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STATE OF SOUTH DAKOTA
Joe Foss, Governor

STATE GEOLOGICAL SURVEY
E. P. Rothrock, State Geologist

REPORT OF INVESTIGATIONS

NO. 78

GROUND WATER RESERVOIRS
NEAR
ABERDEEN, SOUTH DAKOTA

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by

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I. INTRODUCTION

The city of Aberdeen was originally supplied with water from artesian wells and a considerable number of them had been drilled in and about the city by the city and the Milwaukee railroad as well as by farmers in the immediate vicinity. The well water, however, had some disadvantages as a city water supply, one of which was the difficulty of developing a large enough well field to supply the city as its population increased. There was also a difficulty due to the corrosive qualities of the water which made it difficult to keep water mains and plumbing in repair. The heavy draft on the reservoir began to tell on the head and the time arrived when wells no longer flowed but had to be pumped. These and other factors combined to prod the city into seeking other supplies. As a result shortly after the drouth of 1934 a large dam was built on Willow Creek 17 miles northwest of the city and an expensive pipeline and filtration plant erected to take care of the city's needs. Had the dam filled, it would have made an excellent source of water, but the drouth had lowered the water table to a point where it took several years to get water impounded behind the dam. The first winter after the dam finally filled, water found a tiny channel underneath the apron and washed out the entire spillway to such an extent that it has never been rebuilt. The city, therefore, has been depending upon three small dams in the lower parts of Elm River and because of the abundance of rainfall these have proven sufficient. However, certain far-sighted citizens have not been satisfied to operate a city of this size so close to the possibility of a water famine, and in 1948 the city manager, Mr. H. M. Pierce and Mayor J. E. Gorder requested the governor, the Hon. George T. Mickelson, to permit the Geological Survey to look into the situation and ascertain whether other water supplies were available. Consequently a party of four including the State Geologist, Messrs. Robert E. Curtiss, Garner Waddell, and Carl A. Carlson, Jr., was dispatched to Brown County for the summer's field work. This party investigated all the surface possibilities and well records available and found several reservoirs which might help.

A change in the city administration caused the project to be dropped until the summer of 1953. The work of the U. S. Reclamation Bureau, in connection with the Oahe dam and the possibility of making a large-scale irrigation project in the James Valley, disclosed a large buried channel which looked as though it should continue northward near enough to the city to make a good water reservoir. The Survey of its own accord, therefore, sent a geophysical party in to see whether the surmise was correct. This party consisted of Messrs. Bruno C. Petsch, Akeley Miller, R. R. Ruelle, R. C. Wilson, and W. L. Foley. The city of Aberdeen cooperated by drilling three check wells for use in interpreting the geophysical curves.

The following report therefore is a summary of the information gleaned from all these sources as well as much other data from the files of the State Geological Survey and the office of the City Engineer in Aberdeen.

In order to be logical the reservoirs will be divided into: 1. surface water reservoirs, 2. artesian reservoirs, and 3. shallow well reservoirs. The first will include the natural lakes and impounded waters; the second, waters which rise above their reservoirs due to hydrostatic pressure within the reservoir; and third, shallow well reservoirs in which there are no such pressures and which lie within two or three hundred feet of the surface.

It is hoped that this investigation will be of assistance to those in charge of developing a water supply for the city of Aberdeen. The increase in size of the city and the increase in the use of water by individual citizens and industries is making water a problem for all communities not situated on a large body of water or on a big river. While there seems to be abundant water for such places, its development requires an intelligent use of all the possible reservoirs. For this reason, they are all discussed in this report rather than confining it to one or two possible water sources.

II. SURFACE WATER SUPPLIES

Surface water has many advantages over underground water, particularly in the lack of chemical salts which harden grand water, and of iron, magnesium and manganese compounds which not only spoil its taste but are hard on plumbing. In normal times a city can be adequately supplied with surface water. However, periods of drouth have visited South Dakota and under these conditions no surface supply has been adequate. Drouths have occurred in very recent years which have either dried up the waters in streams, lakes and reservoirs entirely or reduced them to levels which made the water unfit for human use. A comprehensive report on the surface water possibilities has been made for the city of Aberdeen. Hence, this phase of the water supply will be discussed only briefly in this report.

Natural Surface Reservoirs

Two sources of surface water are available to the city from natural surface reservoirs; the Sand Lake-Lake Columbia and the Lords Lake basins offer some possibilities. Of these two the first would give the more adequate supply since it lies in a basin approximately 20 miles long and a mile wide, and since this basin lies in the sandy delta which covers the northern part of the Lake Dakota basin. A large volume of water is therefore available and the James River and surrounding sands offer large volumes of water for recharging these lakes.

The lower end of this basin lies about ten or twelve miles airline northeast of Aberdeen near the city of Columbia. The distance from the city would probably prevent this source from being used. However, the present filter plant lies about half way between the city and Columbia. The installation necessary to tap this source, therefore, would only need about five miles of pipeline and the pumps necessary to deliver water to the present filtration plant. Pipelines and pumping equipment now installed in the plant could carry water to the city.

Lords Lake lies in a small basin about six miles southwest of the city. It covers an area of about 300 acres. It has no recharge except from surface run-off. Because of its small size and lack of recharging facilities, it is doubtful that this could be more than an emergency supply. It is also a long way from the present filtration facilities.

Impounded Surface Water

Impounding stream water has been tried by the city with unfortunate results as stated in the introduction. However, this attempt does not condemn these surface reservoirs. They offer, perhaps, the best and cheapest source of surface water available to the city, and should be carefully considered in planning the city's water supply.

The most accessible sites are in the small stream valleys west of the city. Elm River, Foot Creek and Snake Creek flow in valleys which offer dam sites which would impound lakes 20 to 60 feet deep. These valleys are sufficiently narrow to allow the impounding of large volumes of water without the danger of flooding uplands surrounding the valley during times of high run-off. Lake Parmely behind the Mina dam on Snake Creek, the lake behind the Richmond Dam on Foot Creek, and the short lived lake behind the Willow Creek Dam on a large tributary of Elm River, show the possibilities of these sites. These streams all have large collecting areas and with proper construction it should be possible to make dams which would impound sufficient water on one or all of these streams to take care of the city's needs most of the time. However, there is the ever present possibility of drouth similiar to the drouths of 1893 and 1934 in which all surface supplies can go dry.

A standby source of supply would seem to be indicated to supplement these surface waters in times of emergency.

III. ARTESIAN RESERVOIRS

The artesian reservoirs offer the largest source of ground water available to the city. Some of the first flowing wells in the State were drilled in the vicinity of Aberdeen and for many years these wells furnished the only city supplies. More than a score of wells have been drilled within the present city limits but records do not give very much detailed information on their geology. By piecing together the drillers' records on recent wells and a fragmentary set of well samples in the Survey's collections the following facts become evident.

Depths to Reservoirs

1. The total depth to which water bearing sands extend beneath Aberdeen is 1260 feet. Below this it is useless to prospect since the rocks are dense metamorphic and igneous varieties with very low porosity and permeability and belong to what the drillers call "granite". These rocks are extremely hard and expensive to drill and the only water they contain comes from cracks or shattered zones which may occur in them. Their porosity is less than 2% and the chance of hitting a shattered zone which would yield large volumes of water is extremely remote.

2. The highest water sand reported lies between 800 and 910 feet below the surface. One well reports two different flows in this sand, rating one at 380 gallons per minute. This sand correlates with the Dakota formation because of its position. Though no fossils are available it is the first heavy sand below a horizon of lime shells reaching from 510 to 560 which has been identified as Greenhorn limestone. It also lies immediately above 100 feet of a bluish shale impregnated with tiny pellets of manganese carbonate. These pellets have been consistently followed across South Dakota in wells between outcrops of the Fuson formation in the Black Hills and near Sioux City, Iowa. If these pellets are to be relied upon in the Aberdeen vicinity then the water sand we are describing would be placed as Dakota.

3. Immediately below the manganese pellet zone is a 10 foot water sand which has yielded water in some wells but apparently not in the largest volumes. For 65 feet below this upper water sand the section continues to be sandy with either shale partings or a sandy shale. This undoubtedly is part of the Lakota formation. Between 1065 and 1100, however, the sand apparently loosened up enough to allow a heavy flow of artesian water. One report states this would yield 400 gallons per minute. This is one of the chief water horizons according to available records.

4. The lowest water sand is 30 feet thick and will be encountered between 1180 and 1210 feet below the surface. This sand has been reported as yielding 900 gallons per minute. The fact that 80 feet of glauconite clay, pink and grey shale and bentonite lies between it and the water sand described above, indicates that it belongs to the Sundance formation. Glauconite, bentonite and pastel colors are all characteristic of the Sundance formation. Glauconite can also be found in the Cambrian rocks but their hues are usually dark, reddish or dark green, and bentonite is not a constituent. Fifty feet of quartzite immediately underlying the water sand may be a cemented part of the same formation which would give a sand body of 80 feet thickness. Beneath this quartzite is the typical Pre-Cambrian granite discussed above.

From the information at hand, therefore, it appears that artesian water can be had from three reservoirs beneath Aberdeen: the Dakota formation, 800 to 910; the Lakota formation, 900 to 1100; and the Sundance formation, 1180 to 1260.

It should be noted that parts of these sand bodies are tight and will not yield water because of impermeable clays or shales mixed with the sands. However, at least one flow can be expected in each formation and in some it may be possible to encounter two or more.

A composite log made from the information now available follows:

(See page 7)

Composite Log
from
Artesian Wells Drilled in Aberdeen, S. Dak.

Feet Feet	
0- 90 or 180	Glacial drift; boulder clay, sands and gravels.
90-180	Blue clay. Identified as Sharon Springs member of the Pierre formation.
180-310	Marl and chalk. Dark grey clays speckled white, identified as Niobrara formation.
350-510	Shale, grey, Carlile formation
510-560	Lime shells and limestone. Identified by Inoceramus shell prisms as Greenhorn formation.
560-700	Shale, probably correlates with the Graneros formation.
700-710	Sand
710-800	Shale
800-910	water sand with partings of light grey shale two flows noted. Probably correlates with the Dakota formation.
910-990	Blue shale with manganese pellets near top which identify it as Fuson formation.
990-1000	Water sand
1000-1065	Shale and sand
1065-1100	Water sand, heavy flow
1100-1135	Conglomerate
1135-1160	Glauconitic clay indicating Sundance formation.
1160-1180	Bentonite, pink and grey shale
1180-1210	Water sand
1210-1260	Quartzite
1260-1300 plus	Pre-Cambrian, granite

Character of the Water

It is impossible to give accurate information on the character of the waters from the individual reservoirs which have been outlined above. For some reason there seems to have been little interest in obtaining a complete analysis of these waters and only a few are available. A second difficulty is that the individual wells produce from more than one horizon. The waters are therefore mixed and the analyses are a composite of from two to four different waters. The information at hand, however, does give some idea of the character and useability of the waters in these reservoirs.

There are reports of soft water in the upper flows. However, all analyses available show the waters to be hard. The analyses which follow show that this hardness is largely the so-called permanent type caused by the inclusion of a high percentage of the sulphur trioxide (SO_3) radicle among the salts dissolved in the water. Temporary or carbonate (CO_3) hardness is present but always in minor amounts. Because the permanent hardness is extremely difficult and expensive to remove there is probably little use in considering treatment plants to soften it.

The water, however, is fresh, none of the analyses showing over 200 parts per million of salt. Most of them show less than 100. As it takes 500 parts per million to cause the water to taste brackish, the salt content offers no objection for the ordinary uses to which city supplies are put.

There is an objectionable taste to most artesian water in South Dakota, however, especially on the part of users who are accustomed to surface waters or shallow well water. This is usually described as a bitter taste though that is not exactly the word for it. The taste comes largely from iron sulphate which is contained in the water. Many South Dakota waters have lost this taste either in part or in whole when wells had to be pumped with an air lift. The air oxidizes the iron sulphate and removes the taste to such an extent that it is not objectionable.

One very objectionable feature is the fact that the water is corrosive due probably to the amount of iron sulphate it contains. This is especially hard on the ordinary well casing, water mains and plumbing fixtures which are made of iron or steel. Well casings are usually corroded through in a few years. Much of this can be overcome, however, by proper cementing outside of the casing and by use of materials such as brass and plastic in pipes and other water conduits.

Most of this water is not objectionable for lawn sprinkling and irrigation.

The total solids in the artesian water is high. All analyses available show more than 2000 parts per million. In standard water the total solids run less than 1000.

In summary, therefore, these artesian horizons offer a fresh hard corrosive water with a slightly objectionable taste. They are very useable, however, and subject to minor treatment. With the proper use and well construction they can furnish a very acceptable supply for the city.

One of the oldest analyses available was published in U. S. Geological Survey 17th Annual Report, Part 2, p. 677, in 1896, and labeled simply Aberdeen. The water probably came from the upper flows or Dakota formation since none of the early wells were drilled to the lower horizons.

Aberdeen City Water

Well: Not given
Date: Before 1896
Analyst: Professor James H. Sheppard
Dept. Chemistry
South Dakota Agricultural College, Brookings

	Parts Per Million
$NaCl$	23.81
Na_2SO_4	165.38
Na_2CO_3	1.08
$MgSO_4$	.....
$MgCO_3$	8.11
$CaSO_4$	.....
$CaCO_3$	8.79
Total Solids	2073.5

Aberdeen City Water

Well: Loyd Street and 12th Avenue
Date: 1904
Analyst: F. E. Norton
Assistant Chemist
South Dakota Agricultural College, Brookings
Source: U.S.G.S. Folio 165
Reservoir lowest sand (probably Sundance)

		Parts Per Million
Silica	(SiO_2)	30
Oxides of iron & aluminum	($Fe_2O_3+Al_2O_3$)	10
Calcium	(Ca)	178
Magnesium	(Mg)	26
Sodium & potassium	(Na+K)	440
Lithium	(Li)	Trace
Carbonate radicle	(CO_3)	38
Sulphate radicle	(SO_4)	1285
Chlorine	(Cl)	72
Total Solids by evaporation		2078

Aberdeen City Well #4

Location: Jay and 2nd Avenue NE
Date: 1895
Analyst: J. H. Sheppard
Source: U.S.G.S. Folio 165
Reservoir probably mixture of Dakota and Lakota water

		Parts Per Million
Silica	(SiO_2)	9.8
Iron & aluminum oxide	(Fe_2O_3/Al_2O_3)	9.4
Calcium	(Ca)	35
Magnesium	(Mg)	23
Sodium & potasium	(Na/K)	635
Lithium	(Li)	Trace
Carbonate radicle	(CO_3)	117
Sulphate radicle	(SO_4)	1118
Chlorine	(Cl)	134
Total Solids		2090

City Water Aberdeen

Well: Not given, probably new well
Date: 1926
Analyst: Carl B. Stone
State Chemical Laboratory
Vermillion, South Dakota
Source: Analysis reported by State Chemical Laboratory
Reservoir: From depth of well, 1150 feet, and statement that it was cased to top of sandstone layer, the reservoir should be in Lakota formation.

		Parts Per Million
Chlorine	(Cl)	70.9
Sulphur trioxide	(SO_3)	890.5
Calcium oxide	(CO_2)	290.8
Magnesium oxide	(MgO)	100.2
Iron & aluminum oxides	(Fe_2O_3/Al_2O_3)	7.3
Silica	(SiO_2)	10.2
Total Solids		2104.1

Sodium Chloride	116.8
Sodium Sulphate	963.8
Magnesium Sulphate	299.1
Calcium Sulphate	269.1
Calcium Carbonate	321.1
Iron & aluminum oxides	7.3
Silica	10.2
Organic & volatile matter	116.7
Total Solids	2104.1

Total Hardness Calculated as Calcium Carbonate

Calcium oxide - Calcium carbonate	518.8
Magnesium oxide - Calcium carbonate	248.7
Total Hardness	767.5

Use of Artesian Waters

Since this great water source is so easily available to Aberdeen, it should not be overlooked in planning for the city's future water needs. Twice since the State has been settled disastrous dry periods have visited South Dakota. Both times all surface supplies dried up and shallow ground water supplies were depleted to a point where a famine threatened most communities. For such emergencies the artesian reservoirs offer an excellent standby supply, which with reasonable development and use will be inexhaustible.

To use this source for a city the size of Aberdeen, however, it will be necessary to develop a well field, as no single well can supply the water in volumes necessary for the contemplated present use and future growth of the city. The first requirement would be to insure the proper spacing between wells in such a field. Otherwise, with high production, the wells will be stealing water from each other and cause inefficiency in production and a lowering of the volumes each well will yield. Just what the most efficient spacing is depends upon the ability of the reservoirs and this varies not only from one reservoir to another but within individual reservoirs. For a sand reservoir of average permeability, wells should be placed at least 1000 feet apart.

The second consideration is the construction of the wells themselves. As stated above, these waters are corrosive and will require special construction if the wells are to remain in operation for any length of time. There are two things to be accomplished by this construction; first, the artesian head should be maintained to its maximum. It is now known that the height to which water will rise in these wells is at least 100 feet lower than it was when the artesian reservoirs were first penetrated. This is partly because of the waste of water from the artesian horizon and also because corrosion has eaten through casings allowing the wells to leak underground. Just how many wells have been drilled in Aberdeen and are now in this condition is not known but at least a score have been accounted for. These, of course, should be plugged as part of the program for using artesian supplies.

The other reason wells should be properly constructed is to prolong the life of the individual well. Using the proper materials and proper methods, a well can be finished so it will last for twenty to fifty years. Without proper construction the same well would probably last about five.

The corrosion problem can be taken care of in several ways. One of the simplest and cheapest is to make a cement "squeeze". The well is drilled large enough so that a two or three inch space can be left around the casing. Neat cement is then forced down the casing and up the outside of the pipe until the space between the casing and the wall of the well is entirely filled with cement. In a well so constructed the steel casing can be entirely corroded without destroying the cement casing which is not subject to rapid corrosion.

A similar effect though not so effective can be obtained by the use of cement or plastic coated casings which are now on the market. The thin coat of cement or plastic on the inside prevents the casing from coming in contact with the corrosive water and, as long as it is intact, the well will be cased. It is not so effective as the cement squeeze but is better than bare metal. The use of brass and copper has much the same effect but is very much more expensive, and probably will be confined to use as well screens and plumbing. A newcomer in the noncorrosive pipe field is plastic pipe. This is made to be used as water pipe and also as well casing. It does not have the strength of metal casings but it is noncorrosive. It would be an especially useful material for wells in South Dakota and its development should be encouraged by those interested in the use of South Dakota artesian water.

A field of well-spaced, well-constructed wells would insure Aberdeen against water famine under any conditions that have been known to exist in South Dakota.

IV. SHALLOW WELL RESERVOIRS

The term "shallow well" is here used to indicate wells less than a couple hundred feet in depth. The reservoirs which furnish water to such supplies in the Aberdeen area are all glacial sand bodies developed in the region by the continental ice sheets which are responsible for the surface features in this part of South Dakota. Most of the material deposited by these glaciers is boulder clay, which is of no use as a source of large supplies of water. Under certain conditions, however, water torrents from the ice washed the fine material out of this boulder clay and left behind bodies of sand and gravel, sometimes of considerable extent, which make excellent storage reservoirs for ground water. Many of these sands are nothing but pockets and therefore not suitable for development as a city water supply. Some, however, have considerable depth and areal extent, and facilities for recharging, and can therefore be recommended as possible sources of water supply.

Four such reservoirs were investigated and will be described in the following pages. These, of course, do not exhaust the possibilities of shallow reservoirs in the James Basin, but were chosen because they seem to be the only ones close enough to Aberdeen to be considered by the city in developing water supplies under present conditions. These have been designated as the James Valley Fill, the Foot Creek Delta, the Elm River Valley Fill and Delta, and the Lord's Lake Buried Channel.

The James River Valley

The closest point to Aberdeen on the James River is directly east of the city, a distance of ten miles. At its junction with Elm Creek, however, it is only five or six miles from the present Aberdeen filtration plant. It has been theorized that the pre-glacial Missouri river flowed down the course of the present James river. This has been shown to be untrue but the idea persists, and has been made the basis for speculation as to the possibilities of finding large gravel bodies beneath the James channel.

It is known, however, that the present course of the James was a drainage channel for melt water from an ice front which existed near Oaks, North Dakota and there has been considerable scour and fill in this channel. It is therefore possible that sand and gravel bodies could lie in the valley of this stream. A rather hasty look at a few possibilities, however, was not very encouraging. The results are given here for whatever use can be made of them.

It has been reported that the well in the city park at Columbia encountered 90 feet of sand and gravel. To test this report, a well was drilled in the valley two miles east and one mile south of Columbia in the NW¼ Sec. 35, T. 125 N., R. 62 W. This well reached a depth of 52 feet without finding the bottom of the sand and gravel. The fill here was mostly a medium grained sand with some small clay streaks, bits of wood and fresh water shells were very common. The following log was made of this well:

LOG OF

TEST WELL IN JAMES VALLEY
near Columbia
NW¼ Sec. 35 T.125N., R62W.

Feet	Feet	
0 -	5	Black silty muck
5 -	15	Dark, very fine sand, clam shells abundant but no water.
15 -	18	Sand like above with much water.
18 -	20	Smooth, tough blue clay.
20 -	27	Dark, fine quicksand like above, settled as fast as the bit drilled. Limy concretions held up casing for awhile at 27'. Below this, however, the casing settled into the sand readily.
27 -	35	Dark fine sand like above, but has many shell fragments. Spots of blue clay in the bedding suggest thin clay partings. This sand makes water and is very "quick", letting the casing settle as fast as it is drilled.
35 -	42	Smooth blue silt, and sandy silt.
42 -	52	Medium grained sand, dark, with a large quantity of snail and clam shells, bits of wood and plant stems

An electrical sounding taken in the James valley about five miles downstream from the test well just described (SW¼ SE¼ Sec. 35, T. 124 N., R. 62 W.) showed a typical clay curve for a depth of 100 feet. This was just below the junction of the James valley with the valley known as Putney's slough which enters it from the northeast. It was thought this junction offered a good place to look for a sand or gravel reservoir. However, if one is present it is apparently covered by more than a hundred feet of finer sediments.

Another electrical sounding was made in the James valley immediately east of Aberdeen. It was located on the south side of U. S. Highway 12 in the NW¼ NW¼ Sec. 23, T. 123 N., R. 62 W., on the flood plain of the James valley. It showed some possible layers of highly resistant material, which might be sand, in the upper 50 feet. However, there was no clear-cut evidence of a gravel fill. In order to make certain, a test well was drilled one mile north of Highway 12 on the east bank of the river channel, but still on the valley bottoms, in the SE¼ SW¼ Sec. 11, T. 123 N., R. 62 W. The following log is the result of this drilling:

TEST WELL ON JAMES VALLEY FLATS
SW¼ SE¼ Sec. 11, T. 123N., R.62W.
Brown County

Feet	Feet	
0 -	3	Black sandy silt
3 -	13	Fine dark sand and silt
13 -	22	Fine tan sand; makes some water but not enough to allow casing to settle.
22 -	47	Blue silt

While this well did not end in boulder clay or bedrock, it sems to indicate that there is no large body of gravels underlying this part of the James valley at shallow depths.

Foot Creek Delta

The valley of Lower Foot Creek was formed as a spillway for waters from melting ice. In such spillways fine materials tend to be washed out while the coarser ones are left behind in and near the channel. Sand and gravel fills are common in such valleys and near their mouths. Foot Creek therefore was investigated as a possible reservoir site. Small terraces of sand and sandy patches were found in the valley but no large body of either sand or gravel which might make a reservoir of sufficient size to supply a city like Aberdeen.

Where Foot Creek debouched into ancient Lake Dakota, however, a sheet of sand with a little gravel was spread over the lake bottom. This delta covered most of the present site of Aberdeen with a thin layer of loam and sands. The main current, however, was directed southeast from the mouth of the valley. This spread a bar of gravel across the mouth which now is exposed in the series of pits along U. S. Highway 81 one mile east and one mile south of the cemetery in southwestern Aberdeen. This gravel is 10 to 15 feet in depth and covers nearly a square mile east of the pits. However, except for the fairly narrow belt of gravel occupied by the pits, the gravel is rather dirty and contains considerable sand. Most of sections 25, 26, 35, and 36 of T. 123 N., R.64 W., are covered by these sands and gravels but they thin out rapidly and disappear toward the east.

The Foot Creek delta is in a very favorable location with respect to the city, but it is not recommended as a water supply. First, it is too small, the usable depth of sand and gravel occupying only two to three square miles at most, and the greatest depth being only fifteen feet. Such a reservoir could not be depended upon to supply the amount of water for a city as large as Aberdeen. It is also not far from Moccasin Creek into which the effluent from the city's sewage plant flows. There is always a chance of contamination therefore even though the plant is carefully operated. Third, the water in the reservoir has been spoiled by leakage from a string of artesian wells drilled along the railroad. Most of these are not now recognizable at the surface but shallow wells in the delta supply a highly mineralized water which contains not only the usual salts found in glacial gravels but those found in artesian waters in addition. The result is a water not suitable for the usual household uses.

Elm River Reservoir

Elm River is one of the most promising of the shallow reservoirs. This valley was formed during late glacial times as a spillway for melt water from an ice front that lay across the northwestern corner of Brown County. Abundant gravel mounds and ridges found in a northeast-southwest belt through Franklin (T. 120 N., R. 65 W.), Allison (T. 127 N., R. 65 W.) and Palmyra (T. 128 N., R. 65 W.) townships, show that rapidly melting ice stood across the headwaters of Elm River and Willow Creek, pouring torrents of water down the valleys now occupied by these creeks into ancient Lake Dakota. That these were torrents is indicated by the fact that the entire Elm River valley below the mouth of Willow Creek carries a fill of gravel and sand which extends as a delta five miles east of the mouth into the old lake bed. The northern edge of the delta lies nearly two miles north of Ordway from which point it makes a rough circle through points three miles east and three miles south of the Aberdeen filtration plant.

In this valley the fill is largely of gravel and coarse sand which continues as the delta beyond the valley mouth where several large gravel pits are located. Farther from the mouth of the valley the material becomes finer and grades into sands and sandy silts, which finally merge with the clays of the old lake bed. This reservoir was investigated up the valley to a point about three miles above the village of Westport.

The entire reservoir covers an area of about forty square miles, of which five square miles lies in the bottom of Elm River valley proper. This spillway is half a mile wide and is gravel filled in at least the lower ten miles of its course. Drillings made by the city engineer of Aberdeen in 1925 showed gravel to depths of 50 and 60 feet in this spillway. Thus the valley itself is a sizable reservoir in which a large amount of water is stored.

The area of the delta is about thirty-five square miles. Depths of sand and gravel, however, are less than in the valley since these materials thin out in all directions as the delta spreads from the valley mouth. While sands will hold as large a volume of water as gravels, they do not yield it so readily. The best part of the delta, therefore, from a water-reservoir standpoint underlies about four square miles of the delta head near the mouth of the Elm River spillway.

Although a square mile of gravel a foot deep will pump about 62 million gallons for every foot of depth it is saturated, and at this rate the Elm River reservoir could deliver some 15 billion gallons, it could hardly be relied upon to supply all the needs of Aberdeen during a protracted drouth. It is large enough, however, and deep enough to make an important reservoir if properly augmented by other stand-by reservoirs.

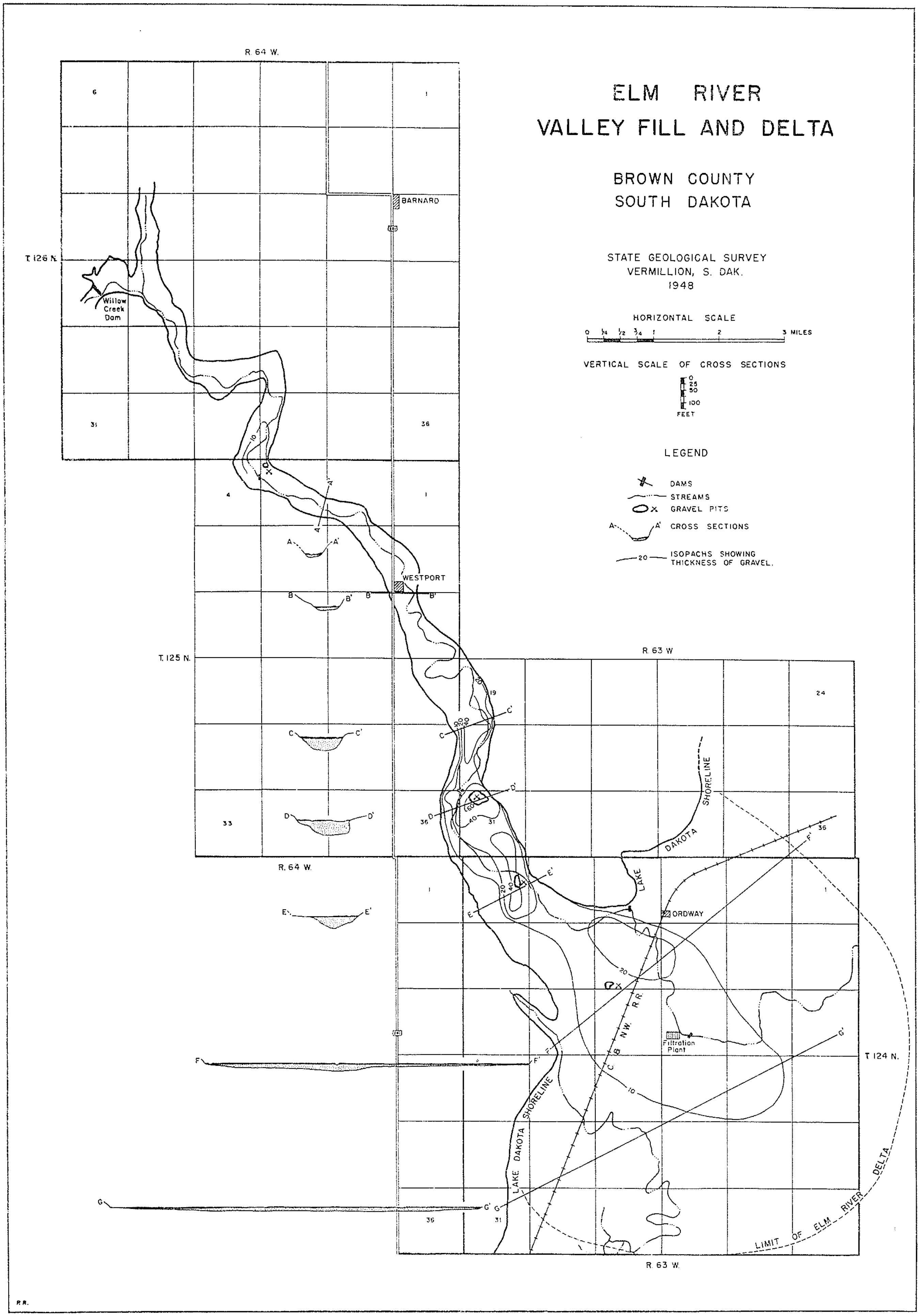
A very important factor in its favor is the recharge it receives from the Elm River. This stream heads about thirty miles above the reservoir and therefore drains a large area. All the runoff which it carries has to pass over the gravel reservoir here described. Whenever the water level in the reservoir is lower than the bottom of the Elm River channel, discharge of stream water into the gravels takes place. This will offer a rapid and ready recharge whenever there is an unusual drain on the storage water of the reservoir.

Elm River has been supplying the needs of the city with its surface runoff from small dams located on the top of the delta and farther downstream. It would seem logical, therefore, to assume that a shallow well field could be developed in the lower reaches of the valley and on the head of the delta which would take care of the present water use except in times of very severe drouth.

Lords Lake Buried Channel

This reservoir is the largest body of sand and gravel in the immediate vicinity of Aberdeen, and is sufficiently deep and well-buried to offer a large water storage in dry times. It lies in an ancient river channel which was filled with clay, sand, and gravel and covered with boulder clay until its course was completely obliterated on the surface. Lords Lake in Secs. 7 & 18, T. 122 N., R. 64 W. is the only suggestion of the original depression as it lies immediately over the center of this old valley.

The channel first came to light during a drilling program carried on by the U. S. Reclamation Bureau in an attempt to discover the depth to bedrock. This program consisted of drilling holes through the glacial drift in east-west lines approximately ten miles apart, from Huron northward. The most northerly of these lines of wells ran westward from Warner, nine miles south of Aberdeen. These lines of borings traced a buried channel, which had been cut in the shale bedrock before glacial times, extending from near Rockham, a



ELM RIVER
VALLEY FILL AND DELTA

BROWN COUNTY
SOUTH DAKOTA

STATE GEOLOGICAL SURVEY
VERMILLION, S. DAK.
1948

little east of north, to a point five miles west of Warner. The southern end of the channel was a broad open valley, but northward from a point six miles south and five miles west of Warner, it deepens into a narrow trench. The borings on the line west of Warner showed a valley about three miles wide and 210 feet deep in the bedrock. They further showed that the bottom 180 feet of this trough was occupied by permeable material, sands and gravels, which were overlain by 30 to 50 feet of boulder clay.

In 1926 a grid of test wells was drilled west of Aberdeen by a city engineer named LeCocq. The northernmost wells were near Wylie Park and the southernmost directly west of the sewage plant. Apparently he attempted to checkerboard the area with these test wells, since with a few exceptions, they lie in east-west lines roughly a mile apart. The only records of these drillings were his notes which were carefully and methodically kept, and are still in the files of the city engineer's office. His wells were drilled to depths over 200 feet and show sand and gravel to that depth. That he did not recognize the type of reservoir is quite evident from the cross sections which have been plotted from his notes. Most of these go part way across the reservoir but none of them show the complete trench in which he was evidently operating. The depths of the bottom of these sands correspond very well to the depth of the buried valley found by drilling west of Warner and since this depression is in line with the trend of the valley as shown by drillings farther south, it is doubtless a continuation of the same buried channel. LeCocq's northern drillings show sand within 30 feet of the top of the test wells which are evidently part of the material in the Elm River delta. Under this, however, lies blue clay and then thicknesses of sand as great as a hundred feet. These sands thin out toward the edges of the channel, where the wells were located to show the bluffs on one side or the other. It is unfortunate that he did not recognize the character of his reservoir and drill complete cross sections.

The descriptions of these wells do not give very complete information on the character or permeability of the sands and gravels. Such terms as sand, fine sand, coarse sand, and gravel are used; Most of his sections being listed simply as sand. The interpretation of this channel, given on the accompanying diagram, shows a large body of fairly permeable material within 200 feet of the surface, but buried under 60 to 80 feet of clay, probably boulder clay. Such a sand body should make a good reservoir if properly developed for water supply.

A check was made between the Reclamation Bureau's drillings at Warner and those of LeCocq to see whether the two gravel bodies connected. An east-west line of electrical soundings through Lords Lake and another halfway between this line and Aberdeen indicated a gravel channel reaching depths of 250 feet below the surface. These soundings of course gave very little information on the materials but upon plotting them it becomes evident that the channel first exposed by the Reclamation Bureau continues northward to that shown by LeCocq's drilling.

Attempts to carry the channel still farther north did not succeed. The only available tool was the electric logger and the curves obtained where the channel should be were not clear enough for positive identification of the old valley. Several sand curves were obtained immediately north and east of Aberdeen and a test hole drilled near one indicated a depth of 95 feet of sandy material. It is probable that the northern extension of the channel was filled with clay which is too much like the underlying shale bedrock to give a clear-cut determination. (See log in appendix). So far as could be determined, therefore, this little sand area is not part of the Lords Lake reservoir.

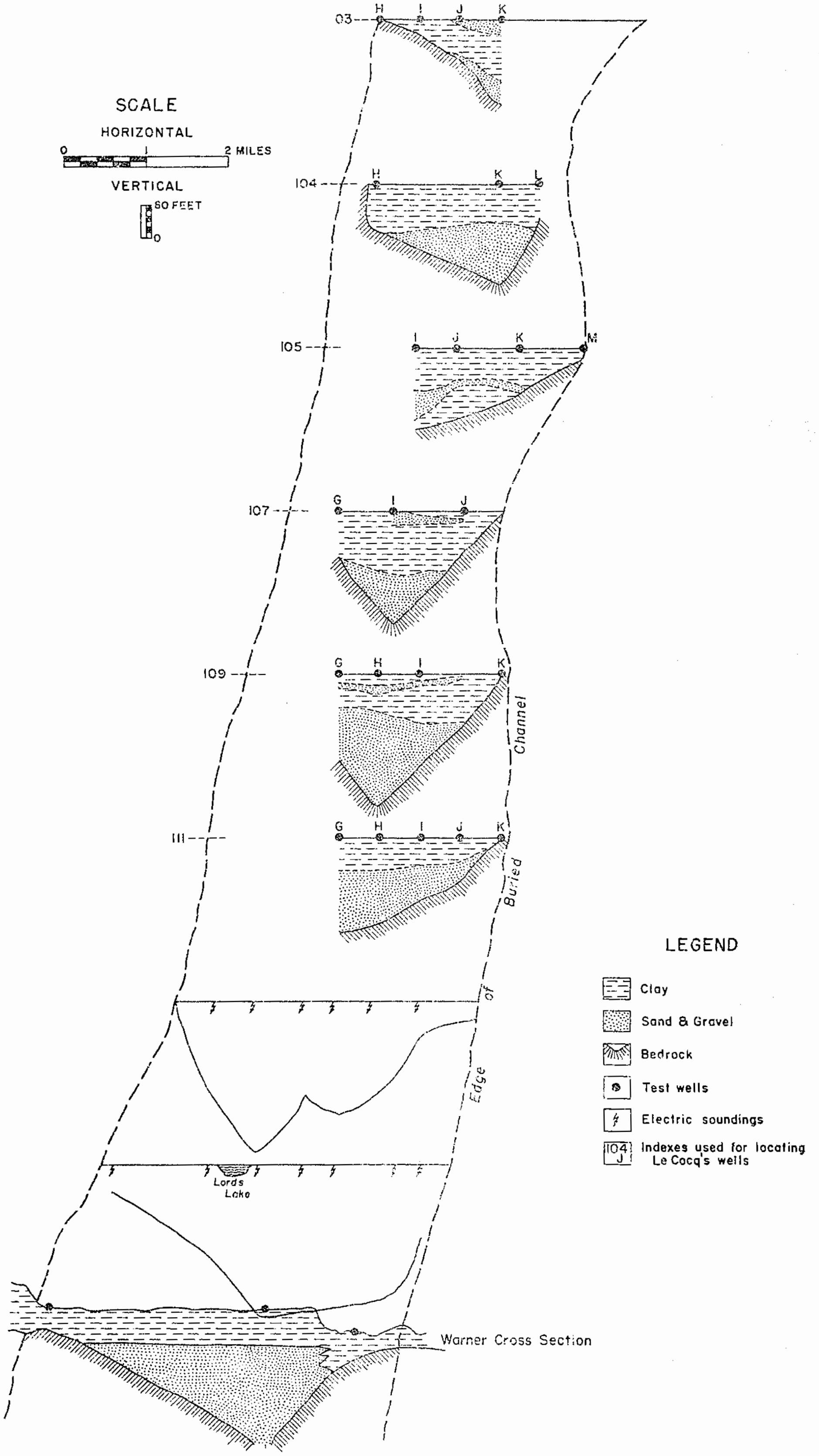
The section of the channel which has been mapped and which is known to contain sand and gravel is sufficiently large to make a good reservoir. Its length is more than 15 miles and its width about four miles. Using a figure of 60 million gallons of water for each square mile filled to a depth of one foot, which is about what glacial gravels will yield, this reservoir could store 150 to 200 billion gallons.

Its only drawback seems to be that it has no immediate recharge such as the fill and delta of the Elm river described above. Its recharge so far as known will have to come through percolation of water into it from the surrounding clays. As this clay presents a very large surface to the reservoir, the percolation would probably be sufficient to keep the reservoir charged unless very large quantities of water were withdrawn rapidly.

No pumping tests were made on this reservoir and the material at the northern end was determined entirely from the written record left by the city engineer. Before attempting to use this reservoir, therefore, further drilling and pumping tests should be made to determine the effective porosity and possible discharge that can be obtained from it.

CROSS SECTIONS OF LORDS LAKE BURIED CHANNEL

Brown County, South Dakota



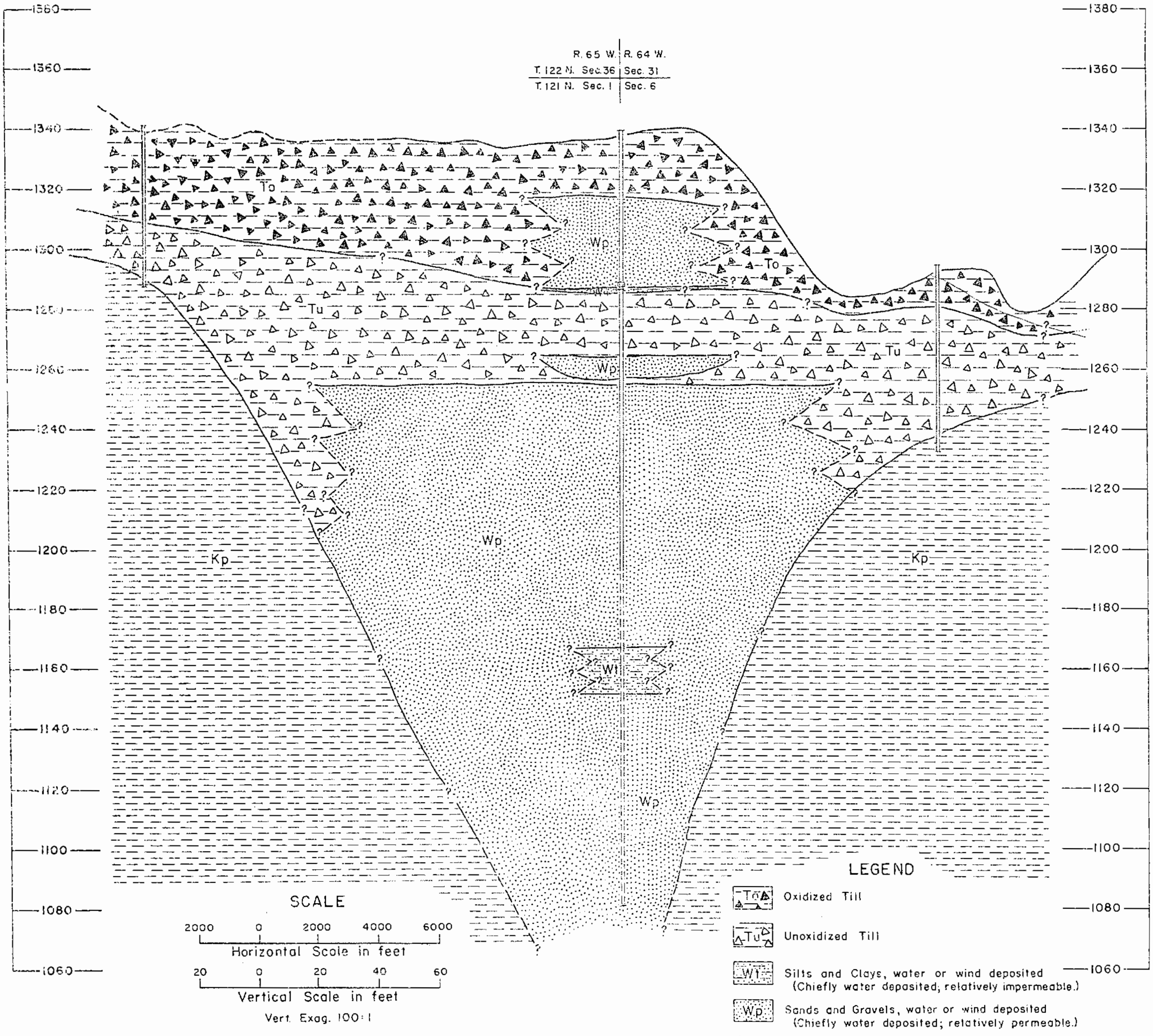
SOUTH DAKOTA GEOLOGICAL SURVEY
Vermillion
1955

P.R.

CROSS SECTION OF LORDS LAKE BURIED CHANNEL

WEST OF WARNER, BROWN COUNTY

SOUTH DAKOTA



MADE BY THE U. S. BUREAU OF RECLAMATION
JANUARY 22, 1952

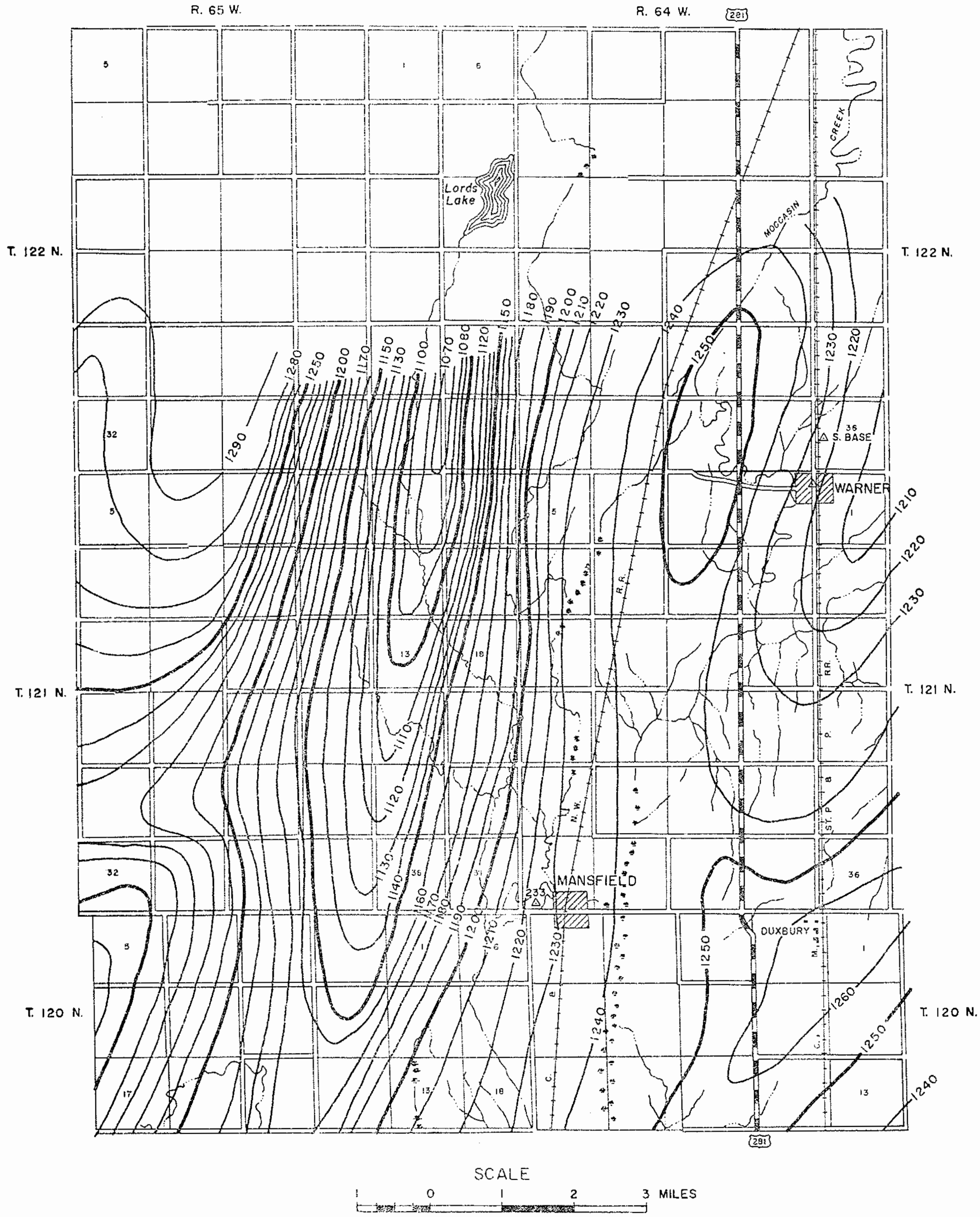
P.R.

CONTOUR MAP

OF THE

SOUTH END OF LORDS LAKE BURIED CHANNEL

BROWN COUNTY, SOUTH DAKOTA



MADE BY THE U. S. BUREAU OF RECLAMATION
FEBRUARY 12, 1952

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SUMMARY

From the foregoing it seems evident that there is no one large source of water for the city of Aberdeen. There is, however, abundant water from several sources, and any attempt to supply the city for the indefinite future must be based on a plan to use these various supplies intelligently and efficiently. Surface water is the most desirable from the standpoint of quality and has served the city well but is in constant danger of depletion in times of drouth. The artesian supplies are the most dependable and the largest supply. They are also the most expensive to develop and the least desirable in quality because of corrosive constituents and bad taste. The Elm River valley fill and delta offer considerable quantities of water, but probably not enough to supply a large city in times of protracted drouth. However, its supplies are cheaply obtained and of good quality. The Foot Creek delta is ruled out largely because of poor reservoir materials and spoilage by leaking artesian water. This last difficulty can be overcome by plugging the old artesian wells. The Lords Lake buried channel offers the largest amount of water storage but has the least ready recharge.

Any of these reservoirs that are to be used, however, should be tested first to determine their hydrologic characteristics. The purpose of this survey was simply to locate possible reservoirs, and their ability to supply the city indefinitely will have to be determined by further investigations. It would seem that for a city of this size and with this water problem, some plan should be developed to use the shallow water supplies as a main source, with a standby of deeper waters. A simple, inexpensive solution to Aberdeen's water problem is not possible.

VI. APPENDIX

Logs of Test Wells North and East of Aberdeen

Pitz Test

Formation test drilled by the City July 21, 1953
Location; NE$\frac{1}{4}$, NE$\frac{1}{4}$, Section 7, T123 N., R. 63 W., Brown Co.
Farm;- Pete Pitz
Contractor;- Independent Drilling Company
Samples logged by Harold E. Erickson, State Geological Survey

Top (feet)	Bottom (feet)	
0	5	Sandy soil.
5	10	Yellow clay.
10	15	Yellow clay with limonite stain, clay is sticking around bit and mud is being pumped away.
15	20	Sandy clay to 17 feet, more sandy below 17-20 feet.
20	25	Sand and fine gravel.
25	30	Coarse sand and fine gravel.
30	35	Coarse sand and fine gravel to 32 feet then more clayey to 34 feet; 34-35 feet more sandier again.
35	40	Coarse sand and gravel to $39\frac{1}{2}$ feet, boulder at $39\frac{1}{2}$ feet. Put on another rod to add weight. Went right through.
40	45	Sandy clay from 42 feet to 45 feet.
45	50	Fine sandy clay to 48 feet. Streak of sand from 48 feet to 50 feet.
50	55	Streak of sand from 50 feet to 52 feet. 52 feet to 55 feet sandy clay.
55	60	Sand down to 56 feet, then 1 foot foot gray clay; fine to medium from 57 feet to 60 feet.
60	65	Good sand down to $62\frac{1}{2}$ feet. Then clayey below $62\frac{1}{2}$ to 65 feet.
65	70	Mostly gray clay.
70	75	Interbedded clay and sand.
75	80	Sandy clay with sand streak from 76 to 78 feet.
80	85	Sandy clay to 84 feet. Then clay from 84 to 85 feet.
85	90	Clay to 88 feet. Then sand 88 to 90 feet.
90	95	Gray clay, soft sandy.
95	100	Gray clay, firmer, still a little sandy.

Top (feet)	Bottom (feet)	
100	105	Soft, plastic, greasy gray clay.
105	110	Soft plastic, greasy gray clay and soft shale.
110	115	Soft, plastic, greasy gray shale; hit layer of slate at 115 feet; didn't drill it.
	115	Total depth.

Stuke Test

Formation test drilled by the City July 19 & 20, 1953.
Location;- SW¼, SW¼, Section 17, T124 N., R. 63 W., Brown Co.
Farm;- Ben Stuke
Contractor;- Independent Drilling Company
Samples logged by Harold E. Erickson, State Geological Survey

Top (feet)	Bottom (feet)	
0	10	Black sandy soil (1½ feet) then fine lake silt and sand.
10	15	Sandy to 13 feet; coarser sand and gravel from 13-15 feet.
15	20	15-15½ feet - coarse sand and gravel 15½-19½ - sandy clay; coarser sand and gravel - 19½-20 feet.
20	25	20-21½ feet - coarse gravel 21½-25 feet - sandy gray clay.
25	30	Sandy gray clay.
30	35	Gray clay more sandy from 32-35 feet.
35	40	Sandy gray clay to 37 feet, more clayey from 37-40 feet. Pulled up and reamed hole at 40 feet; boulder or coarse gravel fell in hole and had to redrill about 2 feet. Are drilling down to 41 feet to take care of gravel falling in hole.
40	45	Sandy gray clay to 42 feet; then coarse sand and gravel to 45 feet.
45	50	Coarse sand and small, fine gravel.
50	55	Coarse sand and fine gravel to 53 feet; then gray sandy clay.
55	60	Sandy gray clay to 56 feet; then getting more sandy to 60 feet.

Top (feet)	Bottom (feet)	
60	65	Mostly sandy gray clay.
65	70	Sandy gray clay; tougher drilling.
70	75	Sandy clay, gray.
75	80	Sandy clay, gray.
80	85	Sandy clay, coarser sand and fine gravel from 81-83 feet.
85	90	Poor sample; none coming up; some coal in sample, may be coal seam. (?)
90	95	Still poor sample, circulated much coal.
95	100	Still poor sample; still coal; some gray clay at 99 feet.
100	105	Light gray, soapy clay.
105	110	Same as above, more sandy.
110	115	Very fine sand.
115	120	Mostly gray clay.
120	125	Pumped away some mud at 121 feet. Hole got too tight; thinned mud and got back mud lost. Hard streak in layer at 123 feet. Could not get through with drag bit, changed to 4 7/8 rock bit.
125	130	Soft, medium gray clay. (July 20, 1953)
130	135	Some firmer from 132-135 feet.
135	140	Same; still not good shale cuttings.
140	144	Gray soft clay.
144	150	Gray soft clay, a little sandy.
150	155	Gray soft clay.
155	160	Same as above.
160	165	Same; firmer.
165	170	Gray, firm clay.
170	175	Same; soft to firm.
175	180	Same.
180	185	Same; more firm.
185	190	Soft shale.
190	195	Same.
195	200	Same.
200	205	Same.
205	207	Same; firm shale
	207	Total depth.

Ness Test

Formation test drilled by the City July 16 & 17, 1953
Location;- SW¼, SW¼, Section 27, T124 N., R. 64 W., Brown Co.
Farm;- J. Ness
Contractor;- Independent Drilling Company
Samples logged by Harold E. Erickson, State Geological Survey

Top (feet)	Bottom (feet)	
0	5	Topsoil and clay.
5	15	Clay; starting sand at 7½ feet with some coarser sand and gravel.
15	20	Sand.
20	25	Sand.
25	30	Sand.
30	35	Sand; coarse gravel from 33-34 feet.
35	40	Sand to 36 feet, then getting more clayey.
40	45	Clay, sandy.
45	50	Clay, sandy.
50	55	Clay, sandy.
55	60	Clay, sandy.
60	65	Clay, sandy.
65	70	Clay, sandy.
70	75	Clay to 73 feet, then more sandy but still much clay.
75	80	Sandy clay.
80	85	Sandy clay; streak of sand above 83 feet. Boulder at 83 feet.
85	90	Light gray clay, greasy.
90	95	Light gray clay, greasy.
95	100	Same as above.
100	105	Same as above.
105	110	Same as above; hard streak from 105½-106 feet.
110	115	Same light gray soft clay and shale.
115	120	Same, only more firm and darker in color.
120	125	Same as above.
125	130	Same, a little harder drilling.
130	135	Medium gray, soft to firm greasy shale. Hit hard layer at 134 3/4 feet. Drilling abandoned at 135 feet. Well into Pierre shale. (July 17, 1953)

Logs of Wells In The Elm River Valley

These records were taken from the note book of C. E. LeCocq, city engineer who drilled these wells in 1925 and 1926.
For location see grid map of Elm River borings.
Elevations are from an assumed datum of 100 feet.

Index Number	Log
Y-45	
	5 ft. Loam
	10 ft. Sandy loam
	3 ft. Sand
	17 ft. Blue clay, gravelly
	35 ft. Total Depth
	El. 88
N-49	
	5 ft. Loam
	11 ft. Clay
	5 ft. Gravel
	5 ft. Sandy gumbo
	6 ft. Shale
	32 ft. Total Depth
	El. 117.55
P-49	
	13 ft. Clay and loam
	15 ft. Gravel and clay
	12 ft. Gumbo
	10 ft. Shale
	50 ft. Total Depth
	El. 109.55

Index Number	Log
Q-45	
	6 ft. Loam
	12 ft. Yellow clay
	17 ft. Blue clay, gravelly
	2+ft. Blue clay
	37 ft. Total Depth
	El. 110
O-49	
	3 ft. Loam
	7 ft. Yellow clay
	25 ft. Blue clay
	35 ft. Total Depth
	El. 113.04
Q-49	
	6 ft. Loam
	5 ft. Fine sand
	17 ft. Gumbo
	7 ft. Sand and gravel
	7 ft. Shale
	42 ft. Total Depth
	El. 110.24

Index Number		Log
R-49		
	15 ft.	Clay and loam
	3 ft.	Gravel
	3 ft.	Gray clay
	7 ft.	Clay
	11 ft.	Sandy gumbo
	5 ft.	Gumbo
	14 ft.	Shale
	58 ft.	Total Depth
		El. 111.15
V-49		
	6 ft.	Loam
	6 ft.	Clay
	9 ft.	Sandy clay
	12 ft.	Fine sandstones
	6 ft.	Blue clay
	39 ft.	Total Depth
		El. 104
Y-49		
	5 ft.	Loam
	10 ft.	Sand
	12 ft.	Clay
	11 ft.	Dry clay
	38 ft.	Total Depth
		El. 104
P-50		
	5 ft.	Sandy loam
	15 ft.	Gravel and clay
	10 ft.	Fine sand
	35 ft.	Fine sand and clay
	65 ft.	Total Depth
		El. 112.99
Q-50		
	14 ft.	Sandy loam
	23 ft.	Fine sand
	1 ft.	Coarse sand
	32 ft.	Blue clay and shale
	70 ft.	Total Depth
		El. 111.62
N-51		
	14 ft.	Yellow clay
	6 ft.	Wet clay
	20 ft.	Gumbo and shale
	40 ft.	Total Depth
		El. 123.66

Index Number Log

O-51
5 ft. Loam
7 ft. Yellow clay
16 ft. Fine sand and clay
7 ft. Gumbo
5+ft. Shale
40 ft. Total Depth

El. 112.89

P-51
No Log

El. 111.95

Q-51
5 ft. Loam
5 ft. Hard pan
10 ft. Fine gravel and sand
5 ft. Coarse sand
10 ft. Fine sand and clay
10 ft. Coarse sand
4 ft. Shale
49 ft. Total Depth

El. 112.83

N-52
5 ft. Sandy loam
2 ft. Clay
15 ft. Sandy gumbo
18 ft. Gravelly gumbo
3+ft. Shale
43 ft. Total Depth

El. 112.00

O-52
15 ft. Sandy loam
9 ft. Gumbo
16 ft. Sandy gumbo
2+ft. Gumbo
42 ft. Total Depth

El. 113.76

P-52
6 ft. Loam
5 ft. Hard pan
8 ft. Clay and gravel
15 ft. Coarse sand
15 ft. Coarse gravel
5 ft. Gumbo
54 ft. Total Depth

El. 114.47

Index Number	Log
Q-52	10 ft. Loam and silt
	5 ft. Gumbo
	17 ft. Quick sand
	6 ft. Gumbo
	38 ft. Total Depth
	El. 108.69
M-53	20 ft. Clay and loam
	9 ft. Fine sand
	18 ft. Coarse gravel
	13 ft. Blue clay
	60 ft. Total Depth
	El. 115.31
N-53	3 ft. Loam
	11 ft. Hard pan
	6 ft. Clay
	13 ft. Gumbo
	13 ft. Gravel and clay
	46 ft. Total Depth
	El. 116.27
O-53	5 ft. Hard pan (Loam cap)
	10 ft. Clay
	5 ft. Sandy
	5 ft. Blue clay
	5 ft. Sandy
	5 ft. Gumbo
	5 ft. Gravel
	24 ft. Sand
	64 ft. Total Depth
	El. 113.33
P-53	7 ft. Loam
	5 ft. Sandy clay
	18 ft. Fine sand
	5 ft. Coarse sand
	10 ft. Gravel
	15 ft. Gravel and clay
	60 ft. Total Depth
	El. 110.34
Q-53	16 ft. Sandy clay
	7 ft. Yellow clay
	27 ft. Sandy clay
	40 ft. Total Depth
	El. 118.91

Index Number		Log
N-54		
	9 ft.	Clay loam
	12 ft.	Sand
	3 ft.	Sand and gravel
	10 ft.	Coarse sand
	14 ft.	Sand and coal
	3+ ft.	Gumbo
	51 ft.	Total Depth
		El. 116.90
O-54		
	13 ft.	Hard pan
	22 ft.	Fine sand
	11 ft.	Gravel
	5 ft.	Blue clay
	5+ ft.	Shale
	56 ft.	Total Depth
		El. 114.76
P-54		
	8 ft.	Loam
	19 ft.	Sandy
	7 ft.	Fine sand
	10 ft.	Coarse sand
	10 ft.	Coarse gravel
	7 ft.	Fine sand
	--	Sandy clay
	61 ft.	Total Depth
		El. 112.29
Q-54		
	17 ft.	Yellow clay
	10 ft.	Blue clay
	12 ft.	Gumbo
	39 ft.	Total Depth
		El. 121.05
M-55		
	15 ft.	Loam
	10 ft.	Sandy loam
	21 ft.	Coarse, fine gravel
	10 ft.	Coarse gravel
	4 ft.	Blue clay
	60 ft.	Total Depth
		El. 117.56
N-55		
	16 ft.	Loam
	13 ft.	Fine sand
	13 ft.	Sand and gravel
	4 ft.	Blue clay
	--	Shale
	46 ft.	Total Depth
		El. 114.46

Index Number	Log
O-55 (600 ft. W.)
4 ft.	Loam
7 ft.	Dry clay
5 ft.	Hard pan
18 ft.	Fine sand and boulders
9 ft.	Sand and gravel
7 ft.	Blue clay
--	Shale
50 ft.	Total Depth
	El. 115.16
P-55 (200 ft. W.)
17 ft.	Yellow clay
13 ft.	Fine sand
3 ft.	Clay
6 ft.	Fine sand
8 ft.	Blue clay
--	Shale
47 ft.	Total Depth
	El. 120.87
N-55½
8 ft.	Loam
11 ft.	Coarse sand
29 ft.	Gravel
2 ft.	Blue clay
50 ft.	Total Depth
	El. 116.58

Index Number	Log
O-55
4 ft.	Loam
7 ft.	Dry clay (H.p. at base)
17 ft.	Sand and stones
15 ft.	Gravel and sand
--	Shale
43 ft.	Total Depth
	El. 115.22
M-55½
31 ft.	Sandy loam
6 ft.	Gravel
19 ft.	Coarse sand and stones
4 ft.	Blue clay
60 ft.	Total Depth
	El. 118.29
O-55½
25 ft.	Gravel and clay
17 ft.	Coarse sand
4 ft.	Fine sand
5 ft.	Blue clay
51 ft.	Total Depth
	El. 112.69

Index
Number Log

M-56 (700 ft. W.)
18 ft. Sandy loam
3 ft. Sandy clay
29 ft. Blue clay
50 ft. Total Depth

El. 118.12

N-56
45 ft. Gravel
5 ft. Fine sand
8 ft. Gravel
5 ft. Blue clay
63 ft. Total Depth

El. 117.87

0-56 (500 ft. E.)
5 ft. Yellow clay
5 ft. Sand and clay
5 ft. Gravel and clay
12 ft. Fine sand
4 ft. Clay
9 ft. Fine sand
5 ft. Blue clay
45 ft. Total Depth

El. 121.33

Index
Number Log

M-56
22 ft. Sandy loam
3 ft. Fine sand
11 ft. Coarse gravel
18 ft. Gravel and clay
5 ft. Blue clay
59 ft. Total Depth

El. 117.25

0-56
25 ft. Sandy clay
10 ft. Fine sand
5 ft. Blue clay
40 ft. Total Depth

El. 112.82

M-56½ (900 ft. W.)
10 ft. Loam
5 ft. Sandy loam
8 ft. Fine sand
7 ft. Gravelly clay
11 ft. Blue clay
41 ft. Total Depth

El. 118.91

Index Number   Log

M-56½ (650 ft. E.)
5 ft. Loam
14 ft. Coarse gravel and clay
16 ft. Coarse sand
5 ft. Gravel
3 ft. Fine sand
28 ft. Fine sand and clay
71 ft. Total Depth

El. 116.78

O-56½
5 ft. Gravel and clay
15 ft. Fine sand and clay
14 ft. Fine sand
10 ft. Coarse sand
6 ft. Gravel
4 ft. Blue clay
54 ft. Total Depth

El. 118. 43

N-57 (300 ft. W.)
43 ft. Gravel
3 ft. Blue clay
46 ft. Total Depth

El. 118.36

Index Number   Log

N-56½ (200 ft. W.)
59 ft. {Coarse gravel above
{Fine gravel below
1 ft. Blue clay
60 ft. Total Depth

El. 117.50

M-57
3 ft. Loam
12 ft. Hard pan
10 ft. Clay
12 ft. Coarse sand
7 ft. Fine gravel
17 ft. Fine sand and clay
61 ft. Total Depth

El. 119.26

N-57
30 ft. Gravel, clay streaks
5 ft. Coarse sand
5 ft. Blue clay
40 ft. Total Depth

El. 118.36

Index Number Log

Index Number Log

N-57 (300 ft. E., 100 ft. S.)

45 ft.	Gravel
12 ft.	Gravel and sand
--	Blue clay
57 ft.	Total Depth

El. 118.19

O-57 (200 ft. W.)

5 ft.	Loam
5 ft.	Sand and clay
5 ft.	Yellow clay
14 ft.	Blue clay
11 ft.	Sand, clay and gumbo
--	Blue clay
40 ft.	Total Depth

El. 127.40

O-57

29 ft.	Yellow clay
5 ft.	Grey clay
30 ft.	Blue clay
64 ft.	Total Depth

El. 145.17

M-57½

11 ft.	Loam
9 ft.	Fine sand and clay
12 ft.	Sticky clay
13 ft.	Coarse sand and clay
5 ft.	Fine sand and clay
50 ft.	Total Depth

El. 120.13

M-57½ (600 ft. E.)

7 ft.	Loam
4 ft.	Clay
27 ft.	Gravel
6 ft.	Blue clay
44 ft.	Total Depth

El. 118.21

M-58

13 ft.	Sandy loam
14 ft.	Coarse sand
8 ft.	Sandy clay
11 ft.	Blue clay
46 ft.	Total Depth

El. 109.25

Index
Number Log

N-58 (600 ft. W.)
10 ft. Loam
12 ft. Sandy loam
4 ft. Hard pan
4 ft. Gravel
4 ft. Fine sand
6 ft. Sandy gumbo
5 ft. Sandy blue clay
45 ft. Total Depth

El. 120.05

Index
Number Log

N-58 (200 ft. S.)
5 ft. Yellow clay
30 ft. Fine sand and clay
5 ft. Fine sand
5 ft. Gumbo
45 ft. Total Depth

El. 122.26

M-59
11 ft. Loam
1 ft. Clay
10 ft. Gumbo
9 ft. Coarse gravel
13 ft. Blue clay
44 ft. Total Depth

El. 116.91

N-59 (600 ft. W.)
21 ft. Loam
7 ft. Clay
46 ft. Gravel
3 ft. Blue clay
77 ft. Total Depth

El. 118.26

N-59
31 ft. Loam
7 ft. Gravelly clay
2 ft. Blue clay
40 ft. Total Depth

El. 120.37

O-59
37 ft. Yellow clay
9 ft. Sand
3 ft. Sandy clay
41 ft. Fine sand
-- Blue clay
90 ft. Total Depth

El. 149.17

Index Number   Log

Index Number   Log

M-60 (650 ft. E.)
10 ft. Sandy loam
15 ft. Sandy clay
25 ft. Sand (Yellow above
(Blue below
5 ft. Sandy clay
7 ft. Shale
62 ft. Total Depth

El. 109.92

N-60
15 ft. Black loam
9 ft. Fine sand
5 ft. Coarse sand
28 ft. Sand and gravel
2 ft. Blue clay
49 ft. Total Depth

El. 119.82

N-60 (450 ft. E.)
14 ft. Black loam
5 ft. Fine sand
5 ft. Gumbo
5 ft. Gumbo and coarse sand
4 ft. Black sand
6 ft. Blue clay
39 ft. Total Depth

El. 114.17

N-61 (300 ft. W.)
10 ft. Sand and loam
27 ft. Sand
13 ft. Sand and gravel
4 ft. Sandy clay
5 ft. Blue clay
3 ft. Sand
2 ft. Blue clay
64 ft. Total Depth

El. 122.96

N-61 (300 ft. E.)
22 ft. Black loam
8 ft. Sandy clay
2 ft. Gravel
35 ft. Sand
5 ft. Blue clay
72 ft. Total Depth

El. 118.41

0-61 (250 ft. W., 250 ft. S.)
6 ft. Loam
9 ft. Sandy clay
44 ft. Fine sand
4 ft. Blue clay
63 ft. Total Depth

El. 120.71

Index
Number Log

0-61
No Log

El. 120.00

0-62 (700 ft. W.)
15 ft. Loam
5 ft. Sandy clay
5 ft. Sand and gravel
5 ft. Sand
16 ft. Gravel and clay
3 ft. Blue clay
49 ft. Total Depth

El. 119.63

N-63
5 ft. Loam
12 ft. Fine sand and clay
3 ft. Clay and gravel
3 ft. Gravel
15 ft. Blue clay
38 ft. Total Depth

El. 122.69

Index
Number Log

N-62 (350 ft. S.)
9 ft. Loam
8 ft. Fine sand
20 ft. Fine sand and clay
29 ft. Fine sand
4 ft. Blue clay
70 ft. Total Depth

El. 129.39

0-62 (200 ft. W.)
13 ft. Sandy loam
15 ft. Clay {Yellow above
Blue below
3 ft. Coarse gravel
10 ft. Clay and gravel
2 ft. Blue clay
43 ft. Total Depth

El. 121.39

N-63 (650 ft. E.)
13 ft. Loam
7 ft. Clay and loam
10 ft. Fine sand and clay
12 ft. Sand and gravel
5 ft. Coarse gravel
4 ft. Blue clay
51 ft. Total Depth

El. 117.59

Index Number   Log

O-63
8 ft. Sandy loam
11 ft. Sticky clay
7 ft. Fine sand
14 ft. Gumbo
9 ft. Fine sand
7 ft. Blue clay
56 ft. Total Depth

El. 116.25

N-64 (300 ft. E.)
No Log

El. 121.75

M-65
No Log

El. 119.80

Index Number   Log

M-64 (800 ft. E.)
No Log

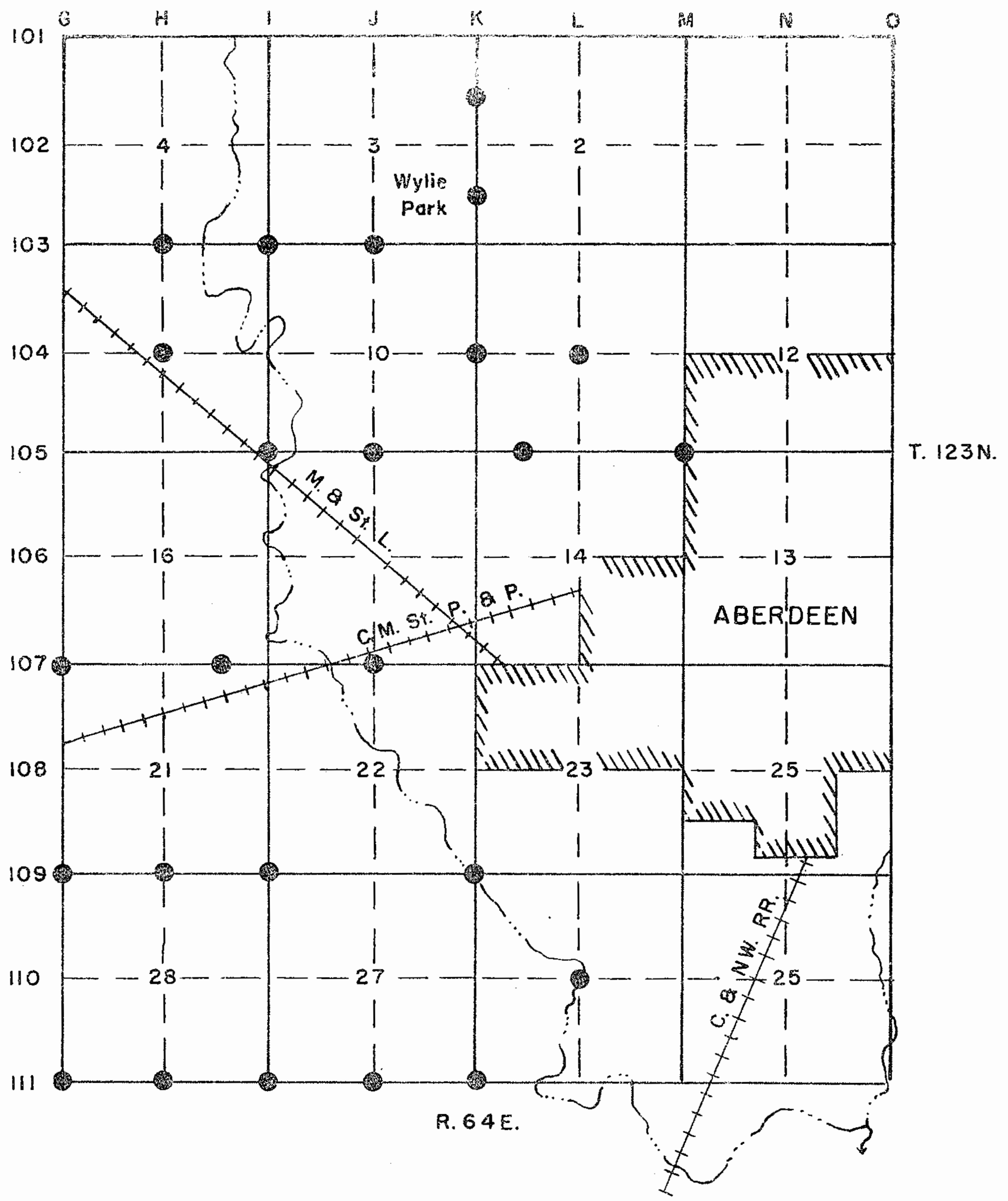
El. 121.02

L-65
No Log

El. 122.97

M-65 (900 ft. E.)
No Log

El. 131.31



INDEX MAP

OF

TEST WELLS

NEAR

ABERDEEN

DRILLED BY
CITY ENGINEER

1926

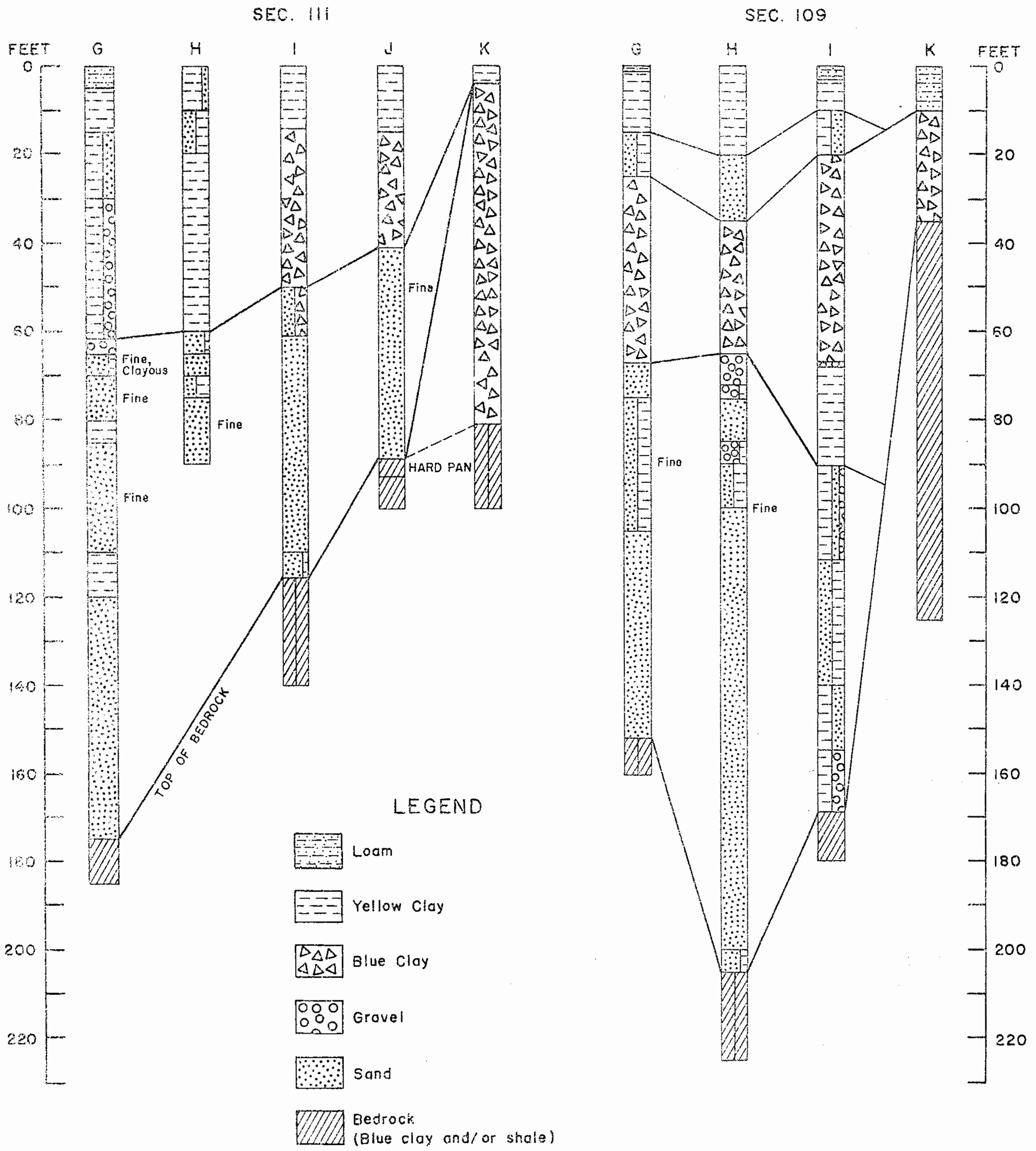
LEGEND

● TEST WELLS

Letters at top
and numbers on
left side of map
are indexes for
locating wells.

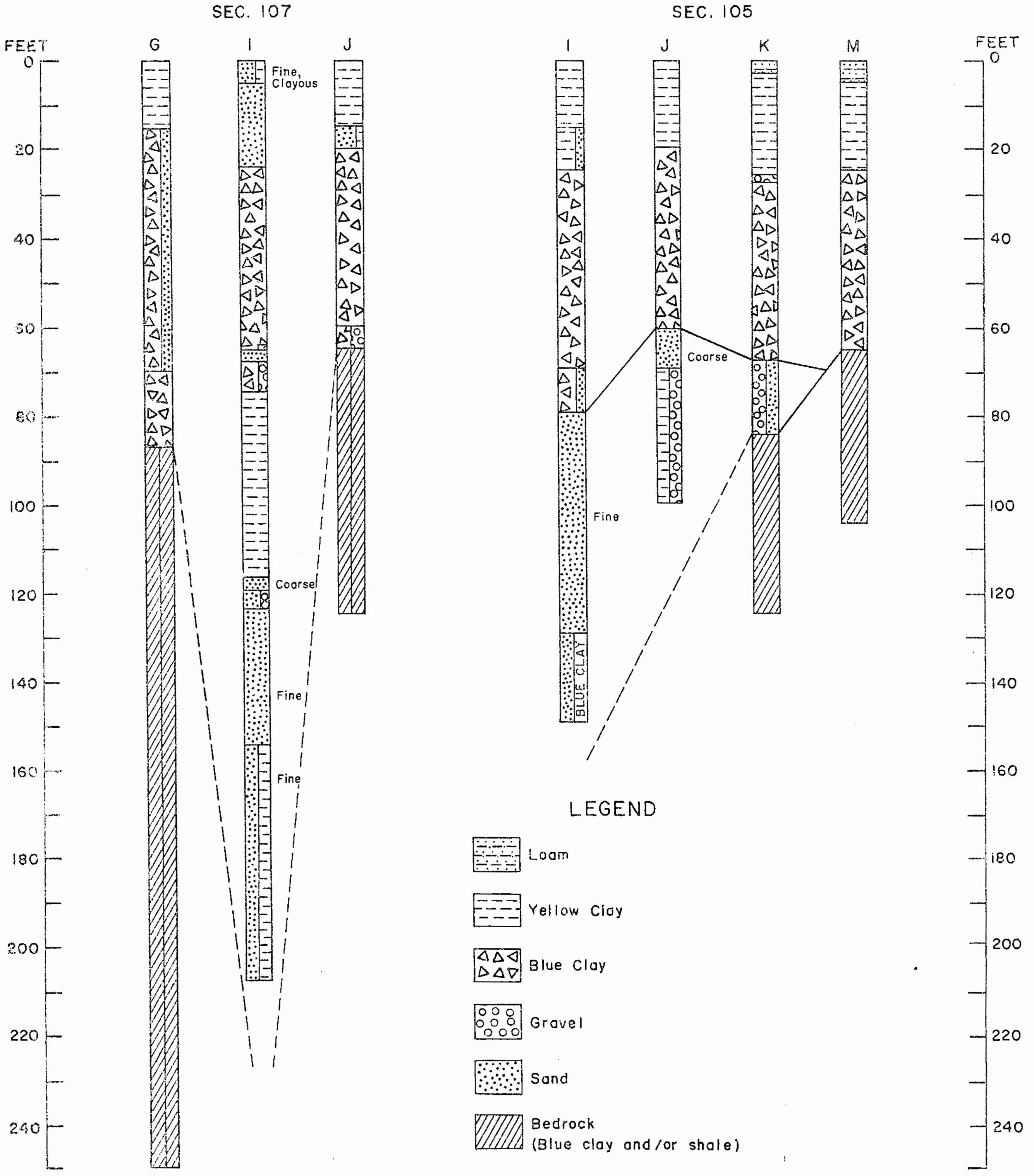
GRAPHIC LOGS OF TEST WELLS IN LORDS LAKE BURIED CHANNEL

1926

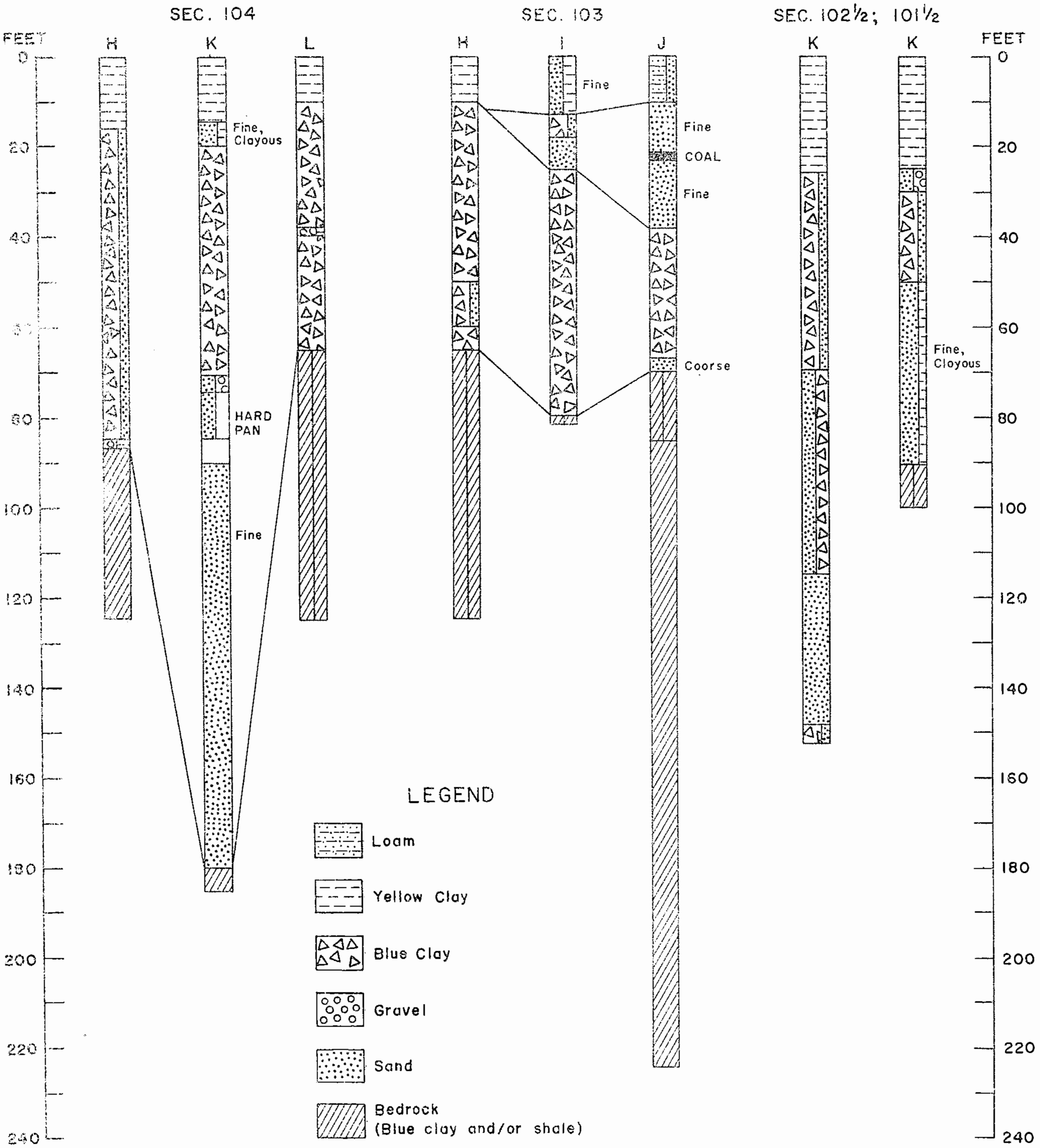


GRAPHIC LOGS OF TEST WELLS IN LORDS LAKE BURIED CHANNEL

1926



GRAPHIC LOGS OF TEST WELLS
IN LORDS LAKE BURIED CHANNEL
1926



Logs of Wells in the Lords Lake Buried Channel

These logs were taken from the note book of C. E. LeCocq, City Engineer, who drilled these as test wells in February and March of 1926.

Index numbers show location of wells on grid map used as an index for the graphs of these logs earlier in this report.

The identifications of materials are those of Mr. LeCocq entirely. No samples were kept.

Well K-101½

Depth to tops in feet	Log
0 ft.	Yellow clay, sandy
25 ft.	Sand and gravel
30 ft.	Blue clay, sandy
50 ft.	Fine sand, clayous
91 ft.	Blue clay or shale
100 ft.	Blue clay or shale
	Water Level 14.0 ft. Not much water.

Well K-102½

Depth to tops in feet	Log
0 ft.	Yellow clay
26 ft.	Blue clay, sandy
35 ft.	Blue clay, sandy
70 ft.	Sand and blue clay
100 ft.	Sand and blue clay
115 ft.	Clean sand
118 ft.	Fine sand
149 ft.	Blue clay and some fine sand
	Water Level 17.0 ft.
153 ft.	Blue clay and some fine sand

Well H-103

Depth to tops in feet	Log
0 ft.	Clay, brown
10 ft.	Blue clay; 6 in. vein sand/5.0 ft.
20 ft.	Blue clay
37 ft.	Blue clay
45 ft.	Blue clay
50 ft.	Blue clay, sandy
60 ft.	Blue clay
65 ft.	Dark clay or shale
80 ft.	Dark clay or shale
125 ft.	Dark clay or shale
	Well completed

Well I-103

Depth to tops in feet	Log
0 ft.	Fine sand and clay
13 ft.	Blue silt
18 ft.	Fine sand, clean
25 ft.	Blue clay
50 ft.	Blue clay
65 ft.	Blue clay
80 ft.	Blue clay and shale
81 ft.	Blue clay
	Well completed
	Water Level 10.0 ft.
Final	Water Level 4.5 ft.

Well J-103

Depth to tops in feet	Log
0 ft.	Sandy loam
10 ft.	Fine sand, brown
21 ft.	Coal
23 ft.	Fine sand
38 ft.	Blue clay
50 ft.	Blue clay
67 ft.	Coarse sand
70 ft.	Blue clay and shale
75 ft.	Blue clay and shale
85 ft.	Grey shale
95 ft.	Grey shale
145 ft.	Grey shale
165 ft.	Grey shale
225 ft.	Grey shale

23 ft.-Water Level 23.5 ft.
Final Water Level 13.0 ft.

Well H-104

Depth to tops in feet	Log
0 ft.	Yellow clay
16 ft.	Blue clay, sandy
25 ft.	Blue clay
30 ft.	Blue clay
70 ft.	Blue clay
85 ft.	Gravel and clay
87 ft.	Blue clay
102 ft.	Blue clay
125 ft.	Blue clay

Well K-104

0 ft.	Yellow clay
15 ft.	Fine sand, clayous
20 ft.	Blue clay
71 ft.	Coarse sand and gravel
75 ft.	Hard pan of fine sand
85 ft.	Hard pan
90 ft.	Hard pan
92 ft.	Fine sand
140 ft.	Fine sand
160 ft.	Fine sand
181 ft.	Shale
186 ft.	Shale

Water Level 11 ft. 8 in.

Well L-104

0 ft.	Yellow clay
10 ft.	Blue clay
35 ft.	Blue clay
38 ft.	Gravel, clayous
40 ft.	Blue clay
65 ft.	Dark clay or shale
125 ft.	Dark clay or shale

Well I-105

Depth to tops in feet	Log
0 ft.	Clay, brown
15 ft.	Clay, grey, sandy
20 ft.	Clay, sandy
25 ft.	Blue clay
50 ft.	Blue clay
70 ft.	Blue clay, sandy
80 ft.	Fine sand, clean
100 ft.	Fine sand, some coal
105 ft.	Fine sand
110 ft.	Fine sand
130 ft.	Blue clay and fine sand
150 ft.	Blue clay and fine sand

Well completed

Water Level 3.0 ft. from 80-150 ft. vein

Well J-105

Depth to tops in feet	Log
0 ft.	Yellow clay
15 ft.	Yellow clay
20 ft.	Blue clay
35 ft.	Blue clay
61 ft.	Coarse sand
70 ft.	Coarse sand
72 ft.	Clay and gravel
100 ft.	Clay and gravel

Water Level 7.5 ft. from 61-72 ft. vein

Well K-105 1500 ft. E.

0 ft.	Loam
3 ft.	Yellow clay
7 ft.	Yellow clay
16 ft.	Clay, grey
26 ft.	Gravel
28 ft.	Blue clay
60 ft.	Blue clay
68 ft.	Gravel and sand, clean
71 ft.	Gravel and sand, clean
75 ft.	Gravel and sand, clean
80 ft.	Gravel and sand, clean
85 ft.	Shale
125 ft.	Shale

Water Level 5 ft. 4 in. from 67-85 ft. vein

Well M-105

0 ft.	Loam
5 ft.	Yellow clay
25 ft.	Blue clay
65 ft.	Blue clay
105 ft.	Blue clay

Well G-107

Depth to tops in feet	Log
0 ft.	Yellow clay and till
10 ft.	Yellow clay and till
15 ft.	Blue clay, sandy
35 ft.	Blue clay, sandy
40 ft.	Blue clay, sandy
45 ft.	Blue clay, sandy
70 ft.	Blue clay, sandy
75 ft.	Blue clay, sandy
87 ft.	Dark clay or shale
250 ft.	Dark clay or shale

Final Water Level 16.5 ft.

Well I-107 1600 ft. W.

Depth to tops in feet	Log
0 ft.	Fine sand, clayous
5 ft.	Fine sand, clean
15 ft.	Fine sand, water Water 15.0 ft.
20 ft.	Fine sand, blue
24 ft.	Blue clay
64 ft.	Blue clay and gravel
65 ft.	Fine sand, clean
68 ft.	Blue clay and stones
75 ft.	Grey shale
80 ft.	Grey shale
110 ft.	Grey shale
117 ft.	Fine sand, clean
120 ft.	Coarse sand, clean
124 ft.	Fine sand, very fine
145 ft.	Fine sand, very fine
155 ft.	Fine sand, some clay
180 ft.	Fine sand and clay
208 ft.	Fine sand

65 ft.-Water rose to 16 ft. 10 in. in casing

Water Level 21.0 ft. from 117-180 ft. vein

Well J-107

0 ft.	Clay
15 ft.	Sand, clayous
20 ft.	Blue clay
60 ft.	Blue clay and gravel
65 ft.	Blue clay or shale
125 ft.	Well completed

Well G-109

0 ft.	Loam
1 ft.	Yellow clay
15 ft.	Sand and clay
25 ft.	Blue clay
67 ft.	Sand
75 ft.	Sand and clay
100 ft.	Fine sand and clay, clay predominating
105 ft.	Sand, slightly dirty
140 ft.	Sand
152 ft.	Blue clay or shale
160 ft.	Blue clay or shale

140 ft.- Water Level 19.0 ft.

Well H-109

Depth to tops in feet	Log
0 ft.	Yellow clay
15 ft.	Yellow clay
20 ft.	Fine white sand
35 ft.	Blue clay
50 ft.	Blue clay
65 ft.	Coarse gravel, clean
70 ft.	Coarse gravel, clean
72 ft.	Coarse gravel and clay
75 ft.	Coarse sand and clay
85 ft.	Coarse gravel, clayous
90 ft.	Coarse sand and clay
100 ft.	Fine sand, clayous
115 ft.	Fine sand, clean
125 ft.	Fine sand, clean
190 ft.	Fine sand, clean
200 ft.	Fine sand, clayous
205 ft.	Grey clay or shale
225 ft.	Grey clay or shale

75 ft. Blasted large boulders
65 ft. Water Level 16 ft. 6 in.
115 ft. Water Level 13.0 ft.

Well K-109

0 ft.	Loam
10 ft.	Blue clay, till
35 ft.	Blue clay, dark
90 ft.	Blue clay, dark
125 ft.	Blue clay, dark

Well I-109

Depth to tops in feet	Log
0 ft.	Loam
3 ft.	Yellow clay
16 ft.	Yellow clay and sand
20 ft.	Blue clay
67 ft.	Coarse gravel and coal
69 ft.	Blue clay
75 ft.	Blue clay
90 ft.	Blue clay and sand; large boulder
100 ft.	Blue clay and sand; and boulders
112 ft.	Sand, clay; very little water
140 ft.	Clay and sand mixed
155 ft.	Clay and coarse sand mixed
169 ft.	Blue clay
180 ft.	Blue clay

Water Level 15.5 ft.
Very slow in coming in

Well L-110 200 ft. N.

Depth to tops in feet	Log
0 ft.	Loam
4 ft.	Yellow clay
10 ft.	Yellow clay and sand mixed
18 ft.	Hard pan of gravel and clay
20 ft.	Gravel
22 ft.	Fine sand and clay; hard pan
25 ft.	Sand, clayous
40 ft.	Sand, clean
59 ft.	Sand and clay mixed
101 ft.	Blue clay
150 ft.	Blue clay or shale

35 ft. Water Level 9 ft. 3 in.
52 ft. Water Level 6 ft. 8 in.

Well G-111

Depth to tops in feet	Log
0 ft.	Loam
5 ft.	Yellow clay
15 ft.	Clay, brown, sandy
30 ft.	Clay and gravel
50 ft.	Clay and gravel
62 ft.	Coarse sand
65 ft.	Fine sand, clayous
70 ft.	Fine sand, clean
75 ft.	Fine sand, clean
80 ft.	Dark clay
85 ft.	Fine sand, clean
110 ft.	Dark clay
120 ft.	Fine sand, clean
175 ft.	Blue clay
185 ft.	Blue clay

110 ft. Water Level 19.0 ft.

Well H-111

Depth to tops in feet	Log
0 ft.	Yellow clay, sandy
10 ft.	Sand and clay
20 ft.	Blue clay
35 ft.	Blue clay; hard pan
60 ft.	Sand, clayous
65 ft.	Sand, clean
70 ft.	Sand and clay
75 ft.	Fine sand, clean
90 ft.	Fine sand, clean

75 ft. Water Level 6.5 ft.

Well I-111

Depth to tops in feet	Log
0 ft.	Yellow clay
14 ft.	Blue clay, dark
30 ft.	Blue clay, dark
50 ft.	Sand and blue clay
61 ft.	Medium fine sand, clean; very good water
90 ft.	Medium fine sand, clean; very good water
100 ft.	Medium fine sand, clean; very good water
110 ft.	Fine sand, clayous; drinks water rapidly
116 ft.	Blue clay or shale
125 ft.	Blue clay or shale
140 ft.	Blue clay or shale

90 ft. Water Level 8.0 ft.
Water Level 7 ft. 6 in.

Well J 111

Depth to tops in feet	Log
0 ft.	Yellow clay
15 ft.	Blue clay
35 ft.	Blue clay
41 ft.	Fine sand
52 ft.	Fine sand; poor water
89 ft.	Hard pan
93 ft.	Shale
100 ft.	Shale

Water Level 9 ft. 8 in.

Well K-111

Depth to tops in feet	Log
0 ft.	Yellow clay
4 ft.	Blue clay
35 ft.	Blue clay
40 ft.	Blue clay
81 ft.	Blue clay or shale
100 ft.	Blue clay or shale