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GROUND WATER SUPPLY AT MOSCOW, IDAHO

by

F. B. Laney, V. R. D. Kirkham and A. M. Piper

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The original publication was no longer of reproducible quality. Geologic and English usage appear as in the original. Only minor typographical errors have been corrected.

January 3, 1924

Transmittal

To the Committee on Water Supply
for the City of Moscow

Gentlemen:

I transmit herewith report by our geologists on the artesian water resources available to the City of Moscow. This presents, in my judgement, a careful, conservative and exhaustive survey of the situation, and the committee is deeply indebted to the gentlemen who have prepared and especially to Mr. Piper who has labored most diligently in the collection of necessary data and in the preparation of the report and the accompanying maps.

The report indicates that there exists at Moscow a sufficient artesian supply to take care of the needs of the City of Moscow for many years and that by proper means this can be made available for municipal use at reasonable cost; also that the apparently alarming decrease in the pumpage from the municipal wells is found to be due to easily explainable causes and to have but little bearing on the ultimate supply. In these conclusions I concur fully.

I trust that you will find time to study the report thoroughly and to examine its data and conclusions carefully.

Faithfully yours,

Francis A. Thomson
Dean, School of Mines and Secretary,
Idaho Bureau of Mines and Geology

T:S

STATE OF IDAHO
Chas. C. Moore, Governor

BUREAU OF MINES AND GEOLOGY
Francis A. Thomson, Secretary

Ground Water Supply at Moscow, Idaho.

by

F. B. Laney, V. R. D. Kirkham and A. M. Piper

Introduction

This report presents the results of a study of the ground water conditions at Moscow, Idaho, made at the request of the City Council and the Chamber of Commerce to determine the feasibility of increasing the public water supply by further development of this underground source as well as the probable permanence of such an increase. The geological staff of the State Bureau of Mines and Geology and the School of Mines of the University of Idaho have collaborated in the study. A considerable part of the data was collected in 1920 by Mr. V. R. D. Kirkham, assistant professor of geology in the School of Mines; to Mr. Kirkham credit is also due for recognition during his previous study of the major geologic features involved. This earlier data has been amplified and extended by the collection of additional data and the whole compiled by Mr. A. M. Piper, a geologist of the State Bureau staff. To Dr. F. B. Laney, professor of geology in the School of Mines, the junior authors are indebted for valuable geologic counsel and for general assistance in the preparation of the report.

Geology of the Moscow Basin.

Moscow is situated in a depression of the Columbia River basalt plateau and very nearly at the eastern extremity of an arm of that basalt embayed into an ancient river valley cut in granitic and sedimentary rocks. The bordering divides of that ancient valley are represented by Kamiah Mtn., Viola Ridge, and Moscow Mtn., on the north; by Temer Butte on the east; and by Genesee Ridge and Bald Butte to the south. These topographic elevations are the summits of former mountain ranges emergent from the volcanic flows that inundated the valley from the westward. Predicating the position of the floor of this ancient valley as mid-way between the nearest exposures of granitic rocks to the north and to the south, the stream of pre-basaltic time flowed directly under Moscow and approximately below the present location of the city of Pullman. These relations are presented graphically on the map, Plate 1, and on the sections, Plates 2 and 3. It is deducted by analogy with conditions as we know them today and from the logs of wells drilled in the Moscow basin that there existed over the surface of the pre-basaltic topography a mantle of coarse sandy soil, in some places a gravel, formed by a mingling of stream-carried debris from the mountains with the products of the disintegration of the granitic rocks in place.

Over this terrane of granitic rocks and of sandy soil and gravel was poured out the basalts making up the Columbia River plateau. This outpouring was not brief and , but extended over a considerable period of time. Records of wells in the Moscow basin show that the succession of flows was periodically broken by periods of quiescence long enough to allow the accumulation of soil, sometimes sandy, sometimes clayey, and the growth thereupon of vegetation. Subsequently, another flow of basalt inundated the area, another stratum or layer of soil was accumulated, and in its turn submerged by another wave of basalt. Each flow of basalt raised the elevation of the embryonic plateau and extended further eastward than its predecessor until checked by the dam formed by the granitic slopes of the valley of that time. By this intermittent process the plateau was built up by a series of basalt flows interleaved with thinner strata of clay and sand to an elevation now marked by the summits of the principal ridges and buttes within the semi-circle of the emergent granitic mountains. Within late geologic time the basalt plateau has been reduced by the abrasive action of streams, slightly modified by the accumulation of soil brought in by the winds, to the surface of rounded hills existing today.

When first poured out the basalt was of necessity very nearly horizontal and an examination of the scattered small areas in the Moscow basin where basalt is exposed at the surface failed to disclose any change from this original horizontality. No apparent departure from the horizontal is seen in the canyon of the South Fork of the Palouse River between Pullman and Colfax. The thickness of the basalt series can only be inferred, inasmuch as they have no where been passed through by the drill and are not cut through by any stream canyon in the vicinity of Moscow. By again falling back on analogy with conditions of today, we may, however, assume their thickness as approximately 500 feet at Moscow with some semblance of accuracy. Further reference to the sections, Plates 2 and 3, will clarify these geological conditions within the Moscow basin.

Ground Water Conditions in the Moscow basin.

Definitions and general conditions of Ground Water Circulation.

Permeable and Impermeable rocks. With respect to their penetrability by water, rocks may be classed as permeable and impermeable. A permeable rock is one whose texture is such that water under ordinary pressure may move through it perceptibly. An impermeable rock is one whose texture is such that water under ordinary pressure may not move through it.

Zone of saturation. All soil and underlying rocks which are permeable contain water in the voids or open spaces. The soil at the surface and for a variable depth below the surface contains water in its voids but not in sufficient quantity to completely fill the voids; such water is termed suspended water. The rocks below this sheet or zone of suspended water comprise the zone of saturation in which the voids of the permeable rocks are completely filled or the rocks are said to be saturated with water.

Ground Water. All water contained in the rocks of the zone of saturation is termed ground water. As will be brought out more fully in the following section on Ground Water Supply, ground water originates as rainfall and percolates downward through the zone of suspended water, into the zone of saturation.

Aquifer. An aquifer (or ground water reservoir) is a rock formation, group of formations, or part of a formation which is water bearing.

Confining bed. A confining bed of an aquifer is one which, because of its position and its low permeability, confines ground water within the aquifer, under pressure. A permeable confining bed is more common than an impermeable confining bed and retains water in the aquifer under pressure by retarding rather than by preventing percolation.

Static level. The static level of the water in an aquifer at a given point is the level at which water will stand in a well drilled into the aquifer at that point. It is generally expressed in feet above sea level.

Piezometric surface. The piezometric surface of an aquifer is an imaginary surface that coincides with the static level of the water at every point in the aquifer.

Isopiestic line. An isopiestic line of an aquifer is a contour of its piezometric surface. That is, it is an imaginary line all points along which have the same static level, expressed in feet above sea level.

Hydraulic gradient. The hydraulic gradient of an aquifer is a vertical section of the piezometric surface. The water in an aquifer moves from the high points of the piezometric surface toward the low points and the speed of movement or of percolation is approximately proportional to the slope of the hydraulic gradient between the two points. The rate of movement of ground water is very slow and is measured in fractions of a mile per year under ordinary conditions rather than in miles per hour as in the case of surface streams.

The Aquifers.

The aquifers, or ground water reservoirs, of the Moscow basin are several in number. The layer of sandy soil and of disintegrated granite that mantled the slopes and the floor of the valley of pre-basaltic time comprises the main aquifer or as it will be termed herein, the parent aquifer. The lower confining bed is the impermeable granite, the upper confining bed is the overlying series of basalt flows which are on the whole of low permeability. This parent aquifer slopes downward from the summits to the north, east, and south and passes under Moscow at the assumed depth of 500 feet. Branching from this parent aquifer are the several beds of sand and clay soil interbedded with the flows of basalt. These beds are permeable and practically horizontal, in them ground water received from the parent aquifer is confined under pressure by the impermeable overlying and underlying basalt flows. Moreover there occur in the basalt layers which are honeycombed or vesicular in texture and which are also secondary aquifers; such aquifers are, however, irregular in both thickness and extent. These secondary aquifers are presumably horizontal, or nearly so, and each derives its supply of ground water from the parent aquifer already described.

The number of secondary aquifers is not known, inasmuch as no well in the Moscow basin has been drilled through them into the parent aquifer. The available logs of wells drilled are not in all cases reliable and can not be correlated satisfactorily one with another. They do, however, establish two secondary aquifers below Moscow, as follows: a crevice or a vesicular zone in the basalt approximately 2430 feet above sea level (or 70 to 90 feet below the surface at various points within the western portion of Moscow), and a stratum described in some logs as sand and in others as vesicular basalt at an elevation of 2350 feet approximately. The former yields but little water in any of the Moscow wells, while the latter is the aquifer tapped by the 12 inch drilled well in the Moscow city pumping plant. What is probably the same aquifer is found in the large well at the University of Idaho heating plant at an elevation of 2300 feet. The relation of these aquifers to the parent aquifer and to each other is shown graphically in Plates 2 and 3.

The inter-relation of the municipal well at Moscow and that at Pullman with respect to the parent aquifer and to the secondary aquifers is of great importance. Based on the assumption that the series of secondary aquifers is horizontal, the aquifer feeding the 12 inch Moscow municipal well would be exposed at the surface in the canyon of the South Fork of Palouse River one or two miles northwest of Pullman. This condition if existent would allow ground water to be discharged from the exposed aquifer in the form of springs. The Pullman municipal well taps a secondary aquifer of sand of unknown thickness below basalt at an elevation of about 2240 feet. On the same assumption of horizontality, this is a different aquifer from that supplying the Moscow well but both join the parent aquifer and are connected by it. These relations, the significance of which with respect to the permanence of the Moscow supply will be discussed more fully later, are shown on Plate 2.

The Piezometric Surface.

It will be recalled that the piezometric surface of an aquifer is an imaginary surface that everywhere coincides with the level to which water will rise from the aquifer in wells. Its position is usually determined by distance below the surface of the ground but when its elevation is expressed in feet above sea level the piezometric surface becomes comparable to a land surface and possesses ridges, slopes, valleys and divides which are, however, much flatter than the corresponding land features. The water within the aquifer circulates in the same direction as though it were flowing over the piezometric surface and the speed of movement is proportional to the difference in elevation on the piezometric surface of the two points between which movement takes place. If such an imaginary surface can be established for the Moscow basin it will determine:

1 - The direction of percolation in the aquifer.
2 - The limits of the area whose ground water will drain under Moscow.

In order to establish a piezometric surface of the Moscow ground water basin as it stands at the time of writing, data was collected on all the deep wells in the city and on most of those within the area lying between the city and the mountains. Records, in varying degrees of completeness, were obtained from 48 wells in the Idaho portion of the area and from 19 wells in Washington. It is to be regretted that in the case of many wells, pumps are rigidly mounted directly on the casings and it was found impossible to measure the depth and the distance to water level. Sufficient data were obtained to construct the piezometric surface with a degree of accuracy commensurate with the needs of the situation. The wells examined are located on the map, Plate 1, with distinguishing numbers and the well records are grouped, with corresponding numbers as an appendix to this report. On the map, Plate 1, this surface is represented by isopiestic lines, that is by lines joining all points of equal elevation on the piezometric surface. The surface presented is that for the parent aquifer within the catchment area combined with that for the upper two of the series of secondary aquifers in the basalt covered area.

<u>Hydraulic gradient and Circulation in the Aquifer.</u> The hydraulic gradient, that is the slope of the piezometric surface, and its relation to the velocity and direction of movement of the ground water has already been discussed in general. For the particular case of the Moscow basin the following essential facts may be derived:

The ground water percolates downward from the encircling mountain ranges toward a center or focus about two miles west of Moscow. Sufficient data was obtained from wells west of Moscow in the state of Washington to show that from this central or focal point the circulation is westward in a broad sheet toward the city of Pullman. The slope of the piezometric surface is higher than normal, showing that the velocity of percolation is abnormal; it must be borne in mind, however, that this abnormal velocity is very slow in comparison with that of surface waters being measures in miles per year rather than in miles per hour.

Secondly we may determine that area from which the ground water drains under Moscow before progressing westward. This area lies to the east and northeast of Moscow and its extent is indicated on the map by lines marked "ground water divide." The ground water in this area, the amount of which will be determined in a subsequent section, represents the reservoir that can be drawn upon by Moscow for an underground water supply.

<u>Piestic decline.</u> Well records show that there has been a gradual piestic decline in the Moscow basin in the last thirty years, or in other words, the piezometric surface and the level of the water in wells reaching the aquifer had dropped. It is established from various sources and beyond reasonable doubt that flowing artesian wells existed in Moscow in 1890 to 1895. The existence of three such wells is undoubted. A well drilled in the 90's about 100 yards west of the present city of Moscow pumping plant on A Street and on land now owned by the Spokane and Eastern Railroad struck water at 80 feet below the surface and flowed for a short time; the well was drilled to a total depth of about 200 feet without increasing the discharge. A second well on the old Fair Grounds northeast of the city was drilled in 1896 and the water stood at the surface or flowed slightly for 10 years. The third well, drilled about 1890 in what are now the grounds of the Gritman Hospital, to a depth of about 100 feet flowed very slightly for about three years. All of these wells are now closed and abandoned; all of them drew their water from the uppermost of the secondary aquifers. The first city well was drilled about 1895, and presumably to the aquifer next underlying that tapped by the early flowing wells and at that time the water level stood close to the surface of the ground; at the present time the water level is 44 feet below the surface when not pumping. Measurements made on other wells in and close to the city shows that all have experienced this drop in the water level. The decline has not been at a uniform rate. The salient points are as follows:

1 - The net pies[redacted]

2 - A rapid drop of several feet was noted after the drilling of the Pullman municipal well in 1912. After this rapid drop the decline became more gradual.

3 - A second rapid drop of 10 or 15 feet has taken place during the past year in the city wells, and this has resulted in a serious decline in pumping capacity.

This decline has very probably been caused by too heavy draft through pumping from a secondary aquifer of small total capacity combined with the reduction in pressure head in the Moscow aquifer produced by the drilling of the large municipal well at Pullman. The effect of the latter cause is discussed in the following section.

Ground Water Supply.

The ground water, that is the water-contained in the zone of saturation below the land surface of the Moscow basin has its origin as rainfall that has percolated downward from the surface. If then we can determine the quantity of water precipitated as rainfall within the area that feeds the underground aquifers and the portions of this rainfall that are discharged at the surface, we have a measure of the amount of water that is being added to the ground water reservoir. Any aquifer that has been tapped by wells will have stored all the water that it can contain. When a well is drilled to such an aquifer and water taken therefrom a part of the water in storage is removed and is slowly replaced by downward percolation from the surface. If ultimate depletion of the ground water supply is to be avoided, the amount of water removed from an aquifer must never exceed the amount being fed to that aquifer from the surface. The importance of determining this amount of annual recharge or the annual increment as it is termed to the ground water supply is quite apparent. No other method than that outlined above is available to determine the amount and it can be measured only as accurately as the various factors are themselves measured. In the following paragraphs an attempt is made to establish the annual ground water increment of the Moscow basin from the data that are obtainable.

Intake area. In order that an aquifer may receive ground water it must slope in such a way that it comes to the surface of the ground at some point or feed from some aquifer that does. The usual condition is that the aquifer is at the surface in a belt along the base of a mountain range and plunges away from that range and below the surface. This area within which an aquifer crops out at the surface is known as its intake area. It will be recalled that the parent aquifer of the Moscow basin is the layer of sandy soil and disintegrated rock that overlies the rock core of the mountains and that this plunges under the basalts. Its intake area is shown on the map, Plate 1, and is bounded on the west by the area of basalts and on the east by the mountain mass; its southerly and north-westerly limits have been determined in the preceding section dealing with the piezometric surface. It has an areal extent of 9,000 acres.

Catchment area. It is usually the case that surface water from higher slopes drains across the intake area of an aquifer and may be added to the ground water supply. The intake area of a given aquifer plus that area whose surface water must drain across the intake area, comprises the catchment area of the aquifer. In the Moscow basin the catchment area, shown on Plate 1, includes the intake area plus the slopes of Moscow Mtn., and Tomer Butte and has a total areal extent of 15,500 acres.

Annual increment of ground water. In the following paragraph we shall trace the division of the rainfall within the catchment area outlined in order to determine the annual increment of the ground water supply. Water may be precipitated upon the catchment area either in the form of rain or of snow. Snow will lie on the ground until such time as it melts; thereafter the water of the melted snow follows the same course as the water of the rain. The first division of the newly precipitated water is by:

A - Immediate run-off.

B - Absorption into the soil or the zone of suspended water.

By run-off is meant the water carried off by the streams. The total of the run-off, measured at the points where the streams leave the intake area, is lost to the ground water basin. The portion absorbed into the soil is subsequently further divided by:

1 - Seepage into the streams.

2 - Evaporation discharge.

  A - Soil discharge

  B - Vegetal discharge

3 - Percolation to the zone of saturation.

The portion seeping into the streams is added to the immediate run-off and is lost to the ground water supply. From the zone of suspension water may be discharged into the atmosphere by direct evaporation from the soil or it may be absorbed by the roots of vegetation and discharged from the leaves into the atmosphere. The total of the soil and vegetal discharge is lost to the ground water basin. The water not removed by run-off and not lost by evaporation is held in the zone of suspended water until this zone contains all the water it can hold in suspension. As soon as the amount of water in the zone of suspension is raised above the carrying capacity, the excess of water moves downward into the zone of saturation and is added to the ground water supply. The annual increment of the ground water supply is therefore the amount of precipitation over the catchment area less the sum of the stream run-off (measured as the points where the streams leave the intake area), the soil evaporation, and lastly the vegetal evaporation.

The first factor in our computation, the precipitation, is accurately known inasmuch as rainfall records have been kept at Moscow for 31 years. The average annual rainfall for that period is 22.24 inches, that is in a year of normal rainfall if all remained where it fell, the surface of the ground would be covered to a depth of 22.24 inches.

The second factor, the stream run-off, can only be approximated. No continuous records of the flow of Paradise Creek and of South Fork of Palouse River, which streams carry the surface drainage from the Moscow catchment area, have been made. Six accurate measurements of the flow of Paradise Creek made during the spring months of different years were made available by Mr. R. Lewis, Associate Professor of Agricultural Engineering at the University of Idaho. These were supplemented by estimated flows for the remaining months of the year and a computation made on this basis and on the assumption that South Fork would flow as much more than Paradise Creek as the drainage basin was larger than that of the latter. Accurate measurements of the flow of the Palouse river 3 1/2 miles below Potlatch were made by the U.S. Geological Survey for the seasons of 1915, 1916, 1917, 1918, and 1919 and observations of rainfall have been kept at Potlatch since 1916 for the U.S. Weather Bureau. The percent portion of the precipitation that was discharged by the Palouse River at Potlatch as run-off was computed for the seasons of 1916, 1917, 1918, and 1919. A second computation of the run-off of Paradise Creek and South Fork was made on the assumption that their run-off would be the same portion of the total precipitation in their drainage basin as the average percentage of run-off of the Palouse River for the four years during which records are available. The two computations checked within reasonable limits and the figure computed by the second method was accepted for the purpose at hand. it is believed to be substantially correct and if in error to err on the side of magnitude which will give the conservative estimate of ground water increment. The run-off of Paradise Creek and of South Fork, expressed in equivalent inches depth over their drainage areas, is 12.31 inches.

The remaining factors of soil and vegetal discharge may be accurately computed from experimental data determined by G. R. McDole, Associate Professor of Agronomy at the University of Idaho. Soil discharge by evaporation is represented by fallow ground condition, the combination of soil and vegetal discharge by land bearing growing crop. The computation was made on the basis of a wheat crop for two reasons:

1 - Wheat is the chief crop of the Moscow basin.
2 - Wheat draws more heavily on the water supply than any other crop.

Land in fallow and in growing wheat discharge very nearly the same amount of water by evaporation. The total loss to the ground water supply by this means, for the cultivated portion of the basin, expressed in equivalent depth over the catchment area, is 8.58 inches. This computation includes the water withdrawn from the zone of suspended water which is replaced before any water can percolate downward to the zone of saturation.

It will be recalled that:

Annual increment = Precipitation - (run-off + soil and vegetal discharge).

Expressing this in the equivalent figures derived above, we have:

Annual increment = 22.24 - (12.31 + 8.58)
= 22.24 - 20.89
= 1.35 inches.

The annual increment to the ground water supply that passes below Moscow, when expressed in the equivalent depth over the entire catchment area of 15,500 acres, is 1.35 inches. To express this figure in more common terms:

Annual increment = 1700 acre feet.[1]
= 73,900,000 cubic feet.
= 550,000,000 gallons.

This estimate ignores the following factors which from the conservative viewpoint are counterbalancing:

1 - Evaporation from soil before and after the growing season. This is small inasmuch as the frost free and growing periods approximately coincide and the loss is offset by regarding land in fallow the same as land in wheat.
2 - Vegetal discharge by forest vegetation and evaporation from snow surfaces. This is probably more than counterbalanced by the heavier precipitation on the mountain slope of which no account has been taken.
3 - Percolation downward and out of the Moscow basin into the granitic mountain core through joint cracks and fissures. This factor is absolutely indeterminate and there is an equal chance that there is similar percolation into the basin.

This quantity of annual ground water increment will be considered further in the section on conclusions.

Shallow ground water.

Within the area capped by basalt there are numerous shallow wells, with a water supply adequate for domestic use, that do not penetrate the basalt. These wells derive their supply from a purely local body of ground water that is upheld above and separated from the main body of ground water by the uppermost stratum of basalt. This supply is small and is discharged from rather than into the intake area; it is to be disregarded as a possible constituent of the municipal supply.

[1] An acre foot of water is that quantity required to cover one acre one foot deep.

Quantity of water now used.

Inasmuch as the quantity of water withdrawn from a ground water reservoir should not exceed the annual increment to the supply, it is necessary that the amount withdrawn be known with reasonable accuracy. Unfortunately no records of any kind have been kept of the quantity of water pumped from the wells of the Moscow basin and this quantity has been estimated on the basis of the best data available. An effort has been made to err on the side of magnitude in order to view the problem from the least favorable angle. The water used by the city of Moscow has been estimated by taking 12 times the consumption for the month of August 1923 and adding 20% for probable leakage; inasmuch as the consumption during August exceeds that for any other month the figure derived is presumably ample. The amount of water used by the University of Idaho was accurately known for the year 1919. In tabular form, the annual withdrawal of water from the Moscow ground water basin is approximately as follows:

City of Moscow	180,000,000	gallons per year.
University of Idaho	21,500,000	" " "
Moscow Steam Laundry	6,500,000	" " "
Hagan and Cushing (packing house)	7,500,000	" " "
Cold Storage Market	3,500,000	" " "
M. P. Miller Milling Co.	3,500,000	" " "
Minor users (domestic and stock)	7,500,000	" " "

Total annual water consumption = 230,000,000 gallons

Conclusions.

In brief, this report has brought out these essential facts:

1 - The annual increment to the ground water supply of the Moscow basin is 550,000,000 gallons, 2 - The amount annually withdrawn is approximately 230,000,000 gallons, equivalent to a steady pumping at the rate of 450 gallons per minute. In considering the various factors involved an effort has been made to err on the side of conservation, making the former figure small and the latter large.

The annual increment to the supply becomes divided between the parent aquifer and the several secondary aquifers in proportions that we cannot assume owing to our ignorance of the conditions existing between the parent aquifer and the aquifer tapped by the city wells. The figure given above for the annual increment is the amount of ground water in all aquifers that would move westward with a front about three-fourths of a mile wide, if none of it were intercepted as it left the Moscow basin. If it is possible to obtain perfect interception of all the ground water across this three-quarter mile front, there would result no depletion of the ground water supply at Moscow as long as the annual water consumption for the entire Moscow basin remains less than the annual increment. A means of securing approximate total interception of this ground water flow will be outlined below and if proper development is carried out in accord with recommendations there should be recovered a permanent public water supply adequate to one and one-half times the present population. This estimated adequacy is based on the report by I. C. Crawford, Dean of the College of Engineering of the University of Idaho, that not less than 100 gallons per capita per day is a sufficient water supply.

In advance of presenting recommendations, an outline of the probable cause of the decline in the city well will be given for comparison with the proposed development. The present well taps, at the most, two of the secondary aquifers which receive only an unknown portion of the ground water increment. Moreover, the present well can intercept at the best approximately one-fourth of the front across which the ground water moves. By pumping approximately one-half the recharge capacity of the ground water basin from a well which can intercept but a small portion of this recharge there has been a long continued over-draft on the aquifer and a partial depletion of the water initially stored therein. Consequently there has been a slow decline in the static level of the water in the well. What has appeared to be a sudden slump in the water supply during the past year is to a considerable extent a decrease in pumping capacity of the well due to the static level having fallen below the critical condition, in which the distance between the water level and the pump intake is equal to the normal drawdown. In addition to the effect of long continued overdraft on the aquifer must be added the probable silting up of the bottom of the well and consequent slight decrease of rate of inflow.

Recommendations.

Well barrier. The development recommended to secure approximately complete interception of the ground water flow is to drill a barrier of wells drawing from all secondary aquifers and from the parent aquifer and to space these wells at such intervals that their areas of influence at full pumping capacity will merge. (The area of influence of a well is that circular area within which water moves toward the well intake during pumping.) In the lack of information of the number and thickness of aquifers, the proper interval between these wells can only be set arbitrarily. This arbitrary spacing of wells is set at 1000 feet and the complete well barrier would consist of four wells equally spaced across a three-fourths mile front.

Test hole. In order to make possible the best development of the ground water supply there should be put down to the granite a small test well or hole before the drilling of any part of the well barrier above outlined. Such a hole should be cored if feasible. The information derived from the careful sinking of such a test hole would make possible the determination of:

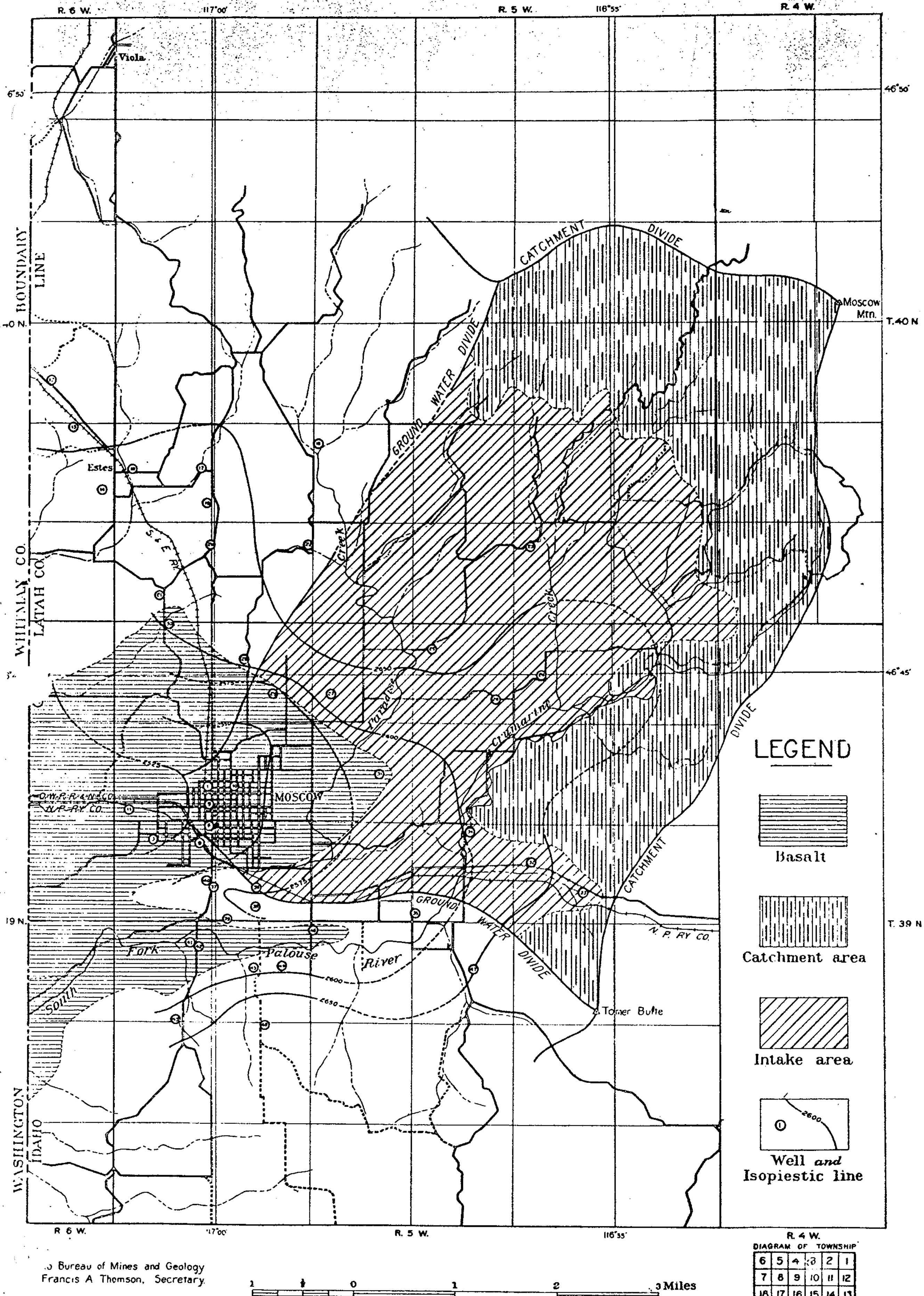
1 - The number, thickness, character, location and estimated capacity of aquifers.
2 - The type of casing and mode of setting best adapted to the formations encountered.

In addition, it would anticipate difficulties of caving or jointed formations to such an extent that the drilling of a large well could proceed with proper caution before the trouble was encountered.

Gravel-walling of the aquifer. Should the aquifer be found adaptable thereto, they should be gravel walled. That is, the fine sand should be pumped from the aquifer and replaced with gravel. This operation has the effect of creating in the aquifer an artificial gravel strainer of large diameter.

Cleaning. Any well put down should be periodically cleaned if such an operation is necessary.

Records. In the future development of the ground water supply, accurate records should be taken and preserved of fluctuations in the static level and rate of drawdown of each well.



Idaho Bureau of Mines and Geology
Francis A. Thomson, Secretary.

Base from U. S. Geological Survey
and U.S. Dept. Agriculture maps
Compiled by A. M. Piper, 1923

DIAGRAM OF TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

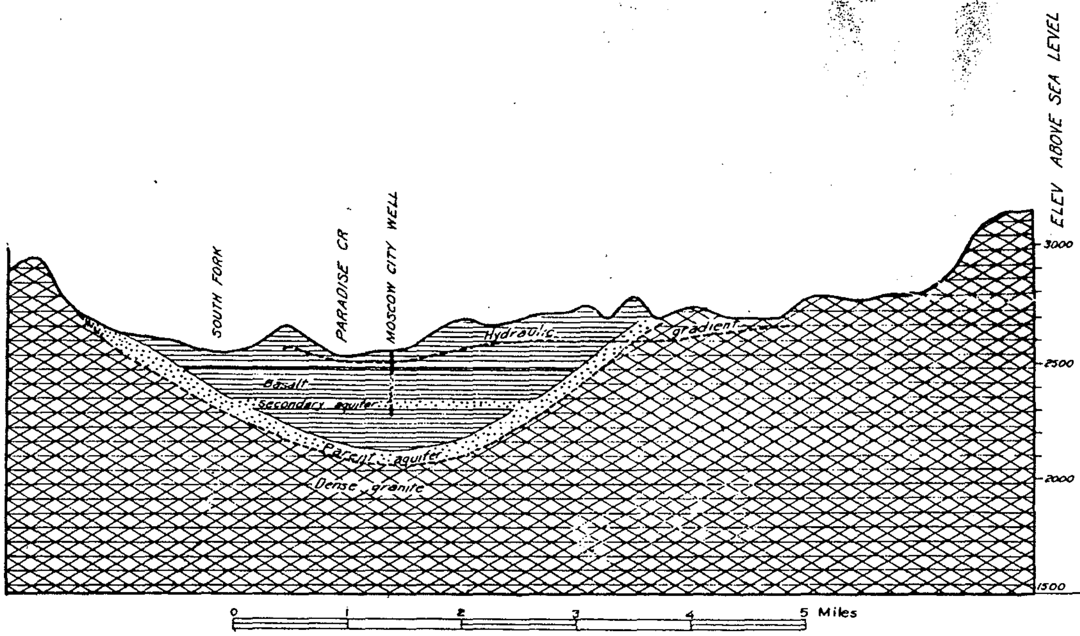


Plate 3. Hypothetical north-south section through Moscow, showing aquifers and hydraulic gradient.

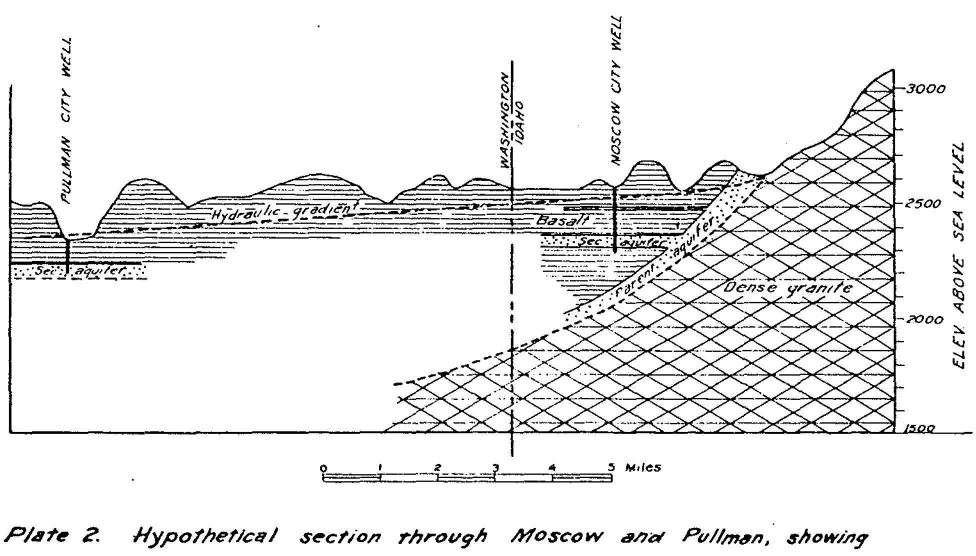


Plate 2. Hypothetical section through Moscow and Pullman, showing aquifers and hydraulic gradient.