bearing sandstone, which is fine-grained and has slight coherence.

Soft water in the Dakota sandstone. *Municipal News and Water Works*, vol. 76, p. 222, June 1929.

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