Correspondence and report re: Water supplies in Wisconsin. 1935-1936

Thwaites, F. T. (Fredrik Turville), 1883-1961
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THE UNIVERSITY AND WATER SUPPLY PROBLEMS

Quantity and ~~of~~ Chemical Quality

Introduction

Waters is one of the major natural resources. Because disease-producing bacteria do not exist far below the surface of the ground, underground waters furnish the safest water for human consumption. True, polluted surface waters can be purified by filters and chemical treatment but such is neither an economical nor a practicable method of obtaining drinking water for farms or small communities. Because the conduction of heat is slow through the ground underground waters derived from ~~moderate~~ depths of not more than a thousand feet have a more equable temperature than do the waters of lakes and streams, one which is very much below the average air temperature in the summer months. Increasing demands are being made upon ground waters for cooling steam and refrigerating condensors as well as for air-conditioning and for certain chemical industries. The total amount of ground water is determined by first the portion of the average precipitation which enters the earth and second by the available openings in the earth. The amount which can be obtained at a given spot is limited by the velocity with which water can pass through the openings at that place. Thus it comes about that not only is the amount of underground water at any locality dependent upon geological conditions but it is possible where demand is concentrated to reach a limit of production beyond which recovery is not economical. The usefulness of ground waters to man also depends upon the amount of and the nature of the dissolved matter which they contain. In times of extreme drought as from 1930 to 1934 the need for conservation of ground waters is apparent to all, for then many surface supplies from streams and reservoirs fail.

THE UNIVERSITY OF WISCONSIN

Department of Hydraulic
and Sanitary Engineering

March 24, 1936

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F. M. Dawson
D. W. Mead
M. G. Glaeser
A. T. Lenz

Gentlemen:

Owing to the fact that all the water resources studies of the Science Inquiry overlap to a great extent and that I am on three of the committees it occurs to me that a general meeting of those interested in the Water studies might be advisable.

Eventually it is logical to assume that these studies will be integrated into a whole and it seems that much of the correlation might be done to better advantage now than later.

I have discussed this question with several members of the committees and now ask if it would be possible for you to attend a meeting at the Hydraulic and Sanitary Laboratory on Friday, March 27 at 4:30 to go over a general outline.

Sincerely yours,

F M Dawson

F. M. Dawson

Amount and Distribution of Waters in Wisconsin

Wisconsin is particularly fortunate in the availability of water which is suitable for human use. North and east lie Lake Superior and Lake Michigan respectively, vast reservoirs the failure of which is impossible so far as human experience can foretell. On the west is the Mississippi River which has never been known to run dry. Throughout most of the state lakes and streams are abundant, although the dry years of 1930 - 1934 showed that the level of these is subject to marked recession. Low lake levels then caused serious loss to owners of shore property, and it is evident that such lakes could not be drawn upon for human consumption without much increasing this damage during time of deficient rainfall. With respect to underground water the State is almost equally fortunate. Fig. 1 shows that there is only a relatively small area in central Wisconsin where underground water supplies are difficult to obtain. The accompanying table shows the geological distribution of waters and fig. 2 demonstrates the enormous underground reservoir which exists in the sandstones which not only underlie our state but furnish water to deep wells in adjacent states.

The Problems - Ground Water

It can not be said that there is a ground water problem; rather there are many problems, all more or less interelated, which involve geology, chemistry, meteorology, physics, bacteriology, engineering, and law. Only a few of the problems have as yet been solved in a satisfactory manner. Many facts are known but the interpretation of these facts, the <u>why</u> of the existing conditions that remains uncertain in amny instances.

(1) Geological problems. The distribution, and the general

character of the water-bearing materials is already well known qualitatively. The accompanying section from central Wisconsin southwest into Iowa indicates that we can map the water-bearing formations quite accurately. But quanitative knowledge of porosity is still lacking; it is not yet possible either to define or to explain the areas where formations which are elsewhere productive are almost imperveous.

(2) Chemical problems. The dissolved mineral matter in underground waters is in general closely connected with the nature of the material in which they occur and is, therefore, related to geology. In regions of hard rocks, like granite, the total maount is small and the waters are classed as soft. In districts where limestone is present the waters are hard, consume soap, and form scale in boilers and hot water heaters. However, geology is not the whole story. In any given water-bearing formation there is a change with distance form the surface outcrop. There is a relatively sharp contact between the moderately hard waters at shallow depths and the extremely hard waters under the cover of overlying impervious strata. Below that there is another zone where the increase in content of common salt appears to be abfupt. Below that little is known as the waters are not potable. The problem is difficult of solution for most deep wells draw on more than one water-bearing formation. It is probable that the key lies in rapidity of the circulation of the water but changes in the nature of the dissolved substances through chemical action with the containing rocks must also be considered. Three substances which, although present in minute quanities, are most annoying are iron, manganes, and fluorine. Very little is definitely known of the origin and geologic relations of these for most published water analyses ignore them. Other unsolved problems involve changes in mineral content of waters as the result of variations in rainfall or of prolonged

withdrawal from wells. Little is known of the composition of waters from deep sources before the pressure is reduced by bringing them to the surface.

(3) Meteorological problems. Studies of the variations in the level of underground water as a result in changes in rainfall have just been commenced by the Conservation Commission. Until such scientific measurments have been caried out for a term of years it is impossible to answer the problem of the relation between vegetal cover and the level of water table or the problem of changes in amount of soak-in as a result of deforestation, cultivation, or pasturage. Many of thecommonly accepted ideas on these subjects will undoubtedly be modified when accurate data are available. For instance, a marked recession of the water-table in Portage County was formerly refered without question to deforestation and cultivation wheras heavy rainfall in later years proved that this condition was due to the drought of the '90's.

(4) Physical problems. Problems of underground waters related to physics comprise more knowledge of the porosity and permiability of the water-bearing formations, the temperatures of waters at varying depths and at different times of year, and the rate of movement under different conditions. Little data is now available along these lines.

(5) Very little is known of the viability of disease-producing bacteria underground. The classic experiments at Fort Caswell, N. C. are the only attempt in this country to obtain scientific information on this important subject. Except in fissured rock we know next to nothing as to the actual behaviour of contaminating solutions such as those introduced by drainage wells and other subsurface sources of pollution, or indeed of the role played by the soil in protecting underground waters from dangerous organisms.

(6) Engineering problems. Wherever there is abnormally concentrated

demand for underground waters there is grave danger of drawing upon the supply faster than it can be replenished by transmission through the ground from other localities. At Chicago the enormous amount of water pumped from deep wells in the stock yards district has lowered the water level in wells more than 300 feet in less than 40 years. This will soon mean that the recovery of underground water will be unprofitable. In other localities prolonged withdrawal has introduced non-potable salt waters from below. In other places improperly constructed wells have allowed the surface waters which were originally of good quality to become mixed with non-potable waters from below. In other places drainage wells and abandoned wells have caused damage to water supplies. Many wells have been condemned as unsafe; they were themselves constructed improperly and allowed contamination to enter at the top. The correction of these conditions involve problems in engineering. Undue lowering of the water at a given locality may, for instance, be minimized by proper spacing of wells. In other places proper construction of wells will prevent lowering of the water level in shallow wells by drainage down deep wells to formations where the pressure is less. In many places it is desirable to draw separately upon different sources because the water level in each is so different. The discovery and proper plugging of abandoned wells is a problem in itself. The life of well casing is also an important problem.

(7) Legal problems connected with ground waters involve interference of wells, such as the drainage of shallow wells and springs by large wells adjacent. In some localities quarrying and mining operations have destroyed shallow water supplies and in others unchecked flow of artesian wells, often locally called "fountians", has caused the cessation of flow in adjacent wells. In some places the unrestrained flow has been from abandoned or improperly cased wells into the soil rather than at the surface. Non-potable waters have

spread from improperly constructed wells with disastrous results to adjacent ground water supplies. Under a decision of the State Supreme Court involving interference of flowing wells well owners are left without any legal remedy in most of these situations. The possibility must also be faced that during periods of extreme drought it may be necessary to restrict the use of ground water for industrial purposes because such waters are more valuable for human consumption. With increased use of ground water for air-conditioning serious interference with public water supplies may arise.

The problems-surface waters.
Introduction

Because of their accessibility surface waters lend themself to accurate study more readily than do those below the ground. It is, therefore, possible to estimate the available amount fairly accurately and the other engineering problems of development are in general much more simple than are those of ground water supply. As much of the water of streams and lakes is direct runoff from snow or rain the amount of mineral matter averages much less than in adjacent ground waters. The aggregate amount of available surface water is in most places far in excess of that underground. On the other hand disadvantages of surface waters for human consumption and industrial use include; (a) great variation in amount with change in precipitation by reason of the more rapid movement, although this statement does not apply to the Great Lakes, (b) great variation in amount of dissolved substances which reach a maximum when slight rainfall makes them chiefly springs water, (c) great range in amount of suspended matter, (d) presence in many waters of large amounts of organic compounds which cause undesirable color, oder, and taste and whose complete removal by treatment is almost impossible at present, (e) great range in temperature which may be so high in summer as to make very unpalatable drinking water or to require an unduly large consumption for cooling, and (f) contamination by human and industrial wastes which involve difficult problems in treatment to render the water safe for drinking.

The problems of surfade waters from the standpoint of human consumption cover much the same field as do those of underground supplies.
(1) Problems in chemistry of surface waters mainly involve organic compounds derived from swamps. Iron and manganese are not important in surface waters. Wastes from certain industries such as paper mills and gas works also involve problems.

(2) Studies of the discharge of streams and the level of lakes are well in ahnd by various governmental agencies so far as the needs of waterpower and navigation require. Data on small streams and most inland lakes seem to be lacking.

(3) The most important problems of the utilization of surface waters are in the field of engineering. Although the bacterial purification and softening of waters has reached a staisfactory state of perfection the problems of taste and odor removal are still unsolved for many kinds of water. Temperature reduction of public supplies during the summer months is an entirely untouched problem which would aid very greatly in promoting the palatibility of many supplies and combating popular prejudice against surface waters. A most important possibility for the furure is the development of regional water supplies similar to electric power distribution systems. It would be entirely feasable to supply a large part of the more densely populated section of Wisconsin from a few large pumping and treatment plants on the shore of Lake Michigan. The hardness of such a supply would be decidedly less than that of most underground waters in the region and water could then be obtained from the lake at points remote from contamination and at depths where cool water is always present. Studies to determine the ultimate cost of such a project

as compared to local supplies now in use are most desirable. Collection of more data on stream flow and lake levels is also needed.

Studies which have been made at the University

Comparatively few studies of water supply problems have been made at the University. Published reports which refer to problems in Wisconsin and adjacent regions are:

W. G. Kirchoffer, The sources of water supply in Wisconsin, Univ. of Wis., Bull. 106, pp. 163 - 249, 1905.

Samuel Weidman and A. R. Schultz: The underground and surface water-supplies of Wisconsin, Wisconsin Geol. and Nat. His. Survey Bull. 35, 664 pp, 1915.

C. S. Slicher, The motions of underground waters, U. S. Geol. Survey Water Supply Paper 67, 106 pp. 1902.

T. C. Chamberlin, The requisite and qualifying conditions of artesian wells, U. S. Geol. Survey Fifth Ann. Rept., pp. 125 - 173, 1885.

T. C. Chamberlin, Artesian wells, Geology of Wisconsin, vol. 1, pp. 689 - 701, 1883.

D. W. Mead, The geology of Wisconsin water supplies, 19 pp. 1894.

Moses Strong, Geology of the Mississippi region north of the Wisconsin River, Geology of Wisconsin vol. 4, pp. 57 - 63, 1882.

Annomyous, Public water supplies of Wisconsin, Wisconsin State Board of Health, 31 pp. 1935.

F. T. Thwaites, Stratigraphy and structure of northeastern Illinois with special references to underground waters supplies, Illinois Geol. Survey Rept. Invest. No. 13, 49 pp. 1927.

Anonymous, Public Water supplies of Wisconsin, Wisconsin State Board of Health, 31 pp., 1935

Unpublished theses comprise:

Andrew Leith, Waters of the St. Peter sandstone, Masters thesis, 1927.

R. C. Lund, Underground Waters of the Niagara limestone, Masters thesis, 1928.

P. R. Wright, Geologic Structure of the Cambrian of Southeastern Wisconsin, Bachelor thesis, 1930.

Specian investigations of the iron-manganese problem at Eau Claire were made both by E. F. Bean and F. T. Thwaites. Although the scientific aspects can hardly be called settled the net practical result was the development of a new supply which up to date has been a very great improvement over the former source. Some of the studies of the lakes waters have involved study of adjacent underground waters and of other features important to human use.

Chauncey Juday, E. A. Birge, and V. W. Meloche, The carbon dioxide and hydrogen ion content of the Lake Waters of northeastern Wisconsin, Wis. Acad. Sci., Trans, vol. 29, pp. 61-64, 1935.

Chauncey Juday and E. A. Birge, The transparencey, the color and the specific conductance of the lake waters of northeastern Wisconsin:
Ibid, vol. 28, pp. 247-253, 1933.

Studies now being made at the University

In 1912 the U. S. Geological Survey presented all of the samples of cuttings from wells in Wisconsin to the museum of the University of Wisconsin. After a few years this work was supported in part by the State Geological Survey (now a part of the University). By gradual growth this work included all problems connected with wells insofar as extremely limited funds and time allowed the data to be collected. Contacts have been made with many well drillers, water superintendents, and engineers, as well as with the Conservation Commission, the State Laboratory of Hygiene and the State Board of Health, but cooperation is only informal although generally helpful. The work of Messers Birge and Juday on lakes has furnished much valuable data on termperatures as yet unpublished.

The work of the State Laboratory of Hygiene is mainly on the sanitary quality of waters and only incidently on their chemical quality. Analyses are limited to determinations of practical importance and to those made at minimum expense. No attempt has yet been made to correlate the available chemical data there collected with geological conditions. Work on fluorine in ground water is now in progress.

Research needed-

The problems of water supply outlined above show very clearly the need of cooperation between departments of the University. Very few of them can be carried to satisfactory completion by a man whose training lies only in one field. For instance, most published reports on underground waters neglect data which is essential to engineers who must estimate the cost of development and recovery. Very few reports have made any serious effort to correlate the geology of the region with the chemistry of the waters. The following suggested lines of research make no pretense to be exhaustive of the field.

In the field of chemistry

Areal mapping of other characteristics of underground waters than total solids might furnish a clue to the origin of iron and manganese in underground waters. Such data would probably allow the construction of wells so as to minimize these objectionable substances. In this connection it is quite probable that determinations other than those made by most analysists would be of greater value in the problem than those now available. Studies of the minerals in the rocks which give rise to the natural soft waters which have undergone base-exchange are important. The tracing of the chemical changes within a given waterbearing formation with distance from its exposure at the surface are of prime importance although hindered by the fact that most deep wells produce from more than one such formation. Areal mapping of the chemical properities of the deeper-seated potable waters would undoubtedly facilitate the extension of the area in which such waters can be recovered by properly constructed wells. The drought of 1934 showed how important "stand-by" deep wells are when surface streams and reservoirs fail.

Study of changes in chemical composition of waters as related to precipitation, time of year and prolonged withdrawal are also needed.

Problems of the distribution of saline waters and of taste, odor, and color removal of surface waters are also necessary.

In the field of geology

Extension and revision of the existing cross sections and subsurface contour maps of water-bearing formations is needed to facilitate forecasts of the depth at which production may be expected. Areal mapping of the capacities of productive formations would also be desirable could the data be secured. Correlation of run off with geology is also desirable.

In the field of physics

Determination of underground temperatures at different depths and, at the shallower depths, at different times of the year are much needed. Such information is of great value in securing waters for cooling.

In the field of bacteriology

Further research into the viability of bacteria underground and their spread from a point of entry into ground water are greatly needed.

In the field of engineering.

The locating and plugging of abandoned wells needs study to determine the best methods. Use of the current meter or other instruments to find underground leaks in wells is important. It is also possible that electrical measurement similar to those made in oil wells would yield valuable information.

Changes in the yield of wells for a given amount of lowering of the water level (specific capacity) demand study to determine the cause or causes and their remedy. Proper casing of wells to improve the sanitary or chemical quality of the water and to prolong the useful life of the well is another pressing problem. Study in part with models of the lowering of water adjacent to producing wells is also needed for many of the mantematical formulae now in use are based upon assumptions rather than experiment. The problem of temperature control of surface supplies is vital to their further development and it may be suggested that it is possible that proper construction of storage reservoirs for treated water might prove a satisfactory solution. Research on the feasibility of regional water supply systems is important in connection with the formulation of a national water supply policy for the proper conservation of desirable sources of water supply.

Summary

It is evident that few if any of the foregoing subjects of research can be solved by men whose experience lies wholly in one field of science. They entail the cooperation of men who are versed in several different branches of learning. When it comes to subjects of research by advanced students it is a deplorable fact that most students choose their "minor" because it is easy and not because it will help them by broadening their knowledge or because it is essential to their research. It is rare for geology majors to minor in either physics or chemistry. Few students who major in chemistry or physics ever take any geology. Where the problem lies between two different colleges of the University existing rules do not encourage students to take work in more than one. As a result few engineers except mining engineers have any extensive knowledge of geology. It is also evident that in the effort to solve any of the foregoing problems other problems, many of them undreamed of, will be disclosed.

Courses offered in the University which bear upon ground water problems
College of Letters and Science

Geology		Credits
Geology 1,	General geology	10
9,	Engineering geology	6
17,	Survey of geology	3
Meteorology		
1,	Weather and climate	3
106	Climatology	3
Chemistry		
1	General chemistry	10
11	Quanitative analysis	6-10
130	Physical chemistry	3
113	Water analysis	1
College of Engineering	Hydraulic engineering	
1 or 2	Hydraulics	3 or 4
110	Hydrology	2
115	Advanced hydraulics	2
121	Water supply engineering	3
113	Hydrological investigation	2
124	Sanitary Chemistry	2
College of Agriculture		
Bacteriology		
1,2	General survey	8

December 2, 1935

POSSIBLE COMMITTEES ON CONSERVATION

Regional aspects: Geography and mapping:

Finch, Bean, Noble Clark

Soil erosion:

Clark, Twenhofel, Wehrwein, E. R. Jones, Leopold

Soil maintenance (fertilizers):

Truog, Christenson, Whitson

Waterpower:

Dawson, D. W. Mead, Glaeser, Lenz

Water supply for consumption:

Quantity and inorganic content:

Thwaites, Dawson, Lenz

Organic content: pollution:

Noland, Ruf, Dawson, Kessler, Nichols, Sevringhaus, Stovall

Lakes:

Birge, Juday

Forestry:

Sweet, Gaus, Rowlands, Sherrard, Trenk, Wehrwein, Winslow, (some economist ?)

Minerals:

Bean, Leith

Wild life management:

Leopold, Cole, Fassett, Herrick, Wagner

Recreational policies as related to environment:

Wehrwein, Kolb, Leopold

Thwaites

December 4, 1935

POSSIBLE COMMITTEES ON CONSERVATION OF NATURAL RESOURCES

Regional aspects: Geography and mapping:

Finch, Bean, Noble Clark.

Soil erosion:

Twenhofel, Clark, Wehrwein, E. R. Jones, Leopold

Soil maintenance (fertilizers):

Truog, Christenson, Whitson, Aamodt.

Waterpower and Navigation:

Dawson, D. W. Mead, Glaeser, Lenz

Water supply:

Quantity and inorganic content:

Thwaites, Dawson, Lenz, E. R. Jones

Organic content: pollution:

Nichols, Noland, Ruf, Dawson, Kessler, Sevringhaus, Stovall

Lakes:

Birge, Juday

Forestry:

Winslow, Sweet, Gaus, Rowlands, Sherrard, Trenk, Wehrwein, Harold Groves

Minerals:

Bean, Leith

Wild life management:

Leopold, Cole, Fassett, Herrick, Wagner

Recreational policies as related to environment:

Wehrwein, Kolb, Leopold, Aust

Legal and administrative aspects:

Gauss, Bunn, Wehrwein, Leopold, Clark.

When the undersigned started work on well records in 1912 the only aim was to secure data on the nature and position of the geological formations but as time went on the bearing of geology upon the practical problems of well drillers and engineers became more and more apparent. Several of the problems related to the safety of water supplies and thus made necessary cooperation with the State Laboratory of Hygiene and the State Board of Health. The use of wells for the disposal of sewage also raised important questions which cannot be solved without cooperation with the above departments. Studies of the mineral quality of underground waters raised problems which can only be solved by cooperative reseach with experts in the field of chemistry. Problems related to bacterial contamination of underground waters also involve cooperation with bacteriologists and involve a number of unknown factors.

Future problems of cooperative research which occur to mind at this time are:

(a) study of underground temperatures particularly the annual changes above the isothermal layer and the mean annual earth temperatures of different localities.

(b) underground travel and life of pathogenic bacteria.

(c) cause of mineralization of waters particularly with iron.

(d) study of relation of ground water level to rainfall.

(e) variation in mineralization of underground waters with change in rainfall

F. T. Thwaites, in charge of well records, Wisconsin Geological Survey

Dear Sir,

There will be a meeting of the Science Inquiry on Tuesday, December 3, 4:30, in my office, 158 Bascom Hall.

I hope that you will find it possible to attend.

Very truly yours,

GLENN FRANK

President