North Dakota Geological Survey

A. G. LEONARD, Director

Bulletin No. 6

Artesian Water Conservation Fund

HOWARD E. SIMPSON, WATER GEOLOGIST
IN CHARGE

Artesian Water Paper No. 4

A Method of Water Prospecting

BY

HOWARD E. SIMPSON

GRAND FORKS, N. DAK., 1927

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Illustration

The Water Supply of Harvey, N. Dak.*

A Method of Water Prospecting

By HOWARD E. SIMPSON

HISTORY OF EARLY SUPPLIES

For twenty years the city of Harvey, North Dakota, obtained its public water supply from the Sheyenne River. This water was impounded by means of a concrete dam built by the "Soo" Railway Company and pumped by the Company in its raw state directly into the mains and tank of the city system. The Railway Company, which has a division point here, was a larger consumer of this water than the city, which had a population of 2019 in 1925. This water was used throughout the city for fire protection, flushing streets and sewers, washing automobiles, and watering lawns and gardens. Being an impounded surface water in its raw state, it was polluted and unsanitary and unfit for drinking, cooking, and many other domestic purposes.

It was therefore necessary for the citizens to supplement this supply with water hauled from shallow wells and springs located near the outer edge of the city and retailed to the consumers from tank wagons. The expense, the danger from pollution, and the inconvenience of this supply made it highly unsatisfactory.

An attempt was made several years ago to secure a good domestic supply by drilling a deep artesian well to the Dakota Sandstone. This well was drilled to a depth of 2235 feet, being the deepest well in North Dakota. It was five inches in diameter above but finished at 1¼ inches below, and yielded 2½ gallons of soft but highly mineral water per minute. The original pressure was 24 pounds per square inch, but on August 10, 1922, the writer gauged it at 18 pounds and the yield had diminished to one gallon. On account of the slight flow and the highly mineral character of the water, this well was not used for a public supply except for occasional bucketfuls and for a public watering trough, but was permitted to waste into a sewer.

Several other attempts were made to locate a ground water supply suitable for public use within the city limits, but each attempt proved a failure and the impounded waters of the Sheyenne River remained the only available city supply for twenty years. The Sheyenne River ceases to flow in midsummer and the impounded waters became stagnant. This very unsatisfactory situation created a demand for an improved water supply and the Mayor and City Council called in T. R. Atkinson, Civil Engineer, and the State Water Geologist for consultation regarding a better supply.

*Reprinted from The North Dakota Engineer, Grand Forks, N. Dak., Vol. III, No. 3, March, 1927.

A GROUND WATER SURVEY

The Water Geologist recommended that a thorough and complete ground water survey of the city and vicinity be made to determine the best available water supply for the city, quantity and quality both considered. This recommendation was accepted and in response to a formal invitation through the City Auditor, the State Water Geologist made this survey on September 10 and 11, 1925. The survey was brief in view of two previous studies of this locality by the same geologist; the first during a general survey of the ground water resources of the state and second during a special survey of the artesian conditions of the Dakota Artesian Basin within North Dakota. As a result an oral report was submitted to the Mayor, Council and interested citizens assembled in the city hall and at their request a written report was prepared and submitted on September 15, 1925, in order that it might be available for the information of all interested and for permanent record.

This report reviewed the results of the several studies that had been made of the city and vicinity and included statements regarding the topography of the region, the several geological formations underlying the locality, the four possible sources of ground water supply for the city, and presented the following general conclusion:

THE GEOLOGIST'S CONCLUSIONS

"The best available source of public water supply for Harvey appears to be the underflow of the Sheyenne River Valley, the water filling the gravels beneath the alluvial deposits of the valley floor."

"In case the valley sands and gravels can be found in sufficient depth and coarseness beneath the alluvium there will be an abundance of water found within them since they receive the drainage of the surface deposits of this entire region. Through these relatively coarse deposits the shallow ground waters are gradually percolating down-valley, like waters through a great trough-like filter. The waters are generally quite independent of the water flowing in the river, being sealed off from the latter by the fine silts and muds which have been deposited by the stream itself. Very rarely and only in times of flood, does the river water pass into the underflow and even then it is filtered thru the fine alluvium. Except in dry regions the land does not drain the rivers; the rivers drain the land."

"The question to be considered and decided in this connection, therefore, is whether there is an abundance of valley gravel water and the best locality in which to secure the supply. It is most desirable on account of the cost of mains to secure it as near the city as possible."

THE GEOLOGIST'S RECOMMENDATIONS

Following these conclusions, recommendations were made for sinking test holes in the Sheyenne Valley floor; first immediately below the impounding dam in order that no possible supply near the city might be overlooked and then two and one-half miles northeast of the city where

the valley floor widened out into broad bottom lands, and where the Water Geologist believed water would be found in heavy gravel beds beneath the valley floor. It was recommended that at this point a series of five test holes be made in such way that their logs would give a good cross section of the filling beneath the valley floor. The basis for this opinion and recommendation lay in the fact that this portion of the valley was recognized as a portion of a deep pre-glacial valley partly filled with water borne glacial drift, and that if this material were sufficiently coarse to permit a good strong underflow, as it was expected it would be, there would be ample water here and of good quality for a city supply.

The method to be followed in the drilling of these test holes including size, depth, and kind of rig to be used and also the methods of logging, the sampling of both materials and water, and of making pumping tests were suggested and the report concluded with the following statement: "If these recommendations and those of the supplementary reports based upon the results obtained in prospecting are carried out, we are strongly of the opinion that a good wholesome supply of shallow ground water may be secured for a public supply for Harvey."

TEST DRILLING FOR WATER

The report was accepted and the engineer took charge of the test drilling and immediately began work in the two localities recommended. In the first test hole drilled down river, after passing through a few feet of alluvium, groundwater level was found at a depth of nine feet below the surface in a bed of coarse sand and this gradually became coarser until at a depth of 60 feet, the gravel could not be removed thru a 4 inch pipe by means of a sand bucket. The drill later penetrated this bed to a depth of 82 feet without reaching the bottom of the bed of very coarse gravel.

Extensive tests were then made to determine something of the area of this gravel deposit and the conclusion was reached that it would yield water in an amount sufficient for a city many times the size of Harvey.

A second progress report was made on the work of prospecting on December 31, 1925. This report indicated that the water geologist's belief that the valley floor two and one-half miles below the city was underlain by a considerable bed of water bearing gravel had been proven correct and that a much deeper bed of gravel, was found even than was anticipated. This second report concludes: "The location of this great gravel bed beneath the floor of the Sheyenne Valley and the coarseness of material below the ground water level indicates a volume of water which would probably be sufficient to supply almost any city in the state of North Dakota and the permanency of the supply is as certain as is the rainfall upon the hills to the west of the city from whence this supply comes."

Samples of water taken from the test hole at depths of 30 feet, 40 feet, and 60 feet were collected and analyzed and the analyses compared with a series of analyses of public supplies in cities in the vicinity of Harvey.

It was found that the quality of the water varied with the depth, becoming more strongly mineralized and having a somewhat disagreeable color, taste, and odor in the deeper portions of the bed. This is, no doubt, due to the fact that the deepest portion is somewhat pocketed, having less circulation than has the shallower water immediately beneath the valley floor where the movement of the underflow probably reached to a depth of 30 to 40 feet at least, keeping the waters both sweet and pure. No danger was anticipated of the lower waters being drawn up to the 40 foot level.

From the study of the water samples it was concluded that "we can anticipate very closely the kind of public supply which may be secured from this general source by taking the water from as near the surface as we may, while sinking the well deep enough to secure an ample amount. This will give the city a water very similar to that recently secured in a new supply accepted for the State Hospital at Jamestown, except that the Harvey water will be much freer from iron than is the hospital supply. In spite of the long standing belief to the contrary, Harvey may have a good and abundant water supply."

It was further recommended that sanitary analyses be made of the waters to determine their safety for drinking purposes.

DEVELOPING THE SUPPLY

The engineer was then directed to prepare plans and specifications for the well, pumping equipment, and mains leading to the city. Bids for the work were opened on April 19, 1926, the contract was let, the work carried out, and the first water was pumped into the city system on or about November 15, 1926.

Two Kelly wells, 285 feet apart, of porous concrete 25 inches in diameter were sunk to a depth of 41 feet and over the northernmost of these the pumping station of reinforced concrete and brick was constructed.

The pumping equipment consists of two 350 gallon per minute centrifugal pumps, the power being supplied by a 60 horse power Diesel engine. To one of these pumps is connected by a flexible coupling a 50 horsepower electric motor so that in case of any repairs to the engine the pump can be operated by the motor. Each pump is so connected to the wells that it can draw from either well or from both wells at the same time. Also both pumps can be placed in use at the same time by driving one with the engine and one with the motor.

The total suction lift is 25 feet when one pump is working at full rated capacity. The maximum drop of ground water level thus far noted has been but seven and two-thirds feet. The total static head pumped against is 200 feet and the total head pumped against, including friction head when one pump is working at full rated capacity is 250 feet.

The water is pumped through an eight inch cast iron main from the pumping station to the elevated tank in the city and flows from this tank to the distribution system. This force main is 12,813 feet long and has gate valves along the line in order that any section may be shut off for repairs at any time.

Careful examinations were made by the State Public Health Laboratory, but none of the examinations have ever shown the presence of harmful bacteria at the pump station. No chemical treatment will be required after the old mains are thoroughly cleaned.

The water is so much better for boiler purposes than the old river water supply that the city has made a contract to supply the "Soo" Railway Company with all the water used at this point for a term of five years. The company has been using an average of 150,000 gallons daily, since the pumps were started, and the total pumpage is about 200,000 gallons daily.

This review of the development of the Harvey water supply has been given to illustrate the method of prospecting for water developed in North Dakota by the State Water Geologist, the State Public Health Laboratory cooperating.

A METHOD OF WATER PROSPECTING

The solution of the problem of obtaining the best available supply of ground water for any city or village requires the services of three or four men each trained and experienced in water work in a distinct scientific field. These are a geologist, a chemist, a bacteriologist, and an engineer. It may be possible in some cases to combine in a single analyst the work of both chemist and bacteriologist. The duty of the geologist is to locate the water in sufficient quantity, the analyst to determine the quality of the same both as to chemical content and freedom from harmful bacteria, and the engineer to pass upon the feasibility and method of its economic utilization.

First to consider the problem is the geologist. He should know not only the general modes of occurrence of ground water but should be familiar with the stratigraphy and structure of the rocks of the region in which he is to work. In case he has not this knowledge of the local region his first duty before entering the field is to obtain as much information as possible from published reports.

On entering the field he should make a complete survey of the topography, geology, and ground water resources by a careful tour throughout the region, an examination of all available outcrops, a study of the logs of the wells already drilled and of the springs and streams in the vicinity of the city. His best information outside the published material on the subject may be obtained from the local well drillers. The information thus obtained may seem very incomplete and unsatisfactory but it becomes very useful and valuable when compared and correlated with the topography, stratigraphy, and geological structure of the region.

A two-quart sample of water should be collected for chemical analyses from the best of each type of wells in the neighborhood, shallow as well as deep. The sanitary conditions of the surroundings of possible shallow supplies should be noted and one-pint samples taken in sterile glass bottles, and placed in iced containers furnished by the Public Health Laboratory.

Springs should be visited, measurements of flow and samples of water taken, and a careful study of the locality of each made to determine the quality and quantity of any possible supply which might be developed from this source.

The entire region within a radius of two to ten miles from the city depending upon the size of the city and amount of water needed should be examined for glacial gravel deposits, including kames, sandplains, outwash plains, and valley trains and preglacial valleys filled with gravel and sand and other glacial debris. Such a survey can ordinarily be made in from one day to one week and a week or more must be allowed for the analyses of the waters. Following this a preliminary report may be submitted which will outline the several possible sources, including available surface waters, weigh the advantages and disadvantages of each as fully as data at hand will permit, give conclusions as to the best available location and horizon and close with recommendations, if necessary for further prospecting with the drill.

Progress reports follow as needed to keep the city officials and citizens advised. When the test hole drilling has been completed, all analyses made and advise secured from the engineer as to the availability of the various supplies, a final report may be made to the Mayor and Council. The development then becomes a problem for the engineer in which he should seek the advice of the Water Geologist in matters pertaining to size, depth, number and spacing of well, and methods of finishing so that the best supply, quantity and quality both considered, may be obtained.

The City Pumping Plant and Park House at Minot, North Dakota
A Result of Water Prospecting

THE THIRD BIENNIAL REPORT

of the

STATE WATER GEOLOGIST

In Charge of the Artesian Water Conservation Fund*

INTRODUCTION

The work of the State Water Geologist has two principal objects as defined by North Dakota law, namely: to conserve the artesian waters of the state and to assist the citizens to secure the largest and best available water supplies for both private and public use. In furtherance of these objects the Water Geologist is endeavoring to formulate a constructive program under which the natural ground water resources may be of the largest possible use to the people of North Dakota.

The plans have been worked out for the reduction of waste from flowing wells and thru a program of education and inspection we confidently believe the rapid rate of decrease of pressure and flow has been materially reduced and that wells are flowing today which would not be flowing were it not for this program. We also firmly believe that if all unnecessary discharge is stopped most of the existing flowing wells may be saved, at least for a long period of time in the future. This may be done without hardship to the owner. Conservation means efficient use. Ground waters like any other mineral resources must be used to be of value. A recent report of the United States Geological Survey following a personal investigation by the Chief Water Geologist of our conservation program in the field "shows that the law passed by the State Legislature in 1921 has already greatly reduced the waste, checked the decline in pressure, and kept wells flowing that would otherwise have failed by this time or would fail in the near future." The entire report of the Federal Government strongly endorses the state policy of conservation. It advises "Every owner of a flowing well in this artesian basin should, for his own good and that of his neighbor, give his utmost support to this program for saving the artesian water." (See U. S. G. S. Water Supply Paper No. 520, page 94). The Chief Water Geologist also pronounces this "The first adequate attempt to conserve artesian waters on a large scale." (Dr. O. E. Meinzer, addressing The State Grain Growers, Fargo, January, 1925).

Equally important is the development of better ground waters for both farm and city supply. That the villages and cities should have the best available water supplies for domestic and industrial uses, quantity and quality both considered, has come to be generally recognized and many cities and towns of the state are now equipped with water supplies developed upon the recommendation of the Water Geologist after a careful survey of the ground water resources of the locality.

*Submitted in mimeographed form to the Governor and the Twentieth Legislative Assembly of the State of North Dakota, 1927.

The importance of having the best available water supply on the farm is just beginning to be recognized. The rapid diversification in farming and the development of the dairying interests in the state is greatly increasing the need for good wholesome farm water supplies. The place of ground water in the development program for a Better North Dakota is not second even to that of the rich coal and clay resources of the state; it is paramount.

NEW ARTESIAN LEGISLATION

The artesian water conservation law passed by the Legislative Assembly of 1921 was greatly strengthened by an amendment passed by the Legislative Assembly of 1925. By this amendment the "owner of an artesian well shall be required, by means of the construction of a reservoir or otherwise, to prevent the flow of his well from running upon land belonging to another or from running into any ditch along any public highway except a regularly established drainage ditch."

While intended primarily as a measure for the improvement of road conditions thru the drying up of many impassable mud holes, this measure acts strongly to conserve the artesian waters by the curtailment of a large amount of the waste that formerly went into the roads and ditches and upon the land of others. Under this law, which has the support of all who appreciate the need of good roads, only that amount of water may flow from an artesian well which may be impounded upon the owner's land and only that amount can be impounded which will either evaporate or be absorbed into the soil.

The flooding of the land and the resulting absorption of the artesian water by the soil are both highly detrimental to the land, since land, once it has been flooded even for a single season, cannot be used for any economic purpose except possibly as yardage for stock. The land damage from the excessive impounding of artesian water is thus very great and must be and will be avoided.

THE FIELD SEASON OF 1925

Owing to the absence of the Water Geologist from the state during the summer of 1925, little field work was done during that season. No experienced water geologists were available and no well drillers experienced in the work on artesian wells could be secured, at the per diem allowed by state law, to carry on the work of inspection. This part of the work was therefore held in abeyance until the next season.

THE FIELD SEASON OF 1926

Immediately after the close of the University, the Water Geologist entered the field using the Ford car purchased by the Artesian Water Fund in 1921. Robert B. Simpson drove the car and served as Assistant in the measurement of the wells. By the use of sleeping adjustments on the car and an auto tent, field expenses were greatly reduced and in many instances much time formerly spent in driving to hotels was saved, meals being taken at any village or occasionally from a small stock of food supplies carried in the car.

By these means the Water Geologist was able to complete the inspection of all artesian wells, flowing and non-flowing, in about forty townships, working on the average of about one township per day during the time available, the remainder of the season being occupied with surveys for village and city water supplies, and with the necessary office work. The forty townships inspected were taken in belts across the artesian basin from east to west, the belts being spaced in such a way as to gain the greatest amount of information regarding conditions in the basin. Belts of townships were thus surveyed in Grand Forks, Cass, Richland, Ransom, and LaMoure Counties. These included many townships in the Red River Valley as well as in that portion of the Dakota Basin where deeper wells prevail.

CO-OPERATION IN SOUTH DAKOTA

Near the close of the field season a trip was made to Pierre, South Dakota for conference with State Engineer John Berg and others, relative to a closer co-operation between these two states possessing the major interest in the Dakota Artesian Basin. The desirability of uniform legislation regarding the conservation of the artesian waters thru the reduction of waste, the proper methods of drilling, casing and finishing of the wells, and the closing of old leakers and wild wells was thoroly reviewed in this conference. On the return an interview was had with United States Senator Norbeck, formerly Governor of South Dakota, who as one of the leading drillers of artesian wells in the Dakota basin has long been an advocate of the conservation of artesian waters and is the author of the present artesian water legislation in South Dakota.

The results of this conference undoubtedly will be a closer co-operation in the work of those in charge of the administration of the artesian water conservation laws and the promotion of better and more nearly uniform legislation for the states sharing the Dakota Artesian Basin.

GENERAL CORRESPONDENCE AND ADVICE

That portion of the state law which provides that the State Water Geologist "shall have the power of oversight and supervision of the waters of the state, and shall advise the citizens of the state as to the practicability of measures affecting the underground waters of the state" has been interpreted to refer to all ground water supplies both individual and public. The further statement that it shall be his duty to "council and consult with the owner and assist him to work out the most desirable control and use of his well", as interpreted, also applies to municipalities as well as individuals and to all ground water supplies including ordinary pump wells and springs as well as to artesians.

This being the interpretation, the Water Geologist has gladly answered all requests for information and advised all who asked as fully and completely as was within his power. This has meant scores of personal interviews in the office, hundreds of individual letters each

requiring suggestions or advice upon particular problems, and literally thousands of circular letters, circulars and reports mailed. He has not felt that this service was to be limited only to the citizens of this state, and the mail has carried responses to inquiries and requests for advice to many states in the Union and to several foreign countries.

The office work involved in this correspondence and in the preparation of this advice and the several reports has occupied most of the holidays of the University year and the shorter vacations, as well as considerable portions of the summer season. This has required clerical assistance and some technically trained service in the drafting of maps.

RELATIONS WITH WELL DRILLERS

It has been the aim of the Water Geologist to give special service to the well drillers of the state in order that they may in turn render the best and most efficient service to the citizens for whom they must be the local water supply experts. In addition to the personal consultation and advice and to the correspondence referred to above, this has involved the examination of a great many samples and series of samples of drill cuttings. Advice has been given regarding the formations in which drilling was being done and the advisability of continuing the drilling in hopes of securing a larger and better quantity of water or of stopping the drill to save needless additional expense. In the latter case advice usually was given for the development to the largest possible degree the shallower veins already encountered and passed in order to secure the best supply available, both quality and quantity being important considerations.

THE NORTH DAKOTA WELL DRILLERS ASSOCIATION

Service has not only been rendered to the individual drillers and drilling firms but in a larger degree to the North Dakota Well Drillers Association. This association grew out of a need for better wells on the farms and villages in North Dakota and for better conditions in the well drilling business. So far as known, no attempt had been made to meet this need until the organization of this association under the advice of the Water Geologist.

In opening the first meeting in 1915 he spoke as follows: "It is hoped that this may be the first of a series of annual meetings in the nature of institutes in this and other states which will bring about a better knowledge of the geologic conditions and of the occurrence of ground water, and a better understanding of the ways of obtaining it for man's use by means of the drill. The result would be of value to the driller and of greater value to the people because of the better and more wholesome supply of water obtained, and water is one of the most fundamental natural resources on which the prosperity of the people depends."

This hope has been largely realized in the annual meetings that have been held since the initial meeting. The 1922 and 1925 meetings were of especial interest because of the presence of Dr. O. E. Meinzer, Chief

of the Ground Water Division of the U. S. Geological Survey. Concerning the former meeting, he says: "The North Dakota Well Drillers' Association is said to be the only organization of its kind in the country. * * * * In a sense the annual three-day meetings of the association may be regarded as a well drillers' school in which the drillers are instructed in the elements of geology, sanitation and technology relating to their work. It is composed essentially of drillers of water wells, and the slogan continually emphasized by the State Water Geologist is that the members should learn to be not only skillful drillers but also the competent water supply specialists for their respective communities."

OTHER WELL DRILLERS ASSOCIATIONS

The idea incorporated into the North Dakota Well Drillers' Association has spread to other states. The Minnesota association, having the same constitution and aim as parent association, has outgrown it in strength and members. The Water Geologist was invited to deliver the address at the annual dinner of the association last February and spoke to a group of over 200 drillers and those closely interested in the drilling business at the St. James Hotel in St. Paul on the theme, "The Conservation and Use of Ground Waters." He has advised, thru correspondence, smaller yet similar groups in South Dakota, Iowa, Nebraska, Michigan, and California.

CITY AND VILLAGE SURVEYS

As in previous years several cities and villages have requested surveys of their ground water resources to determine the best water available for public use. In such cases the Water Geologist has made these surveys, collected samples of water for analysis, and submitted the reports which in most cases have recommended certain lines and methods of prospecting to determine the conditions more fully than it was possible to do by the survey alone. Supplementary reports were made during the period of prospecting, followed by final reports upon which the supervising engineers have based their work of development and installation. In this work the State Public Health Laboratory has co-operated by making the analyses, both sanitary and chemical, of all samples of water submitted to it, and the Department of Chemistry of the University has assisted with chemical analyses of special samples of water and rock material. Always the aim of this work is to determine the best supply of water, surface or ground, available for the public use. In these surveys, since the service was of especial value to but a limited number of citizens, the bills for the expense of the surveys including per diems, calculated exactly as in the state service, have been presented to the city rather than to the state in order that the very limited appropriation may be conserved and expended for the larger good.

During this biennium survey work has been completed and new or additional supplies have been installed or are in process of being developed at the State Hospital for the Insane at Jamestown and in the cities of

Jamestown, Harvey, Crosby, Bottineau, and Lisbon. A survey and preliminary report has been made at Berthold, and special reports have been made concerning ground water conditions at Langdon, Fargo, and Devils Lake.

PUBLICATIONS

The third pamphlet in the series of Artesian Water Papers has been prepared and published by the Artesian Water Fund. This is entitled "The Conservation of Artesian Waters" and includes:

1. A paper entitled "The Principles of Conservation as Applied to Artesian Waters", by Howard E. Simpson, reprinted from the Quarterly Journal of the University of North Dakota.

2. The Artesian Water Law passed by the Legislative Assembly of 1921 as revised by the Legislative Assembly of 1925.

3. The Second Biennial Report of the State Water Geologist, originally submitted in mimeographed form to the Legislative Assembly in January, 1925.

This paper was published in an issue of 5000. A printing of 2000 separates of the revised Artesian Water Law of North Dakota was made in order that copies of the law may be available for distribution with letters of advice to the owners of flowing wells. The two previous artesian water papers, No. 1, "Artesian Water Conditions in North Dakota", 1923, and No. 2, "Methods of Reducing the Flow of Artesian Wells", 1925, are still available for distribution. All expense for printing these papers has been borne by the Artesian Water Fund.

A COURSE IN WATER GEOLOGY

A course in "Water Geology" was given during the last academic year to a group of advanced students in civil engineering in the University in order to fit them better to deal with the problems arising in the development and installation of water supplies and in construction work such as highways, railways, bridge abutments, dam supports, building foundations, etc. This is one of the first three courses offered in this subject in America, the others being offered in the universities of California and Hawaii during the year. The course was given as a regular part of the university curriculum.

EXPERIMENTAL STUDIES

Plans are being made for a more intensive study of the artesian conditions in the Dakota Artesian Basin. This should include experimental studies to obtain definite and precise information regarding the fluctuation of artesian water head and the leakage from the artesian horizons to higher strata thru the wells.

Measurements on the changes of water level can best be made on the dead artesians on either margin of the basin. This has been done in a preliminary way by tape but should be more systematically done on several wells in order to select a few type wells for detailed study. Fluctuations in head of the artesian formation can best be studied by

the establishment of automatic water level recorders, which will permit more precise observations than have been made in the past. For this purpose the Edgeley City Council has already granted the use of the old city well as one to be experimentally studied.

The United States Geological Survey has had an Au current meter especially designed for experimental work on the small diameter wells of North and South Dakota and Hawaii and offers the loan of the instrument for the study of the currents in the well. Work with this meter should give definite and convincing information as to whether or not there is subsurface leakage in the artesian wells of the basin. This leakage is believed to be slight and confined chiefly to the drift formations, a waste which can be readily checked by outer casings, if known. It is believed that the current meter will be very valuable to drillers and owners in locating leaks in old casings and thus simplifying the repair of old wells. One artesian driller suggests, "In five years, I believe, we will not undertake to repair a deep artesian until it has been studied with a current meter to locate the place of needed repairs." This work would be valuable to the owner in saving repair bills and frequently in avoiding the drilling of new wells.

RECOMMENDATIONS

The program for the next biennium will be much the same as that of the past biennium with the additions suggested above:

1. "Stopping the waste of water while permitting unlimited use" should remain the essential principle of the program for the conservation of artesian waters. **Conservation means efficient use.**

2. The census taken first in 1921, which has been omitted for two years in order to conserve the appropriation, should be carefully rechecked in 1927 by the assessors working under the county auditors, and the card index of flowing wells, now numbering over 6,000 should be revised immediately thereafter.

3. The inspection of individual flowing wells, with direct advice to the well owners in the field, should be carried to completion as fast as the appropriations permit. This advice covers the changes necessary to bring the well into full compliance with the law and includes suggestions for the improvement and development of the farm water supply that it may yield the best and most satisfactory results.

4. More attention should be given to the most serious problems involved in "wild wells", "old leakers", and the situations in which large waste of water and damage to land and public highways are involved.

5. The policy of bringing about the enforcement of the law by education, especially by the creation of public sentiment in so far as is possible, rather than by compulsion should be continued. But owners who fail to comply with the instructions following inspection should be brought to compliance thru the process of law where necessary for the public good.

6. The inspection gives a basis on which the assistance of local county and township officers should be invoked for aid in carrying out the provisions of the law. Ample provision is made in the law to protect owners from any mistaken or arbitrary decision by the Water Geologist thru right of appeal to a board of arbitration.

7. Co-operation with the Ground Water Division of the United States Geological Survey in furthering conservation should be continued since the members of the Federal and State Geological Surveys are agreed that "the conservation of water already effected and the further conservation outlined will have an important effect in keeping the wells flowing. * * * * The conditions are certainly hopeful to justify a thoro trial of this program."

8. Surveys of ground water conditions for cities, villages, and industrial plants to determine the best available water supply for each should be undertaken on request whenever possible to arrange for such survey.

9. Equal in importance with the administration of the program of conservation of flowing wells should be a program of development thru experimental studies of ground water supplies on the farms. This is essential to diversified farming and the development of the livestock and dairying interests.

10. The Water Geologist should assist in the standardization of drilled farm wells. Good wells can only be obtained thru proper methods of drilling and finishing. This means the recognition of certain standards so that every farm owner may know when he has a good well and whether he has paid a fair price for it.

These recommendations will guide the State Water Geologist in his work during the next biennium. For these ends we respectfully request that the present biennial appropriation be continued as the least amount with which the program outlined may be carried forward. The current balance due to absence of the Water Geologist from the state during much of the first field season of the biennium, the suspension of the annual census in both years, and the desire to undertake the more intensive experimental work outlined above in 1927, will be utilized before July 1st of this year.

The program outlined above will, we believe, bring about the almost universal observance of artesian water conservation within a few years and will by making possible better farm and city water supplies be of great benefit to the economic prosperity, health and well-being of our people.

Respectfully submitted,

HOWARD E. SIMPSON,

State Water Geologist.

Grand Forks, N. Dak.,
January 3, 1927.

ARTESIAN WATER PAPERS

BULLETINS

OF THE

NORTH DAKOTA GEOLOGICAL SURVEY

No. 1. Artesian Water Conditions in North Dakota, By Howard E. Simpson. 1923. 8 p. (Bulletin No. 2, N. D. G. S.)

No. 2. Methods of Reducing the Flow of Artesian Wells, by Howard E. Simpson. 1924. 4 p. (Bulletin No. 3, N. D. G. S.)

No. 3. The Conservation of Artesian Water, by Howard E. Simpson. 1926. 24 p. (Bulletin No. 5, N. D. G. S.)

No. 4. A Method of Water Prospecting, by Howard E. Simpson. 1927. 20 p. (Bulletin No. 6, N. D. G. S.)

Artesian Water Papers will be sent free on receipt of request addressed to The State Water Geologist, University Station, Grand Forks, N. Dak., accompanied by three cents postage.
