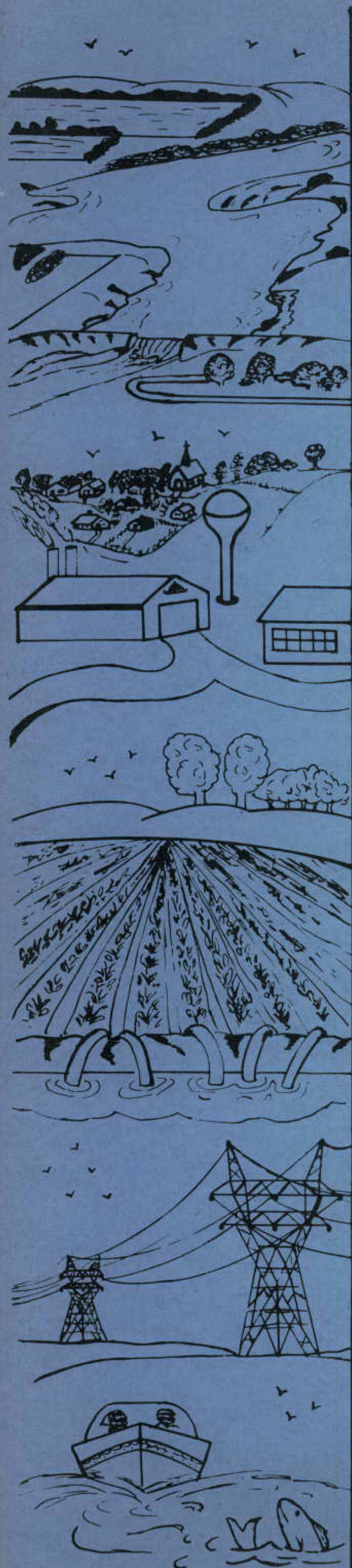


REPORT ON GROUND WATER AVAILABILITY FOR IRRIGATION PURPOSES IN THE LITTLE MUDDY VALLEY AREA, WILLIAMS COUNTY, NORTH DAKOTA

SWCC PROJECT NO. 776

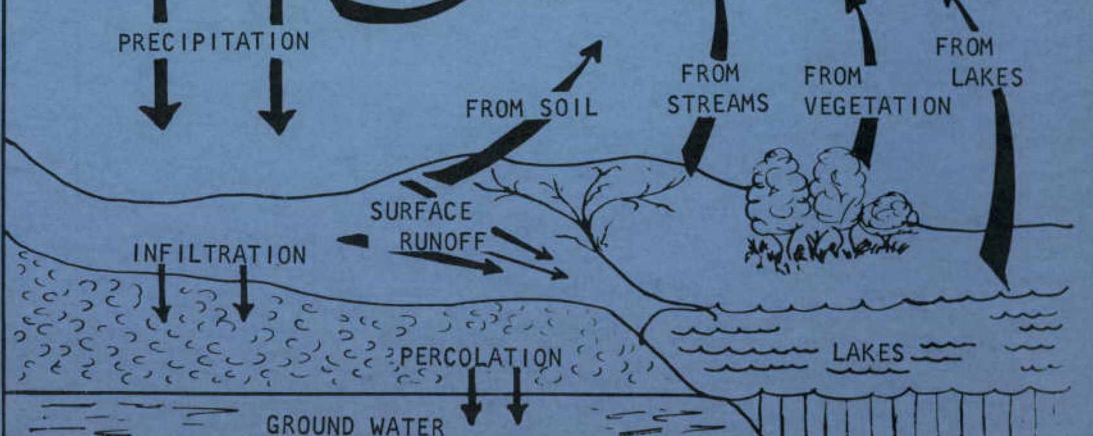
BY
R. W. SCHMID, GEOLOGIST
WITH
RECOMMENDATIONS
BY
MILO W. HOISVEEN, CHIEF ENGINEER

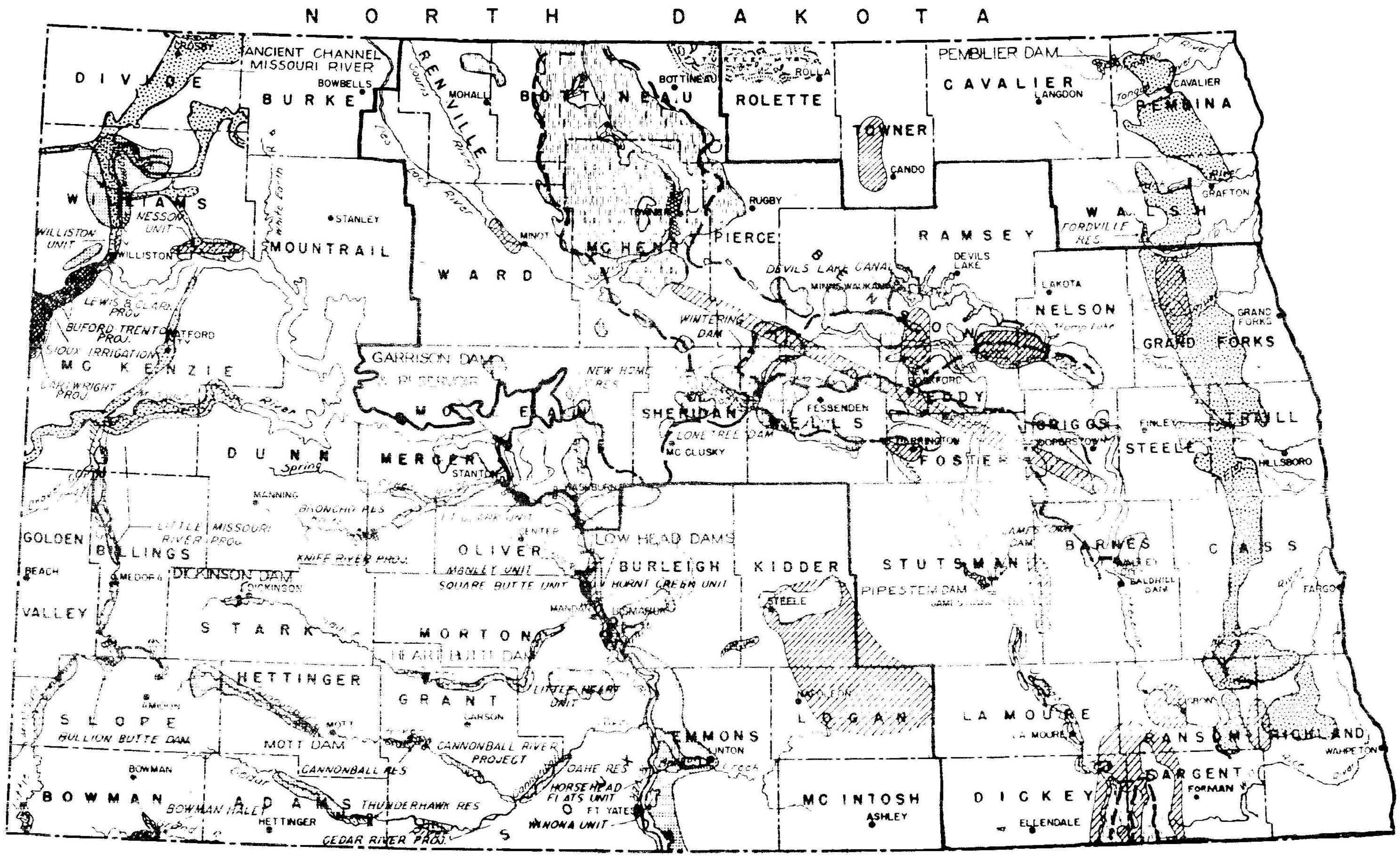
NORTH DAKOTA GROUND WATER STUDIES

NO. 36

PUBLISHED BY
NORTH DAKOTA STATE WATER CONSERVATION COMMISSION
1301 STATE CAPITOL, BISMARCK, NORTH DAKOTA

1961





NORTH DAKOTA STATE WATER CONSERVATION COMMISSION

WATER RESOURCES DEVELOPMENT PLAN

LANDS UNDER IRRIGATION

AREAS CONSIDERED IRRIGABLE

AREAS BEING INVESTIGATED

PROPOSED FOR INVESTIGATION

EXISTING

UNDER CONSTRUCTION OR PROPOSED

DAM & RESERVOIR SITES

PROPOSED CANALS

GARRISON DIVERSION CONSERVANCY DISTRICT BOUNDARY

GROUNDWATER AQUIFERS

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HENRY J. STEINBERGER

REPORT ON GROUND WATER AVAILABILITY FOR IRRIGATION PURPOSES IN THE LITTLE MUDDY VALLEY AREA, WILLIAMS COUNTY, NORTH DAKOTA STATE WATER CONSERVATION COMMISSION PROJECT NO. 776

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Milo W. Hoisveen, Chief Engineer

North Dakota Ground Water Studies No. 36

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-1961-

CONTENTS

ILLUSTRATIONS

TABLES

LOCAL AND GENERAL FEATURES OF THE AREA

This report covers nearly 300 square miles and includes townships 153 through 158 north, range 100 west and townships 154 through 156 north, range 101 west. It is in the northwestern portion of North Dakota in Williams County, which had a population of 22,051 in 1960. (See fig. 1)

The average annual precipitation for Williams County is only 14.47 (1930-1951), but nearly all of this falls during the growing season which averages 132 days. January temperatures in the area average approximately 7°F while the average for July is about 67°F.

The major occupations of the area are dryland farming and ranching. Since the discoverery of petroleum in the Williston Basin, the oil industry has contributed significantly to the economy of the area.

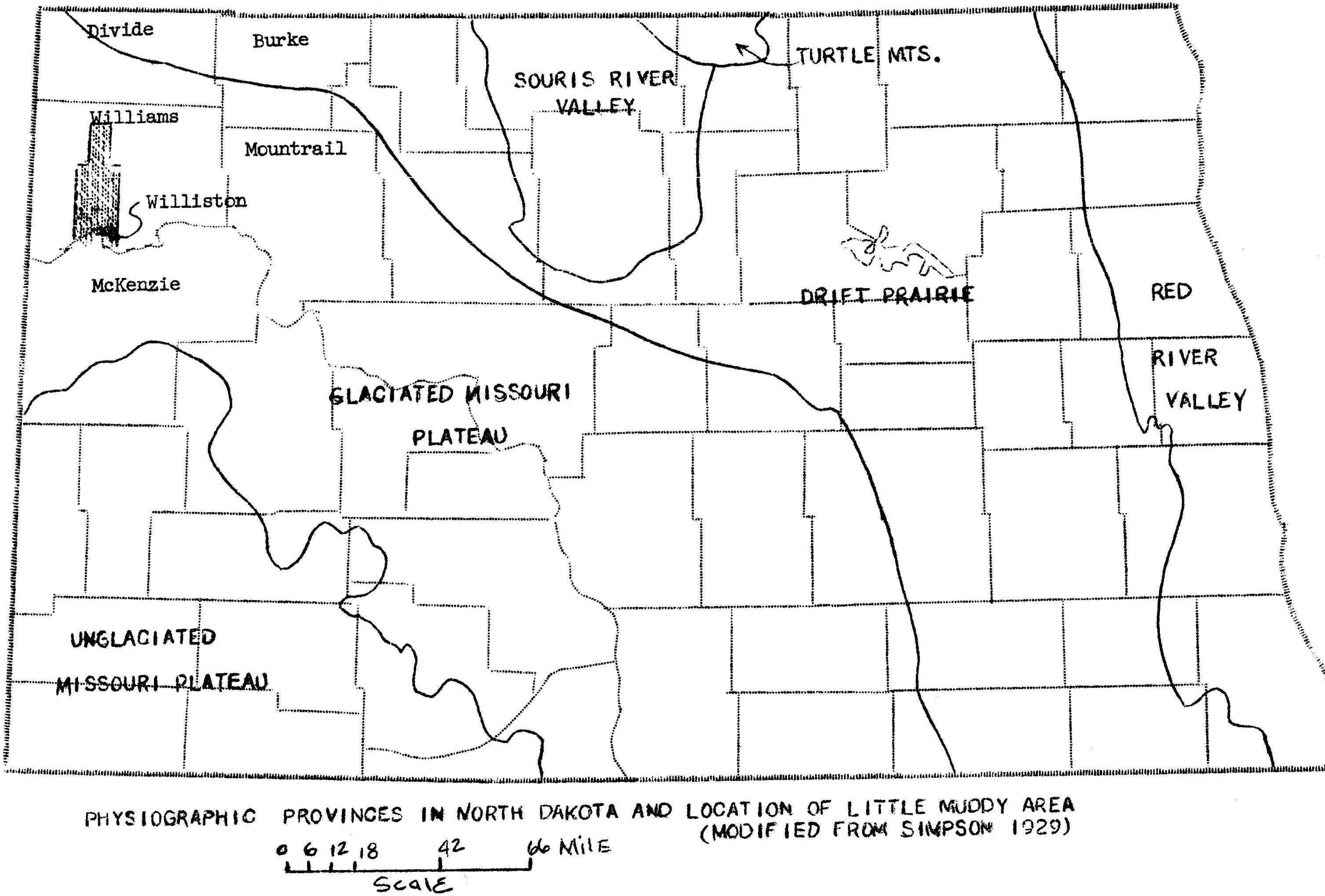
PURPOSE AND SCOPE OF THE INVESTIGATION

The aims of the study are to make a survey of the subsurface conditions in the area by test drilling to evaluate ground-water availability for irrigation use. Some of the data gathered for this report will also be included in a future more comprehensive investigation of all of Williams County; the larger investigation will be part of a continuing statewide program of water-resources investigations. The field-work for this report consisted primarily of test drilling during June, July, and August of 1961 along with a study of the available data.

PREVIOUS INVESTIGATIONS AND ACKNOWLEDGMENTS

Simpson (1929, p. 265-268) discusses the ground-water resources of Williams County briefly in a general study of the whole state. The U. S. Geological Survey and the North Dakota State Water Conservation Commission drilled a series

FIG. 1



PHYSIOGRAPHIC PROVINCES IN NORTH DAKOTA AND LOCATION OF LITTLE MUDDY AREA (MODIFIED FROM SIMPSON 1929) of test holes in the Little Muddy Creek area for their Ancient Channel Study during 1958 and 1959.

The cooperation of the farmers and ranchers in the area greatly facilitated the field-work, as did the valuable assistance of Mr. Ardell A. Liudahl, chairman of the Williams County Irrigation Committee, who contributed much time and effort to this project.

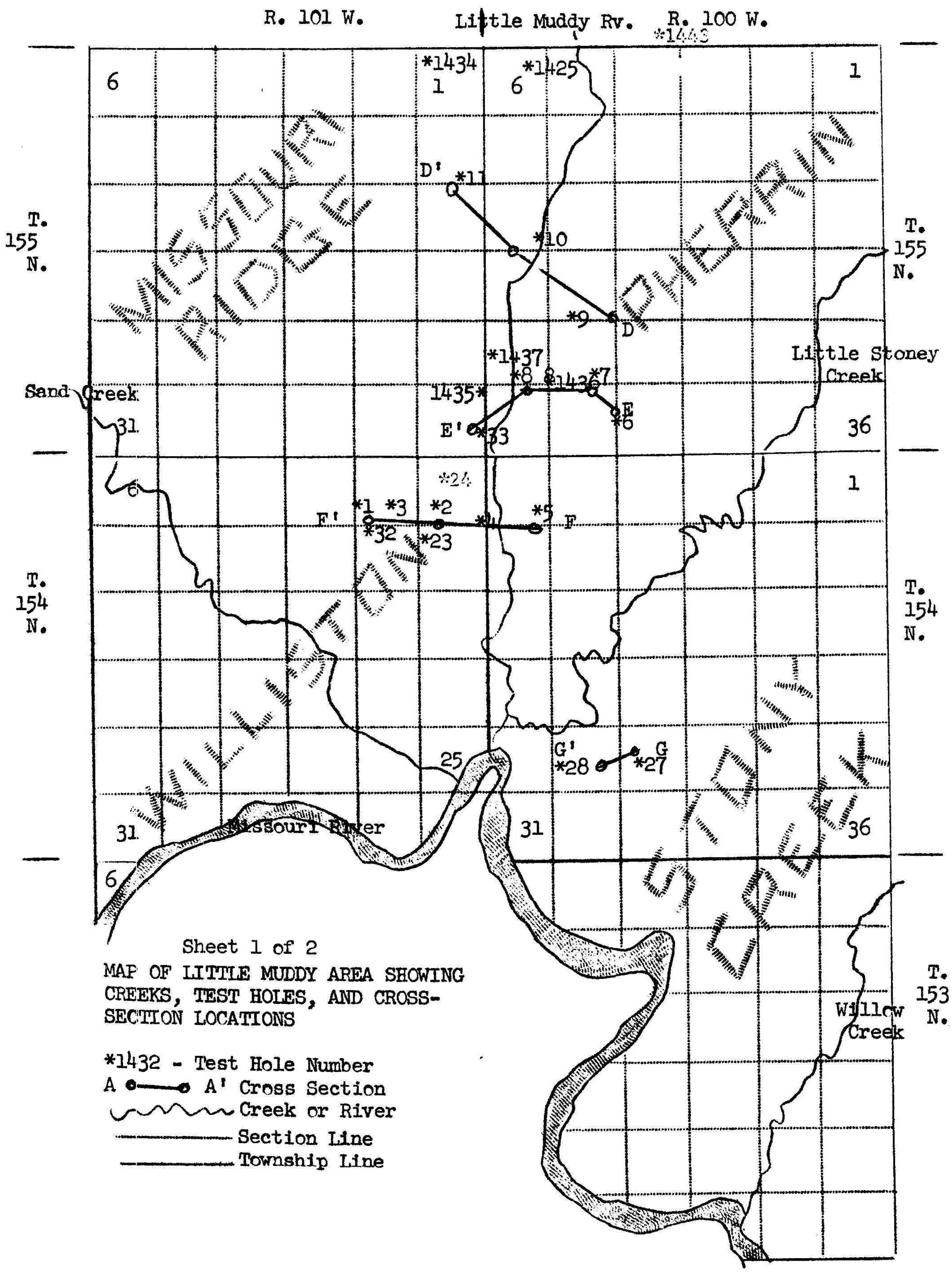
PHYSIOGRAPHY

Fenneman (1931, p. 72-79) places the area studied in the glaciated Missouri Plateau section of the Great Plains physiographic province. He believes that prior to glaciation the topography of the area resembled that of the unglaciated Missouri Plateau section which lies south of a line 35 to 50 miles south of the present Missouri River. The subduing effect of glaciation is seen by a comparison of the two sections. (See Fig. 1)

Elevations in the area range from 1840 to more than 2300 feet above sea level, giving an areal relief of nearly 500 feet.

Runoff from the report area flows into the Missouri River. Sand, Little Stony, Willow and Little Muddy Creeks flow directly into the Missouri River while Cow, Ottertail, Blacktail, and East Fork of the Little Muddy Creeks flow into the Little Muddy Creek. The above mentioned creeks, excluding the Little Muddy, are classified as intermittent streams. (See Fig. 2)

The Fort Union formation is the bedrock underlying the glacial and fluvial deposits of area. Bluffs, such as those south of the Missouri River across from Williston, are formed in the Fort Union formation. Such outcrops, on a smaller scale, are found at various places in the area.


R. 101 W.
Little Muddy Rv.
R. 100 W.
*1443
*1434
*1425
6
1
6
1
D'
*11
*10
*9
D
T.
155
N.
Little Stoney
Creek
*1437
*8
*1436
*7
Sand Creek
1435*
E
*6
31
E'
*33
36
*24
6
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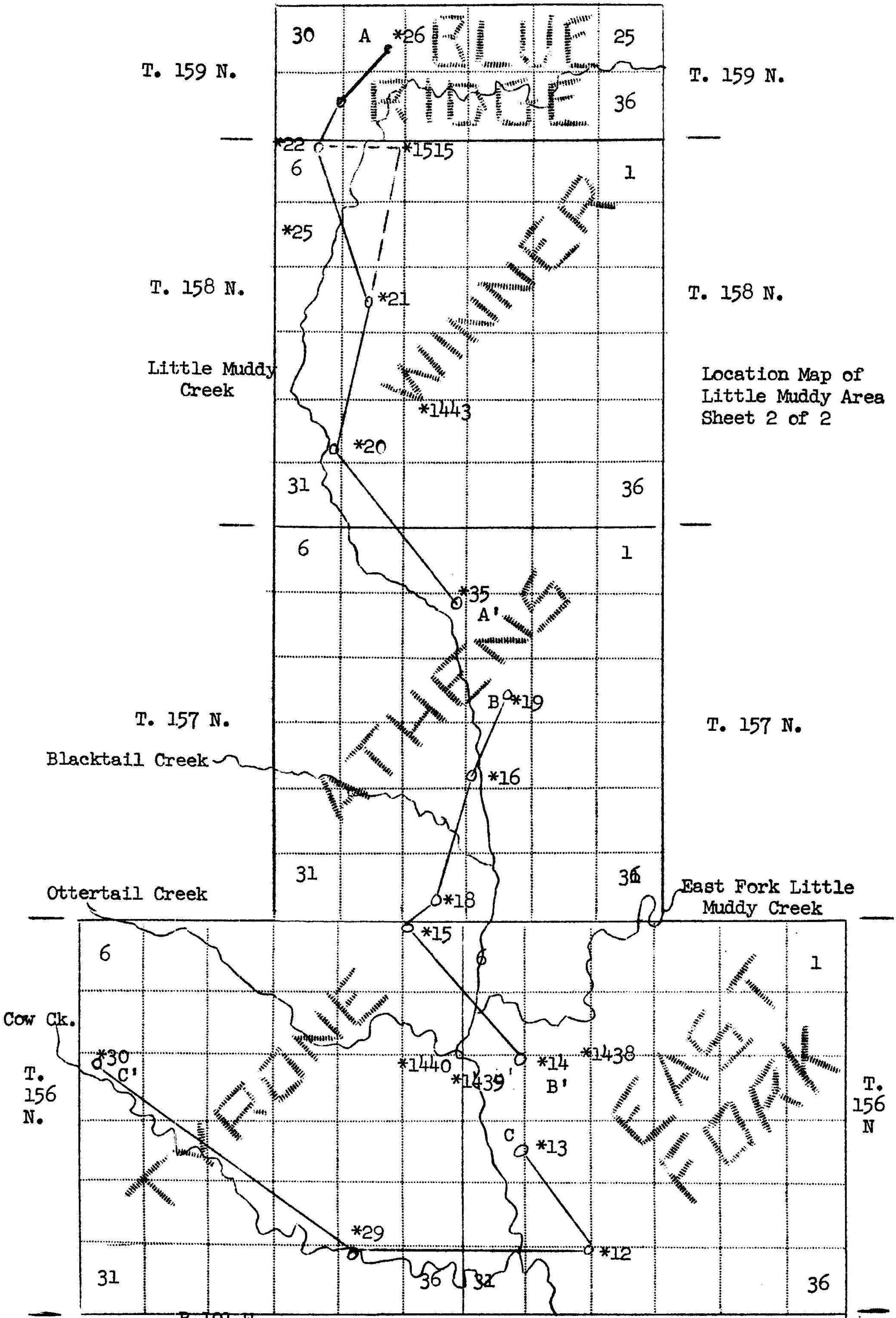
*1
*3
*2
*5
F'
*32
*23
*4
F
T.
154
N.
25
G'
*28
G
*27
31
Missouri River
31
36
6
Willow
Creek
T.
153
N.
MISSOURI RIDGE
PHEARIN
WILLISTON
STONY CREEK
Sheet 1 of 2
MAP OF LITTLE MUDDY AREA SHOWING
CREEKS, TEST HOLES, AND CROSS-
SECTION LOCATIONS
*1432 - Test Hole Number
A A' Cross Section
Creek or River
Section Line
Township Line

FIGURE 2a



BLUE RIDGE
WINNER
ATHENS
FORE
EAST FORK
T. 159 N.
T. 158 N.
T. 157 N.
T. 156 N.
Little Muddy Creek
Blacktail Creek
Ottertail Creek
East Fork Little Muddy Creek
Cow Ck.
Location Map of
Little Muddy Area
Sheet 2 of 2
A
A'
B
B'
C
C'
*26
*22
*1515
*25
*21
*1443
*20
*35
*19
*16
*18
*15
*14
*1438
*1440
*1439
*13
*12
*29
*30
30
25
36
6
1
31
R 101 W.
R 100 W.

FIGURE 2b

WELL-NUMBERING SYSTEM

The well-numbering system used in this report is illustrated in figure 3 and is based upon the location of the well within the grid established by the U. S. Bureau of Land Management's survey of the area. The first numeral denotes the township north of the base line which extends laterally across the middle of Arkansas; the second numeral denotes the range west of the fifth principal meridian, and the third numeral denotes the section in which the well is located. The letters a, b, c, and d, designate, respectively, the northeast, northwest, southwest, and southeast quarter sections, quarter-quarter sections, and quarter-quarter-quarter sections (10-acre tracts). Consecutive terminal numerals are added when more than one well is located within a given 10-acre tract. Thus, well 151-75-25-baa is in the NE¼NE¼NW¼ of sec. 25, T. 151 N., R. 75 W. Similarly, well 162-69-8ddc2 is the second well located in the SW¼SE¼SE¼ of sec. 8, T. 162 N., R 69 W.

EVALUATION OF TEST DRILLING

The North Dakota State Water Conservation Commission crew drilled a total of 6233 feet for this project. (North Dakota State Water Conservation Commission Project #776). Thirty-five test holes ranging in depth from 42 feet to 379 feet were drilled. (See Fig. 2 for test hole locations and Table Part 1 for cross-sections).

Test hole 22-776 (158-100-6-abb) probably contained the best source of irrigation water found in the area. The aquifer at this site contains permeable gravel from the land surface down to 105 feet. Subtracting the 40 feet of dry gravel above the water table, there remain 65 feet of permeable, water-saturated gravel. The aquifer receives direct rather rapid recharge by the infiltration of precipitation that falls on the sandy or gravelly topsoil of this locality. The same aquifer was also drilled into in

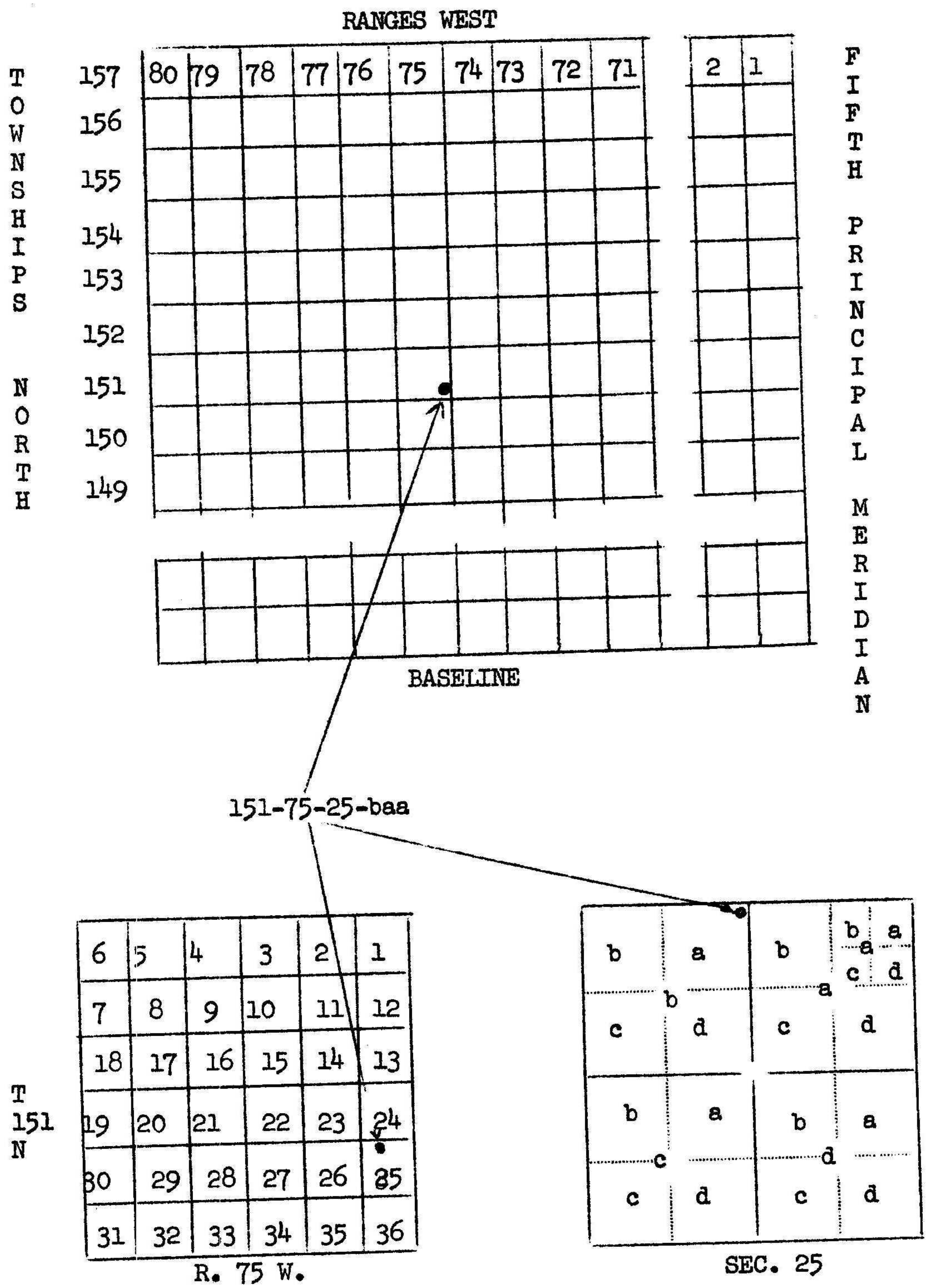


FIGURE 3 - SKETCH ILLUSTRATING WELL NUMBERING SYSTEM

test holes 26-776 (159-100-29-add) and 34-776 (159-100-31-add) north of the report area; there the gravel seems to be more sandy and is interbedded with clay lenses of varied thicknesses. Test hole 25-776 (158-100-7-bcb) south of test hole 22-776 was drilled to a depth of 63 feet only; the entire 63 feet consists of rather coarse gravel.

Irrigation wells in section 6 and the west half of section 7 in Winner township would probably yield large quantities of water. However, before aquifer characteristics (permeability, storage capacity, boundary conditions, and related factors) can be determined, pumping tests are necessary.

The aquifer at test hole 35-776 (157-100-9-aac) probably contains a considerable amount of water in the sands and gravels extending from the surface to a depth of 75 feet. However, because this aquifer consists primarily of sand, less water can be pumped from it than from an aquifer containing mainly gravel. The area near the test hole has a fairly high water table (approximately 10 feet below the surface); this leaves a water-saturated zone of sands and gravels 65 feet thick. Because the sand is fairly permeable, probably a well-designed combination of well, casing, and gravel pack could produce a fairly reliable irrigation well. This, of course, must be determined by a reputable drilling firm.

It is probable that the sands encountered in test holes 19-776 (157-100-15 bdd) and 20-776 (158-100-30 dda) could be correlated with the sands and gravels of test hole 35-776, but this is not certain because of the relatively large distances between test holes (nearly 1½ miles to test hole 19-776 and over 3 miles to test hole 20-776). Additional test holes would probably give a clearer view of the true situation. Completion of satisfactory wells in the high sand content of this aquifer requires the skill, knowledge, and experience of a reliable drilling company.

The 79 feet of sandy gravel in the second aquifer at test hole 20-776 would yield considerable amount of water, but there are two reasons for not using this gravel as a source of irrigation water. The first reason is its relatively great depth; it would probably be uneconomical to drill to and pump from such depths. The second detrimental factor is the quality of water. Nearly all of the deeper aquifers in this area contain water of very poor quality for irrigation (See Table Part 4)

In test hole 35-776 the 25+ feet of sand containing water under artesian pressure has the above draw backs of relatively great depth and probable poor quality plus the poor yielding characteristics of a fine-grained (sandy) aquifer.

Test hole 11-776 (155-101-13-abb) is a good example of a porous gravel. A considerable volume of the test hole samples from 37 to 51 feet consisted of very large pebbles (1½ to 2 inches across). The coarseness of the gravel suggests a highly permeable aquifer; however, the thinness of the aquifer (14 feet of gravel) would greatly reduce the volume that could be pumped from an irrigation well at this location. Also such a thin gravel situated above the valley may have a small areal extent. Additional test holes and a pumping test would be necessary in this area to give a clear idea of the potential of the aquifer.

Test hole 21-776 (158-100-17-caa) may contain enough aquifer footage (36 feet) for a small irrigation well. The lower 19 feet consists of sandy gravel which probably would have fairly good permeability. Above the gravel there is 11 feet of sand overlain by 6 feet of gravel. This combination of sand and gravel, both of which are permeable would perhaps allow yields large enough for irrigation.

The above aquifer may be related to the sand and gravel in test hole 1515 (158-100-5-aaa) drilled in May of 1959 by the North Dakota State Water Conservation Commission and the U. S. Geological Survey. Probably a well in this locality would also be capable of producing a sufficient amount of water for a small irrigation project.

If test holes 21-776 and 1515 are both in the same aquifer, the potential ground water yield of this area would be greatly enhanced. The probable continuity of this aquifer could be determined by additional test drilling and pumping tests.

Test holes 2-776 (154-101-12-bba), 23-776 (154-101-12-bbb), 24-776 (154-101-1-ccd), and 32-776 (154-101-12 bbb) define subsurface conditions in a small area and were drilled for two reasons. The first reason was to further examine the excellent small aquifer found in test hole 2-776. The second reason was to test a water supply sampling technique developed by the State Water Conservation Commission. The time spent working with the water sampler was not charged to this project.

There is approximately 50 to 65 feet of water bearing material in this locality; the basal 17 or 18 feet is gravel or at least, gravelly sand. The remainder consists of sand or sand with a high clay content in some cases. The presence of clay in the otherwise permeable sand tends to slow the movement of water which would thereby reduce the flow into the gravel and adversely effect the irrigation potential of a well in such a location.

Although the irrigation potential of this location is questionable; ground water seems to be plentiful and a test hole at the location of a proposed well site might show that a small irrigation well would be feasible.

The previously mentioned locations have the best irrigation possibilities. The remainder of the holes drilled contained varying amounts of sand and gravel, with the exception of test holes 6-776 (155-100-32 ada) and 17-776 (157-99-19-dcd); both of these were completely without permeable beds above the Fort Union Formation.

Examination of the sand and gravel logs of test holes (See **Table** Part 2 & 3) shows that the holes not discussed were drilled through material not likely to yield ground water in sufficient quantities for irrigation.

RECOMMENDATIONS

By the Chief Engineer of the North
Dakota State Water Conservation Commission

1. The proponents of the proposed ground water irrigation project in the Williston Area should consider requesting that soi scientists from the North Dakota State University make a land classification map of the area which possess irrigation potential. A soil survey of the type required for an irrigation project will enable land owners and technicians an opportunity to evaluate how the soils will react to the artificial application of water. The analysis should reveal whether the elements contained in the water will react with the soil to be irrigated, the determination of length of irrigation runs, whether the conventional surface method or the sprinkler method of irrigation should be used and the desirable rate at which the water might be applied to the surface through the use of the sprinkler method of irrigation without compacting the soil of wasting water.

(a) The conventional surface or gravity method of application is under most conditions the more economical method of applying water. The land leveling supply ditches, drainage ditches and pertinent facilities become a part of the land and their value is reflected in the sales price of the irrigation farm whenever sold. Generally, water can be applied with less labor, when the land has been properly prepared, through the surface method of irrigation.

(b) The advantages of the sprinkler method of applying water is that little or no land preparation is required other than that needed for the normal farming operations. It is most economical to use when the land to be irrigated is undulating and the soils are too shallow to permit land leveling. It is also a more advantageous method of applying water when the soils are so porous that they will not permit irrigation runs in excess of 250 feet. The sprinkler method of irrigation will afford the operator an opportunity to put a greater amount of land under irrigation with much less time and effort. In some instances it will permit the saving of water. Its use in applying water is more easliy learned by labor than is the surface method. DISADVANTAGES of the sprinkler method of irrigation are that additional power is required to run the water through the sprinkler system. This may run as high as $3.00 to $4.00 an acre for the season as a pumping head of approximately 130 feet is required to operate such systems. Depreciation is a considerable factor as the life expectancy of a sprinkler system rarely exceeds 15 years. In some instances, obsolescency is also a factor in sprinkler irrigation as improvements are constantly being effected in regards to this equipment. Specialized systems are needed for tall growing crops such as corn to permit over head sprinkling.

2. The proponents of the project should also consider whether or not they desire to obtain Federal assistance in the construction of the project. The Small Projects Reclamation Act presents landowners an opportunity to obtain interest free money up to 80% of the total cost of a small project. The remaining 20% must be paid from local sources prior to construction of the project. Assistance in applying for such projects can be made through the North Dakota State Water Conservation Commission as it has been designated as the official state agency to clear such

projects to the Bureau of Reclamation. It is quite possible that a very favorable power rate could be obtained from the Bureau of Reclamation for use in connection with a project of this type if it were included under the Small Projects Act. Reclamation projects are favored with a special rate which approximates 2½ mills.

3. The North Dakota State Water Conservation Commission has, on occasions, drilled a well in areas possessing irrigation potential, for test purposes. A pump test is run in connection there with. The Commission has, where the well is adequate for irrigation, turned it over to the district or individuals for the cost of the casing. The casing is then left in the well for use in future development. Should this be the desires of the local project proponents the matter should be called to to the attention of the Commission.

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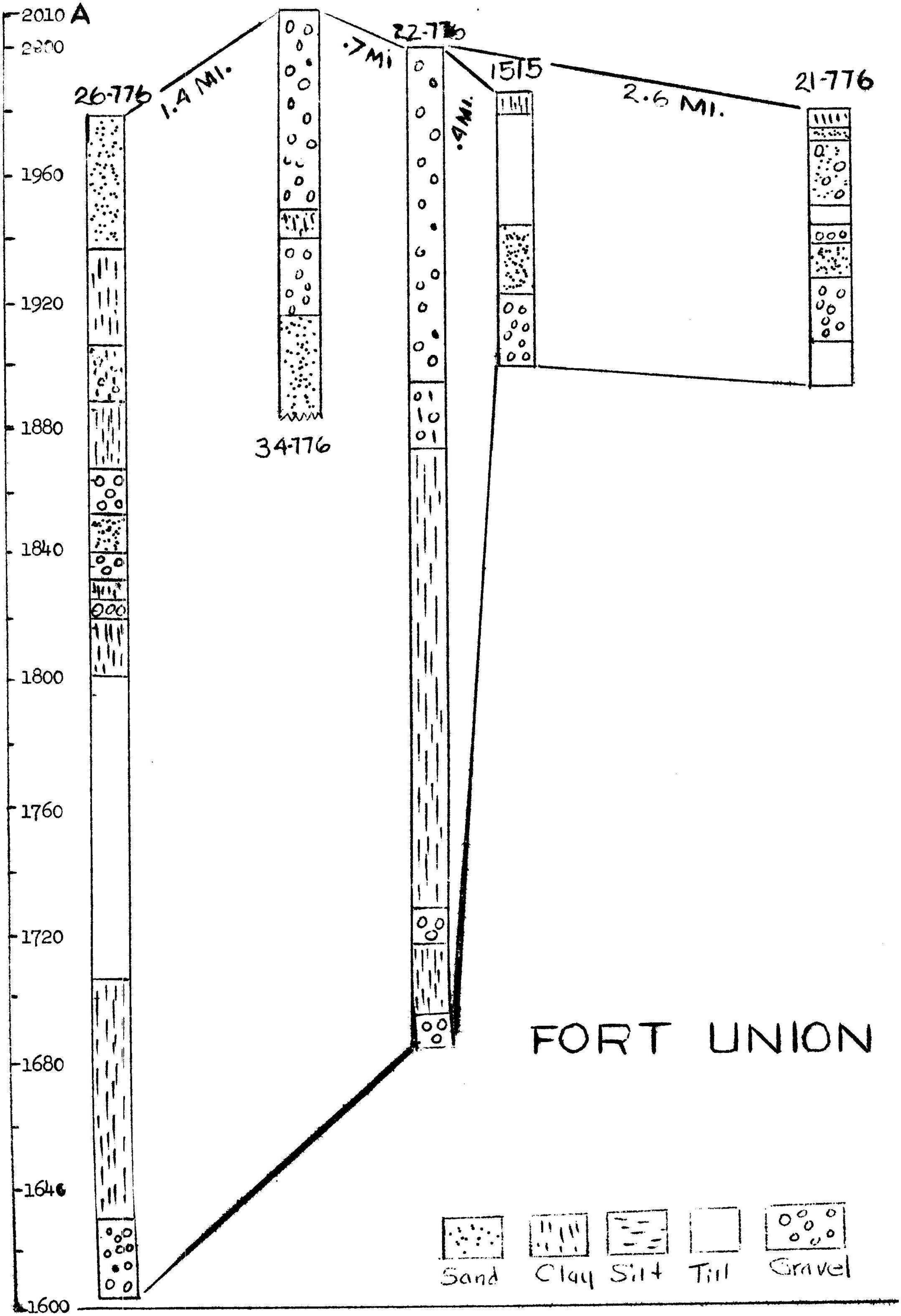

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.7 Mi
22-776
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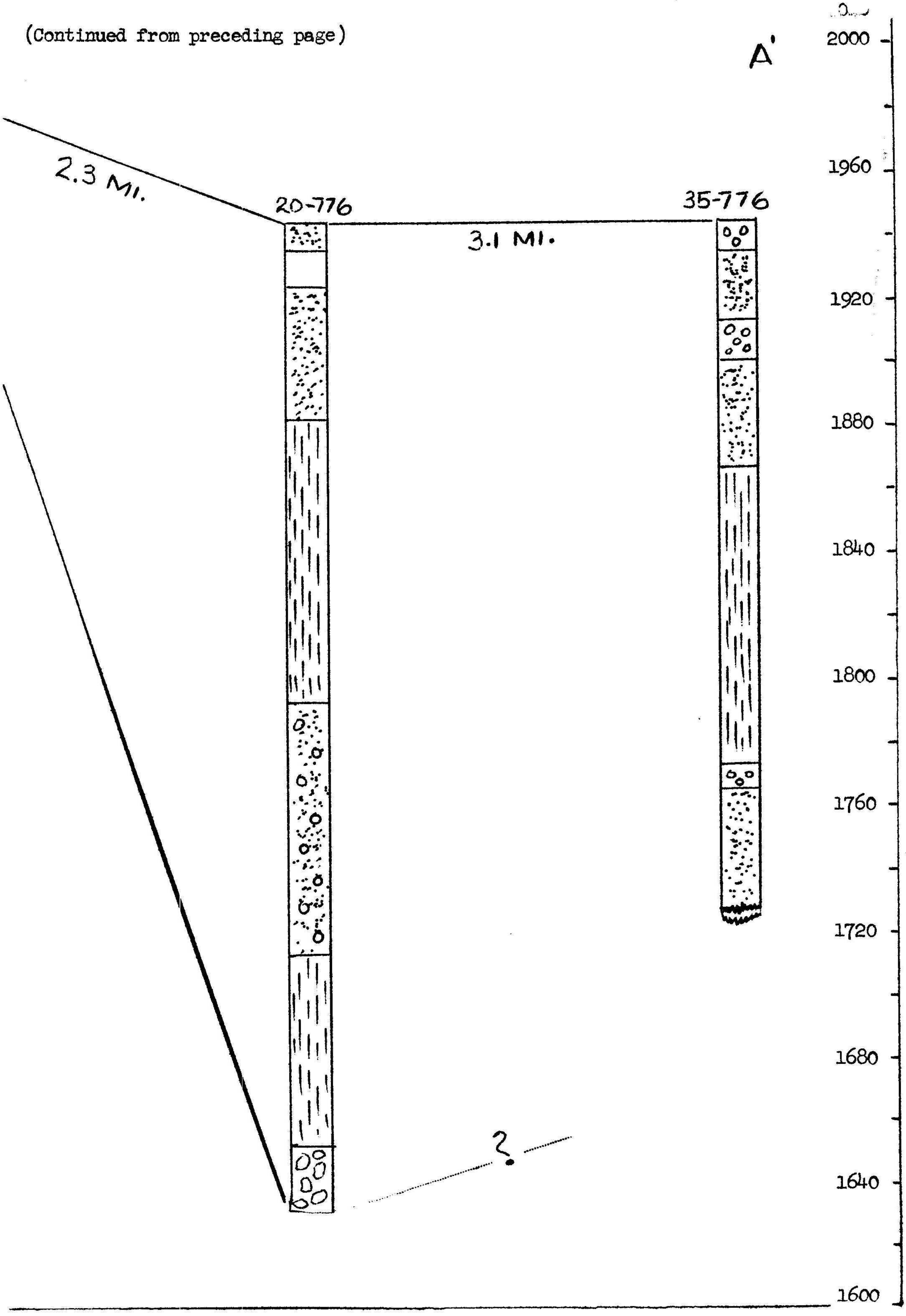
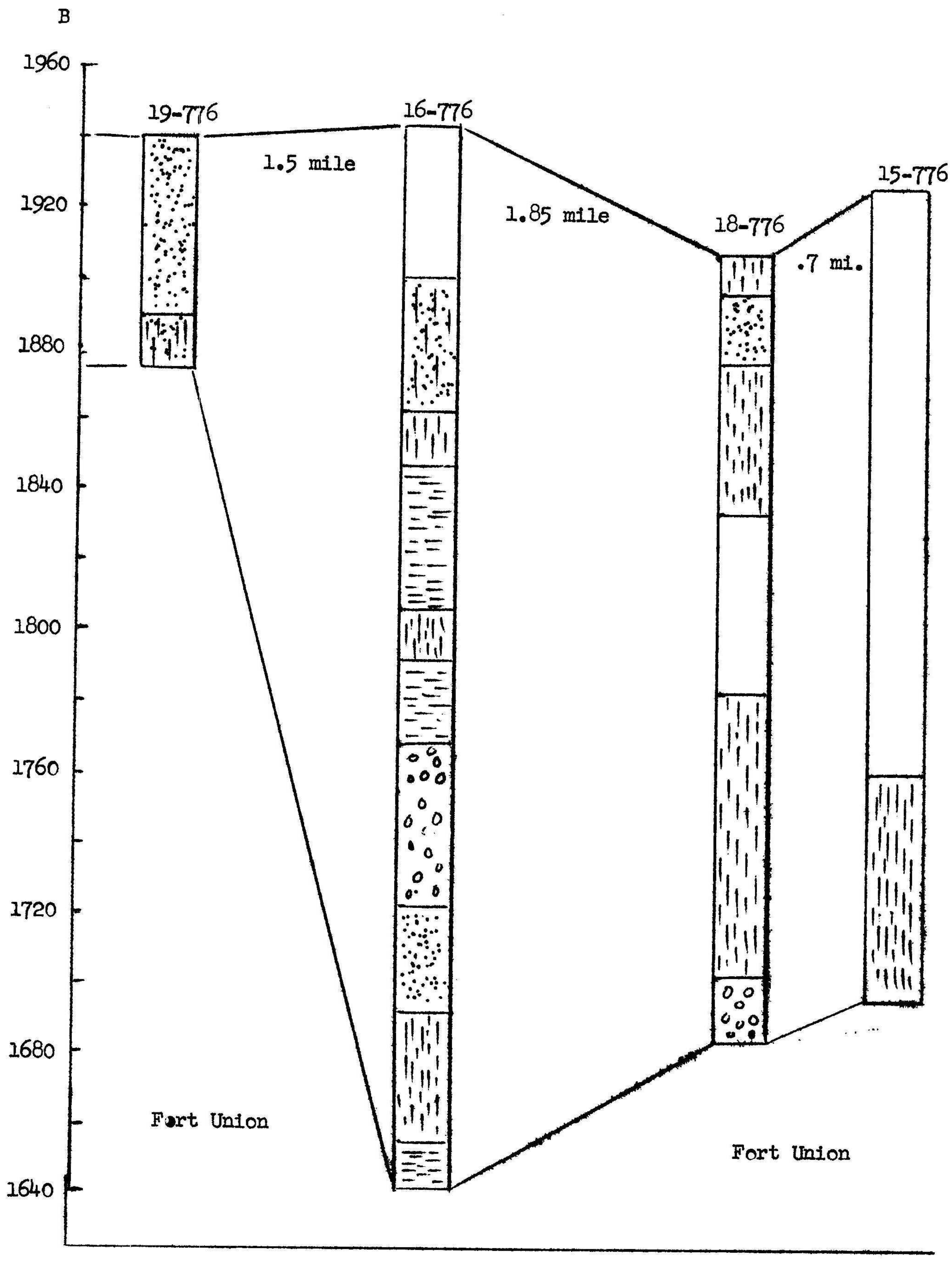
1515
2.6 MI.
21-776
FORT UNION
Sand
Clay
Silt
Till
Gravel

(Continued from preceding page)

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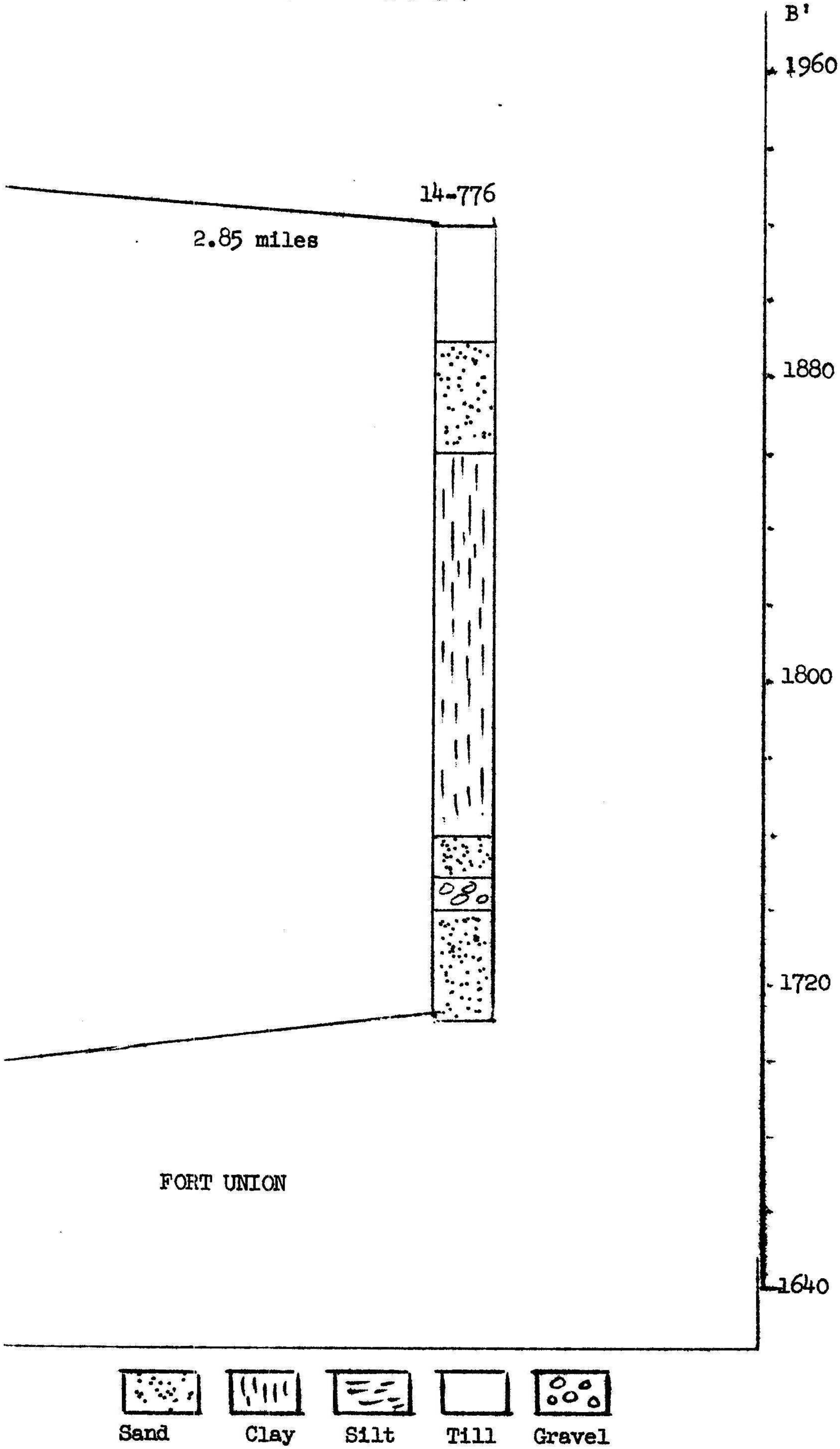
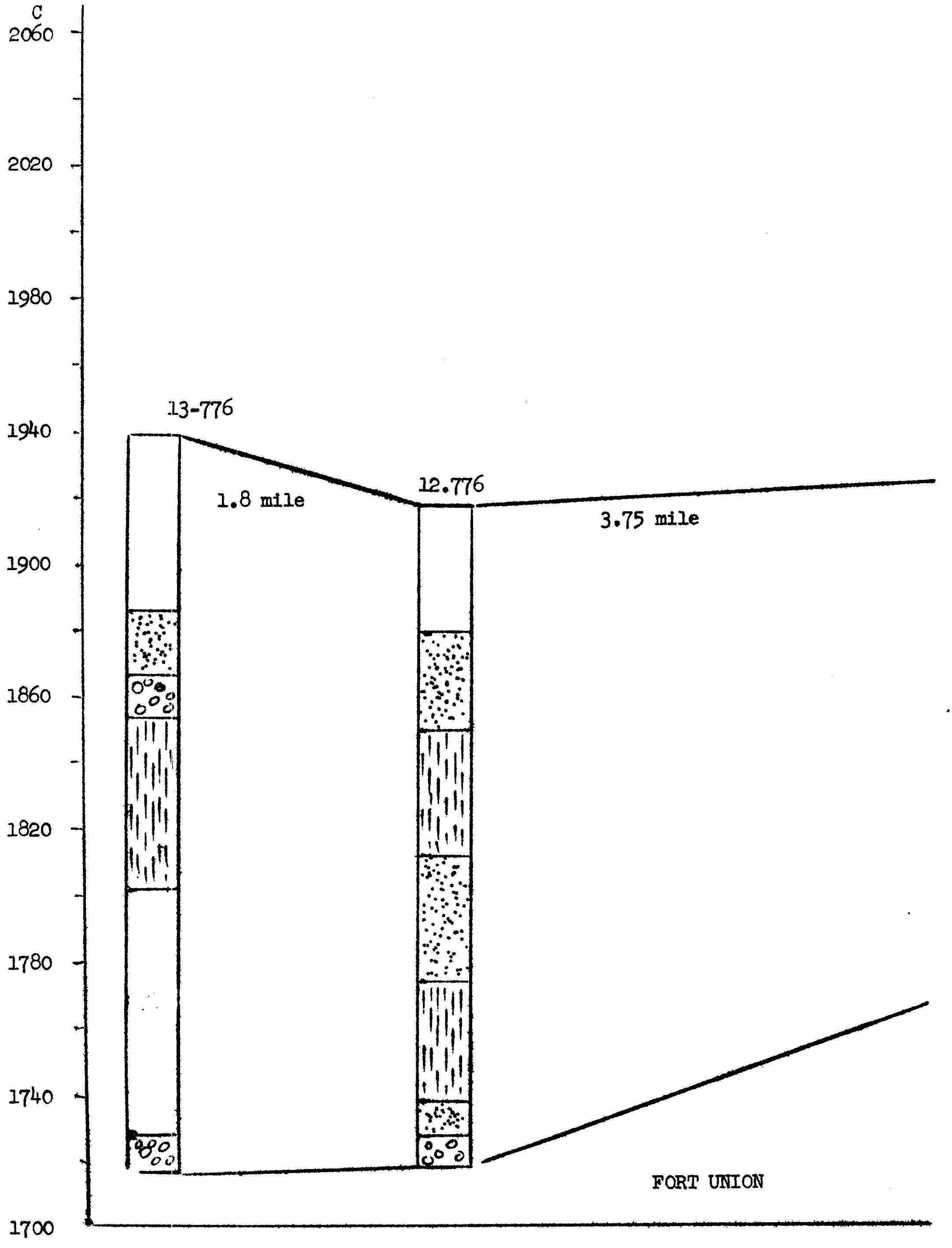
Fort Union
Fort Union

B-B' Continued from preceding page)

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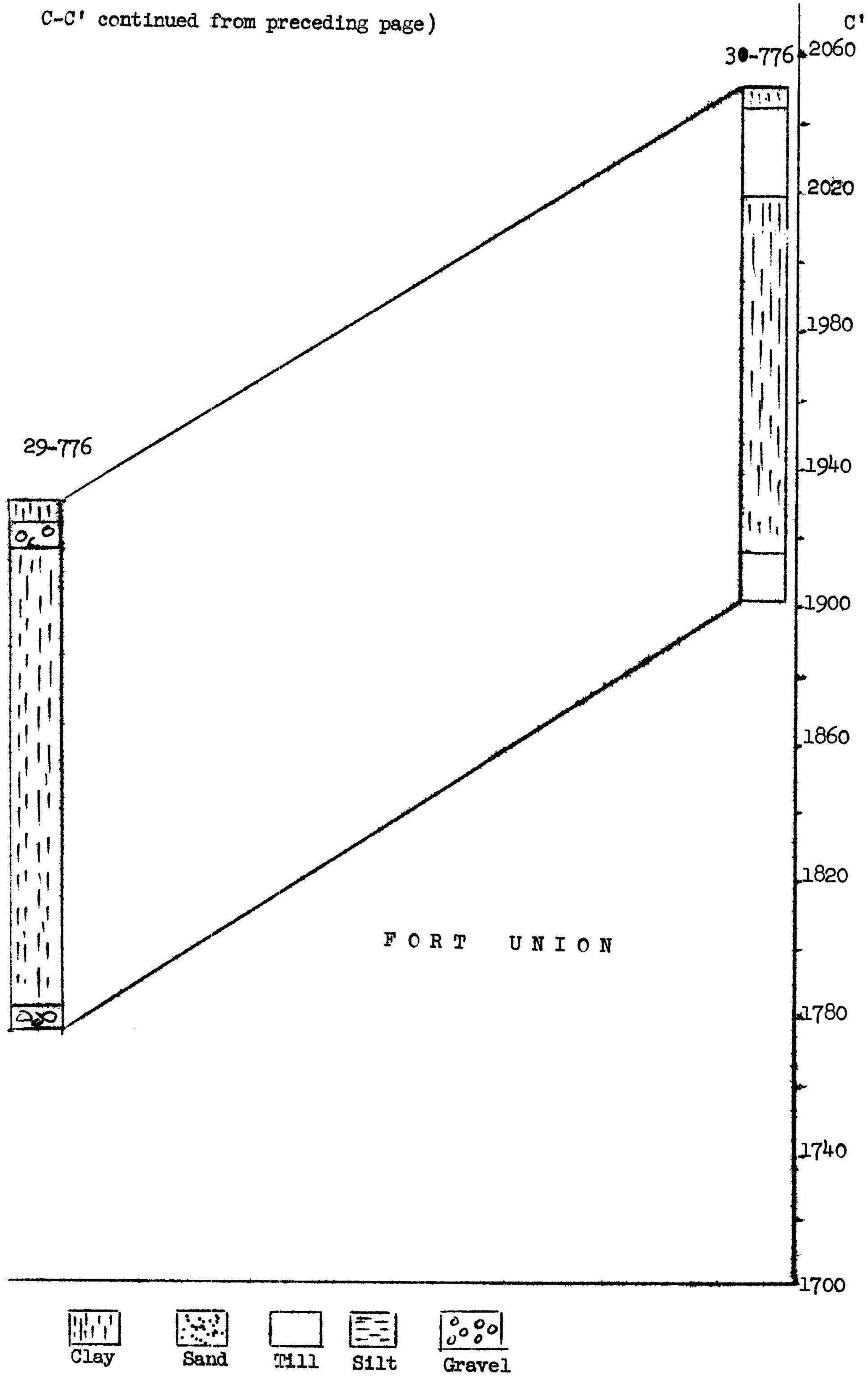
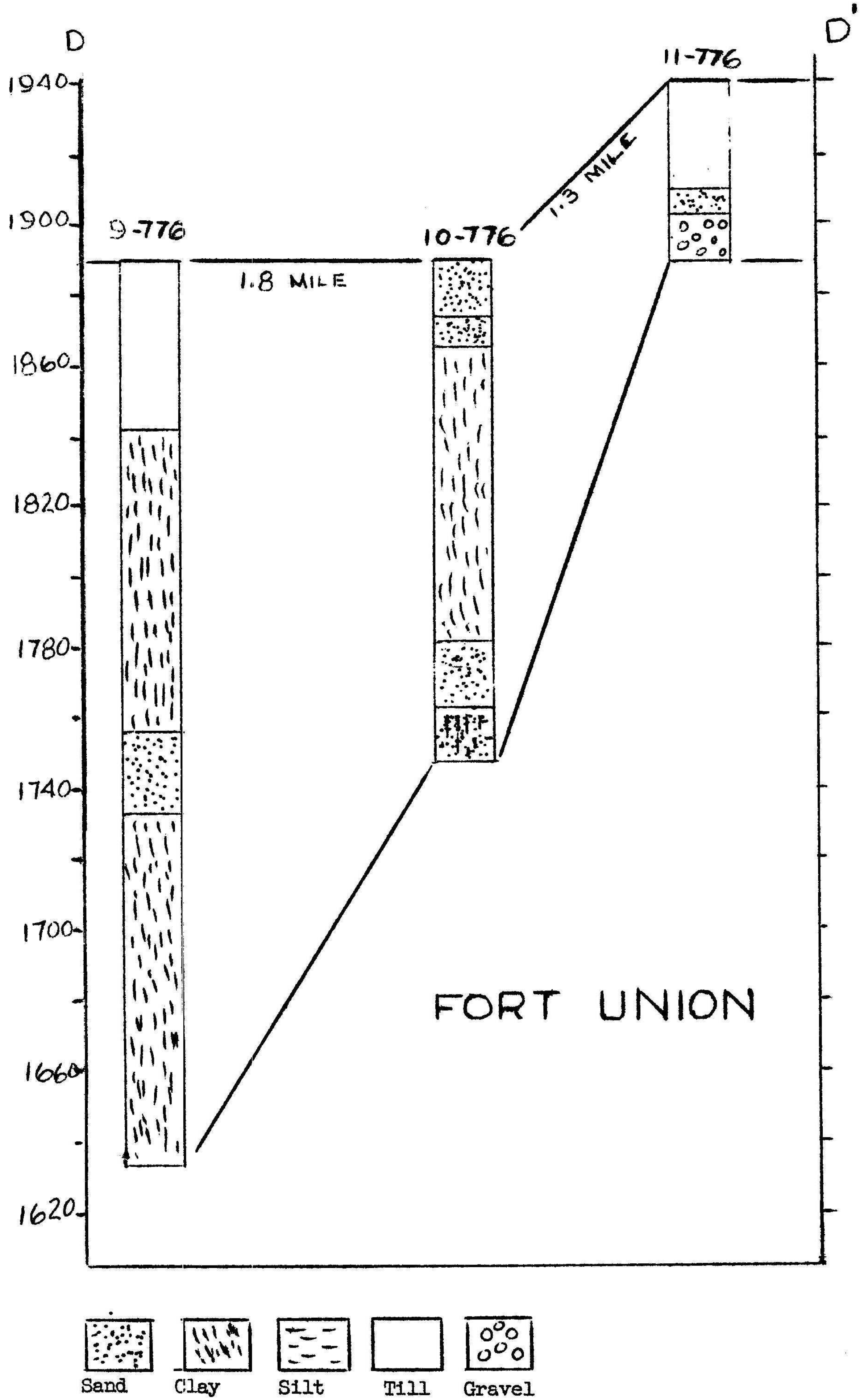
12.776
3.75 mile
FORT UNION

C-C' continued from preceding page)

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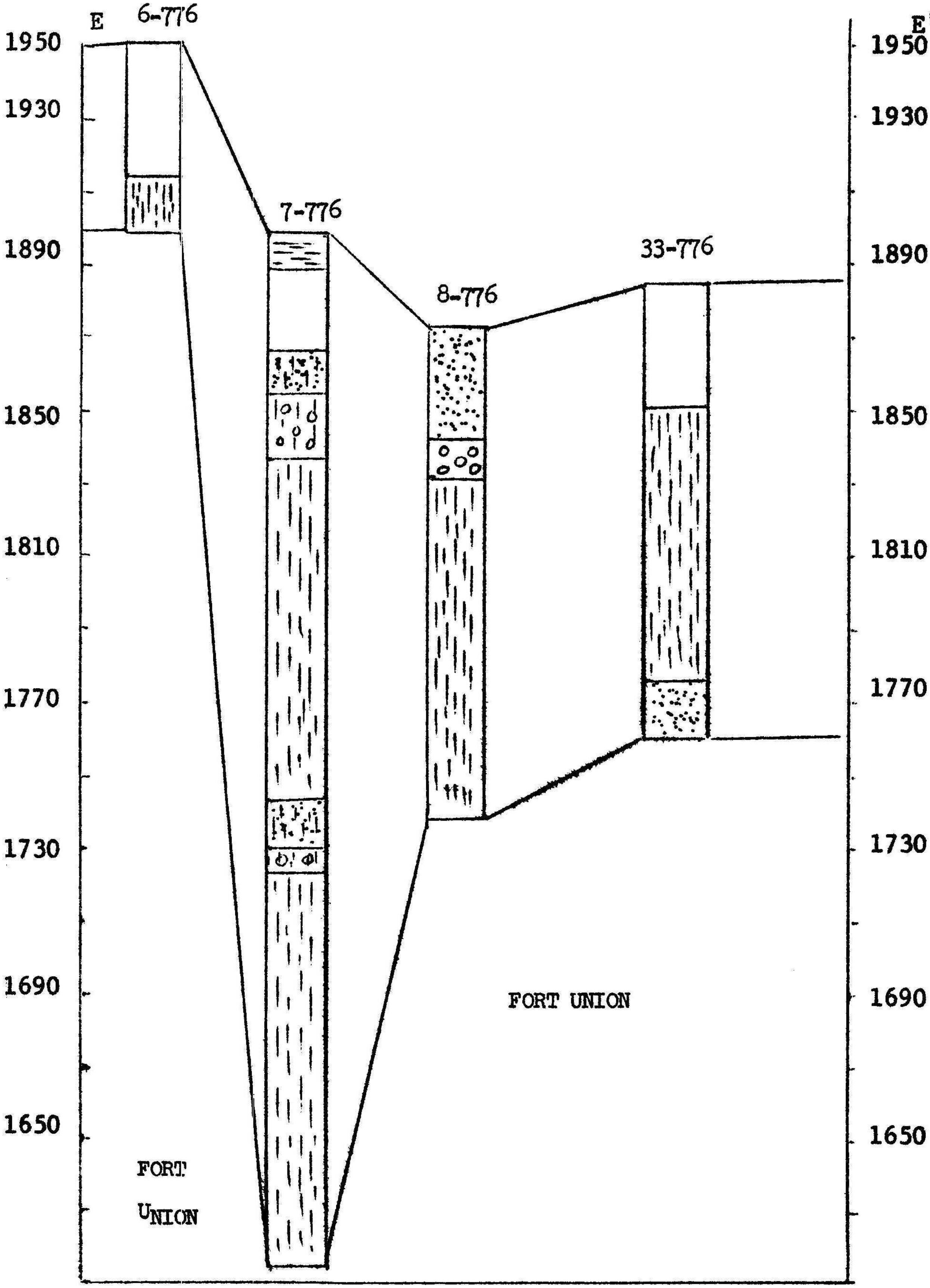
FORT UNION
Sand
Clay
Silt
Till
Gravel


E
E'
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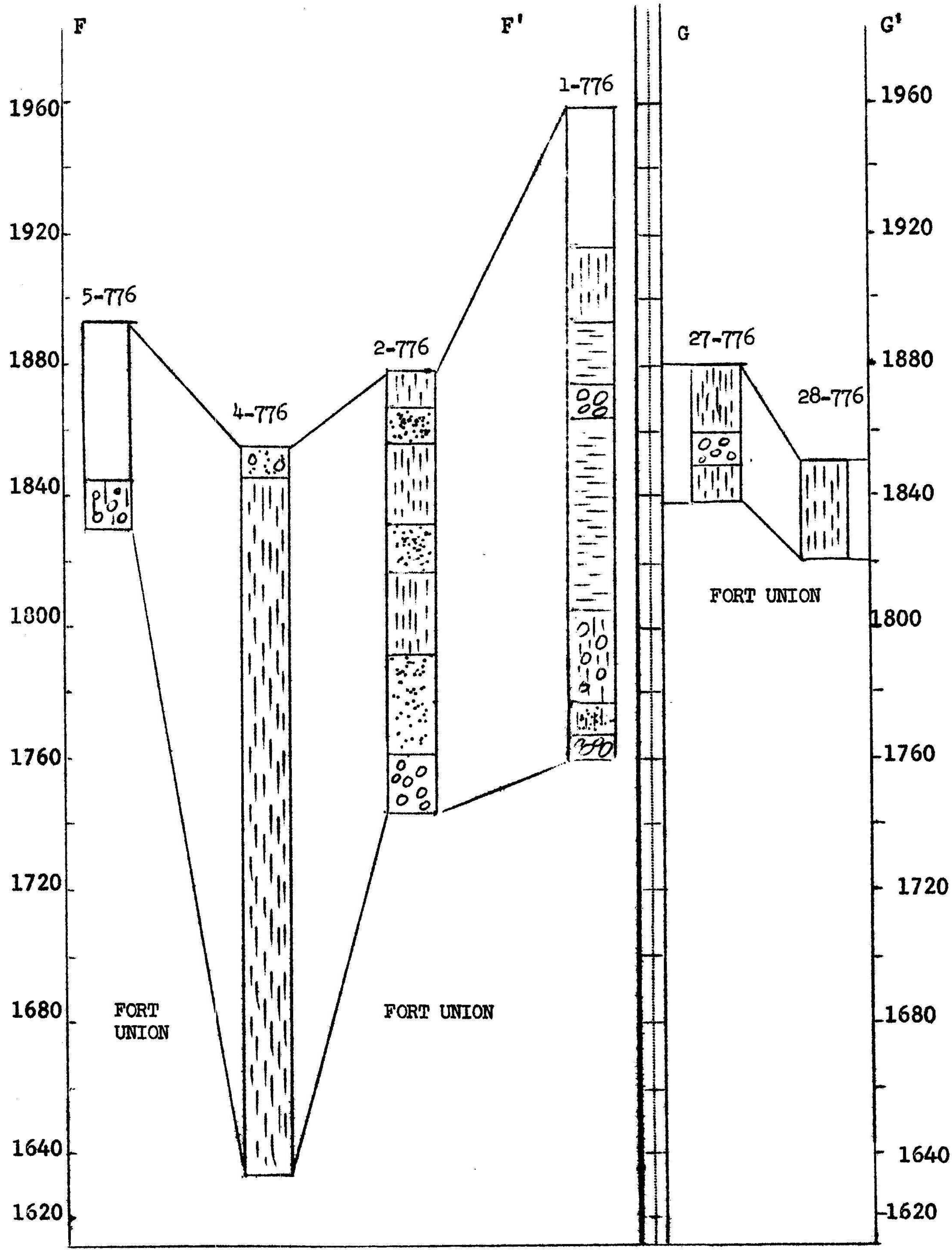
FORT UNION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5-776
4-776
2-776
1-776
27-776
28-776
FORT UNION
FORT UNION
FORT UNION

North Dakota State Water Conservation Commission

Location	Test Hole Number	Surface Elevation	Bedrock Elevation
154-100-7-aab	5-776	1892'	1830'
154-100-28-bcc	27-776	1880'	1839'
154-100-29-dbd	28-776	1850'	1820'
154-101-1-ccd	24-776	1880'	1749'
154-101-2-ccd	1-776	1958'	1761'
154-101-2-cdd	3-776	1940'	1758'
154-101-12-aaa	4-776	1855'	1632'
154-101-12-bba	2-776	1880'	1746'
154-101-12-bbb	32-776	1889'	1752'
154-101-12-bbd	23-776	1880'	1745'
155-100-19-baa	10-776	1890'	1748'
155-100-20-ddd	9-776	1890'	1635'
155-100-31-aba	8-776	1872'	1736'
155-100-32-ada	6-776	1950'	1899'
155-100-32-baa	7-776	1900'	1616'
155-101-13-abb	11-776	1940'	1889'
155-101-22-cca	31-776	2120'	2048'
155-101-36-dac	33-776	1885'	1761'
156-100-18-aaa	14-776	1918'	1712'
156-100-19-daa	13-776	1940'	1717'
156-100-32-aaa	12-776	1918'	1720'
156-101-2-aaa	15-776	1926'	1694'

AND GRAVEL LOGS

Test Holes, Project #776

Total Depth	Aquifer Thickness	Depth to Base of Aquifer	Lithology
73½'	15'	62'	Gravel, sandy
52 '	11'	31'	Gravel, sandy
42 '	None over 10'	—	———
147 '	23'	27'	Gravel 7'/Sand 16'
	12'	62'	Sand
	11'	100'	Gravel 4'/Sand 7'
	26'	131'	Sand 21'/Gravel 5'
220½'	45'	197'	Gravel 28'/Sand 12' /Gravel 5' (clayey)
189 '	19'	155'	Gravel, clayey
	15'	182'	Gravel, clayey
231 '	None over 10'	—	———
147 '	11'	21'	Sand
	14'	61'	Sand
	47'	134'	Sand 30'/Gravel 17'
157½'	26'	100'	Sand, clayey
	32'	137'	Sand, clayey 15'/Gravel 17'
157½'	19'	22'	Sand
	52'	135'	Sand 34'/Gravel 18'
157½'	37'	142'	Sand 19'/Sand clayey 18'
262½'	22'	156'	Sand, gravelly
168 '	40'	40'	Sand 30'/Gravel 10'
73½'	None	—	———
294 '	29'	61'	Sand 11'/Gravel,sandy 11' /Gravel 7' (clayey)
	20'	175'	Sand 13'/Gravel 7' (clayey)
63 '	21'	51'	Sand 7'/Gravel 14'
84 '	41'	72'	Sand, clayey 11'/Sand 21' /Gravel, clayey 9'
136½'	16'	124'	Sand, gravelly
210 '	30'	58'	Sand 14'/Sand, clayey 16'
	48'	206'	Sand 10'/Gravel 10'/Sand 28'
231'	32'	84'	Sand, clayey 11'/Sand 9' /Gravel 12'
	13'	223'	Gravel
210 '	31'	67'	Sand
	30'	143'	Sand
	20'	198'	Sand 12'/Gravel 8'
241½'	None over 10'	—	———

North Dakota State Water Conservation Commission

Location	Test Hole Number	Surface Elevation	Bedrock Elevation
156-101-18 bbc	30-776	2050'	1902'
156-101-35-bba	29-776	1930'	1776'
157-99-19-dcd	17-776	2066'	1945'
157-100-9-aac	35-776	1935'	
157-100-15-bdd	19-776	1940'	1876'
157-100-22-ccc	16-776	1943'	1640'
157-100-33-cad	18-776	1907'	1682'
158-100-6-abb	22-776	2000'	1686'
158-100-7-bcb	25-776	1980'	
158-100-17-caa	21-776	1980'	1894'
158-100-30-dda	20-776	1935'	1630'
159-100-29-add	26-776	1980'	1602'
159-100-31-add	34-776	2010'	

Test Holes, Project #776

Total Depth	Aquifer Thickness	Depth to Base of Aquifer	Lithology
152 '	14'	148'	Gravel
168 '	None over 10'	—	—
126 '	None	—	—
241½'	78'	78'	Gravel 9'/Sand 22'/Gravel 12'/Sand 31'/Gravel 4'
	25≠	241≠	Sand (Artesian Head)
115½'	32'	32'	Sand
	18'	52'	Sand
315 '	38'	80'	Sand, clayey
	76'	251'	Gravel 45'/Sand 31' (clayey)
231 '	20'	30'	Sand
	21'	225'	Gravel
325 '	126'	126'	Gravel 105'/Gravel, clayey 21'
	11'	282'	Gravel
63 '	63≠'	63≠'	Gravel
94 '	25'	30'	Sand 5'/Gravel 25'
	36'	72'	Gravel 6'/Sand 11'/ Gravel 19'
315 '	42'	62'	Sand
	79'	231'	Gravel, sandy
	12'	305'	Gravel
379 '	41'	41'	Sand, coarse to fine
	18'	90'	Gravel, clayey
	35'	146'	Gravel 14'/Sand 13'/ Gravel 8'
	30'	378'	Gravel
157½'	62'	62'	Gravel
	56'	127'	Gravel 24'/Sand 32'

TABLE 3.--SAND AND GRAVEL LOGS
U. S. Geological Survey and North Dakota Water
Conservation Commission Test Holes
Ancient Channels Study

Location	T. H. No.	Total Depth	Aquifer Thickness	Depth to Base	Lithology
155-100-6-aaa	1425	126'	16'	31'	Gravel, sandy
155-100-30-cdd	1437	21'	None over 10'		
155-100-30-ddc	1436	52½'	31'	31'	Sand 9'/Gravel 22'
155-100-31-bbb	1435	115½'	106'	106'	Sand 11'/Sand,clayey 9'/Gravel 17'/Sand Clayey 49'/Sand 9'/ Gravel 11'
155-101-1-bbb	1434	63'	None over 10'		
156-100-7-ccc	1439	52½'	35'	41'	Sand, gravelly
156-100-17-aab	1438	63'	28'	54'	Sand
156-100-33-ccc	1433	—	12'	50'	Sand, gravelly
156-101-12-ccc	1440	52½'	None		
158-100-5-aaa	1515	105'	45'	86'	Sand 22'/Gravel 23'
158-100-19-ccc	1442	—	30'	30'	Sand 5'/Gravel 25'
			34'	76'	Gravel,fine,sandy
158-100-20-cdd	1443	21'	None over 10'		
158-101-24-dcc	1441	63'	61'	63'	Sand 31'/Gravel, fine 30'

TABLE 4a--WATER QUALITY FOR IRRIGATION

Water Quality Interpretation
As Adopted by State Laboratories Department
In July 1961*

Irrigation water must be considered from the standpoint of the total salts (salinity) it contains and the amount of sodium (alkalinity) it carries. Both factors will prove harmful if they are allowed to accumulate in your soil. The sodium is usually the more serious problem. If you have any questions as to how well your water is adapted to your soil see your County Agricultural Agent or your Soil Conservation District Conservationist. The following interpretation of water quality is for your information:

SALINITY

C-1 - Low-Salinity Water - can be used for irrigation with little likelihood that soil salinity will develop.

C-2 - Medium-Salinity Water - can be used if a moderate amount of leaching* occurs.

C-3 - High-Salinity Water - cannot be used on soils with restricted drainage.

C-4 - Very High-Salinity Water - not suitable for irrigation.

SODIUM

S-1 - Low-Sodium Water - can be used for irrigation with little danger of the development of harmful levels of exchangeable sodium.

S-2 - Medium-Sodium Water - is dangerous when used on fine textured soils. It can be used on coarse textured soils with good permeability.

S-3 - High-Sodium Water - will require special soil management, good drainage, high leaching and organic matter additions.

S-4 - Very High-Sodium Water - unsatisfactory for irrigation.

*Leaching is the process of removing the soluble material (salts) from the soil by the passage of water through the soil. The water picks up the salt and carries it below and away from the plant root zone.

*Prior to July 1961 irrigation waters were classified as Excellent, Good, Permissible, Doubtful, and Unsuitable.

TABLE 4b---WATER QUALITY FOR IRRIGATION

Location	Source	Depth	Depth to Water	Rating
154-100-5-a	Well*	122'	42'	Permissible to Doubtful
154-100-21-bc	Well*	116'	26'	Doubtful to Unsuitable
154-100-1-dc	Well*	155'	65'	Doubtful to Unsuitable
154-101-2-dc (1)	Well*	156'	70'	Good to Permissible
154-101-23-db	Well*	700'	---	Unsuitable
154-101-24-c	Well*	163'	83'	Excellent to Good
154-101-24-c	Well*	219'	34'	Doubtful to Unsuitable
154-101-24-d	Well*	143'	53'	Excellent to Good
155-100-5-abb	Seismograph Shot Hole	---	Flow	C_4 S_4
155-100-6-aaa	Test Hole 1425	31'	---	Doubtful to Unsuitable
155-100-7-db	Well*	66'	8'	Permissible to Doubtful
155-100-9-aa	Well*	78'	65'	Good to Permissible
155-100-15-ba	Well*	97'	80'	Excellent to Good
155-100-29-cd (2)	Well*	65'	20'	Permissible to Doubtful
155-100-30-ddc	Test Hole 1436	31'	---	Permissible to Doubtful
155-100-31-bbb	Test Hole 1435	106'	---	Permissible to Doubtful
155-100-32-bc	Well*	54'	32'	Good to Permissible
156-100-7-ccc	Test Hole 1439	41'	---	Permissible to Doubtful
156-100-33-ccc	Test Hole 1433	50'	---	Permissible to Doubtful
156-101-1-aaa	Seismograph Shot Hole	---	Flow	Unsuitable

TABLE 4b---WATER QUALITY FOR IRRIGATION (Continued)

Location	Source	Depth	Depth to Water	Rating
157-100-33-cad	Test Hole 18-776	---	Flow	C_4 S_2
158-100-6-abb(3)	Well	40'	36'	C_3 S_1
158-100-7-bcb	Test Hole 25-776	32'	---	C_3 S_1
158-100-19-ccc	Test Hole 1442	30'	---	Permissible to Doubtful
159-100-29-add	Test Hole 26-776	120'	---	C_3 S_2
159-100-31-add	Test Hole 34-776	95'	---	C_3 S_1

*Collected by Ardell A. Liudahl

Probably from same aquifer as found in:
(1) Test Holes 1-776, 2-776, 3-776, 23-776, 24-776, & 32-776

(2) Test Hole 7-776

(3) Test Hole 22-776