SOUTH DAKOTA

STATE GEOLOGICAL SURVEY

E. P. Rothrock, State Geologist

REPORT OF INVESTIGATIONS

No. 18

WATER SUPPLIES

AT

FORT THOMPSON, S.D.

By

E. P. Rothrock

University of South Dakota
Vermillion, S. Dak.

February, 1934.

TABLE OF CONTENTS

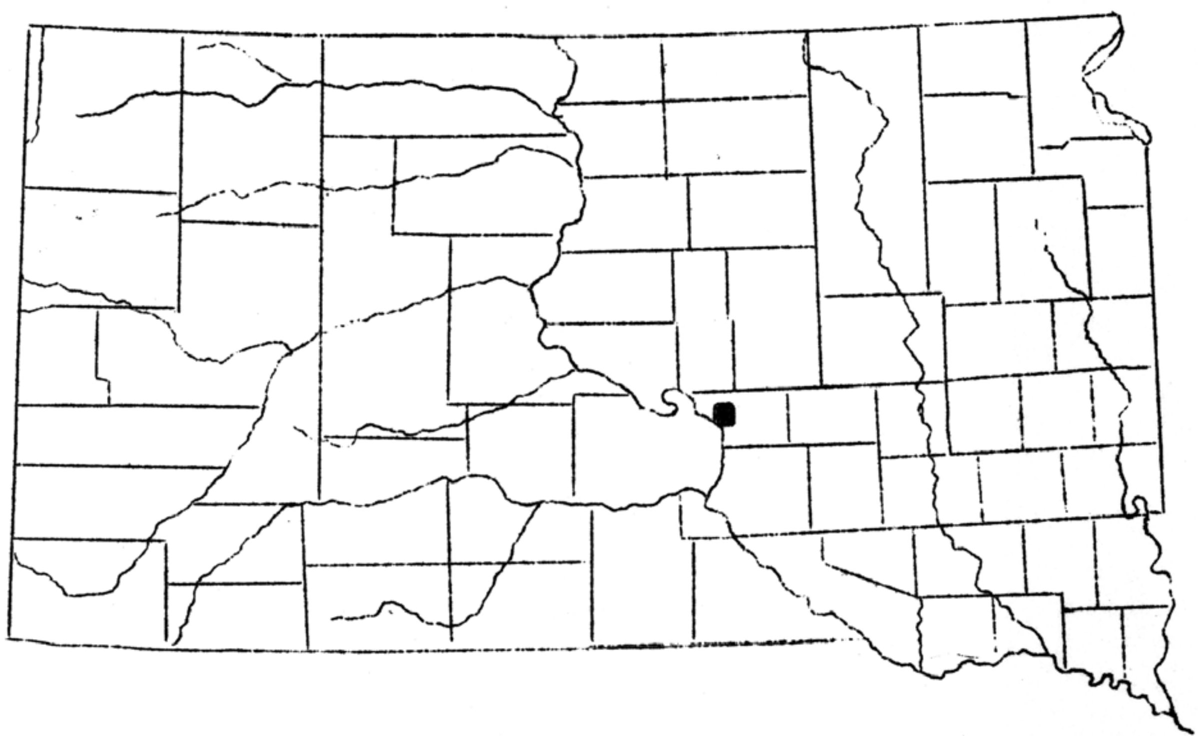
Page

WATER SUPPLIES

AT

FORT THOMPSON

INDEX MAP



■ Area covered by this report.

WATER SUPPLIES AT FORT THOMPSON

Foreword

Difficulties with the water supply at the Crow Creek Agency at Fort Thompson, South Dakota led to a request for data on the possible sources of water supplies for the Agency. The following report is the result of a short field investigation, and a compilation of data from the files of the State Geological Survey, which may assist in solving the problem.

Fort Thompson is located on the banks of the Missouri River in Buffalo County, just below the "Big Bend". It occupies the southern part of Section 23, Township 107 North, Range 72 West. The nearest railroad point is Chamberlain, twenty miles down the Missouri from the Agency. An excellent gravelled highway connects the two.

Approximate sea level elevations were obtained by tying the Highway Profile into the railroad elevation at Chamberlain with the following results:

Elevation of Agency ------------------- 1360 ft.

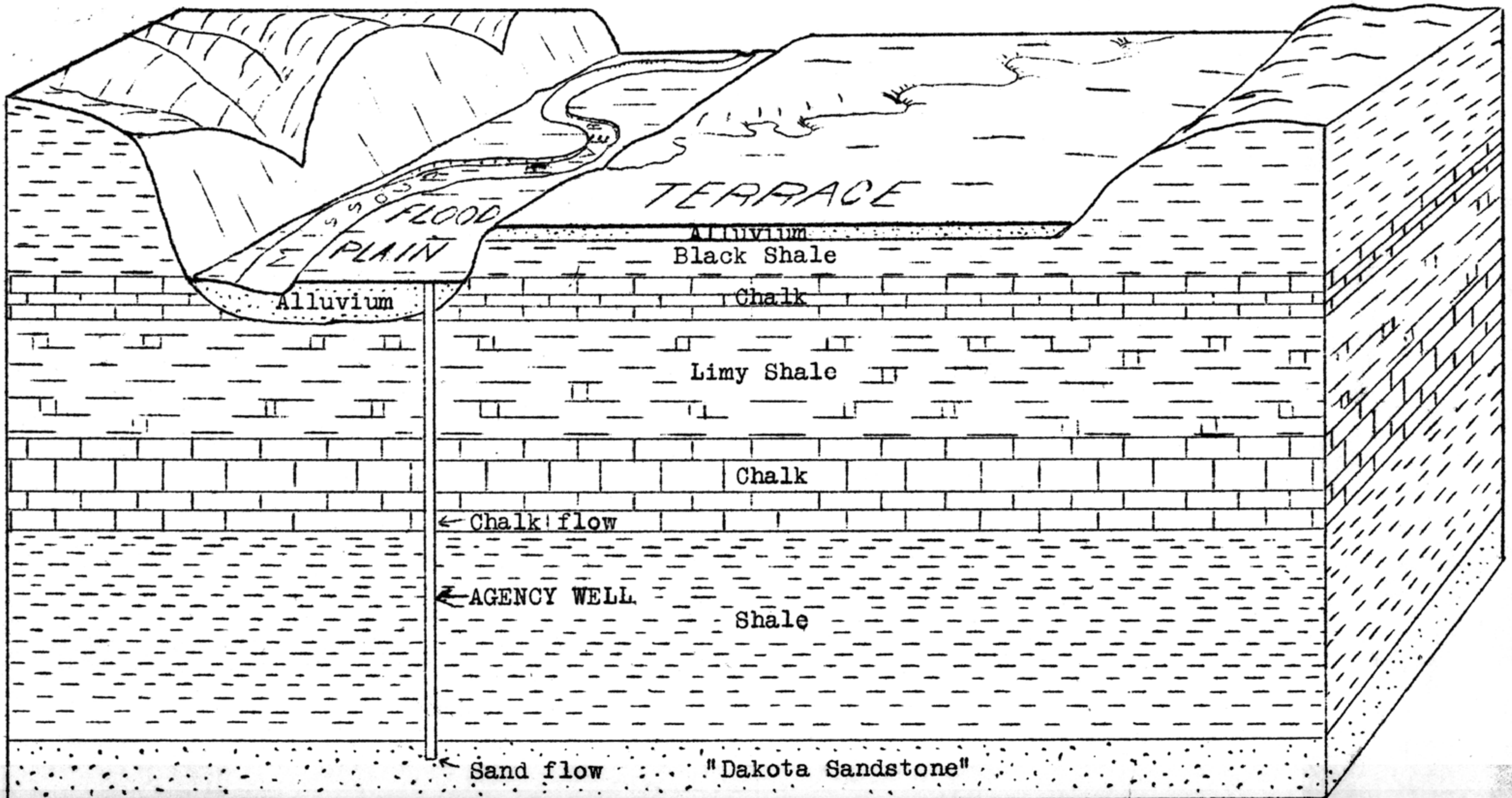
Elevation of Water in Missouri River on January 23, 1934 ------------ 1337 ft.

Elevation of Terrace (Bench) above Agency at the curb of the Agency's Artesian Well --------- 1427 ft.

The Missouri Valley at this point is cut through shales of the Pierre Formation and into the top of a chalk rock known as the Niobrara Formation. The river bed, therefore, is on chalk rock or calcareous shale, but the bluffs are composed of black shales which weather into a gumbo clay. The bottom of the river valley, however, is occupied by a flood plain of sandy alluvium which reaches a depth of 83 feet, according to samples collected from an artesian well drilled in 1896. The Agency stands on this flood plain. At the river's banks the top of the flood plain is sixteen feet above the water level at the time of the investigation (1934), while at the Agency it rises to twenty-three feet above the river level.

On the east side of the valley, immediately behind the Agency, and seventy feet above it stands a bench or terrace two miles wide, which follows the valley northward toward the "Big Bend". Ten to fifteen feet of gravel covered by four to six

DIAGRAM OF FT. THOMPSON GEOLOGY



Legend

- Water bearing sands and alluvium
- Chalk rock
- Limy Shale
- Shale

Scale

Horizontal: 2" = 1 mile
Vertical: 1" = 250 ft.

feet of silt are exposed near the top of this terrace at a number of places along its face. The west side of the valley, opposite the Agency, is a steep bluff unbroken by terraces, and three hundred to four hundred feet in height. Chalk rock outcrops near its base, but the rest of it is made entirely of shale.

Water Supplies

Three possible sources of water present themselves as most usable for the Agency: (1) the Missouri River; (2) wells; (3) the gravel terrace.

The Missouri River:

The channel of the Missouri River lies within a half mile of the Agency and only twenty-three feet below it at low water. There is an abundant supply of water in the river at all times. The minimum flow exceeding eight thousand second feet. The water is very soft, total solids being less than 600 parts per million, even when the water is at low stage. The following analyses furnished by the State Chemical Laboratory will illustrate the point:

Chemical Analyses of Missouri River Water

	Vermillion 1/9/26 Parts per Million	Vermillion 4/1/26 Parts per Million	Pierre Oct.,1925 Parts per Million
Chlorine	14.3	11.3	13.7
Sulphur Trioxide	162.1	154.3	167.4
Calcium Oxide	108.3	81.5	78.2
Magnesium Oxide	45.3	32.7	31.2
Iron & Aluminum Oxides	0.3	0.7	1.5
Silica	20.9	9.9	15.0
Hypothetical Combination			
Sodium Chloride	23.6	18.6	22.6
Sodium Sulphate	156.1	144.4	176.5
Magnesium Sulphate	111.4	97.6	93.1
Magnesium Carbonate	16.9	13.6	10.2
Calcium Carbonate	193.2	135.4	132.0
Iron & Aluminum Oxides	0.3	0.7	1.5
Organic and Volatile Matter	13.5	16.7	10.2
Silica	20.9	9.9	15.0
Total Solids	535.9	436.9	461.1
Total Hardness Calculated as Calcium Carbonate			
Calcium Oxide-Calcium Carbonate	193.2	145.5	139.5
Magnesium Oxide-Calcium Carbonate	112.7	81.1	77.4
Total Hardness	305.9	226.5	216.9

As will be seen from the foregoing the river insures an abundant supply of soft water, but necessitates treatment for removal of silt and for sanitation. It also involves some engineering difficulties in supplying a suitable intake. Some of these difficulties may possibly be avoided by taking water from the sands of the flood plains from some sort of sump or from shallow wells. This water is essentially river water which has drained into the flood plain from the river channel, or forms part of the underflow which is moving down the valley. Such an intake should be placed somewhere between the Agency and the river as it is probable that the fill of alluvial material becomes thin toward the back of the flood plain. Before any such installation is attempted, however, test wells should be sunk to determine the depth and location of gravel or sand veins from which water could be drawn in sufficient quantity. Any attempt to take water from the flood plain sands will meet with dry weather difficulty, unless the sand from which water is being supplied lies below the level of the Missouri River at its lowest stage. This will necessitate test wells at least eighteen or twenty feet in depth. The sands exposed in the banks of the channel are very fine and will not conduct water rapidly, but it is probable that coarser sands will be encountered at great depths.

Such a source is liable to contamination and care must be taken whether water comes from the open river or from shallow wells to see that no pollution gets into the system. It is also possible to make the water much harder through infiltration of artesian water entering the river above the intake or by allowing it to flow uncontrolled over the surface of the flood plain. Poorly cased or leaky artesian wells may allow water to seep into the sands of the flood plains. Wells in the immediate vicinity, therefore, should be kept in good condition, and their overflow properly controlled to insure the best supply for the Agency.

Deep Wells

Aside from the shallow wells in the flood plain, there are at least two possible sources of obtaining a well water supply. At least two strata underlie Fort Thompson which will produce water. One is the chalk rock, which is a water bearer in several parts of the state, and the other the deep artesian sand, commonly known as the Dakota Sandstone. In a well drilled at the Agency some years ago, 1896, a flow was encountered at the base of a 150 feet of "gray chalk", at a depth of 409 feet. The water from this flow "barely rose to the surface."[1] The second and largest flow came from a sandstone at a depth of 780 feet. It is reported that "The well at first threw out white sand," which indicates that the arestian flow came from the Dakota sandstone.

1. Darton, N. H., U. S. Geological Survey Water Supply Paper 227, p. 76.

No information is available on the possibility of encountering other flows below this one as no wells made in this vicinity have penetrated the entire thickness of this sand zone. There are several horizons in the zone, however, which furnish water, and it has been penetrated to a thickness of 140 feet at Chamberlain, and about 70 feet at Pukwana. It is probable that the sand zone at Crow Creek Agency will not exceed two hundred feet in thickness. The log indicates that the flow at the old Agency well came from the top twenty feet of the sand zone, so that it is probable that other flows can be encountered deeper in this sand.

Experience in other regions shows that the sand is not uniformly grained. The fine grained portions are tight; that is, they do not allow ready passage of water, and shale partings occur in many places. The number and depth of flows, however, can only be ascertained by drilling.

<u>Crow Creek Agency Well</u> [1]

0--40	No record
40--78	Gravelly beds, some clay
78--88	Gray clay on thin bed of small gravel (Samples show very fine sand on clean coarse sand.)
88-242	Gray shale (Samples: Calcareous shale at 95 ft. Soft limestone and crystalline calcite at 225 ft.)
242-252	Gray limestone
252-409	Gray chalk, etc., with first flow at 409 ft.
409-435	Pyrites
435-700	Shale (?) on 3-foot layer of pyrites.
700-760	Shale with pyrites.
760-780	Sandstone, main flow. Depth of well. The flow is very large, and water rises five feet above the surface when well is wide open; the closed pressure exceeded 180 pounds. The temperature of the water was 72° F.

<u>Carpenter Farm Well, Pukwana, S. Dak.</u> [2]

0--60	Black loam
60--72	Yellow sand
72-196	Blue clay
196-435	Chalk rock
435-536	Black clay
536-559	First sand
559-749	Blue-black clay
749-771	Second sand
771-845	Light chalky clay
845-907	Third sand (Dakota sandstone)

1. U. S. G. S. Water Supply Paper No. 227, p. 76, (1909).
2. U. S. G. S. Water Supply Paper No. 227, p. 75, (1909).

Chamberlain Power Well [1]

Location: T. 104 N., R. 71 W., Brule County, South Dakota.

0--22	Sand and gravel
22--42	Blue clay
42--132	Chalk rock
132--498	Blue clay, tough and dark below
498--507	Sand
507--555	Tough dark clay
555--584	Sand and clay with flow
584--612	Fine dark sand, very fine below
612--619	Hard sand rock
619--633	Compact sandstone
633--689	Sandstone under capstone yielding a flow of 4,350 gallons per minute from an 8-inch pipe.

Water from both sources mentioned is highly charged with mineral matter. That from the chalk carries calcium salt dissolved from the lime rock. No analyses of this flow are available. The artesian horizon is always highly charged with salt, averaging 1800 to 2200 parts per million of total solids. Some waters are soft but inevitably taste so salty due to a high concentration of sodium salt that little use is made of them. Where other water is not available the population becomes accustomed to the taste and medicinal properties of artesian water and are able to use it, though there is always considerable damage to pipes and other equipment due to corrosion, and the deposition of salts. The artesian water problem, therefore, resolves itself into one of removing the salts in a softener sufficiently to prevent corrosion and to give a palatable water. An inspection of the following analyses indicates the nature of the problem.

Analyses of 900-Foot Artesian Well, Crow Creek Agency, South Dakota.

Sample taken from well Oct. 27, 1927

	Parts Per Million
Total Solids	2060.
Silica	41.
Al_2O_3	6.8
Iron	1.37
Magnesium	60.
Calcium	274.
Chlorides	1130.
Sulphate	1140.
Carbonates	96.
Sodium Chloride	186.
Sodium Sulphate	588.
Magnesium Sulphate	296.
Calcium Sulphate	720.
Calcium Carbonate	157.
Nitrates	---.
Nitrites	---.

1. U. S. G. S. Water Supply Paper 227, p. 75.(1909).

Analysis of Old (1896) Crow Creek Agency Well

	Parts per Million
Total Solids - - - - - - - - - - - - - - - -	2100.
Chloride - - - - - - - - - - - - - - - - - -	99.5
Sulphate - - - - - - - - - - - - - - - - - -	1146.5

Analysis of Artesian Well at Chamberlain, Brule County, South Dakota.

Analysis from U. S. G. S., 17th Annual Report, Part II, p. 677.

	Parts Per Thousand.	(Parts Per Million)
Sodium Chloride- - - - - - - - - - - - -	.1800	(180.0)
Sodium Sulphate- - - - - - - - - - - - -	.3618	(361.8)
Sodium Carbonate - - - - - - - - - - - -	.----	(---.-)
Magnesium Sulphate - - - - - - - - - - -	.4375	(437.5)
Magnesium Carbonate- - - - - - - - - - -	.----	(---.-)
Calcium Sulphate - - - - - - - - - - - -	.6920	(692.0)
Calcium Carbonate- - - - - - - - - - - -	.1573	(157.3)

Analysis of Artesian Water in Well at Pierre, S. Dak.

Analysis from U. S. G. S., 17th Annual Report, Part II, p. 677.

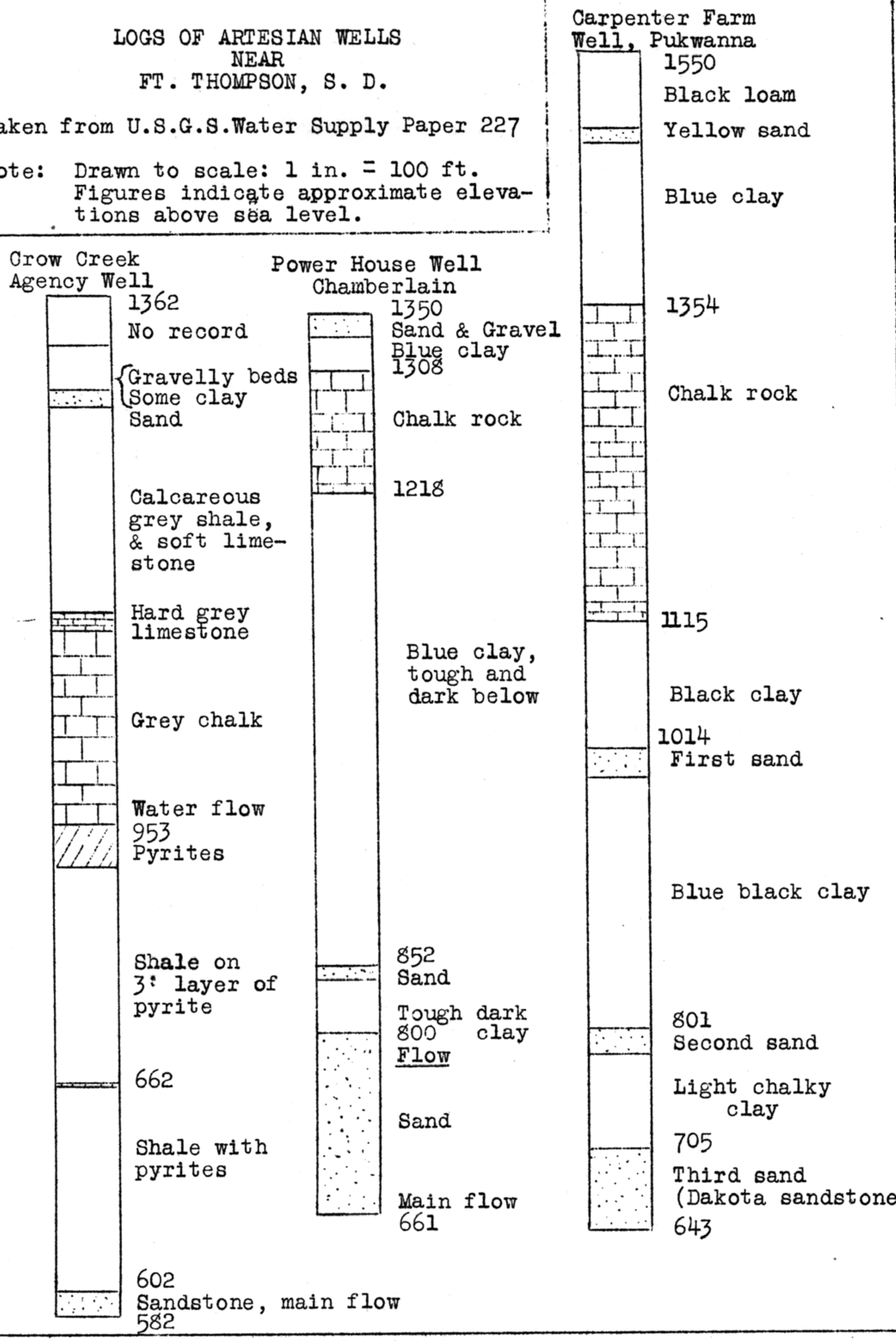
	Parts Per Thousand.	Parts Per Million
Sodium Chloride- - - - - - - - - - - - -	2.8052	(2805.2)
Sodium Sulphate- - - - - - - - - - - - -	.----	(---.-)
Sodium Carbonate - - - - - - - - - - - -	.5711	(571.1)
Magnesium Sulphate - - - - - - - - - - -	.----	(---.-)
Magnesium Carbonate- - - - - - - - - - -	.0050	(5.0)
Calcium Sulphate - - - - - - - - - - - -	.----	(---.-)
Calcium Carbonate- - - - - - - - - - - -	.0771	(77.1)

The volume obtainable from artesian wells is more than ample to provide for the needs of the Agency. The well drilled in 1896 was reported to have thrown a six inch stream five feet into the air, which would give a volume of about fifteen hundred gallons per minute. The present artesian well, seventy feet higher, flows at the rate of one hundred and eighty gallons per minute.

LOGS OF ARTESIAN WELLS NEAR FT. THOMPSON, S. D.

Taken from U.S.G.S.Water Supply Paper 227

Note: Drawn to scale: 1 in. = 100 ft.
Figures indicate approximate elevations above sea level.



If the artesian well supply is used, care should be taken to preserve the artesian head as long as possible. Several wells have been drilled in the neighborhood, and are being allowed to flow wide open. This will, of course, reduce the pressure available to the main well and will lower the head much more rapidly than necessary. A second source of loss of pressure will be found in the abandoned wells at the Agency. These are either flowing feebly or have been shut off at the surface. Corrosion in the pipes, however, allows the water from the Dakota sand to leak away in the chalk rock, higher up, which results in the loss of enormous amounts of water, even though the flow does not show at the surface. These old wells should be plugged, sealing them off just above the artesian sand, and the hole filled with clay or other impervious material.

The Gravel Terrace

This is an unused and untested possibility, but is worthy of consideration because of the large volume of water it is capable of storing, and the ease with which water could be moved to the Agency. The terrace is an ancient flood plain. Because of stream erosion subsequent to its formation, it now lies seventy feet above the modern flood plain, on which the Agency stands. The lower fifty feet of the terrace is made of rock, ten to fifteen feet of chalk being exposed along its base as far as it was followed. About forty feet of black shale overlies the chalk and this makes the bedrock of the terrace. On this bedrock lies twenty feet of alluvium. The bottom of this alluvium is coarse gravel, which is exposed along the face of the terrace at a number of places, and can be detected in the bluffs of Warrior Creek. Thicknesses of from seven to eighteen feet of gravel appear in stream cuts at the face of the terrace, the deeper gravels being found on the steep bluffs west of the valley of Warrior Creek. The gravels are very coarse and contain a high percentage of limonite concretions such as occur abundantly in the shales of the Missouri River bluffs. These are found as pebbles, cobbles and small boulders.

At least fifteen square miles of the terrace lies within reach of the Agency, its width being about two miles. This volume of gravels affords an enormous reservoir for water storage, and one from which water could be easily drawn in large quantities.

The supply of water in the gravels depends entirely upon local rainfall, however, and this is one of the possible drawbacks to this source of supply. No large stream flows through this alluvium, and the drainage area which feeds it is entirely on its eastern side and is not very wide. The average rainfall at Chamberlain is about eighteen inches and has fallen as low as twelve inches. Therefore, the supply cannot compare in volume with that which the recent flood plains are drawing from the underflow of the Missouri River. The terrace gravels suffer a considerable loss due to leakage through springs and seeps at the face of the terrace. From the foregoing it will be seen that the amount of water in the terrace gravels will vary considerably with the rainfall and would be especially precarious after several dry seasons.

These factors make it necessary to test the terrace carefully before any development is undertaken. No wells have been dug into the gravels and only one live spring was found in the area examined (1934), although three other springs, which had dried up, were located. Testing should begin with a series of wells placed about a mile back from the face of the terrace. These wells should penetrate the gravel to bedrock, a depth not exceeding twenty-five or thirty feet.

The water from this terrace would doubtless be hard, due to the solution of the limy materials contained in the gravels and possibly in the overlying silt. The water from the spring a half mile northeast of the Agency is hard enough to coat pebbles in the neighborhood of the spring, and to form scale in the teakettle in which it is used. It serves as the sole water supply for a single family, however.

SUMMARY OF WATER SOURCES

1. Missouri River and its underflow.

   Supply: Abundant.

   Character of water: Soft. 300 to 600 p.p.m. hardness.

   Easily accessible.

2. Deep Wells.

   Supply: Abundant.

   Source: Chalk flow at 400 to 500 feet.

   Artesian sands at 800 to 900 feet.

   Character of water: Hard.

3. Terrace Gravels.

   Supply: Untested, but chance for large amounts in normal and wet seasons.

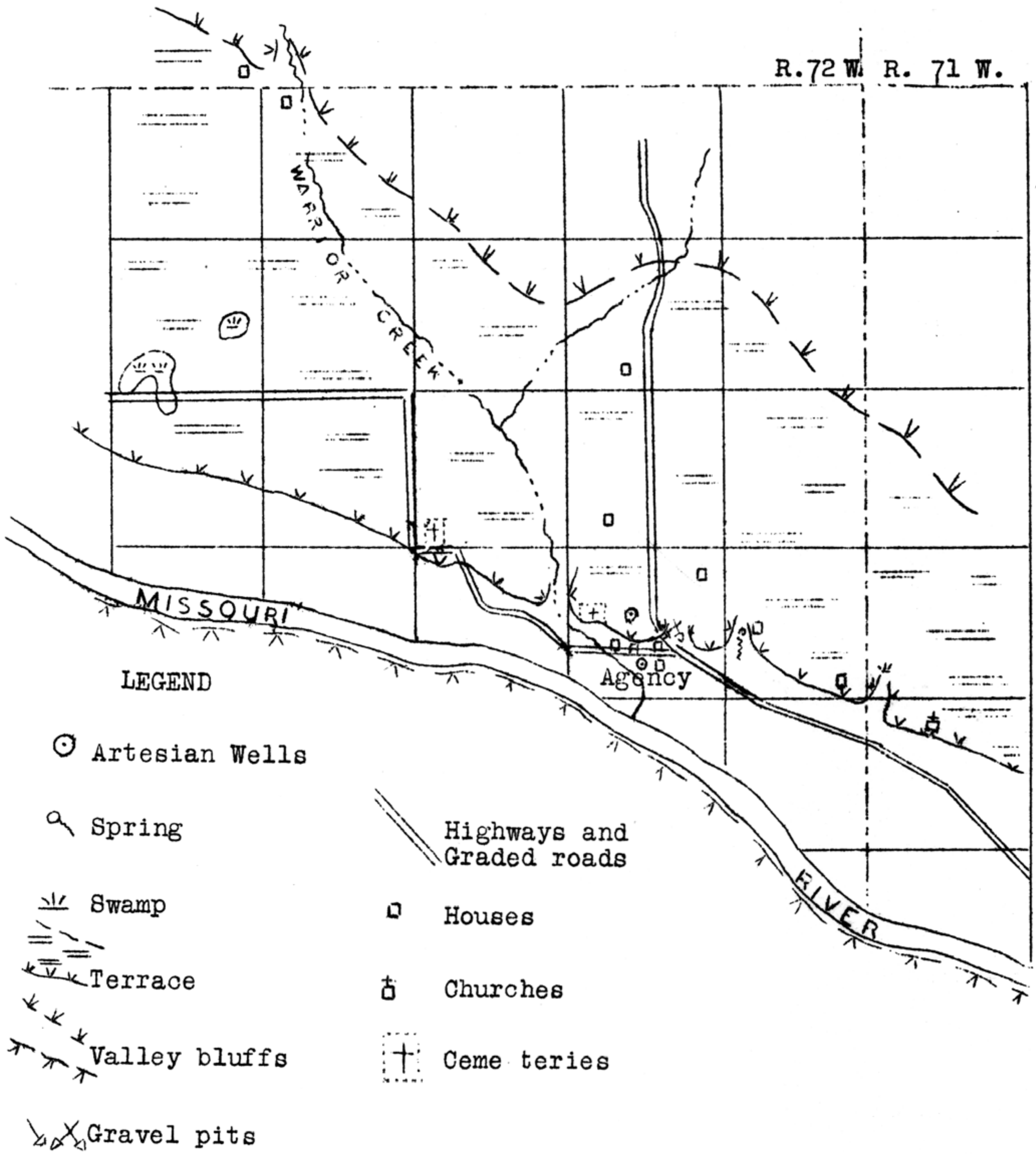
   Character of water: Hard.

   Development by series of shallow wells or galleries.

MAP OF THE MISSOURI VALLEY

AT

FT. THOMPSON, S. D.



Scale: 1 inch = 1 mile.