FINAL
Preliminary Assessment Report
Bismarck Army Aviation Support Facility #1
North Dakota

Perfluorooctane-Sulfonic Acid (PFOS) and Perfluorooctanoic Acid (PFOA)
Impacted Sites
ARNG Installations, Nationwide

August 2020

Prepared for:

Army National Guard Bureau
111 S. George Mason Drive
Arlington, VA 22204

UNCLASSIFIED

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Acronyms and Abbreviations

AASF	Army Aviation Support Facility
AECOM	AECOM Technical Services, Inc.
AFFF	aqueous film forming foam
AOI	Area of Interest
ARNG	Army National Guard
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CSM	conceptual site model
EDR™	Environmental Data Resources, Inc.™
°F	degrees Fahrenheit
FTA	fire training area
NDARNG	North Dakota Army National Guard
PA	Preliminary Assessment
PFAS	per- and poly-fluoroalkyl substances
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
SI	Site Inspection
US	United States
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency

Executive Summary

The Army National Guard (ARNG) is performing Preliminary Assessments (PAs) and Site Inspections (SIs) for Perfluorooctanesulfonic acid (PFOS) and Perfluorooctanoic acid (PFOA) Impacted Sites at ARNG Facilities Nationwide. A PA for per- and polyfluoroalkyl substances (PFAS)-containing materials was completed for North Dakota Army Aviation Support Facility (AASF; also referred to as the "facility") in Bismarck, North Dakota, to assess potential PFAS release areas and exposure pathways to receptors. The Bismarck AASF #1 is constructed on a parcel of land that has been owned and operated by the North Dakota ARNG (NDARNG) since 1996. The performance of this PA included the following tasks:

- Reviewed available administrative record documents and Environmental Data Resources, Inc. (EDR)™ report packages to obtain information relevant to potential PFAS releases, such as: drinking water well locations, historical aerial photographs, Sanborn maps, and environmental compliance actions in the area surrounding the facility;
- Conducted a site visit 13 September 2019 and completed visual site inspections at locations where PFAS-containing materials were suspected of being stored, used, or disposed;
- Interviewed current and retired NDARNG personnel, NDARNG environmental managers, and operations staff
- Completed visual site inspections at known or suspected potential PFAS release locations and documented with photographs
- Identified the Area of Interest (AOI) at the facility

One AOI related to potential PFAS releases was identified at the Bismarck AASF #1 during the PA. The AOI is shown on **Figure ES-1** and described in **Table ES-1**.

Table ES- 1: AOI at Bismarck Army Aviation Support Facility

Area of Interest	Name	Used by	Potential Release Date
AOI 1	Main Hangar (Fire Suppression/TriMax30™ Maintenance/Overland Firefighting Equipment)	NDARNG	2006

Based on potential PFAS releases at AOI 1, there is potential for exposure to PFAS contamination in media at or near the facility. The preliminary CSM for AOI 1, which presents the potential receptors and media impacted, is shown on **Figure ES-2**. Based on the US Environmental Protection Agency (USEPA) Unregulated Contaminant Monitoring Rule 3 data, it was indicated that no PFAS were detected in a public water system above the USEPA lifetime Health Advisory within 20 miles of the facility. The HA is 70 parts per trillion for PFOS and PFOA, individually or combined. PFAS analyses performed in 2016 had method detection limits that were higher than currently achievable. Thus, it is possible that low concentrations of PFAS were not detected during the UCMR3 but might be detected if analyzed today.

CLIENT	ARNG			
NOTES	Preliminary Assessment for PFAS at Bismarck AASF #1, ND			
REVISED	6/19/2020	GIS BY	MS	6/19/2020
SCALE	1:9,600	CHK BY	JW	6/19/2020
Base Map: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,		PM	RG	6/19/2020

Summary of Findings

AECOM
12420 Milestone Center Drive
Germantown, MD 20876

Figure ES-1

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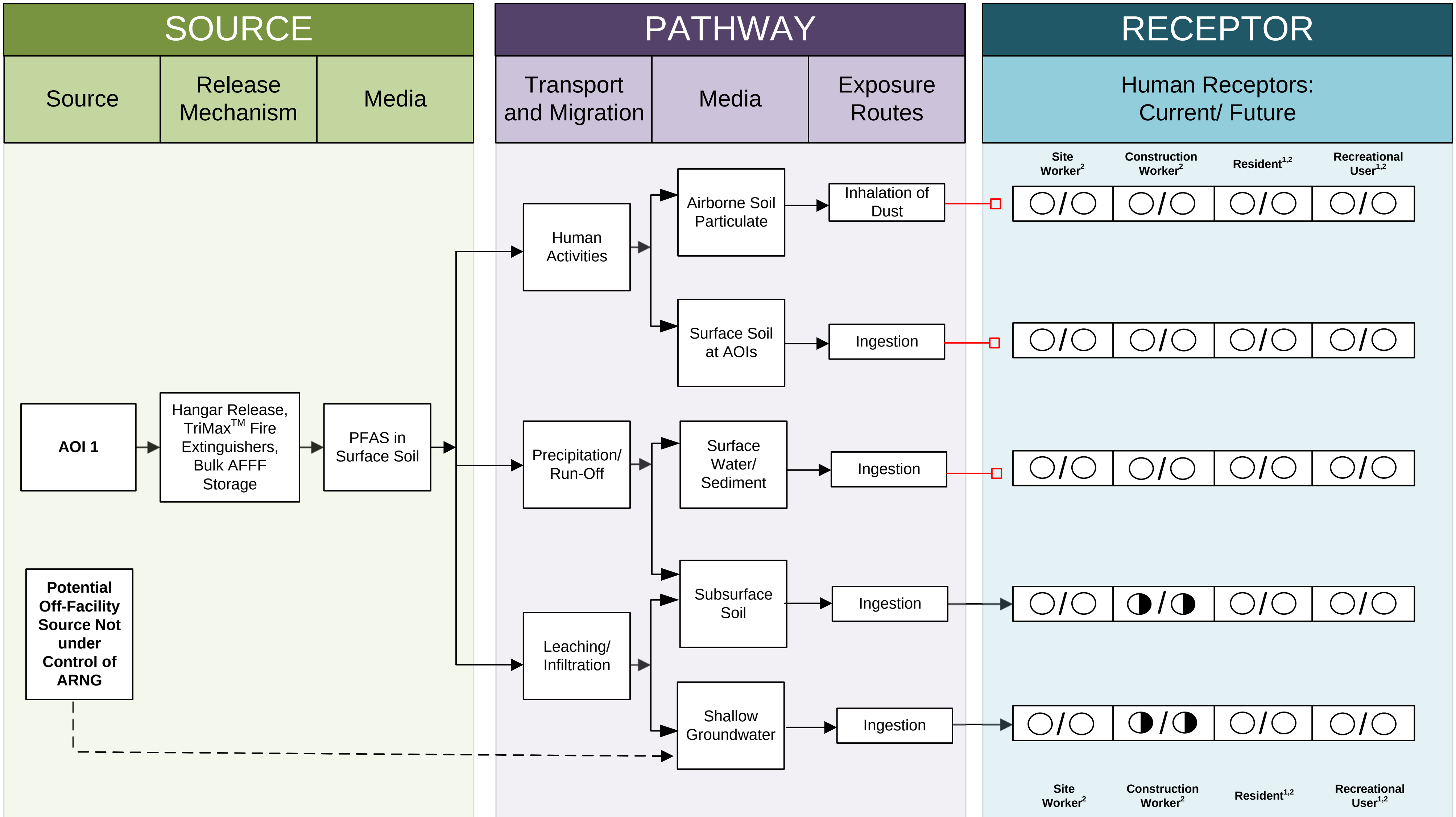


LEGEND

Flow-Chart Stops

Flow-Chart Continues

Partial / Possible Flow

Incomplete Pathway

Potentially Complete Pathway

Complete Pathway

Notes:
1. The resident and recreational users receptors refer to an off-facility resident and off-facility recreational users.
2. Dermal contact exposure pathway is incomplete for PFAS.

Figure ES-2
Preliminary Conceptual Site Model
Bismarck AASF #1

1. Introduction

1.1 Authority and Purpose

The Army National Guard (ARNG)-G9 is the lead agency in performing *Preliminary Assessments (PAs) and Site Inspections (SIs) for Perfluorooctanesulfonic acid (PFOS) and Perfluorooctanoic acid (PFOA) at Impacted Sites at ARNG Facilities Nationwide*. This work is supported by the United States (US) Army Corps of Engineers (USACE) Baltimore District and their contractor AECOM Technical Services, Inc. (AECOM) under Contract Number W912DR-12-D-0014, Task Order W912DR17F0192, issued 11 August 2017.

The ARNG is assessing potential effects on human health related to processes at facilities that used per- and poly-fluoroalkyl substances (PFAS), primarily in the form of aqueous film forming foam (AFFF) released as part of firefighting activities, although other PFAS sources are possible. In addition, the ARNG is assessing businesses or operations adjacent to the ARNG facility (not under the control of ARNG) that could potentially be responsible for a PFAS release.

PFAS are classified as emerging environmental contaminants that are garnering increasing regulatory interest due to their potential risks to human health and the environment. PFAS formulations contain highly diverse mixtures of compounds. Thus, the fate of PFAS compounds in the environment varies. The regulatory framework at both federal and state levels continues to evolve. The US Environmental Protection Agency (USEPA) issued Drinking Water lifetime Health Advisories for PFOA and PFOS in May 2016, but there are currently no promulgated national standards regulating PFAS in drinking water. The HA is 70 parts per trillion for PFOS and PFOA, individually or combined.

This report presents the findings of a PA for PFAS-containing materials at the North Dakota Army Aviation Support Facility #1 (Bismarck AASF #1; also referred to as the “facility”) in Bismarck, North Dakota, in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended, the National Oil and Hazardous Substances Pollution Contingency Plan (40 Code of Federal Regulations Part 300), and Army requirements and guidance.

This PA documents potential locations where PFAS containing materials are stored and have the potential to be released into the environment at or adjacent to the AASF. The term PFAS will be used throughout this report to encompass all PFAS chemicals being evaluated, including PFOS and PFOA, which are key components of AFFF.

1.2 Preliminary Assessment Methods

The performance of this PA included the following tasks:

- Reviewed available administrative record documents and Environmental Data Resources, Inc. (EDR)™ report packages to obtain information relevant to potential PFAS releases, such as: drinking water well locations, historical aerial photographs, Sanborn maps, and environmental compliance actions in the area surrounding the facility;
- Conducted a site visit on 13 September 2019 and completed visual site inspections (VSIs) at locations where PFAS-containing materials were suspected of being stored, used, or disposed;
- Interviewed current and retired North Dakota ARNG (NDARNG) personnel, NDARNG environmental managers, and operations staff

- Completed visual site inspections at known or suspected potential PFAS release locations and documented with photographs
- Identified the Area of Interest (AOI) at the facility

1.3 Report Organization

This report has been prepared in accordance with the USEPA *Guidance for Performing Preliminary Assessments under CERCLA* (USEPA, 1991). The report sections and descriptions of each are:

- **Section 1** – **Introduction:** identifies the project purpose and authority and describes the facility location, environmental setting, and methods used to complete the PA
- **Section 2** – **Fire Training Areas:** describes the fire training areas (FTAs) at the facility identified during the site visit
- **Section 3 – Non-Fire Training Areas:** describes other locations of potential PFAS releases at the facility identified during the site visit
- **Section 4** – **Emergency Response Areas:** describes areas of potential PFAS release at the facility, specifically in response to emergency situations
- **Section 5** – **Adjacent Sources:** describes sources of potential PFAS release adjacent to the facility that are not under the control of ARNG
- **Section 6** – **Preliminary Conceptual Site Model:** describes the pathways of PFAS transport and receptors for the AOIs and the facility
- **Section 7** –**Conclusions:** summarizes the data findings and presents the conclusions of the PA
- **Section 8 – References:** provides the references used to develop this document
- **Appendix A** – Data Resources
- **Appendix B** – Preliminary Assessment Documentation
- **Appendix C** – Photographic Log

1.4 Facility Location and Description

The Bismarck AASF #1 is in Burleigh County, approximately 3 miles south of Bismarck, North Dakota (**Figure 1-1**). The facility is adjacent to Bismarck Airport and accessible from Yegen Road from the south off Airway Avenue.

The Bismarck AASF #1 is constructed on a parcel of land that has been leased and operated by the NDARNG since 1996 (**Appendix A**). The Bismarck AASF #1 comprises approximately 33.65 acres of land owned by the City of Bismarck. The term of the lease began in 1996 with a 50 year duration. Real property documents for the facility provided by the NDARNG are included in **Appendix A**.

1.5 Facility Environmental Setting

The Bismarck AASF #1 lies within the Apple Creek Uplands subdistrict, which is characterized by steeply dissected valley walls and uplands; stream erosion produces this valley setting. The Apple Creek is the main stream channel near the facility. Apple Creek ultimately discharges to the Missouri River located to the south.

1.5.1 Geology

The Bismarck AASF #1 lays within the Apple Creek Uplands subdistrict of the Coteau Slope district in Burleigh County. The Apple Creek Uplands subdistrict is known for having steeply dissected valley walls and uplands. These valley walls and uplands have a thin sheet of drift over the bedrock, allowing water to flow over them south towards the Missouri River. The glacial drift in this area is almost non-existent and typically just contains boulders and scattered patches of till. The till was left by Wisconsin glaciation, but postglacial stream erosion has modified the areas. In the Lake McKenzie Basin, alluvial sand and gravel primarily cover the floodplain deposits. This area is also known for its moraine landforms, which were created from a buildup of drift and till that was deposited from the glacial ice. The sheet moraine that subsides in the Apple Creek Uplands subdistrict has a thin layer of drift composed of till that lays over the stream-eroded bedrock. The layer of drift comprises outwash plain, end moraine, dead-ice moraine, ground moraine, and sheet moraine (North Dakota Geological Survey, 1965) (North Dakota State Water Commission, 1984).

1.5.2 Hydrogeology

The Apple Creek Uplands subdistrict, which encompasses the Bismarck AASF #1, is known for its stream-eroded bedrock and is covered with sheet moraine. In the drainage basin of Apple Creek, there are notable sand dune areas. This drainage valley carries some outwash but typically carries meltwater. The meltwater channels flow on a high bedrock drainage divide and combines with other meltwater locations into the Missouri River. The meltwater also carries valley fill and has been found in several locations where testing has occurred. The valley fill ranges from depths of 4 to 20 feet (North Dakota Geological Survey, 1965).

No potable water wells are located within the boundary of the Bismarck AASF #1; however, two domestic, seven irrigation, thirteen monitoring, and four unknown wells were located within a 2-mile radius of the facility (**Figure 1-2**). Drinking water for the Bismarck AASF #1 is supplied by the City of Bismarck Public Works, which sources water from the Missouri River (Bismarck Capital City of North Dakota, 2019).

Based on the USEPA Unregulated Contaminant Monitoring Rule 3 data, it was indicated that no PFAS were detected in a public water system above the USEPA HA level within 20 miles of the facility. PFAS analyses performed in 2016 had method detection limits that were higher than currently achievable. Thus, it is possible that low concentrations of PFAS were not detected during the UCMR3 but might be detected if analyzed today.

1.5.3 Hydrology

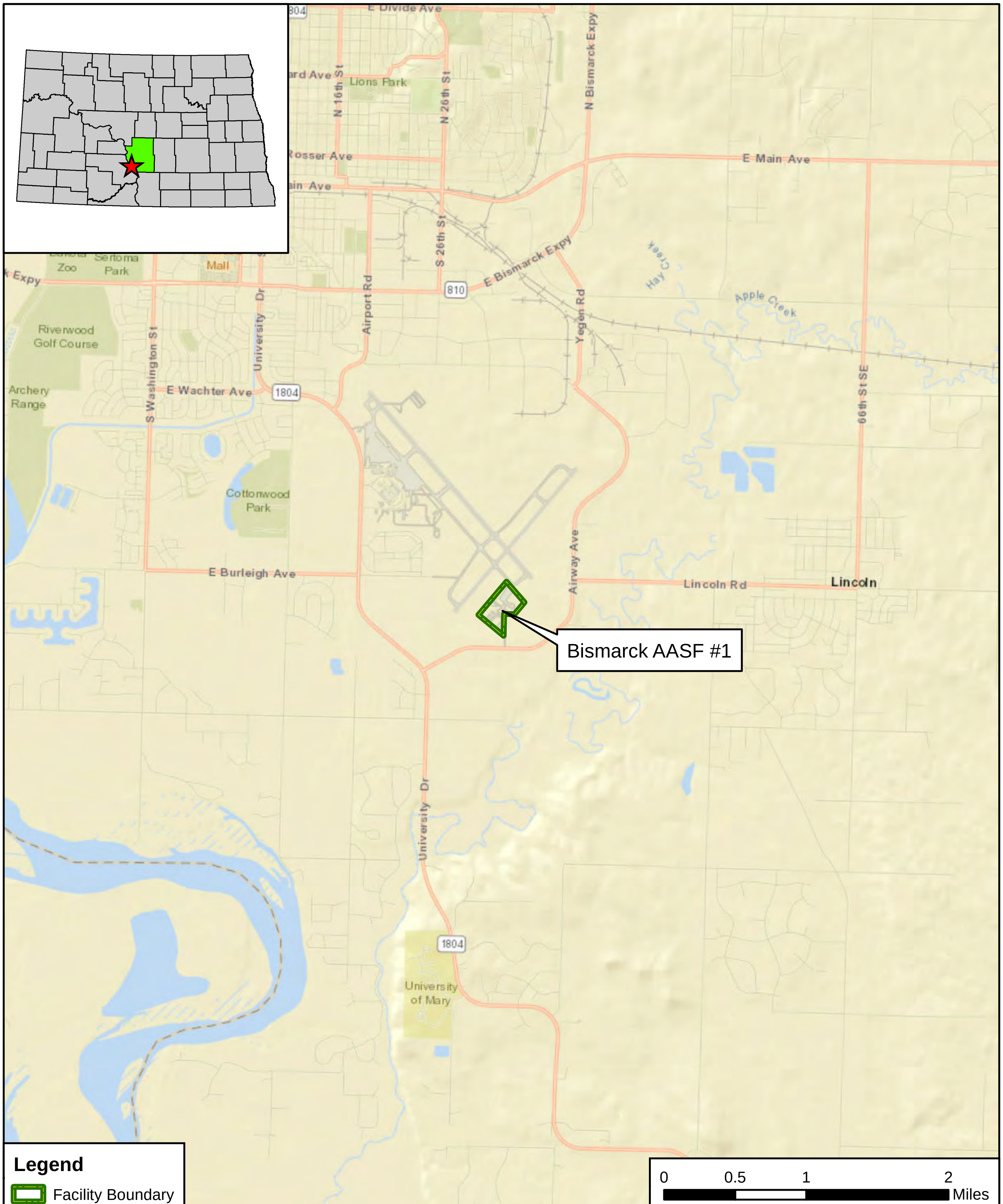
An Environmental Data Resources, Inc. (EDR)™ report conducted a well search for a 1-mile radius surrounding the facility (**Appendix A**). Using additional online resources, such as state and local GIS databases, wells were researched to a 4-mile radius of the facility. The Bismarck AASF #1 is in the Great Plains Physiographic Province in the Williston Basin, just to the east of the Missouri River (**Figure 1-3**). Apple Creek is located approximately 0.5 mile to the east of the facility, which flows to the south and discharges to the Missouri River. The Bismarck AASF #1 is connected to the Bismarck City Sewer System which leads to the Bismarck City Waste Water Treatment Plant (WWTP) (Bismarck Capital City of North Dakota, 2019). The surface water flow for the facility is southeast towards Apple Creek (North Dakota Geological Survey, 1965) (North Dakota State Water Commission, 1984).

1.5.4 Climate

The climate at the facility consists of warm summers; freezing, dry, windy winters; and is partly cloudy year-round. The average temperature is 42.8 degrees Fahrenheit (°F), with warmer temperatures to at least 84 °F and colder temperatures to at least -1.6 °F. Average precipitation is 17.82 inches of rain (World Climate, 2019).

1.5.5 Current and Future Land Use

The Bismarck AASF #1 is a controlled access facility with public roads and is adjacent to the Bismarck Airport. The facility consists of hangars, one administration building, and office areas. Exterior features are vehicle parking areas and roads. Land use at the AASF is not anticipated to change.



CLIENT	ARNG			
NOTES	Preliminary Assessment for PFAS at Bismarck AASF #1, ND			
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SCALE	1:63,360	CHK BY	JW	1/14/2020
Base Map: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI,		PM	RG	1/14/2020

N

Facility Location

AECOM

12420 Milestone Center Drive
Germantown, MD 20876

Figure 1-1

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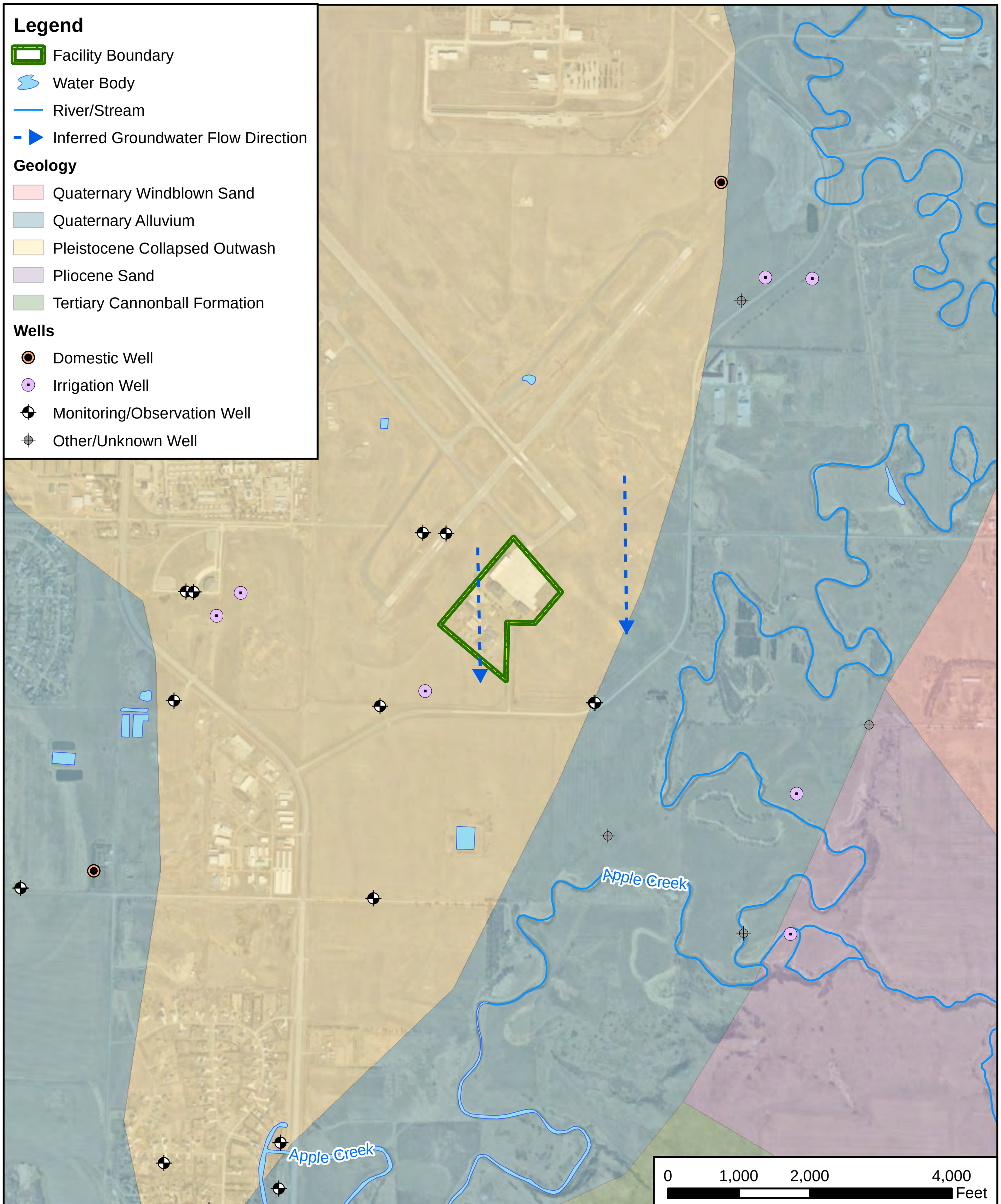

CLIENT	ARNG				
NOTES	Preliminary Assessment for PFAS at Bismarck AASF #1, ND				
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SCALE	1:24,000	CHK BY	JW	1/14/2020	
Base Map: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,		PM	RG	1/14/2020	

Groundwater Features

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Figure 1-2

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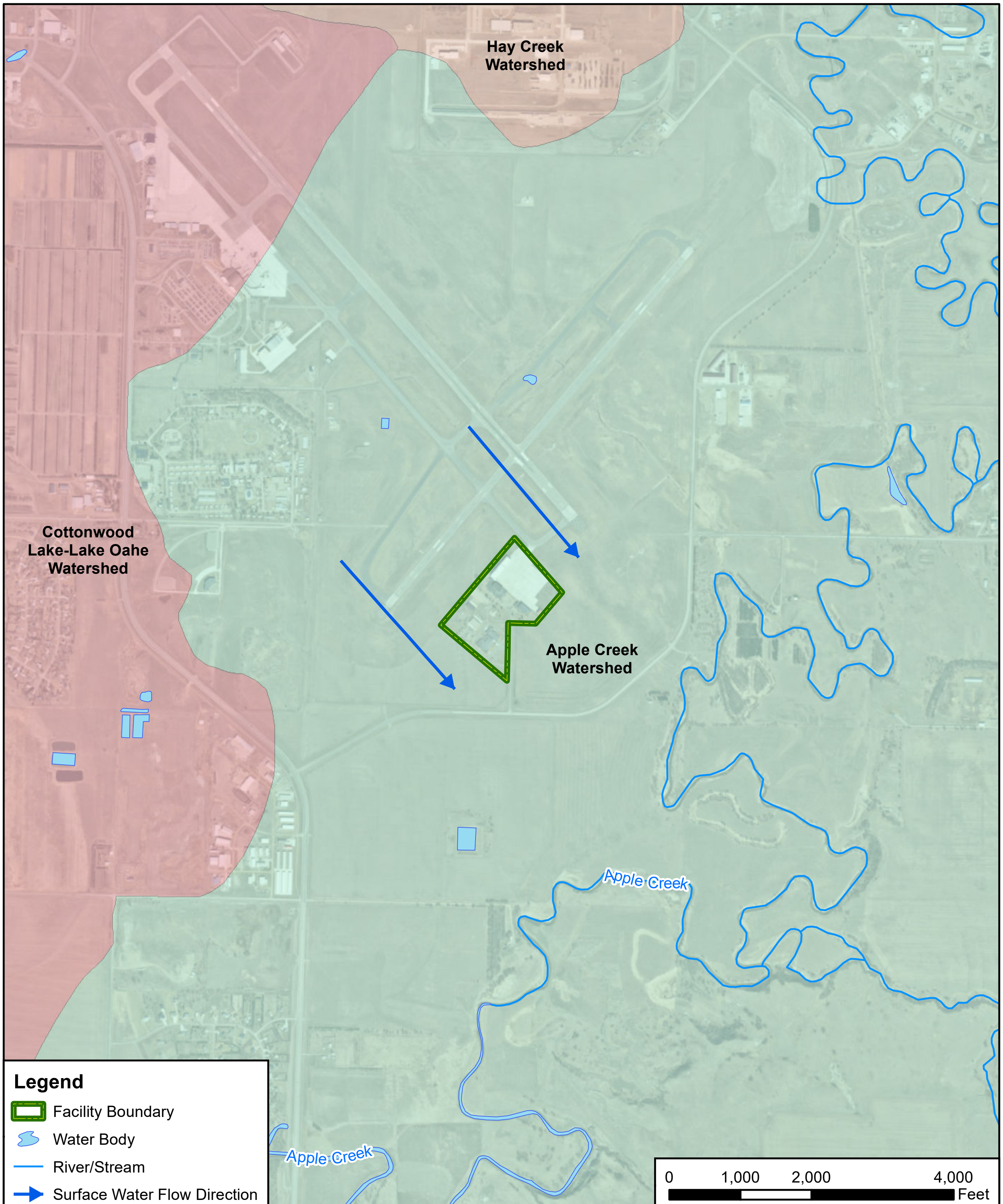

CLIENT	ARNG				N	**Surface Water Features**
NOTES	Preliminary Assessment for PFAS at Bismarck AASF #1, ND					
REVISED	2/24/2020	GIS BY	MS	2/24/2020		AECOM 12420 Milestone Center Drive Germantown, MD 20876
SCALE	1:24,000	CHK BY	JW	2/24/2020		**Figure 1-3**
Base Map: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,		PM	RG	2/24/2020		

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2. Fire Training Areas

No FTAs were identified within the facility during the PA through interviews (**Appendix B**) or document review (**Appendix A**). NDARNG fire training exercises are not conducted at the Bismarck AASF #1, nor do any other DoD or non-DoD units perform fire training exercises at the facility. Additionally, there is no history of fire training at the Bismarck AASF #1.

3. Non-Fire Training Areas

In addition to FTAs, the PA evaluated areas where PFAS-containing materials may have been broadly used, stored, or disposed. This may include buildings with fire suppression systems, paint booths, AFFF storage areas, and areas of compliance demonstrations. Information on these features obtained during the PA are included in **Appendices A** and **B**. Three non-FTAs were identified during the PA. Descriptions are presented below and shown on **Figure 3-1**. Photographs of the non-FTAs are included in the Photographic Log (**Appendix C**).

3.1 Hangar Fire Suppression System

The Main Hangar is located in the northwestern portion of the Bismarck AASF #1 property (46°45'50.4"N and 100°44'32.2"W) and consists of two hangar spaces connected by a smaller room used for the storage of maintenance equipment (Maintenance Room) (**Figure 3-1**). The southern hangar was built in 1975 without a fire suppression system, and the northern hangar was built in 2006. A fire suppression system for the entire Main Hangar was installed in 2006 by the NDARNG during the construction of the northern hangar. The geographic coordinates of the hangar fire suppression system room are 46°45'50.4"N and 100°44'32.2"W (**Figure 3-1**). The hangar fire suppression system consists of one 300-gallon tank filled with 2 percent C2 High Expansion Foam (HEF). Following installation in 2006, the fire suppression system was tested resulting in a full system release to the hangar. The hangar doors were closed during testing; therefore, the foam went down the Main Hangar drains to the oil/water separator, ultimately discharging to the City of Bismarck sanitary Waste Water Treatment Plant (WWTP). Once the water is treated, it is discharged to the Missouri River.

Annual maintenance since 2006 is completed by a contractor who tests the pressure of the system without a release. There have been no reported leaks from the 300-gallon tank, and no evidence of leaking was observed during the site visit. Additionally, two 55-gallon drums of bulk 2% C2 HEF are stored in the fire suppression room. There are no reports of any leaking or spills from the drums.

A C12 hangar is located southeast of the hangar; however, it does not have a fire suppression system. There is no evidence of use or storage of AFFF in the C12 hangar.

3.2 TriMax30™ Fire Extinguishers

There are 14 TriMax30™ fire extinguishers filled with AFFF and are located within the Main Hangar, ramp area and mounted on small vehicles. The TriMax30™ fire extinguishers were introduced to the AASF in 2004. An additional fire extinguisher is filled with soap and water by the NDARNG for fire training exercises. Every five years, the TriMax30™ fire extinguishers are emptied by the NDARNG into polyethylene tanks and stored in the Maintenance Room. The emptied TriMax30™ fire extinguishers are sent to a contractor to undergo hydrostatic testing. When the fire extinguishers are returned, they are refilled by the NDARNG with the original AFFF solution from polyethylene tanks in the Maintenance Room. No spills or leaking has occurred during the emptying and refilling process. All the drains in the Maintenance Room discharge to the oil/water separator. The TriMax30™ fire extinguishers filled with AFFF have never been dispensed or used to put out a fire, or in fire training exercises. Prior to 2004, Halon and Purple K mobile fire extinguishers were present at the Bismarck AASF #1.

3.3 Overland Firefighting

The NDARNG responds to wildfires locations west of the Mississippi River when called upon to provide emergency response. The NDARNG uses Bambi Buckets® filled with water to fight wildfires. AFFF can be deployed using a specialized dispensing system for the Bambi Buckets®, which releases AFFF below the water stream not directly in the bucket. The dispensing system has a control unit, a tank that holds the AFFF, and hoses. The aircraft picks up a load of water in the Bambi Bucket® and the control unit triggers a specified amount of the AFFF to be released from the hoses over the fire. The aircraft then returns to the fill point for a refill of water, and the process is repeated until there is no AFFF left in the dispensing system. There are approximately three AFFF dispensing systems. The exact dates when the dispensing systems were used are unknown; however, based on interviewee knowledge, the last time they were used were in approximately 2008.

According to personnel, the Bambi Buckets® have been in use as needed. Since 2008, the Bambi Buckets® have been deployed to fight fires with water only. At least one Bambi Bucket® is kept in the Main Hangar, and there are several more stored in Hanger C-12.

The AFFF specifically for the overland firefighting missions are stored in the Hazardous Material room off the Hangar. The geographical coordinates are 46°45'50.08"N and 100°44'33.17"W.The AFFF is stored in three different containers. The 6% AFFF concentrate is shipped from the supplier in approximately 15-gallon blue plastic containers (**Appendix C**). The NDARNG then transfers the AFFF concentrate directly to small 5-gallon brown canisters or into a 55-gallon drum. The 55-gallon drum had a pumping system that fills the smaller 5-gallon brown canisters. The small 5-gallon brown canisters are used to fill the dispensing system of the Bambi Bucket®, which only occurs in the field. There is approximately 100-gallons of bulk 6% AFFF stored in the Hazardous Materials room. The cannisters were not rinsed upon returning from a mission, and according to personnel, there is residue present in the 5-gallon canisters. It is unknown when the bulk 6% AFFF arrived at the AASF, and when the AFFF was transferred to the smaller canisters and 55-gallon drum.

CLIENT	ARNG			
NOTES	Preliminary Assessment for PFAS at Bismarck AASF #1, ND			
REVISED	6/19/2020	GIS BY	MS	6/19/2020
SCALE	1:3,600	CHK BY	JW	6/19/2020
Base Map: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,		PM	RG	6/19/2020

Non-Fire Training Areas

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12420 Milestone Center Drive
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Figure 3-1

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4. Emergency Response Areas

No emergency response areas were identified within the Bismarck AASF #1 during the PA through interviews or document review. Bismarck Airport Fire Department provides fire emergency services for the Bismarck AASF #1.

5. Adjacent Sources

Two potential off-site PFAS sources adjacent to the Bismarck AASF #1 were identified during the PA through interviews and document review (**Appendix A** and **Appendix B**). **Figure 5-1** presents the locations of potential adjacent source areas.

5.1 Bismarck Airport Fire Department

The Bismarck Airport Fire Department provides emergency response to the Bismarck AASF #1. The fire department is located approximately 0.75 miles northwest of the facility on the Bismarck Airport property, and upgradient of the facility. The Bismarck Airport Fire Department has three firetrucks with AFFF tanks. One truck has a capacity of 400 gallons of AFFF, and the other two have a capacity of 200 gallons of AFFF. The fire department has approximately 800 to 1,000-gallons of bulk 6% AFFF stored within the fire station. The fire department has never had to respond to a fire or crash at the airport. During annual firetruck nozzle testing, the AFFF is dispensed from the firetrucks and containerized in 55-gallon drums. It is unknown whether the nozzle testing has always been performed in a manner that containerizes AFFF. Annual fire training by the fire department is currently conducted using only water, but it is unknown whether AFFF has ever been used for training purposes.

5.2 Corporate Hangars

Private corporate hangars are located approximately 0.88 miles northwest and upgradient of the Bismarck AASF #1. There are also numerous hangar facilities located northwest of the Main Terminal. An interviewee with the NDARNG stated that the corporate hangars have a fire suppression system; however, the type of fire suppressant used in the fire suppression system is unknown. The corporate hangars have been identified as a potential adjacent source due to the possibility that the fire suppression system may contain AFFF. No additional information for the corporate hangar was available during the site visit.

CLIENT	ARNG			
NOTES	Preliminary Assessment for PFAS at Bismarck AASF #1, ND			
REVISED	1/15/2020	GIS BY	MS	1/15/2020
SCALE	1:9,600	CHK BY	JW	1/15/2020
Base Map: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,		PM	RG	1/15/2020

Adjacent Sources

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Figure 5-1

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6. Preliminary Conceptual Site Model

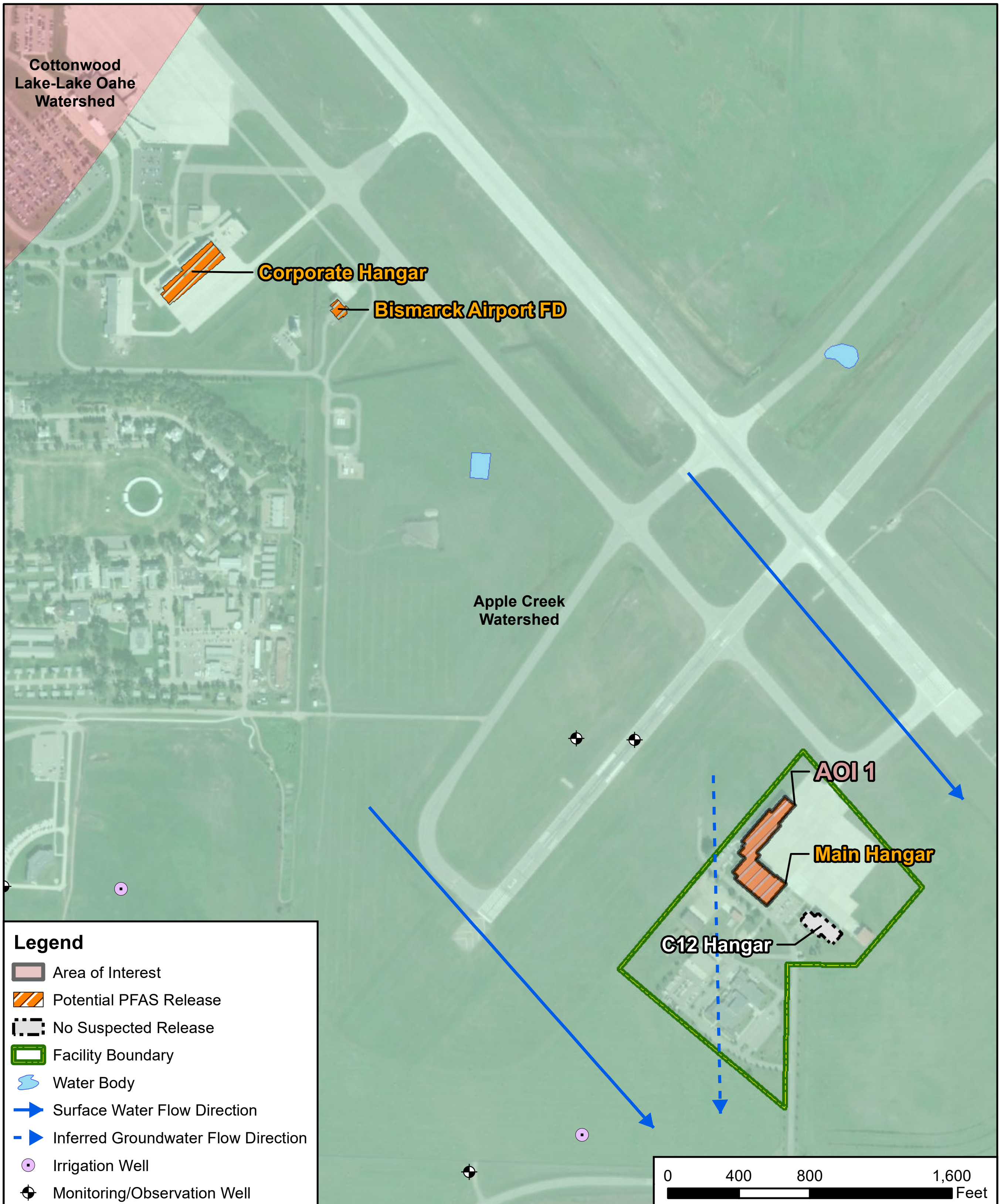
Based on the PA findings, one non-FTA was identified where PFAS may have been incidentally spilled or discharged to the ground surface: AOI 1 Main Hangar. As such, this area is determined to be an AOI and may be a potential PFAS source area. The AOI location is shown in **Figure 6-1**.

The following section describes the CSM components and the specific preliminary CSM developed for AOI 1. The CSM identifies the three components necessary for a potentially complete exposure pathway: (1) source, (2) pathway, (3) receptor. If any of these elements are missing, the pathway is considered incomplete. The preliminary CSM for AOI 1 is shown in **Figure 6-2**.

6.1 AOI 1 Main Hangar

A fire suppression system for the Main Hangar was installed in 2006 by the NDARNG during the construction of the northern section of the Main Hangar. The Main Hangar fire suppression system consists of one 300-gallon tank filled with 2 percent C2 High Expansion Foam (HEF). Following installation in 2006, the fire suppression system was tested resulting in a full system release to the Main Hangar. The Main Hangar doors were closed during testing, the foam release was contained within the hangar. Annual maintenance since 2006 is completed by a contractor who tests the pressure of the system without a release. Additionally, there are 14 TriMax30™ fire extinguishers filled with AFFF and are located within the Main Hangar, ramp area and mounted on small vehicles. Approximately, 100-gallons of bulk 6% AFFF for use during overland firefighting response is stored in the Hazardous Materials Room, located on western side of the Main Hangar. All drains within AOI 1 lead to the oil/water separator, ultimately discharging to the City of Bismarck sanitary WWTP. Stormwater at the AASF is managed by a series of grassed trenches and small retention basins before being discharged to Apple Creek, and ultimately to the Missouri River.

Potential AFFF releases identified at the AASF may have occurred on paved surfaces. The entire footprint of the AASF is concrete; therefore, it is not likely that releases to the paved surfaces could have migrated to surrounding surface soil. AFFF releases to the paved surfaces could have infiltrated the subsurface via cracks in the pavement or joints between areas that are paved with different materials. Ground-disturbing activities may result in potential exposure to subsurface soils and groundwater for construction workers. The preliminary CSM for AOI 1 is shown on **Figure 6-2**.



CLIENT	ARNG				N	Area of Interest
NOTES	Preliminary Assessment for PFAS at Bismarck AASF, ND					
REVISED	6/19/2020	GIS BY	MS	6/19/2020		AECOM 12420 Milestone Center Drive Germantown, MD 20876
SCALE	1:9,600	CHK BY	JW	6/19/2020		Figure 6-1
Base Map: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,		PM	RG	6/19/2020		

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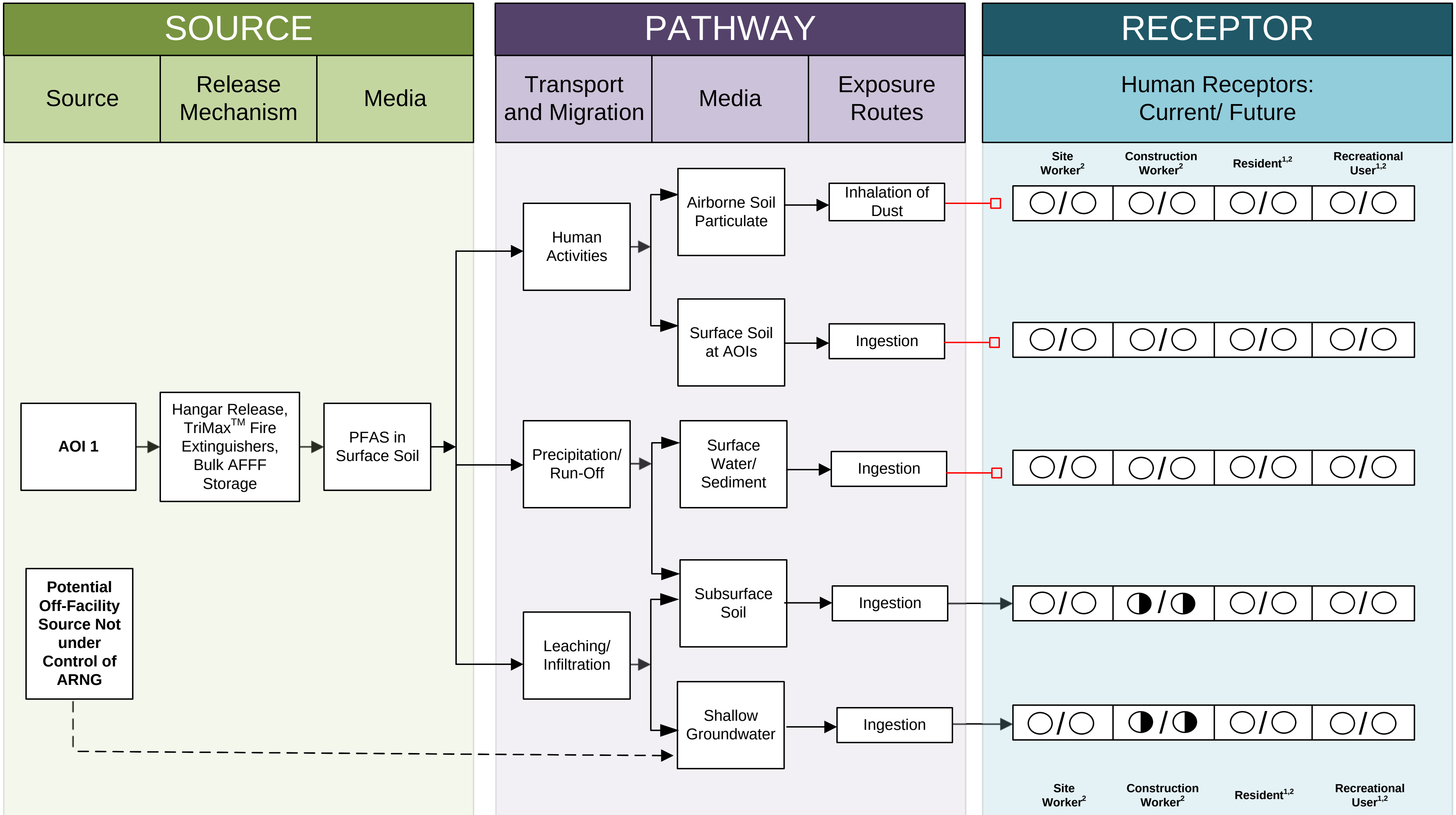


LEGEND

- Flow-Chart Stops
- Flow-Chart Continues
- Partial / Possible Flow
- Incomplete Pathway
- Potentially Complete Pathway
- Complete Pathway

Notes:
1. The resident and recreational users receptors refer to an off-facility resident and off-facility recreational users.
2. Dermal contact exposure pathway is incomplete for PFAS.

Figure 6-2
Preliminary Conceptual Site Model
AOI 1 Main Hangar

7. Conclusions

This report presents a summary of available information gathered during the PA on the use and storage of AFFF and other PFAS-related activities at the Bismarck AASF #1. The PA findings are based on the information presented in **Appendix A** and **Appendix B**.

7.1 Findings

One AOI related to a potential PFAS release was identified (**Table 7-1**) at the Bismarck AASF #1 during the PA (**Figure 7-1**).

Table 7-1: AOI at Bismarck Army Aviation Support Facility #1

Area of Interest	Name	Used by	Potential Release Dates
AOI 1	Main Hangar (Fire Suppression/TriMax30™ Maintenance/Overland Firefighting Equipment)	NDARNG	2006

Based on potential PFAS releases at AOI 1, there is potential for exposure to PFAS contamination in media at or near the facility. The preliminary CSM for AOI 1 is shown on **Figure 6-2**, which presents the potential receptors and media impacted. Two off-facility sources located northwest of the AASF were identified as potential PFAS release areas during the PA (**Figure 7-1**). Groundwater surrounding the Bismarck AASF #1 is inferred to flow to the south and the potential adjacent sources may impact the facility based on their upgradient locations.

The following areas, which were discussed in **Section 2** through **Section 5**, were determined to have no suspected PFAS releases (**Table 7-2**).

Table 7-2: No Suspected Release Areas

No Suspected Release Area	Used by	Rationale for No Suspected Release Determination
C12 Hangar	NDARNG	The hangar has never had a fire suppression system, or AFFF fire extinguishers.

7.2 Uncertainties

Several information sources were investigated during this PA to determine the potential for PFAS-containing materials to have been present, used, or released at the facility. Historically, documentation of PFAS use was not required because PFAS were considered benign. Therefore, records were not typically kept by the facility or available during the PA on the use of PFAS in training, firefighting, or other non-traditional activities, or on its disposition.

The conclusions of this PA are based on all available information, including: previous environmental reports, EDRs™, observations made during the VSI, and interviews. Interviews of personnel with direct knowledge of a facility generally provided the most useful insights regarding a facility's historical and current PFAS-containing materials. Sometimes, the provided information was vague or conflicted with other sources. Gathered information has a degree of uncertainty due to the absence of written documentation, the limited number of personnel with direct knowledge due to staffing changes, the time passed since PFAS were first used (1969 to present), and a reliance on personal recollection. Inaccuracies may arise in potential PFAS release locations, dates of release, volume of releases, and the concentration of AFFF used. There is also a possibility the PA has missed a source of PFAS, as the science of how PFAS may enter the environment continually evolves.

In order to minimize the level of uncertainty, readily available data regarding the use and storage of PFAS were reviewed, retired and current personnel were interviewed, multiple persons were interviewed for the same potential source area, and potential source areas were visually inspected. **Table 7-3** summarizes the uncertainties associated with the PA.

Table 7-3: Uncertainties

Area of Interest	Source of Uncertainty
AASF	Potential off-facility PFAS release areas exist adjacent to the Bismarck AASF #1. Because these areas are located upgradient of the facility, it is unknown whether or not these potential PFAS releases may affect site media at the Bismarck AASF #1.
AOI 1	It is unknown when the AFFF dispending units were used with the Bambi Buckets® or when the bulk AFFF arrived on facility.
AASF	It is unknown whether the 2 percent C2 HEF contains fluorinated compounds.

7.3 Potential Future Actions

Interviews and records (covering 1995 to present) indicate that ARNG activities may have resulted in a potential PFAS release at the one AOI identified during the PA. Based on the preliminary CSM developed for the AOI, there is potential for receptors to be exposed to PFAS contamination in media at or near the facility. **Table 7-4** summarizes the rationale used to determine if the AOI should be considered for further investigation under the CERCLA process and undergo an SI.

ARNG will evaluate the need for an SI at the AASF based on the potential receptors, the potential migration of PFAS contamination off the facility, and the availability of resources.

Table 7-4: PA Findings Summary

Area of Interest	AOI Location	Rationale	Potential Future Action
AOI 1 Main Hangar	46°45'50.4"N; 100°44'32.2"W	The fire suppression system was tested resulting in a full system release with the hangar doors closed. Bulk AFFF for overland firefighting response is stored in the hangar. In addition, TriMax30™ fire extinguishers are filled and emptied with AFFF in the hangar.	Proceed to SI focus, on soil and groundwater.

CLIENT	ARNG				
NOTES	Preliminary Assessment for PFAS at Bismarck AASF #1, ND				
REVISED	6/19/2020	GIS BY	MS	6/19/2020	
SCALE	1:9,600	CHK BY	JW	6/19/2020	
Base Map: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS,		PM	RG	6/19/2020	

N

Summary of Findings

AECOM
12420 Milestone Center Drive
Germantown, MD 20876

Figure 7-1

C:\Users\stankevichm\OneDrive - AECOM Directory\ARNG_PFAS_GIS_60552172\MXDs\ND\Bismark_AASF_Figures\Fig_7-1_Bismarck_AASF_Summary.mxd

8. References

Bismarck Capital City of North Dakota. 2019. *Wastewater Treatment Plant.* November.

North Dakota Geological Survey. 1965. *Geology and Ground Water Resources of Burleigh County, North Dakota: Part 1- Geology.* November.

North Dakota State Water Commission. 1984. *Geohydrology of the South Bismarck Area, Burleigh County, North Dakota.* November.

United States Environmental Protection Agency (USEPA). 1991. *Guidance for Performing Preliminary Assessments under CERCLA.* September.

World Climate. 2019. Available at http://www.worldclimate.com/climate/us/north-dakota/bismarck (Accessed November 14, 2019)

Appendix A
Data Resources

Data Resources will be provided separately on CD. Data Resources for Bismarck AASF #1.

Bismarck AASF #1 Leases, Licenses, and Permits

- 1996 Airport Use Agreement
- 1996 Airport Property Lease

Bismarck AASF #1 Environmental Background Documents

- 1965 Burleigh County Ground Water Study Part I
- 1965 Burleigh County Ground Water Study Part II

EDR Report

- 2019 Bismarck AASF #1 EDR Report

AIRPORT USE AGREEMENT

THIS INDENTURE made and entered into this 25TH day of June, 1996, by and between the City of Bismarck, Burleigh County, North Dakota, a public body, corporate and politic, for itself, its successors and assigns, hereinafter referred to as the "CITY" and the STATE OF NORTH DAKOTA, by and through the ADJUTANT GENERAL, its successors and assigns, hereinafter referred to as the "GUARD";

WITNESSETH:

WHEREAS, Federal funds are to be provided for the Federal Government's portion of the cost of construction of an Army Aviation Support Facility/Armory Complex; and

WHEREAS, the Adjutant General is authorized under the provisions of § 37-10-03 of the North Dakota Century Code, to provide for the support and maintenance of National Guard facilities, operations and services described herein, and to allocate funds for the Guard's portion of the cost of such services; and

WHEREAS, the CITY has presented evidence acceptable to the GUARD of the availability of such services; and

WHEREAS, the GUARD is agreeable to obtaining said support services, and the parties wish to reduce their agreement to writing.

NOW THEREFORE, it is hereby agreed that for and in consideration of the covenants and agreements herein contained, the said parties hereby covenant, promise and agree with each other as follows:

1. The term of this Airport Use Agreement shall be for a period of thirty (30) years, commencing on July 1, 1996, and ending on June 30, 2026, unless sooner terminated and canceled as provided for hereinafter, or by mutual agreement of the parties hereto.

2. As consideration for the services received under this Airport Use Agreement, the GUARD hereby covenants and agrees to pay the CITY as payment for said services the annual sum of $9,469.00, one-fourth (¼) of such sum to become due and payable quarterly beginning October 1, 1996, and on such quarterly date thereafter. Unless otherwise agreed to by the GUARD and the CITY, the annual payment as herein provided shall be adjusted to July 1, 2000 and readjusted each five years thereafter to reflect any change upward or downward in the Consumer Price Index of the Bureau of Labor Statistics, United States Department of Labor, such payments being subject to appropriations. The parties reserve the right to renegotiate the annual payment in the event that the Guard substantially changes its based fleet mix.

3. The CITY agrees to provide all services pursuant to this Airport Use Agreement that the GUARD is entitled to receive for which the CITY is charging the GUARD a proportionate share of the costs of operating and maintaining the various common airport facilities and services.

4. The GUARD shall retain the right to do necessary snow removal, provide security to its leased premises and provide self-fueling capability for military or military-related aircraft.

5. The GUARD shall comply with regulations noted in the Airport Operations Manuals and the regulations of the Federal Aviation Administration as it relates to the Bismarck Municipal Airport.

6. It is further agreed that the GUARD shall indemnify and save forever harmless the CITY from any and all claims for damages of any kind or nature which may hereafter be made against the CITY on account of any personal injuries or property damage resulting from the use of said premises by the GUARD, as permitted by law.

7. This Agreement may be terminated at any time by either the CITY or the GUARD if any of the representations by either party are not true and accurate in all material respects or either party has failed to perform in all material respects any of their respective obligations or covenants ereunder.

8. Any Party having the right to terminate this Agreement may, by written notice to any other Party:

a. extend the time for the performance by such other Party of any of his obligations or other actions hereunder; or,

b. waive or modify the performance of any obligations of such other Party.

The CITY or GUARD will be entitled to enforce specific performance of this Agreement as well as to seek damages in the event of any wrongful termination of this Agreement. The remedies provided herein shall not be deemed to limit the remedies of the Parties and each shall have all remedies provided for herein, at law, or in equity.

9. Any and all notices or other communications required or permitted by this Agreement or by law to be served on or given to either Party hereto, CITY or GUARD, by the other Party to this Agreement shall be in writing and shall be deemed to have been duly served when delivered personally, or if mailed by first class mail, postage pre-paid and correctly addressed to the Party to be notified, when actually received or on the fifth (5th) business day after mailing (whichever is sooner).

10. Neither this Agreement nor any interest therein shall be assigned by CITY or GUARD without the prior written consent of the other.

11. Except as otherwise specifically provided herein, this Agreement may be modified or amended only by writing signed by both Parties.

12. If any provision of this Agreement is held to be illegal, invalid, or unenforceable under any present or future law, such provision shall be fully severable, and this Agreement shall be construed and enforced as if such illegal, invalid, or unenforceable provision had never comprised a part hereof and the remaining provisions of this Agreement shall remain in full force and effect and shall not be affected by the illegal, invalid, or unenforceable provision or its severance from this Agreement. Furthermore, in lieu of such illegal, invalid, or unenforceable provisions, there shall be dded automatically as a part of this Agreement a provision as similar in terms to such illegal, invalid, or unenforceable provision as may be possible and be legal, valid or enforceable.

13. This Agreement shall be governed by and construed in accordance with the laws of the State of North Dakota.

IN WITNESS WHEREOF, We, the CITY and the GUARD, have hereunto set our hand and seals to the foregoing Airport Use Agreement on the day and date first above written.

CITY OF BISMARCK, NORTH DAKOTA

By: Bill Sorensen
Mayor

By: W.C. Wocken
City Administrator

On this 25th day of June, 1996, before me, a Notary Public, personally appeared Bill Sorensen and W.C. Wocken, known to me to be persons who are described in and who executed the within instrument and acknowledged to me that they executed the same.

Kimberla K. Bohrer
Notary Public, State of North Dakota
My Commission Expires: 7-24-96

STATE OF NORTH DAKOTA

By: Keith D. Bjerke

Keith D. Bjerke
Brigadier General, NDANG
The Adjutant General

ATTEST:

Ronald L. Gangness
Col, GS, NDARNG
Director of Facilities Engineering

Jerald L. Engelman

Jerald L. Engelman
Col, NDANG
North Dakota Judge Advocate General

On this 28th day of June, 1996, before me, a Notary Public, personally appeared Keith D. Bjerke, Ronald L. Gangness and Jerald L. Engelman, known to me to be persons who are described in and who executed the within instrument and acknowledged to me that they executed the same.

NANCY SHANTA
Notary Public, STATE OF NORTH DAKOTA
My Commission Expires 6-18-97

Nancy Shanta
Notary Public, State of North Dakota
My Commission Expires: 6-18-97

OFFICE OF REGISTER OF DEEDS BURLEIGH COUNTY ND

STATE OF NORTH DAKOTA } SS
COUNTY OF BURLEIGH, }
I hereby certify that the within instrument was filed in this office for record on the ___ day of JUL 3 1996 A.D. 19___ at 2:10 o'clock P M. and was duly recorded. 486968

REGISTER OF DEEDS

Agreement No. MISC-640

$16.00 pd Attn: Jerry Engelman ND Nat'l Guard JAG PO Box 5511 Bsk ND 58506-5511

LEASE

THIS INDENTURE made and entered into this 25th day of June, 1996, by and between the City of Bismarck, Burleigh County, North Dakota, a public body, corporate and politic, for itself, its successor and assigns, hereinafter referred to as "LESSOR" and the STATE OF NORTH DAKOTA, by and through the ADJUTANT GENERAL, its successors and assigns, hereinafter referred to as the "LESSEE";

WITNESSETH:

WHEREAS, Federal funds are to be provided for the Federal Government's portion of the cost of construction of an Army Aviation Support Facility/Armory Complex; and

WHEREAS, the Adjutant General is authorized under the provisions of § 37-10-03 of the North Dakota Century Code, to provide for the acquisition and maintenance of National Guard facilities described herein, including the lease of property of such facilities, and to allocate funds for the State's portion of the cost for the construction of such facilities; and

WHEREAS, the LESSOR has presented evidence acceptable to the LESSEE of the availability of a building site; and

WHEREAS, the LESSOR warrants that it is the title owner of the leased premises and is authorized by law to enter into this agreement; and

WHEREAS, the LESSOR certifies the title and records describing the past ownership, tenants and activities taking place on the leased premises shows no evidence of environmental contamination; and

WHEREAS, the LESSOR is agreeable to leasing said property and the parties wish to reduce their agreement to writing.

NOW THEREFORE, it is hereby agreed by and between the parties for the single payment of Fifty Dollars ($50.00) and other valuable consideration, the sufficiency of which is acknowledged by all parties, as follows:

1. The LESSOR for and in consideration of the covenants and agreements hereinafter to be performed by LESSEE, hereby lets, rents and leases to the LESSEE for and during the term of this lease, the following described property, to-wit:

> *An irregular shaped tract of land located at the Bismarck Municipal Airport lying in the North one-half (N½) of Section Twenty three (23), Township One Hundred Thirty Eight North (T 138 N), Range Eighty West (R 80 W), of the Fifth Principal Meridian (5th PM), Burleigh County, North Dakota, and more particularly described as follows:*

Commencing at the NW Cor. of said Section 23; thence Southerly along the West section thereof a distance of 1,322.84 feet; thence North 89 degrees 44 minutes 00 seconds East (N 89° 44' 00" E) a distance of 1,880.39 feet to the True Point of Beginning; thence North 38 degrees 32 minutes 45 seconds East (N 38° 32' 45" E) a distance of 1,539.09 feet; thence South 42 degrees 54 minutes 00 seconds East (S 42° 54' 00" E) a distance of 1,019.39 feet; thence South 38 degrees 32 minutes 45 seconds West (S 38° 32' 45" W) a distance of 577.94 feet; thence South 89 degrees 44 minutes 00 seconds West (S 89° 44' 00" W) a distance of 386.51 feet; thence South 00 degrees 29 minutes 46 seconds East (S 00° 29' 46" E) a distance of 811.91 feet; thence North 51 degrees 41 minutes 03 seconds West (N 51° 41' 03" W) a distance of 1216.62 feet; thence North 38 degrees 32 minutes 45 seconds East (N 38° 32' 45" E) a distance of 68.24 feet to the True Point of Beginning and there terminating, said tract of land contains 33.65 acres, more or less. (See Attachment A affixed to this lease for a detailed diagram.)

2. The LESSEE shall hold the above-described premises with all of the rights, privileges, easements and appurtenances thereto for a term of fifty (50) years from and after the date hereof. It is further agreed that the LESSEE shall have the option to renew this lease for an additional forty-nine (49) year period under the same terms and conditions.

3. The LESSEE hereby covenants and agrees and the LESSOR hereby covenants and agrees that the LESSEE shall use the above-described property for the purpose of providing land for the construction, operation and maintenance of an Army Aviation Support Facility/Armory Complex for the North Dakota National Guard, and such other use not inconsistent with such purposes.

4. The LESSEE shall retain ownership of any building or buildings placed on the leased premises provided that the same are removed from the premises within one hundred twenty (120) days after the expiration or termination in any manner of this lease and the leased premises are restored to their original condition, or in a condition acceptable to the LESSOR. The LESSEE may leave the building or buildings on the leased premises and pass ownership to the LESSOR only upon the consent of the LESSOR.

5. The LESSEE shall have the right to assign its rights to this lease to the United States of America for the purposes stated in paragraph three. The LESSEE shall have the right, consistent with federal military facilities requirements, to sublet or assign any part of the leased premises not inconsistent in support of National Guard purposes. Furthermore, the LESSEE shall comply with regulations noted in the Airport Operations Manuals and the regulations of the Federal Aviation Administration as it relates to the Bismarck Municipal Airport.

6. These premises leased, or any part thereof, shall not be used, nor will LESSEE permit them to be used, by any person, agency, group or corporation other than LESSEE except as otherwise authorized by LESSOR pursuant to this lease.

7. The LESSOR shall provide access, immediately adjacent (i.e.: within 100 feet) to the leased premises, to water, sanitary and storm sewer utilities and the LESSEE shall have the right to connect with and use such utilities at LESSEE's own expenses and at the usual rate for the amounts used. LESSEE shall have the right to connect with and use all available electricity and gas utilities as may be located at the leased premises at LESSEE's own expense. The LESSOR agrees to provide such easements as may be necessary for all electrical and gas connections to the described facilities. The parties recognize that there is a question as to whether state owned or controlled land may be made the subject of special assessments without prior agreement and/or legislative appropriation of payment of the same. In the event LESSEE should desire to have any special assessment district established, negotiations will be entered into leading to an agreement providing for the payment of said assessments by the State of North Dakota. In the event LESSOR should wish to establish a special assessment district wherein special assessments will be spread against property leased by LESSEE, prior negotiations will be entered into and agreement reached prior to establishment of such district if LESSEE's leased premises are to be subject to special assessments. Furthermore, LESSOR agrees to provide an access road to the leased premises, including maintenance of said road.

8. The LESSOR covenants with the LESSEE that upon performing the obligations herein provided on its part to be performed, the LESSEE shall quietly enjoy the same demised premises during the term of this lease or any extension thereof.

9. LESSEE agrees to indemnify, to the extent permitted by law, and save forever harmless LESSOR from any and all claims for damages of any kind or nature which may hereafter be made against LESSOR on account of any personal injuries or property damage arising out of or resulting from LESSEE's use of the leased premises.

10. Nothing in this lease shall be construed to prevent LESSOR from taking any action it considers necessary to protect the aerial approaches to its airport from obstructions or to keep LESSOR from preventing LESSEE from erecting, or permitting to be erected on the leased premises, any building, structure or obstruction which, in the opinion of LESSOR, would limit the usefulness of the airport or constitute any kind of a hazard to aircraft.

11. This lease shall be subordinate to the provisions of any existing or future agreement between LESSOR and the United States, relative to the operation or maintenance of the airport, the execution of which has been or may be required as a condition precedent to the expenditure of federal funds for the development of the airport

12. The Guard shall perform environmental testing upon the property covered by the Old Hanger Lease, dated August 1, 1957, and the City shall perform environmental testing on the new property described in this Lease which is an addition to the Lease dated March 1, 1974. Each party shall bear the cost of the testing conducted by it and shall provide the other party with a copy of the results. Such test results shall be delivered prior to the execution of this Lease.

13. The LESSOR and its agents shall use due care to treat confidentially all matters pertaining to the LESSEE's business except those things which of necessity must become part of a public record.

14. Upon termination of the lease in any manner, LESSOR may recover and resume possession of the demised premises, and it shall be lawful for the LESSOR to immediately enter upon the demised premises.

15. All provisions hereof, and words and phrases used herein, shall be governed and construed under the laws of the State of North Dakota, except insofar as the provisions of such laws or the benefits accruing therefrom are specially waived.

16. Upon execution of this lease, the lease entered into on the 1st day of August, 1957, between the parties (a copy hereinafter affixed as Attachment B) shall become terminated and any and all buildings and improvements located thereon shall become the property of the City of Bismarck. Furthermore, the lease entered into on the 1st day of March 1974 between the parties (a copy hereinafter affixed as Attachment C) shall become terminated and any and all buildings and improvements located thereon shall remain the property of the State of North Dakota, by and through the Adjutant General.

17. Each of the parties agrees to execute a short form of this lease upon request for recording purposes.

IN WITNESS WHEREOF, the parties hereto have executed this lease the day and year first above written.

CITY OF BISMARCK, NORTH DAKOTA

By: Bill Sorensen
Mayor

By: W Walker
City Administrator

On this 25th day of June, 1996, before me, a Notary Public, personally appeared Bill Sorensen and W. C. Wocken, known to me to be persons who are described in and who executed the within instrument and acknowledged to me that they executed the same.

Kimberla K. Bohrer
Notary Public, State of North Dakota
My Commission Expires: 7-24-99

STATE OF NORTH DAKOTA

By: Keith D Bjerke
Keith D. Bjerke
Brigadier General, NDANG
The Adjutant General

ATTEST:

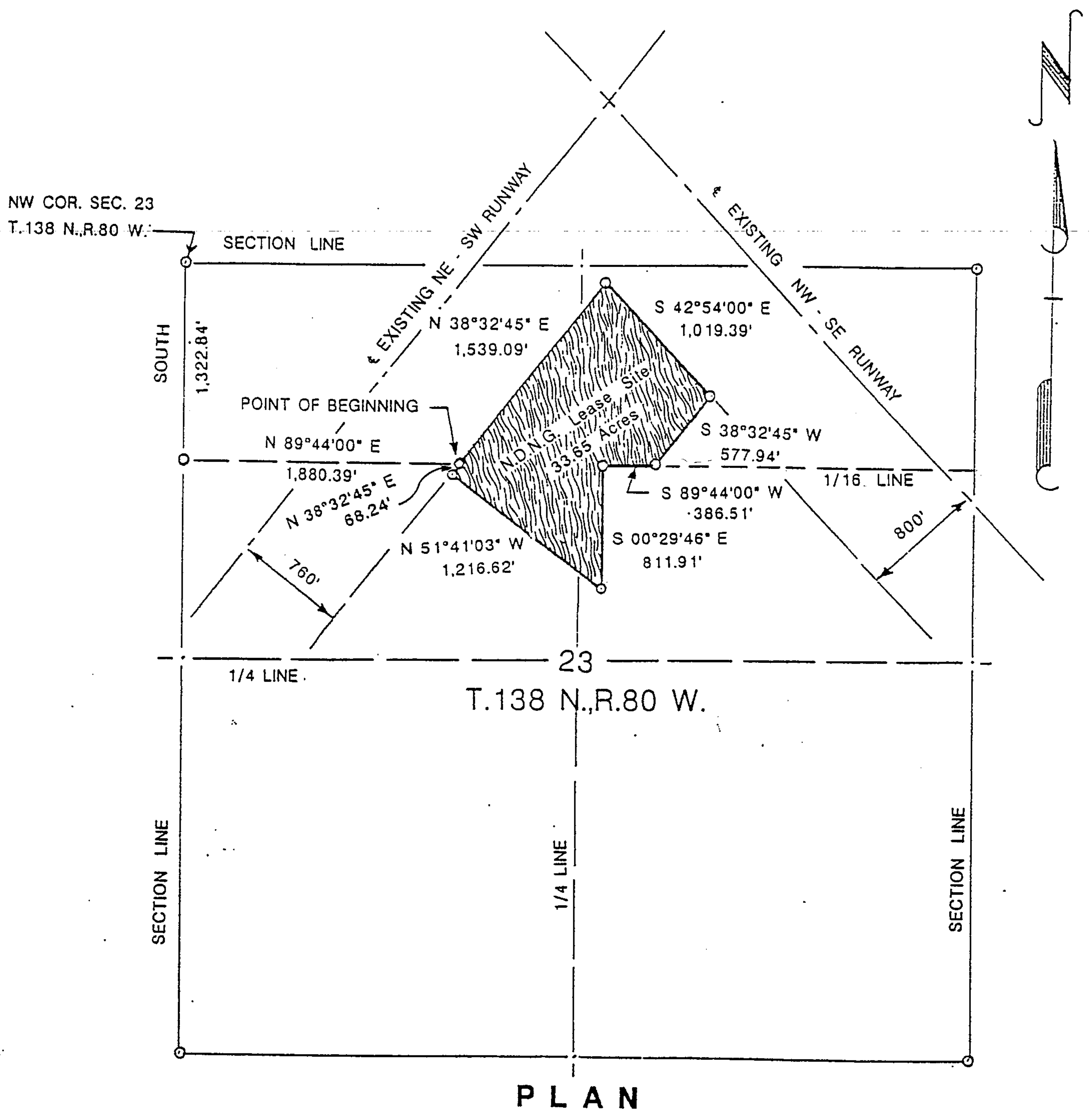
Ronald L. Gangness
Col, GS, NDARNG
Director of Facilities Engineering

Jerald L. Engelman
Col, NDANG
ND Judge Advocate General

On this 28th day of June, 1996, before me, a Notary Public, personally appeared Keith D. Bjerke, Ronald L. Gangness and Jerald L. Engelman, known to me to be persons who are described in and who executed the within instrument and acknowledged to me that they executed the same.

NANCY SHANTA
Notary Public, STATE OF NORTH DAKOTA
My Commission Expires 6-18-97

Nancy Shanta
Notary Public, State of North Dakota
My Commission Expires: 6-18-97



PLAN

SCALE 1' = 1000'

ND NATIONAL GUARD LEASE SITE
N 1/2 SECTION 23, T.138 N.,R.80 W.
BURLEIGH COUNTY
BISMARCK MUNICIPAL AIRPORT
BISMARCK, NORTH DAKOTA 58501

NORTH DAKOTA NATIONAL GUARD
FRAINE BARRACKS, BISMARCK, ND 58502

N.D.N.G. LEASE SITE

ATTACHMENT A

MAY, 1996

NORTH DAKOTA GEOLOGICAL SURVEY

WILSON LAIRD, *State Geologist*

Bulletin 42

NORTH DAKOTA STATE
WATER CONSERVATION COMMISSION
Milo W. Hoisveen, State Engineer

COUNTY GROUND WATER STUDIES 3

GEOLOGY AND GROUND WATER RESOURCES

of Burleigh County, North Dakota

PART I - GEOLOGY

By
Jack Kume and Dan E. Hansen

GRAND FORKS, NORTH DAKOTA

1965

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ILLUSTRATIONS

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TABLES

THE GEOLOGY OF BURLEIGH COUNTY NORTH DAKOTA

by Jack Kume and Dan E. Hansen

ABSTRACT

Burleigh County in south-central North Dakota lies within the Missouri River Trench, Coteau Slope, and Missouri Coteau physiographic districts of the Glaciated Missouri Plateau section. Subdivisions of the Coteau Slope in Burleigh County are the Burnt Creek, Badger Creek Uplands, Lake McKenzie Basin, Long Lake, Apple Creek Uplands, Long Lake Basin, and Painted Woods Creek subdistricts.

The Missouri River Trench includes the floodplain, four recognizable outwash and alluvial terraces, and the dissected bedrock valley walls of the Missouri River. The Coteau Slope, the glaciated bedrock slope between the Missouri River Trench and the Missouri Coteau, is subject to active erosion by integrated streams draining into the Missouri River and has moderately thick to thin to non-existent drift. The Missouri Coteau, a high morainic belt of predominantly dead-ice moraine with associated stagnant ice-disintegration features, has non-integrated drainage and thick drift.

Pleistocene Wisconsin glaciation in Burleigh County consisted of the Napoleon, Long Lake, Burnstad, and Streeter ice advances. End moraine was deposited by the Long Lake and Streeter advances. Drift differentiation on a lithostratigraphic basis was not successful because the color, pebble lithology, and grain size of the drifts were nearly identical. Glacial morphostratigraphic units in Burleigh County are the Napoleon, Long Lake and Burnstad Drifts. A Pleistocene fossil molluscan fauna is represented by 30 specific and subspecific taxa of 19 genera. Molluscan shells in Burnstad Drift were radiocarbon dated at 9,990 and 10,100 years B.P.

The preglacial drainage in south-central North Dakota included the ancestral, northeastward trending, river systems of the Knife, Cannonball, Heart, and Grand Rivers. Two major glacial diversions of the Missouri River occurred in this area and captured the preglacial drainage, directing it southward. An extensive Wisconsin meltwater channel system existed in the Coteau Slope and was integrated into the Missouri River system.

The bedrock in Burleigh County consists of 8000 feet of Paleozoic, Mesozoic, and Cenozoic sedimentary rocks. The surface bedrock includes the Late Cretaceous Pierre, Fox Hills, and Hell

Creek Formations, and the Tertiary Paleocene Fort Union Group consisting of the Ludlow, Cannonball, and Tongue River Formations.

Major mineral resources in Burleigh County include sand and gravel, lignite, and water. No commercial oil production has been found.

INTRODUCTION

Scope and Purpose of Study

This is a general geological study of Burleigh County which comprises 1648 square miles in south-central North Dakota. The purpose is to provide a comprehensive investigation of the areal geology and the occurrence of ground water. The geological investigation is part of a cooperative ground water project involving three agencies: the North Dakota Geological Survey, the United States Geological Survey, and the North Dakota State Water Conservation Commission. This report presents the results of a comprehensive study of the surficial geology and a general study of the subsurface geology. The discussion of the surficial geology is based on surface mapping and test hole drilling, and includes a proposed physiographic classification, detailed descriptions of the exposed bedrock, profiles and cross-sections, the glacial geology, the drainage history, and the fossil molluscan fauna of Pleistocene sediments. The discussion of the subsurface geology includes a summary of petroleum exploratory drilling wells (tops of formations), cross-sections, and brief lithologic descriptions of the formations.

Methods of Study

The field work of the Burleigh County project began in September 1960 with the drilling of shallow test holes in the Long Lake area. The samples from 28 test holes were described by George E. Summers, Jr. and Jack Kume. In October 1960 approximately 100 square miles in southeastern Burleigh was mapped by Kume. During the field season of 1961 and May 1962 Dan E. Hansen mapped approximately 46 percent of Burleigh County in the central, northern, and eastern part. The remainder of the county was mapped by Kume during the field seasons of 1961 and 1962. During 1961 and 1962, 114 shallow test holes were completed. Most of the samples were described by Roger W. Schmid of the North Dakota State Water Conservation Commission, but some were described by Kume. In March 1963 four additional test holes were drilled in the Driscoll area, and the samples were described by Schmid. Electric logs were run in most of the test holes. Elevations were established for the test holes by the use of a United States Geological Survey matched set of altimeters.

The surficial geologic mapping was done on 1957 Burleigh County highway maps, scale 1:63,360, prepared by the North Dakota State Highway Department. Topographic maps including the Bismarck, Menoken, McKenzie and Driscoll 15 minute series; the Bismarck, Menoken SW, Mercer SW, Mercer SE, Horse Lake, and Florence Lake 7.5 minute series were used for mapping. Burleigh County (1952) aerial photo stereopairs, scale 1:63,360, obtained from the Aero Service Corporation were used to accurately place geologic contacts. The surficial mapping was done by driving along all the section line roads and trails, and lithologic determinations were recorded at each roadcut or exposure. Occasionally it was necessary to walk into less accessible areas within the section. In areas covered by shallow alluvium or wind-blown deposits, lithologic information was obtained by use of a hand auger, shovel, or a six foot post-hole auger mounted on a jeep. The color names used in the lithologic descriptions are those given in the Rock Color Chart (Goddard, and others, 1951).

The North Dakota State Water Conservation Commission provided a rotary rig for the drilling project. The United States Geological Survey provided a truck mounted auger capable of augering 100 feet for additional lithologic information.

Acknowledgments

The writers would like to express their appreciation to the various individuals and agencies who have contributed to this study. Dr. Wilson M. Laird, State Geologist, visited the writers in the field and made many helpful suggestions. He guided all phases of the fieldwork and manuscript preparation. Other members of the North Dakota Geological Survey also materially contributed to this study.

The friendly cooperation between the Federal and State agencies was sincerely appreciated. Edward Bradley, former District Geologist, U. S. Geological Survey, offered information, suggestions, and guidance. Phil G. Randich worked closely in the field with the writers, and aided in obtaining additional pertinent data. Milo W. Hoisveen, State Engineer, has shown continued interest in this study. The North Dakota State Water Conservation Commission was responsible for drilling the test holes. Roger W. Schmid provided lithologic descriptions of many of the test holes.

George E. Summers, Jr., geologist, was consulted during the initial phase of test drilling. Various individuals in Burleigh County have shown interest in this study, and landowners were cooperative in providing data of privately drilled test holes and access to their property for conducting investigations.

Previous Work

REGIONAL STUDIES

In 1883 Chamberlin presented a reconnaissance map of the Missouri Coteau in "Terminal Moraines of the Second Glacial Epoch." Todd (1896) described in detail the moraines of the Missouri Coteau. In Burleigh County, Todd mapped "the first, outer, or Altamont Moraine" and named the "Long Lake Loop". He discussed the preglacial drainage and thought that the Cannonball and Heart Rivers probably once flowed through Long Lake valley. Leonard (1916) described the "pre-Wisconsin drift" of North Dakota. He placed the western boundary of the Wisconsin drift at the front of the "Altamont Moraine." Townsend and Jenke (1951) named the "Max Moraine" for a portion of the vast area that was previously referred to as the "Altamont Moraine." They described the "Max Moraine" as extending "from the vicinity of Bismarck" northwestward for 800 miles. Colton and Lemke (1957) prepared a glacial map of North Dakota. Lemke and Colton (1958) presented a summary of the Pleistocene geology of North Dakota. In 1963, Colton, Lemke, and Lindvall published a preliminary glacial map of North Dakota. Their report and maps are an excellent source of information concerning the glacial deposits of North Dakota.

LOCAL STUDIES

Leonard (1912a, 1912b) mapped and described in detail the geology of the Bismarck quadrangle which included the southwestern part of Burleigh County, and parts of Morton, Emmons, and Oliver Counties. To the west, Laird and Mitchell (1942) described the geology of the southern part of Morton County. On the south, Fisher (1952) mapped and described the geology of Emmons County.

Hall (1958, unpublished Masters thesis) mapped the Cannonball Formation in south-central North Dakota which included the southwestern part of Burleigh County. Holland and Cvancara (1958) described fossil crabs from the Cannonball Formation of southern Burleigh and Morton Counties.

East of Burleigh County, Rau, Bakken, Chmelik, and Williams (1962) mapped and described the glacial geology of Kidder County. To the southeast, Clayton (1962) and Bonneville (1961, unpublished Masters thesis) mapped and described the glacial geology of Logan and McIntosh Counties. On the north, Sherrod and Gustavson (1963, 1964, unpublished Masters theses) have mapped and described the glacial geology of Sheridan County. East of Kidder County, Winters (1963) has described the geology of Stutsman County.

Summaries including lithologic descriptions of Burleigh County petroleum exploration drilling cuttings have been published (Caldwell, 1953a, 1953b, 1954; Smith, 1954; George, 1957; Eisenhard, 1958; Mendoza, 1959).

GEOGRAPHY

Location and Extent of Area

Burleigh County comprises 1648 square miles in Townships 137-144 North and Ranges 75-81 West in south-central North Dakota (fig. 1). The county is bordered on the south by Emmons County, on the east by Kidder County, on the north by Sheridan and McLean Counties, and on the west by Oliver and Morton Counties. The Missouri River forms most of the western county boundary.

Climate

Burleigh County is situated near the western boundary of the dry subhumid climate and the eastern boundary of the semiarid climate. The area is characterized by a wide temperature range, scanty rainfall, and rigorous winters. The prevailing wind direction is from the northwest. The coldest temperature recorded was -45°F and the warmest temperature was 114°F. The average temperature is 9.4°F in January and 70.9°F in July. The growing season averages 140 days. Annual precipitation is 15.34 inches of which over two-thirds falls between May and September. The average date for the first killing frost is September 27 and that for the last killing frost is May 10. These statistics are from records kept from 1900-1940 by the U. S. Department of Agriculture (1941). Trewartha (1954) has placed Burleigh County in the Humid Microthermal Continental Climate, Cool Summers or the "spring wheat" type of climate.

Culture

POPULATION

In 1960 Burleigh County had a population of 34,016 or about 21 people per square mile. Bismarck, the State Capitol and County Seat, with a population of 27,670, had 81.3 percent of the county population. The populations of the towns were as follows: Wilton (105 in Burleigh, 634 in McLean), Wing (303) and Regan (104) (U. S. Bureau of Census, 1960). Other unincorporated communities include Driscoll, Moffit, Sterling, Menoken, McKenzie, Arena, and Baldwin.

TRANSPORTATION

Burleigh County is served by the Northern Pacific Railroad which crosses the county in an east-west direction and by the Minneapolis, St. Paul, and Sault Ste. Marie Railroad which crosses in a southeast-northwest direction. The Northern Pacific has a main line from Driscoll to Bismarck and a branch line from Arena to Wilton.

Two Federal highways are paved across the county. U. S.

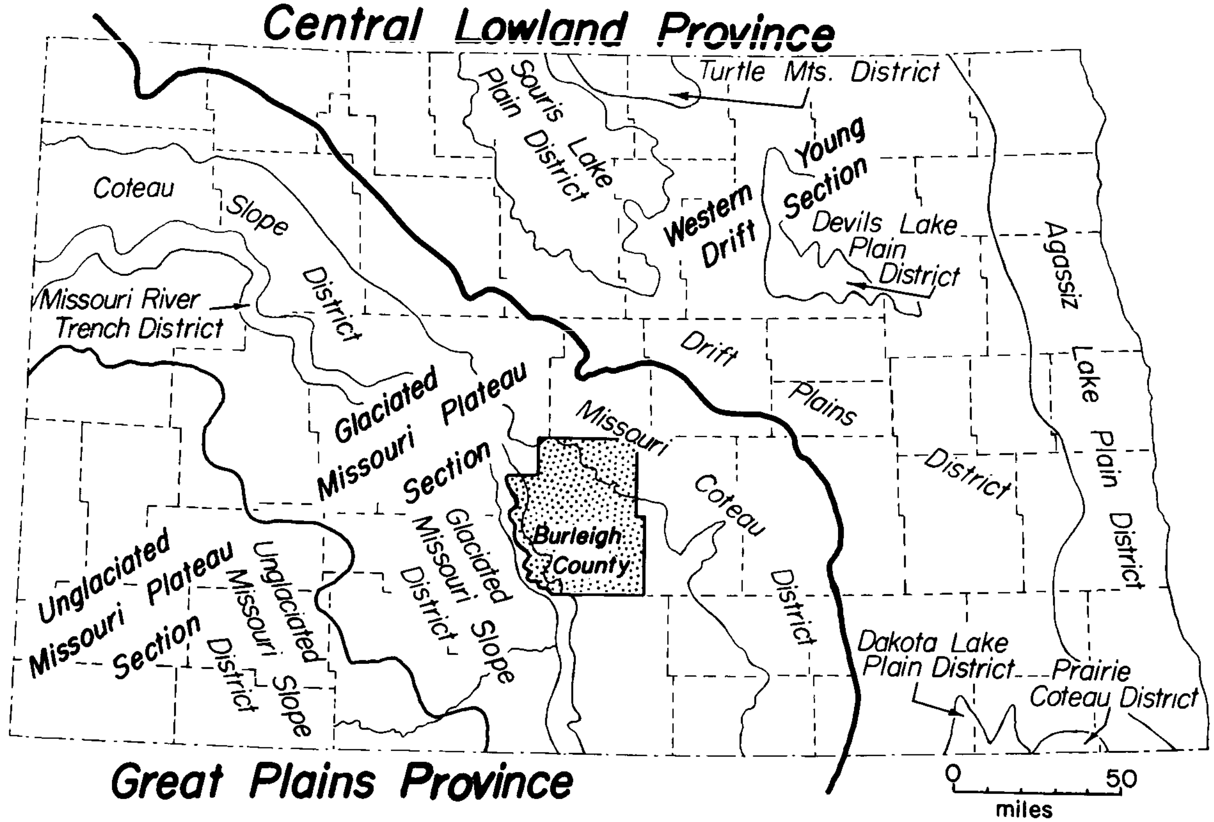

Figure 1. Index map showing location of Burleigh County and the physiographic subdivisions of North Dakota.

Highway 10 crosses in an east-west direction and U. S. Highway 83 crosses in a southeast-northwest direction. State Highway 41 along the northwest county border is paved. State Highway 14 from Sterling north across the county is an all weather partly bituminous and partly graveled road. Many all weather graveled roads and section line roads serve the county.

Airline service to Bismarck is provided by Northwest, Frontier and North Central Airlines.

INDUSTRY

Agriculture is the main industry. On the basis of the type of farming Kristjanson and Heltemes (1949) have placed Burleigh County in the South-Central Livestock-Grain Area. In 1950 forty-three percent of all farm land was worked by dryland methods. That same year 92 percent of the farms raised cattle. Gravel pits for construction and road metal are numerous. Lignite is mined in the Wilton area.

Soil

The soils of Burleigh County are classified in the Chestnut soil group, a dark brown soil of the cool and temperate, subhumid to semiarid grasslands (U. S. Department of Agriculture, 1941). The county can be divided into a southern and northwestern occurrence of dark brown soils separated by a northeastern, central western, and adjacent to Missouri River occurrence of the hilly and steep soils (Dept. of Soils, North Dakota State University and U. S. Soil Conservation Service, 1962, p. 73). The dark brown soils are loam and silt loam underlain by a light colored lime accumulation. These areas are used for grazing and the production of small grains, flax, corn, and forage. The hilly and steep soils on crests of hills and on steep slopes have a black or very dark brown surface layer but lack a subsoil, and the lime accumulation is very shallow. These areas are used mostly for grazing, but also for small grains and forage.

PHYSIOGRAPHIC UNITS AND LANDFORMS

Burleigh County, according to Fenneman's physiographic classification of the United States (1931, 1946 map), lies in the Interior Plains major division, the Great Plains province, and the Glaciated Missouri Plateau section. Fenneman (1931, p. 73-74) divided the Glaciated Missouri Plateau section at the Missouri River into two subdivisions and designated the morainic belt east of the river as the Missouri Coteau. Lemke and Colton (1958, fig. 1) subdivided the Glaciated Missouri Plateau section into four units, designating two of these units as the Missouri River Trench and the Coteau du Missouri. Clayton (1962, p. 14) has divided the Glaciated Missouri Plateau section into three districts: the Glaciated Missouri

Slope, Coteau Slope, and Missouri Coteau. In addition to these three districts a fourth district, the Missouri River Trench district (fig. 1 and table 1), is added in this report. These districts represent four distinct types of topography: (1) Missouri Coteau, the high morainic belt with non-integrated drainage; (2) Coteau Slope, the glaciated slope west of the Missouri Coteau, subject to active erosion with mostly integrated drainage; (3) Missouri River Trench, the floodplain, terraces, and dissected valley walls of the Missouri River; and (4) Glaciated Missouri Slope, the glaciated strip of dissected plateau west of the Missouri River subject to active erosion with integrated drainage.

Missouri River Trench District

The Missouri River Trench district in Burleigh County is characterized by a trench floor of variable width and valley walls steeply dissected in bedrock (fig. 2). The till is thin or non-existent; the alluvium and outwash are quite thick. Alluvial, outwash, and bedrock terraces are present, and various levels have been assigned to them (pl. 1 and fig. 2). The Missouri River flows southward diagonally across the regional strike of the bedrock in Burleigh County. North of Bismarck the gently curving stream meanders are inclosed by steep valley walls in a youthful valley. South of Bismarck the meanders broaden in a more mature valley which suggests that it was part of a preexisting drainage system.

TRENCH FLOOR

The trench floor of the Missouri River bordering Burleigh County varies in width from one mile (sec. 1 and 2, T. 141 N., R. 81 W.) to seven miles (immediately south of Bismarck). The constricted trench floor cuts across preglacial drainage divides (pl. 7). Twenty-one test holes in the trench floor show the average thickness of alluvium and outwash to be 100 to 115 feet thick, but immediately south of Bismarck it is up to 155 feet thick (pl. 5). The valley fill is composed mostly of sand and gravel, with minor silty and sandy clay. The only occurrence of till was reported in test hole 2057 which drilled through terrace 4 south of Bismarck. This early (?) Wisconsin till is underlain and overlain by outwash and alluvium. The till indicates early (?) Wisconsin glaciation over a preexisting valley partly filled with outwash.

Four terraces, numbered from the lowest to the highest, are recognized in the valley terrace complex (fig. 2). The highest terrace is the site of the State Penitentiary and is here designated the Penitentiary Terrace, or terrace 4. This outwash terrace is about 40 to 60 feet above the river level between the elevations of 1660 and 1680 feet. Terrace 4 probably represents a high fill and cut terrace. South of Bismarck terrace 4 lies over the buried channel of the ancestral Heart River. Here the depth to bedrock is 31 feet on the south, 170 feet in the central part, and 47 feet in the northern

TABLE 1.—Characteristics of the four districts of the Glaciated Missouri Plateau section in North Dakota.

	Glaciated Missouri Slope (Modified from Clayton, 1962)	Missouri River Trench	Coteau Slope (Modified from Clayton, 1962)	Missouri Coteau (Modified from Clayton, 1962)
Drainage	Integrated; Flows eastward	Integrated; Flows southward	Mostly integrated; Flows westward; Partly internal	Non-integrated; Numerous undrained depressions; Internal
Streams	Perennial, Intermittent, Ephemeral	Perennial, Intermittent, Ephemeral	Intermittent, Ephemeral	Nearly absent or very short segments; Ephemeral
Topography	Stream dissected bedrock	Floodplain, terraces Dissected valley wall	Stream dissected bedrock	Largely high glacial relief; Dead-ice moraine
Age of Drift	Early (?) Wisconsin	Early (?) Wisconsin	Mostly early (?) Wisconsin; Some late Wisconsin	Late Wisconsin
Drift Thickness	Non-existent or very thin	Thin to non-existent till, thick outwash and alluvium	Moderate, thin to non-existent	Thick

part of the terrace. The second highest, upon which the site of Fort Lincoln is located, is here designated the Fort Lincoln Terrace, or terrace 3. This outwash terrace is about 20 to 40 feet above the river level between the elevations of 1640 and 1660 feet. Fort Lincoln Terrace slopes gently toward the northwest and is marked by uneven cutting. A paired terrace, also designated terrace 3, on the west side of the river (fig. 2) has been cut into the

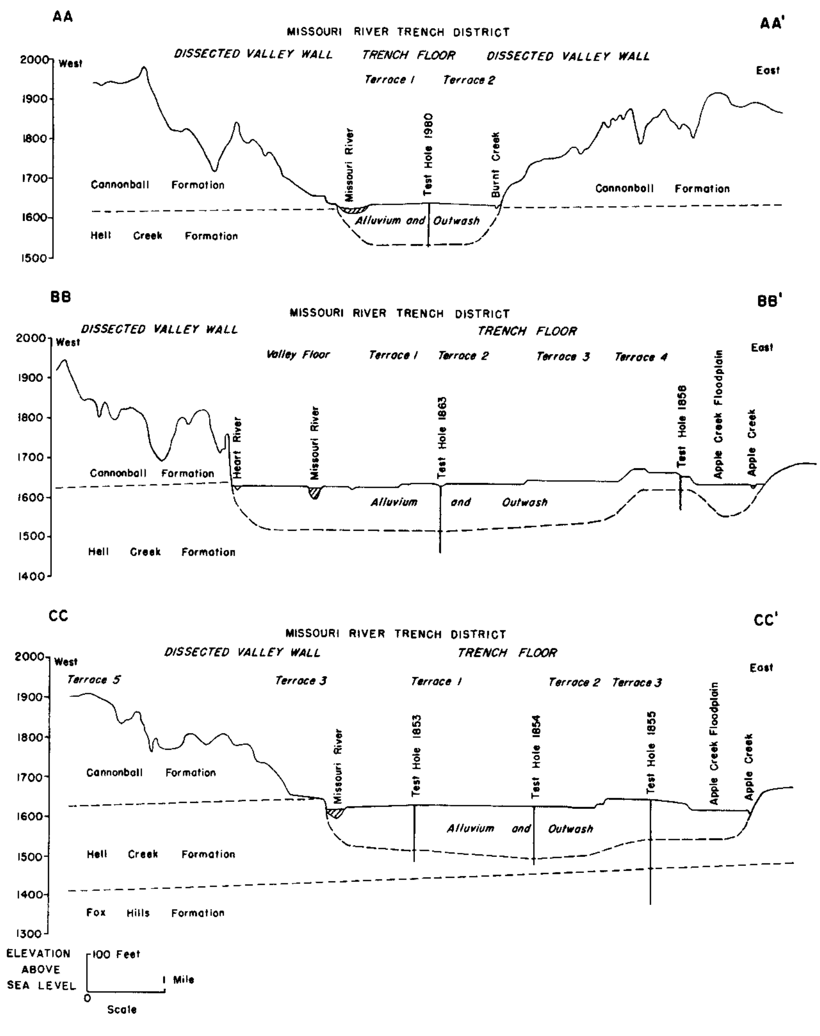

Figure 2. Profiles and geologic sections of the Missouri River Trench District.

Cannonball Formation. The two lowest are alluvial terraces at elevations between 1630 and 1640 feet and are here designated Wachter Terrace, or terrace 2, and Prison Farm Terrace, or terrace 1, for their development in the vicinity of the Wachter Farm and the Prison Farm properties. Wachter Terrace is quite featureless. The Prison Farm Terrace is a "bottom land" terrace marked by meander scars, bar deposits, and channel fillings. Separating terraces 1 and 2 is a low scarp which can easily be distinguished on aerial photos and topographic maps. Wood fragments collected by Rodger Schmid from an alluvial sand bed at a depth of 21 to 80 feet in test hole 1949 on terrace 1 have been radiocarbon dated at 210 + 200 years B. P. (W-1432) in SW1/4 NW1/4 NE1/4 sec. 24, T. 137 N., R. 80 W. by the U. S. Geological Survey. Bedrock cut terraces 2 and 3, are covered by thin alluvium along the valley walls in west-central Burleigh County.

The floodplain alluvium adjacent to and within the river channel consists of channel and meander bars. These features, formed and modified by the present stream, consist chiefly of sand, silt, and clay.

Apple Creek floodplain, adjacent to and east of terraces 3 and 4, is included in the trench floor of the Missouri River Trench, because the bedrock trench filled with outwash and alluvium extends beneath Apple Creek to the east valley wall. However, the surface deposits of Apple Creek floodplain are composed of Recent alluvium. Apple Creek has been deflected southward by terrace 4 and has cut its floodplain below the level of terraces 3 and 4 (fig. 2).

DISSECTED VALLEY WALLS

The dissected valley walls of the Missouri River Trench are steep and rugged (fig. 2). In northwestern Burleigh County the walls rise to an elevation of 2200 feet, about 550 feet above the floodplain. Generally, the walls are about 450 feet higher than the floodplain. The bedrock valley walls are composed of the Hell Creek Formation in southwestern Burleigh, the Cannonball Formation in west-central Burleigh, and the Cannonball and Tongue River Formations in northwestern Burleigh. The Hell Creek and Cannonball Formations are easily eroded and form the lower slopes, whereas the basal Tongue River Formation contains a resistant limy sandstone and conglomerate bed which caps many of the buttes, hills, and ridges (section 10-62, Appendix A). The glacial drift on the dissected valley walls is generally thin or non-existent and consists chiefly of scattered boulders, except along the extreme northwestern border of the county where a thin sheet of till is draped over the bedrock. Several minor outwash deposits are also present. The till of the Napoleon Drift in some places extends to the floodplain, which indicates that the till covered area now included in the Missouri River Trench district was present prior to the early (?) Wisconsin Napoleon glaciation. It also suggests that the glacier probably extended further west, and at that time the Missouri River probably flowed through one of the diversion channels.

Active intermittent and ephemeral streams are rapidly eroding headward in the dissected valley wall. The top of the valley wall forms a sharp boundary between the Missouri River Trench district and the Burnt Creek subdistrict (fig. 2).

Along the dissected valley wall, above and adjacent to the floodplain, are bedrock terraces covered with a veneer of alluvium. These terraces, upstream extensions of terraces 2 and 3, are especially well-developed along the northwestern border of Burleigh County. The terrace surfaces slope gently toward the floodplain. The veneer consists of silt, probably partly reworked by wind, underlain by sand and gravel, and occasionally by till.

A prominent upland bench marks the upper boundary of the dissected valley walls at elevations of 1900 to 1940 feet, about 300 feet above the floodplain. It is here designated Custer Terrace, or terrace 5, because it is well-developed south of Mandan on Custer Flats.

Coteau Slope District

The Coteau Slope district in Burleigh County is the glaciated slope west of the Missouri Coteau district that is subject to active erosion by nearly completely integrated drainage. The streams flow westward to the Missouri River. The Coteau Slope district in Burleigh County is divided into seven proposed subdistricts (fig. 3) and their characteristics are summarized in table 2. These proposed physiographic subdivisions are given formal names for ease of discussion in this report.

BURNT CREEK SUBDISTRICT

Burnt Creek subdistrict coincides with the drainage basin of Burnt Creek and lies entirely within Burleigh County. This subdistrict is characterized by steeply dissected valley walls and uplands which, in part, contain a thin sheet of drift over bedrock. The drainage is completely integrated with intermittent and ephemeral streams flowing southward to the Missouri River.

Dissected valley walls and uplands. — The southern half of Burnt Creek subdistrict is highly dissected and the valley walls rise to an elevation of 2000 feet, about 300 feet above the Burnt Creek floodplain. The uplands rise to an elevation of 2160 feet at Keever Butte. Other prominent buttes in this subdistrict are Burnt, Ball, and Coal Buttes (pl. 1). The Tongue River Formation caps most of the buttes, hills, and ridges, and the Cannonball Formation forms most of the slopes and valley walls. Glacial drift in this area is thin to non-existent and consists mainly of scattered boulders and scattered patches of till. This valley was in existence at the time of early (?) Wisconsin glaciation as shown by patches of till in some places on the valley sides as well as on the uplands. Generally postglacial stream erosion has greatly modified the land surface throughout the area.

The alluvial sand and gravel in Burnt Creek valley is nine feet thick in test hole 1982 and fourteen feet thick in test hole 2004.

Moraine. — Moraines are landforms composed of accumulations of drift, chiefly till, deposited directly from glacial ice and having glacial constructional relief. Moraines have been classified into three major types: end moraine, dead-ice moraine, and ground moraine. In this study two additional minor types of moraines have been recognized: subdued-end moraine and sheet moraine.

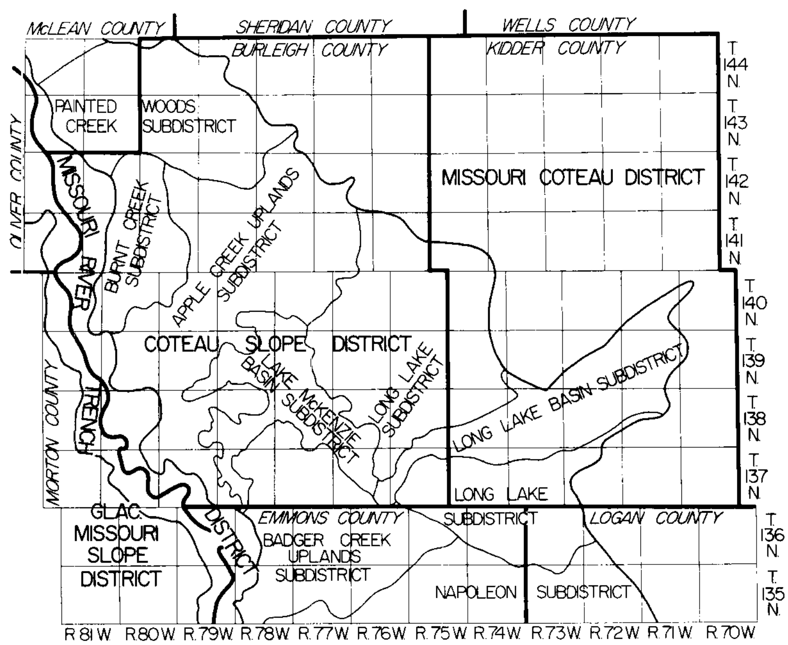

Figure 3. Map of the physiographic subdivisions of the Coteau Slopes district in Burleigh and Kidder Counties.

TABLE 2. — Characteristics of the seven subdistricts of the Coteau Slope district in Burleigh County.

	Painted Woods Creek Subdistrict	Burnt Creek Subdistrict	Apple Creek Uplands Subdistrict	Lake McKenzie Basin Subdistrict	Badger Creek Uplands Subdistrict	Long Lake Subdistrict	Long Lake Basin Subdistrict
Drainage	Partly integrated to non-integrated	Completely integrated	Almost completely integrated	Internal and partly integrated	Completely integrated	Non-integrated to partly integrated	Internal and partly integrated
Streams	Intermittent and Ephemeral	Intermittent and Ephemeral	Intermittent and Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral
Undrained Depressions	Common to abundant	None	Few	Common	None	Very abundant	Common to abundant
Dominant Topography	Dead-ice moraine Sheet moraine Ground moraine	Stream eroded bedrock Extensive sheet moraine	Stream eroded bedrock Extensive sheet moraine Sand dunes	Lake plain Outwash plain Sand dunes	Stream eroded bedrock Minor sheet moraine	End moraine Ground moraine	Outwash plain Lake plain Sand dunes
Age of Surface Drift	Mostly late (?) Wisconsin	Early (?) Wisconsin	Mostly early (?) Wisconsin	Early (?) to late Wisconsin	Early (?) Wisconsin	Late Wisconsin	Late Wisconsin
Drift Thickness	25 to 80 feet	Absent to less than 40 feet	Absent to less than 50 feet	150 to 230 feet	Absent to less than 25 feet	50 to 175 feet	150 to 350 feet (Kidder County)

Sheet moraine. — The northern half of Burnt Creek subdistrict has a thin discontinuous layer of drift, chiefly composed of till, which is draped over stream-eroded bedrock topography. In this report the term sheet moraine is proposed to refer to this accumulation of drift. Sheet moraine is a landform composed of mappable, blanket-like, thin accumulations of drift deposited directly from glacial ice and having low glacial constructional relief. The general lack of kettles is an integral part of its recognition. In places this thin drift resembles ground moraine, but due to its thin nature, and since it reflects the topography of the underlying bedrock, it is not properly ground moraine (Flint, 1957, p. 131). In this report the term drift sheet refers to the entire drift accumulation related to a significant glacial advance. A drift sheet includes the outwash plain, end moraine, dead-ice moraine, ground moraine, and sheet moraine (fig. 4).

Sheet moraine in Burleigh County is generally found in areas of moderate to high relief reflecting the topography of the underlying bedrock. The sheet moraine in the Burnt Creek subdistrict is from 5 to 20 feet thick, overlying a stream-eroded topography which has 80 to 100 feet of relief per square mile and more in areas where the drainage is well-developed.

Meltwater channel. — Burnt Creek valley was a glacial meltwater channel (pl. 8) during the Wisconsin glaciation. Meltwater flowed southward to the Missouri River and deposited outwash in the channel.

BADGER CREEK UPLANDS SUBDISTRICT

Badger Creek Uplands subdistrict lies within Emmons and Burleigh Counties. In Burleigh County the subdistrict includes the bedrock upland area south of Lake McKenzie Basin subdistrict. In Emmons County this subdistrict includes the steeply dissected drainage basin of the ephemeral Badger Creek. In Burleigh County an upland bedrock ridge marks the north drainage divide of Badger Creek. North of this divide the land slopes toward Lake

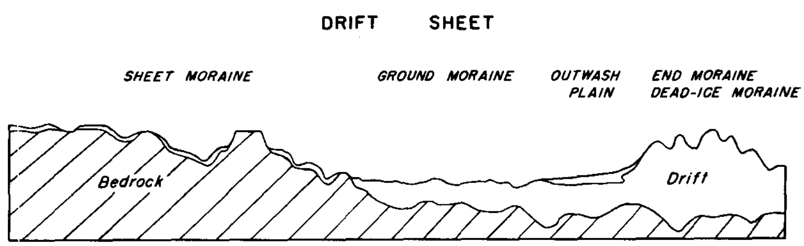

Figure 4. Diagrammatic profile and cross-section of a drift sheet.

McKenzie Basin. The drainage in this subdistrict is complete integrated.

Stream-eroded bedrock topography. – Most of the subdistrict has a stream-eroded bedrock topography. A few scattered patches of till and common boulder erratics give evidence that the area has been glaciated, but the surface shows only slight glacial modification. The highest uplands exceed 2200 feet in elevation, about 500 feet above McKenzie lake plain and Badger Creek. The Cannonball Formation caps most of the highest hills and ridges, whereas the Hell Creek Formation forms the steep slopes.

Four test holes were drilled to bedrock in this subdistrict. Test holes 1830 and 1868 encountered 19 and 20 feet of till respectively, and test holes 1936 and 2047 encountered 7 and 5 feet of clay respectively.

Meltwater channel. – Badger Creek valley is a deep channel of the ancestral Cannonball River system, which was cut into the Cretaceous Pierre and Fox Hills Formations. It was a significant meltwater channel during Wisconsin time (pl. 8) when the valley was partly filled with outwash and alluvium. South of Long Lake 179 feet of fill was found in test hole 1938 in Badger Creek valley.

Dune sand. – Eolian sand deposits characterized by dunes with numerous blowouts are present at three localities in this subdistrict. The largest dune area, part of which is in Lake McKenzie Basin subdistrict, covers about 14 square miles.

Individual dunes are usually low, but some attain 21 feet in height, and they are aligned in a northwesterly direction, paralleling the prevailing winds. The dunes are grass-covered and fairly stable except in a few blowout areas where the wind is actively removing the sand. The dunes are composed of a brown, fine-grained sand, mostly quartz, derived from glacial lake sediments and from local bedrock, especially the Cannonball Formation.

LAKE McKENZIE BASIN SUBDISTRICT

Lake McKenzie Basin lies entirely within Burleigh County, and it contains an extensive lake plain, a dune sand area, and an outwash plain. The basin is surrounded by the hills of the Long Lake moraine and the bedrock uplands of Badger Creek and Apple Creek subdistricts. The lake plain is in an extensive valley cut into the Fox Hills and Hell Creek Formations. Underlying the lake plain are buried channels of the ancestral Heart River (pl. 7) filled with lake sediments and outwash. Glacial Lake McKenzie was a proglacial and ice marginal lake during Wisconsin time. The present drainage in this subdistrict is internal and partly integrated.

Lake plain. – The gently undulating lake plain contains extensive swamps, the largest of which is McKenzie Slough. Long Lake is a permanent lake at the southeast boundary of the lake plain. The swamp and lake areas serve as catchment basins for the internal and partly integrated drainage. Apple, Random, and Long Lake Creeks are among the several streams in the subdistrict. The lake plain ranges from 1700 to 1730 feet (fig. 5) in elevation and slopes gently upward toward the outwash plain in the northern part of the subdistrict. The lake plain is 500 feet below the Badger Creek Uplands, 250 feet below the Long Lake end moraine, and 400 feet below Apple Creek Uplands. The southwestern part of the basin is confined to the narrow valley of Glencoe Channel where several knobs of bedrock protrude through the lake plain.

Undrained depressions or potholes are common in the lake

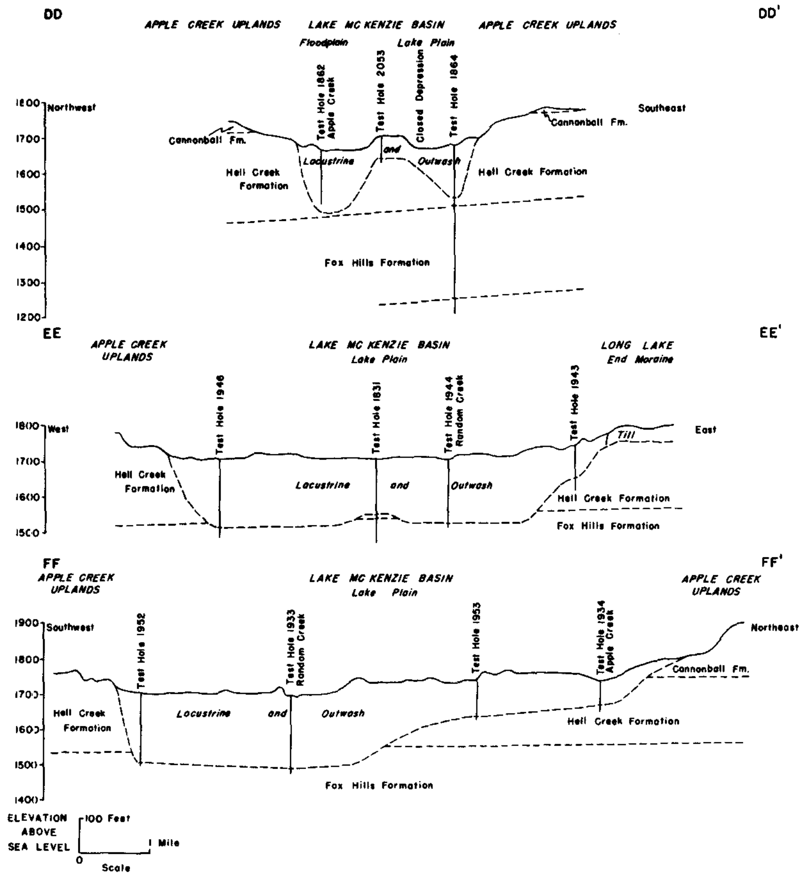

Figure 5. Profiles and geologic sections of the Lake McKenzie Basin.

plain especially in the Menoken and McKenzie area. The depressions are frequently 20 to 30 feet deep and are variable in extent. One of the larger depressions, in sec. 31, T. 139 N., R. 78 W., covers about a half a section. Test hole 1864, in this depression encountered 145 feet of lacustrine clay and silt, and two feet of gravel above the bedrock (fig. 5, section DD-DD[1]). The walls of the depressions are frequently very steep, as is shown in the depression immediately west of Menoken. Steep walled depressions would be anomalous in a lake plain unless they were formed as kettle holes. The kettles probably formed from individual blocks of ice that had rafted from the ice front or stagnant ice from a previous glacial advance. The blocks of ice were buried by lake sediments. When these blocks melted, steep walled depressions were formed. The present depressions usually contain some water in the spring and during wet years, but they are often dry during the summer and fall. Several permanent lakes occur in shallow depressions in the McKenzie Slough area. During times of abundant precipitation the overflow drains through Random Creek into Apple Creek. Apple Creek has incised its floodplain from 10 to 40 feet into the lake plain. Most of the Apple Creek floodplain deposits are probably Recent alluvium.

Dune sand. — The southwestern part of the subdistrict is characterized by sand dunes. The area is hummocky with low rounded, elongated hills of sand. The dunes are aligned in a northwest-southeast direction parallel to the prevailing winds. Blowouts are common in areas not covered by vegetation. The dune sand is underlain mostly by lake sediments, but along the southern border of the area, it is underlain by bedrock.

Outwash plain. — The northern and eastern part of the subdistrict is an outwash plain which has about 30 feet of local relief. The thin outwash sand and gravel is underlain by a thick sequence of clay and sand. Test hole 1953 encountered three feet of surficial sand and gravel underlain by 101 feet of clay and sand over bedrock. Test hole 2016, to the east, encountered clay and gravel over till. This outwash plain probably formed partly from material carried in by Long Lake glacial meltwater. However, most of the outwash was carried in by Burnstad and Streeter meltwater through Apple Creek Channel. Burnstad and Streeter meltwater flowing by way of Random Creek Channel through a breach in the Long Lake end moraine, deposited coarse material in Lake McKenzie forming an outwash plain. Test holes 1942, 1943, and 2028 indicate that a buried valley underlies this outwash and extends beneath the Long Lake moraine.

The outwash plain slopes gently toward the lake plain. The elevation of the outwash plain ranges from 1730 feet at the lake plain boundary to 1780 feet at the end moraine boundary.

Sheet moraine. — A thin accumulation of till on lake sediments and outwash occurs in the western part of Lake McKenzie Basin adjacent to Apple Creek. An auger hole (center SW1/4, sec. 3, T. 138 N., R. 79 W.) encountered 30 feet of early (?) Wisconsin till underlain by 70 feet of clay and sand. While this till was being deposited, the ice dammed this outlet to Glacial Lake McKenzie, forcing meltwater to flow through Glencoe and Badger Creek Channels.

Bedrock valley. — The large valley cut into bedrock in Lake McKenzie Basin is part of the ancestral Heart River system. Various segments of this system in the Lake McKenzie Basin are parts of the Glencoe Channel, Random Creek Channel, Apple Creek Channel, and Heart River Channel (pl. 3 and 7). The altitude of the bedrock valley ranges from about 1400 to 1650 feet, but the floor is commonly at 1500 to 1550 feet. Lake sediments over bedrock highs with 100 to 150 feet of relief above the valley floor are shown by test holes 1945, 1954 and 2054. In the Glencoe Channel, boulder covered bedrock knolls crop out of the lake plain.

Forty-six test holes were drilled in the basin. Thickness of the lake sediments and outwash material (pl. 5) is commonly 150 to 200 feet, but it ranges from about 60 to 230 feet (fig. 5). The maximum fill was encountered in test hole 1940. The basin fill is composed mostly of clay, silty and partly sandy, with variable amounts of sand and gravel. The buried gravel is generally confined to narrow elongate accumulations, or gravel trains, coinciding with the deeper bedrock valleys of the basin. A significant buried gravel train in the area southeast of McKenzie to a mile beyond test hole 1939 (pl. 4, section I-I[1]), is joined from the northeast by a buried gravel train beneath Random Creek. The thickness of these two gravel trains amounts to 23 feet in test hole 1939 and 51 feet in test hole 2023. Buried gravel trains are also present in the other parts of the Heart River Channel especially northwest of McKenzie and in Apple Creek valley. Glencoe Channel also contains significant amounts of buried gravel and an abundance of sand.

Buried till in the basin has been reported in test holes 1831, 1939, 2010, 2016, 2031, 2032, 2037, 2053, and 2054. Test holes 2016 and 2032 are adjacent to the Long Lake end moraine and the till is probably part of the same drift. The till in test holes 1831 and 1939 has been reported as questionable by the well site geologist. These two occurrences of till near the center of the basin may be remnants of a till sheet over a partly filled basin. Such may be the case in hole 2031 where the till is overlain by 134 feet of valley fill. The remaining four test holes containing till are in the Menoken area. The tills suggest glacial activity in the basin while it was being filled. Nearly all of the till was buried, but test hole 2054 encountered till on a bedrock drainage divide bordering Apple Creek Channel.

The valley walls are cut into the Cretaceous Hell Creek Formation. The valley floor is also the Hell Creek Formation, except in the deepest parts, where it is the Cretaceous Fox Hills Formation (fig. 5).

LONG LAKE SUBDISTRICT

The Long Lake subdistrict lies within Burleigh, Logan, Emmons, and Kidder Counties. The two major drainages in this subdistrict are Long Lake Creek and Random Creek. Much minor drainage on the western morainal slope flows into McKenzie Slough and Apple Creek. In eastern Burleigh County the drainage is non-integrated in part, and probably could have been included in the Misouri Coteau district, but this area includes part of the Long Lake end moraine and therefore is placed in the Long Lake subdistrict. The predominant landform is end moraine, with elevations ranging from 1780 feet north of McKenzie to 2100 feet east of Apple Creek.

Glacial Landforms

End moraine. – Landforms composed of accumulations of drift, chiefly till, deposited directly from an active glacier along its margin and having glacial constructional relief are end moraines. Linear trends are an integral part of their recognition. End moraines in Burleigh County have moderate to high local relief.

Todd (1896, p. 15) named and described the Long Lake loop of the Altamont moraine. The Long Lake end moraine lies within eastern Burleigh County, northeastern Emmons County, northwestern Logan County, and southwestern Kidder County.

In this study three loops of the Long Lake end moraine in eastern Burleigh County are recognized: the south, middle, and north loops. The drift of all three was deposited on bedrock highs. The south loop, breached by Long Lake, is characterized by an arcuate linear ridgelike accumulation of till. Slopes are steep with knobs and kettles. The local relief is about 40 to 60 feet with a maxmium of 100 feet. Boulders are quite numerous on the surface. The Cretaceous Fox Hills Formation is exposed in the south loop where it is breached by Long Lake. A prominent interlobate area that exists between the south and middle loops (fig. 6) is characterized by high local relief, prominent northeast-southwest linear ridges, and abundant kettles. The town of Sterling is built on the middle loop which is a rather wide, overall linear moraine rather than a ridged moraine. Boulders are fairly numerous on the surface of this gently sloping moraine on which the local relief is about 30 to 40 feet. The western slope has well-developed drainage. In contrast to the south loop, the middle loop has fewer kettles, moderate slopes, and a subdued topography, except for the southern part of the middle loop, where low till ridges resemble those of the south loop. The north loop is characterized by steep slopes and hummocky drift with numerous boulders on a southeast trending bedrock ridge. It is wide, has a few minor ridges, and contains local relief of 40 to 60 feet with a maximum of 100 feet. The western slope is well-drained, but the crest and inner parts have interior drainage. On the proximal side, the north loop grades into subdued end moraine. The north loop is overlapped at its northern boundary by dead-ice moraine and collapsed outwash topography. This overlap, acording to Clayton (1962, p. 30-31), represents a significant glacial readvance; however, it could also be a minor readvance or adjustment of the Long Lake ice-sheet. This correlation will be discussed in a later section with the Long Lake and Burnstad Drifts.

Ground moraine. — Landforms composed of accumulations of drift, chiefly of till, deposited directly from an active glacier behind its margin and having glacial constructional relief are ground moraines. Relative lower relief is an integral part of their recognition. Ground moraines in Burleigh County have low relief, and they may contain minor linear elements.

The Long Lake ground moraine lies within eastern Burleigh

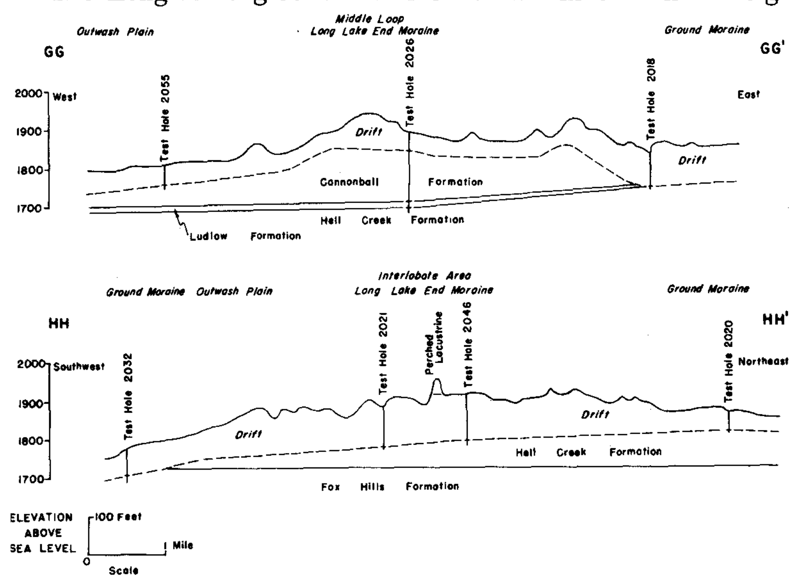

Figure 6. Profiles and geologic sections of the middle loop and the interlobate area between the middle and south loop of Long Lake end moraine.

County and western Kidder County on the proximal side of the end moraine loops. A narrow strip of ground moraine fringes Long Lake and is transitional with the south loop. Here the relief is low to moderate except for an occasional area of higher relief due to the underlying bedrock topography. Cretaceous Fox Hills Formation outcrops are surrounded by this ground moraine in Kidder County. Ground moraine on the proximal side of the middle loop is a till plain with about 5 to 20 feet of relief in the vicinity of the town of Driscoll. A few large lakes and sloughs are present, and surface boulders are fairly numerous. A small area of ground moraine occurs on the proximal side of the north loop. It is nearly flat with about five feet of relief. Because this ground moraine has no integrated drainage it is included in the Missouri Coteau district.

Collapsed outwash topography. — Landforms composed of hummocky accumulations of drift, chiefly glaciofluvial, with abundant kettles are defined as collapsed outwash topography. In Burleigh County collapsed outwash topography has moderate to high relief.

Collapsed outwash topography occurs on the distal side of the north loop of the Long Lake end moraine adjacent to the East Branch of Apple Creek. The relief ranges from low to high with a maximum of 50 feet. The outwash was deposited on disintegrating ice and collapsed when the ice melted.

A small area of collapsed outwash topography with local relief of 30 to 40 feet lies between the north and middle loops. The outwash surface is characterized by a series of random ridges and scattered erratic boulders.

Ice-contact lacustrine topography. — A perched or elevated landform composed of accumulations of drift, chiefly glaciolacustrine, deposited in an ice-walled lake is defined as ice-contact lacustrine topography. The deposits are usually stratified and have steep ice-contact faces.

Small ice-contact lacustrine deposits occur in the interlobate area between the south and middle loops, capping three prominent till highs whose local relief ranges from 80 to 100 feet above the surrounding end moraine (fig. 6). The lake sediments are about 35 feet thick and consist of alternating dusky yellow and light olive-gray laminated silts and clays. Test hole 2025 penetrated 153 feet of till beneath the perched lake sediments. The lake sediments are horizontally bedded, but the landforms are rounded, probably due to slumping of the steep ice-contact edges.

In another small area of ice-contact lacustrine deposits in the north loop, the lake sediments have about 20 to 25 feet of relief and slope into a large kettle.

Linear distintegration ridges. — Linear, narrow, boulder covered ridges composed of unsorted outwash and till are superimposed on the Long Lake end moraine. These ridges are similar to eskers or crevasse fillings, but differ from them in composition as they are usually not composed of washed and bedded drift. Linear disintegration ridges were formed during the disintegration of stagnant glacial ice. Disintegration ridges are more numerous and of greater variety in the dead-ice moraine of northern Burleigh County, so a detailed description is presented with the discussion of the Missouri Coteau district.

In the middle loop there are three occurrences of linear disintegration ridges: (1) A till ridge extending from sec. 18, T. 140 N., R. 75 W., into sec. 24, T. 140 N., R. 76 W. The relatively straight boulder covered ridge is almost two miles in length with local relief of 15 to 20 feet and a maximum of 30 feet; (2) A ridge about half a mile long in secs. 5, 7, and 8, T. 140 N., R. 75 W., composed of washed drift with relief of 5 to 15 feet; and (3) An east-west boulder covered ridge in secs. 31 and 32, T. 140 N., R. 75 W. and sec. 36, T. 140 N., R 76 W. This prominent narrow, linear ridge has relief of up to 30 feet and is composed of till and washed drift. In the north loop are two areas of linear disintegration ridges: (1) Several short ridges in the frontal part of the north loop composed of till and unsorted gravel, with up to 10 feet of relief; and (2) A narrow till ridge about two miles long in secs. 28 and 29, T. 142 N., R. 75 W. This ridge lies in an east-west direction about three-fourths of a mile south of an area of collapsed outwash topography. Relief of the ridge is 5 to 20 feet.

Kames. – Kames are prominent hills composed of outwash and till deposited in contact with, or within glacial ice.

In the middle loop is a boulder covered kame in sec. 17, T. 141 N., R. 75 W. with relief of about 40 to 50 feet. A rather low kame in the middle loop about a mile west of Sterling has been breached by roadcuts on U. S. Highway 10. This kame is composed of poorly sorted outwash and probably had less than 30 feet of relief. A low kamelike mound about a quarter of a mile to the east of this kame has about 10 to 15 feet of relief. Another kamelike mound is in sec. 15, T. 139 N., R. 76 W.

In the interlobate area between the middle and south loop a prominent kame in secs. 18 and 19, T. 138 N., R. 75 W. has about 30 feet of relief.

Partly buried channels and kettle chains. – Prominent channel sags partly buried by drift, and channels marked by an alignment of numerous kettles are partly buried channels and kettle chains.

A partly buried channel in the middle loop and the adjacent ground moraine in secs. 1, 12, and 13, T. 140 N., R. 75 W., extends southeastward into Kidder County. Test holes penetrated as much as 168 feet of till and gravel in the buried channel. In Burleigh County this channel has about 35 feet of relief in the ground moraine and 60 to 100 feet of relief in the end moraine. In Kidder County this channel is competely buried by ground moraine.

In the south loop a kettle chain in secs. 12, 13, and 14, T. 138 N., R. 75 W. extends southwestward from Kidder County into Burleigh County. The kettle chain has 40 to 60 feet of relief. The southern end of the kettle chain joins a valley that extends to Long Lake.

Proglacial Landforms

Outwash plains. – Gently undulating to nearly flat landforms of generally stratified accumulations of drift, chiefly glaciofluvial sediments, are outwash plains.

Outwash plains on the distal side of the three Long Lake end moraine loops are composed of sand and gravel. The outwash plains have low relief of about 5 to 10 feet, and they slope westward into the sediments of the Lake McKenzie Basin. Several irregular thin outwash deposits occur near the Long Lake breach of the south loop, surrounding Cretaceous Fox Hills Formation outcrops. Outwash merges into ground moraine on the distal side of the south loop and in the interlobate area. An extensive outwash plain on the distal side of the middle loop has been discussed in the section on Lake McKenzie Basin subdistrict. This slightly pitted outwash plain furnished the sand and silt that was wind deposited on the western edge of the middle loop.

Outwash valley floor. – A landform composed of accumulations of drift, chiefly stratified glaciofluvial sediments in a valley, is an outwash valley floor.

Outwash valley floor in a meltwater channel extends from the ground moraine area on the proximal side of the middle loop to Lake McKenzie Basin. It occurs in a shallow meltwater channel from Kidder County to the middle loop. The channel, now occupied by Random Creek, breaches the middle loop southeast of Sterling through a 60 foot cut. The fact that this channel is extremely shallow in the ground moraine, and that it breaches the end moraine, suggests that meltwater was probably flowing in a superglacial channel while the middle loop was being deposited.

Lake plain. – A lake plain lies in the Rice Lake area between the middle and north loops. Lacustrine clays and silts are exposed in road cuts along North Dakota Highway 14. The lake plain merges with collapsed outwash topography to the west and northwest. This general area was probably part of a pre-existing valley which was partly filled with lake and outwash deposits.

APPLE CREEK UPLANDS SUBDISTRICT

Apple Creek Uplands subdistrict is characterized by stream-eroded bedrock topography extensively covered by sheet moraine. The subdistrict nearly coincides with the drainage basin of Apple Creek which is completely integrated. An extensive sand dune area characterizes the southern part of this subdistrict.

Stream-eroded bedrock topography. – Much of the subdistrict contains a glacially modified, stream-eroded bedrock topography. Boulder erratics are common, and a thin layer of till covers much of the area. Bedrock crops out throughout the subdistrict, and many small areas were mapped as bedrock, because the till cover was thin or non-existent except for scattered erratic boulders.

The highest uplands are at an elevation of over 2200 feet, about 700 feet above the McKenzie lake plain. The local relief is commonly over 100 feet per square mile, but may reach several hundred feet in the butte areas. The Tongue River Formation caps most of the highest uplands in the northern part of the subdistrict with the Cannonball Formation forming the lower slopes. In the southern one-third of the subdistrict the Cannonball Formation caps the uplands and the Hell Creek Formation forms the lower slopes. Generally, postglacial stream erosion has been extensive.

Sheet moraine. – The northern two-thirds of the subdistrict has an extensive but discontinuous sheet moraine cover. Local relief on the sheet moraine area is commonly over 100 feet per square mile, but this is merely a reflection of the bedrock topography. The sheet moraine contains a few scattered kettles, and the drift is generally less than 10 feet thick.

Kames. – Kames, in groups of two or three, composed of till, sand, and gravel are numerous in the northeastern part of this subdistrict. Perhaps the most conspicuous kames are in secs. 10, 15, and 16, T. 141 N., R. 77 W. (fig. 7). Here, there are three groups of kames on sheet moraine behind a high bedrock ridge. The relief of the kames is approximately 50 to 75 feet. Boulders are common and the bedding, though not well-developed, is best seen in a gravel pit in sec. 10 (fig. 7). The next township to the east, T. 141 N., R. 76 W., has kames in secs. 7, 8, 17, and 18. The next township to the north, T. 142 N., R. 76 W., has kames in secs. 5 and 6. Here, the kames have 10 to 30 feet of local relief. Three adjoining kames with nearly flat bedding in sec. 24, T. 142 N., R. 77 W. have about 30 feet of relief. Two minor kames are in secs. 14 and 23, T. 141 N., R. 79 W.

Meltwater channels and outwash valley floor. – The streams of this subdistrict are ephemeral except for the intermittent Apple Creek. All of the major drainage valleys contain some outwash, and during glaciation most of these channels carried meltwater.

Figure 7. — Prominent kames in Apple Creek Uplands subdistrict (T. 144N., R. 77 W., Burleigh County). Upper picture: Kame complex in sec. 15. Lower two pictures: Gravel exposures in a kame in sec. 10. Note the bedding and boulders.

In the northeastern part of this subdistrict several upper branches of the East Branch of Apple Creek probably were significant meltwater channels (pl. 8). One of these upper branches, extending southward from the village of Wing, follows along the front of the Long Lake end moraine. This channel has made cuts from 40 to 125 feet deep, with an average depth of 100 feet. Test hole data indicate a valley fill thickness of about 57 feet. Another upper branch meltwater channel extends southeastward from Lake Canfield. This meltwater channel was superimposed on a high bedrock drainage divide and joined the meltwater channel from Wing. The relief of this channel ranges from about 30 feet in the northern part to about 150 feet where it passes through the high bedrock area. Commonly, it has about 120 feet of relief. Thirty feet of valley fill was encountered in one test hole. Apparently these two upper branch channels carried meltwater from the ablating Burnstad ice (pl. 8).

The valley occupied by West Branch of Apple Creek contains an outwash valley floor. The valley fill ranges from 4 to 20 feet thick in three test holes. Apparently this channel carried meltwater mostly from the ablating Napoleon ice.

Dune sand. — Eolian sand deposits are characterized by dunes and blowouts southeast of Bismarck in two separate areas in this subdistrict. South of Apple Creek the largest dune development in Burleigh County covers about 21 square miles. The dune area is in a broad upland valley between bedrock hills. The valley probably was a preglacial channel and a minor meltwater channel. As shown by two auger holes, in secs. 20 and 19, T. 138 N., R. 79 W., respectively, the sand ranged from 1 to 3 feet thick. However, a sand thickness of 5 to 15 feet has been observed in blowouts. The dunes are low, rounded and elongated mounds of sand oriented in a northwesterly direction. A dune area is also present along the Burleigh-Emmons County line.

LONG LAKE BASIN SUBDISTRICT

Long Lake Basin subdistrict lies mostly within Kidder County, but it extends into southeastern Burleigh County at Long Lake. In Kidder County this subdistrict is characterized by internal and partly integrated drainage. Topographically, it is a broad basin containing an extensive outwash and lake plain. Dune sand is present in two separate areas. Surrounding much of the basin is the high morainal belt of the Missouri Coteau which has non-integrated drainage.

Outwash and lake plain. — The outwash and lake plain of this subdistrict is nearly flat, but it slopes gently toward the center of the basin. The elevation of the basin is about 1800 feet at the edge and about 1700 feet at the center. The surface deposits are mostly sand, but clay deposits are common. Several large aligned kettles, near the center of the basin, are in a chain that nearly marks the buried channel of the ancestral Cannonball River. Here, the valley fill ranges from 124 to 168 feet thick in Burleigh County and up to 300 feet thick in Kidder County. The fill is composed of sand, clay, till, and gravel. The bedrock valley of the ancestral Cannonball River is cut into the Cretaceous Pierre and Fox Hills Formations.

Dune sand. – Sand dunes occur in two areas in the Long Lake Basin subdistrict (Rau, and others, 1962). The largest dune area, six miles south of the town of Dawson, covers about 25 square miles, and the other covers about three square miles near the town of Tappen.

PAINTED WOODS CREEK SUBDISTRICT

Painted Woods Creek subdistrict lies within McLean and Burleigh Counties. The glacial topography of this subdistrict is transitional from thin drift covered bedrock on the south to dead-ice moraine in the northern part. The drainage basin of Painted Woods Creek is the site of a large drift covered bedrock valley. The predominant landform, dead-ice moraine, is due to drift accumulation by large-scale stagnation of continental glaciers. The valley is cut into the Tongue River Formation in the southern uplands and into the Cannonball Formation in the remainder of the subdistrict. Elevations in Painted Woods Creek subdistrict range from 1790 to 2100 feet.

Glacial Landforms

Dead-ice moraine. – Landforms composed chiefly of hummocky accumulations of drift, chiefy till, with 20 to 60 feet of relief extend from the Missouri Coteau district into the Painted Woods Creek subdistrict. These landforms, which are called dead-ice moraine, are deposited by stagnant glacial ice. A detailed discussion of dead-ice moraine is presented in the description of the Missouri Coteau district. The dead-ice moraine in this subdistrict contains numerous sloughs, is notable for surface boulders, and ranges from 25 to 80 feet thick. Elevations on the moraine range from 1790 to 2000 feet.

An elongate area mapped as dead-ice moraine north of Grass Lake may possibly be an end moraine without well-developed ridges. However, the bedrock is at shallow depths in this area, and the preglacial bedrock surface is reflected in the overlying dead-ice moraine.

Collapsed outwash topography. – Hummocky outwash borders the dead-ice moraine northwest of the town of Regan. The relief of this collapsed outwash ranges from 10 to 30 feet and it lies at elevations between 2020 and 2060 feet. The northern boundary between the outwash and the dead-ice moraine is marked by a narrow disintegration ridge composed of till and gravel. Collapsed outwash along the south valley wall of Painted Woods Creek in sec. 25, T. 144 N., R. 79 W., and sec. 30, T. 144 N., R. 80 W. merges into an outwash terrace which is probably stream-modified collapsed outwash. Elevations on the collapsed outwash range from 1840 to 1870 feet and the local relief is about 10 to 20 feet.

Linear disintegration ridges. – Several short gravel and sand ridges with 10 to 30 feet of relief are along the valley wall of Painted Woods Creek in T. 144 N., R. 79 W. In sec. 29, one ridge extends down on the valley floor. Scattered boulders are abundant on the ridges. Two ridges, one composed of gravel and the other of till, in the northern part of sec. 3 have from 5 to 15 feet of relief.

Sheet moraine. – The upland area south of the dead-ice moraine contains sheet moraine. The topography is gently rolling with from 10 to 100 feet of relief at elevations ranging between 2000 and 2200 feet. The Tongue River Formation crops out of the drift which ranges in thickness from a veneer to about 40 feet. Surface boulders on the drift are sporadically numerous, and here kettles are more abundant than in the sheet moraine south of this subdistrict.

Proglacial landforms

Meltwater channels and outwash valley floor. – Painted Woods Creek flows in a meltwater channel which ranges from about a quarter of a mile to two miles wide. The Cannonball Formation crops out in three places in the channel. Outwash on the valley floor composed of gravel, sand, and clay, ranges in thickness from 20 to 66 feet. Elevations in the channel range from 1790 feet at the Burleigh-McLean County line to 1850 feet three miles south of the Sheridan County line. Meltwater probably formed the channel during stagnation and ablation of the Burnstad ice, and much of the valley floor outwash probably was deposited during the ablation of the Streeter ice.

A shallow meltwater channel along the southern boundary of the dead-ice moraine is marked by sloughs. Valley outwash composed of sand and clay was deposited in the channel which was probably formed by meltwater during the ablation of Burnstad ice.

Nonglacial Landforms

Recent drainage. – Painted Woods Creek is an intermittent stream in a meltwater channel. Well-developed tributaries to Painted Woods Creek in the dead-ice moraine along the southern part of the drainage basin have incised the drift as much as 80 feet.

Missouri Coteau District

The Missouri Coteau district includes the northeastern part of Burleigh County and is characterized by extensive areas of dead-ice moraine and associated stagnant ice-disintegration features such as: collapsed outwash topography, disintegration trenches, disintegration ridges, abundant kettles containing lakes and sloughs, collapsed lacustrine topography, kames, and kame terraces. The predominant landform, dead-ice moraine, is due to drift accumulation by large-scale stagnation of continental glaciers. This landform is well-preserved in this district because the drainage is not integrated and postglacial erosion is insignificant.

The Missouri Coteau district contains the highest glacial constructional relief and thickest till in Burleigh County. The drift ranges from a feather edge near the bedrock outcrop areas to a maximum thickness of 165 feet, with an average thickness of about 60 feet. However, the topography along part of the western boundary of the Missouri Coteau district reflects the till-covered bedrock highs of the Fort Union Group. The Cannonball Formation crops out in several small exposures southwest and northwest of Wing (pl. 1). The Tongue River Formation crops out in an upland ridge northwest of Haystack Butte.

The Florence Lake loop of the Streeter end moraine is in the Missouri Coteau district along the Burleigh-Sheridan County line. Dead-ice moraine borders both sides of the Streeter end moraine.

Glacial Landforms

Dead-ice moraine. — Landforms composed of hummocky accumulations of drift, chiefly till, deposited directly by stagnant glacial ice and having glacial constructional relief are dead-ice moraines. Generally dead-ice moraine lacks linear trends, contains abundant knobs and kettles, high constructional relief, and non-integrated drainage.

Dead-ice moraine in Burleigh County has high relief of 50 to 150 feet, and the maximum relief is due partly to underlying bedrock highs. The dead-ice moraine lacks linear trends, contains abundant kettles with small sloughs and lakes, and is composed chiefly of till with minor accumulations of outwash and lacustrine sediments. Surface boulders are abundant. The dead-ice moraine in Burleigh County occurs at elevations between 1900 and 2100 feet.

Associated with the dead-ice moraine are stagnant ice-disintegration features which will be discussed under separate headings. Gravenor and Kupsch (1959, p. 48-64) have classified these features in three groups: (1) controlled disintegration features which show the influence of the previous active ice; (2) uncontrolled disintegration features which do not reveal the influence of former ice flow; and (3) disintegration features which were superimposed on active ice features. Using their classification the controlled disintegration features in this district include linear disintegration ridges and kettle chains. The uncontrolled disintegration features include collapsed outwash topography, closed disintegration ridges, collapsed lacustrine topography, kames, and kame terraces. Disintegration trenches are both controlled and uncontrolled disintegration features (Clayton, 1964, oral communication). The linear disintegration ridges on the end moraine in Long Lake subdistrict, exemplify superimposed disintegration features.

The origin of morainal topography in the Missouri Coteau district was suggested by Townsend and Jenke (1951, p. 857), who thought that it "may have been deposited largely by ablation." They also suggested that the moraine "may be a special type more nearly related in extent and mode of deposition to ground moraine than to end moraine." The terminology, origin, and usage of dead-ice moraine has been discussed by various workers (Christiansen, 1956; Lemke and Colton, 1958; Gravenor and Kupsch, 1959; Rau, and others, 1962; Clayton, 1962; and Winters, 1963). For a detailed background on dead-ice moraine these works should be consulted as only a brief discussion is presented here.

The dead-ice moraine in Burleigh County probably originated in much the same manner as that in Logan and McIntosh Counties. Clayton (1962, p. 34-38) discussed this origin and part of his interpretation was: (1) the high relief probably originated from "letting-down of superglacial till from stagnant ice"; (2) most of the superglacial drift probably originated from marginal imbricate thrusting of thin ice; (3) the ice was covered by an insulating blanket of drift which resulted in slow melting and a wide band of stagnant ice; and (4) dead-ice moraine is the result of large-scale glacial stagnation.

The dead-ice moraine in Burleigh County reaches a maximum thickness of 165 feet which is much thinner than the maximum of 500 feet in Logan and McIntosh Counties. The maximum relief is similiar being about 100 feet in both areas.

Collapsed outwash topography. — Landforms composed chiefly of hummocky accumulations of drift, chiefly glaciofluvial sediments with abundant kettles, are included in collapsed outwash topography. In Burleigh County, collapsed outwash topography has moderate to high relief, similar to that of dead-ice moraine. Ice-disintegration ridges are commonly associated with collapsed outwash.

In Burleigh County the collapsed outwash topography in T. 142 N., R. 75 W. is a westward continuation of an extensive outwash area in Kidder County which was deposited by the Burnstad advance (Clayton, 1962, p. 31 and 63). Elevations on the outwash range between 1840 and 1900 feet, and the local relief is about 10 to 50 feet. Kettles and ice-contact features are abundant. A channel-like extension of collapsed outwash trends from Harriet Lake northwest to Wing.

North of Arena and Wing (pl. 1) are several minor areas of collapsed outwash topography in the dead-ice moraine. The outwash is thin with moderate relief and hummocky topography. To the north is a channel-like deposit of collapsed outwash composed of numerous boulder covered low ridges that coalesce to form an outwash sheet of moderate relief. The relief of the ridges is about 5 to 15 feet. Another area of boulder covered collapsed outwash to the northwest has low to moderate relief. Four miles north of Wing a relatively flat outwash surface is elevated 50 to 80 feet above the surrounding topography. It is similar to the ice-restricted lacustrine deposits of the "moraine plateaus" as described by Gravenor and Kupsch (1959, p. 51-52). West of Wing is an area of ice-marginal collapsed outwash with relief of 5 to 20 feet.

The largest area of collapsed outwash topography occurs on the distal side of the Streeter end moraine (pl. 1) and it is generally less than 30 feet thick. The collapsed outwash is thicker near Bunce Lake where 50 feet of gravel is exposed, and it is through this layer of outwash gravel that the lake is recharged. Kettle lakes are abundant in the outwash. The elevation of the outwash ranges from 1930 to 2000 feet, and the relief is moderate.

East of Painted Woods Creek (pl. 1) is a small area of collapsed outwash topography with relief of about 30 feet. To the east the outwash merges with dead-ice moraine.

Another minor area of collapsed outwash topography along the Burleigh-Sheridan County line, is at an elevation of 1950 feet with 15 to 25 feet of relief.

Disintegration trenches. — Clayton (1962, p. 42) first recognized and defined disintegration trenches as being "a trench or channel formed by the inversion of topography on disintegrating stagnant glacial ice and subsequent burial under outwash."

Disintegration trenches in northern Burleigh County are recognized on aerial photo stereopairs, but are difficult to identify in the field. The trenches are short and have a random pattern. These trenches, common in all of the areas of collapsed outwash topography, are best developed southwest of Salt Lake.

Linear disintegration ridges. — Narrow ridges of drift, composed chiefly of till, are common in the dead-ice moraine and collapsed outwash topography in the Missouri Coteau district. Gravenor and Kupsch (1959, p. 53-54) have defined linear disintegration ridges as straight or slightly arcuate, linear ridges resulting from controlled ice disintegration and composed chiefly of till which may contain pockets of stratified material. They (p. 49) define controlled ice disintegration as the process of ice separation along fractures in a stagnant glacier.

Disintegration ridges in Burleigh County are narrow, straight or arcuate, linear ridges, are generally less than 30 feet high, are less than a mile to several miles long, and are composed either of till, outwash, or a mixture of the two. Surface boulders are a common feature of these ridges.

Three disintegration ridges occur in the collapsed outwash topography in sec. 24, T. 142 N., R. 76 W. These till and gravel ridges are 5 to 15 feet high and less than a quarter of a mile long. Several other short disintegration ridges in and along a meltwater channel southwest of Wing are 5 to 10 feet high and are composed chiefly of gravel.

A series of short disintegration ridges in the dead-ice moraine northwest of Arena are as much as 30 feet high. These boulder covered ridges, aligned in a southeastward trend for about five miles, extend from dead-ice moraine to collapsed outwash topography. Two small kamelike mounds are associated with these ridges.

A disintegration ridge about 5 miles long marks the boundary between dead-ice moraine and the outwash plain on the distal side of the Streeter end moraine. The boulder covered ridge is up to 200 feet wide with 20 to 30 feet of relief.

Other disintegration ridges occur in the dead-ice moraine in secs. 27 and 28, T. 144 N., R. 77 W. and in sec. 3, T. 144 N., R. 79 W. These ridges are generally less than a mile long.

Closed disintegration ridges. – Circular, oval, or irregularly closed ridges of drift, composed chiefly of till, are common in the dead-ice moraine in the Missouri Coteau district. Gravenor and Kupsch (1959, p. 52-53) have defined closed disintegration ridges as circular, oval, or irregularly closed ridges of glacial material, chiefly till, resulting from uncontrolled ice disintegration. They (p. 49) define uncontrolled ice disintegration as the breaking up of an ice sheet equally in all directions into numerous small blocks.

Closed disintegration ridges occur throughout the dead-ice moraine of Burleigh County but less commonly than in many other areas of the Missouri Coteau district. In Burleigh County the ridges generally are 50 to 300 feet in diameter, less than 10 feet high, and are rudely circular in plan. The ridges are composed chiefly of till with pockets of washed drift. The more regular circular ridges surround an obvious central depression and some of the oval shaped ridges are breached at both ends. Closed disintegration ridges are difficult to observe in the field but are very noticeable on aerial photos.

Collapsed lacustrine topography. — Very small areas of collapsed lacustrine deposits occur along the rims of depressions and kettles in the dead-ice moraine. The depressions are usually 5 to 10 feet deep, and rarely attain a depth of 20 feet. The rimmed lacustrine deposits are slightly elevated above the depression and are composed of clay and silt which appears to grade into the surrounding till.

The collapsed lacustrine deposits are fossiliferous and collections have been made from a number of sites (see discussion of the fossil molluscan fauna of Pleistocene sediments). The branchiate molluscan fauna indicates that the enclosing sediments were deposited in permanent ponds, whereas the existing sloughs are ephemeral.

Kame terraces and kames. — A terracelike accumulation of ice-contact stratified drift, composed chiefly of glaciofluvial materials, deposited between glacial ice and an adjacent valley wall is a kame terrace.

A series of paired kame terraces occur about 30 feet above an east-west meltwater channel in secs. 23 and 24, T. 143 N., R. 76 W., adjacent to the Long Lake north loop boundary. The terraces are composed of two to six feet of sand and gravel, have about five feet of relief, and are partly covered by boulders. Streams have modified these terraces.

A kame with 25 feet of relief occurs in sec. 25, T. 144 N., R. 75 W. In this area of dead-ice moraine only a few recognizable kames are present. A kame occurs in sec. 36, T. 143 N., R. 77 W.

Kettle chains. — Northeast of Canfield Lake a kettle chain in a drift covered drainage channel breaches a bedrock ridge in secs. 10 and 16, T. 143 N., R. 77 W. The kettle chain is narrow and has up to 40 feet of relief. Another kettle chain along the Burleigh-Sheridan County line in secs. 1 and 2, T. 144 N., R. 79 W. is about half a mile wide, and has 30 to 40 feet of relief.

End moraine. — The only loop of the Streeter end moraine in Burleigh County, here named the Florence Lake loop, occurs along the Burleigh-Sheridan County line. The Streeter end moraine is a prominent ridged accumulation of drift with several arcuate looped segments.

The Florence Lake loop is a high till ridge with a gravel ridged outer margin, and numerous parallel superimposed till ridges. The loop has about 50 feet of relief with a maximum of 100 feet. The superimposed ridges are 10 to 50 feet high and are from 700 to 2500 feet apart. A collapsed outer part of the loop suggests that part of the end moraine was deposited on stagnant ice, and this part was mapped as collapsed end moraine.

Collapsed outwash topography occurs on the distal side of the Florence Lake loop from Pelican Lake in Burleigh County to the interlobate area with the West Woodhouse Lake loop in Sheridan County. A breach in the loop northeast of Pelican Lake in sec. 6, T. 144 N., R. 76 W. is now occupied by a collapsed outwash train.

The distal side of the Florence Lake loop merges into dead-ice moraine and collapsed outwash. The West Woodhouse Lake loop in Sheridan County is fronted by an outwash plain that extends into northeastern Burleigh County.

Subdued-end moraine. – End moraine of a transitional nature between end moraine and ground moraine was mapped as subdued-end moraine in Townships 141 and 142 north.

Subdued-end moraine is defined as a subdued ridgelike accumulation of till with moderate relief of 20 to 40 feet per square mile deposited along the margin of an active glacier.

The Long Lake subdued-end moraine is at elevations between 1900 and 2000 feet and has a knob and kettle topography in an over all linear trend. The moraine slopes gently to the east with a relief of 10 to 30 feet. The moraine resembles a collapsed moraine formed after the deposition of the north loop of the Long Lake end moraine. The subdued-end moraine is composed of till with numerous boulders on the surface. The boundary with the ground moraine is arbitrarily placed at an abrupt change in slope at the end moraine contact.

Ground moraine. – A small area of ground moraine in T. 142 N., R. 75 W. has less than 10 feet of relief. Much of the area contains small potholes floored by postglacial sediments.

Proglacial Landforms

Meltwater channels. – Three prominent channels draining meltwater from the Burnstad ice breached bedrock divides near the western margin of the Missouri Coteau district.

A meltwater channel in secs. 23 and 24, T. 142 N., R. 76 W. has been discussed in the section on kame terraces. This channel probably formed as an ice-marginal channel since its course lies between the dead-ice moraine and the north loop of the Long Lake end moraine. The channel bottom is about 50 feet below the crest of the end moraine and about 30 feet below the general level of the dead-ice moraine. The deposits in the channel are composed of outwash and alluvium. At its west end the bottom of the channel is about 40 feet higher than that of a deep north-trending meltwater channel which heads near Wing, and forms the upper

East Branch of Apple Creek. This channel was probably formed by meltwater confined between walls of ice. South of Wing the channel flows throuh dead-ice moraine for about three miles, then it cuts through a ridge of the Cannonball Formation. The channel is very narrow, especially in the dead-ice moraine.

East of Lake Canfield in T. 143 N., R. 77 W. a spillway cuts through a ridge of the Tongue River Formation. The channel is 60 to 120 feet below the crest of the bedrock ridge and is floored with sheetwash and alluvium. Beyond the bedrock ridge the meltwater channel separates into two segments, a minor segment trending southwest and a main segment trending through Lake Canfield. South of Lake Canfield the two rejoin and flow into the East Branch of Apple Creek. The main segment in the Lake Canfield area is marked by large shallow kettles with 10 to 20 feet of relief.

Outwash plain. – East of Salt Lake is an outwash plain with a few small kettles along the Burleigh-Sheridan County line. In the Salt Lake area the outwash plain merges into collapsed outwash on the distal side of the Florence Lake loop. The elevation of the plain is near 1960 feet with about 10 feet of relief.

Painted Woods Creek meltwater channel contains an outwash plain which extends from Johns Lake in Sheridan County south for two miles into Burleigh County. The outwash plain merges into outwash valley floor in Burleigh County, and in Sheridan County it merges into collapsed outwash topography. The plain has about 10 feet of relief, has surface elevations of 1850 to 1870 feet, and contains a few kettles.

Non-glacial Landforms

Lakes and drainage. – South and southeast of Arena numerous saline lakes occur in collapsed outwash topography and ground moraine. Harriet Lake is the largest saline lake in this area. Numerous saline and fresh lakes in the dead-ice moraine are Twin Lake, Horseshoe Lake, Lone Tree Lake, Obrien Lake, and Canfield Lake. In the collapsed outwash topography on the distal side of the Florence Lake loops are Florence Lake, Pelican Lake, Bunce Lake, and Salt Lake.

This district is characterized by non-integrated drainage, with short streams draining into lakes and kettles.

GENERAL STRATIGRAPHY - SUBSURFACE BEDROCK

Precambrian Rocks

The oldest rocks in Burleigh County are Precambrian granites. Five petroleum exploration wells have bottomed in pink to reddish-brown or gray granite at depths of from 6,100 feet in southeastern Burleigh County to 8,000 feet in the west.

Paleozoic Rocks

CAMBRO-ORDOVICIAN ROCKS

The Deadwood Formation of Cambro-Ordovician age consists of about 200 to 335 feet of glauconitic sandstones, limestones and shale. The Deadwood unconformably overlies Precambrian rocks and is unconformably overlain by Middle Ordovician rocks.

ORDOVICIAN ROCKS

Ordovician rocks are represented by, in ascending order: the Winnipeg, Red River, Stony Mountain and Stonewall Formations. The Winnipeg consists of a basal sandstone and an overlying shale. The Red River consists of limestone and dolomite, and the Stony

ERA	SYSTEM	SERIES	GROUP	FORMATION	THICKNESS (Feet)	LITHOLOGY
MESOZOIC	CRETACEOUS	UPPER CRETACEOUS	Colorado	Niobrara Carlile	450-575	Shale Shale
				Greenhorn Belle Fourche	320-375	Shale Limestone Shale
		LOWER CRETACEOUS	Dakota	Mowry Newcastle Skull Creek	250-320	Shale Sandstone Shale
				Fall River Lakota	110-300	Sandstone Sandstone
	JURASSIC			Swift Rierdon Piper	400-630	Shale Shale Limestone Anhydrite
PALEOZOIC	PENNSYLVANIAN		UNC.	Minnelusa	0-118	Sandstone
				Amsden	0-300	Dolomite
				Tyler	115-170	Shale Sandstone
	MISSISSIPPIAN		UNC. Big Snowy	Kibbey	0-35	Siltstone-Lime
			Madison	Poplar Interval	0-150	Evaporite
				Ratcliffe Interval	90-160	Limestone
				Frobisher-Alida Interval	170-215	Limestone
				Tilston Interval	105-140	Limestone
				Bottineau Interval	480-625	Limestone
				Bakken	0-25	Shale Limestone
	DEVONIAN	UPPER DEVONIAN	UNC.	Three Forks	0-20	Siltstone Shale
			Jefferson	Birdbear	40-80	Limestone
				Duperow	150-215	Limestone
		MIDDLE DEVONIAN	Manitoba	Souris River	25-135	Dolomite Limestone
				Dawson Bay	0-100	Dolomite
			Elk Point	Prairie	0-45	Evaporite
				Winnipegosis	0-100	Limestone
	SILURIAN		UNC.	Interlake	50-240	Dolomite
	SILURO-ORDOVICIAN			Stonewall	50-70	Limestone Dolomite
	ORDOVICIAN		Big Horn	Stony Mountain	150-170	Limestone Shale
				Red River	590-660	Limestone Dolomite
				Winnipeg	185-220	Shale Sandstone
	CAMBRO-ORDOVICIAN		UNC.	Deadwood	200-335	Shale Sandstone
	PRECAMBRIAN		UNC.			Granite

Figure 8. Burleigh County subsurface bedrock stratigraphic column.

Mountain consists of limestone and shaly limestone. The Stonewall Formation, of Upper Ordovician to Silurian (?) age, consists of limestone and dolomite. Ordovician rocks range in thickness from about 975 to 1120 feet.

SILURIAN ROCKS

The Interlake Formation of Silurian age consists of from 50 to 240 feet of dolomite and limestone. The Interlake Formation is unconformably overlain by rocks of Middle Devonian age.

DEVONIAN ROCKS

The Devonian rocks have been divided into seven formations which in ascending order are: Winnipegosis, Prairie, Dawson Bay, Souris River, Duperow, Birdbear, and Three Forks Forma-

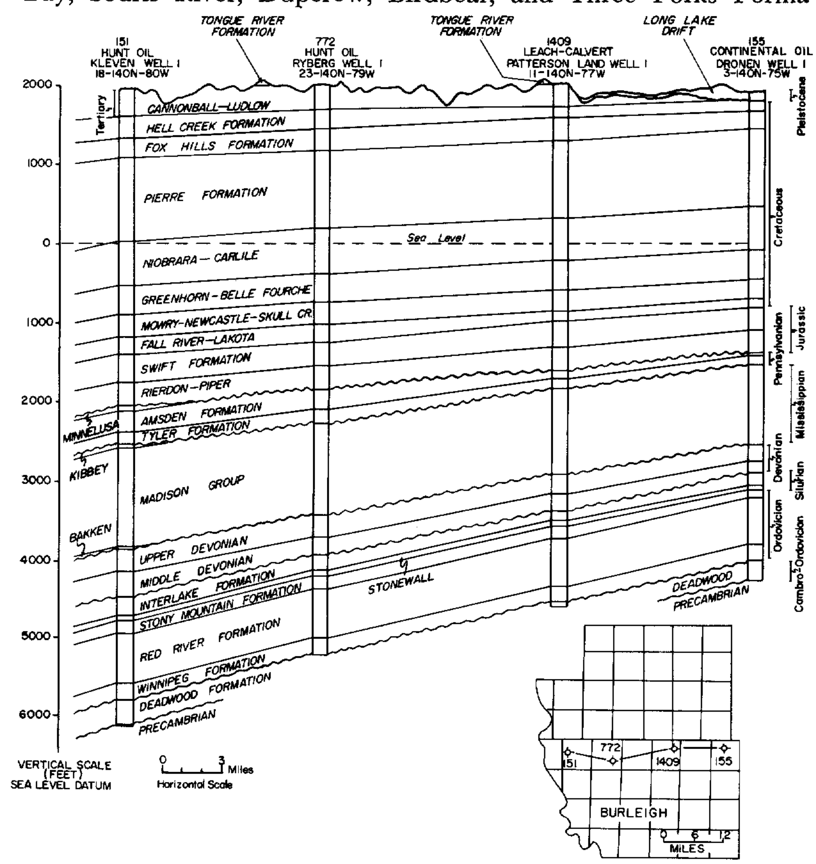

Figure 9. Burleigh County subsurface bedrock stratigraphic cross-section.

tions. The Winnipegosis and Prairie Formations consist mainly of limestone with some anhydrite. The Dawson Bay and Souris River Formations consist of limestone and dolomitic limestone. The Duperow and Birdbear Formations are also mainly limestones. The Three Forks Formation consists of siltstone and shale. Devonian rocks thin somewhat southeastward due to depositional thinning and to post-depositional erosion. Only the Birdbear, Duperow, Souris River and Prairie Formations are present throughout Burleigh County (S. B. Anderson, personal communication). Devonian rocks range in thickness from about 200 to 600 feet.

MISSISSIPPIAN ROCKS

Mississippian rocks have been divided into the Bakken Formation, the Madison Group, and the Big Snowy Group. The Bakken Formation consists of shale and limestone. Previously the Madison Group was divided into the Lodgepole, Mission Canyon, and Charles Formations, but now it is generally divided into five marker bed defined intervals (Smith, 1960, p. 959). The Madison Group consists mainly of limestone with some interbedded anhydrite. The Big Snowy Group is present only in the western part of Burleigh County where the Kibbey Formation is represented by limestone and a little shale. Mississippian rocks thin southeastward due mainly to pre-Pennsylvanian erosion. Mississippian rocks range in thickness from about 880 to 1330 feet.

PENNSYLVANIAN ROCKS

Pennsylvanian rocks are divided into the Tyler, Amsden, and Minnelusa Formations. The Tyler Formation, which occurs throughout the county, consists of shale and sandstone. The Amsden Formation is composed of limestone, dolomite, and shale. The Minnelusa Formation, which is present only in western Burleigh County, is composed of sandstone and shale. Pennsylvanian rocks thin southeastward due to pre-Jurassic erosion and range from about 110 to 560 feet thick.

Mesozoic Rocks

JURASSIC ROCKS

Rocks of Jurassic age have been divided into the Piper, Rierdon and Swift Formations. The limestones, shales, and anhydrites of the Piper Formation at the base of the Jurassic are overlain by the Rierdon Formation, which is composed mainly of shale. The Swift Formation consists of shale, sandstone, and siltstone. Jurassic rocks range in thickness from 400 to 630 feet.

CRETACEOUS ROCKS

In Burleigh County, Cretaceous rocks which do not crop out at the surface, or subcrop beneath glacial drift, have been divided into the Dakota and Colorado Groups. The Dakota Group is composed of quartzose sandstones of the Lakota and Fall River Formations, shale of the Skull Creek Formation, sandstone of the Newcastle Formation, and shale of the Mowry Formation. The Dakota Group ranges in thickness from 360 to 620 feet in Burleigh County. The Colorado Group consists of shale of the Belle Fourche Formation, shale and shaly limestone of the Greenhorn Formation, shale of the Carlile Formation, and calcareous shale of the Niobrara Formation. In Burleigh County, the Colorado Group ranges in thickness from about 770 to 950 feet.

DETAILED STRATIGRAPHY – SURFACE BEDROCK

Mesozoic Rocks

UPPER CRETACEOUS ROCKS – MONTANA GROUP

The Montana Group in North Dakota consists of the Pierre and Fox Hills Formations. Both are present in Burleigh County, but only the Fox Hills is exposed. Detailed lithologic descriptions of some exposures are provided in Appendix A.

Pierre Formation

The Pierre Formation, a marine shale of Late Cretaceous age, is composed of medium dark gray to light gray shale. It ranges in thickness from 946 to 1,020 feet in Burleigh County with only the uppermost part sub-cropping beneath the drift. The contact with the overlying Fox Hills Formation is gradational and is difficult to pick. The Pierre is overlain by the Fox Hills except in parts of Badger Creek and Cannonball River Channels (pl. 2 and test hole 1938) in southeastern Burleigh County, where the Pierre is overlain by glacial drift.

The Pierre Formation was penetrated in eight test holes. A structure map (fig. 11) was drawn using the information from

ERA	SYSTEM	SERIES	GROUP	FORMATION	THICKNESS	LITHOLOGY
CENOZOIC	TERTIARY	PALEOCENE	Ft. Union	Tongue River	0-215 Feet	Sandstone Shale Lignite
				Cannonball Ludlow	0-340 Feet	Sandstone Siltstone Shale Lignitic Shale
MESOZOIC	CRETACEOUS	UPPER CRETACEOUS		Hell Creek	0-280 Feet	Mudstone Sandstone Lignite
			Montana	Fox Hills	0-300 Feet	Sandstone Shale
				Pierre	946-1020Feet	Shale

Figure 10. Burleigh County surface bedrock stratigraphic column.

these tests and from 14 petroleum exploration wells. The regional dip of the Pierre Formation to the west and northwest amounts to about 12.5 feet per mile, but in northeastern Burleigh County the regional dip is slightly reduced due to local structural influences.

Fox Hills Formation

The Fox Hills Formation, a marine sandstone of Late Cretaceous age, is exposed in the southeastern part of Burleigh County near Long Lake (pl. 1), but is better exposed to the south in Em-

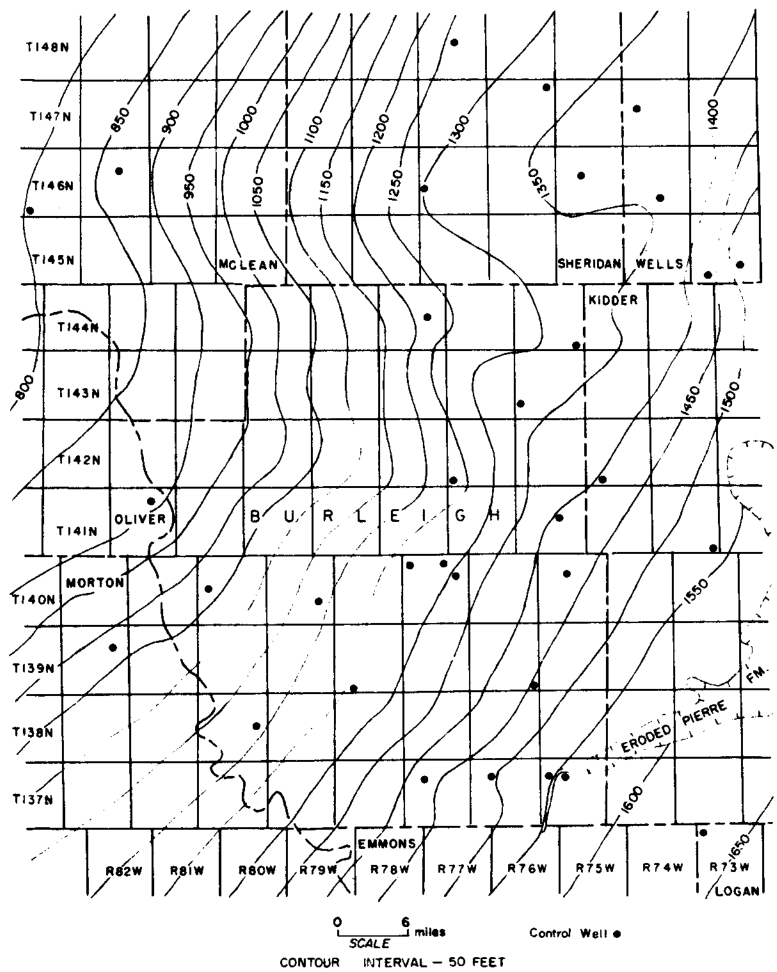

Figure 11. Structure contour map on the Cretaceous Pierre Formation.

mons County. In that area, Fisher (1952) recognized an upper and a lower sequence in the Fox Hills Formation. He further recognized a division of the lower sequence into a lower Trail City Member and an upper Timber Lake member, following the work of Morgan and Petsch (1945) in north-central South Dakota. Morgan and Petsch also divided the upper sequence into some thin bedded sandstones which they referred to as the "Banded Beds", and an overlying unit called the "upper sandstone".

The Fox Hills Formation was penetrated in 48 test holes. Seven petroleum exploration tests also provided some data. The Fox Hills consists of several sequences of interbedded sandstones and shales. In test holes 1830, 1857, and 1864 the Fox Hills can be divided into four lithologic units of alternating shales and sandstones, which are somewhat similar to the units previously recognized in surface work to the south of this area. Sandstones of the Fox Hills are friable except for siliceous beds which contain numerous ironstone concretions. In areas of cross-bedded sandstones, the Fox Hills contains carbonaceous and ferruginous material along the bedding planes. Bedding ranges in thickness from 1 mm to 1 m. The varicolored shales also contain occasional streaks or thin beds of carbonaceous material.

The Fox Hills Formation is directly overlain by glacial drift in many buried glacial channels and also in the Missouri River Trench in southwestern Burleigh County (pl. 2 and 7). In other areas the Fox Hills Formation is conformably and gradationally overlain by the Hell Creek Formation. The lower contact of the Fox Hills is placed at the top of a medium gray to grayish-black shale of the Pierre, and the upper contact is at the base of the lowermost lignite or carbonaceous shale in the Hell Creek Formation. The contact between the Hell Creek and Fox Hills Formation was cored in test hole 2047.

A structure contour map (fig. 12), shows the regional dip of the Fox Hills Formation to the west and northwest to be about 14.6 feet per mile in southern Burleigh County and about 13.6 feet per mile in the central part. In the eastern part of the county the regional dip is slightly less due to local structures.

The upper part of the Fox Hills Formation is exposed in southeastern Burleigh County, especially north of Long Lake. A roadcut in SW 1/4 SE 1/4 sec. 11, T. 137 N., R. 76 W. shows sandstone beds as thin as 1 mm that are probably equivalent to the "Banded Beds" as recognized by Morgan and Petsch (1945) in South Dakota. Test holes 1827 and 1828, located one mile east of the outcrop in sec. 11, penetrated at least 200 feet of the Fox Hills Formation. Since this outcrop is 50 feet higher than the ground surface near the test holes, the Fox Hills Formation is about 250 feet thick in this area. Such a thickness represents nearly a complete section of the Fox Hills Formation (fig. 13).

Hell Creek Formation

The Late Cretaceous Hell Creek Formation is of continental origin except for the marine Brien member. The Hell Creek is exposed in southwestern and south-central Burleigh County along the banks of the Missouri River and in the bluffs south of Bismarck, Menoken, and McKenzie. The Hell Creek Formation directly underlies the glacial drift in the Wing Channel, in Lake McKenzie Basin, under much of the Long Lake moraine, and in the Missouri River Trench to the southwest, (pl. 2). Subsurface Hell Creek Formation relationships were interpreted from 65 test holes.

The Hell Creek consists of sandstones, mudstones, siltstones, carbonaceous shales, and lignite in surface exposures. The light

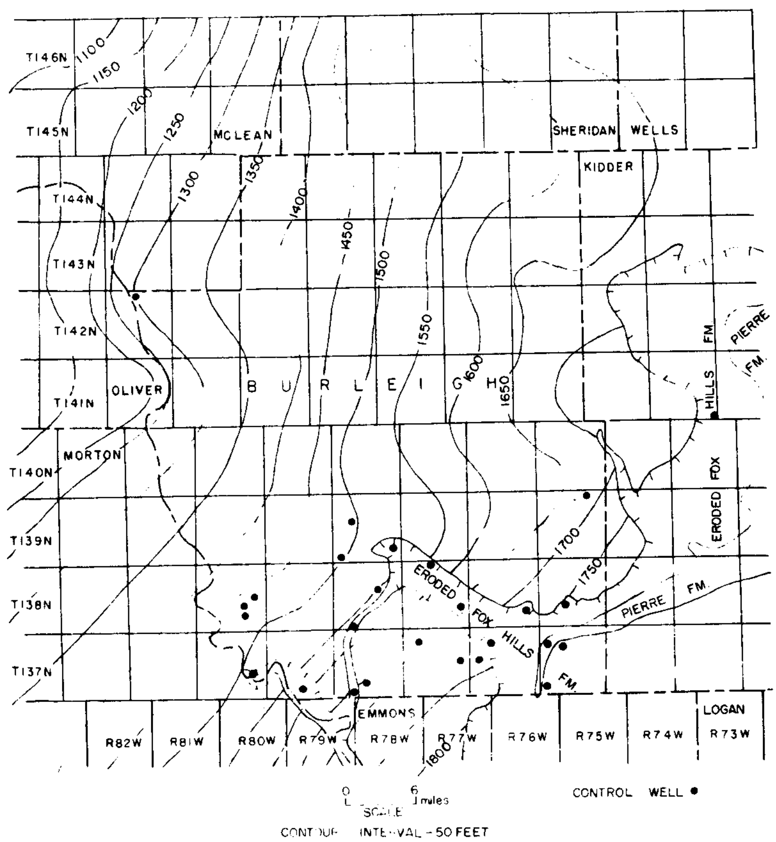

Figure 12. Structure contour map on the Cretaceous Fox Hills Formation.

gray and brown beds have commonly been referred to as the "Somber Beds" due to their distinctive colors.

The Hell Creek Formation consists of several sequences of interbedded gray, greenish-gray and brown shales, siltstones, and sandstones in the subsurface. The brownish shales contain abundant carbonaceous material and occasional thin lignite seams. The sandstones are friable, clayey, medium to fine-grained, and contain many dark minerals which give a "salt and pepper" appearance.

In northwestern Burleigh County, the Hell Creek is about 185 feet thick in test hole 1984, the only complete subsurface section of the formation found in test drilling. South of Bismarck the thickness is estimated at about 260 feet based on a measured

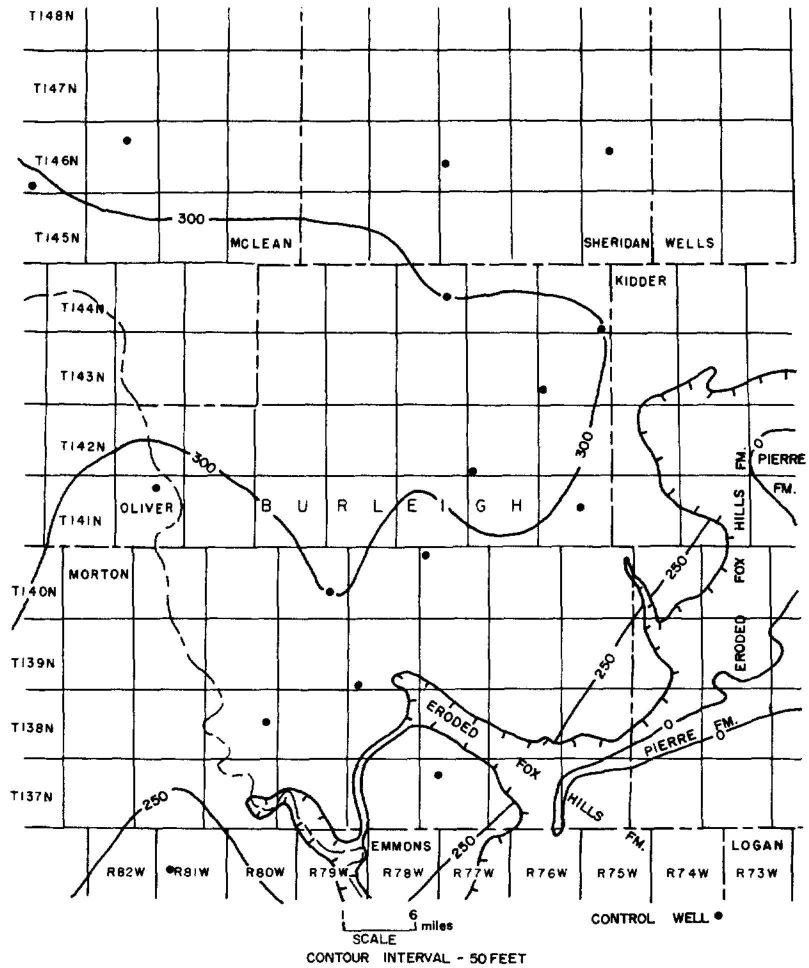

Figure 13. Isopach map of the Fox Hills Formation.

section in the SW 1/4 SE 1/4 sec. 26, T. 138 N., R. 80 W. and test hole 1857 two miles to the south. Eighty feet of the upper part of the Hell Creek Formation is exposed, and the contact with the overlying Tertiary Ludlow-Cannonball Formations is at an elevation of 1730 feet. The contact with the underlying Fox Hills Formation is at an elevation of 1467 feet in the test hole.

The formation contacts are conformable and gradational and have been placed at thin marker beds of lignite, lignitic shale, or carbonaceous shale. The lower contact is at the base of the "last lignite" of the Hell Creek Formation and the upper contact is at the base of the "first lignite" of the Ludlow.

Tertiary Rocks

PALEOCENE SERIES – FORT UNION GROUP

The Fort Union Group (Dorf, 1940) includes the Ludlow, Cannonball, and Tongue River Formations, all three of which are exposed in Burleigh County.

Ludlow Formation

The Ludlow Formation, a continental formation of Paleocene age, is exposed in southwestern and south-central Burleigh County. Although it occurs in areas where the upper part of the Hell Creek Formation crops out, it is not easily shown as a separate formation on the geologic map because it is very thin. Therefore, during the surficial mapping, the Ludlow Formation was included with its marine facies equivalent, the Cannonball Formation. Outcrops of the Ludlow are in secs. 26, 34, and 35 of T. 138 N., R. 80 W.; secs. 2 and 13 of T. 137 N., R. 80 W.; secs. 31 and 33, T. 139 N., R. 79 W.; and sec. 17, T. 138 N., R. 79 W. In the subsurface the Ludlow relationships were interpreted from test holes 1935, 1984, and 2026. The Ludlow Formation in the subsurface consists of olive black, carbonaceous and lignitic siltstone and shale, lignite, and micaceous friable sandstones.

The Ludlow Formation at the surface consists of interbedded yellow and brown sandstones, brownish-gray to black shales, and lignitic beds. The sandstones are friable and may contain shale partings and ferruginous sandstone concretions. The shales are fissile, non-calcareous, and carbonaceous. Two prominent lignitic beds are exposed, the lower one is a foot thick.

The Ludlow Formation in Burleigh County generally is about 13 feet thick. South of Bismarck in the bluffs along Apple Creek in SW 1/4 SW 1/4 sec. 26, T. 138 N., R. 80 W. the Ludlow is 19 feet thick, but the entire thickness was not exposed.

The contact of the Ludlow with the Cannonball Formation is conformable and gradational. The Ludlow Formation probably interfingers with the Cannonball as suggested by carbonaceous and lignitic shales interbedded with friable sandstones and shales which are lithologically similar to the Cannonball Formation. The Ludlow Formation is thin in Burleigh County, and thickens westward to 49 feet in Morton County (Laird and Mitchell, 1942, p. 17). They also state (p. 21) that the Cannonball Formation thins westward where it is replaced by the Ludlow.

Cannonball Formation

The Cannonball Formation, a marine formation of Paleocene age, is widespread in Burleigh County, but much of it is covered by drift. The best exposures are along the Missouri River Trench and the bluffs north and south of Bismarck, Menoken, and McKenzie. The Cannonball directly underlies the glacial drift along the north county line and throughout much of the east-central part of the county. The Cannonball relationships were interpreted from 38 test holes.

The Cannonball Formation at the surface consists of interbedded yellowish-brown, yellow gray, and olive gray sandstones, siltstones, shales, and lenticular limestones. The sandstones are friable, commonly non-calcareous, except where locally cemented and indurated, contain scattered ironstone concretions and dark mineral grains, which give it a "salt and pepper" appearance. The siltstones and shales are non-calcareous, flaky to fissile, and frequently sandy.

The Cannonball in the subsurface consists of interbedded olive, greenish-black and brownish-gray claystone, sandstones, siltstones, and limestone. The sandstones are friable, glauconitic, and non-calcareous. The claystones and siltstones are non-calcareous, with much macerated plant and carbonaceous material and scattered flakes of mica.

The Cannonball Formation in northwestern Burleigh County is about 340 feet thick, based on the elevation of the contact with the Ludlow Formation in test hole 1984 and the elevation of an exposed contact with the Tongue River Formation one mile east of the test hole. In east-central Burleigh County the formation is about 275 feet thick based on test hole 1935 and an exposed contact with the Tongue River Formation 1.5 miles west of the test hole.

Elevations of the contact with the Tongue River Formation taken from test holes 1939, 1990, and 2038 as well as from many contacts in outcrops show a regional dip to the west and northwest. It is estimated that the dip generally averages 12 to 14 feet per mile. Test holes 1985 and 1990 suggest a minor syncline in the Regan area (pl. 4, cross-section $G\text{-}G^1$).

The Cannonball contact with the overlying Tongue River Formation is sharp and disconformable as shown by local scouring. Excellent exposures of this contact are at the SE corner NW 1/4 sec. 13, T. 140 N., R. 81 (fig. 15), and NE 1/4 SE 1/4 sec. 11, T. 140 N., R. 80 W. The upper part of the Cannonball Formation is a sequence of interbedded siltstones, sandstones, shales, and an occasional lenticular limestone bed. Directly overlying this sequence is a massive, cross-bedded "basal sandstone" unit of the Tongue River Formation. Lenticular accumulations of rounded shale pebbles, probably derived from the Cannonball shale are interbedded with the "basal sandstone" unit adjacent to the contact. These sediments reflect the change in sedimentation from marine sea to continental alluvial plain deposition.

Fossils from the Cannonball Formation of Burleigh County, are not abundant, but during this study collections were made from three localities. Fossils from two of these sites had previously been reported by Holland and Cvancara (1958). Fossil crabs (**Camarocarcinus arnesoni**), petrified wood fragments, and shark teeth were collected from sand blowouts along roads bordering secs. 21 and 28, T. 137 N., R. 77 W. At a third locality (NE 1/4 SE 1/4 sec. 12, T. 141 N., R. 81 W.) pelecypod fragments and abundant **Halymenites** (fig. 14) were collected.

Tongue River Formation

The Tongue River Formation, a continental formation of Paleocene age, is exposed in the west-central part of the county. It is the youngest bedrock in Burleigh County, and it is found at the higher elevations. The Tongue River is best exposed north and west of Burnt Creek especially along the dissected valley wall of the Missouri River Trench district and in the areas of Keever Butte and the West Branch of Apple Creek.

The Tongue River Formation directly underlies the glacial drift near Wilton and Regan, but in most places the drift is thin and patchy with exposures of bedrock. The subsurface Tongue River Formation stratigraphy was interpreted from test holes 1985, 1990, 2005 and 2038.

The Tongue River Formation at the surface consists of a basal sandstone unit overlain by interbedded sandstones, claystones, siltstones, shales, limestone, and lignite. The basal sandstone unit is an excellent marker and was used to map the contact of the Tongue River and Cannonball Formations. This marker unit generally gives rise to sand blowouts in roadcuts (fig. 15).

The yellowish-gray, grayish-olive, and olive gray standstones of the basal unit are mostly friable, but partly indurated by calcareous or ferruginous cement. They are generally cross-bedded, medium to fine-grained with a few lenticular, fine to very fine-grained, sandstone beds. The sandstones contain fragments of petrified wood, abundant dark mineral grains and ironstone concretions. A shale and siltstone pebble conglomerate with a sand matrix, probably derived from the Cannonball Formation, is present locally near the formation contact. The upper part of the basal sandstone unit is resistant sandstone, sandy intraformational conglomerate, and sandy limestone. A section in the NW 1/4 NE 1/4 sec. 31, T. 141 N., R. 80 W. shows the base of the resistant beds to be about 108 feet above the top of the Cannonball Formation. The resistant beds at this site are 46 feet thick but the upper part is missing because of erosion.

Overlying the basal sandstone unit are interbedded shales, claystones, and lignite. The yellowish-orange, dusky yellow, and brownish-black shales and claystones are commonly silty and calcareous, flaky to fissile, locally interbedded with sandstones, and occasionally carbonaceous with abundant plant fragments and seams of lignite. The freshwater limestone is sublithographic, argillaceous, and lenticular. Occasionally, it is stained with ferruginous material. The limestone is highly fractured and weathers into rubble.

The Tongue River Formation in the subsurface consists of a basal sandstone unit overlain by interbedded shales, claystones, siltstones, and lignite. The basal sandstone is friable except for minor indurated beds. The sands are coarser in the lower part

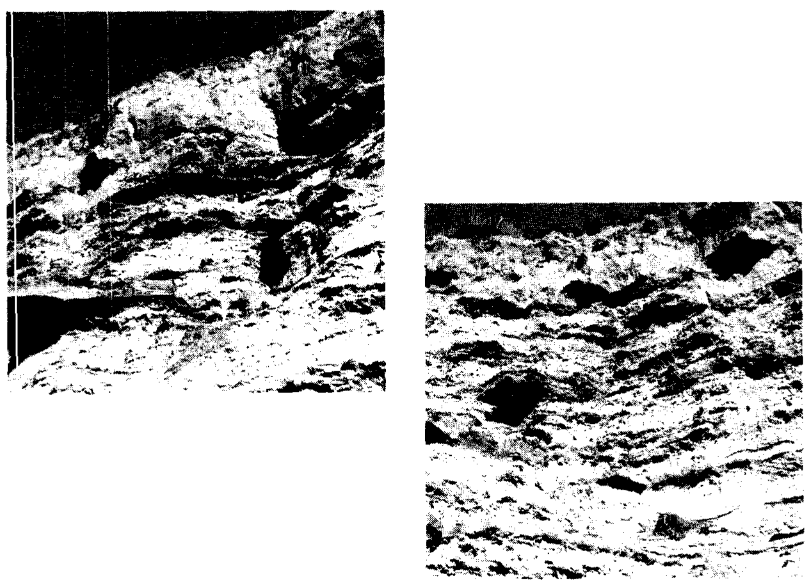

Figure 14. – Abundant **Halymenites** in lenticular sandstone and sand of the Cannonball Formation. NE 1/4 SE 1/4 sec. 12, T. 141N., R. 81W., Burleigh County.

of the formation. The yellowish-brown, olive gray, and brownish-black shales, claystones, and siltstones are soft, calcareous, and interbedded with thin lignite seams.

The Tongue River Formation in northwestern Burleigh County is represented only by the lower part of the formation. At Wilton the Tongue River Formation is 215 feet thick in test hole 1985. At Regan the Tongue River Formation is 68 feet thick in test hole 1990. Near its southern limit in Burleigh County the Tongue River Formation is 130 feet thick as shown by test hole 2038 which peneterated 105 feet of Tongue River sediments 25 feet below the top of the outcrop. This variable thickness is due to erosion of the upper part of the formation.

Fossils collected from 11 sites in the Tongue River Formation (fig. 16), include gastropods, pelecypods and ostracods. Vertebrates are represented by fish bones and teeth. Petrified wood is abundant in the basal sandstone. Tongue River fossils frequently are found in the drift and snail shells are locally abundant in gravels.

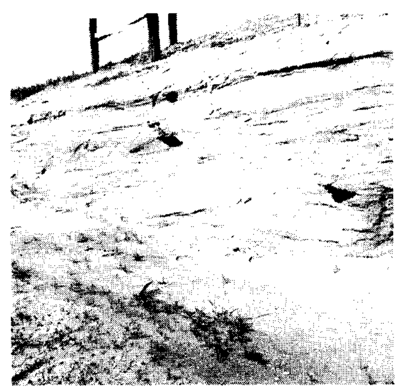

Figure 15. — Contact of the Cannonball and Tongue River Formations is at the base of shovel in left photo. SE corner NW 1/4 sec. 13, T. 140 N., R. 81, Burleigh County. Described in measured section 5-62, Appendix A.

1.	NE cor.	12-141N-80W
2.	NE cor. NW	26-141N-80W
3.	NW cor. SW	7-143N-79W
4.	NW cor. NE	12-141N-79W
5.	0.1 mi. N of SW cor.	10-142N-78W
6.	NW cor. NE	29-142N-78W
7.	0.2 mi. E of SW cor.	14-142N-78W
8.	0.2 mi. E of NW cor.	30-142N-78W
9.	SE cor.	5-142N-77W
10.	0.2 mi. N of center	33-141N-80W
11.	0.2 mi. N of SW cor.	23-141N-80W

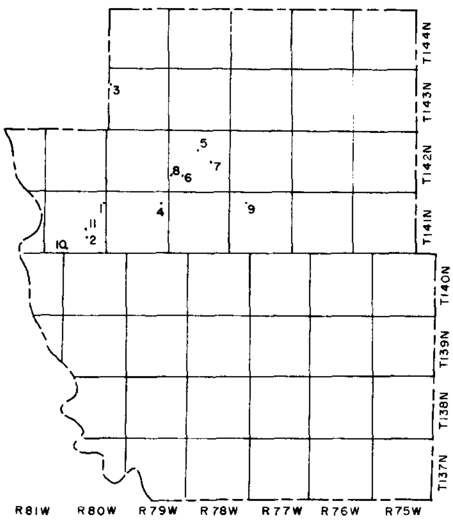

Figure 16. Locations of the Tertiary Tongue River Formation fossil sites in Burleigh County.

GLACIAL DEPOSITS

Pleistocene Series

The unit of geologic time during which glacial and post-glacial materials were deposited is the Pleistocene Epoch. The time-stratigraphic equivalent is the Pleistocene Series. In Burleigh County glacial deposits are referred to two subdivisions of the Pleistocene Epoch, the Wisconsin Age and Recent Age. The time-stratigraphic equivalents are the Wisconsin Stage and Recent Stage. Stages older than the Wisconsin may be present in the county but evidence for their recognition is lacking. Four radiocarbon dates have been obtained in Burleigh County, but correlations in Burleigh County are based mainly on comparisons with previous work in south-central North Dakota.

Wisconsin Stage

The drift sheets in Burleigh County range in age from early (?) to late (?) Wisconsin. The Napoleon Drift which overlies bedrock in western Burleigh County is early (?) Wisconsin and the Long Lake and Burnstad Drifts, are late (?) Wisconsin.

LITHOSTRATIGRAPHY

The similarity in lithology of Burleigh County drifts is shown by various analyses. Color and grain size are nearly identical, making differentiation on the basis of lithostratigraphy difficult.

Drift Analysis

Stone counts. – Thirty-four samples of pebbles from Burleigh County (fig. 17) were studied and the results are tabulated in Table 3. The pebbles were collected from fresh till surfaces containing about 100 pebbles. Pebbles of approximately one-half to one inch and larger were collected. Shale and friable lithologies were tabulated in the field and the remaining pebbles were identified later.

Limestones and dolomites are the most abundant lithology in every sample except three in which shale was the major constituent and limestones and dolomites were next. Shale was second in abundance in fourteen samples and granite was second in eleven samples.

By grouping the pebbles into limestones and dolomites, igneous and metamorphics, and local bedrock types, they can be plotted as shown in figure 18. Howard (1960, p. 39-40) used pebble analyses in differentiating individual drift sheets in northwestern North Dakota and the plots of the various drifts in Burleigh County indicate some apparently significant trends. The Napoleon Drift

Sample No.	Location
1.	SE SW 12-140N-75W
2.	NE NE 36-141N-75W
3.	NW SW 28-139N-76W
4.	SW NE 20-138N-75W
5.	NE NE 13-138N-76W
6.	SE SW 19-140N-76W
7.	SW SW 4-139N-76W
8.	SE SE 23-140N-76W
9.	NE NE 11-139N-76W
10.	NE NE NW 12-140N-76W
11.	NW NW NW 25-141N-76W
12.	NW NW 22-138N-79W
13.	NE NW 10-139N-80W
14.	NW NE 28-140N-79W
15.	SE SW SW 21-141N-75W
16.	SE NE NE 12-142N-76W
17.	SE SE NE 30-142N-75W
18.	SE SE SW 4-141N-75W
19.	SE SE NE 16-140N-77W
20.	SW SE 36-139N-75W
21.	NW NW 36-137N-75W
22.	NE NW NE 7-140N-78W
23.	NE NE SE 3-139N-79W
24.	SE SE SE 10-144N-75W
25.	NW NW NW 14-143N-76W
26.	SE SE SE 22-143N-75W
27.	NE NE SE 6-144N-76W
28.	NW NW NW 34-144N-77W
29.	SW NW SW 30-144N-77W
30.	NE NE NE 7-144N-77W
31.	SW SW NW 30-144N-79W
32.	NE NE 7-142N-79W
33.	NE NE NW 20-141N-78W
34.	SE SE SE 21-142N-78W

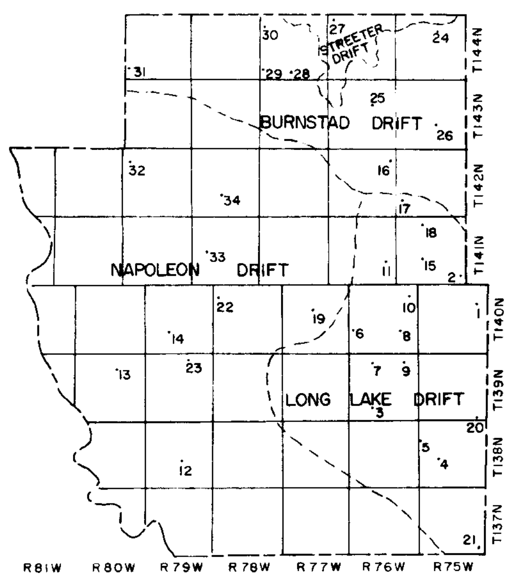

Figure 17. Drift boundaries and sample localities in Burleigh County.

is low in igneous and metamorphic pebbles, containing less than twenty-five percent and as low as five percent of this fraction, but it shows high counts of local bedrock types and limestones, probably due to the occurrence of this drift as scattered patches over bedrock. The Long Lake Drift appears transitional from a local bedrock influence to one containing more of other rock types probably due to there being fewer areas of bedrock exposures in areas of Long Lake Drift, than in areas of Napoleon Drift. The lithology of the Burnstad Drift, including the Streeter Drift, is influenced least by local bedrock.

The Long Lake Drift has a greater abundance of shale pebbles than the other drifts. This is probably due to a different direction of ice movement with the movement being from the east and north over the Cretaceous shale.

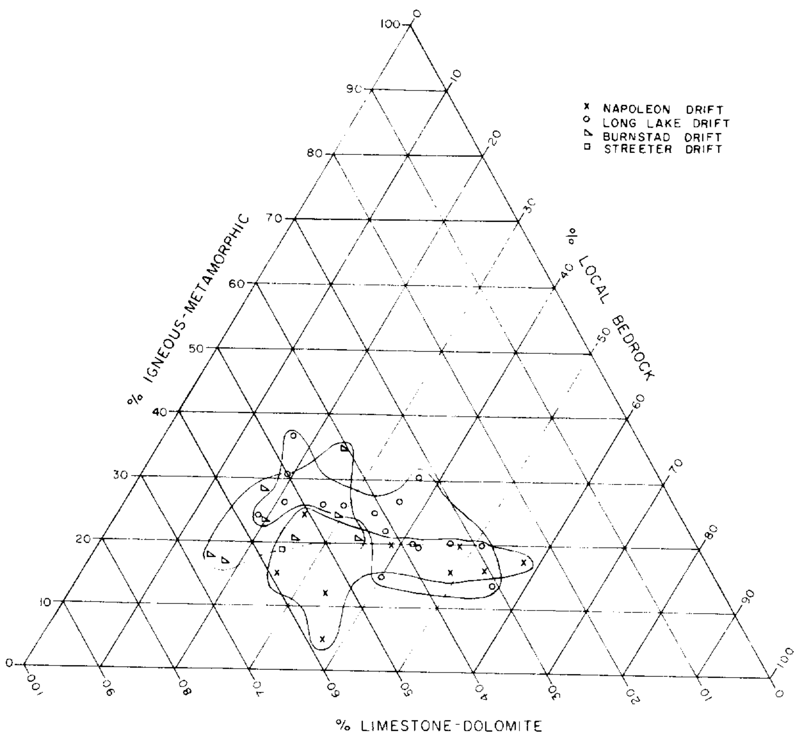

Figure 18. Triangular diagram showing pebble lithology of 34 samples in Burleigh County.

Sample No.	Granite	Quartzitic	Basic	Foliated Metamorphic	Limestone Dolomite	Sandstone	Shale	Chert	Iron Concretion	Clay	Miscellaneous	Number of Pebbles Counted
1	17.0		2.0	1.0	29.0	10.0	35.0		6.0			100
2	12.2	1.0	11.2	1.0	40.8	5.1	15.3	7.2	6.2			98
3	13.4	0.9	4.5	1.8	33.0	2.7	34.7	2.7	0.9	4.5	0.9	112
4	15.1	1.0	1.0	3.0	38.4	2.1	34.3	2.1	3.0			99
5	9.8	1.0	2.9	1.0	45.1	5.9	20.6	2.0	7.8	3.9		102
6	10.8	1.0	7.8	2.0	41.2	7.8	9.8	4.9	11.8	2.9		102
7	15.8	2.1	12.6		32.6	7.4	27.4		2.1			95
8	25.4		9.4	1.9	46.3	1.9	15.1					106
9	8.9		4.9		30.7	1.0	46.5	2.0	4.0	2.0		101
10	17.0	0.9	1.9		37.8	4.7	28.3	6.6	2.8			106
11	16.7	0.9	9.2		37.0	4.7	19.4	0.9	6.5	4.7		108
12	9.7		10.7		40.8	2.9	11.7		15.5	8.7		103
13	5.1		11.1		30.3	3.0	5.1	2.0	19.2	22.2	2.0	99
14	13.9		10.9		50.5	5.9	5.9	1.0	7.9	4.0		101
15	19.0	1.0	5.0	1.0	45.0	2.0	23.0		1.0	3.0		100
16	17.3	1.0	6.7		46.2		16.3	2.9	7.7	1.9		104
17	16.5		10.1		52.3		9.2	0.9	6.4	4.6		109
18	15.4		12.5	2.9	50.0	4.8	3.8	1.0	6.7	2.9		104
19	2.0		3.0		57.5	5.9	1.0		16.8	7.9	5.9	101
20	11.6		12.6		56.8	4.2	8.4		5.3	1.1		95
21	15.1		10.4	0.9	47.2		11.3	3.8	9.4	1.9		106
22	5.0	2.0	5.0		54.0	3.0	19.0	1.0	9.0	1.0	1.0	100
23	7.0		7.0	1.0	59.0	4.0	15.0		4.0	1.0	2.0	100
24	8.2	2.0	10.2		54.1		13.2	4.1	6.2	2.0		98
25	25.8	1.0	7.9		40.6	5.9	6.9	3.0	6.9	2.0		101
26	12.3	4.1	10.2	2.0	54.1	4.1	5.1	1.0	5.1		2.0	98
27	12.6	1.9	2.9	1.9	56.3		8.7		4.0	10.7	1.0	103
28	9.8		6.9	1.0	66.6	2.0	1.0	3.9	5.9	2.9		102
29	13.4	2.9	6.7	1.0	56.7		10.6	1.0	4.8	1.9	1.0	104
30	8.0	1.0	8.0		65.0		13.0		1.0	4.0		100
31	11.9	2.0	5.9	1.0	45.5	3.0	26.7		2.0		2.0	101
32	12.9		4.9		24.8	10.9	20.8	15.8	8.9		1.0	101
33	6.0	1.0	12.0	1.0	32.0	20.0	3.0		22.0	3.0		100
34	6.9	1.0	7.9		35.3	8.8	22.5	1.0	2.9		13.7	102

TABLE 3. – Glacial pebble analyses in Burleigh County. Lithology expressed as percent of total sample.

Grain size. – Thirty-three samples of till from Burleigh County were mechanically analyzed for grain size, using the hydrometer method to determine the silt and clay fraction and the sieve analysis for the sand fraction. Particles greater than sand size were not included in the analysis. Results are tabulated in Table 4.

Sand-silt-clay percentages were determined for thirty-three samples. Sand is most abundant in seventeen samples, silt in seven

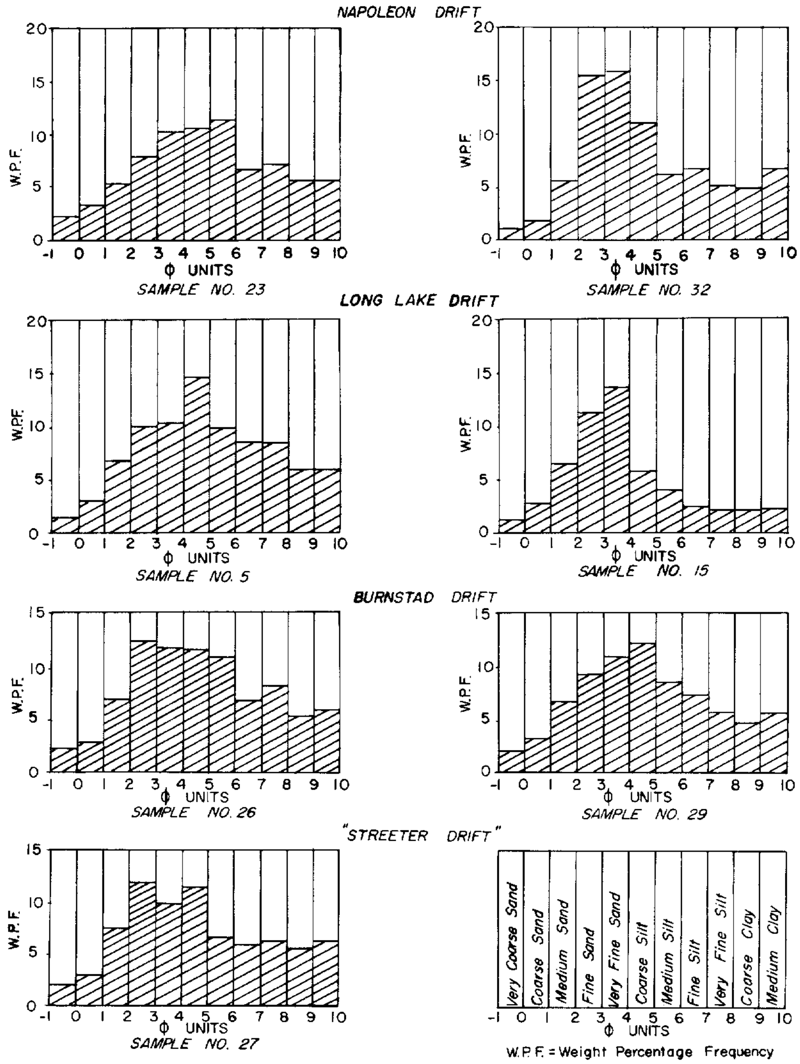

Figure 19. Histograms showing grain size frequencies in 7 samples of till in Burleigh County.

samples, and clay in nine samples. Seven of the thirty-three samples were tested for the distribution of particle sizes from very coarse sand to medium clay according to the Wentworth classification (fig. 19). One sample was highest in medium silt and two samples were highest in each of the coarse silt, fine sand, and very fine sand sizes. The sand-silt-clay ratios were plotted on triangular coordinate diagrams (fig. 20) and the results indicate little difference in grain size between the various tills.

The Napoleon Drift has four samples higher in clay than any others. Five out of nine Napoleon Drift samples had a higher percentage of clay than silt or sand. In the Long Lake Drift twelve samples out of fifteen show the sand fraction to be the greatest. The other three samples were highest in silt. In the Burnstad Drift, five out of eight samples show nearly equal sand-silt-clay ratios, and three samples were higher in sand and silt.

Shepps (1953, p. 34) used mechanical analyses to correlate multiple tills. He concluded that grain size is generally finer in the younger tills. The results of the grain size analysis in Burleigh

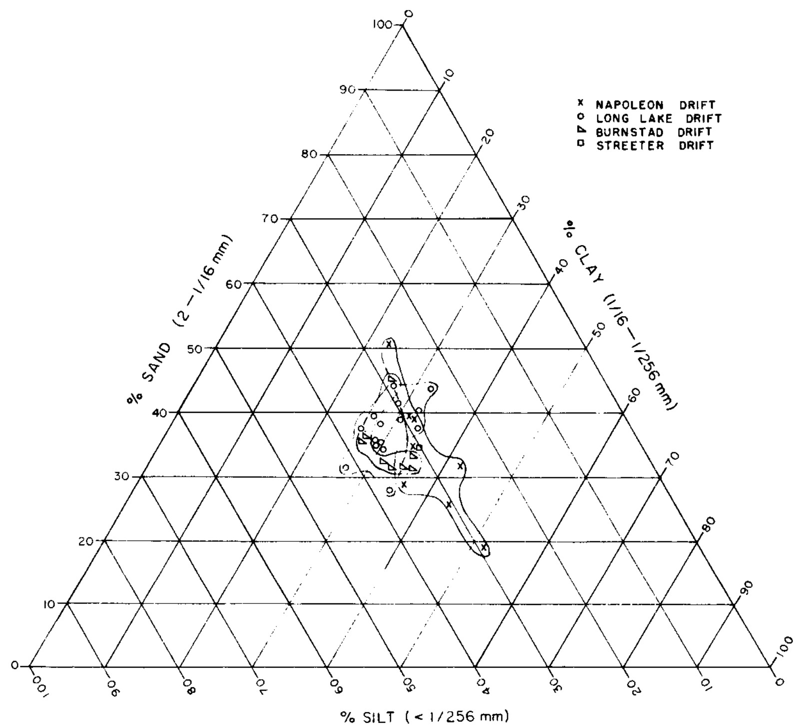

Figure 20. Triangular diagram showing grain size composition of 33 till samples in Burleigh County.

Sample No.	Sand	Silt	Clay	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand	Coarse Silt	Medium Silt	Fine Silt	Very Fine Silt	Coarse Clay	Medium Clay
1	36.0	35.5	28.5											
2	44.0	29.0	27.0											
3	39.8	34.0	26.2											
4	35.9	34.7	29.4											
5	31.7	41.6	26.7	1.4	3.1	6.8	10.1	10.3	14.7	9.9	8.5	8.5	5.9	5.9
6	39.8	27.4	32.8											
7	34.4	35.8	29.8											
8	41.2	29.8	29.0											
9	37.8	28.7	33.5											
11	39.0	30.2	30.8											
12	34.2	31.2	34.6											
13	18.9	29.8	51.3											
14	31.5	26.2	42.3											
15	35.5	35.3	29.2	1.3	2.8	6.4	11.3	13.7	5.8	4.0	2.5	2.2	2.2	2.3
16	36.7	36.6	26.7											
17	38.4	33.6	28.0											
18	43.9	23.8	32.3											
19	25.6	30.6	43.8											
20	28.1	37.4	34.5											
21	38.0	36.5	25.5											
22	50.4	26.1	23.5											
23	28.9	35.9	35.2	2.2	3.3	5.3	7.9	10.2	10.7	11.3	6.7	7.1	5.6	5.6
24	32.1	35.0	32.9											
25	45.0	28.4	26.6											
26	36.0	37.3	26.7	2.2	2.8	6.9	12.3	11.8	11.7	10.8	6.7	8.1	5.2	5.9
27	34.2	30.6	35.2	2.0	2.9	7.5	11.9	9.9	11.5	6.7	5.9	6.3	5.7	6.3
28	33.6	31.2	35.2											
29	31.9	33.6	34.5	2.0	3.2	6.6	9.2	10.9	12.2	8.5	7.3	5.7	4.7	5.7
30	32.5	36.0	31.5											
31	30.9	33.9	35.2											
32	39.5	29.0	31.5	1.0	1.7	5.6	15.4	15.8	10.9	6.2	6.7	5.1	4.9	6.7
33	23.3	26.8	49.9											
34	39.4	29.0	31.6											

TABLE 4. – Grain size analyses of till in Burleigh County. Grain size expressed as percent of total sample.

County do not agree with this conclusion, as the older Napoleon Drift has more samples with a higher percentage of clay than do the younger Long Lake and Burnstad drifts. However, this does not necessarily refute his conclusions, as the number of analyses run in Burleigh County were probably not enough to adequately test his hypothesis. However, it is suggested that the grain size of the tills in Burleigh County are probably influenced more by local bedrock than by age of the tills.

Pebble orientation. — Orientation of pebbles was observed in a till exposure southeast of Wilton in NE 1/4 sec. 7, T. 142 N., R. 79 W. This site is a relatively flat upland in sheet moraine. The analysis is based on the orientation of 100 pebbles whose long axis measured at last twice the short axis. The preferred orientation is in a northeast direction. Holmes (1941, p. 1301) demonstrated that the long axes of pebbles tend to parallel the direction of ice flow. The ice flow in the Wilton area was from the northeast based on the pebble orientation. Lineations in the drift, and the drift borders provide further evidence to support this conclusion.

Composition of Drift

Till. — Till consists of sediments deposited directly by glacial ice and composed of unsorted, unstratified, and heterogeneous materials whose particle size ranges from boulder to clay.

The till in Burleigh County is generally light olive gray (5Y 5/2) when wet, and yellowish-gray (5Y 7/2) when dry, and is oxidized to depths of 20 to 30 feet. It is generally compact with joints absent or poorly developed. The zone immediately beneath the upper soil horizon frequently has a mottled appearance due to the concentrations of calcium carbonate and the undersides of free cobbles and pebbles are frequently encrusted with caliche. Rounded shale particles from sand to pebble size and lignite fragments are common. Boulder, cobble, and pebble content of the till is estimated at five percent, so the major fraction consists of sand, silt, and clay.

Boulders, common on the till surface, are relatively more numerous in eastern Burleigh County. Most of the boulders are granite, a few were derived from basic and metamorphic rocks. Boulders derived from local sandstones and siliceous rocks are generally rare except near bedrock outcrops. Limestone and dolomite boulders are occasionally found in eastern Burleigh County, but rarely in the west.

Glaciofluvial sediments. — Sediments deposited by meltwater streams and composed of washed, sorted, and stratified materials consisting mostly of sand and gravel, are classified as glaciofluvial sediments. Outwash, when used to mean any washed drift, is synonymous with glaciofluvial sediments.

The glaciofluvial sediments in Burleigh County are composed mainly of stratified sands and gravels. The size range is from fine sand to pebbles with coarse sand predominant.

The pebble composition is similar to that of till but with fewer shale pebbles. Boulders are rare in proglacial outwash but in ice-contact outwash deposits, boulders are quite common. Collapsed outwash and other ice-contact outwash deposits generally consist of poorly sorted boulders, cobbles, gravel, and sand. In ice-contact outwash the grain size generally ranges from granules to pebbles.

Glaciolacustrine sediments. – Sediments deposited in ice-walled, ice-marginal, or proglacial lakes, composed mostly of washed, sorted, and stratified materials consisting chiefly of silts and clays, are glaciolacustrine sediments.

The glaciolacustrine sediments in Burleigh County when moist and unoxidized are dark greenish-gray (5GY 4/1), olive gray (5Y 3/2) and medium bluish-gray (5B 5/1). The moist and oxidized sediments are dark yellow brown (10YR 4/2) and light olive gray (5Y 5/2). The sediments are mostly calcareous silts and clays in beds less than one inch thick.

MORPHOSTRATIGRAPHY

The drifts in Burleigh County are recognized by their surface form, geographic position, and inferred geologic history. The morphostratigraphic unit as proposed by Frye and Willman (1962, p. 112-113) was modified by Clayton (1962, p. 53). In this report a glacial morphostratigraphic unit is defined as a body of drift identified by its surface form and position, consisting of all the drift deposited by significant glacial advance. The basic unit is a drift rather than a moraine, although the glacial morphostratigraphic unit is generally named and identified by the major moraine with which it is associated. The three glacial morphostratigraphic units in Burleigh County are the Napoleon Drift, Long Lake Drift and Burnstad Drift.

Napoleon Drift

The Napoleon Drift was proposed as a morphostratigraphic unit by Clayton (1962, p. 56) who designated the type area in western Logan County. The Napoleon Drift covers portions of west and central Burleigh County. This glacial morphostratigraphic unit is recognized as chiefly sheet moraine, located in front of younger drifts to the north and east. The topography is that of a rugged, stream-dissected, bedrock upland with integrated drainage. Frequently, boulders provide the only evidence of former glacial activity.

Correlation. – The correlation of the Napoleon Drift has been discussed in detail by Clayton (1962, p. 59). Briefly, his correlations are: (1) morphostratigraphically with the "Tazewell (?)" drift of Lemke and Colton (1958, p. 47 and fig. 3); and (2) time-stratigraphically with the lower part of the Wisconsin Stage, because it is slightly weathered, has integrated drainage, is radiocarbon dated at older than 38,000 years (W-990), and is correlative with the Tazewell of South Dakota. The Napoleon may also be as young as 28,700 years (W-1045) which would place it in upper Wisconsin. Fossil gastropod and pelecypod shells in Napoleon glaciofluvial sediments have been dated at greater than 38,000 years (W-1433) in NE1/4 SW1/4 SW1/4 sec. 34, T. 139 N., R. 79 W. Burleigh County. Some reworked shells from the Tongue River Formation were present with the Pleistocene shells. An attempt was made to obtain only a Pleistocene shell collection, however, there exists the possibility of older shells in the sample.

A lower jaw of a large Pleistocene horse was found in Napoleon outwash by Dan E. Hansen, about six miles east of Bismarck, in SW1/4 NW1/4 sec. 35, T. 139 N., R. 79 W. (fig. 21). The jaw was identified by C. W. Hibbard of the University of Michigan (letters dated Jan. 29 and Feb. 26, 1962) as **Equus hatcheri** Hay (University of Michigan, Museum of Paleontology number 44573). Hibbard stated in his first letter that, "It seems to fit best with the late Kansan to Illinoian horses I have seen." In his second letter he states, "There is no reason why the large horse could not be Wisconsin. I have taken the large horses from Sangamon deposits. I have never taken it later, but James Quinn described one (**Equus scotti**) from a Wisconsin deposit in West Texas." Although the jaw fragment was found in Napoleon Drift, it is conceivable that it could have been derived from earlier deposits and may be of pre-Wisconsin age.

Long Lake Drift

The Long Lake Drift was proposed as a morphostratigraphic unit by Clayton (1962, p. 61) who designated the type area in the northwest corner of Logan County. The Long Lake Drift in Burleigh County is in the eastern part. This glacial morphostratigraphic unit is recognized as mainly end moraine and ground moraine, located between the Napoleon Drift and the Burnstad Drift. The topography is mainly due to glacial construction but several bedrock highs account for part of the surface relief. The Long Lake Drift is also distinguished from the Napoleon Drift on the basis of drainage development which is not completely integrated.

Correlation. — The correlation of the Long Lake Drift has been discussed by Clayton (1962, p. 62). Briefly, his correlations are: (1) morphostratigraphically with no other drift, although it may be correlative with the Zeeland Drift in southern McIntosh County; and (2) time-stratigraphically with the upper part of the

Wisconsin Stage, because it is overlapped by, and therefore older than the Burnstad or 11,500 years, and because it lacks integrated drainage. The Long Lake Drift probably is 12,000 to 13,000 years old.

The north loop of the Long Lake end moraine is truncated by Burnstad dead-ice moraine. This truncation has been interpreted as an overlap due to a significant readvance of Burnstad ice,

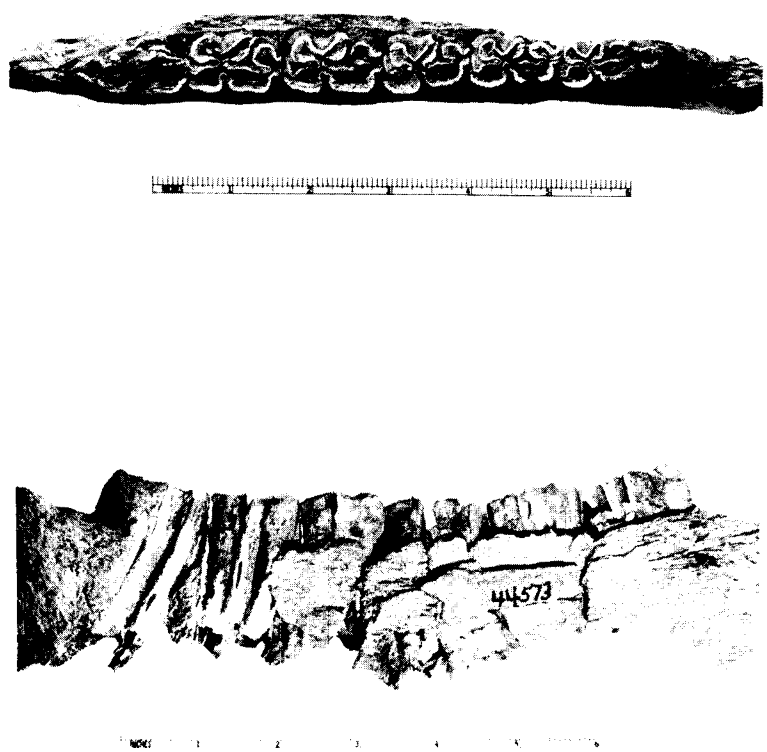

Figure 21. – Horsejaw of a large Pleistocene horse **(Equus hatcheri)** found in Napoleon Drift, SW1/4 NW1/4 sec. 35, T. 139 N., R. 79 W., Burleigh County (photo courtesy of C. W. Hibbard, Univ. Michigan).

(Clayton, 1962, p. 62-63), but the overlap may represent a minor readvance or an adjustment of the Long Lake glacier.

Burnstad Drift

The Burnstad Drift was proposed as a morphostratigraphic unit by Clayton (1962, p. 62-63) who designated the type area in west-central Logan County. The Burnstad Drift in Burleigh County is mostly in the north. This glacial morphostratigraphic unit is recognized as chiefly dead-ice moraine with collapsed outwash topography behind the Napoleon and Long Lake Drifts. Probably the main basis for distinguishing the Burnstad Drift is its inferred geologic history. It is distinguished from the Napoleon and Long Lake Drifts because it has non-integrated drainage. The topography is mainly due to glacial stagnation construction, but bedrock highs are a factor along its southern border. The prominent ridged Streeter end moraine is in the northeastern part of the county adjacent to the Burnstad dead-ice moraine. The Streeter Drift has been included in the Burnstad Drift by Clayton (1962, p. 63). Briefly, his reasons are: (1) these deposits are from a single significant advance which included the minor Streeter advance; (2) lithology and topography are similar; and (3) stagnant ice existed in front of the Streeter moraine while it was being formed. In Burleigh County Streeter collapsed outwash topography on the distal side of the Florence Lake loop overlies Burnstad dead-ice moraine. The Burnstad end moraine is not present in Burleigh County.

Correlation. — The correlation of the Burnstad Drift has been discussed by Clayton (1962, p. 66-68). Briefly, his correlations are: (1) morphostratigraphically with the "post-Tazewell-pre-Two Creeks" and "post-Cary maximum advance no. 1" of Lemke and Colton (1958, figure 3 and 4) and with the "Mankato" drift of Flint (1955, pl. 1); and (2) time-stratigraphically with the upper part of the Wisconsin Stage because of several radiocarbon dates which range from 11,650 $\pm$ 310 years (W-974) to 9,000 $\pm$ 300 years (W-1019).

Two radiocarbon age determinations by the U. S. Geological Survey on gastropod and pelecypod shells in Burleigh County Burnstad Drift gave ages of 9,990 $\pm$ 300 years B. P. (W-1436) in sec. 19, T. 143 N., R. 75 W. (site 10 in the section on fossils) and 10,100 $\pm$ 300 years B. P. (W-1434) in sec. 12, T. 144 N., R. 79 W. (site 8 in the section on fossils).

An alternate interpretation of the inferred glacial history has been discussed by Rau, and others, (1962, p. 27-32). Briefly, their interpretations are: (1) the south loop of Long Lake end moraine is truncated by Burnstad Drift; (2) Burnstad Drift is overlapped by the Lake George end moraine loop of the Streeter Drift; (3) Streeter Drift is bordered on the south by Burnstad Drift and on the west by Long Lake Drift; and (4) dead-ice moraine between the Long Lake end moraine and the Streeter end moraine is Streeter Drift.

Recent Stage

Sediments deposited in Burleigh County during the Recent Stage are generally difficult to distinguish from the postglacial Wisconsin Stage sediments. Recent sediments occur as alluvium in shallow depressions, sloughs, lakes, and floodplains. The floodplain alluvium of the Missouri River consists of channel bars and meander bars, formed and continually being modified by present stream action. The alluvium is composed mostly of sand, silt and clay. Postglacial eolian sand is probably Wisconsin and Recent. Sheetwash and colluvium deposits are Recent.

DRAINAGE HISTORY

Existing Drainage

The present integrated drainage system in south-central North Dakota consists of the Missouri River and its tributaries. The Missouri River tributary pattern is asymmetrical. The well-developed western tributaries in the Glaciated Missouri Slope district include the Knife, Heart, and Cannonball Rivers. The under-developed eastern tributaries in the Coteau Slope district are Snake Creek, Painted Woods Creek, Burnt Creek, Apple Creek, and Badger Creek. The drainage of the Missouri Coteau district is non-integrated.

MISSOURI RIVER

The drainage history of the Missouri River has been discussed by various workers (Warren, 1869; Leonard, 1912b; Todd, 1914; Alden, 1932; Benson, 1952; Flint, 1955; Howard, 1960; and Simpson, 1960) and a brief summary will be presented here.

The ancestral Missouri River flowed northeastward from the northwestern corner of North Dakota into Hudson Bay. As the continental glacial ice sheet advanced from the north the ancestral Missouri River was blocked, assumed an ice-marginal position, and was diverted to the southeast. The present channel of the Missouri River comprises segments representing preexisting river channels and segments of superposed drainage divide channels (pls. 7 and 8). The drainage divide channel segments are narrow, youthful valleys, whereas the preexisting river channel segments are broader, more mature valleys. The major preglacial drainage divides are shown on plate 7. The diverted Missouri River has captured many east flowing rivers on the Missouri Plateau of North and South Dakota. This has resulted in a one sided pattern of tributaries. This present channel probably was the second major diversion of the ice-marginal drainage in south-central North Dakota. Earlier the Missouri River had been diverted through a channel existing in Morton and Mercer Counties along Big Muddy Creek and Elm Creek.

Preexisting Drainage

The preexisting drainage in south-central North Dakota consisted of the preglacial and pre-Wisconsin drainage (pls. 3 and 7), and the diversion and Wisconsin drainage (pl. 8). In this report new names and definitions are applied to many of these channels for ease of discussion. A few of the channel names have been adapted from previous publications, but all of the channels have been redefined or extended in this report. The drainage in Burleigh County will be discussed in detail, that outside of the county will be mentioned briefly.

The preglacial and pre-Wisconsin drainage of south-central North Dakota consisted of the ancestral Knife River, Cannonball River, and Grand River systems (pl. 7). The ancestral Knife River system extends from McLean County into Sheridan and Burleigh Counties. The Cannonball River system including the smaller ancestral Heart River system, can be traced from Morton County across Burleigh and Kidder Counties and into Stutsman County. The Grand River system (Flint, 1955) in South Dakota has several upper branches in Sioux, Emmons, Logan, and McIntosh Counties in North Dakota. According to previous workers these three major ancestral river systems eventually flowed eastward and northward toward Hudson Bay. This study supports that conclusion.

The diversion and Wisconsin meltwater drainage of south-central North Dakota (pl. 8) comprises two major diversions of the Missouri River and numerous meltwater channels. The ice-marginal or diversion drainage roughly parallels the limit of glaciation. The first major diversion in a channel cut in bedrock extends from the Knife River through Elm Creek Valley, southeastward and into Big Muddy Creek Valley. Initially this water then flowed through the Strasburg Channel system. Later the water flowed through the Porcupine Creek Channel system when the ice front covered the Strasburg Channel and filled it with till. In the second major diversion along the present course of the Missouri River, Wisconsin meltwater flowed into the Missouri River through the following channels: Turtle Creek, Painted Woods Creek, Burnt Creek, Apple Creek, Heart River, Random Creek, Glencoe, Cannonball River, Badger Creek, Clear Creek, and Beaver Creek Channels.

ANCESTRAL KNIFE RIVER SYSTEM

The ancestral Knife River system as shown on plate 7 includes the present Knife River and the following channels: Knife River, Painted Woods Creek, Garrison, and Snake Creek Channels. A major preglacial drainage divide in Oliver, Burleigh, and Kidder Counties separated this drainage system from the ancestral Cannonball River system to the south. The course of the east flowing ancestral Knife River changes abruptly northward as it passes through the bedrock escarpment of the Missouri Plateau at Lincoln Valley in Sheridan County.

Painted Woods Creek Channel. – In northwestern Burleigh County the only channel of the ancestral Knife River system is here referred to as the Painted Woods Creek Channel. Topographically, it is a meltwater channel which ranges from about a quarter of a mile to two miles wide and contains valley outwash. The floodplain is about 110 feet below adjacent high ground. Test hole data show that the channel contains a thin fill of outwash and till ranging in thickness from 20 to 66 feet. The valley of Painted Woods Creek is a small part of a broad bedrock swale in northern Burleigh County (pl. 3), in the Cannonball Formation. Painted Woods Creek Channel probably consisted of two minor tributary segments of the ancestral Knife River (pls. 3 and 7). The valley of Painted Woods Creek was a Wisconsin meltwater channel (pl. 8).

ANCESTRAL CANNONBALL RIVER SYSTEM

The ancestral Cannonball River System as shown on plate 7 includes the Cannonball River, Heart River, Little Heart River, Sweetbriar Creek, and Square Butte Creek, and the following channels: Badger Creek, Apple Creek, Random Creek, Glencoe, Heart River, Sibley Butte, Rice Lake, Cannonball River, Big Muddy Creek, Logan, and Wing. A major preglacial drainage divide in Sioux, Emmons, and Logan Counties separated this drainage system from the ancestral Grand River system (pl. 7). The ancestral Cannonball River flowed northeastward from Sioux and Grant Counties across Burleigh and Kidder Counties into Stutsman County.

Badger Creek Channel. – A large abandoned valley occupied in part by the underfit Badger Creek is here named Badger Creek Channel. The valley can be traced from the Missouri River, across the northwestern corner of Emmons County, and into southeastern Burleigh County, with a small segment southwest of Long Lake. The valley walls have from 200 to 300 feet of local relief. The valley fill consists mostly of lake sediments and outwash deposits with minor surficial alluvium. Dune sand occurs along the Burleigh-Emmons County line. Test hole data indicates a thick valley fill (pl. 4, cross-section, A-A^1), ranging in thickness from 30 to 179 feet. The bedrock valley floor in the Long Lake area is the Cretaceous Pierre Formation, and the valley walls are cut into the Cretaceous Fox Hills Formation. In Emmons County the bedrock valley floor and walls are both cut in the Fox Hills Formation. Badger Creek Channel probably was a segment of the main channel of the ancestral Cannonball River. During the Wisconsin, Badger Creek

Channel was a significant meltwater channel from Glacial Long Lake (pl. 8).

Glencoe Channel. — A large abandoned valley which has poorly developed surface drainage is here named Glencoe Channel. It extends from the northwestern corner of Emmons County northward to McKenzie Slough in south-central Burleigh County. The valley floor is about 100 feet below adjacent high ground. The valley fill consists mostly of lake sediments and outwash deposits with minor surficial alluvium. Dune sand and other wind blown deposits are common in the central and lower valley. Test hole data has shown a thick valley fill of outwash composed mostly of sand and gravel but also much silt and clay, ranging in thickness from 57 to 221 feet. It is commonly over 175 feet thick. The valley, in its deepest part, is cut into the Cretaceous Fox Hills Formation and the adjacent valley walls are Hell Creek. Glencoe Channel probably was a tributary of the ancestral Heart River. During the Wisconsin, Glencoe Channel was a significant meltwater channel draining into Glacial Lake McKenzie.

Heart River Channel. — In the southern part of Burleigh County several valleys which are occupied in part by Apple, Random, and Long Lake Creeks are here referred to as the Heart River Channel. Some of the valleys are abandoned and have poorly developed surface drainage. In the McKenzie Slough area the exact position of the Heart River channel is obscured by the overlying lake plain. This channel can be traced from the present mouth of the Heart River in Morton County eastward toward McKenzie in Apple Creek valley and southeastward to Long Lake at Moffit (pl. 4, cross-section J-J[1]). In the Lake McKenzie Basin, test hole data indicate that the ancestral Heart River had two separate channels. The western channel is associated with the Glencoe tributary (pl. 7). The valley floor is about 100 feet below the adjacent high ground except in Lake McKenzie Basin which is a plain of low relief. The valley fill consists mostly of lake sediments and outwash deposits with minor floodplain alluvium along present streams. Test hole data reveal thick valley fill (pl. 4, cross-sections H-H[1] and D-D[1] composed mostly of clay and silt with variable amounts of sand and gravel. The fill ranges in thickness from 105 to 245 feet, but it is generally about 150 to 200 feet thick. The bedrock valley is cut into the Cretaceous Fox Hills Formation in the Lake McKenzie Basin area and into the Hell Creek Formation to the west. The Heart River Channel probably was a segment of the main channel used by the ancestral Heart River from Morton County to its former junction at Long Lake with the ancestral Cannonball River.

Apple Creek Channel. — In the central part of Burleigh County the bedrock valley of Apple Creek coincides with much of its present valley and is here named Apple Creek Channel. The channel begins in a broad bedrock valley of Lake McKenzie Basin and narrows quickly upstream along the branches of Apple Creek. The floodplain is about 200 feet below the adjacent high ground. Test hole data indicate a valley fill of outwash and alluvium ranging in thickness from 23 to 71 feet. The valley is cut into the Hell Creek and Cannonball Formations. Apple Creek Channel probably was a minor tributary of the ancestral Heart River but part of the configuration of its bedrock valley can be attributed to cutting by Wisconsin meltwater. The ancestral Heart River drainage was well-developed in the West Branch of Apple Creek, but the East Branch was a shorter tributary. The present upper part of East Branch formerly drained through Rice Lake Channel, but during the Wisconsin the direction of flow was reversed (pls. 7 and 8).

Random Creek Channel. – South of Sterling in Burleigh County a meltwater channel containing outwash and presently occupied by Random Creek is here named Random Creek Channel. The maximum local relief of the valley walls is about 150 feet where it cuts the Long Lake end moraine. Test hole data show that the valley fill is thick near its junction with the Heart River Channel in the Lake McKenzie Basin, but it thins markedly eastward from 127 feet to as little as 5 feet thick. The valley is cut into the Hell Creek Formation. Random Creek Channel probably was a minor tributary of the ancestral Heart River. During the Wisconsin, Random Creek Channel was a significant meltwater channel (pl. 8).

Cannonball River Channel. – A channel can be traced from its junction with the Heart River and Badger Creek Channels at Long Lake in Burleigh County, northeastward across Kidder County into Stutsman County, and is here referred to as the Cannonball River Channel. Topographically, it initially appears as an abandoned valley occupied by Long Lake, followed by a chain of kettles, until it finally loses its topographic expression where it passes beneath the drift in the Missouri Coteau district. The valley floor is about 100 feet below adjacent high ground. Test hole data have shown that the valley fill is from 124 to 168 feet thick (pl. 4, cross-section B-B[1]). In Kidder County, Rau, and others (1962, p. 37) reported valley fill up to 300 feet thick. The bedrock valley floor is cut into the Cretaceous Pierre Formation and the adjacent walls are cut into the Fox Hills Formation. The Cannonball River Channel probably was the former main channel of the ancestral Cannonball River. During the Wisconsin, part of the Cannonball River Channel was a significant spillway.

Sibley Butte Channel. – A channel in western Kidder County curves across the county line into Burleigh and is here named Sibley Butte Channel. Topographically, it is a partly buried valley filled with till, with local relief from about 35 to 100 feet. In Burleigh County test hole data indicate valley fill ranging in thickness from 136 to 184 feet, composed of till, sand, and gravel. The valley is cut into the Fox Hills and Hell Creek Formations. Sibley Butte Channel, probably a tributary of the ancestral Cannonball River, was filled with drift during the Wisconsin.

Rice Lake Channel. — A short channel extending from eastern Burleigh County into Kidder County is here named the Rice Lake Channel. It comprises an upper part of the East Branch of Apple Creek, an outwash channel, and a buried channel beneath the Long Lake moraine. The local relief varies from about 50 to 100 feet. According to test hole data the valley fill of till, sand, and gravel, ranges from 74 to 105 feet thick. The valley is cut into the Hell Creek and Cannonball Formations. Rice Lake Channel probably was a tributary of the Sibley Butte Channel of the ancestral Cannonball River system. During the Wisconsin, Rice Lake Channel was partly filled with drift.

Wing Channel. — A channel can be traced from eastern Kidder County to northeastern Burleigh County and is here referred to as the Wing Channel. The Wing Channel in Burleigh County comprises at least three kettle chains. The local relief is about 100 feet. The valley fill of till, sand, and gravel, ranges from 112 to 197 feet thick as shown by test drilling. The bedrock valley is cut into the Hell Creek and Cannonball Formations. The preexisting Wing River drainage probably was a tributary of the ancestral Cannonball River. During the Wisconsin, the Wing Channel was filled with drift.

Little Heart River Channel. — South of Bismarck a short buried channel can be traced beneath the outwash and alluvial terraces and is here named the Little Heart River Channel (pls. 3 and 7). The valley fill is mostly sand and gravel about 125 to 170 feet thick.

ANCESTRAL GRAND RIVER SYSTEM

The ancestral Grand River system shown on plate 7 includes the Grand River, Porcupine Creek, Beaver Creek, Sand Creek, Clear Creek, Cattail Creek, Little Beaver Creek, and Strasburg Channel. The ancestral Grand River can be traced from Logan, McIntosh, Emmons, and Sioux Counties in North Dakota into the ancestral Cheyenne River in north-central South Dakota.

Synthesis of Drainage History

The preglacial and pre-Wisconsin river systems of south-central North Dakota included the ancestral Knife River, Cannonball River, and Grand River systems. These three river systems flowed east on the Missouri Plateau slope, through the Missouri Plateau escarpment, and north into Hudson Bay.

During glaciation as the ice sheet encountered these rivers it blocked them, ponding water in the channels. With further glacial encroachment these drainage systems became partly to completely filled with drift and the direction of the drainage was reversed as the channels carried meltwater away from the ablating glacier. Interfluves across preglacial and pre-Wisconsin drainage divides were cut by the diverted meltwater. The new drainage took a southerly course near the outer glacial margin.

The ancestral Missouri River was initially diverted through the valleys of Elm Creek and Big Muddy Creek and through the Strasburg Channel system. When the glacier advanced and buried the Strasburg Channel, the water flowed through the Porcupine Creek Channel system. The second major diversion of the Missouri River along its present course is nearer the Wisconsin morainal belt in the Missouri Coteau district. Wisconsin meltwater flowed into the diverted Missouri River through numerous channels in the Coteau Slope district.

SYNTHESIS OF PLEISTOCENE HISTORY

Pre-Wisconsin Ages

No evidence for glaciation older than the Wisconsin Age was found in Burleigh County. Since the limit of glaciation in south-central North Dakota is some distance west and southwest of Burleigh County (pl. 8), it is conceivable that at least one earlier glacier spread over this area but evidence is lacking to establish which glaciation occurred.

The preglacial and pre-Wisconsin drainage in Burleigh County consisted of the ancestral Knife River system and the ancestral Cannonball River system (pl. 7). The drainage flowed east and north into Hudson Bay cutting many deep channels into bedrock.

Wisconsin Age

Wisconsin Age ice advanced four times into Burleigh County. The Napoleon advance was the first followed by the Long Lake, Burnstad, and Streeter advances. Except for the Burnstad Drift, radiocarbon dating of these advances in Burleigh County is yet to be established, but it is assumed they are equivalent to the sequence of glacial advances in Logan and McIntosh Counties where several radiocarbon dates have been determined.

The Wisconsin drainage in Burleigh County consisted of the Missouri River and various meltwater channels (pl. 8). The meltwater streams reoccupied many of the preexisting channels but the stream flow was in the opposite direction from that of the preglacial drainage. The integrated Wisconsin drainage flowed to the south. Many of the preexisting channels became partly filled with glaciolacustrine and glaciofluvial sediments.

NAPOLEON GLACIAL ADVANCE

During the Wisconsin glaciation the Napoleon glacier advanced across Burleigh County and deposited sheet moraine upon a stream-eroded bedrock topography (fig. 22) probably over 38,000 years ago, but perhaps as recently as 28,700 years ago. By this time the ancestral Missouri River had been diverted and carried meltwater from the ablating Napoleon ice. The meltwater flowed through the Heart River, Glencoe, and Badger Creek Channels which were being partly filled with outwash. The Napoleon advance probably didn't continue for an extended period as suggested by the uniformly thin till and by the lack of constructional features such as end moraines.

Following the Napoleon advance was a period of glacial recession and erosion in Burleigh County. Clayton (1962, p. 70) assumed that this period lasted over 25,000 years, but in Burleigh County the Napoleon till is not extensively eroded or weathered, and in many respects is quite similar lithostratigraphically to Long Lake and Burnstad tills, so it may not have lasted that long. Locally where drainage is well-developed, much of the Napoleon till has been eroded, but part of this erosion is postglacial.

LONG LAKE GLACIAL ADVANCE

The Long Lake glacier advanced into eastern and northern Burleigh County about 12,000 to 13,000 years ago (fig. 23). End moraine was deposited in the eastern part of the county, and as the ice receded it became more lobate and formed three distinct loops of end moraine. The moraine in the northern part of the county was later overridden by the Burnstad advance.

Meltwater from the ablating Long Lake ice flowed through the Burnt Creek, Apple Creek, Heart River, and Badger Creek Channels partly filling them with outwash. Outwash was also being transported to the Missouri River and to the newly formed Glacial Lake McKenzie. This proglacial lake formed on the distal side of the south and middle lobes of ice. Spillways from the lake drained through the Heart River, Glencoe, and Badger Creek Channels. Glacial Lake McKenzie could have been formed, in part, by the damming of the Missouri River as the Zeeland glacier advanced over the Strasburg Channel in Emmons County. The ponding probably was caused partly by the filling of the spillways with outwash.

The Long Lake glacial advance probably lasted only a short period of time.

BURNSTAD GLACIAL ADVANCE

The Burnstad glacier advanced into northern Burleigh County about 12,000 years ago (fig. 24). The glacier overrode the moraine deposited by the Long Lake glacier in the northern part of the county, and truncated the north loop of the end moraine. The margin of the Burnstad glacier stagnated forming dead-ice moraine.

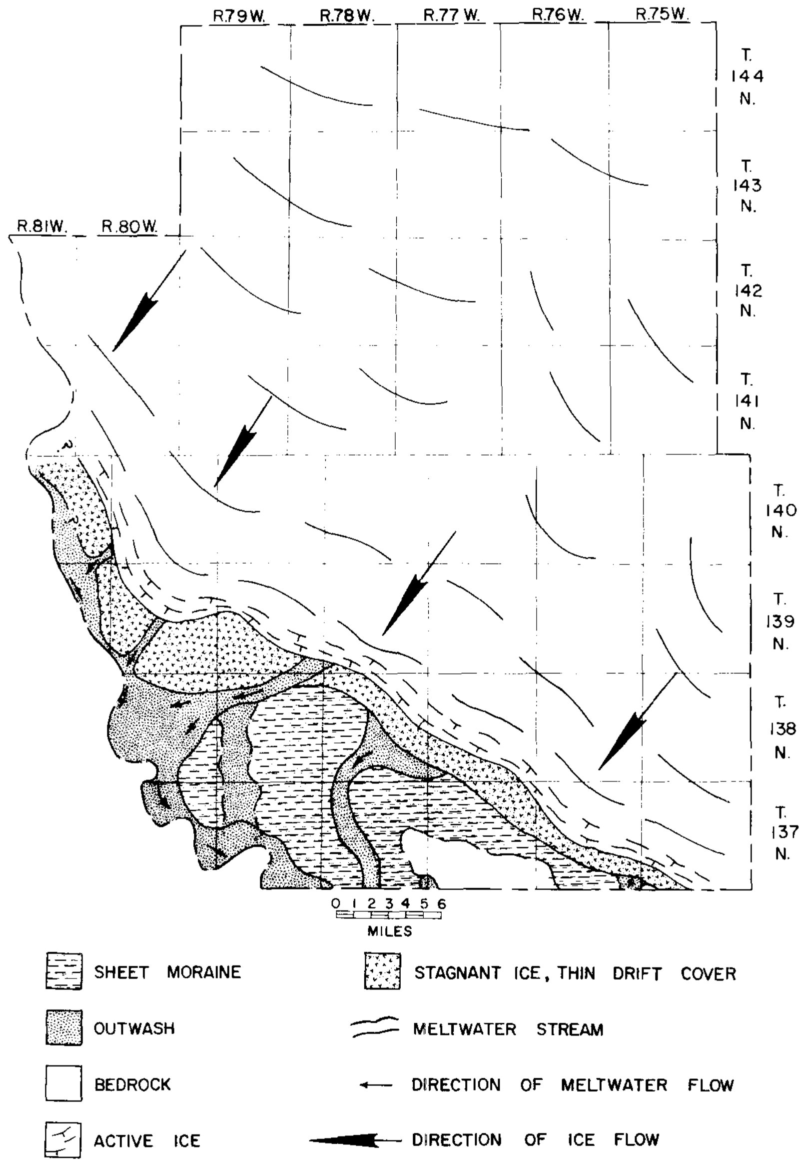

Figure 22. Napoleon glacial advance with the deposition of sheet moraine.

Meltwater from the ablating Burnstad ice flowed through Apple Creek, Random Creek, and Cannonball River Channels

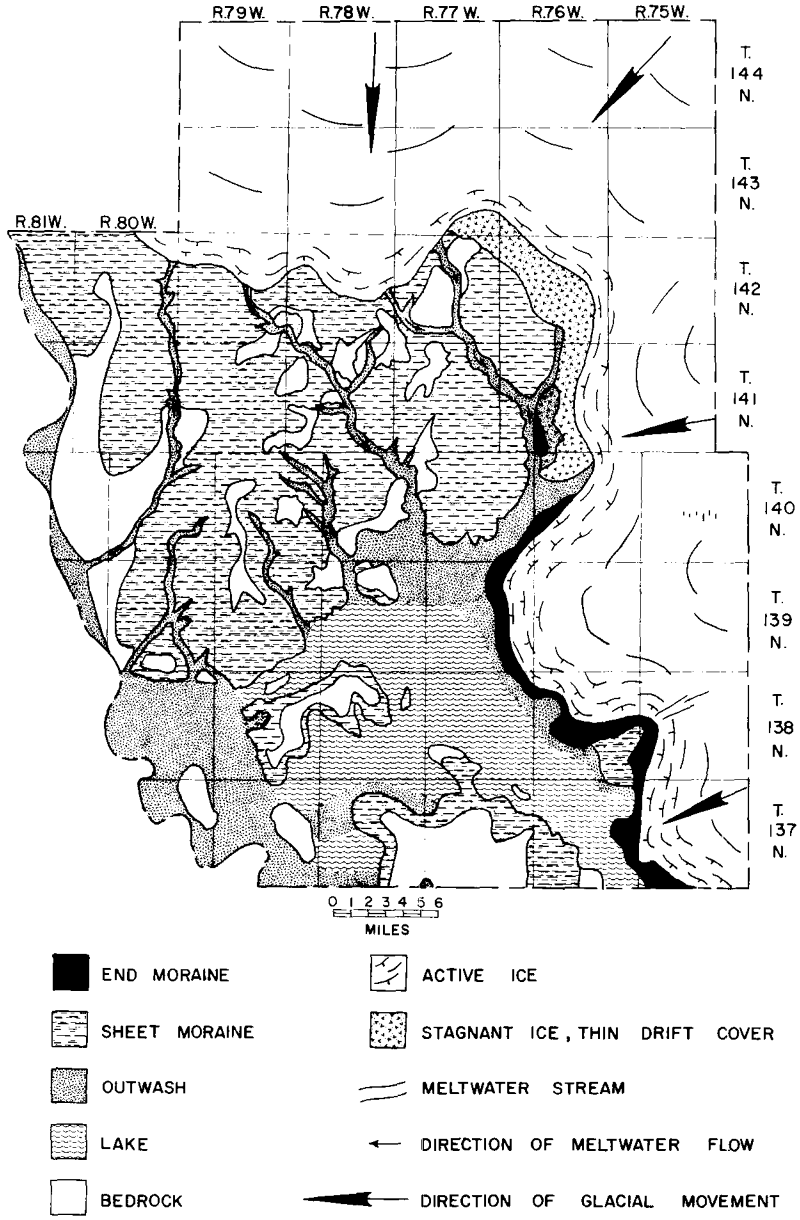

Figure 23. Long Lake glacial advance with the deposition of the Long Lake end moraine and the McKenzie lake plain.

into Glacial Lake McKenzie. Outwash transported by the meltwater formed an outwash plain in the northern part of Lake McKenzie. Cutting and filling on the floodplain of the Missouri River perhaps formed the higher terraces at this time.

Wind erosion and deposition in southwestern Burleigh County formed sand dunes along the south Lake McKenzie Basin and along the Missouri River Trench. Most of the sand was derived from outwash.

All that remained of the Burnstad ice sheet was a stagnant remnant, covered with drift, as the Streeter glacier advanced.

STREETER GLACIAL ADVANCE

The Streeter glacier advanced into northern Burleigh County about 12,000 years ago (fig. 25). A number of end moraine loops were deposited along its lobate ice front and a small portion of one loop of the Streeter end moraine is in T. 144 N., Rs. 76 and 77 W., on the northern border of Burleigh County.

Meltwater from the ablating Streeter ice flowed through Painted Woods Creek and Badger Creek Channels into the Missouri River and through Apple Creek, Random Creek, and Cannonball River Channels into Glacial Lake McKenzie. Outwash was deposited in the meltwater channels on the distal side of the end moraine and also on the stagnant Burnstad ice. The outwash on Burnstad ice collapsed when the ice melted. Cutting and filling in the Missouri River floodplain continued to modify the terraces.

Sand dunes were built up by wind erosion and deposition in southeastern Burleigh County.

Slow melting of the drift-covered Burnstad ice continued following the Streeter advance. Clayton (1962, p. 68) states that the Burnstad ice continued to melt for over 2,000 years; the resulting deposits of dead-ice moraine were slowly assuming their present surface expression during that time.

Recent Age

The final phase of the Pleistocene history, the Recent, began about 5,000 years ago and continues to the present. During this period much of the Coteau Slope was modified by stream erosion and slope wash, and the present drainage pattern was established. Numerous kettles and other depressions on the Missouri Coteau caught surface water and were partially filled with slope wash sediments. The sand dunes have been intermittently active, reflecting wet and dry climatic cycles.

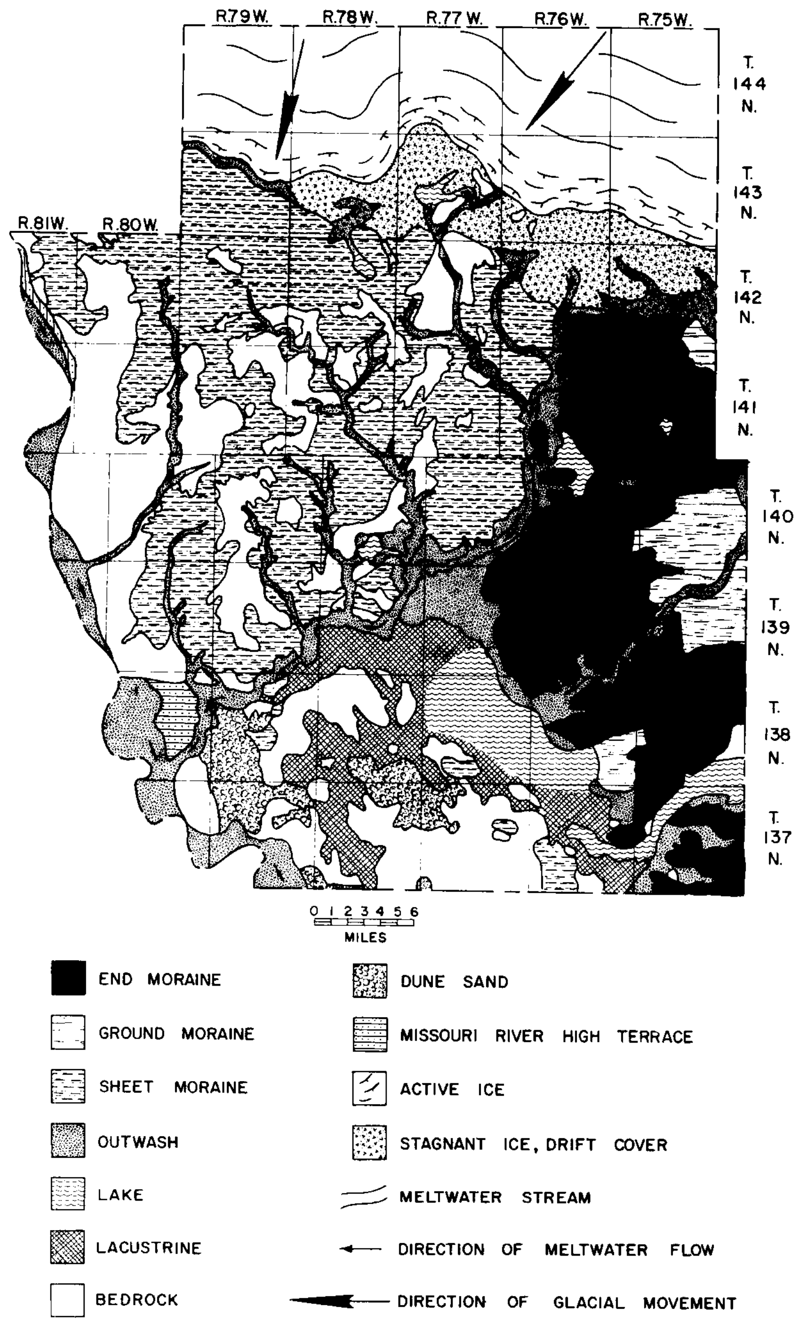

Figure 24. Burnstad glacial advance with the truncation of the Long Lake end moraine and the stagnation of Burnstad glacial ice.

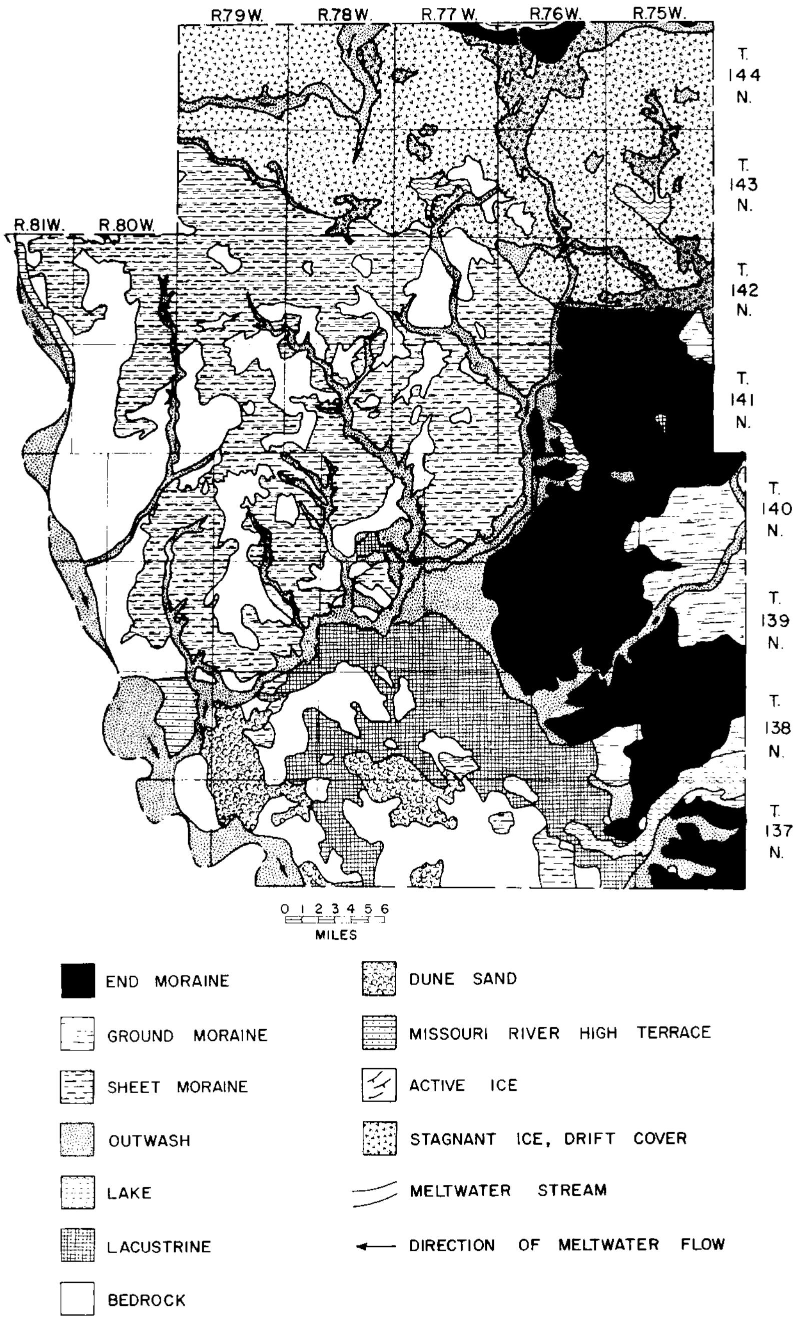

Figure 25. Streeter glacial advance with the deposition of the Streeter end moraine and Burnstad dead-ice moraine.

ECONOMIC GEOLOGY

PETROLEUM

Fourteen petroleum exploratory wells have been drilled in Burleigh County since 1949. Five of the wells were drilled to the granite basement, seven wells were drilled to the Deadwood Formation, and two were drilled to the Madison Group. Summaries, providing lithologic descriptions of seven of these wells have been published (Caldwell, 1953a, 1953b, 1954; Smith, 1954; George, 1957; Eisenhard, 1958; Mendoza, 1959).

A slight show of oil was reported from the Winnipeg Formation sandstone at a depth of 6576-6629 feet in the Continental Oil Company-Duemeland No. 1 well (sec. 3, T. 140 N., R. 77 W.), but there has been no oil production in the county.

LIGNITE

Lignite from the Tongue River Formation is the second most valuable mineral in Burleigh County (Mullen, 1963, p. 806). Lignite in the underlying Ludlow and Hell Creek Formations is generally too thin to mine economically. Test hole 1985 at Wilton and test hole 1990 at Regan penetrated several lignite beds in the Tongue River Formation. At the Wilton test hole the first lignite bed is at a depth of 22 to 26 feet below the surface. This seam crops out in the Wilton area, and its areal extent is probably quite small. The second, the Wilton bed at a depth of 59 to 65 feet, contains three feet of interbedded shale. The third seam is only one foot thick at a depth of 106 feet. The fourth lignite bed at a depth of 138 feet, is one foot thick underlain by six feet of silt and lignitic material. This seven foot unit about 73 feet below the Wilton bed apparently is equivalent to a commercial lignite bed that was mined in the Wilton area. The fifth lignite bed at a depth of 163 feet, is one foot thick underlain by two feet of lignitic sand. This unit appears to be equivalent to the Fairman bed, another commercial lignite bed in Burleigh County. In test hole 1985 it is underlain by the "basal sandstone" unit of the Tongue River Formation. In T. 143 N., R. 81 W. where Brant (1953) reported a Fairman bed outcrop, it appears that only the lowermost part of the Tongue River Formation is present so it is assumed that this lignite is equivalent to the Fairman bed. At test hole 1990, near Regan, only the lower two lignite beds were present, each one foot thick. In test hole 1990 the fifth, or Fairman bed, is 66 feet above the Cannonball Formation contact, but in the Wilton test hole it is 56 feet above the same contact (see pl. 4, cross-section G-G[1]).

During 1961, as reported by the State Coal Mine Inspector (Easton, 1961), Burleigh County had only one operating lignite mine. It was the Ecklund-Taplin strip mine near Wilton which produced 13,084 tons of lignite. During the summer of 1962 the same company operated a strip mine in sec. 8, T. 142 N., R. 79 W.

CONSTRUCTIONAL MATERIALS

Sand and gravel. – In 1962 Burleigh County ranked sixth in the State in sand and gravel production (Mullen, 1963, p. 806). Sand and gravel presently ranks as the most valuable mineral in the county. It is used for building, paving and fill. The best possibilities for commercial production are the terraces along the Missouri River, outwash deposits, and kames. The locations of the gravel pits in Burleigh County are shown on plate 1. The terraces south of Bismarck contain two of the largest pits in Burleigh County. Test holes in the terraces reveal a thickness of about 100 feet of sand and gravel, but this area is more valuable as a source of ground water than as gravel pits. Much of the gravel in the county contains shale in amounts which are detrimental for concrete.

Clinker. – Burleigh County has a minor amount of clinker or scoria, a material formed by burning lignite beds which baked the overlying sediments. Clinker is used mostly for road metal. A clinker pit is in SW 1/4 SE 1/4 sec. 4, T. 142 N., R. 79 W.

Riprap and building stone.–Abundant glacial erratic boulders, which may be used as riprap, are found in Burleigh County. Riprap and building stone can also be obtained from the Tongue River Formation which contains beds of resistant sandstone, conglomeratic sandstone, and sandy limestone. It is not of high quality, but it has been used locally as a decorative building stone, mainly for retaining walls, gardens, and patios.

Clay. – Clay deposits are abundant in Burleigh County in glacial deposits as well as in the Tongue River and Cannonball Formations. There are no commerical clay operations in Burleigh County, but there is a light weight aggregate plant in Morton County west of Mandan using Cannonball Formation clay.

SURFACE WATER

Much of the surface water in Burleigh County is in numerous undrained depressions, intermittent streams, and a few permanent lakes. The largest source is the Missouri River which provides the muncipal water supply for Bismarck and is also used for irrigation.

GROUND WATER

Ground water is abundant in Burleigh County. Aquifers are found in the sands and gravels in the Missouri River terraces and the buried drainage channels (pls. 7 and 8). Smaller aquifers are found in the sandstones and sands of the Fox Hills, Hell Creek, Cannonball, and Tongue River Formations. The sandstones of the Fox Hills Formation and basal sandstone unit of the Tongue River Formation probably contain the best bedrock aquifers. In Burleigh County quantity is generally not a problem, but the chemical quality is not satisfactory for all uses. The ground water is generally acceptable for stock-watering, but locally it may not be satisfactory for irrigation. Several chemical analyses of irrigation water show a salinity, sodium, and residual sodium carbonate hazard. Some of this water may be safely used for irrigation, even though it may rate poorly according to some quality standards. Ground water irrigation is being conducted on the river terraces south of Bismarck and on the lake plain southeast of McKenzie.

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APPENDIX A

DETAILED DESCRIPTIONS OF SURFACE SECTIONS

SECTION 1-62 SW 1/4 SW 1/4 sec. 35, T. 137 N., R. 77 W.
Moffit Southwest Section 1
0.2 mi. east of road, west side of bluff.

Cretaceous – Hell Creek Formation	Feet	Inches
8. Sandstone, as in unit 4, friable, massive.	2	9
7. Claystone, sandy to very sandy, lenses of sand (as in unit 4), light olive gray, scattered iron staining.	4	0
6. Sandstone and sand, friable, as in unit 4 interbedded shale, light olive gray, flaky, very lenticular bedding, sand similar to unit 4.	4	10
5. Shale, light olive gray, sandy, contains plant fragments.	0	3
4. Sandstone, yellowish-gray (5Y7/2) to light brown (5YR5/6) due to iron staining and oxidation, fine-grained ironstone concretions (one measured 6 in. thick, 30 in. long), friable, non-calcareous, minor shale and claystone interbedded.	1	0
3. Shale, light olive gray to olive gray (5YR3/2), numerous carbonaceous and woody fragments, fissile to blocky, macerated plant fragments.	6	10
2. Coal, dark gray (N3), woody structure, lenticular.	0	9
1. Shale, light olive gray (5Y5/2) blocky, compact.	4	9
Total	25	2

SECTION 2-62 SW 1/4 NW 1/4 sec. 35, T. 137 N., R. 77 W.
Moffit Southwest Section 2
East roadcut, 0.4 mi. south of sec. corner.

Cretaceous – Hell Creek Formation	Feet	Inches
4. Sandstone, moderate yellowish-brown, fine to very fine-grained, massive; sandstone, dusky yellow (5Y6/4), friable, fine to very fine-grained.	10	10
3. Sandstone and sand, moderate yellowish-brown (10YR5/4) to light brown (where iron stained), fine to very fine-grained, abundant ironstone concretions and fragments, occa-		

sional streaks of carbonaceous material and plant fragments, mica flakes.	4	10
2. Shaly sandstone, friable, light olive gray, light brown (5YR5/6) and grayish-orange (10YR-7/4) where oxidized and iron stained, fine to very fine-grained, numerous plant fragments and stems, round ironstone concretions (sandy), increasing shale content toward upper part of unit.	4	0
1. Claystone or mudstone, light olive gray, (5Y5/2), very sandy, weathers light gray (N7), numerous ironstone fragments; sand, fine to very fine-grained.	8	10
Total	28	6

SECTION 3-62 SW 1/4 SE 1/4 sec. 11, T. 137 N., R. 76 W.
Long Lake Section
North roadcut, measured from base of hill.

	Feet	Inches
Pleistocene – Long Lake Drift		
6. Till, olive gray (5Y 4/1), clayey and silty, abundant stones (sand to boulder size), mostly limestone and igneous rocks, calcareous.	5	0
Cretaceous – Fox Hills Formation		
5. Sandstone, as in unit 1, abundant indurated sandstone weathering into a flaggy (1-2 in.) rubble.	7	0
4. Sandstone, as in unit 1, friable, massively bedded.	5	0
3. Sandstone, as in unit 1, abundant ironstone concretions, thinly bedded, indurated, noncalcareous.	1	8
2. Sandstone, as in unit 1, except lack of fractures filled with calcareous material, very thinly bedded (1 mm), abundant black carbonaceous and ferruginous material along some bedding planes.	3	2
1. Sandstone, light olive gray (5Y 5/2) to pale olive (10Y 6/2), weathering to yellowish-gray (5Y 7/2), friable except for numerous ironstone concretions and indurated beds, noncalcareous, fine to very fine-grained, numerous dark mineral grains, common fractures filled with calcareous material, thinly bedded (1/4 to 1 in.), some cross-bedding.	14	6
Total	36	4

SECTION 4-62 NW 1/4 NW 1/4 sec. 16, T. 138 N., R. 75 W.
Long Lake Moraine Section

Pleistocene — Ice-contact lacustrine	Feet	Inches
1. Clay, light olive gray (5Y 5/2) and olive gray (5Y 3/2), silty, calcareous, blocky to flaky, weathers yellowish-gray (5Y 7/2), abundant plant material.	14	6

SECTION 5-62 SE corner NW 1/4 sec. 13, T. 140 N., R. 81 W.
Riverview School No. 1 Section.
West roadcut, measured from base of knoll.

Tertiary — Tongue River Formation ("basal sandstone")	Feet	Inches
7. Sandstone and sand, grayish-olive (10Y 4/2), weathering grayish-orange (10Y 7/4) to dark yellowish-orange (10YR 6/6), strongly cross-bedded, medium to fine-grained, few interbedded lenses of fine to very fine-grained sand, non-calcareous except when cemented with calcite or ferruginous material.	14	6

Tertiary — Cannonball Formation.	Feet	Inches
6. Shale and siltstone, as in unit 4, contact appears disconformable (excellent exposure).	8	10
5. Limestone, pale yellowish-brown (10YR 6/2) argillaceous and silty, lenticular.	0	1
4. Shale and siltstone, interbedded. Shale, dark yellowish-brown, (10YR 4/2), silty, numerous olive black plant and other carbonaceous fragments, non-calcareous, blocky, thinly to fissile bedding, compact. Siltstone, dark yellowish-brown, shaly, sandy, non-calcareous, blocky. Shale olive black (5Y 2/1), fissile and blocky, minor amount.	5	4
3. Siltstone, as in unit 1, interbedded with sandstone, friable as in unit 2.	0	6
2. Sandstone, light olive gray (5Y 5/2), friable, very silty, very thinly bedded to laminated (1-3mm), non-calcareous, very fine-grained.	0	7
1. Siltstone, dusky yellow (5Y 6/4) weathering yellowish-gray (5Y 7/2), thinly (2-5mm) to laminated bedding, non-calcareous, blocky.	1	8
Total	31	6

SECTION 6-62 NE 1/4 NW 1/4 sec. 13, T. 140 N., R. 81 W. West roadcut, 1180 feet north of Section 5-62 Stratigraphically 51 feet 8 inches above Cannonball Formation contact.

Tertiary – Tongue River Formation	Feet	Inches
10. Sandstone and sand, dusky yellow, weather grayish-yellow, very fine-grained, minor fine-grained, cross-bedded, calcareous, numerous ironstone concretions, local lenticular shale conglomerate.	15	10
9. Conglomerate, shale pebbles and rounded fragments, light olive gray (5Y 5/2); sand matrix, dusky yellow (5Y 6/4), very fine and fine-grained, calcareous; sandstone, dusky yellow, very fine-grained, calcareous.	15	9
8. Sandstone and sand of intervening unit between Sections 6-62 and 5-62.	1	6
Total	33	1

Intervening unit between Sections 6-62 and 5-62	Feet	Inches
8. Sandstone and sand, yellowish-gray (5Y 7/2) weathering yellowish-gray (5Y 8/1), friable, fine to very fine-grained, scattered shale pebbles, lenticular shale pebbles (appear to be reworked Cannonball Formation), cross-bedded.	27	6
7. Sandstone, as in unit 7 of Section 5-62, petrified tree log (32 in. long, 10 in. diameter), friable, cross-bedded.	9	8
Total	37	2

SECTION 7-62 SW corner sec. 1, T. 140 N., R. 81 W. Coal Butte Section
West cut, north-south section-line road.

Tertiary – Tongue River Formation	Feet	Inches
8. Covered interval, slope wash.	10	0
7. Shale, dark yellowish-orange, calcareous, weathers grayish-yellow, compact.	0	11
6. Siltstone, light gray (N 7), friable, very fine-grained sand, calcareous, massive.	3	11
5. Claystone, dark yellowish-orange (10YR 6/6), indurated, calcareous, ferruginous, resistant, occurs in thin beds (up to 3 in. thick); interbedded shale, dusky yellow, compact, calcareous, weathers grayish-yellow.	5	10
4. Shale, carbonaceous, brownish-black (5YR 2/1), abundant plant material, non-calcareous.	0	2
3. Shale, dusky yellow (5Y6/4), compact, weathers yellowish-gray (5Y7/2), non-calcareous.	1	2

	Feet	Inches
2. Shale, pale yellowish-brown (10YR6/2), fissile, abundant brown carbonaceous material, non-calcareous.	0	6
1. Shale, carbonaceous and thin seams (1 in.) of lignite coal; shale, brownish-black (5YR2/1) carbonaceous, blocky, non-calcareous, weathers medium light gray (N6).	1	9
Total	24	3

SECTION 8-62 SW 1/4 NE 1/4 sec. 31, T. 139 N., R. 80 W.
Northern Pacific Railway Section
South railcut, east of bridge.

Pleistocene – Drift	Feet	Inches
10. Sand, yellowish-gray (5Y7/2), very fine-grained, silty, calcareous, igneous pebbles and boulders on bedrock contact.	20	0
Tertiary – Cannonball Formation		
9. Siltstone, olive gray, sandy, non-calcareous, lenticular, dusky yellow (5Y6/4) sand, very fine-grained, moderate brown (5YR4/4) ferruginous coating.	13	6
8. Siltstone, light olive gray (5Y6/1), compact shaly, fissile to flaky, non-calcareous.	10	10
7. Siltstone, dark gray, olive black, brownish-black, (5YR2/1) interbedded, shaly, fissile to flaky, soft, non-calcareous.	16	5
6. Shale, dark gray (N3), flaky to fissile, non-calcareous, soft.	0	7
5. Claystone concretions, dark yellowish-orange (10YR6/6) and light brown (5YR5/6), tube-like forms and pebble size; sandstone matrix, olive gray, friable, fine to very fine-grained, silty, clayey.	1	1
4. Siltstone, olive gray and olive black, slightly calcareous, flaky and fissile, weathers light olive gray.	7	3
3. Sandstone, light bluish-gray (5B7/1) weathers light gray (N7), friable except where locally indurated with calcareous cement, abundant dark grains.	4	0
2. Sandstone, light olive gray (5Y5/2), friable, non-calcareous, very thinly bedded; siltstone, as in unit 1.	2	1
1. Siltstone, olive gray (5Y3/2), olive black (5Y2/1), interbedded, flaky, soft, non-calcareous.	2	9
Total	78	6

SECTION 9-62 SW 1/4 SE 1/4 sec. 26, T. 138 N., R. 80 W.
Apple Creek Section
South bank, northwest side of bluff.

Tertiary — Ludlow Formation	Feet	Inches
12. Shale and siltstone, olive gray and dusky yellow, fissile to compact, flaky, non-calcareous, ferruginous ironstone concretions.	8	10
11. Shale, brownish-black, brownish-gray, and grayish-black (N2), fissile, carbonaceous, in part lenticular lignite beds; interbedded sandstone, yellowish-gray (5Y7/2), friable very fine-grained, ferruginous concretions.	8	5
10. Sandstone, dusky yellow and brownish-gray (5YR4/1), friable, very thinly bedded (1-2mm), carbonaceous, shale partings, non-calcareous, very fine-grained, silty, ferruginous concretions.	3	5
Cretaceous — Hell Creek Formation		
9. Shale, olive black (5Y2/1), olive gray, fissile to flaky, non-calcareous, silty.	2	2
8. Mudstone, light olive gray (5Y5/2), silty, ironstained, weathers into a convex upward mudcracked slope, spongy and cohesive when wet (bentonitic), non-calcareous, occasional manganiferous concretion.	21	8
7. Sandstone, as in unit 5.	2	8
6. Siltstone, brownish-black, very sandy, abundant black carbonaceous material, non-calcareous.	1	4
5. Sandstone, as in unit 4, friable, interbedded shale, dark yellowish-brown, carbonaceous material, sandy.	14	2
4. Sandstone, dusky yellow (5Y6/4), weathers yellowish-gray (5Y7/2), dark yellowish-orange (10YR6/6) iron stains, fine to very fine-grained, non-calcareous, friable.	4	10
3. Siltstone, brownish-black (5YR2/1), sandy, clayey, compact, much carbonaceous material, non-calcareous.	2	6
2. Shale and mudstone, dark yellow-brown (10YR4/2), compact to flaky, mudcracked and convex upward slope (bentonitic), non-calcareous, fine-grained sand lenses, partly carbonaceous.	19	4
1. Sandstone, light gray (N7), friable except lo-		

cally cemented by calcite, strongly cross-bedded, lenticular carbonaceous and macerated plant accumulations, very dusky red purple (5RP2/2) manganiferous concretions, medium to fine-grained, silty and clayey.	11	0
Total	100	4

SECTION 10-62 NW 1/4 NE 1/4 sec. 31, T. 141 N., R. 80 W.
Missouri River Section
Roadcut between two buttes, north of curve in road.

Tertiary – Tongue River Formation	**Feet**	**Inches**
7. Conglomerate, as in unit 5, forms resistant cap on butte, lenticular, cross-bedded; sandstone, very pale orange (10YR8/2), strongly cross-bedded, fine to very fine-grained calcareous, very thinly bedded.	17	6
6. Sandstone, yellowish-gray, very calcareous, very fine-grained, cliff former, variable bedding (less than an inch to 2 ft.), cross-bedded.	19	4
5. Conglomerate, rounded limestone particles, sandstone matrix, pale yellowish-brown (10-YR6/2), weathers light brown and grayish-orange, variable bedding (over 4 ft. to 3 in.); sandstone, yellowish-gray, very fine-grained, cross-bedded, cliff former.	6	0
4. Sandstone, yellowish-gray (5Y8/1), very fine-grained, silty, friable and indurated, calcareous cement, thinly bedded, cliff base.	3	1
3. Covered interval, slope wash.	84	2
2. Sandstone and sand, grayish-olive (10Y4/2) and light olive gray (5Y5/2), medium to fine-grained, cross-bedded, mostly friable, petrified wood fragments, easily eroded by wind (blowout), non-calcareous, abundant dark mineral grains, "basal sandstone" unit of the Tongue River Formation.	24	2
Tertiary – Cannonball Formation		
1. Shale and siltstone, moderate yellowish-brown (10YR5/4) and light olive gray (5Y5/2), calcareous, interbedded, soft, flaky to fissile, scattered carbonaceous fragments, thinly bedded.	6	0
Total	160	3

SECTION 11-62 NW corner NW 1/4 SW 1/4 sec. 10, T. 140 N., R. 79 W.
Test Hole 2038 Section
East roadcut, outcrop above test hole.

Tertiary – Tongue River Formation	Feet	Inches
4. Limestone, as in unit 2.	3	0
3. Shale, dark yellowish-orange (10YR6/6), very silty, calcareous, flaky to fissile, soft, interbedded sandstone, friable, dusky yellow, medium to fine-grained.	2	0
2. Limestone, yellowish-gray (5Y7/2) and light olive gray (5Y5/2), sublithographic, fractured into a rubble, argillaceous, lenticular, ferruginous staining.	2	11
1. Sandstone, dusky yellow (5Y6/4), indurated to friable, calcareous cement, strongly cross-bedded, thinly bedded (1-2 in.), medium to fine-grained, "salt and pepper" appearance due to abundant dark mineral grains, ferruginous concretions.	7	2
Total	15	1

SECTION 12-62 NE corner sec. 20, T. 138 N., R. 75 W.
Test Hole 2025 Section
West roadcut, exposure above test hole.

Pleistocene – Ice-contact lacustrine	Feet	Inches
2. Covered interval, top of hill.	5	0
1. Silt and clay, interbedded dusky yellow (5Y-6/4) and light olive gray (5Y5/2), laminae bedding (1 mm), calcareous, blocky to flaky.	12	3
Total	17	3

SECTION 13-62 NE 1/4 NE 1/4 SE 1/4 sec. 27, T. 140 N., R. 81 W.
Missouri River Trench Shell Section
South side of gully on east side of river road.
0.25 mile NW of road junction.

Recent Alluvium	Feet	Inches
10. Soil and windblown material, olive gray.	2	0
Pleistocene – Outwash and lacustrine		
9. Sand, grayish-orange (10YR7/4) and light gray, very poorly sorted, clayey and silty, very coarse to very fine-grained, mostly medium to fine-grained, calcareous.	2	3

8. Marl, very light gray (N8) and silt, light gray (N7), very fossiliferous (molluskan), extremely calcareous, lenticular, interbedded dark yellow orange sand, medium to fine-grained.	1	5
7. Sand, yellowish-gray and dark yellowish-orange (10YR 6/6), well sorted, fine to very fine-grained, non-calcareous.	4	10
6. Gravel, medium size, about 50 percent sand, poorly sorted, mostly igneous, limestone, and local bedrock particles.	3	4
5. Clay, dusky yellow, very silty, poorly bedded, very calcareous.	3	8
4. Clay, olive gray (5Y 3/2) and light olive gray (5Y 5/2), interbedded yellowish-gray (5Y 7/2) silt, calcareous.	3	4
3. Gravel, fine to medium size, mostly reworked local bedrock particles, detrital snails from Tongue River Formation.	1	10
2. Sand, dusky yellow (5Y 6/4), medium to very fine-grained, mostly fine to very fine-grained, poorly sorted, silty, calcareous.	2	9
Tertiary — Cannonball Formation		
1. Shale, grayish-orange and light olive gray (5Y 6/1), blocky, light brown (5YR 5/6), ferruginous stains along the bedding and fracture planes, very silty, non-calcareous.	7	2
Total	32	7

SECTION 14-62 NE 1/4 NE1/4 SE 1/4 sec. 11, T. 104 N., R. 80 W.
School No. 3 Section
West roadcut, north side of hill.

Tertiary — Tongue River Formation ("basal sandstone")	Feet	Inches
3. Sandstone and sand, dusky yellow (5Y 6/4), medium to fine-grained, poorly sorted, locally calcareous cemented, abundant dark mineral grains, friable, easily eroded by wind (blowout), petrified wood fragments; contact with Cannonball Formation is marked by claystone ferruginous concretions and fragments, moderate yellowish-brown and grayish-red; disconformable contact.	15	6
Tertiary — Cannonball Formation		
2. Shale, olive black (5Y 2/1), fissile, carbonace-		

ous, non-calcareous; sands, siltstones, and claystone, dusky yellow (5Y 6/4) and light olive gray, friable, slightly calcareous to non-calcareous.	16	1
1. Shale, siltstone, and sandstone, interbedded, moderate yellowish-brown (10YR 5/4) and light olive gray (5Y 5/2), very thinly bedded, calcareous, fine to very fine-grained friable sand, few sandstone concretions.	15	0
Total	46	7

SECTION 15-62 SE 1/4 SW 1/4 sec. 31. T. 139 N., R. 79 W.
Trailer Park Section
North roadcut, 0.3 mi. west of sec. corner.

	Feet	Inches
Tertiary – Cannonball Formation		
5. Covered interval	4	10
4. Sandstone, siltstones, and shale, interbedded, soft, friable, yellowish-gray, light olive gray, and dusky yellow, calcareous, fine to very fine-grained sand, thinly bedded, ironstone concretions.	14	6
Tertiary – Ludlow Formation		
3. Shale, brownish-gray (5YR 4/1) and brownish-black (5YR 2/1), carbonaceous, lignitic, silty non-calcareous.	2	0
2. Siltstone, light olive gray (5Y 6/1), friable, very fine, sandy, shaly, abundant carbonaceous fragments, thinly bedded, non-calcareous, iron stained.	7	6
1. Sandstone, dusky yellow (5Y 6/4), friable, fine to very fine-grained, ferruginous staining, ironstone concretions, thinly bedded, non-calcareous.	4	8
Total	33	6

APPENDIX B

SUMMARY OF EXPLORATORY WELLS

N.D.G.S. Well Number	19	145	151	155	174	701	723
N.D.G.S. Permit Number		161	167	171	190	714	736
N.D.G.S. Circular Number		21	33	39	42		
Operator	Continental-Pure	Continental-Pure	Hunt	Continental	Continental	Caroline Hunt	Caroline Hunt
Well Name	Davidson #1	P. H. McCay #1	Emma Kleven #1	N. Dronen #1	Duemeland #1	Board Univ. & School Lands #1	R. P. Schlabach #1
Location	6-140N-77W	32-137N-76W	18-140N-80W	9-140N-75W	3-140N-77W	36-144N-75W	36-139N-76W
Date Drilled	1949	1952	1952	1952	1952	1954	1954
Elevation Kelly Bushing	1909	1869	1922	1912	1981	2023	1877
Total Depth	6957	6185	8115	6155	6864	6300	5859
Surface Rocks	Cannonball	Pleistocene	Cannonball	Pleistocene	Cannonball	Pleistocene	Pleistocene
Mechanical Log—Depth to Formation Tops							
Cretaceous-Fox Hills	353					397	
K. – Pierre	630	377	890	473	710	703	424
K. – Niobrara	1629	1323	1910	1428	1687	1671	1391
K. – Greenhorn	2170	1896	2482	1971	2218	2118	1920
K. – Mowry	2533	2263	2840	2343	2538	2460	2290
K. – Fall River	2812	2522	3126	2593	2857	2697	2544
Jurassic-Swift	2924	2798	3360	2704	2984	2943	2725
J. – Rierdon	3249	2963	3697	2989	3310	3147	2997
Pennsylvanian-Minnelusa			3938				
P. – Amsden	3542	3199	4056	3274	3587		3287
P. – Tyler	3699	3360	4357	3293	3697	3455	3293
Mississipian-Kibbey			4502				
M. – Madison-Poplar	3867		4539	3430	3850	3568	
M. – Madison-Ratcliffe	3961	3507	4690	3458	3930	3648	3473
M. – Madison-Frobisher Alida	4078	3630	4837	3599	4048	3741	3582
M. – Madison-Tilston	4296	3818	5043	3770	4266	3932	3753
M. – Madison-Bottineau	4438	3923	5183	3892	4400	4056	3880
M. – Bakken	5002		5810		4952	4580	
Devonian-Three Forks			5830				
D. – Birdbear	5009	4407	5850	4418	4960	4597	4361
D. – Duperow	5072	4470	5915	4455	5018	4634	4425
D. – Souris River	5254	4614	6129	4632	5197	4832	
D. – Dawson Bay	5357		6260	4697	5292	4935	
D. – Prairie	5432		6350	4752	5350	5000	
D. – Winnipegosis			6370				
Silurian-Interlake	5485	4720	6432	4782	5380	5053	4740
Siluro-Ordovician-Stonewall	5628	4803	6671		5553	5184	4803
Ordovician-Stony Mountain	5690	4850	6730	4920	5620	5243	4870
O. – Stony Mountain Shale	5750	4922	6799	4995	5679	5303	4923
O. – Red River	5850	5020	6897	5090	5774	5401	5024
O. – Winnipeg-Roughlock	6498	5608	7557	5686	6398	6022	5623
O. – Winnipeg-Icebox	6537	5683	7600	5744	6449	6071	5687
O. – Winnipeg-Black Island	6664	5811	7728	5873	6577	6198	5818
Cambro-Ordovician-Deadwood	6684	5828	7773	5887	6594	6220	5833
Precambrian	6946	6163	8088	6144	6861		

SUMMARY OF EXPLORATORY WELLS

N.D.G.S. Well Number	756	763	765	772	1371	1375	1409
N.D.G.S. Permit Number	769	776	778	785	1383	1387	1421
N.D.G.S. Circular Number				177	188		222
Operator	Caroline Hunt	Caroline Hunt	Caroline Hunt	Caroline Hunt	Continental-Pure	Continental	Leach-Calvert
Well Name	R. A. Nicholson #1	Anton Novy #1	Soder Investment #1	Paul Ryberg #1	J. F. Miller #1	Patterson Land Co. #1	Patterson Land Co. #1
Location	32-137N-77W	14-144N-77W	31-142N-76W	23-140N-79W	30-143N-75W	15-141N-75W	11-140N-77W
Date Drilled	1954	1954	1954	1954-1955	1957	1957	1957
Elevation Kelly Bushing	1891	1947	2027	2007	2051	2073	2019
Total Depth	6157	6919	6750	7230	4290	4160	6595
Surface Rocks	Hell Creek	Pleistocene	Cannonball	Cannonball	Pleistocene	Pleistocene	Pleistocene
Mechanical Log - Depth to Formation Tops							
Cretaceous-Fox Hills		410	460	520	392	364	
K. – Pierre	442	710	784	822	710	654	706
K. – Niobrara	1422	1710	1750	1811	1680	1622	1678
K. – Greenhorn	2000	2235	2268	2370	2184	2153	2212
K. – Mowry	2376	2597	2637	2740	2535	2517	2588
K. – Fall River	2645	2854	2899	3011	2783	2773	2853
Jurassic-Swift	2820	3097	3031	3243	3082	2895	2963
J. – Rierdon	3103	3399	3367	3539	3274	3183	3302
Pennsylvanian-Minnelusa							
P. – Amsden	3313	3670	3668	3840		3486	3591
P. – Tyler	3478	3727	3740	4093	3594	3509	3687
Mississipian-Kibbey							
M. – Madison-Poplar	3618	3880	3890	4270	3724	3650	3829
M. – Madison-Ratcliffe	3697	4010	3993	4333	3811	3684	3855
M. – Madison-Frobisher Alida	3830	4129	4118	4490	3952	3821	4018
M. – Madison-Tilston	4008	4344	4323	4695	4136	3989	4218
M. – Madison-Bottineau	4152	4486	4452	4830	4273	4122	4355
M. – Bakken	4670	5073	5042	5432			4912
Devonian-Three Forks							
D. – Birdbear	4677	5096	5050	5457			4918
D. – Duperow	4715	5146	5093	5514			4975
D. – Souris River	4880	5352	5283	5704			5153
D. – Dawson Bay	4959	5490	5392	5808			5256
D. – Prairie	5007	5573	5448	5881			5310
D. – Winnipegosis		5600					
Silurian-Interlake	5039	5640	5490	5929			5368
Siluro-Ordovician-Stonewall	5089	5834	5654	6132			5483
Ordovician-Stony Mountain	5160	5895	5720	6197			5550
O. – Stony Mountain Shale	5217	5959	5780	6264			5610
O. – Red River	5312	6053	5880	6361			5709
O. – Winnipeg-Roughlock	5904	6704	6514	7008			6326
O. – Winnipeg-Icebox	5974	6745	6562	7057			6380
O. – Winnipeg-Black Island	6103	6873	6686	7177			6507
Cambro-Ordovician-Deadwood	6120	6898	6717	7230			6523
Precambrian							

THE FOSSIL MOLLUSCAN FAUNA OF PLEISTOCENE SEDIMENTS OF BURLEIGH COUNTY, NORTH DAKOTA

by

Samuel J. Tuthill

INTRODUCTION

Thirty specific and subspecific taxa of nineteen genera are represented in the Pleistocene fossil molluscan fauna of Burleigh County. These collections are stored at the Department of Geology, University of North Dakota, Grand Forks, North Dakota. Gastropods of the families Viviparidae, Valvatidae, Hydrobiidae, Lymnaeacea, Planorbidae, Physidae, Pupillidae, Valloniidae, Succineidae, Endodontidae, and Zonitidae and pelecypods of the families Unionidae and Sphaeridae occur. These fossils were found at twenty-three sites (see fig. 26, table 5) by Kume and Hansen. They collected bulk samples which I examined. They are responsible for the lithologic and stratigraphic information, and I am responsible for the identifications of fossils and paleoecology.

About 500 ml of sediments from each bulk sample were wet sieved in a series of micropaleontological sieves (Tyler series 20, 40, 60, 80, and 100 mesh) and the fossils were removed under binocular microscope magnification of 15X and 45X. References used in identification of the fossil mollusks were: Dall (1905), Baker (1928a, 1928b, and 1945), van der Schalie (1933), Pilsbry (1946, 1948), Hubendick (1951), Leonard (1950, 1952), Taylor (1960) and Herrington (1962).

The species represented in the Pleistocene fauna of Burleigh County are, with the exception of **Viviparus**, all still extant in North Dakota. **Viviparus** sp., found at the Apple Creek site is not of Pleistocene age, in my opinion, but rather a reworked fossil from the Paleocene Tongue River Formation. This may also be true of some of the **Sphaerium** sp. specimens.

The ecology of the various species in their modern environments, insofar as it is known, was used for paleoecologic reconstructions.

Since none of the species are extinct, they cannot provide indices for geologic age of the sediments; however, their shell material may supply chronologic data through radiocarbon analyses and several sites in Burleigh County have been dated. Faunules in the Missouri Coteau district, which are dominated by the branchiate genera **Valvata** and **Amnicola,** are very different from the Recent aquatic molluscan fauna and are therefore regarded as pre-Recent. This idea is borne out by studies elsewhere in the Missouri Coteau district where radiocarbon data are available.

Sound paleoecologic reconstructions require evaluation of several aspects of the relationship of the sediments and the fauna. The matter of whether the fossils have been transported from older sediments or from contemporaneous environments in other geographical locations must be considered. The ecologic requirements of the various species can be inferred from the ecologic requirements of related Recent forms. If the stratigraphic and lithologic relationships of the sediments which contain the fossils is in essential agreement with the ecologic requirements of the fossil species, it is assumed that the fossils represent the biota which was living at the time, and roughly in the place, in which deposition occurred. This assumption is safer when lake faunas are found in lake sediments, and less safe when stream faunas are found in stream sediments. This is because the criteria by which the stream origin of sediments are recognized implies transport and sorting of fossil shells as well as the containing sediments. When specimens of a species comprise a significant element of the total fauna and require ecologic conditions other than those indicated by the lithology, the fossil assemblage is assumed to be a thanatacoenose.

1. Billingmeier Ranch site
2. Salt Lake site
3. Florence Lake site
4. Muller Ranch site 1
5. Muller Ranch site 2
6. Detlef Ranch site
7. Wheelock Ranch site
8. Painted Woods site
9. Pelican Lake site
10. Boynton Ranch site
11. Harris Ranch site 1
12. Harris Ranch site 2
13. Blekkinsh Ranch site
14. McDonald Ranch site
15. Coonan Ranch site
16. Stopp Ranch site
17. Hay Creek site
18. Griffin Ranch site
19. Harvey Ranch site
20. Apple Creek site 1
21. Johnson Ranch site
22. Haberlin Ranch site
23. Blackman Ranch site

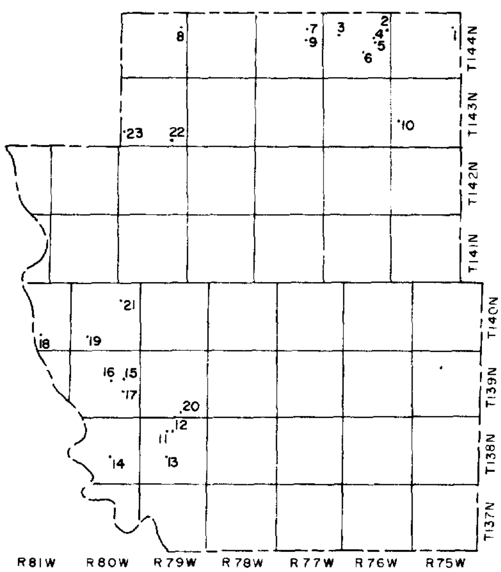


Figure 26. Locations of the fossil molluscan fauna sites in Burleigh County.

Because of the complex nature of any drainage system, finite microhabit types are not found in disjunct units or discrete geographic relationships throughout the system. Any drainage is a complex of gradational molluscan habitats (Tuthill, 1963, p. 24-29), many of which have similar characteristics, both as to type of sediment and fauna. While suggesting great caution in paleoecologic reconstructions, this complexity of the modern drainage system does not depreciate the usefulness of fossil mollusks as clues to the environments which existed during the past. Where species requiring diverse ecologic conditions are mixed, the paleoecologist can reason that the various habitats indicated did, indeed, exist in the drainage system, but the point of deposition represents a composite picture of ecologic conditions within that drainage system.

The radiocarbon dates on fossil mollusk shells do not date the underlying sediments (i.e. tills) except to indicate a minimum age. This limitation is of importance in Burleigh County as the sediments of the Missouri Coteau district are assumed to be younger than those in the Coteau Slope district on the basis of geomorphological evidence. The molluscan faunas of the two districts are dissimilar in certain aspects, (table 5) suggesting a possible dissimilarity in age. An alternate explanation is that the nature of the differences between the molluscan faunas of the two districts may represent different ecologic conditions. Such conditions may have existed at the same or at different times.

MOLLUSCAN FAUNA

The following thirty taxa of mollusks were taken from the twenty-three samples from Burleigh County, North Dakota:

Phylum MOLLUSCA
- Class PELECYPODA
  - Order EULAMELLIBRANCHIA
    - Superfamily NAIADAE
      - Family UNIONIDAE
        - Naiad Fragments
  - Order TELEODESMACEA
      - Family SPHAERIDAE
        - **Sphaerium** spp.
        - **Pisidium** spp.
- Class GASTROPODA
  - Subclass STREPTONEURA
    - Order MESOGASTROPODA
      - Superfamily VIVIPARACEA
        - Family VIVIPARIDAE
          - **Viviparus** sp.
      - Superfamily VALVATACEA

Family VALVATIDAE
Valvata lewisi Currier, 1868
Valvata tricarinata (Say), 1817
Superfamily RISSOACEA
Family HYDROBIIDAE
Amnicola limosa (Say), 1817
Subclass EUTHYNEURA
Order BASSOMATOPHORA
Superfamily LYMNAEACEA
Family LYMNAEIDAE
Lymnaea palustris (Müller), 1774
Lymnaea humilis (Say), 1822, (sensu Hubendick)
Lymnaea stagnalis (Linne), 1758
Lymnaea sp.
Superfamily ANCYLACEA
Family PLANORBIDAE
Gyraulus parvus (Say), 1817
Gyraulus sp.
Promenetus exacuous (Say), 1821
Armiger crista (Linne), 1758
Helisoma trivolvis (Say), 1817
Helisoma campanulatum (Say), 1821
Helisoma anceps (Menke), 1830
Helisoma sp.
Family PHYSIDAE
Physa cf. P. gyrina (Say), 1821
Physa sp.
Order STYLOMATOPHORA
Suborder ORTHURETHRA
Superfamily PUPILLACEA
Family PUPILLIDAE
Gastrocopta armifera (Say), 1821
Pupilla blandi Morse, 1865
Family VALLONIIDAE
Valonia gracilicosta Reinhardt, 1883
Valonia sp.
Suborder HETERURETHRA
Superfamily SUCCINEACEA
Family SUCCINEIDAE
Catinella grosvenori (Lea), 1864
Catinella grosvenori gelida (Baker), 1927
Succinea avara (Say), 1824
Suborder SIGMURETHRA
Infraorder AULACOPODA
Superfamily ENDODONTACEA
Family ENDODONTIDAE
Discus cronkhitei (Newcomb), 1865

Superfamily ZONITACEA
Family ZONITIDAE
Zonitoidea arborea (Say), 1816

I believe that one taxon, **Viviparus** sp., is not of Pleistocene Age. Ostracod carapaces and stems and oögonia of calcareous algae, probably of the genus **Chara,** were also found in the sediments.

The twenty-three locations were given informal site names, taken from the ranch name, or the township name in which they occur. The Plat book in the library of the North Dakota Geological Survey was the source of these names. Geographic distribution of these sites is shown in fig. 26. The location, nature of the sediments, probable aquatic environment as reconstructed from the faunal assemblage, grain size of the sediments, fauna, and pertinent remarks are given below for each site. The fauna of the Coteau Slope district (table 5) has striking differences from those taken from the sediments of the Missouri Coteau district. The lack of naiads and the greater number and variety of terrestrial snails in the Coteau Slope district suggests drier conditions for the environment than that postulated (Tuthill, 1963) for the Missouri Coteau in eastern Burleigh, McIntosh, Stutsman, Logan, Sheridan, and Divide Counties. The presence of **Valvata tricarinata, Amnicola limosa,** and **Viviparus** sp. makes this fauna different from the present molluscan fauna of the region, insofar as the latter is known. The disjunct nature of the geographic distribution of the terrestrial and aquatic elements of the Pleistocene molluscan fauna is shown on figs. 27 and 28. The number of aquatic taxa (specific and subspecific rank) in each faunule as a percent of the total number of aquatic taxa found in Burleigh County has been made into an isopleth map (fig. 27). The occurrence of **Viviparus** sp. has been ignored in this treatment. **Helisoma** sp. has not been regarded as a separate taxon because of the slight likelihood that it represents another species than those given in the systematic list. Thus the denominator for the percentage relationship is 19 rather than the 21 found in the systematic list and on table 5.

Essentially the same procedure was followed for the terrestrial snails. Eight taxa of snails formed the denominator of this relationship and the results may be seen on fig. 28.

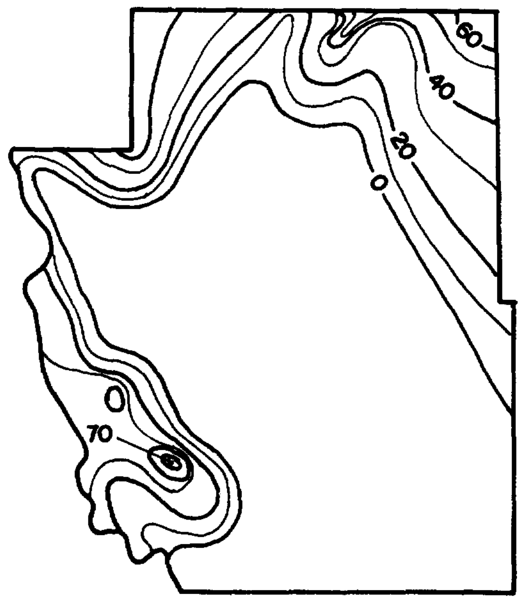
The relative number of branchiate (gill-breathing) gastropod species and pelecypod species in each site faunule as a function of the total number of species present, has been converted to a percentage and an isopleth map, showing the geographic distribution of these relationships, has been made (fig. 29).

This treatment of the data points up the existence of two areas in Burleigh County, which, during pre-Recent Pleistocene time, contained permanent bodies of water which did not concentrate salts by excessive evaporation, as in the case in the entire county at present. This indicates that the evapo-transpiration vs. precipitation ratio of the area must have been a positive value rather than a negative one.

The specimens of **Viviparus** sp. are probably reworked Tongue River Formation fossils. **Valvata** and **Amnicola** have not been described from the Tongue River Formation and the condition of the shell material and the stratigraphy of the collection sites indicates that they are probably of Pleistocene age. However, they may represent additions to the resident fauna transported by meltwater from the Missouri Coteau district during late Wisconsin time.

FOSSILIFEROUS SITES IN THE MISSOURI COTEAU DISTRICT

The following sites in Burleigh County were discovered and collected by D. E. Hansen.



Isopleth Interval — 10 Per Cent

Fig. 27. Percent of the Total Pleistocene Aquatic Mollusk Species Represented in Individual Site Faunules as a Function of Geographic Distribution ($\frac{Sa}{Ta}$ x 100 = %, where Ta = Total Number of Pleistocene Aquatic Species found in Burleigh County (12) and Sa = Number of Pleistocene Aquatic Species found in Individual Site faunules.)

1. Billingmeier Ranch site: – This site is in the NW 1/4 sec. 12, T. 144 N., R. 75 W. The few fossils recovered were contained in silty marl taken from dead-ice moraine of the Burnstad Drift.

Faunal list:	Gastropods:	**Gyraulus parvus**
		Gyraulus sp.
	Pelecypods:	**Sphaerium** sp.

Probable Environment: – The marl and silt suggest a well oxygenerated pond. The molluscan fossils indicate that seasonally temperate water was present at some time.

2. Salt Lake site: This site is in the NE 1/4 SE 1/4 sec. 12, T. 144 N., R. 76 W. The samples were collected from light tan to light grayish-brown silt and clay from stagnation features of the Burnstad Drift.

Faunal list:	Pelecypods:	**Pisidium** sp.
	Gastropods:	**Valvata tricarinata**
		Amnicola limosa
		Helisoma anceps
		Gyraulus parvus

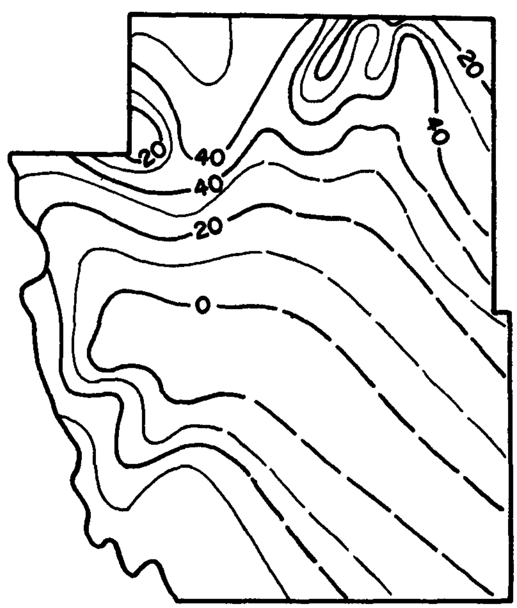


Fig. 28. Percent of the Total Pleistocene Terrestrial Mollusk Species Represented in Individual Site Faunules as a Function of Geographic Distribution. ($\frac{St}{Tt}$ x 100 = %, where St = the Total Number of Pleistocene Terrestrial Species found in Burleigh County (8) and Tt = the Number of Pleistocene Terrestrial Mollusk Species found in Individual Site Faunules.)

Probable Environment: — Shallow lake.

3. Florence Lake site: — This site is in the NW1/4 NW1/4 sec. 17, T. 144 N., R. 76 W. The samples were collected from very light tan silty marl, which is interbedded with gravel, in an area of collapsed outwash on the distal side of the Streeter Moraine of the Burnstad Drift.

Faunal list:	Gastropods:	**Valvata tricarinata**
		Amnicola limosa
		Lymnaea humilis
		Helisoma campanulatum
		H. anceps
		Gyraulus parvus
		Promenetus exacuous

Probable Environment: — Stream.

4. Muller Ranch site 1: — This site is in the NE1/4 NE1/4 sec. 14, T. 144 N., R. 76 W., 0.25 miles west of the NE section corner. The fossils were enclosed in silts of the Burnstad Drift.

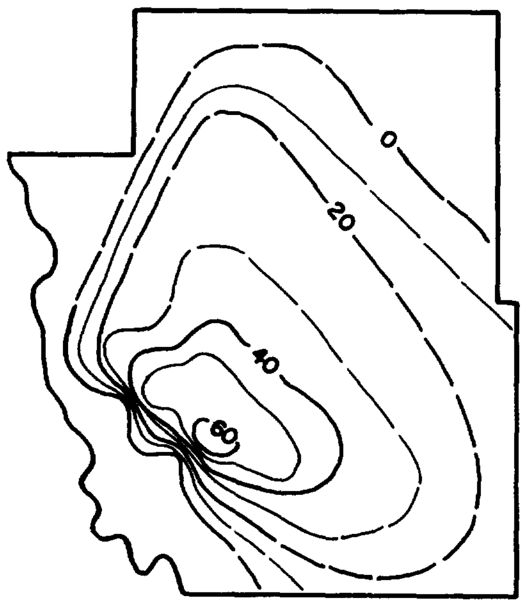


Fig. 29. Branchiate Gastropod and Pelecypod Species in each Site Faunule as a percent of the Number of Species in each Site Faunule as a Function of Geographic Distribution. $\frac{Gb + P}{St + Sa} \times 100 = \%$, where Gb = Branchiate Gastropod Species, P = Pelecypod Species, and St and Sa are as described in Fig. 2 and 3.)

Faunal list:	Gastropods:	**Valvata tricarinata**
		Amnicola limosa
		Lymnaea sp.
		Gyraulus parvus
		Gyraulus sp.
		Promenetus exacuous
	Pelecypods:	**Pisidium** sp.

Probable Environment: – Shallow lake.

5. Muller Ranch site 2: – This site is 0.25 miles south of the section corner of NW1/4 NW1/4 sec. 14, T. 144 N., R. 76 W. The samples were collected from a thin bed of silty marl, near the base of the exposure, in collapsed outwash sediments of the Burnstad Drift.

Faunal list:	Gastropods:	**Valvata tricarinata**
		Lymnaea sp.
		Helisoma anceps
		Gyraulus parvus
		Gyraulus sp.
		Armiger crista
	Pelecypods:	**Pisidium** sp.
		Naiad fragments

Probable Environment: – Stream or shallow lake. Although the aquatic pulmonates are very numerous, **V. tricarinata** is an important part of the fauna. Permanent water was undoubtedly present throughout the time that the fauna lived. Vegetation, both marginal and aquatic, was probably present and the water was temperate during the warm season.

6. Detlef Ranch site: – This site is in the NE1/4 NW1/4 sec. 22, T. 144 N., R. 76 W., 0.6 miles west of Highway 14. Samples were collected from silty marl in collapsed outwash deposits on the distal side of the Streeter Moraine of the Burnstad Drift.

Faunal list:	Gastropods:	**Valvata tricarinata**
		Amnicola limosa
		Helisoma campanulatum
		Lymnaea sp.
		Gyraulus sp.
		Promenetus exacuous

Probable Environment: – Shallow lake.

7. Wheelock Ranch site: – This site is 0.6 miles south of the NW section corner in the NW1/4 SW1/4 sec. 11, T. 144 N., R. 77 W. Samples were collected from a silty marl bed, which is about three

feet thick, in dead-ice moraine deposits of the Burnstad Drift.

Faunal list:	Gastropods:	**Valvata tricarinata**
		Amnicola limosa
		Lymnaea cf. L. humilis
		Helisoma campanulatum
		H. anceps
		Gyraulus parvus
		Gyraulus sp.
		Promenetus cf. P. exacuous
	Pelecypods:	**Pisidium** sp.

Probable Environment: – Shallow lake.

8. Painted Woods site: – This site is 0.7 miles east of the NW corner sec. 12, T. 144 N., R. 79 W. The samples were collected from a very light tan silty marl bed, overlying clay and sand, and interfingering with till, in dead-ice moraine deposits of the Burnstad Drift.

Faunal list:	Gastropods:	**Valvata tricarinata**
		Amnicola limosa
		Helisoma campanulatum
		Physa cf. P. gyrina
		H. anceps
		Gyraulus parvus
		Gyraulus sp.
		Promenetus excauous
		Armiger crista
	Pelecypods:	**Sphaerium** spp.
		Pisidium spp.

Probable Environment: – Shallow lake.

9. Pelican Lake site: – This site is in the NW1/4 SW1/4 sec. 13, T. 144 N., R. 77 W. The samples were collected from marl deposits on the edge of a kettle in dead-ice moraine.

Faunal list:	Gastropods:	**Valvata tricarinata**
		Gyraulus sp.
	Pelecypods:	**Pisidium** spp.

Probable Environment: – Shallow lake. Marl suggests standing, clear permanent water bodies. The fauna, although it is small and simple, supports this idea.

10. Boynton Ranch site: – This site is 0.5 miles south of NE corner sec. 19, T. 143 N., R. 75 W. Samples were collected from a four foot bed of light brownish-gray sandy and silty clay of

dead-ice moraine deposits of the Burnstad Drift.

Faunal list:	Gastropods:	**Valvata tricarinata**
		Amnicola limosa
		Helisoma anceps
		Gyraulus parvus
		Gyraulus sp.
		Promenetus excauous
		Armiger crista
	Pelecypods:	**Pisidium** spp.

Probable Environment: — Shallow lake.

FOSSILIFEROUS SITES IN THE COTEAU SLOPE DISTRICT

The following sites in Burleigh County were discovered and collected by Mr. Jack Kume.

11. Harris Ranch site 1: —— This site is in a road cut in the NW1/4 NE1/4 sec. 9, T. 138 N., R. 79 W. just south of the bridge on old U.S. Highway 10, approximately four miles east of Bismarck. The sediments are fine to medium-grained sand. The fauna was transported, but the shells are only slightly worn and could not have been carried far.

Faunal list:	Pelecypods:	**Sphaerium** sp.
	Gastropods:	**Valvata tricarinata**
		Amnicola limosa
		Helisoma trivolvis

Probable Environment: — The number of specimens taken from this site is small. The sediments indicate a stream environment of deposition. **Valvata** and **Amnicola** are presently found in the eastern part of North Dakota and in the Coteau Slope district in Logan and Kidder Counties. The **Amnicola limosa** living in eastern North Dakota at present are found exclusively in streams, most of which are capable of transporting coarse sand or finer sediments during part of the year. **Valvata** have been found only in lakes in North Dakota, but are known in streams elsewhere in the Midcontinent. **Sphaerium** is not out of place in streams. **Helisoma trivolvis** is typically found in standing bodies of water, characterized by finer grained sediments. Its inclusion in sediments of sand size may be explained by the fact that the margins of most streams have microhabitats suitable to the species and these specimens may have lived in backwaters and then been floated or carried into the faster currents after death. **Valvata** and **Amnicola** are both branchiate forms and also require relatively clear water.

The fauna represents a drainage system which was clear, except possibly in periods of flood, seasonally temperate, and vegetated with both aquatic and marginal plants.

12. Harris Ranch site 2: – This site is located in NW1/4 NE1/4 sec. 9, T. 138 N., R. 79 W., in the south road ditch at the same location as Harris Ranch site 1. The sample was taken from 16 to 22 feet below the surface in test hole 1861. The sediments are coarse silt and fine to medium-grained sand indicating a fluviatile environment of deposition. The fauna was probably carried a short distance from its place of life.

Faunal list:	Pelecypods:	**Sphaerium** sp.
		Pisidium sp.
	Gastropods:	**Amnicola limosa**
		Gyraulus parvus
		Helisoma anceps
		Physa sp.

Probable Environment: – The sediments were probably deposited in relatively quiet water in a stream. The pulmonate species **Gyraulus parvus** and **Physa** sp. are typical of the subhumid areas of North Dakota today. **Helisoma anceps** is considered by Baker (1928, p. 319) to be a river and stream form. This species has been collected in North Dakota only from the Cannonball River in Grant County, but it is common in late Wisconsin sediments of the Missouri Coteau district. **Amnicola limosa** is currently a stream form, and **Sphaerium** and **Pisidium** are both found in stream environments in North Dakota today. Thus, while the fauna was no doubt transported to some minor degree, it is a reasonable assemblage for stream laid sediments. These two species of pelecypods (**Sphaerium** and **Pisidium**) strongly dominate the fauna, representing 46 percent of the individuals. **Amnicola limosa** is the least frequent of the species (three percent). If the frequency distribution of species has any validity for determining environment, it would seem that conditions during the lives of the fossil mollusks were not much different from those now existing in the Coteau Slope district.

13. Blekkinsh Ranch site: – This site is in a roadcut on the south side of a section-line road on the side of a coulee in NW1/4 NE1/4 sec. 21, T. 138 N., R. 79 W. The sediments are silt-sized.

Faunal list:	Pelecypods:	**Pisidium** sp.
	Gastropods:	**Lymnaea palustris**
		Gyraulus parvus
		Helisoma trivolvis
		Promenetus excauous
		Armiger crista
	Other Fossils:	**Ostracods**
		Chara sp.

Probable Environment: – Shallow lake. This faunal assemblage is identical with that of the present Coteau Slope district as reported by Tuthill and Laird (1963). It is an assemblage which could exist in a recent permanent or ephemeral slough. **Lymnaea**

palustris and **Gyraulus parvus** comprise 30.9 percent and 29 percent of the fauna, respectively. There are no branchiates among the gastropods and **Pisidium** is known to inhabit nearly amphibious habitats. Thus the sedimentary and faunal evidence suggest a slough type environment which may or may not have been a permanent body of water.

14. McDonald Ranch site: – This site is in the NW corner SW1/4 sec. 22, T. 138 N., R. 80 W. The fossils were found directly beneath the soil zone in a bluff which is five and one half feet thick, composed of silty to sandy soil and clay.

Faunal list:	Pelecypods:	**Sphaerium** sp.
	Gastropods:	**Lymnaea humilis**
		Lymnaea stagnalis
		Gyraulus parvus
		Physa sp.
	Other Fossils:	**Ostracods**

Probable Environment: – Shallow lake. Like the fauna at the Blekkinsh Ranch site, this assemblage and the sediments which contain it suggest deposition in a slough which may or may not have been a permanent body of water. All species are common in the Coteau Slope district today. The stratigraphy of the site suggests that the sediments are of late Wisconsin Age, but the possibility that they are of Recent Age is not precluded by the fossil assemblage.

15. Coonan Ranch site: – This site is in a fresh roadcut on the west side of the section-line road in the SE1/4 NE1/4 sec. 14, T. 139 N., R. 80 W. Samples were collected from a local lense of outwash sand associated with till and clay at the crest of a bedrock knoll.

Faunal list:	Gastropods:	**Viviparus** sp.
		Vallonia gracilicosta
		Catinella grosvenori
		Pupilla blandi
		Discus cronchitei

Probable Environment: – Stream bank or floodplain. All of the gastropods in this fauna are terrestrial forms except **Viviparus**, which I believe is reworked from Tongue River Formation sediments and is not a part of the Pleistocene fauna of Burleigh County. This idea stems from the worn condition of the Viviparidae specimens I have examined, and the fact that the Tongue River Formation is the immediate sub-Pleistocene bedrock of this part of the county.

The fauna from this site may be of pre-Recent age, and if it is, it is of considerable significance in that the large number of terrestrial species in the Coteau Slope district of western Burleigh County is in striking contrast with the paucity of land snails in the Missouri Coteau district. This might be accounted for by the fact that the Coteau Slope district faunas represent a terrestrial-fresh-water bio-facies, while the Coteau district faunas represent a superglacial aquatic bio-facies. Thus, the Coteau Slope district faunas are typified by pulmonates, both Bassomatophora and Stylomatophora, while the Coteau district faunas are typified by a general dominance of branchiate snails. The fact that both areas are typified by a pulmonate Recent aquatic snail fauna and the Recent terrestrial snail fauna has not been studied, is a complicating factor. Thus one must rely on stratigraphic criteria or radiocarbon dating for establishment of geologic age.

16. Stopp Ranch site: – The site is on the south side of the section-line road in SE1/4 SE1/4 sec. 15, T. 139., N. R. 80 W. Samples were collected from lacustrine silt and clay near the top of a roadcut.

Faunal list:	Pelecypods:	**Pisidium** sp.
	Gastropods:	**Valvata tricarinata**
		Lymnaea humilis
		Gyraulus parvus
		Helisoma anceps

Probable Environment: – Shallow lake. The presence of **Valvata** suggests a permanent, clear body of water. The other pulmonate snails, especially **H. anceps** support this idea despite their ability to live in environments not suitable to **Valvata. H. anceps**, as previously mentioned, is typical of rivers and streams in the Midcontinent, but has been found in lakes lacking inflowing or outflowing streams (Tuthill, and others, 1963). Thus its presence does not rule out a totally lacustrine environment of deposition for the sediments at this site. An alternative possibility is that inflowing streams carried shells of **H. anceps** into the environment of deposition after the death of the snails.

17. Hay Creek site: – The site is on the west side of a roadcut in the SE1/4 SE1/4 sec. 23, T. 139 N., R. 80 W. The samples were collected from unconsolidated, clean, outwash of fine to medium-grained sand at the crest of the bedrock knoll.

Faunal list:	Gastropods:	**Viviparus** sp.
		Catinella grosvenori gelida
		Succinea avara
		Discus cronkhitei

Probable Environment: – Stream bank or floodplain. All of the mollusks are terresetrial, except **Viviparus** sp. which I believe is a reworked Tongue River Formation and does not represent ecologic conditions at the time of deposition of these sediments.

Thus, total reliance on sedimentary evidence is required. The stream which laid down the sediments, must have passed through grassland or woods. All the snails are extant in North Dakota even in the areas where only prairie is found. The possibility that these sediments are of Recent age is not great, since streams capable of depositing outwash-type sediments do not now exist in the area.

18. Griffin Ranch site: – This site is in the south bank of a fresh, narrow, exposure in an east-west coulee, east side of the road in the NE1/4 SE1/4, sec. 27, T. 140 N., R. 81 W. Samples were collected from a very light gray marl, and light gray silt, with interbedded dark yellowish-orange medium to fine-grained sand overlain by two feet of wind blown soil.

Faunal list:	Pelecypods:	**Pisidium** sp.
	Gastropods:	**Gyraulus parvus**
		Lymnaea sp.
		Physa sp.
		Helisoma campanulatum
	Other Fossils:	**Chara? Oögonia and stems**
		Ostracod carapaces

Probable Environment: – Shallow lake. The presence of marl in the sediments virtually assures a limnitic environment, at least for that stratum, and strongly indicates that the entire sequence is a lacustrine deposit. The sand layers may indicate increased current or greater sorting due to wave action. The fauna is one typical of lakes, **H. campanulatum** being considered strictly a lake form.

19. Harvey Ranch site: – This site is in the north bank of Burnt Creek in the ditch on the east side of the road in the NW1/4, NW1/4, sec. 29, T. 140 N., R. 80 W. Samples were collected from sand and clay in an outwash channel.

Faunal list:	Gastropods:	**Vallonia gracilicosta**
		Vallonia sp. (juveniles)
		Gastrocopta armifera

Probable Environment: – Stream bank or floodplain. Both these taxa are typical of the long and short grass prairie biome in North Dakota today. They are capable of withstanding protracted periods of dry weather by sealing their aperture with a mucous epiphram. I have observed living specimens of **Succinea** estivating in joints in the terrace sediments of the Little Missouri River. If the snails were to die there, it is conceivable that they might be mistaken for fossils. If this habit is shared by **Gastrocopta** and **Vallonia**, this may explain their presence in these sediments. Kume suggests that the shells are Recent and while I found no living animals in them, I am inclined to think he is right.

20. Apple Creek site 1: – This site is on the north side of U. S.

Highway 10 about five miles east of Bismarck in the uppermost terrace of Apple Creek, in SW1/4 SW1/4, sec. 34, T. 139 N., R. 79 W. Samples were collected from the upper fifteen feet of very fine sand and silt sediments.

Faunal list:	Gastropods:	**Gyraulus parvus**
		Gyraulus sp.
		Lymnaea humilis
		Zonitoides arboreus
		Catinella grosvenori gelida
		Gastrocopta armifera (specimens destroyed during identifications)
		Discus cf. D. cronkhitei
		Vallonia gracilicosta

Probable Environment: – Stream bank or floodplain. The first three taxa are aquatic forms, but may occupy very unstable environments. Because of a large number and variety of land snails, I believe the sediments to be redistributed stream deposits, the fossil content of which was enriched by resident and nearby terrestrial snails. Wind may well have been the agent of transportation as sand dunes are known in the area.

21. Johnson Ranch site: – The site is in the NW1/4 NW1/4 sec. 11, T. 140 N., R. 80 W. The fossils came from sand deposits along the north edge of the floodplain of Burnt Creek.

Faunal list:	Gastropods:	**Discus cronkhitei**
		Succinea cf. S. avara

Probable Environment: – Stream bank or floodplain. I believe that these specimens are from a fauna of Recent Age. Both species are known in Grant County to the southwest and they are no doubt also resident in Burleigh County. Stream valleys are a normal environment of these species in North Dakota today.

22. Haberlin Ranch site: – The site is in the NW corner of section 35, T. 143 N., R. 79 W. Lacustrine marls, silts and clays overlying till comprise the lithology of this site. These deposits lie approximately two miles beyond the distal side of the Burnstad dead-ice moraine of north and northeastern Burleigh County.

Faunal list:	Gastropods:	**Valvata tricarinata**
		Valvata lewisi
		Gyraulus parvus
		Helisoma sp.
		Lymnaea humilis
		Promenetus exacuous
	Pelecypods:	**Pisidium** sp.

Probable Environment: – Shallow lake.

23. Blackman Ranch site: – The site is located in the SW1/4 NW1/4 sec. 30, T. 143 N., R. 79 W., three miles beyond the distal side of the Burnstad dead-ice moraine in sheet moraine of the Napoleon Drift. The samples were collected from lacustrine sand and silt overlying till.

Faunal list:	Gastropods:	**Valvata lewisi**
		Lymnaea humilis
		Gyraulus parvus
		Succinea cf. S. avara
		Vallonia sp.
		Zonitoides arborea

Probable Environment: – Shallow lake. The land snails **S. avara**, **Vallonia** sp., and **Z. arborea** are minor elements of the fauna from this site. **V. lewisi** is a lake form of this genus. The high silt and sand content of these sediments is probably indicative of an environment of deposition near shore in a clear lake rather than of fluviatile inlets. The land snails were probably blown into the lake and the aquatic snails probably resided in the immediate vicinity. Thus a clear lake is indicated with abundant aquatic and border vegetation.

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TABLE 5 – Species composition of the Molluscan faunules by sites in Burleigh County. See text for locations of sites, listed here by number.

Mollusks	Missouri Coteau Sites											Coteau Slope Sites												No. of
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Occurrence
PELECYPODS																								
Naiad frags.					x																			1
Sphaerium spp.	x							x			x	x		x										5
Pisidium spp.		x		x	x		x	x	x	x		x	x			x		x				x		12
GASTROPODS																								
Viviparus sp.															x		x							2
Valvata tricarinata		x	x	x	x	x	x	x	x	x	x					x						x		12
V. lewisi																						x	x	2
Amnicola limosa		x	x	x		x	x	x		x	x	x												9
Lymnaea palustris													x											1
L. humilis			x				x							x		x				x		x	x	7
L. stagnalis														x										1
Lymnaea sp.				x	x	x												x						4
Gyraulus parvus	x	x	x	x	x		x	x		x		x	x	x		x		x		x		x	x	16
Gyraulus sp.	x			x	x	x	x	x	x	x										x				9
Promenetus exacuous			x	x		x	x	x		x			x									x		8
Armiger crista					x			x		x			x											4
Helisoma trivolvis											x		x											2
H. campanulatum			x			x	x	x										x						5
H. anceps		x	x		x		x	x		x		x				x								8
Helisoma sp.																						x		1
Physa cf. P. gyrina								x																1
Physa sp.												x		x				x						3
Gastrocopta armifera																			x	x				2
Pupilla blandi															x									1
Vallonia gracilicosta															x				x	x				3
Vallonia sp.																			x				x	2
Catinella grosvenori															x									1
C. g. gelida																	x			x				2
Succinea avara																	x				x		x	3
Discus cronkhitei															x		x			x	x			4
Zonitoides arborea																				x			x	2
Number of species in each faunule	3	5	7	7	8	6	9	11	3	8	4	6	6	5	5	5	4	5	3	8	2	7	6	133

14 Species found in the Missouri Coteau District Faunules.

23 Species found in the Coteau Slope District Faunules.

North Dakota Geological Survey
WILSON M. LAIRD, *State Geologist*
BULLETIN 42
North Dakota State
Water Conservation Commission
MILO W. HOISVEEN, *State Engineer*
COUNTY GROUND WATER STUDIES 3

GEOLOGY AND GROUND WATER RESOURCES

of Burleigh County, North Dakota

PART II

GROUND WATER BASIC DATA

By
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Prepared by the United States Geological Survey
in cooperation with the North Dakota Geological Survey and the
North Dakota State Water Conservation Commission
GRAND FORKS, NORTH DAKOTA, 1965

This is one of a series of county reports which will be published cooperatively by the North Dakota Geological Survey and the North Dakota State Water Conservation Commission in three parts. Part I is concerned with geology, Part II, basic data which includes information on existing wells and test drilling, and Part III which will be a study of hydrology in the county. Part III will be published later and will be distributed as soon as possible.

CONTENTS

ILLUSTRATIONS

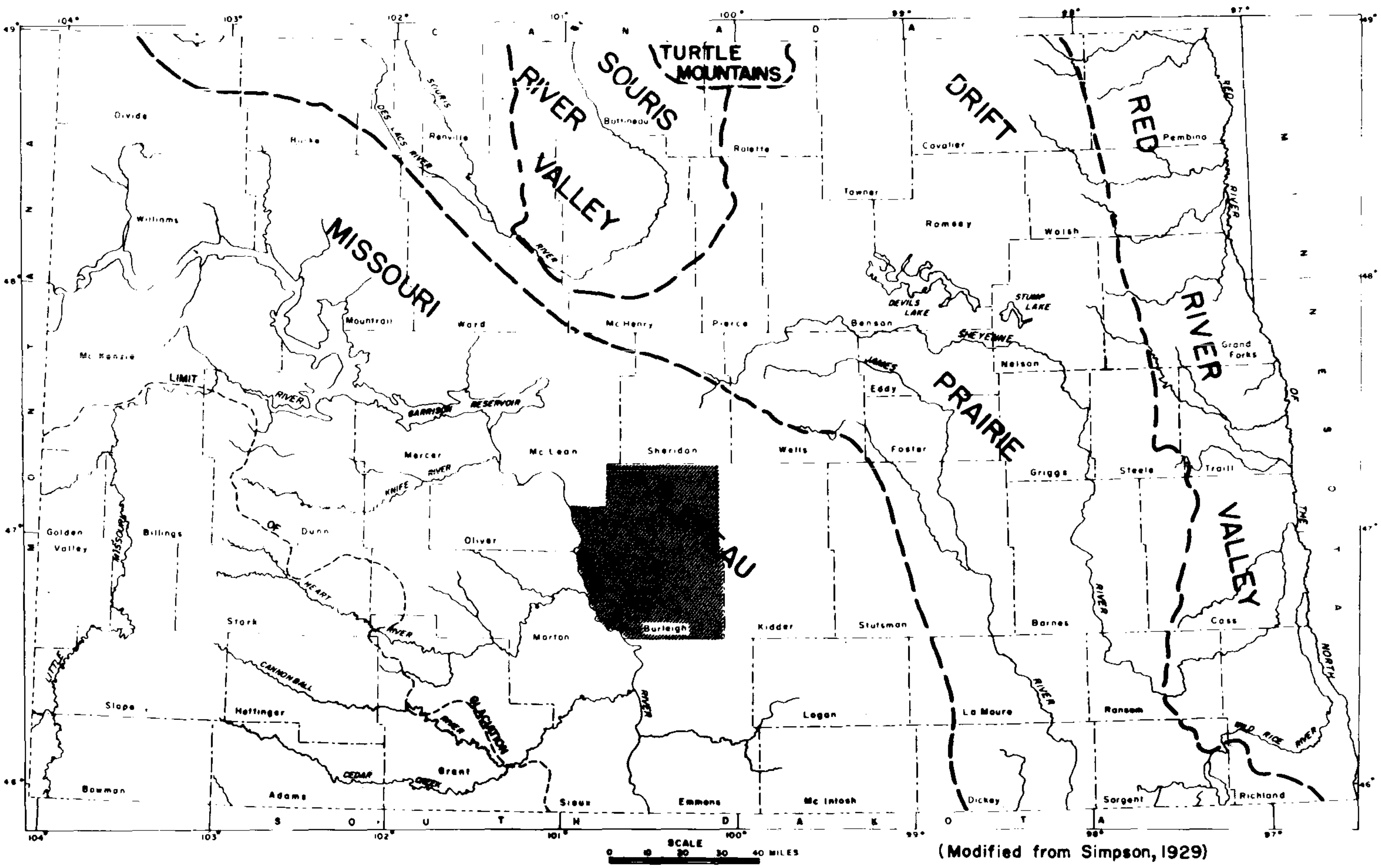
TABLES

Introduction

The study of the geology and ground-water resources of Burleigh County, North Dakota has been a cooperative investigation made by the U. S. Geological Survey, the North Dakota State Water Conservation Commission, and the North Dakota Geological Survey. Burleigh County is near the center of the state in the Missouri Plateau physiographic province (figure 1). The results of the study are being published in 3 parts consisting of : Part I, an interpretive report describing the geology, Part II, ground-water basic data, and Part III, an interpretive report describing the ground-water resources. 1/

1/ The classification and nomenclature of the rock units conform to the usage of the North Dakota Geological Survey and also, except for the Fort Union Group and its subdivisions, to that of the U. S. Geological Survey, which regards the Fort Union as a formation. The Fort Union Group as used by the North Dakota Geological Survey includes the Cannonball and Tongue River Formations.

This report contains the basic-data collected during the Burleigh County investigation, and serves as a supplement to the interpretive reports, Parts I and III. The information in this report was collected during the period 1960 to 1964, and consists of: (1) data from an inventory of existing wells, (2) logs of test holes, (3) measured water-levels in key observation wells and (4) chemical analysis of water samples from selected wells. Most of the well-inventory data were collected during the period of study, however, some well data collected before 1960 is also included. Additional analyses of



(Modified from Simpson, 1929)

FIGURE I--MAP SHOWING PHYSIOGRAPHIC PROVINCES IN NORTH DAKOTA AND LOCATION OF BURLEIGH COUNTY.

ground water are published in U. S. Geological Survey Water-Supply Papers 598 and 1428. The logs of test holes are composite logs from a synthesis of drillers logs, sample analysis logs, and in most cases, electric logs. The commercial logs are quoted as they were received from private individuals or concerns. All the 152 test holes were drilled with rotary drilling equipment.

Water levels in key observation wells were measured and reported monthly, except where water-level recorders are installed. An almost continuous water-level record is available for those wells equipped with recorders and water levels are reported as the low water level recorded on every 5th day and the last day of the month. Water samples from selected wells were analyzed for chemical quality by the North Dakota State Laboratories Department, the U. S. Geological Survey, and the North Dakota State Health Department.

The well-numbering system used in this report, illustrated in figure 2, is based upon the location of the well in the federal system of rectangular surveys of the public lands. The first numeral denotes the township north of the base line, 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 section, quarter-quarter sections, and

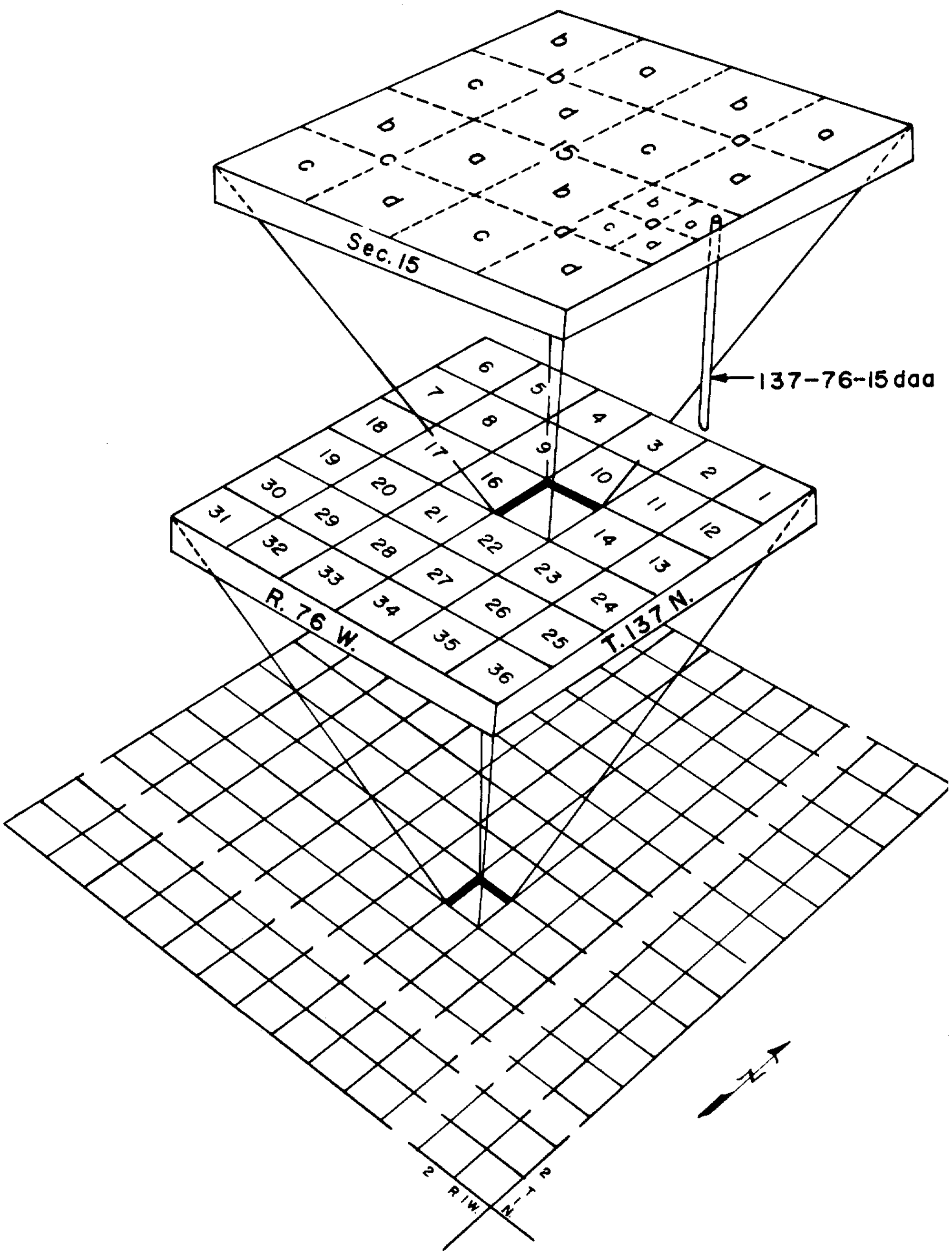


FIGURE 2--SYSTEM OF NUMBERING WELLS AND TEST HOLES.

quarter-quarter-quarter sections (10-acre tracts). Thus a typical well 137-76-15daa is in the NE$\frac{1}{4}$ NE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 15, T. 137 N., R. 76 W.

The data in this report are useful for predicting subsurface conditions when used in conjunction with the interpretive reports on the geology and ground-water resources in Burleigh County (Parts I and III of this Bulletin). The aquifer depth and thickness, water-level, and quality of water may be estimated for a potential site by examining the records of nearby wells shown in tables 1-5, and figures 2 and 3.

Logs of test holes drilled prior to 1960 are indicated by the 1000 numbering series; those drilled during 1960 by the 1800 numbering series; and those drilled from 1961 thru 1963 by the 1900 or 2000 numbering series. Logs of test holes drilled prior to 1961 were prepared from samples collected at the drilling sites and analyzed after the field season had ended. Logs of test holes drilled after 1961 were analyzed and sample-analysis logs were prepared on the drilling site of each test hole. Sample analysis included color chart comparisons (Goldman, 1928), visual examinations using a binocular microscope, and tests for carbonate. If there was effervescence, when acid contacted the material it is said to be calcareous. Grain-size designations used in all logs refer to the Wentworth size scale (Wentworth, 1922). When the term oxidized is used, it means the material was subjected to the action of waters carrying oxygen, carbon dioxide, etc. The terms angular, subangular, subrounded, rounded, and well rounded are the terminologies used to indicate various degrees of roundness. Roundness is expressed as the ratio of the average radius of curvature of the maximum inscribed sphere. The term cohesion is used to indicate the tendency for particles of the described material to stick or adhere together. As a descriptive term till indicates an unsorted, unstratified, cohesive, agglomeration of particles ranging from clay to boulder size. Till is also used to indicate the origin of the material.

Modifying terms such as clayey, silty, sandy, and gravelly are textural terms used to indicate that the material described contains an appreciable, but not a dominant amount of the material. The formation name refers to a mappable stratum of reasonably continuous material. Material listed under glacial drift, such as till, is presumed to have been deposited from glacial ice. Bedrock formations were picked by Mr. Jack Kume, N. Dak. Geol. Survey to coincide with the interpretive report on the geology.

In areas where a potential aquifer was penetrated, an observation well was developed from the test hole. These observation wells normally consisted of 1¼ inch flexible plastic pipe, slotted the thickness of the sand and/or gravel deposit. In areas where a recorder was installed on the observation well a 4 inch casing was used. From these wells water levels were measured (table 5), and samples collected for chemical analysis (tables 3 and 4).

The author is especially grateful to Schnell Inc., and other drillers who supplied many commercial drillers logs for this report. Thanks are also due to all the farmers engaged in and interested in irrigation, Capital Electric, the Bismarck Chamber of Commerce, and the people of Burleigh County for their help in the collection of these data. Data collected during a reconnaissance study of the Missouri River near Bismarck (Greenman, 1953) was useful in preparing table 1.

TABLE 1.--Records of wells and test holes in Burleigh County, North Dakota

Owner: USGS, United States Geological Survey; USBR, United States Bureau of Reclamation.

Depth of well: Measured depths are given in feet, tenths, and (or) hundredths; reported depths are in feet.

Type of well: Dr, drilled; Du, dug, Dv, driven.

Depth to water: Measured depths are given in feet, tenths, and (or) hundredths; reported depths are in feet.

Use of water or well: D, domestic; Irr, irrigation; N, not used; O, observation of water level; PS, public supply; S, stock; T, test hole.

Aquifer: Gv, gravel, Lig, lignite; Sd, sand; Sh, shale; Ss, sandstone.

Remarks: BR-20, bedrock encountered at 20 feet; C, chemical analysis is shown in table 3; L, log described in table 2; SC-2,360, specific conductance in micromhos at 25° C; Wad, water supply reported to be adequate for present use; Wal, water reported to have alkaline taste; Wh, water reported to be hard; Win, water supply reported to be inadequate for present use; Ws, water reported to be soft; TD-240, total depth drilled.

TABLE 1.--Records of wells and test holes in Burleigh County, North Dakota

Location No.	Owner or name	Depth of well (feet)	Diameter or size (inches)	Type	Date completed	Depth to water below land surface (feet)	Use of water or well	Aquifer	Elevation at land surface	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
137-75										
6abb1	W. Backhaus	35	2	Dr	1906	20	S	Sd	....	Wad, Wh.
6abb2	..do....	52	2	Dr	1958	30	D	Sd	....	Wad.
8dda	USGS Test hole 1829	157	5	Dr	1960	.....	T	Gv	1,712	BR-124, L.
10bab	H. Carlisle	90	...	Dr	1937	.....	D,S	Gv	....	Wad.
12ddc	E. Preszler	90	2	Dr	1938	Flow	D,S	Gv	....	SC-1,430, Wh.
13bb	Mrs. S. R. Goodings	60	...	Dr	1932	14	D,S	Ss	....	Wad.
14bb	M. B. Swenson	65	...	Dr	1913	30	D,S	Sd	....	..Do....
17bbb	USGS Test hole 1828	189	5	Dr	1960	.....	T	Sd & Gv	1,716	BR-168, L.
18acc	E. Porter	35	...	Du	1913	.....	D,S	Clay	....	Wad.
21bbc	F. A. Lahr	50	...	Dr	1927	.....	D,S	Gv	....	..Do....
22add	F. Johnson	82	...	Dr	1956	34	D,S	Sd	....	C, SC-684, Wad.
24cc	Federal Land Bank	90	...	Dr	....	40	D,S	Clay	....	Wad.
25dd	R. Arvig	85	...	Dr	....	.....	D,S	Sd & Gv	....	..Do....
26cdc	Bank of N. Dak.	90	...	Dr	....	16	D,S	Sd & Gv	....	..Do....
27cda	M. Keller	80	2	Dr	1959	30	D,S	Sd & Gv	....	Wad, 35 grains
28cbb	R. Preszler	20	8	Du	....	6	D,S	Gv	....	Wad, Wh.
29ddc	J. Glovich	12.15	48	Du	....	4.82	D,S	Gv	....	..Do....
30dd	H. Swanson	90	2	Dr	....	15	S	Sd	....	..Do....
31aab	USGS Test hole 2048	45	5	Dr	7-30-62	......	T	..	1,825.8	BR-30, L.
31bab	J. P. Jenson	187	2	Dr	....	......	N	Sd	....	Wad.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
137-75 (Cont.)										
32aba	H. Swanson	60	2	Dr	....	.....	N	Sd	....	Wad.
32bab1	..do....	90	2	Dr	1931	20	D,S	Sd	....	Wh, Win.
32bab2	..do....	120	3	Dr	1957	20	D	Sd	....	SC-1050, Win.
33bb	C. W. Chefman	90	...	Dr	....	25	D,S	Gv	....	Wad.
34bb	Bank of N. Dak.	65	...	Dr	....	25	D,S	Sd	....	..Do....
34cba	S. Materi	180	4	Dr	....	40	D,S	..	....	Wad, Wh.
137-76										
2bbb	USGS Test hole 2031	165	5	Dr	1962	......	T	Gv	1,762.6	BR-141, L.
2bbd	E. M. Enockson	80	2	Dr	1960	30	S	Sd	....	Wad, Wh.
4cab	E. L. Bailey	213	2	Dr	1942	40	D,S	Sd	....	Wad.
5daa	Schauer	190	2	Dr	....	70	D,S	Sd	....	C, SC-1,700, Wad.
6cc	W. S. Hoen Estate	235	2	Dr	1927	......	D,S	Gv	....	Wad.
7daa	C. Renz	180	2	Dr	....	40	D,S	Sd	....	SC-1,340, Ws.
8cdd	G. Adams	215	5	Dr	1962	......	T	Sd	....	C, L.
9add	N. Edwards	196	2	Dr	....	30	D,S	Sd	....	SC-1,830, Wad, Ws.
9bbc	USGS Test hole 1825	252	5	Dr	1960	......	T	Sd & Gv	1,735	BR-126, L.
12cdd	W. Lane	275	2	Dr	1953	75	S	Sd	....	Wad, Ws.
12ddd	USGS Test hole 1827	73	5	Dr	1960	......	T	Sd	1,804	BR-47, L.
14aa	B. F. Lane	226	2	Dv	1908	156	D,S	Sh	....	Wad.
14add	W. Lane	265	2	Dr	1955	100	D,S	Sd	....	Wad, Ws.
17aaa	USGS Test hole 1826	173	5	Dr	1960	......	T	Sd & Gv	1,726	L.
17ddd	City of Moffit	170	2	Dr	1955	40	D,S	Sd	....	Wad, Ws.
18cc	State of N. Dak.	100	2	Dr	1928	50	D,S	Sd	....	Wad.
18ccd	USGS Test hole 2047	115	5	Dr	7-62	......	T	Sd	1,821.4	L, BR-5.
18dcc	L. Klepp	40	2	Dr	....	......	D,S	Sd	....	SC-1,110, Wad, Wh.
19caa	Unknown	150	.	Dr	1934	......	D,S	Sd	....	SC-1,200, Wad, Ws.
20bbb	H. Feist	90	2	Dr	1955	......	D,S	..	....	Wad.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
137-76 (Cont.)										
21bbc	USGS Test hole 1824	315	5	Dr	1960	......	T	Ss	1,760	BR-O, L.
22ddd	V. Jensen	160	2	Dr	1931	10	D,S	Sd	....	Wad.
26aca	U.S. Fish and Wildlife Svc	182	2	Dr	1953	4	D,PS	Sd	....	C, Reptd solids 850, Wad.
28dad1	G. Fried	80	2	Dr	....	45	D,S	..	....	Wad, Wh.
28dad2	..do....	240	2	Dr	....	60	S	Sd	....	Wad, Ws.
29dda	H. Faust	150	2	Dr	1918	100	D,S	..	....	Wad, Wh.
30dd	W. E. Nickel	110	2	Dr	1920	......	D,S	Sd	....	Wad.
32bb	P. H. McCay (oil test 1)	6,180	13	Dr	1952	......	...	..	1,858	
32bbb	P. H. McCay	305	8	Dr	....	98.61	S,O	Sd	....	C, Wad.
32ddc1	..do....	90	2	Dr	....	60	S	..	....	Wad, Wh.
32ddc2	..do....	226	2	Dr	1956	140	D,S	Sd	....	Wad, Ws
35aaa	USGS Test hole 1937	126	5	Dr	8-31-61	......	T	Ss	1,719.8	BR-107, L.
36abb	USGS Test hole 1938	199	5	Dr	8-31-61	......	T	Sd	1,713.9	BR-179, L, PC
36ba	M. Benz	180	2	Dr	....	......	D,S	..	....	C.
137-77										
1dd	W. I. Mills	175	2	Dr	1920	......	S	Sd	....	Wad.
4caa1	W. MacDonald	280	2	Dr	....	30	D	Sd	....	Wad, Ws.
4caa2	..do....	70	2	Dr	....	30	S	Sd	....	Wad.
8bdd	..do....	76	2	Dr	....	30	S	Sd	....	..Do....
8ddd	USGS Test hole 1830	493	5	Dr	1960	......	T	Ss	1,868	BR-59, L.
10aab1	L. Morrison	30	36	Du	1909	12	D,S	Sd	....	Wh, Win.
10aab2	..do....	170	2.5	Dr	1950	100	D,S	Sd	....	Wad,
14dda	P. Hoover	100	2	Dr	1957	30	S	Sd	....	Wad.
14ddd	USGS Test hole 1936	147	5	Dr	8-30-61	......	T	Ss	1,832.6	BR-7, L.
15ccc	A. Westbrook	90	2	Dr	....	30	S	Sd	....	Wad, Wh.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
137-77 (Cont.)										
17aaa	D. Beard	90	2	Dr	1956	12	D,S	Sd	....	C, Wad, Wh.
20acc1	A. Westbrook	185	2	Dr	....	60	D,S	Sd	....	Wad, Ws.
20acc2	..do....	145	2	Dr	....	50	S	Sd	....	..Do....
22add	P. Hoover	50	2	Dr	1956	18	D,S	Sd	....	Wad, Wh.
24cba	E. Magnew	90	2	Dr	....	30	D,S	Sd	....	..Do....
24dab	..do....	160	2	Dr	....	......	S	Sd	....	..Do....
28abc	W. Mills	266	2.5	Dr	1953	130	D,S	Sd	....	C, SC-695, Wad.
30dba	C. Day	268	2	Dr	....	100	S	Sd	....	Wad, Ws.
30dbb	..do....	86	2	Dr	....	30	D,S	Sd	....	Wad
32cdd	A. Nickolson	300	2	Dr	....	120	D,S	Sd	....	Wad, Ws.
34bcc	C. Hoover	159	2	Dr	1959	80	D,S	Sd	....	..Do....
137-78										
2bb	M. Ives	5	60	Du	1935	3	S	Sd	....	Wad.
2cc	J. Borner	260	2	Dr	1910	100	D,S	Sd	....	..Do....
3baa	H. Hogue	315	2	Dr	....	75	D,S	Sd	....	SC-1,710, Wad.
4abb1	J. G. Schmidt	275	2	Dr	....	90	D	Sd	....	Wad, Ws.
4abb2	..do....	257	2	Dr	1958	77	S	Sd	....	SC-1,570, Wad.
6add	Federal Land Bank	30	36	Du	1938	4	D,S	Clay	....	Wad.
7bb	State of N. Dak.	25	..	Du	1934	18	D,S	Sd	....	..Do....
8bcb	USGS Test hole 2014	216	5	Dr	7-18-62	47.69	T,O	Sd	1,719.5	BR-216, C, L, TD-240.
8cbb	C. Malard	250	2	Dr	1958	80	D,S	Sd	....	Wad, Ws.
8dbd	A. Stewart	90	2	Dr	....	......	D,S	..	....	Wad.
9ddd	W. F. Cameron	110	..	Dr	1916	......	D,S	Sd	....	..Do....
12bbb	J. Horner	100	2.5	Dr	1920	30	D,S	Ss	....	..Do....
14caa1	W. Magstadt	203	2	Dr	....	140	D,S	Sd	....	Win, Ws.
14caa2	..do....	200	2	Dr	....	80	D	Sd	....	Wad, Ws.
17ccc	USGS Test hole 2040	180	5	Dr	7-20-62	......	T	Sd	1,696.4	BR-169, L.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
137-78 (Cont.)										
19bab	G. Register	60	2	Dr	....	35	D,S	Sd	....	Wh.
20baa	W. M. Oder	250	2	Dr	....	....	D,S	Sd	....	C, SC-1,862, Wad.
20dad	W. M. Mc Murrich	300	2	Dr	....	60	D,S	Sd	....	Wad, Ws.
21cc	W. Webb	12	2	Dv	1930	5	S	Sd	....	Wad.
22bcc	A. Anderson	200	2	Dr	1958	100	D,S	Sd	....	Wad, Ws.
22ccc	USGS Test hole 2013	105	5	Dr	7-18-62	....	T	..	1,739.4	BR-100, L.
24cdd	O. M. Mills	137	2	Dr	....	112	D,S	Sd	....	Wad, Wh.
24dab	A. Giovannoni	148	3	Dr	1922	138	D,S	Lig & Sd	....	..Do....
26cbb	F. S. Vogel	28	36	Du	1958	8	D,S	Sd	....	..Do....
26daa	H. Mills	190	2	Dr	1959	170	D,S	Sd	....	Wad, Ws.
29aba	C. Dietrich	230	2	Dr	....	120	D,S	Sd	....	Wad.
30ada1	M. Dietrich	192	2	Dr	....	....	D,S	Sd	....	Wad, Ws.
30ada2	..do....	135	2	Dr	....	....	S	Sd	....	..Do....
33aba	USGS Test hole 2039	185	5	Dr	7-23-62	....	T,O	Sd	1,711.1	BR-221. C,L, TD-240.
33cc	G. Kratt	150	3	Dr	1909	50	D,S	..	....	....
35abb	J. H. Kershaw	230	2	Dr	1918	200	D,S	Sd	....	Wad, Ws.
137-79										
2aaa	L. Malard	325	3	Dr	1909	100	D,S	Sd	....	SC-2,375, Wad
2dcc	D. E. McLean	87	2	Dr	1890	48	D,S	Sd	....	Wad, Wh.
5dd	S. Robinson Estate	180	2	Dr	1914	20	D,S	Sd	....	Wad.
6a	J. Claridge	200	2	Dr	....	....	D,S	..	....	C.
6dad	G. Claridge	80	3	Dr	....	50	S	Sd	....	Wad, Wh.
7aa	S. Woodworth	170	2	Dr	....	30	D,S	Sd	....	Wad.
7bdc	G. Claridge	120	4	Dr	....	55	D,S	Sd	....	Wad, Ws.
8bbb	C. Swenson	70	2	Dr	1952	30	S	Sd	....	Wh, Win.
8cad	E. Woodworth	256	2	Dr	....	....	D,S	Sd	....	Ws.
8ccd	L. Clark	201	2	Dr	1954	30	D,S	Sd	....	Wad, Ws.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
137-79 (Cont.)										
10ddc	B. Brown	208	2	Dr	1916	......	D,S	Sd	....	Wad, Ws.
11ddd	S. Irvine	100	2.5	Dr	1906	35	D,S	Sd	....	Wad.
12ccc	A. Irvine	100	2	Dr	1927	30	D,S	Sd	....	..Do....
14aaa	J. Irvine	100	2	Dr	....	30	D,S	Sd	....	SC-750, Wad.
16ab	J. Crawford	83	2	Dr	1927	20	D,S	Sd	....	Wad.
16cad	W. W. Woodworth	23	1.25	Dr	....	8	D,S	Sd	....	Wad, Ws.
18aab	C. D. Kimball	287	2	Dr	1944	200	D,S	Sd	....	..Do....
26cbb	USGS Test hole 2015	86	5	Dr	7-19-62	14.23	T,O	Sd & Gv	1,724.7	BR-100, C, L, TD-105.
26ccb	A. Maclean	20	1.5	Dv	1928	3	D,S	Sd	....	Wad.
27dd	G. O'Callaghan, Jr.	95	3	Dr	....	......	T	Sd	....	C, L.
137-80										
1bbd1	C. Swenson	200	2.5	Dr	1951	70	D	Sd	....	Win, Ws.
1bbd2	..do....	131	2	Dr	1954	65	S	Sd	....	BR-130, Wad, Wh.
1cbb1	J. Swenson	60	2	Dr	1946	40	S	Lig	....	Wad.
1cbb2	..do....	165	2	Dr	1958	90	D,S	Sd	....	C, Wad, Ws.
2aa	..do....	100	2	Dr	....	85	D,S	..	....	Wad.
3aaa1	Annunciation Priory	375	6	Dr	....	......	PS	Sd	....	BR-0, Win, Ws.
3aaa2	..do....	40	8	Dr	....	13.5	PS	Sd	....	..Do....
3abb	USGS Test hole 1852	84	5	Dr	1960	......	T	Ss	1,625	BR-42, L.
3cbb	W. L. Falcner	150	4	Dr	1956	12	D,S	Sd	....	Wad, Ws.
3dab	USGS Test hole 1851	63	5	Dr	1960	......	T	Ss	1,620	BR-31, L.
11bda	A. Ashbridge	125	2	Dr	....	105	D,S	..	....	C, Wad.
11dcc	R. Small	180	2.5	Dr	1953	100	D,S	Sd	....	Wad, Wh, high iron
12bb	C. Ferris	160	2	Dr	1914	140	D,S	..	....	Wad.
12ca	A. Boyer	178	2	Dr	1905	160	D,S	..	....	..Do....
13bda	J. Bobidou	197	2	Dr	1926	190	D,S	Sd	....	C, Wad, Ws.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
137-80 (Cont.)										
14ad	O. Lighthouser	125	2	Dr	1900	110	D,S	..	....	Wad.
24abc	USGS Test hole 1949	126	5	Dr	9-15-61	9.00	T	Sd & Gv	1,627.0	C, L. BR-115.
138-75										
2bb	W. Bros.	300	2	Dr	1910	175	D,S	Sd	....	Wad,
4cba	K. Fried	302	3	Dr	1957	200	D,S	Sd	....	C, Wad.
5aa	Federal Land Bank	150	2	Dr	....	......	D,S	..	....	Wad.
5ddd	USGS Test hole 2046	136.5	5	Dr	7-19-62	......	T	Sd	1,919.5	BR-122, L.
6bb	C. Syverson	144	2.5	Dr	1907	20	D,S	..	....	Wad.
8baa	F. Trautman	225	2	Dr	1949	134	D,S	Sd	....	Wad.
8cdd	USGS Test hole 2021	120	5	Dr	7-16-62	......	T	Ss	1,885.3	BR-104, L.
9bcb	USGS Auger hole 18	16	3	Dr	10-18-62	......	T	..	1,930	L.
10cbb	R. Fried	175	1.5	Dr	1915	84	D,S	Sd	....	C, Wad, Wh.
16bbb	USGS Auger hole 17	22	3	Dr	10-18-62	......	T	..	1,900	L.
18aaa1	H. Pederson	160	3	Dr	1959	60	D,S	Sd	....	Wad, Wh.
18aaa2	..do....	157	2	Dr	1937	60	S	Sd	....	..Do....
18bbc	Olson Bros.	100	2	Dr	....	......	S	Sd	....	Wad, Wh.
20aaa	USGS Test hole 2025	199.5	5	Dr	7-18-62	......	T	Gv	1,923.6	BR-173, L.
20dda	F. W. Aichele	280	2	Dr	1946	60	D,S	..	....	Wad, Ws.
22ac	A. Whitman	140	2	Dr	1957	......	S	..	....	Wad, Wh.
24bdc	J. Krous	120	2	Dr	1915	60	D,S	Sd	....	Wad.
27cd	A. Whitman	170	2	Dr	1959	50	S	Sd	....	Wad, Wh.
29bd	..do....	160	2	Dr	1956	50	S	..	....	..Do....
30ca	..do....	110	2	Dr	1949	50	S	..	....	..Do....
30daa1	..do....	250	2	Dr	1947	40	S	..	....	Wad, Ws.
30daa2	..do....	260	3	Dr	1952	40	D,S	..	....	..Do....
32aab	..do....	110	2	Dr	1947	30	S	..	....	Wad, Wh.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
138-76										
4aa	A. Schauer	133	2	Dr	1941	40	S	Sd	....	Wad, Ws.
6ada1	..do....	133	2	Dr	1952	53	D	Sd	....	..Do....
6ada2	..do....	175	2	Dr	1936	......	S	Sd	....	..Do....
7add	USGS Test hole 1942	147	5	Dr	9-7-61	Flow	T	Sd & Gv	1,732.6	BR-127, C, L.
8abb	USBR drill hole 27	40	3	Dr	1959	8.6	T	Sd	1,755.6	L.
8bab	USBR drill hole 26	35	3	Dr	1959	Flow	T	Gv	1,743.9	..Do....
10cbc1	E. A. Schauer	190	2.5	Dr	1957	45	D,S	Sd	....	Wad.
10cbc2	..do....	135	2.5	Dr	1940	45	D,S	Sd	....	Wad.
15bd	..do....	160	2	Dr	1956	60	S	Sd	....	Wad, Ws.
17dad	M. Bertsch	219	2	Dr	1920	2	D,S	..	....	..Do....
18daa	O. Jerset	240	2	Dr	1951	......	D,S	Sd	....	Wad.
19aad	C. Monroe	48	2	Dr	....	8	D,S	Sd	....	Wad, Ws.
19a	..do....	70	4	Dr	1961	60	T	Sd	....	C, L.
19b	..do....	100	4	Dr	1961	......	T	Sd	....	L.
19abb	USGS Auger hole 11	107	3	Dr	10-16-62	......	T	Sd	1,725	L.
20bbb	USGS Auger hole 12	87	3	Dr	10-16-62	......	T	Gv	1,740	..Do....
20ccc	C. Anderson	14	18	Dr	....	11	D,S	Sd	....	Wad.
22ddd	F. Doehle	80	2	Dr	1934	......	S	..	....	Wad, Wh.
24cbb1	G. D. Adams	140	2	Dr	....	40	D	Sd	....	C, Wad, Ws.
24cbb2	..do....	35	2	Dr	1925	20	S	Sd & Gv	....	C, Wad, Wh.
26aaa	USGS Test hole 2032	90	5	Dr	7-27-62	......	T	Gv	1,777.6	BR-70, L.
26bab1	E. Doehle	140	2	Dr	1957	......	D	Sd	....	Wad, Ws.
26bab2	..do....	120	2	Dr	1921	20	S	..	....	..Do....
26db1	C. Sherman	25	18	Du	....	15	S	Sd & Gv	....	Wad, Wh.
26db2	..do....	247	2	Dr	1949	37	D,S	Sd	....	Wad, Ws.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
138-76 (Cont.)										
28ada1	M. Lewis	60	3	Dr	1954	4	S	Sd	....	Wad, Ws.
28ada2	..do....	353	3	Dr	1954	6	D,S	Sh	....	Wad, Wh.
28bcc1	E. A. Schauer	12	36	Du	1898	3	...	Sd	....	Wad.
28bcc2	..do....	20	2	Dr	1920	1.00	D	Sd	....	Ws.
30bcc	C. Monroe	173	2	Dr	1943	12	D,S	Clay	....	Wad, Ws.
31aab	USGS Test hole 2029	180	5	Dr	7-26-62	....	T	Sd & Gv	1,713.2	BR-164, T.
31bac	C. Monroe	83	2	Dr	1959	10	S	Gv	....	Wad.
31dbc	..do....	174	2	Dr	1945	8	S	..	....	Wad, Ws.
33bbb	USGS Test hole 2022	110	5	Dr	7-16-62	6.22	T,O	Gv	1,726.9	BR-111, C, L,TD-120.
35cbb1	E. M. Enockson	180	2	Dr	1949	50	D	Sd	....	Wad, Ws.
35cbb2	..do....	140	2	Dr	1950	40	S	Sd	....	Wad,
36aaa	USGS Auger hole 16	112	3	Dr	10-18-62	......	T	Sd	....	L.
138-77										
2abb	USGS Auger hole 7	77	3	Dr	10-12-62	......	T	Sd & Gv	1,770	BR-65, L.
2daa	L. E. Heaton, Jr.	90	3	Dr	1929	20	D,S	Sd	....	Wad.
3abb	USGS Auger hole 8	32	3	Dr	10-12-62	......	T	..	1,725	L.
3ccd	USGS Test hole 1944	189	5	Dr	9-8-61	......	T	Gv	1,706.5	BR-178, L.
4acc	USBR drill hole 21	100	3	Dr	1958	8.2	T	..	1,704.2	L.
4adc	USBR drill hole 22	70	3	Dr	1958	5.8	T	..	1,706.2	..Do....
4add	USBR drill hole 23	70	3	Dr	1958	11.2	T	Sd	1,705.1	..Do....
5cbb	USBR drill hole 18	35	3	Dr	1959	......	T	Sd	1,739.9	..Do....
5dab	USBR drill hole 20	60	3	Dr	1958	9.2	T	Sd	1,705.4	..Do....
5dbb	USBR drill hole 19	60	3	Dr	1959	9.9	T	..	1,706.1	..Do....
6ccd	USBR drill hole 15	59.8	3	Dr	1959	13.7	T	Sd	1,706.7	..Do....
6cda	USBR drill hole 16	60	3	Dr	1959	16.2	T	..	1,709.3	..Do....
6daa	USGS Test hole 1945	84	5	Dr	9-11-61	......	T	Sd & Gv	1,734.8	BR-64, L.
6dbd	USBR drill hole 17	60	3	Dr	1959	11.8	T	..	1,710.5	L.
7cbb	USGS Test hole 1946	220	5	Dr	9-11-61	......	T	Gv	1,702.6	BR-184, L.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
138-77 (Cont.)										
7daa	Northwest Mortgage Co.	125	2	Dr	1919	30	D	Sd	....	Wad.
9bdb	USGS Test hole 1831	231	5	Dr	1960	......	T	Sd	1,700	BR-153, L.
10d	W. McDonald	160	4	Dr	1961	......	T	Gv	....	L.
10dca	..do....	160	4	Dr	1961	......	T	Gv	....	..Do....
10dcd	..do....	198	4	Dr	1961	......	T	Gv	....	..Do....
11aaa	USGS Test hole 1943	126	5	Dr	9-8-61	......	T	Sd	1,742.6	BR-90, L.
12bda1	R. Heaton	65	2	Dr	1951	50	D	Sd	....	Wad, Wh.
12bda2	..do....	80	2	Dr	1960	51	S	Sd	....	Wh.
13aaa	USGS Test hole 2028	120	5	Dr	7-27-62	......	T	Gv	1,722.7	BR-100, L.
13cab	W. G. Fischer	100	2	Dr	1946	14	D,S	Sd	....	Wad.
14add	Test hole 1940	231	5	Dr	9-6-61	......	T	Gv	1,721.0	L.
14ccc	USGS Test hole 1941	136	5	Dr	9-7-61	......	T	Sd & Gv	1,716.9	BR-126, L.
14dbb	Bank of N. Dak.	130	..	Dr	1915	12	D,S	Sd	....	Wad.
15aaa	USGS Test hole 2023	210	5	Dr	7-17-62	12.63	T,O	Gv	1,720.6	BR-213, C, L. TD-225.
15bbb	USGS Auger hole 13	112	3	Dr	10-17-62	......	T	Sd	1,706	L.
15cca	W. Anderson	150	4	Dr	1961	......	T	Sd	....	..Do....
15dcb	..do....	138.4	17	Dr	6-61	13.19	Irr, O	Gv	1,717.6	C, L, Wad.
17cc	Northwest Mortgage Co.	112	2	Dr	1930	35	N	Sd	....	Wad.
18cc	Federal Land Bank	120	2	Dr	1927	......	N	Sd	....	Win.
19bb	C. Monroe	100	2	Dr	1915	40	N	Sd	....	Wad.
20aaa	USGS Test hole 1867	231	5	Dr	1960	......	T	Gv	1,700	BR-171, L.
20add	G. R. Krause	150	2	Dr	1939	20	D,S	Sd	....	Wad.
21cbc1	W. Anderson	240	2	Dr	....	40	D	Sd	....	Wad, Ws.
21cbc2	..do....	90	2	Dr	....	40	S	Sd	....	Wad, Wh.
22aad	USGS Test hole 1955	126	5	Dr	9-22-61	11.38	T,O	Gv	1,720.0	BR-122, L, C.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
138-77 (Cont.)										
22bb	W. Anderson	140	2	Dr	1918	25	D	Sd	....	Wad.
22bdd	..do....	130	4	Dr	1961	......	T	Sd	....	L.
22cac	..do....	130	4	Dr	1961	......	T	Gv	....	..Do....
22dda	USGS Auger hole 15	110	3	Dr	10-18-62	......	T	Sd	1,724	..Do....
23aac	USGS Test hole 1979	130	5	Dr	5-31-62	26.95	T,O	Sd & Gv	1,736.4	BR-122, L.
23ddb1	R. Baeth	105	17	Dr	9-13-61	37.30	Irr	Sd & Gv	1,738.9	C, L, Wad.
23ddb2	Baeth screen test hole	90	5	Dr	5-18-62	37.73	T,O	Sd & Gv	1,738.0	L.
23ddb3	Baeth pumping test observation well	107	5	Dr	10-30-61	23.37	T,O	Sd & Gv	1,730.5	..Do....
24abb	M. Burke	85	3	Dr	....	22	D,S	Gv	....	Wad.
24bbb	USGS Auger hole 14	112	3	Dr	10-17-62	......	T	Gv	1,722	L.
24caa1	M. Burke	16.5	4	Dr	1958	4	S	Sd	....	Wad.
24caa2	..do....	107.4	4	Dr	1961	27.37	S	Gv	1,735.3	..Do....
24ccc	USGS Test hole 1939	168	5	Dr	9-1-61	......	T	Gv	1,740.4	BR-160, L.
24dcc	USGS Auger hole 9	112	3	Dr	10-15-62	......	T	Sd	1,729	L.
24ddd	USGS Auger hole 10	102	3	Dr	10-15-62	......	T	Sd	1,718	..Do....
25a	W. McDonald	100	4	Dr	1961	......	T	Gv	....	..Do....
25aa	C. A. Anderson	200	2	Dr	1918	20	S	Sd	....	Wad.
25bbd1	G. Adams	78.2	17	Dr	6-61	39.72	Irr,O	Gv	1,741.3	C, Wh.
25bbd2	Adams screen test hole	80	5	Dr	5-31-62	37.63	T	Gv	1,741	L.
25d	W. McDonald	60	7	Dr	1961	......	T	Gv	....	..Do....
25daa	..do....	56	4	Dr	6-6-61	26.38	T,N	Gv	1,738.2	L, Wad.
26adc	USGS Test hole 1954	63	5	Dr	9-20-61	31.74	T,O	Gv	1,738.4	BR-74, C, L, TD-78.75.
26bba	R. Baeth	150	2	Dr	1918	15	D,S	Sd	....	Wad.
26daa	G. Adams	60	2	Dr	1909	30	D,S	Sd	....	..Do....
26dda	USGS Test hole 1869	231	5	Dr	1960	......	T	Gv	1,698	BR-179, L.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
138-77 (Cont.)										
27aaa	W. Anderson	250	2	Dr	1937	15	S	Sd	....	Wad.
27dab	..do....	140	2	Dr	....	60	S	Sd	....	..Do....
28ddd	J. W. Dean	108	4	Dr	1914	60	D,S	Sd	....	..Do....
30add	A. Stark	114	2	Dr	1953	72	D,S	Sd	....	Wad, Ws.
31dd	J. W. Dean	30	12	Dr	1930	8	S	Sd	....	Wad.
32daa	USGS Test hole 1868	210	5	Dr	1960	......	T	Sd	1,813	BR-22, L.
32dd	State Land Dept.	81	2.5	Dr	1920	20	N	Sd	....	Wad.
34add	A. Edwards	137	2	Dr	....	70	D,S	Sd	....	Wad, Ws.
35bbb	USGS Test hole 2030	60	5	Dr	7-26-62	......	T	Sd	1,769.0	BR-40, L.
35bca	A. Edwards	100	2	Dr	....	50	S	Sd	....	Wad.
36dd	C. A. Anderson	100	2	Dr	1925	20	S	Sd	......	..Do....
138-78										
1abb	USGS Test hole 1952	210	5	Dr	9-18-61	......	T	Sd & Gv	1,702.5	BR-198, L.
1ddd	USBR drill hole 14	60	3	Dr	1959	9.2	T	Sd	1,703.0	L.
2cdd	USBR drill hole 12	24.7	3	Dr	1959	......	T	Sd	1,727.2	..Do....
3bb	C. Schmitz	60	2	Dr	....	30	S	Sd	....	Wad.
5aaa	T. A. Thach	142	2.5	Dr	1948	......	D,S	Sd	....	Wad, Wh.
6bad	N. A. Nissen	180	1.5	Dr	1941	40	D,S	Sd	....	Wad, Ws.
9aad	C. Schmitz	138	2	Dr	1918	70	D,S	Sd	....	Wad.
9dd	G. W. Vernum	115	4	Dr	1905	25	D,S	Lig	....	..Do....
10dcd	M. Evans	190	2	Dr	....	......	D,S	Sd	....	..Do....
11aa	Northwest Mortgage Co.	115	3	Dr	1906	35	S	Sd	....	..Do....
14bda	W. Johner	90	2	Dr	....	......	D,S	Sd	....	..Do....
14dcb1	P. C. Ehnen	190	2	Dr	....	60	S	Sd	....	..Do....
14dcb2	..do....	228	2	Dr	1953	35	D	Sd	....	Wad, Ws.
15bcc	H. L. McLean	190	2	Dr	....	70	D,S	Sd	....	C, Wad, Ws.
15dd	F. Johnson	90	2	Dr	....	30	D,S	Sd	....	Wad.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
138-78 (Cont.)										
16cbc	D. W. McLean	200	2.5	Dr	1950	......	D,S	Sd	....	Wad, Ws.
16daa	..do....	150	2	Dr	....	......	S	Sd	....	..Do....
17dac	T. Dorman	80	2	Dr	1959	40	D,S	Sd	....	Wad, Wh.
19abb	USGS Test hole 1948	84	5	Dr	9-15-61	......	T	Sd	1,758.9	BR-60, L.
21ccc	USGS Test hole 2041	105	5	Dr	7-24-62	......	T	..	1,739.4	BR-83, L.
22caa	M. Knoll	120	2	Dr	1910	......	D,S	Sd	....	Wad.
22daa	..do....	125	2	Dr	1948	60	S	Sd	....	Wad, Ws.
23aaa	USGS Test hole 1947	178	5	Dr	9-14-61	......	T	Sd & Gv	1,697.5	BR-173, L.
23bbb	USGS Test hole 1870	231	5	Dr	1960	......	T	Sd & Gv	1,695	BR-132, L.
26ddd	E. Dutton, Sr.	92	2	Dr	1910	40	D,S	Lig	....	Wad.
27ccd	USGS Test hole 2042	210	5	Dr	7-23-62	42.35	T,O	Sd & Gv	1,723.7	BR-220, C, L, TD-230.
27dad	I. Funston	280	2	Dr	1946	20	D,S	..	....	C, Wad.
28ccd1	C. K. Boyd	133	2	Dr	1934	18	D,S	Sd	....	Wad.
28ccd2	..do....	136	2	Dr	....	24	D	Sd	....	..Do....
30add	L. Dappler	180	2	Dr	1958	65	D,S	Sd	....	Wad, Ws.
31aaa	J. Welch	85	2	Dr	1915	25	D,S	Sd	....	Wad.
31dd	L. Dappler	86	2	Dr	1926	25	D,S	Sd	....	..Do....
32aaa	R. M. Welch	138	2	Dr	1925	25	D,S	Sd	....	..Do....
32bb	J. O. Welch	76	2	Dr	1906	20	D,S	Sd	....	..Do....
32daa	USGS Test hole 2012	185	5	Dr	7-17-62	48.22	T,O	Sd & Gv	1,727.9	BR-198, C, L, TD-210.
34bbc	C. K. Boyd	262	2	Dr	....	30	D,S	Sd	....	Wad, Ws.
35aaa	E. Dutton, Jr.	210	2	Dr	....	60	D,S	Sd	....	..Do....
35cc	E. Olson	154	2	Dr	....	40	D,S	Sd	....	Wad.
138-79										
2aaa	USGS Test hole 2053	75	5	Dr	8-2-62	......	T	Sd	1,702.9	BR-62, L.
2abb	F. Miller	258	2	Dr	1954	50	D,S	Sd	....	Wad, Ws.
2cdb	W. Layee	95	2	Dr	1957	25	D,S	Sd	....	Wad, Wh.
3cac	USGS Auger hole 5	107	3	Dr	8-11-62	......	T	Sd	1,700	L.
4ccd	T. D. Sullivan	120	2	Dr	1935	3	..	..	....	Wad.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
138-79 (Cont.)										
4ddd	W. Field	140	2	Dr	1920	30	D	Sd	....	Win.
5dd	H. Tatley	150	4	Dr	1935	......	...	..	....	Wad.
6ccc	Mrs. W. Erlenmeyer	89	2	Dr	1938	3	...	..	....	..Do....
6ddd	P. Rannick	20	..	Du	1934	12	...	Sd	....	..Do....
8aaa	USGS Test hole 1860	158	5	Dr	1960	......	T	..	1,651	L, BR-116
9abb	USGS Test hole 1861	105	5	Dr	1960	Flow	T	Gv	1,655	C, L.
10aab	W. Inko	158	4	Dr	1919	40	D	Gv	....	Wad.
10cbb	C. O. Nelson	170	4	Dr	1926	60	D,S	..	....	..Do....
12bbc	A. J. Braun	108	2	Dr	1953	30	D,S	Sd	....	..Do....
14bbb	C. O. Nelson	115	4	Dr	1902	40	...	..	....	..Do....
16cdd	L. F. McCurty	175	2	Dr	1917	75	S	..	....	..Do....
17cd	E. Taix	270	2	Dr	1913	100	S	Sd	....	Wad, Ws.
18cca1	H. Tatley	100	2	Dr	....	......	D,S	..	....	C.
18cca2	..do....	180	2	Dr	....	......	D,S	..	....	..Do....
19dcd	USGS Auger hole 4	17	3	Dr	8-11-62	......	T	..	1,740	L.
20ccc	USGS Auger hole 3	7	3	Dr	8-11-62	......	T	..	1,754	..Do....
24caa	R. Brown	70	2	Dr	....	......	D,S	..	....	Wad.
26ccd	W. S. Malard	126	2	Dr	....	65	D,S	Sd	....	SC-1,465, Wad.
30bb	H. Swanson	24	4	Dv	1938	18	...	Sd	....	Wad.
34ccc	A. Robidion	250	2	Dr	1925	......	...	Sd	....	..Do....
138-80										
1dcc	USGS Auger hole 1	97	3	Dr	8-11-62	......	T	Sd & Gv	1,640	L.
1dda	H. Hammond	140	4	Dr	1950	25	D	Gv	....	Wad.
2bbc	USGS Test hole 2058	84	5	Dr	9-7-62	......	T	Sd	1,677.9	BR-47, L.
2ccc	USGS Test hole 2057	142	5	Dr	9-5-62	21.13	T,O	Sd & Gv	1,668.5	BR-170, C, L, TD-174.
4acc	Armours Creamery	390	4	Dr	....	......	D,PS	Sd	....	C.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
138-80										
4acd	Yegen Dairy	470	4	Dr	....	......	D,S	Sd	....	C.
8ddd	USGS Test hole 1863	168	5	Dr	1960	......	T	Gv	1,635	BR-114, L.
9bcd	P. Wachter	105	17	Dr	9-60	20.71	Irr	Gv	1,643.3	C, L.
11aa	R. Small	144	2	Dr	1926	130	D,S	..	....	Wad.
11ddd	USGS Test hole 1858	84	5	Dr	1960	......	T	..	1,665	BR-31, L.
12bbc	USGS Test hole 1859	115	5	Dr	1960	......	T	Gv	1,664	L.
13bbb	A. W. Cook	163	2	Dr	1950	40	D,S	Gv	....	Wad, Ws.
13cbb	C. P. Yegen	171	5	Dr	1961	......	T	..	....	L.
13ccb	..do....	90	4	Dr	1961	......	T	Sd	....	..Do....
13ccc	USGS Test hole 1857	493	5	Dr	1960	......	T	Sd	1,641	BR-84, L.
13cdd	C. P. Yegen	90	4	Dr	1961	......	T	Gv	....	BR-89, L.
13dcd1	..do....	380	6	Dr	....	Flow	D,S	Sd	....	Wad, Ws.
13dcd2	..do....	120	3	Dr	....	70	D,S	Gv	....	Wad, Wh.
15bbd	Fort Lincoln Nursery	129	17	Dr	1958	43.68	Irr	Gv	1,657.8	C, L.
15cba	Fort Lincoln Nursery	164	17	Dr	1952	46.11	Irr	Gv	1,663.9	C, L, PC.
15cdd	USGS Test hole 1956	168	5	Dr	9-28-61	38.17	T,O	Gv	1,658.4	BR-156, L, C.
17aad	R. L. Melville	32	1.75	Dv	....	10	S	Gv	....	Wad.
17aca	USGS Auger hole 22	72	3	Dr	10-22-62	17.86	T,O	Gv	1,737.2	L.
17acb1	J. Peterson	90	17	Dr	1961	19.10	Irr,O	Gv	1,638.1	C, L.
17acb2	USGS Auger hole 21	67	3	Dr	10-22-62	18.10	T,O	Sd & Gv	1,637.5	L.
19add	F. Borbage	58	3	Dr	1956	15	D,S	Gv	....	Wad, Wh.
20aab	C. S. Huber	40	1.25	Dr	1938	20	D,S	..	....	Wad.
21ccc	USGS Test hole 1854	147	5	Dr	1960	......	T	Gv	1,631	L, BR-124
22abd	USGS Test hole 1958	157	5	Dr	10-4-61	44.65	T,O	Gv	1,662.0	BR-152, L.
22aac	D. McDonald	131	17	Dr	10-60	45.64	Irr,O	Gv	1,660.9	C, L.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
138-80 (Cont.)										
22abd2	USGS Test hole 1957	157.5	5	Dr	10-4-61	41.82	T,O	Gv	1,659.4	BR-152, L, C.
22baa	D. McDonald	260	1.5	Dr	1937	40	D,S	Gv	....	Wad.
22bbc	..do....	130	5	Dr	1962	......	T	Gv	....	L.
23aab	D. Solberg	100	4	Dr	1961	......	T	Sd	....	..Do....
23aba	..do....	100	4	Dr	1961	......	T	Sd	....	..Do....
23bdc	..do....	110	15	Dr	8-61	37.43	Irr,O	Gv	1,656.9	BR-110, C, L, C.
23ccc	USGS Test hole 1855	273	5	Dr	1960	......	T	Gv	1,651	BR-98, L.
24aba	C. P. Yegen	120	3	Dr	....	70	D,S	Gv	....	Wad, Wh.
24bcb	M. Bachmeier	97	2.5	Dr	1959	30	D	Gv	....	Wad.
24cac1	C. P. Yegen	80	17	Dr	9-60	13.48	Irr,O	Gv	1,633.7	C, L, TD-85
24cac2	..do....	90	4	Dr	1962	......	T	Sd	....	L.
24cac3	..do....	90	4	Dr	1961	......	T	Sd	....	..Do....
24cbd	..do....	91	4	Dr	1961	......	T	Gv	....	..Do....
24cca	..do....	90	4	Dr	1961	......	T	Sd	....	..Do....
24daa	USGS Auger hole 2	27	3	Dr	10-11-62	......	T	Sd	1,680	..Do....
24dac	C. P. Yegen	150	4	Dr	1961	......	T	Sd	....	..Do....
24ddc	..do....	211	4	Dr	1961	......	T	Sd	....	..Do....
25bab	..do....	100	17	Dr	....	14.03	Irr,O	Gv	....	L.
25bba	..do....	81	4	Dr	1962	......	T	Sd	....	..Do....
25cda	..do....	60	4	Dr	1961	......	T	Sd	....	..Do....
25dac	..do....	155	6	Dr	1963	34	Irr,O	Sd	....	C,L.
25dbd	..do....	80	4	Dr	1963	......	T	Sd	....	L.
25dda1	..do....	201	4	Dr	1961	......	T	Sd	....	..Do....
25dda2	..do....	180	4	Dr	1963	24	T	Sd	....	..Do....
25dda3	..do....	186	36	Dr	1963	......	T	Sd & Gv	....	..Do....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
138-80 (Cont.)										
25ddb	C. P. Yegen	160	4	Dr	1963	......	T	Sd	....	L.
25ddd	..do....	195	4	Dr	1963	40	T	Sd	....	..Do....
26abb	E. Taix	186	2	Dr	1955	13	D,S	Sd	....	Wad, Ws.
26bc	W. B. Falconer	210	2.5	Dr	1955	60	D,S	Sd	....	Wad.
27cdc	USGS Test hole 1929	52.5	5	Dr	8-24-61	......	T	Sd	1,627.9	L, BR-41
27cdd	F. Aune	55	2	Dr	1958	......	D	Gv	....	Wad, Wn.
27dad	A. Falconer	105	2	Dr	1905	90	D,S	Sd	....	Wh, Win.
27dda	USGS Test hole 1856	147	5	Dr	1960	......	T	..	1,630	BR-43, L.
28bad	G. Briese	60	2	Dr	1958	......	D,S	Gv	....	Wad, Wh.
29ada	W. R. Mills	25	1.25	Dr	1940	13	D	Sd	....	..Do....
29bab	USGS Test hole 1013	70	5	Dr	1958	......	T	Gv	....	L.
29bad	N. Dak. Prison farm	93	17	Dr	1961	20	Irr	Gv	....	C, L, Wad, TD-110.
29bbb1	USGS Test hole 1012	130	5	Dr	1958	......	T	Gv	....	BR-125, L.
29bbb2	USGS Test hole 1853	147	5	Dr	1960	......	T	Gv	1,639	BR-111, L.
34dbc	J. Robidou	31	1.25	Dr	....	16	D,S	Sd	....	Wad, Wh.
35bb	S. Francis	215	2	Dr	1936	200	D,S	Sd	....	Wad.
139-75										
3ddd	USGS Test hole 1977	284	5	Dr	1-23-62	......	T	..	1,820	BR-74, L.
4bdc1	Berg Bros.	120	1.5	Dr	1959	......	D	Gv	....	Wad, Ws.
4bdc2	..do....	125	1.5	Dr	1950	......	D,S	Gv	....	..Do....
4bdc3	..do....	130	...	Dr	1948	......	S	..	....	..Do....
4bdc4	..do....	100	...	Dr	1956	......	S	..	....	..Do....
4dd	R. Quale	12	48 x 48	Du	1959	10	S	Sd	....	Wad, Wh.
6ccc	R. Sorenson	80	3	Dr	....	15	S	..	....	..Do....
7dvd	A.A. Fischer	100	2	Dr	....	50	D,S	Sd	....	Wad, Ws, Temp.-46°F
7ddc	..do....	100	2	Dr	1930	50	D,S	..	....	Wad, Ws.
8dba	J. Reiderer	125	2.5	Dr	....	......	N	Sd	....	Ws.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
139-75 (Cont.)										
9daa1	R. Quale	78	3	Dr	1959	20	D,S	Sd	....	C, Wad.
9daa2	..do....	119	2	Dr	1959	15	D	Sd	....	Wad, Ws.
9daa3	..do....	70	16	Dr	1910	18	S	Sd & Gv	....	Wad.
10dcc	D. Pfennig	35	..	Dr	....	......	D,S	Gv	....	..Do....
11cd	A. H. Wanner	60	2	Dr	....	15	D,S	Sd	....	Wad, Wh.
12ccd	D. Nelson	124	2	Dr	1961	65	D,S	Sd & Gv	....	..Do....
13cca	J. Taszarek	135	2.5	Dr	1957	18	D,S	Sd	....	C, Wad.
14ddc	H. Rinder	...	4	Dr	....	35	D,S	..	....	
15ccd	G. C. Tank	100	2	Dr	....	50	D,S	Sd	....	Wad, Ws.
16cdd	J. Marquart	150	2.5	Dr	....	......	S	Sd	....	..Do....
17ada	O. Reiderer	120	2.5	Dr	1920	......	D,S	Sd	....	..Do....
18ccd	O. Auck	150	2	Dr	1943	90	D,S	Sd	....	Wad.
19caa	USGS Test hole 2049-D	52.5	5	Dr	3-22-63	......	T,O	Gv	1,815.3	BR-46, C, L.
22abb	R. H. Halsne	140	2	Dr	1956	25	S	Sd	....	Wad, Ws.
22ccb	USGS Test hole 2020	60	5	Dr	7-16-62	......	T	..	1,871.1	BR-57, L.
24aac1	R. Olson	135	2	Dr	1955	111	D	Sd	....	Wad, Ws.
24aac2	..do....	80	2	Dr	....	75	S	Sd	....	Wad.
26bcb	R. Schumaker	122	2	Dr	1959	85	D,S	Sd	....	Wad, Wh.
27ccb	H. Brushwood	204	2	Dr	1958	30	D,S	Ss	....	..Do....
28aba1	O. Morast	150	4	Dr	1948	......	D	..	....	Wad.
28aba2	..do....	70	4	Dr	....	......	S	..	....	..Do....
32cda	Christianson Estate	170	2.5	Dr	1910	120	D,S	Sd	....	..Do....
33cb	A. Geist	150	2	Dr	1944	35	D,S	..	....	Wad, Wh. Temp. 44.5°F.
139-76										
3bdd	E. Renschler	124	2.5	Dr	1944	......	S	..	....	Wad.
4abb	F. Envick	220	2	Dr	1910	140	D,S	..	....	..Do....
5ada	R. Brown	230	2.5	Dr	1948	30	D,S	Sd	....	Wad, Ws.
6acc	J. Brown	160	2	Dr	....	35	S	Sd	....	..Do....
6ddc	..do....	160	2	Dr	....	35	S	Sd	....	..Do....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
139-76 (Cont.)										
8add1	W. Johnson	220	2.5	Dr	....	......	D	Sd	....	Wad, Ws.
8add2	..do....	130	2.5	Dr	....	......	S	..	....	..Do....
9bcb	N. L. Funston	189	2.5	Dr	1956	180	D,S	Sd	....	Wad, Wh.
11bbd1	E. Renschler	170	2.5	Dr	1955	......	D	..	....	....
11bbd2	..do...	150	2.5	Dr	....	50	S	..	....	Wh.
12aad	R. Sorenson	100	2	Dr	....	22	D,S	Sd	....	Wad, Wh.
14bbc	J. Lang	175	2.5	Dr	....	......	D,S	Sd	....	Wad, Ws.
14dda	H. Olson	150	2	Dr	1946	90	S	Sd	....	C, Wad.
15aac	J. Lang	180	2.5	Dr	....	......	S	Sd	....	Wad, Ws.
16bbd	E. Lang	320	2.5	Dr	1956	......	D	..	....	Ws.
19bcb	M. Envik	240	2	Dr	1958	......	D,S	Sd	....	Wad, Ws.
20abb	USGS Test hole 2017	50	5	Dr	7-11-62	......	T	..	1,961.4	BR-42, L.
20cdd1	T. A. Lang	300	2.5	Dr	....	180	D	Sd	....	Wad, Ws.
20cdd2	..do....	180	2.5	Dr	....	......	S	..	....	Wad.
22dc	P. Biegler	300	3	Dr	1954	40	D,S	Sd	....	Wad, Ws.
23aab	W. Dickenson	140	3	Dr	1948	90	D,S	Sd	....	..Do....
23cbb1	J. Lang	180	2	Dr	1949	130	S	Sd	....	..Do....
23cbb2	..do....	205	2	Dr	1958	......	D	Sd	....	..Do....
24bba1	H. Olson	150	2	Dr	1941	90	S	Sd	....	Wad, Ws, Temp.-43°F.
24bba2	..do....	150	2	Dr	1953	140	D	Sd	....	Wad, Ws.
26dda	USGS Test hole 2034	42	5	Dr	7-30-62	......	T	Gv	1,810.2	BR-5, L.
27cdc	D. Goetz	140	2	Dr	1946	30	D,S	Sd	....	Wad, Ws.
28cb1	B. Nelson	155	2	Dr	1958	90	D	Sd	....	..Do....
28cb2	..do....	160	2	Dr	1958	50	S	Sd	....	..Do....
31cd	A. Scharer	58	2	Dr	1956	40	S	Sd	....	Wad, Wh.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
139-76 (Cont.)										
34aba	S. Fletcher	93	2	Dr	....	......	S	Sd	....	C, Wad.
35aad	P. Biegler	180	2	Dr	1954	50	D	Sd	....	Wad, Ws.
35baa	..do....	190	2	Dr	1942	......	S	Sd	....	..Do....
36aa	..do....	500	6	Dr	1952	78.85	N	Sd	....	
36dad	..do....	160	2	Dr	....	......	S	Sd	....	..Do....
139-77										
1bbb	USGS Test hole 2055	63	5	Dr	7-30-62	......	T	..	1,809.2	BR-51, L.
2bcc	R. J. Boyd	90	2	Dr	....	30	D,S	Sd	....	Wad, Wh.
6aaa	USGS Test hole 1934	94	5	Dr	8-29-61	......	T	Sd	1,739.8	BR-68, L.
6aac	P. P. Bliss	100	2.5	Dr	....	25	D,S	Sd	....	Wad, Ws.
8cbc	USGS Test hole 1953	115	5	Dr	9-20-61	......	T	Sd	1,739.8	BR-104, L.
10ccd	B. Zahn	88	2	Dr	1935	60	D,S	Sd	....	C, Wad, Wh.
14aad	A. Vetter	60	..	Dr	1889	28	D,S	Sd	....	Wad, Wh.
15ccc	USGS Test hole 2016	45	5	Dr	7-11-62	......	T	..	1,753	BR-30.5, L.
20ccc	USGS Test hole 2036	225	5	Dr	7-25-62	......	T	Sd	1,705.0	BR-209.5, L.
20ddc1	W. Knutson	127	2	Dr	....	......	D	Sd	....	Wad.
20ddc2	..do....	150	2	Dr	1960	60	S	Sd	....	Wad, Ws.
21aa	H. Hubesthal	100	2	Dr	1913	45	D,S	..	....	Wad.
22cc	T. T. Hughes	224	2	Dr	1918	100	D,S	..	....	..Do....
25dcc	E. Fiest	170	2	Dr	....	......	D,S	Sd	....	Wad.
26cdb	E. Shira	225	2	Dr	1951	30	S	Sd	....	Wad, Ws.
27bcc	G. Geiger	121	2	Dr	1955	48	S	Sd	....	..Do....
27ccc	N. Erickson	112	2	Dr	1907	......	D,S	Sd	....	..Do....
28cc1	McKenzie School	200	2	Dr	....	6	D,S	Sd	....	..Do....
28cc2	Methodist Ch ch	200	2	Dr	1951	6	D	Sd	....	..Do....
28cc3	J. Maier	300	2	Dr	....	Flow	D	Sd	....	C, Wad, Ws.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
139-77 (Cont.)										
28daa1	G. Geiger	336	2	Dr	1952	48	D	Sd	....	Wad, Ws.
28daa2	..do....	104	2	Dr	1954	80	S	Sd	....	Wad, Wh.
29dad	W. Knutson	50	3	Dr	1910	4	S	..	....	..Do....
30bbc	M. Victor	90	2	Dr	1959	10	D,S	..	....	..Do....
32aaa	USGS Test hole 1866	252	5	Dr	1960	......	T	Gv	1,708	BR-200, L.
34bbb	USGS Test hole 2035	45	5	Dr	7-26-62	......	T	Sd	1,752.8	BR-27, L.
35bba	E. Shira	200	2	Dr	....	30	D,S	Sd	....	Wad, Ws.
36abb	E. Fiest	280	3	Dr	1945	......	S	Sd	....	..Do....
139-78										
2aa	J. Agnew	80	2	Dr	1942	......	S	Sd	....	Ws.
2cd	W. Wachal	160	2	Dr	1917	21	D,S	Sd	....	Wad, Wh.
3aad1	J. Agnew	50	36	Dr	1928	12.85	N	Sd	....	Wad.
3aad2	..do....	70	2	Dr	1944	30	D,S	Sd	....	Wad, Ws, Temp.-46°F.
4ad	M. D. Agnew	125	2	Dr	....	30	D,S	Sd	....	Wad, Wh.
4cdc1	R. McCormick	120	2	Dr	....	......	S	Sd	....	Wad.
4cdc2	..do....	80	2	Dr	1950	......	D	Sd	....	Wad, Wh.
4dcd	M. Agnew	115	2	Dr	1956	50	S	Sd	....	..Do....
8aaa	USGS Test hole 1950	105	5	Dr	9-18-61	......	T	..	1,716.6	BR-92, L.
10dcb	M. Agnew	180	2	Dr	....	40	S	Sd	....	Wad, Wh.
10ddd	..do....	80	2	Dr	....	20	D,S	Sd	....	..Do....
11aaa	USGS Test hole 1951	63	5	Dr	9-18-61	......	T	..	1,715.6	BR-35, L.
11abb	USGS Test hole 1932	63	5	Dr	8-25-61	......	T	..	1,746.8	BR-34, L.
12acd	D. & C. Bohrer	190	2	Dr	1960	......	S	Sd	....	Wad, Wh.
13caa	L. O. Salter	80	2.5	Dr	1946	......	S	Gv	....	Wad.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
139-78 (Cont.)										
14acc	D. & C. Bohrer	300	2	Dr	....	......	S	Sd	....	Wad, Ws.
14cdd	..do....	95	4	Dr	....	30	D,S	Gv	....	Wad, Wh.
15aac	L. O. Salter	60	24	Du	1907	......	D,S	Sd	....	..Do....
15bcc1	..do....	200	2	Dr	1950	60	D	Sd	....	Wad, Ws.
15bcc2	..do....	75	2	Dr	1943	......	S	Sd	....	Wad, Wh.
16ccc	USGS Test hole 1865	210	5	Dr	1960	......	T	Gv	1,682	BR-159, L.
17daa1	A. Neugebauer	50	2	Dr	....	37	D,S	Sd	....	Wad, Wh.
17daa2	..do....	340	2	Dr	1951	63	D	Sd	....	Wad, Ws.
18bd	R. Boone	70	2	Dr	....	40	D,S	Sd	....	Wad, Wh.
18db	..do....	140	2	Dr	....	......	S	Sd	....	Wad, Ws.
19ddd	USGS Test hole 2011	135	5	Dr	7-11-62	......	T	Sd	1,717.5	BR-90, L.
20ad1	J. C. Pfeiffer	200	2	Dr	1950	30	D,S	Sd	....	Wad, Ws.
20ad2	..do....	90	2	Dr	....	25	S	Sd	....	Wad, Wh.
21dbc	L. Salter	140	2	Dr	1950	30	D,S	Gv	....	..Do....
22bb	T. C. Casey	195	4	Dr	1960	......	T	Gv	....	L.
22bd	..do....	180	4	Dr	1960	......	T	Gv	....	..Do....
22cc	..do....	180	4	Dr	1960	......	T	Sd	....	..Do....
22cd	..do....	216	4	Dr	1960	......	T	Sd	....	..Do....
23cda	USGS Test hole 2010	265	5	Dr	7-9-62	......	T	Sd & Gv	1,718.5	BR-260, L.
24baa	D. & C. Bohrer	100	2	Dr	....	......	D,S	..	....	Wad, Wh.
24cdc	USGS Test hole 1933	231	5	Dr	8-25-61	......	T	Gv	1,699.5	BR-211, L.
27cbb	USGS Test hole 2037	255	5	Dr	7-24-62	......	T,O	Gv	1,713.3	BR-245, C, L.
28bd	J. Schmidt	125	2	Dr	....	50	D,S	Sd	....	Wad, Ws.
29dda1	E. W. Klipstein	90	2	Dr	1936	30	S	Sd	....	Wad, Wh.
29dda2	..do....	400	2	Dr	....	15	D,S	Ss	....	Wad, Ws.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
139-78 (Cont.)										
30cdd	USGS Test hole 2054	45	5	Dr	8-2-62	20	T	..	1,883.1	BR-17, L.
31baa	E. W. Klipstein	90	2	Dr	....	20	D,S	Sd	....	Wad, Wh.
31ddb	USGS Test hole 1864	472	5	Dr	1960	......	T	Ss	1,680	BR-147, L.
32aaa	E. W. Klipstein	400	2	Dr	....	15	D,S	Ss	....	Wad, Ws.
33bb	A. C. Dance	100	2	Dr	....	......	D	..	....	Wad.
33bbc	USGS Auger hole 6	57	3	Dr	1962	......	T	Sd	1,690	L.
34cc	C. D. King	137	2	Dr	....	......	D,S	..	....	Wad.
139-79										
1acc	W. Trygg	160	2.5	Dr	1936	......	S	..	....	Win.
2ccc	A. Ashbridge	165	2	Dr	1902	......	D,S	..	....	Wad.
4dd	G. Anderson	170	2.5	Dr	....	106	S	..	....	..Do....
5ccd	O. Swanson	235	2.5	Dr	1924	135	S	..	....	..Do....
8bb	F. H. Trygg	150	2.5	Dr	1904	75	D,S	..	....	..Do....
10bb	G. Anderson	89	2	Dr	1935	70	D,S	..	....	..Do....
12bbc	H. Galet	390	2.5	Dr	1922	190	S	..	....	..Do....
18dad	Magnolia Petroleum Co.	80	5	Dr	1944	......	T	..	....	L.
18ddc	G. Gabel	80	4	Dr	1902	60	D,S	..	....	Wad.
19aab	Magnolia Petroleum Co.	80	5	Dr	1944	......	T	..	....	L.
20ddd	Mrs. Stimitz	180	2.5	Dr	1916	10	S	..	....	Wad.
22aaa	Magnolia Petroleum Co.	80	5	Dr	1944	......	T	..	....	L.
22acc	J. Gabel	57	48	Du	1939	......	S	..	....	Wad.
24bcc	USGS Test hole 1930	42	5	Dr	8-24-61	......	T	Gv	1,677.2	BR-26, L.
25dd	J. P. French	50	3	Dr	1916	10	S	..	....	Wad.
28bb	J. Gabel	65	2.5	Dr	....	......	S	..	....	..Do....
29adc	A. Gabel	150	2.5	Dr	1918	......	S	..	....	..Do....
29dba	J. Gavel, Jr.	160	2.5	Dr	1916	......	D,S	..	....	..Do....
32ccb	V. Brown	108	2	Dr	....	......	D,S	..	....	..Do....
33aad	USBR drill hole 5	34.6	3	Dr	1959	......	T	..	1,663.7	L.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
139-79 (Cont.)										
35aad1	USGS Test hole 1862	147	5	Dr	1960	......	T	Gv	1,660	L.
35aad2	USGS Test hole 1862 A	152	5	Dr	1960	......	T	Gv	1,660	..Do....
35ca	USBR drill hole 8	30	3	Dr	1958	6.7	T	Sd	1,662.3	..Do....
35cba	USBR drill hole 7	49.8	3	Dr	1958	2.4	T	Sd	1,663.1	..Do....
36bcc	I. Reict	50	2.5	Dr	1920	......	D,S	..	....	Wad.
139-80										
2aa	W. E. Sellens	307	2	Dr	1930	......	D,S	Clay & Gv	....	..Do....
2bba	Magnolia Petroleum Co.	90	5	Dr	1944	......	T	..	....	L.
2ccd	J. W. Paysens	165	2	Dr	....	24	D,S	..	....	Wad.
3abb	USGS Test hole 1981	55	5	Dr	6-18-62	......	T	Sd	1,844.3	BR-39, L.
4bab	Magnolia Petroleum Co.	80	5	Dr	1944	......	T	..	....	L.
4ccc	Federal Land Bank	260	2	Dr	....	......	S	..	....	Wad.
6bd	Cook	90	2	Dr	....	......	S	Clay	....	C, Wad.
8abb	L. Bunker	260	2	Dr	1920	......	D,S	..	....	Wad.
8cc	O. Felck	73	2	Dr	1925	15	S	Gv	....	..Do....
8ddd	M. Haider	158	2	Dr	1928	50	D,S	Sd	....	..Do....
9ada	Magnolia Petroleum Co.	80	5	Dr	1944	......	T	..	....	L.
10aaa1	H. Breen	56	4	Du	1890	52	D,S	Sd	....	Wad.
10aaa2	Magnolia Petroleum Co.	80	5	Dr	1944	......	T	..	....	L.
12dbd	Flanagan Estate	175	2	Dr	....	25	S	Sd	....	Wad.
13dca	C. McGarvey	345	2	Dr	1916	15	D,S	..	....	..Do....
16ccb	C. F. Sturtz	225	3	Dr	1923	75	D,S	Sd	....	..Do....
20dab	G. W. Jennings	180	2	Dr	1919	......	D,S	Sd	....	..Do....
21dd	C. Chrisk	275	2	Dr	1920	......	D,S	Sd	....	..Do....
22abb	Magnolia Petroleum Co.	80	5	Dr	1944	......	T	..	....	L.
22ddd	USGS Test hole 2059	21	5	Dr	9-7-62	......	T	Gv	1,700.8	BR-12, L.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
139-80 (Cont.)										
24bcc	S. Turnbow	230	2	Dr	1918	50	D,S	..	....	Wad.
26bcc	T. Yeller	140	2	Dr	1936	......	D,S	..	....	..Do....
28aad	Magnolia Petroleum Co.	80	5	Dr	1944	......	T	..	....	L.
29bcb	B. Robertson	240	2	Dr	....	......	D,S	Sd	....	C, Wad.
29cac	A. H. Christianson	33	2	Dr	....	......	D,S	Sd	....	..Do....
30aa	B. Ward	150	2	Dr	....	......	S	Sd	....	Wad.
30bd	J. W. Tyler	140	2	Dr	....	......	D,S	Sd	....	..Do....
33bdb	C. Leonhard	240	2	Dr	....	......	D	Sd	....	C, Wad.
35cc	R. Breen	317	2	Dr	1925	45	D,S	..	....	Wad.
35ddd	USGS Test hole 2060	84	5	Dr	9-7-62	......	T	..	1,660.2	BR-70, L.
36bcd	USBR drill hole 2	65	3	Dr	1958	11.5	T,O	Sd	1,669.7	L.
139-81										
1ab	R. Jiran	60	2	Dr	....	......	S	Sd	....	..Do....
1bcc	W. A. Sellens	125	2	Dr	....	......	D,S	Sd	....	Wad.
2aa	R. Jiran	160	2	Dr	....	......	D,S	Sd	....	..Do....
2cbb	USGS Test hole 1980	110	5	Dr	6-18-62	......	T	Sd	1,643.5	BR-106, L.
3dc	R. Johnson	28	1.5	Dr	....	9.69	D	Sd	....	Wad.
3dd	..do....	35	1.25	Dv	....	......	D	Sd	....	..Do....
11adc	R. Ward	104	7	Dr	1960	15	Irr,O	Sd	....	C, Wad.
11cd	G. E. Shipp	30	1.25	Dv	1935	12	D,S	Sd	....	Wad.
12bdc	M. G. Ward	220	2	Dr	1933	90	D,S	Sd	....	..Do....
14aba	J. McClusky	22	1.25	Dv	....	11.21	D	Sd	....	..Do....
14dc	P. Garsa	20	1.25	Dv	....	......	D	Sd	....	..Do....
23aa	R. Windgreen	20	1.25	Dv	....	......	D	Sd	....	..Do....
24da	F. M. Roberts	250	2	Dr	....	......	D	Sd	....	..Do....
25aa	R. Moetvedt	75	2	Dr	....	......	D	Sd	....	..Do....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
140-75										
1aaa	USGS Test hole 2049 A	179	5	Dr	3-20-63	52.30	T,O	Gv	1,917.2	BR-179, C, L, TD-189.
2bbb1	M. E. Christenson	146	3	Dr	1960	74	S	Ss	....	Wad, Wh.
2bbb2	..do....	128	2	Dr	....	116	D,S	Sd	....	..Do....
4dca	A. Dronen	135	2	Dr	1944	50	S	Sd	....	..Do....
6dbd	G. Vik	160	2	Dr	1946	100	D,S	Sd	....	Wad, Ws.
7cc	A. Seibel	90	2	Dr	1959	15	S	Sd	....	Wad, Wh.
8ad	W. Malsam	115	2.5	Dr	1938	60	D,S	Sd	....	Wad, Wh, temp.-45°F.
8bc	A. M. Hansen	84	2	Dr	....	30	D,S	Sd	....	Wad, Ws.
9aa	A. Dronen	320	7	Dr	1952	25	N	Sd	....	BR-reported 220, Ws.
9dac	..do....	135	2	Dr	1946	50	S	Sd	....	Wad, Wh.
10bcc1	Mrs. N. Dronen	100	2	Dr	1952	......	D	Sd	....	..Do....
10bcc2	..do....	135	2	Dr	1905	......	S	Sd	....	..Do....
10dcc	A. Dronen	60	2	Dr	1910	25	D,S	Sd	....	..Do....
11bdd	..do....	267	3	Dr	1960	120	S	Sd	....	Wad, Ws.
11cd	..do....	180	2	Dr	1958	60	S	Sd	....	..Do....
12ccc	Federal Land Bank	67	22	Dr	1907	60	D	..	....	Win.
12cdd	USGS Test hole 2049	167	5	Dr	7-30-60	13.46	T,O	Gv	1,862.7	BR-184, C, L, TD-189.
15ddd	A. J. Wanner	80	2	Dr	....	20	S	Sd	....	Wad, Wh.
16dcb	P. Pasley	150	2.5	Dr	1940	......	S	Sd	....	..Do....
17dd	L. Kluksdahl	186	2	Dr	1952	25	D,S	Sd	....	Wad, Ws.
18dd	..do....	100	..	Dr	1958	25	S	Sd	....	..Do....
20aaa	P. Pasley	60	2.5	Du	....	20	D,S	Sd	....	Wh, Win.
20bc	J. Kluksdahl	110	2	Dr	1952	15	D,S	Sd	....	Wad, Ws.
20cdd	R. Fichter	160	2	Dr	1945	12	D,S	Sd	....	..Do....
21ddd	USGS Test hole 2003	90	5	Dr	7-12-62	......	T	..	1,880.6	BR-66, L.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
140-75	(Cont.)									
22ccc	Sam Vik	60	2	Dr	1910	35	D,S	Sd	....	Wad, Wh.
23dcd	E. Carlson	130	3	Dr	1958	16	S	Sd	....	Wad, Ws.
24ccd	R. Rnschler	90	2	Dr	....	16	D,S	Sd	....	Wad, Wh.
24daa	R. Shoepp	90	3	Dr	1920	8	D,S	Gv	....	..Do....
24ddd	USGS Test hole 2049 B	132	5	Dr	3-21-63	4.66	T,O	Gv	1,836.7	BR 136, L, TD-147.
25aba	H. Espesetl	100	2	Dr	1918	30	D,S	..	....	Wad.
26ada1	E. Carlson	125	2	Dr	....	16	S	lig	....	Wh.
26ada2	..do....	220	2	Dr	1959	25	D,S	Sd	....	Wad.
26bdc	O. Knudson	60	3	Dr	....	20	D,S	Sd	....	Wad, Wh.
27acc	J. Kocovrek	135	2	Dr	1958	50	S	Sd	....	..Do....
27dcc	..do....	130	2	Dr	1914	60	D,S	Sd	....	C, Wad, Wh.
28aaa	S. Vik	100	2	Dr	1956	40	S	Sd	....	Wad, Wh.
28dda	M. Kluksdahl	125	2	Dr	1922	20	D,S	Sd	....	Wad, Wal, Wh.
29cdd	A. Schumaker	66	2	Dr	1961	37	S	Sd	....	Wad, Wh.
30bad	C. A. Belile	63	2.5	Dr	....	20	D,S	Sd	....	..Do....
31add1	J. Pfennig	60	2	Dr	....	35	D,S	Sd	....	..Do....
31add2	..do....	125	2	Dr	....	35	S	Sd	....	..Do....
32dcc	USGS Test hole 2049 C	73.5	5	Dr	1963	.....	T	..	1,832.6	BR-64, L.
33daa	R. Olauson	154	2.5	Dr	1917	20	D,S	Sd	....	Wad, Ws.
34bdc	A. Schumaker	42	2	Dr	1957	20	D	Sd	....	Wad, Wh.
35add	USGS Test hole 2033	75	5	Dr	1963	.....	T	Sd	1,820.7	BR-58, L.
140-76										
2cd	R. Johnson	120	2	Dr	....	18	D,S	Sd	....	Wad, Ws.
4aa	F. Gershaw	70	2	Dr	1934	13	D,S	Sd	....	Wad.
8ccc	A. Pidarson	120	2	Dr	....	.....	D,S	Sd	....	Wad, Ws.
10ccc	L. Clark	140	2	Dr	1944	25	D,S	Sd	....	Wad, Wal, Ws.
12cdd	A. Seibel	90	2	Dr	....	25	D,S	Sd	....	Wad, Wh.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
140-76 (Cont.)										
14ad	A. Seibel	80	2	Dr	1933	40	D,S	Sd	....	Wad, Wh.
14daa	USGS Test hole 2019	120	5	Dr	7-12-62	......	T	..	1,858.5	BR-106, L.
17bab	A. Miller	165	2	Dr	1934	20	D,S	Sd	....	Wad, Wh.
18bbc	USGS Test hole 1935	94	5	Dr	8-29-61	......	T	Gv	1,816	BR-23, L.
19acc	Patterson Ranch	120	2	Dr	1961	30	S	Sd	....	Wad, Ws.
20dd	E. Smith	250	2	Dr	1944	160	D	Sd	....	..Do....
21bcd	..do....	160	2	Dr	1915	65	S	Sd	....	..Do....
24cd1	D. B. Harmon	190	2	Dr	1960	60	D	Sd	....	..Do....
24cd2	..do....	160	2	Dr	....	60	S	Sd	....	..Do....
25ccc	USGS Test hole 2018	70	5	Dr	7-12-62	Flow	T,O	Sd	1,835.4	BR-83, C, L, TD-90.
28bbb	J. Kerger	240	2	Dr	....	65	D,S	Sd	....	Wad, Ws.
28dbd	E. Elness	115	2	Dr	1944	30	D,S	Sd	....	..Do....
29aad	J. Kerger	160	2	Dr	....	45	S	Sd	....	Wad.
30baa1	E. Renschler	50	12	Dr	1919	40	S	Sd	....	Wad, Wh.
30baa2	..do....	145	2	Dr	1955	25	D,S	Sd	....	Wad, Ws.
32aaa	USGS Test hole 2026	210	5	Dr	7-27-62	......	T	Sd	1,893.1	BR-48, L.
33aab	C. Elness	265	2	Dr	1947	18	D,S	Sd	....	Wad, Ws.
34cc	J. Clark	100	2	Dr	1935	55	S	Sd	....	Wad.
36bbb	R. Sorenson	154	2	Dr	....	20	S	Sd	....	Wad, Ws.
140-77										
2aa	Patterson Ranch	80	2	Dr	1910	35	S	Sd	....	..Do....
3bb	Dumeland oil test 1	6,860	13	Dr	1952	......	T	..	1,970	
6dd	P. Davidson	125	2	Dr	1929	......	D,S	Sd	....	Wad.
7cc1	W. M. Conner	75	2	Dr	....	10	D,S	Sd	....	Wad, Ws.
7cc2	..do....	130	2	Dr	1952	......	D,S	Sd	....	..Do....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
140-77 (Cont.)										
8aa	R. Kohler	282	3	Dr	1918	80	S	Sd	....	Wad, Ws.
8dbd	P. L. McNeill	62	2	Dr	1960	7	S	Sd	....	Wad, Wn.
10dbb	..do....	150	2	Dr	1909	40	D,S	Sd	....	Wad, Wal, Wh.
11dbb	Patterson Ranch	190	2	Dr	1956	80	S	Sd	....	Wad, Ws.
12ccd	..do....	90	3	Dr	....	45	D,S	Sd	....	..Do....
13bab	..do....	90	2	Dr	....	45	D,S	Sd	....	C, Wad, Ws.
14bad	..do....	120	2	Dr	1906	80	S	Sd	....	Wad, Wh.
14ccd	O. G. Darwver	160	2	Dr	1925	75	D,S	Sd	....	Wad, Ws.
14dca	..do....	135	2	Dr	1959	30	S	Sd	....	..Do....
16dbb	Patterson Ranch	90	2	Dr	....	25	S	Sd	....	Wad, Wh.
22cb1	E. Bloomquist	280	2	Dr	....	60	D,S	Sd	....	Wad, Wal, Ws.
22cb2	..do....	90	2	Dr	1948	8	D,S	Gv	....	Wad, Wh.
24ddd	A. Roth	148	2	Dr	1939	16	D,S	Sd	....	Wad, Ws.
25aaa	..do....	124	2	Dr	1953	4	S	Sd	....	..Do....
26ca	M. Roth	90	2	Dr	1936	Flow	S	Sd	....	Wad, Wh.
26cad	..do....	140	2	Dr	....	18	D,S	Sd	....	Wad, Ws.
29bb	D. & M. Holding Co.	120	2	Dr	1915	80	D,S	..	....	Wad.
34cc	H. Larson	90	2	Dr	1920	......	D,S	Sd	....	..Do....
35dbd	Dr. M. W. Roan	120 +	2	Dr	1958	30	S	Sd	....	Wad, Ws.
36acc	Patterson Ranch	90	2	Dr	....	15	S	Sd	....	..Do....
140-78										
2bc	H. McCormick	65	2	Dr	....	28	D,S	Sd	....	C, Wad, Ws.
4aa	M. Bourgois	250	2.5	Dr	1909	......	S	Sd	....	Wad.
6cda	C. Ryberg	125	2	Dr	1925	30	D,S	Sd	....	Wad, Ws.
8aa	G. Hendrickson	300	2	Dr	1905	159	S	..	....	Wad.
10ac	A. Miller	100	2	Dr	1938	50	D,S	Ss	....	Wad, Ws.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
140-78 (Cont.)										
11ddc1	W. Kershah	160	2	Dr	1960	6	D	Sd	....	Wad, Ws.
11ddc2	..do....	175	2	Dr	1915	Flow	S	Sd	....	..Do....
14aaa	USGS Test hole 2008	30	5	Dr	7-5-62	......	T	Gv	1,771.5	BR-19.5, L.
16dbb	P. McCormick	220	2	Dr	1921	12	S	Sd	....	Wad, Wal, Ws.
18bb	E. Ryberg	175	2	Dr	1900	30	...	..	....	Wad.
20bbb	I. Sherman	200	2	Dr	....	100	D,S	Sd	....	Wad, Ws.
20cbb	A. Hogue	80	2	Dr	1940	......	D,S	Sd	....	..Do....
22aac	P. McCormick	180	2	Dr	1936	25	D,S	Sd	....	Wad, Wal, Ws.
26bb	F. D. Owen	90	2	Dr	....	40	D,S	Sd	....	..Do....
30ca1	E. McCormick	180	2	Dr	1924	10	S	Sd	....	Wad, Ws.
30ca2	..do....	42	2	Dr	1925	10	D	Sd & Gv	....	Wh, Win.
32ddd	USGS Test hole 1931	63	5	Dr	8-25-61	......	T	..	1,767.9	BR-42, L.
34acd	USGS Test hole 2027	60	5	Dr	7-25-62	......	T	..	1,751.8	BR-36, L.
34bb	A. Shower	130	2	Dr	1926	25	...	Sd	....	Wad.
36bba	USGS Test hole 2009	86	5	Dr	7-5-62	12.52	T,O	Sd & Gv	1,742.4	BR-86, C, L, TD-105.
140-79										
1cb	C. E. Cunningham	29	36	Du	1932	7	D,S	Sd	....	Wad, Wh.
2dab	..do....	318	2	Dr	....	198	S	Sd	....	Wad, Ws.
4aa	V. Couch	250	2	Dr	1904	35	D,S	Sd	....	Wad.
5bb	T. Burkhart	28	6	Dr	1934	15	D,S	Sd & Gv	....	..Do....
5cbc	E. Bourgess	274	2	Dr	1923	......	D,S	Sd	....	..Do....
6aba	J. Parsons	28	36	Du	1916	23	D,S	Gv	....	..Do....
6bcc	J. G. Thysell	300	2	Dr	1928	275	D,S	Sd	....	..Do....
7ccd	Federal Land Bank	225	2	Dr	1929	200	D,S	Sd	....	..Do....
10bdb	C. Martinson	95	2	Dr	....	85	D,S	Sd	....	Win.
10cbb	USGS Test hole 2038	115	5	Dr	7-25-62	......	T	Ss	2,129.6	BR-1, L.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
140-79 (Cont.)										
11dd	C. Martinson	15	24	Du	1934	13	S	Gv	....	Wad.
14bbc	C. Johnson	300	2	Dr	1900	280	D,S	Sd	....	..Do....
14cc	A. W. Johnson	290	2	Dr	1924	270	D,S	..	....	..Do....
14dd	P. Ryberg	225	2	Dr	1902	200	D,S	..	....	C, Wad.
16aa	H. Erickson	112	2	Dr	1917	60	S	..	....	Wad.
16dd	State of N. Dak.	135	2	Dr	1916	80	D,S	Sd	....	..Do....
19cc	F. G. Grambs	280	2	Dr	1929	240	S	Sd	....	..Do....
20cc	G. Clooten	200	2	Dr	1918	144	D,S	Sd	....	..Do....
20dbd	Martinson Estate	260	2	Dr	1920	200	D,S	Ss	....	..Do....
22bb	H. P. Solberg	230	2	Dr	1910	100	D,S	..	....	..Do....
22ccd	H. Solberg	192	2	Dr	1910	100	D,S	Sd	....	..Do....
23bb	Paul Ryberg oil test 1	7,230	10	Dr	1954	......	T	..	2,007	
26aca	A. H. Solberg	125	2	Dr	1903	65	D,S	Sd	....	..Do....
26dd	C. A. Johnson	35	2	Dr	1910	20	D,S	..	....	Wad.
27aa	R. Erickson	54	2	Dr	1933	25	S	..	....	..Do....
28aa	D. Ryberg	27	2	Dr	1900	20	D,S	Sd	....	Win.
28bb	M. Flanagan	82	2	Dr	1900	70	D,S	Sd	....	Wad.
30ccc1	I. Houge	180	2	Dr	1917	170	D,S	Sd	....	Win.
30ccc2	..do....	330	2	Dr	....	......	S	Sd	....	C, Wad.
32bb	B. Holte	210	2	Dr	1929	175	D,S	..	....	Wad.
34abd	A. L. Small	160	2	Dr	1917	140	D,S	..	....	..Do....
34cc	Erickson Bros.	130	2	Dr	1905	30	D,S	Sd	....	..Do....
35cc	Campbell Estate	68	2	Dr	1934	38	S	..	....	..Do....
140-80										
1ccc	G. Werble	25	48	Du	1917	20	D,S	..	....	..Do....
2dbb	M. Bourgois	235	2	Dr	1912	200	D,S	..	....	..Do....
4bac	E. Lenihan	280	2	Dr	1900	......	D,S	..	....	..Do....
6bda	E. Morris	170	2	Dr	1900	......	D,S	..	....	Win.
7cbb	R. Schonert	17.4	24	Du	1939	4.83	S	Sd	....	Wad, Wh.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
140-80 (Cont.)										
8bbd	H. Andahl	135	2	Dr	....	......	D,S	Sd	....	SC-679, Wad, T.-49°F.
8ccc	R. Andahl	80	2	Dr	....	......	D,S	Sd	....	SC-710, Wad, T.-50°F.
11cc	C. Schulz	320	2	Dr	1924	300	D,S	..	....	Wad.
12bb	E. Baumgart	12	48	Du	1928	9	D,S	..	....	..Do....
12ddd	A. Borkhart	228	2	Dr	1939	200	D,S	..	....	..Do....
17bbb	R. Andahl	365	2	Dr	1957	......	D,S	Sd	....	C, SC-750, Wad, T.-50°F.
17bdd	..do....	400	2	Dr	1959	......	S	Sd	....	Wad.
18bac	G. Satler	170	2	Dr	1903	100	D,S	..	....	..Do....
18cc	E. Kleven oil test 1	7,970	11	Dr	1952	......	T	..	1,910	
19bba	W. Paul	325	2	Dr	1908	200	D,S	..	....	..Do....
19dd	L. Blatner	220	..	Dr	1920	......	D,S	..	....	..Do....
22aad	H. Schonert	160	2	Dr	1917	100	D,S	..	....	..Do....
23bbc	R. Hague	280	2	Dr	1917	200	D,S	..	....	..Do....
24aab	E. J. Barker	275	2	Dr	1912	200	D,S	..	....	..Do....
24ccb	J. B. Raock	225	2	Dr	1922	......	D,S	Clay	....	..Do....
25ccc	W. Miller	250	2	Dr	1908	200	D,S	Clay	....	..Do....
26aab	C. Spitzer	22	30	Dr	1910	10	D,S	..	....	..Do....
26ddd	A. Bertsch	80	2	Dr	1900	60	D,S	..	....	Win.
27aab	E. Flanagan	180	..	Dr	1916	......	D,S	..	....	..Do....
29cbb	USGS Test hole 1982	20	5	Dr	6-19-62	......	T	Gv	1,703.9	BR-14, L.
30ccd	J. Mahoney	135	2	Dr	1914	100	D,S	..	....	Wad.
30dda	G. Kulish	70	4	Dr	....	......	D,S	Sd	....	Wad, T.-48°F.
33dad	L. Ward	180	2	Dr	1915	100	D	..	....	Wad.
35ccc	W. H. Morris	200	2	Dr	1908	150	...	..	....	..Do....
36dcc	W. Clooten	180	2	Dr	1917	100	D,S	..	....	..Do....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
140-81										
1ddc	P. J. Jahner	107	2	Dr	1919	95	D,S	Sd	....	SC-790, Wad, T.-49°F.
2bbc	H. Schaefer	9.5	48	Du	....	6.24	N	Sd	....	......
2dcb	..do....	300	2.5	Dr	1939	......	D,S	Sd	....	Wad, T.-47°F.
4ac	E. Bourgeois	280	2	Dr	....	......	D,S	Sd	....	Wad.
5aa	N. Pederson	30	2	Dr	1929	14	D,S	Sd	....	C,Wad.
5aaa	USGS Test hole 1983	90	5	Dr	6-19-62	7.35	T,O	Sd & Gv	1,644.6	C, L. TD-105.
9bac	C. L. Sanders	376	2	Dr	1941	Flow	D,S	Ss	....	C, SC-2,720, Wad.
9ddc	..do....	280	2	Dr	1947	40	S	Sd	....	Wad, T.-49°F.
13bcc	J. Flannigan	160	2	Dv	1909	150	D,S	Sd	....	Wad.
14acd	G. Hage	130	2	Dr	1913	115	S	Sd	....	..Do....
21dd	W. Koch	20	1.25	Dv	....	......	D	Sd	....	..Do....
22ca	E. Bourgeois	120	2	Dr	....	......	D	Sd	....	..Do....
23aa	N. Worst	216	2	Dr	1909	210	D,S	Sd	....	..Do....
24bb	E. Bourgeois	280	2	Dr	1925	70	D,S	Sd	....	..Do....
25cc	G. O. Hagen	184	2	Dr	1920	180	D,S	..	....	..Do....
35bac	E. Bourgeois	135	2	Dr	1933	132	D,S	Sd	....	..Do....
35dca	L. W. Sperry	118	2	Dr	1913	115	D,S	Clay	....	..Do....
141-75										
2bb	M. Heidt	168	2	Dr	1929	75	D,S	Sd	....	Wad, Ws.
2dbc	..Do....	280	2.5	Dr	1949	95	D,S	Sd	....	..Do....
4dd	R. Heidt	120	1.25	Dr	1909	100	D,S	Sd	....	Wad, Wh.
5bb	E. Koski	160	3	Dr	1961	110	S	Sd	....	..Do....
8ccc	C. M. Bjerke	67	2.25	Dr	1909	57	D,S	Sd	....	Wad.
10aab	P. I. Eness	124	2.25	Dr	1918	25	D,S	Sd	....	..Do....
10bdc	R. Heidt	80	1.125	Dr	1908	40	D,S	Sd	....	..Do....
10daa	E. Hinkel	40	18	Du	1934	30	D,S	Sd	....	..Do....
11bcb	G. F. Regier	140	2.5	Dr	1916	15	D,S	Sd	....	..Do....
20aa	A. Kangor	160	2	Dr	1920	80	D,S	Sd	....	..Do....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
141-75	(Cont.)									
21dbd1	H. O. Arneson	140	4	Dr	1913	80	S	Sd	....	C, Wad, Wh.
21dbd2	..do....	300	4	Dr	1948	120	D,S	Sd	....	Wad, Ws.
21ddd	USGS Test hole 2002	105	5	Dr	6-29-62	......	T	Sd	1,952.6	BR-93, L.
25bcc	E. Heidt	180	2	Dr	....	70	D,S	Gv	....	Wad, Wh.
26ddc	..do....	114	2	Dr	1961	40	S	Gv	....	..Do....
27cdd	J. O. Rise	140	4	Dr	1906	60	D,S	Sd	....	Wad.
28aaa	S. Lien	135	2	Dr	1908	80	D,S	Sd	....	..Do....
30bda	N. Pehl	200	3	Dr	1953	70	D,S	Sd	....	C, Wad, Ws, oil film.
32acb	G. Vik	90	2	Dr	1913	60	S	Sd	....	Wad.
33aa	E. Spilde	140	2	Dr	....	100	S	Sd	....	..Do....
34dab	B. N. Lein	127	4	Dr	1916	30	S	Sd	....	..Do....
141-76										
2bbc	K. Pihlaja	100	2	Dr	1915	50	D,S	Sd	....	..Do....
4cc	A. Holmes	50	2	Dr	1920	30	D,S	Sd	....	..Do....
6cdd	Federal Land Bank	215	3	Dr	1929	75	D,S	...	....	..Do....
8bb	Bismarck Loan and Investment	150	2	Dr	1926	40	D,S	Gv	....	..Do....
10dcc	H. Conhain	15	48 x 60	Du	1912	12	D,S	Sd	....	Win.
12aa	J. Surtela	120	2.5	Dr	1907	40	D,S	Sd	....	Wad.
12cdd	Federal Land Bank	100	2	Dr	....	40	D,S	Clay	....	..Do....
14aad	E. Coheses	82	2	Dr	1908	40	...	Sd	....	..Do....
16bba	USGS Test hole 1998	60	5	Dr	7-3-62	......	T	Sd	1,872.2	BR 43, L.
17cbb	I. Thorsen	40	30 x 30	Du	1911	20	D,S	Clay & Sd	....	Win.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
141-76	(Cont.)									
18aa	N. L. Church	125	2	Dr	1921	30	D,S	Clay & Sd	....	Wad.
18cc	State of N. Dak.	78	5	Dr	1931	25	D,S	Gv	....	Wad, Wh.
20cbc	Bank of N. Dak.	65	2	Dr	1920	18	D,S	Sd	....	Wad.
22dca	J. Nokana	80	34 x 34	Du	1908	47	D,S	Sd	....	..Do....
24bb	Bank of N. Dak.	275	2	Dr	1914	150	D,S	Sd	....	..Do....
26bc	J. C. Spitzer	75	2.5	Dr	1909	40	D,S	Clay & Sd	....	..Do....
28ada	USGS Test hole 2000	60	5	Dr	7-2-62	......	T	..	1,857.4	BR-56, L.
29ccd	USGS Test hole 2001	75	5	Dr	7-2-62	......	T	..	1,857.6	BR 55, L.
32aad	N. S. Dobbler	200	2	Dr	1921	0	...	Sd	....	Wad.
34cbb	E. Johnson	30	48 x 48	Du	....	19	N	Clay & Gv	....	....
141-77										
1cdd	USGS Test hole 1999	45	5	Dr	7-3-62	......	T	Gv	1,892.0	BR-30, L.
2ddd	M. Erickson	160	2.5	Dr	1936	60	D,S	Sd	....	Wad.
6ccd	Federal Land Bank	50	18	Dr	1912	48	D,S	Clay	....	Win.
6daa	A. T. Spangberg	70	2	Dr	1907	50	D,S	..	....	Wad.
8aab	J. Bender	159	1.5	Dr	1915	125	D,S	Sd	....	..Do....
12bdd	Bank of N. Dak.	90	2	Dr	1924	16	D,S	Sd	....	..Do....
14dbd	H. Inget	225	2	Dr	1909	......	D,S	Ss	....	Wad, Ws.
18aaa	H. Nelson	400	2	Dr	1914	80	D,S	Sd	....	Wad.
18bdc	G. Nelson	200	2	Dr	1934	125	D,S	Sd	....	..Do....
20daa	P. Trygg	280	2	Dr	1918	80	D,S	Sd	....	..Do....
22dda	J. Neimi	260	2	Dr	1910	......	...	..	....	..Do....
24dd	J. C. Pfeiffer	160	2	Dr	....	10	S	Lig	....	C, Wad, Ws.
26aaa	Magnolia Petroleum Co.	80	5	Dr	1944	......	T	..	....	L.
28aba	S. Lundquist	200	2	Dr	....	......	N	..	....	....
30aa	C. L. Trygg	240	2	Dr	1939	70	D,S	..	....	Wad.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
141-77 (Cont.)										
31aaa	K. Schlepp	120	2	Dr	....	......	N	..	....	....
32cdd	E. Lang	180	2	Dr	....	30	D,S	Lig	....	Wad, Ws.
33dbb	Patterson Ranch	120	2	Dr	....	40	N	Sd	....	Ws.
36caa	M. Agnew	200	2	Dr	1950	120	S	Sd	....	Wad, Wh.
141-78										
3aa	E. T. Hendershott	98	18	Dr	1937	85	D,S	Sd & Gv	....	Wad.
4cbb	Stover Estate	39	24	Dr	1930	23	D,S	Sd & Gv	....	Win.
4dd	E. Ramstad	50	18	Dr	....	22	N	Sd	....	....
5ddd	USGS Test hole 2006	15	5	Dr	7-5-62	......	T	..	1,929.9	BR-4, L.
8cab	R. Jiras	30	24 x 24	Du	1900	25	D,S	Clay	....	Wad.
8dda	P. Freeman	45	16	Dr	1904	30	D,S	Gv	....	..Do....
10ccc	J. Varley	26	2	Dv	1937	18	D,S	Sd	....	..Do....
11bb	H. Strom	55	2	Dr	1915	45	D,S	Sd	....	..Do....
12bbc	Bank of N. Dak.	36	18	Dr	1917	31	D,S	Clay	....	Win.
12cdb	State Land Bank	35	18	Dr	1908	30	N	Gv	....	....
14aa	Federal Land Bank	28	4	Dr	1935	25	D,S	Sd	....	Wad.
14cdc	..do....	245	2	Dr	1933	220	D,S	Clay	....	Win.
16aa	F. Schroeder	12	48 x 48	Du	1936	5	S	Gv	....	Wad.
18cc	B. E. Trask	26	54 x 54	Du	1939	20	S	Sd	....	..Do....
20bdb	F. H. Schroder	356	2	Dr	1912	225	S	Ss	....	..Do....
20cdc	I. Fricke	100	2	Dr	1915	44	D,S	..	....	..Do....
22bbc	Federal Land Bank	180	4	Dr	1915	150	D,S	Ss	....	..Do....
26bb	K. Kaiser	148	28	Dr	1935	128	D,S	Sd	....	..Do....
27bb	Bank of N. Dak.	100	2	Dr	1929	50	D,S	Sd	....	..Do....
30add	J. Engdahl	145	2	Dr	1915	45	D,S	Sd	....	..Do....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
141-78 (Cont.)										
30cc	J. Engdahl	155	2	Dr	1914	125	S	Sd	....	Wad.
31aa	..do....	125	2	Dr	1903	90	N	Sd	....	....
35bbb	USGS Test hole 2007	15	5	Dr	7-5-62	......	T	Gv	1,845.6	BR-12, L.
141-79										
1dcd	W. Ryberg	57	3	Dr	1919	55	D	Sd	....	Wad.
2aaa	A. Bourgois	40	24	Dr	1922	23	D	Ss	....	..Do....
3dbd	W. Fricke	210	2	Dr	1904	140	D	Sd	....	..Do....
6bdc	Carlson Estate	63	24 x 36	Du	1885	61	N	Sd	....	....
6ccc	E. Bourgois	40	36 x 36	Du	....	34	D	..	....	....
7bca	R. H. Lewis	50	24	Dr	....	45	D	Clay	....	Win.
7dad	J. Meyer	112	2	Dr	....	......	D	Sd	....	C, Wad.
8bad	..do....	60	20	Dr	1902	50	D	Sd	....	Wad.
8bcc	N. T. Meyer	59	24	Dr	1914	47	D	Sd	....	..Do....
9aad	A. M. Rupp	120	3	Dr	1903	115	D	Sd	....	..Do....
10ccd	H. Kickiel	142	2	Dr	1905	112	D	Sd & Gv	....	..Do....
10dad	I. J. Falkenstein	134	4	Dr	1919	118	D	Sd	....	..Do....
12abc	Brown Estate	70	2	Dr	1928	60	D	Sd	....	..Do....
17cc	H. T. Meyer	175	3	Dv	....	......	D	..	....	..Do....
18bdb	G. G. Rupp	40	36 x 42	Du	....	38	D	Sd	....	..Do....
18cc1	F. A. Wood	13	30 x 30	Du	1927	10	D	Sd	....	..Do....
18cc2	I. Fricke	30	24	Dr	....	28	D	Sd & Gv	....	..Do....
19bb1	G. G. Rupp	14	24 x 24	Du	1914	12	D,S	Sd & Gv	....	Win.
19bb2	H. T. Meyer	20	14	Dr	1935	10	D	Sd & Gv	....	Wad.
19dbc	..do....	35	24	Dr	....	32	D	Ss	....	..Do....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
141-79 (Cont.)										
20dd	Federal Land Bank	80	2	Dr	1925	......	D	Ss	....	Wad.
23bba	H. W. Little	100	4	Dr	1910	90	D	Sh	....	..Do....
24bb	H. Bourgois	114	2	Dr	....	100	D	..	....	..Do....
24cc	O. Swanson	93	2	Dr	1923	73	D	Gv	....	..Do....
26bbc	Federal Land Bank	35	48 x 48	Du	1931	29	D	Sd	....	Win.
29aad	..do....	100	3	Dr	....	......	D	..	....	Wad.
30abb	J. T. Lenihan	30	48 x 48	Du	1919	25	D	Clay	....	Win.
30dda	A. R. Lenihan	150	2	Dr	1925	55	D	Sd	....	Wad.
31aad	D. J. McGillis	390	3	Dr	1933	200	D	Sd	....	..Do....
33add	Bismarck Loan & Investment	26	8	Dr	1927	23	S	Gv	....	..Do....
35aa	J. S. Fevold	135	2	Dr	1929	128	D	Sd & Gv	....	..Do....
141-80										
1cba	R. Spitze	50	24	Dr	1909	40	D,S	..	....	..Do....
3dda	A. E. Anderson	158	4	Dr	1929	......	D,S	..	....	..Do....
4aa	A. Johnson	60	24	Dr	1914	6	D,S	..	....	..Do....
4cbb	J. M. Jacobson	45	24	Dr	1939	35	D,S	..	....	..Do....
10aad	B. R. Monroe	150	4	Dr	1935	100	D,S	..	....	..Do....
12aca	C. Mount	78	4	Dr	....	......	D,S	..	....	..Do....
12baa	E. Strandome	40	48 x 48	Du	1918	36	D,S	..	....	..Do....
14dd	S. E. Strandome	55	24	Dr	1902	50	D,S	..	....	..Do....
18bcd	E. Simons	114	4	Dr	1939	90	S	..	....	..Do....
24baa	E. A. Lewis	32	4	Dr	1919	......	D,S	Sd	....	..Do....
27cda	P. Bourgois	198	4	Dr	1932	178	D,S	..	....	..Do....
34bad	A. Christianson	75	24	Dr	1939	50	D	..	....	..Do....
34cab	A. Kooher	60	24	Dr	1923	40	...	..	....	..Do....
34daa	L. Christianson	40	36 x 48	Du	....	20	D	..	....	..Do....
35cba	C. DeLong	25	24	Dr	1925	20	D	..	....	..Do....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
141-80 (Cont.)										
35cc	C. Delong	19	36 x 36	Du	....	15.75	O,N	Sd	....	....
36abd	USGS Test hole 2004	15	5	Dr	6-21-62	......	T	Gv	1,865.4	BR-9, L.
36bab	W. Larson	126	4	Dr	1911	20	D,S	..	....	Wad.
141-81										
2aa	A. Long	26	1.25	Dv	....	......	D	Sd	....	..Do....
12aa	D. Long	80	2	Dr	....	......	D,S	Sd	....	..Do....
36ca	L. Larson	140	2	Dr	....	......	D	Sd	....	..Do....
142-75										
1ddd	B. Wutske	199	3	Dr	1923	60	D,S	Gv	....	Wad, Wh.
2bbc	L. Trusty	10	48 x 48	Du	....	6	D,S	Gv	....	C, Wad, Wal, Wh.
3cc	H. Rachel	90	2	Dr	....	50	D,S	Sd	....	Wad.
3dcd	E. Jaquous	12	48 x 48	Du	1928	8	D,S	Sd	....	..Do....
4abc	C. Schopp	30	2	Dr	1926	16	D,S	Gv	....	..Do....
6bcb	D. Olson	60	16	Dr	1912	40	S	Gv	....	..Do....
8aa	J. Knittel	6	48 x 48	Du	1934	Flow	D,S	Gv	....	..Do....
10aca	R. Leach	186	3	Dr	1920	......	D	Clay & Sd	....	..Do....
14bbb	I. Eide	132	2	Dr	1916	......	D,S	Sd & Sh	....	..Do....
15cda	USGS Test hole 1994	120	5	Dr	6-27-62	......	T	Sd	1,846.5	BR-112, L.
19ccb	USGS Test hole 1995	210	5	Dr	6-27-62	5.96	T,O	Gv	1,890.1	BR-196, L, C.
22acc	USGS Test hole 2045	195	5	Dr	7-30-62	......	T	Gv	1,846.0	BR-172, L.
22cac	F. Plews	90	..	Dr	1927	40	D,S	Gv	....	Wad.
24aaa	H. Ochsner	180	2	Dr	1920	20	D,S	Sd	....	..Do....
24ccc	J. Trautman	30	36 x 36	Du	....	3	D,S	Sd	....	..Do....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
142-75 (Cont.)										
26bb	J. Alexander	94	..	Dr	1919	27	D,S	Sd	....	Wad.
26ddb	J. Mehloff	130	..	Dr	1919	13	D,S	Sd	....	C, Wad.
30bbb	L. R. Beall	100	..	Dr	1914	60	D,S	Sd	....	Wad.
30cbc	C. Josephson	76	3	Dr	1913	42	D,S	Sd	....	..Do....
32dbc1	E. Koski	140	2	Dr	1941	45	D,S	Sd	....	Wad, Wal, Wh.
32dbc2	..do....	223	2	Dr	1959	......	D	Sd	....	Wad, Ws.
34bab	W. Kehres	75	2	Dr	1919	......	S	Sd	....	Wad, Wh.
34bdd	W. M. Deckert	80	36	Du	1916	63	D,S	Gv	....	..Do....
35ccc	D. Buller	65	16	Dr	1935	40	D,S	..	....	Wad.
142-76										
2ccd	Howard Lanville	57	2	Dr	1963	Flow	D,PS	Sd	....	C, Wad.
3daa	Unknown	87.75	3	Dr	....	5.64	S	Gv	....	Wad, Wh.
3dda	USGS Test hole 1997	75	5	Dr	6-28-62	......	T	Gv	1,892	BR-57, L.
4bb	Bank of N. Dak.	130	..	Dr	1910	90	D,S	..	....	Wad.
6aba	F. Gillig	300	2	Dr	1912	60	D,S	Sd	....	Wad, Ws.
6dda	T. Fischer	90	2	Dr	1909	40	D,S	Ss	....	..Do....
7aaa	USGS Test hole 1978	105	5	Dr	4-10-62	......	T	..	1,994	BR-36, L.
8bdb	Soder Investment	270	3	Dr	1920	35	D,S	Sd	....	Wad, Ws.
10aac	W. Josephson	58	4	Dr	1924	45	D,S	Clay	....	Wad.
12bcc	E. Oswald	140	2	Dr	1955	30	D,S	Sd	....	Wad, Wal, Wh.
14cac	Federal Land Bank	45	36 x 36	Du	1909	40	D,S	Gv	....	Win.
17aa	Soder Investment	300	3	Dr	....	200	S	Sd	....	Wad, Ws.
18aa	S. Hiberstad	170	2	Dr	1928	90	S	..	....	Wad.
20bba	Bank of N. Dak.	50	2	Dr	1906	......	D	..	....	..Do....
22aab	J. Leno	44	24	Dr	1907	10	D,S	Sd	....	Wad, Wh.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
142-76 (Cont.)										
22ddd	USGS Test hole 2024	75	5	Dr	6-29-62	......	T	Sd	1,931.8	BR-57, L.
23bcb	USGS Test hole 1996	30	5	Dr	6-29-62	......	T	Gv	1,886.0	BR 23, L.
26aab	Federal Land Bank	125	2	Dr	1910	60	D,S	Sd	....	Wad.
26bcc	S. Sehta	190	2	Dr	1907	180	D,S	Clay	....	..Do....
30aaa	Federal Land Bank	150	2	Dr	1919	100	D,S	Sd	....	..Do....
30baa	Union Investment Co.	200	2	Dr	1922	50.	D,S	Sd	....	..Do....
142-77										
2add	M. Thorston	100	2.5	Dr	....	47	D,S	Sd	....	..Do....
4bbb	V. Little	60	24	Dr	....	......	D	Clay	....	..Do....
4ddd	C. Little	405	4	Dr	1959	30	D,S	Sd	....	C, Wad, Ws.
5add	..do....	120	4	Dr	1960	30	S	Sd	....	Wad, Ws.
6bcc	R. Nelson	65	2	Dr	1955	32	D,S	Sd	....	Wad, Wh.
10abb	S. W. Newitz	35	24	Dr	1915	33	D,S	Sd	....	Win.
15aa	W. Hoerr	10	30 x 30	Du	1936	7	S	Clay	....	Wad.
16add	Hopkins Ranch	200	2	Dr	1960	......	D,S	Sd	....	Wad, Ws.
18cbc	A. Ryberg	96	2	Dr	1909	90	S	Lig	....	Wad.
20bba	Bank of N. Dak.	100	4	Dr	1923	80	D,S	Sd	....	..Do....
20ccc	Federal Land Bank	80	24	Dr	1909	60	D,S	..	....	..Do....
21cdc	A. Anderson	12	30 x 30	Du	1929	9	D,S	Sd	....	..Do....
22dd	S. E. Olson	180	2	Dr	1909	125	D,S	Ss	....	..Do....
24bac	L. Hopkins	14	60 x 60	Du	1928	10	D,S	Sd	....	..Do....
26bcc	Dr. Brandt	38	24	Dr	1934	20	D,S	Sd	....	..Do....
30aaa	A. Olson	68	3	Dr	1915	40	D,S	..	....	..Do....
30bac	K. Hettick	60	6	Dr	1909	20	D,S	Clay	....	..Do....
32ccb	O. Magnuson	37	18	Dr	1913	30	D,S	Sd	....	..Do....
34bb	S. A. Nelson	45	6	Dr	1932	35	D,S	Clay	....	..Do....
34ccd	..do....	34	48 x 48	Du	1915	34	N	Clay	....	Win.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
142-77 (Cont.)										
34dd	E. Noset	67	18	Dr	1913	52	D,S	Clay	....	Wad.
142-78										
2dcd	T. E. Morris	75	6	Dr	1909	50	D	Sd	....	..Do....
3ddc	Federal Land Bank	36	24	Dr	....	34	D	Gv	....	..Do....
4adb	F. B. Shala	70	3	Dv	....	50	D	Lig	....	..Do....
4bcc	H. B. Gill	40	4	Dr	1922	30	D	Sd	....	..Do....
5aaa	N. Tosseth	52	24	Dr	....	48	D	Sd	....	..Do....
5bb	A. Strom	67	3	Dr	1927	39	D	Lig	....	..Do....
6adb	V. Strom	64	20	Dr	1914	24	D	Lig	....	..Do....
6ccc	A. B. Johnson	72	4	Dr	1917	20	D	Gv	....	..Do....
8bbc	A. Hedstrom	100	6	Dr	1920	70	D	Clay	....	..Do....
8cac	A. Tosseth	100	4	Dv	1904	70	D	Sd	....	..Do....
8cbb	E. Sundquist	120	4	Dv	1920	70	D	..	....	..Do....
9aaa	W. A. Drawver	72	4	Dr	1919	52	D	Sd	....	..Do....
9bab	W. H. Gill	39	24	Dr	1916	31	D	Sd	....	..Do....
10bbc	J. Spangberg	100	4	Dr	1927	40	D	Sd	....	..Do....
11cbb	V. Engelbritson	72	6	Dr	1927	15	D	Clay	....	..Do....
12bab	S. R. Little	48	4	Dr	1909	......	D,S	Gv	....	..Do....
12cc	J. Kierland	70	4	Dr	1913	60	...	Clay	....	..Do....
12dd	A. Ryberg	100	4	Dr	....	50	D	..	....	..Do....
13bbb	C. W. Magnuson	70	18	Dr	1909	52	N	Sd	....	..Do....
14aa	H. J. Magnuson	62	24	Dr	1904	52	D	Sd	....	..Do....
14bcc	M. V. Magnuson	70	24	Dr	1908	52	D,S	Sd	....	..Do....
14cdd	A. Anderson	52	24	Dr	1917	49	D	Clay	....	..Do....
15daa	N. Alm	16	36 x 36	Du	1915	14	D	..	....	..Do....
18bca	Coleman Estate	120	4	Dr	1920	......	D	..	....	..Do....
20bb	F. Perkins	145	2	Dr	....	100	D	..	....	..Do....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
142-78 (Cont.)										
21cdb	H. Brosts	110	5	Dv	1922	90	D	Sd	....	Wad.
22bbd	A. Rupp	75	24	Dr	....	35	D	..	....	..Do....
23ccb	W. J. Schimanski	68	24	Dr	1911	55	D	..	....	..Do....
24bb	Bank of N. Dak.	77	3	Dr	....	60	D	Sd	....	..Do....
24ccc	O. W. Backman	142	6	Dv	1922	135	D	..	....	..Do....
26cbc	Bank of N. Dak.	60	4	Dv	....	50	D	..	....	..Do....
26dd	C. W. Scott	127	4	Dr	....	67	D	Sd	....	..Do....
28aaa	E. Olson	60	24	Dr	....	50	S	..	....	..Do....
28bdb	A. Helgeson	80	3	Dr	1927	60	D	Clay	....	..Do....
29bac	L. V. Siand	50	6	Dr	1919	40	D	Ss	....	Win.
30bbb	Federal Land Bank	110	3	Dr	1935	......	D	Gv	....	Wad.
32ccd	R. Cohan	75	4	Dr	....	......	...	Sd	....	..Do....
33daa	L. Mennenga	34	6	Dr	1931	13	D	Gv	....	..Do....
35ddc	O. Coleman	14	48 x 48	Du	1925	8	D	Sd	....	..Do....
142-79										
2ddc	H. H. Speten	67	24	Dr	1937	55	D,S	..	....	..Do....
3cc	V. Franklund	50	6	Dr	....	35	S	Sd	....	Win.
4cdc	T. J. Asplund	190	2	Dr	....	......	D,S	..	....	Wad.
4dd	B. Anderson	40	36	Du	....	10	S	Sd	....	Win.
6cbc	R. D. Flavin	62	24	Dr	....	30	S	Lig	....	Wad.
8bcb	Eckland Bros.	45	24	Dr	1916	38	D,S	..	....	..Do....
8dbb	E. E. Backman	68	24	Dr	1908	55	D,S	Sh	....	..Do....
9aa	McCahey Bros.	60	24	Dr	1925	50	S	Lig	....	..Do....
10abb	H. C. Asplund	35	24	Dr	....	33	D,S	Lig	....	..Do....
10bbb	A. Fesberg	27	24	Dr	....	4	S	..	....	Win.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
142-79 (Cont.)										
11baa	R. Taplin	85	2	Dr	....	75	D,S	Sd	....	Wad.
11cc	H. Taplin	249	2	Dr	1934	180	D,S	..	....	..Do....
12aba	W. Falkenstein	60	4	Dr	....	55	D,S	..	....	Win.
12bba	H. Taplin	105	4	Dr	1919	73	D,S	Sd	....	Wad.
12ccc	L. Johnson	84	24	Dr	1937	80	D,S	Lig	....	..Do....
13bbc	E. Kling	100	2	Dr	....	80	D,S	..	....	..Do....
14cc	J. Vollan	120	2	Dr	1925	100	D,S	Sd	....	..Do....
14dd	A. F. Anderson	150	4	Dr	1911	140	D,S	Sd	....	..Do....
15bba	A. Hagstrom	260	4	Dr	....	225	D,S	Sd	....	..Do....
16ccd	A. Hedberg	200	4	Dr	1911	190	N	Sd	....	Win.
18ddc	L. Gordon	50	24	Dr	1934	40	D,S	..	....	..Do....
19bb	S. Schules	160	4	Dr	1912	......	D,S	Sd	....	Wad.
20bbd	G. E. Gordon	140	2	Dr	1907	135	D,S	Gv	....	..Do....
21cc	P. Monroe	283	2	Dr	1927	200	D,S	Sd	....	..Do....
22aa	A. Engstrom	156	2	Dr	....	135	D,S	Lig	....	..Do....
22cab	W. Spangerg	183	2	Dr	1925	175	D,S	Sd	....	..Do....
24dcc	J. M. Thompson	90	3	Dr	1900	80	D,S	Sd	....	..Do....
26acb	V. Franklin	58	5	Dr	1960	21	D,S	Gv	....	C, Wad, Wh.
26cdd	H. McCullough	75	3	Dr	....	65	D,S	..	....	Wad.
26ddd	USGS Test hole 2005	45	5	Dr	7-3-62	......	T	Gv	2,027.6	BR-20, L.
27ccd	J. Sorch, Jr.	151	3	Dr	1919	126	D,S	Sd	....	Wad.
28bda	E. Hilker	52	24	Dr	1912	25	D,S	Sd	....	..Do....
29cc	L. Fisher	120	2	Dr	1920	100	D,S	Sd	....	..Do....
29dad	J. Sorch	157	2	Dr	1933	140	D,S	Sd	....	..Do....
30aa	C. Krotz	74	18	Dr	....	70	D,S	..	....	Win.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
142-79 (Cont.)										
30cc	C. Spitzer	94	24	Dr	1932	80	D,S	Gv	....	Wad.
31bbb	A. W. Franklund	56	24	Dr	....	53	D,S	Ss	....	..Do....
32bcb	L. Spitzer	56	24	Dr	....	50	D,S	Gv	....	..Do....
32ddd	J. Sorch	190	2	Dr	1909	170	D,S	..	....	..Do....
33bda	H. Diede	70	24	Dr	1934	50	D,S	Sd	....	..Do....
36abb	H. Brown	30	24	Dr	....	20	D,S	Gv	....	..Do....
142-80										
1bdb	N. Krush	85	24	Dr	1936	70	S	Gv	....	..Do....
2abb	City of Wilton #1	220	3	Dr	....	60	T	Sd	....	L.
2bb	A. Kilian	180	2	Dr	1928	150	D,S	Sd	....	Wad.
3aaa	USGS Test hole 1985	225	5	Dr	6-20-62	......	T	Sd	2,170.9	BR-7, L.
4baa	M. Triska	40	24 x 24	Du	....	32	D,S	Sd & Gv	....	SC-1,250, Wad, Wh.
5cdd	Wilton Mutual Store	80	24	Dr	1932	78	S	Ss	....	Win.
6aaa	P. K. Katman	71	24	Dr	....	44	D,S	Gv	....	Wad.
6bb	D. Iverson	60	24	Dr	1900	54	N	Lig	....	..Do....
8bbb	J. Brown	228	2	Dr	1912	190	D,S	Sd	....	SC-2,477, Wad, Ws.
8dd	A. Nelson	12	48 x 48	Du	1933	8	D,S	Clay	....	Wad.
9bdb	R. Backman	208	4	Dr	1946	150	D,S	Sd	....	SC-1,700, Wad, Ws.
10bb	D. Bost	100	24	Dr	1915	95	D,S	Lig	....	Wad.
10cdc	G. Doerr	165	4	Dr	....	125	D,S	Sd	....	..Do....
12aa	G. Pfieffer	62	24	Dr	1889	49	N	Sd	....	Win.
12bbc	M. Garowski	150	2	Dr	1931	80	D,S	..	....	Wad.
12dcc	E. A. Gray	48	24	Dr	1935	46	N	Sd	....	..Do....
13bba	S. M. Anderson	50	48 x 48	Du	1908	35	D,S	Clay	....	..Do....
14ccc	A. Gorden	35	4	Dr	....	20	D,S	..	....	Wad, Wh, T.-47°F.
17aa	A. Stenquist	160	4	Dr	1916	90	D,S	..	....	Wad.
19cdc	H. Johnson	34	48 x 48	Du	1922	30	D,S	Gv	....	..Do....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
142-80 (Cont.)										
20bbc	W. A. Johnson	50	24	Dr	1912	48	N	Clay	....	....
21adb1	F. Murrey	60	4	Dr	1931	38	D,S	Sd	....	SC-1,380, Wad, Wh.
21adb2	..do....	180	1.5	Dr	1956	......	D	Sd	....	SC-1,600, Wad, Ws.
21bb	L. Maynard	45	24	Dr	1926	35	D,S	Sd	....	Wad.
22baa	D. Murrey	240	3	Dr	....	70	S	Lig	....	Wad, T.-48°F.
23aa	J. Chubey	54	4	Dr	1936	50	S	Lig	....	Wad.
24aa	C. Peterson	42	24 x 24	Du	1885	36	D,S	Clay	....	..Do....
24dbc	G. Montgomery	42	24	Dr	1936	34	D,S	Lig	....	..Do....
26ccd	J. Partyka	200	2	Dr	....	......	D,S	Gv	....	..Do....
29cdb	G. Hagen	200	2	Dr	1917	100	D,S	Gv	....	..Do....
31aba	D. Albright	28	24	Dr	1934	23	D,S	Gv	....	Win.
34ddc	A. E. Holden	200	2	Dr	1915	170	D,S	Ss	....	Wad.
35cbb	S. Moisa	200	2	Dr	1937	100	D,S	Ss	....	..Do....
36cbc	P. Strandemo	101	2	Dr	1926	70	D,S	Sd & Gv	....	..Do....
142-81										
1dd	H. Thompson	14	2	Dv	1934	10	D,S	Sd	....	..Do....
2aab1	J. Franklund	101	3	Dr	1951	50	S	Sd	....	SC-1,455, Wad, Wh.
2aab2	..do....	85	2	Dr	1950	45	D	Sd	....	Wad, Wh.
2baa	F. Brown	240	2	Dr	1960	20	D	..	....	SC-2,036, Wad, Ws.
4adc	USGS Test hole 1984	435	5	Dr	6-21-62	Flow	T	Ss	1,666.3	BR-7, C, L.
12bab	N. Erickson Estate	77.60	30	Du	1925	63.98	N	..	....	....
13aaa	A. Peterson	150	2	Dr	1948	......	D,S	Sd	....	Wad, Wh, T.-48°F.
14abd	C. Peterson	54	24	Dr	1941	......	D,S	Sd	....	SC-1,200, Wad, Wh.
14bca	F. Nelson	55	24	Dr	1912	45	N	Clay	....	....
15bc	B. Biersterfield	45.1	24	Dr	....	27.30	S	Sd	....	Wad.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
142-81 (Cont.)										
15cd	R. E. Hogen	37	1.25	Dv	....	......	D,S	Sd	....	Wad.
22ab	..do....	12.2	100	Du	....	1.83	N	Sd	....	..Do....
22ac	..do....	37.8	18	Dr	....	29.62	N	Sd	....	..Do....
22ddb	L. Davenport	47	4	Dr	1961	20	S	Sd & Gv	....	C, Wad, Wh.
23ccb	..do....	96	4	Dr	1948	75	D,S	Lfg	....	Wad, Ws.
24cda	Federal Land Bank	36	24	Dr	1936	32	D,S	..	....	Win.
26db	N. Simonson	18.6	18	Dr	....	5.23	D	Sd	....	Wad.
27bab	D. C. Swanks	28	2	Dv	1931	20	D,S	Sd	....	..Do....
35aab	T. Morgan	100	2	Dr	1917	44.99	D,S	Gv	....	..Do....
36cac	G. Larson	115	2	Dr	1920	40	D,S	Sd	....	..Do....
36cdd	W. Johnson	132	2	Dr	1929	80	D,S	Sd	....	..Do....
36ddd	D. Riebe	60	24	Dr	1939	10	D,S	Ss	....	Win.
143-75										
2cdd1	E. Wagner	65	18	Dr	1911	40	S	Gv	....	Wad, Wal, Wh.
2cdd2	..do....	85	2	Dr	1946	25	D,S	Gv	....	..Do....
3acc	L. Dockter	67	3	Dr	1961	16	S	Sd	....	Wad, Wh.
4add	..do....	130	3	Dr	....	45	D,S	Sd	....	Wad, Wal, Wh.
6cbc	J. Harris	40	24	Dr	1908	20	S	Clay & Gv	....	Wad.
8abd	Federal Land Bank	...	3	Dr	1910	30	S	Sd	....	Win.
9dcc	Soder Investment Co.	187	2.5	Dr	1933	......	D,S	..	....	Wad.
13ccd	J. Wutzke	140	2	Dr	1916	25	D,S	Ss	....	..Do....
14aa	E. Sandberg	142	3.5	Dr	1918	20	D,S	Clay	....	..Do....
14bb	J. Wolff	180	2	Dr	1958	40	S	Sd	....	Wad, Ws.
16acc	USBR drill hole 41	40	3	Dr	1960	6.9	T	Sd	1,897.6	L.
16bdd	USBR drill hole 40	45	3	Dr	1960	8.1	T	Sd	1,902.9	..Do....
17aac	USBR drill hole 39	30	3	Dr	1960	30	T	Sd	1,900.5	..Do....
18aaa	H. Trautman	130	3	Dr	....	37	D,S	Sd	....	C, SC-1,768, Wad.
19acc	..do....	137	4	Dr	....	67	S	Sd	....	Wad.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
143-75 (Cont.)										
19daa	USGS Test hole 2056	105	5	Dr	7-31-62	......	T	..	1,892	BR-81, L.
20cc	R. Bailey	105	4	Dr	1926	50	S	Sd & Gv	....	Wad.
20dab	C. Rath	153	2.5	Dr	1916	30	S	Sd	....	..Do....
22bab1	J. Wolff	50	3	Dr	1906	40	S	Sd	....	Win.
22bab2	..do....	140	2	Dr	1958	25	D,S	Sd	....	Wad, Ws.
23cdd	C. Wagner	185	2	Dr	1962	75	S	Sd	....	..Do....
24dad	USBR drill hole 42	60	3	Dr	1960	4.9	T	..	1,862.4	L.
26abc	C. Wagner	195	2.5	Dr	1910	70	S	Sd	....	Wad.
26bcb	J. Gilner	90	24	Dr	1909	80	S	..	....	Win.
29acc	A. J. Batter	120	4	Dr	1960	30	S	Sd	....	Wad.
30cdd	F. Miller	269	2	Dr	1933	153	N	Sd	....	....
32bcc	A. J. Batter	180	3	Dr	....	40	S	Sd	....	Wad.
32ccc	A. Kraft, Jr.	23.41	30 x 30	Du	....	11.73	S	Sd	....	Wad, Wh.
35ccb	L. Trusty	60	2	Dr	1963	12	S	Sd	....	C, Wad.
143-76										
3ddc	Patterson Land Co.	240	2	Dr	1919	40	D,S	..	....	Wad.
4baa	V. Miller	196	2	Dr	....	120	S	Sd	....	..Do....
6bdb	J. Skei	33	36 x 36	Du	....	30	D,S	..	....	..Do....
6ddd	H. G. Bailey	60	4	Dr	1947	12	D,S	Sd	....	Wad, Wh.
7baa	USGS Test hole 1991	75	5	Dr	6-26-62	......	T	..	1,932	BR-30, L.
7ddd	E. Sorlie	60	4	Dr	....	16	D,S	Gv	....	Wad, Wh.
8ccc	G. Harmon	39	48 x 48	Du	1938	28	D,S	Sd	....	Win.
10ccd	D. Bossert	46	30	Dr	....	35	D,S	Clay	....	Wh, Win.
10ddd	A. Dagner	40	24	Dr	1934	22	D,S	Sd	....	Wad.
12da	USBR drill hole 38	40	3	Dr	1960	8.3	T	Silt	1,973.3	L.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
143-76 (Cont.)										
13ccd	G. Jackson	180	2	Dr	1936	40	D,S	Sd	....	C, Wad, Ws.
14bcb	C. Berg	62	24	Dr	....	54	S	Gv	....	Wad.
15baa	D. Bossert	230	4	Dr	1962	80	S	Gv	....	Wad, Wh.
20adc	O. Jacobson	160	3	Dr	....	84	D,S	Sd	....	Wad, Ws.
22aab	J. Weber	60	24	Dr	....	25	S	..	....	Wad.
22dad	M. Hochbatter	50	3	Dr	....	......	D,S	Sd	....	..Do....
25caa	G. Jackson	135	2	Dr	1958	......	D,S	Ss	....	Wad, Ws.
28ddc	B. Michel	30	48 x 48	Du	1902	20	D,S	..	....	Wad.
30dcc1	H. Williams	330	2	Dr	1960	230	D,S	Sd	....	Wad, Ws.
30dcc2	..do....	285	3	Dr	1955	180	S	Clay	....	..Do....
32bb	..do....	280	2	Dr	1958	98	S	Clay	....	..Do....
33a	C. Josephson	190	2	Dr	....	......	S	Sd	....	C, Wad.
143-77										
2aab	J. Novy	180	6	Dr	1908	150	D,S	Sd	....	Wad.
6abb	A. H. Lundberg	45	48 x 48	Du	1934	40	D,S	..	....	Win.
6bcc	G. Mowder	50	6	Dr	1924	30	D,S	Sd	....	Wad.
6ccc	Federal Land Bank	65	30	Dr	1900	50	D,S	Clay	....	..Do....
6dcc	Bank of N. Dak.	...	4	Dr	1905	70	D,S	Sd	....	..Do....
8cc	R. H. Lundberg	120	3	Dr	1957	25	D,S	Sd	....	..Do....
10bb	M. Hienkenmer	90	4	Dr	1905	80	D,S	Clay	....	Win.
11dd	R. H. Lundberg	128	3	Dr	1955	55	S	Sd	....	Wad, Wh.
12cdc	State Land Bank	125	2	Dr	....	45	D,S	Sd	....	Wad.
14adc	Federal Land Bank	70	2	Dv	1914	60	D,S	..	....	..Do....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
143-77 (Cont.)										
14bb	M. Lendsay	65	6	Dr	1910	55	D,S	Ss	....	Wad.
14ccd	J. McCoy	65	6	Dr	1910	60	D,S	Sd	....	Win.
16bcb	C. Morris	60	4	Dr	1957	30	D,S	Gv	....	Wad, Wh.
17dcc	R. H. Lundberg	61	3	Dr	1949	23	D	Sd	....	C, Wad, Wh.
18aca1	A. Strand	25	36 x 36	Du	1902	20	N	..	....	Win.
18aca2	..do....	45	6	Dr	1925	30	D,S	..	....	Wad.
21dad	School land	75	4	Dr	1926	70	D,S	Sd	....	Win.
22ccb	O. Olson	175	2	Dr	1915	25	D,S	Sd	....	Wad.
24baa	M. Walters	160	2	Dr	1918	62	D,S	Sd	....	..Do....
25dd	H. Williams	160	2	Dr	1961	50	S	Clay	....	Wad, Wh.
28dda	C. Little	16.00	2	Dr	....	6.76	N	Sd	....	....
30aca	N. Schroder	80	2	Dr	1928	40	D,S	Gv	....	Wad.
30cdc	C. McCullough	464	2	Dr	1960	200	D,S	Sd	....	C, Wad, Ws.
31cbb	H. D. Watkins	110	6	Dr	1928	50	D,S	..	....	Wad.
31dd	F. P. Rusch	75	6	Dr	....	60	D,S	..	....	..Do....
34bb	H. C. Patton	90	4	Dr	1924	20	D,S	Sd	....	Win.
143-78										
2aab1	Folmer	110	3	Dr	1955	......	S	Sd	....	Wad, Wh.
2aab2	..do....	235	2	Dr	1953	40	D	Sd	....	Wad, Ws.
2ddd	W. N. Uhde	92	4	Dr	1904	64	D,S	..	....	Wad,
3bbc	J. E. Carlson	100	6	Dr	1920	50	D,S	Sd	....	Win.
4bcc	Bank of N. Dak.	90	4	Dr	....	20	D,S	Sd	....	Wad.
4cc	J. Hausauer	43	24	Dr	1929	41	D,S	Sd	....	..Do....
6aba	N. L. Church	85	6	Dr	....	75	D	..	....	..Do....
7cbb	USGS Auger hole 26	52	3	Dr	10-24-62	......	T	..	....	BR-44, L.
9bba	C. Hausauer	279	2	Dr	1945	80	D,S	Sd	....	Wad, Ws.
10ccc	J. E. Zelmer	93	4	Dr	....	36	D,S	..	....	..Do....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
143-78 (Cont.)										
10dcc	P. Michelson	76	4	Dr	1917	14	D,S	Sd	....	Wad, Ws.
11daa	E. A. Jose	60	3	Dr	....	......	D,S	Gv	....	Wad, Wh.
12aad	Agriculture Credit Corp.	60	6	Dr	1919	50	...	..	....	Wad.
12ddd	L. Goll	89	4	Dr	....	39.05	S	Sd	....	C, Wad.
13cc	F. Folmer	108	5	Dr	1920	30	N	Sd	....	
13dda	N. W. Davenport	113	4	Dr	....	73	D,S	Sd	....	Win.
14aba	W. M. Udhe	90	6	Dr	1914	80	D,S	Gv	....	Wad, Wh.
18abc	O. Hagstrom	111	4	Dr	....	60	D,S	Sd	....	..Do....
18bbb	USGS Auger hole 20	25	3	Dr	10-62	......	T	..	....	L.
18ddc	G. L. Johnson	300	4	Dr	1934	117	D,S	Ss	....	Wad, Ws.
20aa	N. H. Broehl	16	24 x 44	Du	1934	8	N	Sd	....	....
20cda	P. Johnson	50	6	Dr	1938	38	D,S	Sd	....	Wad.
20dbd	D. E. Ghylin	40	24	Dr	1916	36	D,S	Sd	....	..Do....
21dad	J. Wise	80	4	Dr	1911	......	D,S	Sd	....	Wad, Wh.
23aa	G. Michelson	84	4	Dr	1918	30	N	Sd	....	....
23ccc	W. Michelson	85	4	Dr	1918	22	D,S	Ss	....	Wad.
24bbb	A. McCullough	93	4	Dr	1959	40	D,S	Gv	....	Wad, Wh.
24dcc	F. Reimann	65	4	Dr	1946	....	D,S	Sd	....	..Do....
25dd	McHugh	140	4	Dr	....	80	N	..	....	
28ccc	L. Lundberg	85	4	Dr	1916	50	D,S	Lig	....	..Do....
28dad	A. Manning	65	4	Dr	1950	26	D,S	Sd	....	..Do....
30bbc	D. Bauer	30	48 x 48	Du	1960	10	D,S	Sd	....	..Do....
31dcc	Federal	50	18	Dr	1930	25	S	Clay	....	Wad.
32aba	L. Lundberg	85	4	Dr	....	48	S	Sd	....	Wad, Wh.
32ccc	B. T. Benson	52	24	Dr	1926	30	D,S	Ss	....	Wad.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
143-78 (Cont.)										
34ddc	J. Keefer	58	24	Dr	....	50	D,S	Sd	....	Wad.
35bdd	B. Worden	65	6	Dr	1925	35	D,S	..	....	....
35cc1	A. T. Tourtloote	36	4	Dr	1929	30	D	Lig	....	..Do....
35cc2	C. N. Lien	42	5	Dr	1939	36	D	Sd	....	..Do....
35ccc	USGS Test hole 1990	135	5	Dr	6-26-62	......	T	Sd	2,042.9	L, BR-32.
143-79										
2cbb	M. H. Kozek	44.12	42 x 42	Du	1903	41.62	N	..	....	....
4cc	N. Spoynagnatch	65	24	Du	....	60	N	Clay	....	Win.
5aa	P. Osheny	80	24	Dr	1933	72	N	Clay	....	..Do....
6cbc	E. W. Aune	82	4	Dr	1941	18	D,S	Sd	....	Wad, Ws.
6dda	Agriculture Corp.	35	24	Dr	1926	34	D,S	Sd	....	Win.
8cda	C. W. Noon	43	24	Dr	1927	23	D,S	..	....	Wad.
8dbc	D. Noon, Jr.	431	3	Dr	1959	10	D,S	Ss	....	Wad, Ws.
10baa	USGS Auger hole 19	89.5	3	Dr	10-19-63	60	T	Sd	....	BR-79, L.
10bbc	E. Johnson	40	4	Dr	1958	25	D,S	Sd	....	Wad, Wh.
11aad	USGS Auger hole 25	52	3	Dr	10-23-62	......	T	Sd	....	BR-46, L.
13bcb1	O. Hagstrom	300	2	Dr	1951	80	D,S	Sd	....	Wad, Ws.
12bcb2	Erickson Bros.	60	24	Dr	1919	45	D,S	..	....	C, Wad.
14cbb	F. Hentz	44	54 x 54	Du	1936	28	N	Clay	....	Wad.
14dad	USGS Auger hole 27	97	3	Dr	10-24-62	......	T	..	....	BR-95, L.
15cc	S. Beranick	60	2	Dr	1936	52	D,S	Sd	....	Win.
17ada	R. Johnson	50	18	Dr	1903	45	D,S	Sd	....	Wad, Wh.
18bcb	J. Noon	110	4	Dr	1936	50	D,S	Gv	....	Wad.
18bcc	..do....	120	4	Dr	1927	80	D,S	Gv	....	..Do....
20cdd	J. Olson	33.31	24	Dr	1909	20.48	N	..	....	....
21cbb	H. Thor	46	24	Dr	1932	38	D,S	Clay	....	Wad.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
143-79	(Cont.)									
21ddd	J. Law	70	2	Dr	1927	60	N	..	....	Win.
23bcc	W. Noon	50	4	Dr	1961	5	D,S	Sd	....	Wad, Wh.
24bdb	N. Asplund	35	2	Dr	1919	30	D,S	Clay	....	Win.
24dbb	J. Johnson	41	24	Dr	1936	26	D,S	Sd	....	Wad.
26ccb	L. M. Nordquist	32	24	Dr	1937	20	D,S	Lig	....	..Do....
26daa	A. Asplund	30	48 x 48	Du	1904	15	D,S	Sd	....	..Do....
27ccc	H. Danielson	49	6	Dr	1932	36	D,S	Sd	....	..Do....
27dcc	C. Olson	55	18	Dr	1934	50	D,S	Clay	....	Win.
28ada	R. Johnson	30	8	Dr	1936	19	D,S	Sd	....	Wad.
28cc	F. Achernecker	50	24	Dr	1916	35	N	Sd	....	....
28dd	A. Thor	61	24	Dr	1935	53	N	Clay	....	....
29aa	M. Magnuson	50	2	Dr	1933	35	N	Clay	....	....
29ddc	O. M. Thor	47	72 x 72	Du	1909	45	D,S	..	....	Wad.
30aa	J. Dahlgren	50	24	Dr	1935	36	D	Lig	....	..Do....
30cc	L. Backman	276	4	Dr	1928	75	D,S	Sd	....	..Do....
30dda	G. Webber	44	3	Dr	1936	28	D,S	Clay	....	..Do....
32baa	H. Renner	62	36	Dr	....	49	D,S	Sd	....	C, Wad, Wh.
33aa	A. Thor	45	2	Dr	1923	38	D	Clay	....	Win.
34bcc	..do....	42	36	Du	1895	32	D,S	..	....	....
34ccc	V. Enstrom	32	24	Du	1932	30	D,S	Gv	....	Wad.
36bbb	J. L. Asplund	32	38 x 38	Du	1914	20	D,S	Sd	....	..Do....
36ccc	W. Asplund	50	2	Dr	1910	20	D,S	Sd	....	..Do....
36ddd	A. Backman	50	2	Dr	1907	33	D,S	Lig	....	..Do....
143-80										
35daa1	City of Wilton #1	96	10	Dr	....	81	PS	Sd	....	C, Win, produces 18 gpm.
35daa2	City of Wilton #2	164	4	Dr	....	62	T	Sd	....	L.
36cbb1	City of Wilton #4	101	10	Dr	....	95	PS	Sd	....	Win, produces 14 gpm.
36cbb2	City of Wilton #3	104	4	Dr	....	64	T	Sd	....	L.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
144-75										
4ccc	A. Dockter	40	36	Du	1922	25.04	D,S	Sd & Gv	....	SC-2,470, Wad, Wh.
6ccc1	O. Biech	220	2	Dr	1952	......	D,S	Sd	....	SC-1,890, Wad, Ws.
6ccc2	..do....	40	24	Dr	....	20	S	Sd	....	Wad.
7cbc	T. Hertz	350	3	Dr	1956	......	D,S	Sd	....	SC-2,300, Wad.
8cbb	State Bank of N. Dak.	160	3	Dr	....	30	D,S	..	....	Wad.
8dbb	Federal Land Bank	64	24	Dr	....	62	D	..	....	Win.
10ada	L. Schaeffer	140	2	Dr	....	......	D,S	..	....	Wad, Ws.
10baa	J. Sutter	40	24	Dr	....	20	D,S	..	....	Wad.
15aaa	USGS Test hole 1993	112	5	Dr	6-27-62	......	T	..	2,016	BR-110, L.
20aa	A. Wilkinson	120	2	Dr	1914	......	D,S	Ss	....	Wad.
20dcd	D. Glanville	130	3	Dr	....	85	D,S	Sd	....	SC-120, Wad.
22ddd	State Bank of N. Dak.	132	2	Dr	1926	......	D,S	..	....	Wad.
23ccd	H. Albers	156	2.5	Dr	1914	......	DDS	..	....	..Do....
24bbc	R. Papke	270	4	Dr	1957	100	D,S	Sd	....	SC-2,360, Wad.
28dd	S. McIntyre	160	4	Dr	1930	60	D,S	..	....	Wad.
32cbb	A. Vollmer	300	2	Dr	1952	60	D,S	Sd	....	C, SC-2,680, Wad.
34dbc	E. Pond	20	36	Du	1933	18	D,S	Clay	....	Wad.
35cbc	J. Miller	42	3	Dr	1962	10	D,S	Gv	....	C, Wad.
35da	..do....	185	2	Dr	1961	40	S	Sd	....	Wad, Wh.
144-76										
6aad	J. Witt	10	48	Du	1936	6	D,S	Gv	....	Wad.
7dad	USGS Test hole 2052	150	5	Dr	8-1-62	......	T	Gv	1,929	BR 135, L.
8dd	H. Steve	27	24	Dr	1938	23	D,S	Sd	....	Win.
9caa	H. Crimmins	128	2	Dr	1956	30	S	Lig	....	Ws.
9ccc	J. Fitzgerald	10	36	Du	1908	8	D,S	Sd	....	Win.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
144-76	(Cont.)									
10cdd	E. Glannville	24	48	Du	1918	22	D,S	Gv	....	Wad.
12bbb	USGS Test hole 2044	180	5	Dr	7-31-62	......	T	Gv	1,950	BR-165, L.
12ccc	R. Rauscher	160	2	Dr	1954	50	D,S	Gv	....	Wad, Wh.
14dcc	E. Heinrich	120	3	Dr	1961	15	D,S	Sd	....	SC-1,380, Wad.
18daa	J. Bernhardt	31	48	Du	1934	23	D,S	Gv	....	C, Wad, Wh.
19dbb	H. Crimmins	131	4	Dr	1962	15	S	Gv	....	Wad, Wh.
19dd	..do....	3	30	Du	1936	Flow	S	Gv	....	Spring.
20bbc	J. Bernhardt	45	2	Dr	....	......	N	Gv	....	Wh.
21dd	C. Kindred	196	6	Dr	1926	146	D,S	Gv	....	Wad.
22ccd	E. Sellinger	208	2.5	Dr	1936	48	S	Sd	....	Wad, Ws.
23bcc	E. Heinrich	120	3	Dr	1961	15	S	Sd	....	Wad.
24daa	J. Tees	200	3	Dr	1918	60	D,S	Gv	....	..Do....
26aa	F. Smith	180	2	Dr	1909	140	S	..	....	..Do....
27bba	E. Sellinger	209	2	Dr	1959	40	D,S	Sd	....	Wad, Ws.
29aaa	USGS Test hole 1992	75	5	Dr	6-27-62	......	T	Sd	1,968	BR-67, L.
30aaa	V. Bailey	35	6	Dr	1932	7	D,S	Sd	....	Wad.
30bbc	C. Johnson	37	36	Du	1907	31	D,S	Sd	....	..Do....
30dcc1	H. Crimmins	133	4	Dr	1956	40	D,S	Gv	....	..Do....
30dcc2	..do....	120	2	Dr	1950	60	S	Gv	....	..Do....
31bcd	USBR drill hole 36	25	3	Dr	1960	21.8	T	Sd	1,936.9	L.
31dbb	USBR drill hole 37	35	3	Dr	1960	7.0	T,O	Sd	1,932.3	..Do....
32add	H. Bailey	70	4	Dr	1908	66	D,S	Clay	....	Wad.
35ccb	J. Scallon	200	3	Dr	1918	150	D,S	Ss	....	..Do....
144-77										
1caa	H. Crimmins	133	4	Dr	1961	40	S	Sd	....	Wad, Wh.
2ddd	A. Bender	22	36	Du	1934	20	S	Gv	....	Win.
3dbd	Unknown	22.48	48	Du	....	1.26	S	Gv	....	Wad.
4bcc	G. Migrin	14	36	Du	1910	6	D,S	Sd & Gv	....	..Do....
4cdc	J. Streh	16	36	Du	1926	13	D,S	Gv	....	..Do....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
144-77 (Cont.)										
7aaa	C. Kvasnicka	35	36	Du	1927	27	S	Sd & Gv	....	Wad.
8aaa	T. Roubal	300	2	Dr	1948	48	D,S	Sd	....	Wad, Ws.
8aab	USGS Auger hole 23	112	3	Dr	10-23-62	87	T	Sd	....	BR-32, L.
8bbc	R. Rasmussen	385	2	Dr	1940	40	D,S	Ss	....	Wad, Ws.
9caa	T. Roubal	300	2	Dr	1948	35	S	Sd	....	..Do....
12cbb	C. Knudson	197	4	Dr	1930	60	D,S	Sd & Gv	....	Wad.
15acc	R. Celley	215	4	Dr	1962	10	S	Lig & Sd	....	..Do....
15ddc	..do....	217	2.5	Dr	1957	70	S	Sd	....	Wad, Ws.
17caa	A. J. Braun	135	2	Dr	1950	30	S	Sd	....	..Do....
17dd	Halvorson Bros.	65	4	Dr	1960	40	S	Sd	....	Wad, Wh.
18daa	USGS Test hole 1988	60	5	Dr	6-26-62	......	T	Sd	1,408.1	BR-42, L.
18dd	B. Danielson	65	24	Dr	1910	38	D,S	Gv	....	Win.
19aab	Halvorson Bros.	40	4	Dr	1952	9	D,S	Gv	....	Wad, Wh.
20bca	E. Sohuh	60	30	Dr	1923	35	N	Gv	....	....
21acc	R. Celley	207	4.5	Dr	1961	5	S	Sd	....	Wad.
23aab	A. Novy	200	2	Dr	1919	150	D,S	Sd	....	..Do....
23bad	J. Novy	70	4	Dr	1924	50	D,S	Gv	....	..Do....
23cac	USGS Test hole 2043	180	5	Dr	8-1-62	......	T	Gv	1,930	BR-149, L.
23ccc	A. Nycia	220	2	Dr	1961	74	S	Sd	....	Wad.
24baa	R. J. Marchant	74	4	Dr	1932	35	D,S	Gv	....	..Do....
26ddd	E. Nolan	90	2	Dr	1913	60	D,S	Sd & Gv	....	..Do....
27ada1	R. Celley	56	4.5	Dr	1962	9	D,S	Gv	....	C, Wad, Wh.
27ada2	..do....	270	2.5	Dr	1952	65	D	Sd	....	C, Wad, Ws.
27bbb	..do....	200	4.5	Dr	1962	80	S	Sd	....	Wad, Ws.
27bdd	..do....	45	2.5	Dr	....	9	S	Sd	....	Win.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
144-77 (Cont.)										
28ccc	K. Celley	62	2.5	Dr	....	2	S	Gv	....	Wad.
28ddd	W. W. Spery	64.05	3	Dr	....	34.97	N	Gv	....	....
30bab	M. R. Rasmussen	165	3	Dr	1955	20	D,S	Sd	....	Wad.
32cc	I. Munson	50	24	Dr	1918	42	N	Gv	....	....
34ccc	E. Novy	60	6	Dr	1928	40	D,S	Gv	....	Wad.
36acb	USBR drill hole 35	35	3	Dr	1960	10.9	T	Sd	1,935.5	L.
36bac	USBR drill hole 34	30	3	Dr	1960	14.7	T	Gv	1,939.5	..Do....
36bb	W. M. Ryan	31	44	Du	1933	22	D,S	Sd	....	Wad.
36bbd	USBR drill hole 33	40	3	Dr	1960	10.6	T	..	1,940.8	L.
144-78										
2ddc	H. Schafer	40	48 x 48	Du	....	30	N	..	....	Wad.
3ccb	J. Anderson	12	48 x 48	Du	1933	11	D,S	..	....	..Do....
3cdd	USGS Test hole 1987	40	5	Dr	6-25-62	......	T	Sd	1,879.2	BR-24, L.
8baa	B. Schutz	180	3	Dr	1959	63	D,S	Sd	....	Wad, Wal, Ws.
10bbb	J. L. Anderson	15	48 x 48	Du	1954	13	D,S	Gv	....	C, Wad, Wh.
12bcc	E. T. Schafer	48.16	24	Dr	....	9.52	N	Gv	....	....
12dcb	G. Zellmer	140	4	Dr	....	120	D,S	..	....	Wad.
14ccc	USBR drill hole 28	25	3	Dr	1960	22.4	T	Gv	1,864.6	L.
14cdc	USBR drill hole 29	30	3	Dr	1960	10	T	Silt	1,855.6	..Do....
15cc	W. Steinart	200	3	Dr	1962	45	S	Sd	....	Wad, Ws.
15ddd	USBR drill hole 27 A	25	3	Dr	1960	16.6	T	Gv	1,864.6	L.
18ddd	A. Delzer	210	3	Dr	1954	35	D,S	Sd	....	Wad, Ws.
21aaa	USGS Auger hole 24	80	3	Dr	10-23-62	......	T	..	1,910	BR-72, L.
21aad	P. Zellmer	117	4	Dr	....	110	D,S	..	....	Wad.
22abb	F. Berquist	100	4	Dr	1920	90	...	..	....	..Do....

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
144-78 (Cont.)										
22cbc	W. Steinart	150	3	Dr	1956	......	D,S	..	....	Wad, Ws.
22dda	R. Patzner	92	6	Dr	1922	70	D,S	Sd	....	Wad.
23aa	USBR drill hole 31	30	3	Dr	1960	8.9	T	Silt	1,862.0	L.
23abb	USBR drill hole 30	40	3	Dr	1960	7.5	T	Sd	1,855.6	..Do....
26cdc	USGS Test hole 1989	30	5	Dr	6-26-62	......	T	Gv	1,844.2	BR-26, L.
27ccc	C. Berndt	13	48 x 48	Du	....	4	D,S	Gv	....	Wad, Wh.
28aad	C. Anderson	90	4	Dr	....	50	D,S	..	....	Wad.
32bcb	J. C. Olson	72	18	Dr	1909	58	D,S	Clay	....	Win.
32daa	J. Gehring	85	6	Dv	....	80	D,S	..	....	Wad.
33aaa	C. Berndt	160	4	Dr	1960	20	S	Sd	....	..Do....
144-79										
1ccb	USGS Test hole 2051	60	5	Dr	8-1-62	......	T	Sd	1,821.5	BR-35, L.
2ccb	D. Stelter	20	24	Dr	....	15	D,S	Sd	....	Wad, Wal, Wh.
8abb	A. E. Nelson	90	24	Dr	1901	80	S	Gv	....	Wad.
8bbc	R. Hansen	90	3	Dr	1955	25	D,S	Sd	....	Wad, Wh.
10ddb	C. Stelter	184	3	Dr	1961	15	D,S	Ss	....	Wad, Ws.
12dad	F. Bender, Jr.	135	4	Dr	1924	......	D,S	Sd	....	Wad, Wal, Ws.
14dd	K. Prockop	20	48 x 48	Du	....	15	S	Gv	....	Wad.
18cbc1	E. Wagner	325	2	Dr	1947	185	D,S	Sd	....	Wad, Ws.
18cbc2	..do....	130	24	Dr	1902	125	S	Sd	....	Win.
20bba1	H. E. Redington	65	24	Dr	1937	57	S	Sd	....	Wad.
20bba2	..do....	180	2	Dr	1920	100	S	..	....	..Do....
23bab	V. Bucholz	290	3	Dr	1935	......	D,S	Sd	....	Wad, Ws.
24aba	W. Stebert	275	3	Dr	1960	50	D,S	Sd	....	C, Wad, Ws.
24bb	J. Schaffer	25	24 x 24	Du	....	20	S	..	....	Wad.
24cdc	E. Hochhalter	28	24	Dr	1915	18	S	Gv	....	Wad, Wh.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
144-79 (Cont.)										
25bcc	USGS Test hole 1986	75	5	Dr	6-25-62	......	T	Gv	1,830.8	BR-66, L.
25dd	P. E. Mattis	20	48 x 48	Du	....	15	S	Sd & Gv	....	Wad.
26cdd	Unknown	30.07	24	Dr	....	16.16	N	..	....	....
27dd	F. Lange	104	24	Dr	1903	92	D	Gv	....	Wad.
29ccb	USGS Test hole 2050	30	5	Dr	8-1-62	......	T	..	1,801	BR-20, L.
30ada	Hryzckow Bros	250	3	Dr	1959	120	D,S	Sd	....	Wad, Ws.
30bcc	N. Hall	227	3	Dr	1960	65	D,S	Ss	....	....
32cda	J. Kassian	20	24	Dr	1928	12	...	Sd	....	Wad.
32daa	M. Oschanyk	25	24	Dr	1918	18	S	Sd	....	..Do....
33bba	J. Hruby	150	4	Dr	....	......	...	Gv	....	..Do....
33ddd	P. Hruby	80	4	Dr	1926	70	S	Sd	....	..Do....
34aba	P. Duma	203	3	Dr	1957	53	D,S	Sd	....	Wad, Ws.
34cdd	P. Hruby	275	3	Dr	1959	......	D,S	Sd	....	..Do....

TABLE 2.--Logs of test holes

137-75-8dda
Test hole 1829

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black, sandy	5	5
	Till, yellowish-brown, oxidized	11	16
	Till, dark-gray, calcareous	27	43
	Clay, dark-gray	15	58
	Sand, dark-gray, fine to medium	3	61
	Gravel, medium; sand, very coarse	2	63
	Till, gray, silty to sandy, lignite fragments	10	73
	Till, olive-gray, silty, lignite smears	51	124
Fox Hills Sandstone:			
	Sandstone, greenish-gray, fine-to-medium-grained, clayey, well sorted, glauconitic, limonite streaks	28	152
Pierre Shale:			
	Shale, dark-gray, compact	5	157

137-75-17bbb
Test hole 1828

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Roadfill, clay and sand, brown	5	5
	Sand, black, clayey, humus	5	10
	Clay, brownish-gray, silty	11	21
	Clay, medium-gray, lignite chips	21	42
	Clay, medium to dark-gray	62	104
	Gravel, medium; sand, very coarse	16	120
	Clay, dark-gray, silty	27	147
	Gravel, coarse; sand, very coarse	5	152

TABLE 2.--Logs of test holes -- Continued

137-75-17bbb, Continued
Test hole 1828

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Sand, gray, fine to medium lignite, fragments	16	168
Fox Hills Sandstone:			
	Sandstone, greenish-gray, very fine grained, well-sorted, rounded, very glauconitic; siltstone, dark-gray, minor constituent, interbedded	10	178
Pierre Shale:			
	Shale, dark-gray, compact	11	189

137-75-31aab
Test hole 2048

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, very fine to medium, silty, unsorted, oxidized	4	4
	Clay, moderate-yellowish-brown, silty, cohesive, calcareous, oxidized	8	12
	Silt, dark-greenish-gray, clayey, cohesive, mica and lignite flecks, calcareous	18	30
Fox Hills Sandstone:			
	Silt, greenish-gray, indurated, sparse lignite fragments	15	45

TABLE 2.--Logs of test holes -- Continued

137-76-2bbb
Test hole 2031

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil	1	1
	Clay, moderate-yellowish-brown, silty to sandy, shale pebbles, calcareous, oxidized	32	33
	Clay, grayish-orange, silty, cohesive, calcareous, oxidized	10	43
	Clay, dark-greenish-gray, very silty, cohesive, calcareous	20	63
	Silt, dark-greenish-gray; sand, very fine to fine; highly-calcareous	19	82
	Clay, dark-greenish-gray, very silty, cohesive, highly calcareous	12	94
	Silt, dark-greenish-gray; sand, very fine, highly calcareous	32	126
	Clay, dark-greenish-gray, very silty, cohesive, highly-calcareous	8	134
	Gravel, fine, sandy, subrounded, unsorted	7	141
Fox Hills Sandstone:			
	Sand, very fine to fine, clayey, abundant glauconite grains	24	165

137-76-8cdd
Glen Adams test hole 3
Log by Schnell, Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Sand	5	7
Brown clay	18	25

137-76-8cdd, Continued
Glen Adams test hole 3
Log by Schnell, Inc.

Material	Thickness (feet)	Depth (feet)
Blue clay	78	103
Sand	25	128
Sandy clay	15	143
Sand	15	158
Gravel	51	209
Large gravel	3	212
Clay	3	215

137-76-9bbc
Test hole 1825

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, brown, silty to sandy	5	5
	Clay, yellowish-brown, hard	16	21
	Clay, yellowish-brown, soft	73	110
	Sand, fine to medium; gravel, medium to coarse; unsorted, angular to rounded	16	126
Fox Hills Sandstone:			
	Shale, medium-gray, silty	31	157
	Sandstone, grayish-green, fine-grained, very glauconitic	11	168
	Shale, grayish-green, soft, sandy, scattered yellowish-brown shale stringers	42	210
	Shale, grayish-brown to green, sandy; sandstone, greenish-gray fine-grained, glauconitic	21	231

TABLE 2.--Logs of test holes -- Continued

137-76-9bbc, Continued
Test hole 1825

Formation	Material	Thickness (feet)	Depth (feet)
Pierre Shale:			
	Shale, gray, sandy	21	252

137-76-12ddd
Test hole 1827

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, brown, fine to medium, well-rounded, sorted	10	10
	Sand, brown to gray, fine to coarse, well-rounded, poorly-sorted	11	21
	Sand, brown, fine to medium well-rounded, well-sorted	5	26
	Clay, medium-gray, silty	5	31
	Clay, medium to dark-gray, cohesive	16	47
Fox Hills Sandstone:			
	Sandstone, greenish-gray, very fine to fine, well-sorted, well-rounded, glauconitic	26	73

137-76-17aaa
Test hole 1826

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, yellowish-brown	15	15
	Clay, gray, smooth	70	94

TABLE 2.--Logs of test holes -- Continued

137-76-17aaa, Continued
Test hole 1826

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Clay, gray, sandy	6	100
	Sand, greenish-gray, very fine to fine	5	105
	Sand, fine to very coarse	21	126
	Sand, fine to medium, shaley	5	131
	Clay, gray, silty	5	136
	Gravel, medium to coarse; sand, fine to coarse; poorly-sorted, lignite fragments	32	168
	Sand, medium to very coarse, gravelly	5	173

137-76-18ccd
Test hole 2047

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, yellowish-brown, sandy, silty, oxidized	5	5
Hell Creek Formation:			
	Clay, dusky-yellow, silty, streaks of leached material, oxidized	4	9
	Clay, moderate-olive-brown, silty, slightly-sandy, oxidized	8	17
	Clay, medium-bluish-gray, silty; sand, fine to medium; carbonaceous layers	19	36
	Sand, medium-bluish-gray, silty, abundant lignite fragments	8	44

TABLE 2.--Logs of test holes -- Continued

137-76-18ccd, Continued
Test hole 2047

Formation	Material	Thickness (feet)	Depth (feet)
Hell Creek Formation-Continued:			
	Clay, brownish-gray, silty, lignite smears; sand, bluish-green, fine	10	54
	Clay, medium-bluish-gray, silty, with green sand and lignite fragments	3	57
	Shale, olive-gray, very carbonaceous	1	58
	Clay, medium-bluish-gray, some sands and lignite fragments	6	64
	Sand, bluish-green, carbonaceous streaks, sandstone from 66-77 feet	6	70
	Shale, olive-gray to brown	4	74
	Clay, medium-bluish-gray, green to gray specks and lignite	2	76
	Shale, dusky-brown, carbonaceous	4	80
	Shale, olive-black, silty, abundant black carbonaceous plant and other material	1	81
	Shale, brownish-black, silty, carbonaceous, compact	1/2	81 1/2
	Shale, olive-black, silty, carbonaceous, lignitic layers, marcasite common	4 1/2	86
	Shale, olive-black, carbonaceous, lignitic layers, becoming sandy, very fine; scattered celenite crystals	1 1/2	87 1/2
	Siltstone, light-gray, clayey	2 1/2	90
	Siltstone, medium-dark-gray, clayey, massive, compact	3/4	90 3/4
	Siltstone, medium-gray, clayey, compact, massive, thinly-bedded	2	92 3/4
	Siltstone, medium-gray, clayey, thin layers of sandstone, friable	1/2	93 1/4

TABLE 2.--Logs of test holes -- Continued

137-76-18ccd, Continued
Test hole 2047

Formation	Material	Thickness (feet)	Depth (feet)
Fox Hills Sandstone:			
	Sandstone, medium-gray, with interbedded siltstone, friable----	3/4	94
	Sandstone, medium-bluish-gray, very fine to fine, friable, numerous rounded green grains, glauconitic-----------------------	1	95
	Sandstone, medium-bluish-gray, friable, glauconitic, indurated------	2 1/2	97 1/2
	Sandstone, dark-greenish-gray, very glauconitic, friable--------------	7 1/2	105
	Shale, light-olive-gray, compact, platy---------------------------	1 3/4	106 3/4
	Shale, dark-greenish-gray, silty, compact, sand, very fine---------	1 1/4	108
	Sandstone, medium-bluish-gray, very fine to fine, rounded, silty, glauconitic, friable--------------	7	115

137-76-21bbc
Test hole 1824

Formation	Material	Thickness (feet)	Depth (feet)
Fox Hills Sandstone:			
	Sandstone, yellowish-brown, fine-grained, oxidized----------------	10	10
	Clay, yellowish-brown, oxidized-----	6	16
	Clay, yellowish-brown; shale, medium-gray, silty; oxidized---------	10	26
	Shale, medium-gray, soft------------	21	47
	Sandstone, light-gray, fine-grained; shale, gray--------------	16	63
	Shale, gray, soft, silty to sandy-----------------------------	37	100
	Shale, medium-gray, soft------------	5	105

TABLE 2.--Logs of test holes -- Continued

137-76-21bbc, Continued
Test hole 1824

Formation	Material	Thickness (feet)	Depth (feet)
Fox Hills Sandstone- Continued:			
	Shale, medium-gray, silty	26	131
	Shale, medium-gray, soft	42	173
	Clay, gray; sand, gray, fine	16	189
	Sand, light-greenish-gray, fine, clayey, glauconitic	5	194
	Clay, light-gray, sandy, bentonitic	11	205
	Clay, light-gray, bentonitic, shale, gray, interbedded	5	210
	Sand, very fine to fine, rounded, glauconitic; clay, gray, soft (drillers lost circulation at 220')	21	231
	Clay, greenish-gray, soft, sandy	21	252
	Sand, gray, fine, subrounded, shaley	11	263
Pierre Shale:			
	Clay, gray, soft	10	273
	Shale, gray, soft	42	315

137-76-35aaa
Test hole 1937

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil	1	1
	Clay, yellowish-gray, very sandy, silty	4	5
	Clay, medium-gray, silty to sandy	36	41
	Clay, medium-gray, silty; sand, coarse, snail shells; interbedded	22	63

137-76-35aaa, Continued
Test hole 1937

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Clay, olive-gray, silty	41	104
	Gravel, fine to medium	3	107
Fox Hills Sandstone:			
	Sandstone, greenish-gray, indurated, very fine to fine-grained, very glauconitic; shale, medium-gray, silty; interbedded	19	126

137-76-36abb
Test hole 1938

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, light-olive-gray, very sandy, silty	10	10
	Clay, dark-greenish-gray, silty	10	20
	Sand, medium to coarse	2	22
	Clay, dark-greenish-gray, silty, abundant snail shells	23	45
	Gravel, fine to medium	2	47
	Clay, olive-gray; silt, olive-gray	44	91
	Sand, gray, fine	2	93
	Silt, olive-gray, clayey	7	100
	Gravel, fine to medium; sand, coarse to very coarse, abundant shale pebbles	3	103
	Clay, olive-gray, silty, gravelly	12	115
	Gravel, fine to medium; sand, coarse to very coarse; abundant shale	9	124
	Sand, coarse to very coarse, abundant shale pebbles, well-rounded	24	148

TABLE 2.--Logs of test holes -- Continued

137-76-36abb, Continued
Test hole 1938

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Sand, coarse to very coarse, abundant shale pebbles; clay, olive-gray, silty and sandy; lignite fragments; interbedded-----	31	179
Pierre Shale:			
	Shale, medium-dark-gray, silty-------	20	199

137-77-8ddd
Test hole 1830

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, brown, sandy-----------------	2	2
	Till, yellowish-brown, sandy, oxidized, abundant shale pebbles-------	19	21
	Till, medium-gray, silty to sandy-----	10	31
	Sand, greenish-gray to medium-green, abundant dark-green minerals--------	28	59
Hell Creek Formation:			
	Shale, brown, lignitic; sandstone, greenish-gray, friable--------------	4	63
	Shale, greenish-gray, compact, silty; sandstone, medium-gray, very fine grained, friable-------------------	21	84
	Sandstone, greenish-gray, fine to medium, friable---------------------	26	110
	Shale, brownish-black, lignitic-------	11	121
	Shale, medium-gray, compact-----------	5	126
	Shale, light-greenish-gray, silty, glauconitic (?)--------------------	5	131

137-77-8ddd, Continued
Test hole 1830

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Shale, greenish-gray, lignitic; sandstone, greenish-gray, fine to medium-grained, glauconitic (?)-----	10	141
	Shale, brownish-gray, lignitic--------	11	152
	Shale, medium-gray, silty, compact----	5	157
	Sandstone, dark-greenish-gray, fine-grained, clayey, friable, glauconitic (?)------------------------	6	163
	Lignite; shale, brownish-black; interbedded--------------------------	6	169
	Shale, brownish-gray, lignitic-------	4	173
Fox Hills Sandstone:			
	Shale, greenish-gray, lignitic (?); sandstone, greenish-gray, friable; interbedded------------------------	37	210
	Siltstone, greenish-gray; shale, medium-gray---------------------------	10	220
	Siltstone, greenish-gray; shale, medium-gray; sandstone, medium-gray, very fine-grained-------------------	16	236
	Sandstone, light-greenish-gray, fine to medium-grained, glauconitic------	27	263
	Sandstone, light-greenish-gray, fine to medium, glauconitic; shale, light-greenish-gray, silty----------	10	273
	Shale, light-greenish-gray; siltstone, medium-gray------------------------	5	278
	Shale, light-greenish-gray------------	21	299
	Sandstone, dark-greenish-gray, fine to medium-grained, clayey, friable, glauconitic-------------------------	79	378
	Sandstone, dark-green, abundant glauconite grains, friable; shale, medium-gray; interbedded---------------	21	399
	Sandstone, dark-greenish-gray, fine to medium-grained, friable, abundant glauconite grains--------------	37	436

137-77-8ddd, Continued
Test hole 1830

Formation	Material	Thickness (feet)	Depth (feet)
Fox Hills Sandstone-Continued:			
	Sandstone, very-dark-green, fine to medium-grained, friable, very glauconitic-----------------------	9	445
Pierre Shale:			
	Shale, dark-gray to black-----------	48	493

137-77-14ddd
Test hole 1936

Formation	Material	Thickness (feet)	Depth (feet)
Colluvium:			
	Clay, light-olive-gray, silty to very sandy, oxidized--------------	7	7
Hell Creek Formation:			
	Claystone, light-olive-brown, silty and sandy, soft, oxidized---------	8	15
	Claystone, brownish-gray, lignitic, soft------------------------------	6	21
	Claystone, grayish-olive, lignitic, soft------------------------------	9	30
	Sandstone, grayish-olive, very fine to fine-grained, silty and clayey, abundant glauconite grains---------	22	52
	Claystone, dark-greenish-gray, silty, soft; sandstone, brownish-gray, friable, silty and clayey----------	6	58
	Sandstone, mediu-bluish-gray, very fine to fine-grained, friable, silty, mica flakes------------------------	9	67
	Sandstone, medium-bluish-gray, very fine-grained, friable, silty-------	7	74

TABLE 2.--Logs of test holes -- Continued

137-77-14ddd, Continued
Test hole 1936

Formation	Material	Thickness (feet)	Depth (feet)
Hell Creek Formation-Continued:			
	Claystone, brownish-gray, very fine, soft, silty and sandy	5	79
	Sandstone, medium-bluish-gray, very fine to fine-grained, friable, silty	4	83
	Claystone, olive-gray, soft, silty	7	90
	Sandstone, dark-greenish-gray, very fine to fine-grained, silty, abundant glauconite grains	10	100
	Claystone, brownish-gray, silty, carbonaceous	10	110
Fox Hills Sandstone:			
	Sandstone, dark-greenish-gray, friable, very fine to fine-grained, glauconitic	11	121
	Claystone, greenish-gray, silty	5	126
	Sandstone, dark-greenish-gray, indurated	1	127
	Sandstone, dark-greenish-gray, friable, indurated	20	147

137-78-8bcb
Test hole 2014

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, very fine to medium, silty, poorly-sorted, oxidized	5	5
	Sand, very fine to medium, silty, unsorted, abundant limestone, calcareous, oxidized	11	16
	Clay, dark-greenish-gray; sand, very fine to fine, lignite fragments	1	17

137-78-8bcb, Continued
Test hole 2014

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Silt, dark-greenish-gray, clayey to sandy, cohesive, lignite fragments, mica flakes	13	30
	Sand, very fine to fine, poorly-sorted, abundant limestone grains, lignite fragments, mica flakes	17	47
	Silt, dark-greenish-gray, lignite fragments; sand, very fine to fine, poorly-sorted	15	62
	Sand, very fine to fine, poorly-sorted, abundant limestone, some lignite and mica	20	82
	Silt, dark-greenish-gray, lignite fragments; sand, very fine to fine, poorly-sorted	40	122
	Clay, olive-gray, silty, hard, lignite fragments	9	131
	Sand, very fine to very coarse, gravelly, subrounded to well-rounded, abundant limestone, lignite fragments; clay, olive-gray, silty, in thin layers throughout	85	216
Fox Hills Sandstone:			
	Clay, greenish-black, very sandy, abundant glauconite	24	240

137-78-17ccc
Test hole 2040

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil	2	2

TABLE 2.--Logs of test holes -- Continued

137-78-17ccc, Continued
Test hole 2040

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Sand, dark-yellowish-brown, very fine to medium; clay, cohesive; lignite fragments, highly-calcareous	13	15
	Sand, very fine to medium, fair sorting, angular to subangular, abundant lignite fragments	58	73
	Silt, light-olive-gray, clayey, cohesive, calcareous	29	102
	Clay, moderate-yellowish-brown, very sandy, oxidized, highly-calcareous	10	112
	Sand, dark-greenish-gray, clayey, unsorted, abundant lignite fragments, slightly-calcareous	57	169
Fox Hills Sandstone:			
	Clay, dark-greenish-gray, silty, indurated	11	180

137-78-22ccc
Test hole 2013

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, fine to medium, well-sorted, angular to subrounded, predominantly quartz, oxidized	8	8
	Clay, dark-yellowish-orange, mottled, silty, cohesive, highly-calcareous, partially-oxidized	18	26
	Clay, olive-gray, very silty, cohesive, calcareous, occassional oxidized area	19	45

TABLE 2.--Logs of test holes -- Continued

137-78-22ccc, Continued
Test hole 2013

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Clay, olive-gray, silty, very cohesive, calcareous-----------------	55	100
Fox Hills Sandstone:			
	Sandstone, dusky-yellow, fine-grained, silty, indurated, oxidized---------	2	102
	Sandstone, medium-bluish-gray, very fine to fine-grained, with black and green grains, some mica--------	3	105

137-78-33aba
Test hole 2039

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil-------------------------------	2	2
	Sand, very fine to medium, subangular to subrounded, lignite fragments, calcareous-------------------------	6	8
	Clay, olive-gray, silty, cohesive; sand, very fine to medium, abundant snail shells-----------------------	7	15
	Sand, very fine to medium, clayey, subangular to subrounded, lignite fragments--------------------------	5	20
	Clay, olive-gray, very silty, cohesive, calcareous-----------------	57	77
	Silt, dark-gray, sandy, abundant lignite fragments, calcareous------	7	84
	Clay, olive-gray, silty, cohesive, calcareous-------------------------	12	96
	Silt, olive-gray, sandy, lignite fragments, mica flakes, dry--------	9	105

137-78-33aba, Continued
Test hole 2039

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Clay, dark-greenish-gray, silty, cohesive, hard, slightly calcareous	27	132
	Gravel, fine, sandy, unsorted, subrounded, abundant limestone and lignite fragments	19	151
	Silt, dark-greenish-gray, sandy, slightly-calcareous	6	157
	Sand, dark-greenish-gray, very fine to fine, unsorted, abundant shale and lignite fragments, slightly-calcareous	32	189
	Silt, dark-greenish-gray, clayey, cohesive, calcareous	15	204
	Sand, very fine to very coarse, gravelly, subrounded to well-rounded, abundant limestone and lignite	16	220
Fox Hills Sandstone:			
	Sand, grayish-blue-green, very fine to fine, silty, predominantly quartz and green sand grains	20	240

137-79-26cbb
Test hole 2015

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Silt, dusky-yellow to moderate-olive-brown, very clayey, lignitic, calcareous, oxidized	10	10
	Silt, dark-greenish-gray, clayey, cohesive, lignite fragments	6	16

TABLE 2.--Logs of test holes -- Continued

137-79-26cbb, Continued
Test hole 2015

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Sand, very fine to medium, unsorted, silty, lignite fragments	14	30
	Sand, very fine to medium, unsorted, lignite fragments	20	50
	Gravel, fine, sandy to clayey, subrounded to well-rounded, abundant carbonates, lignite fragments	10	60
	Gravel, fine, sandy, abundant lignite, some snail shells and wood fragments	10	70
	Gravel, fine to medium, sandy, subrounded to well-rounded, abundant lignite and clay	30	100
Fox Hills Sandstone:			
	Clay, dark-greenish-gray, silty, cohesive; sand, very fine to fine	5	105

137-79-27dd
G. O'Callaghan, Jr. test hole
Log by Norman Stal

Material	Thickness (feet)	Depth (feet)
Silt loam topsoil	3	3
Yellow silt clay	5	8
Sand	5	13
Clay layer	3	16
Sand	12	28
Lignite and sand	2	30
Sand with lignite traces	12	42
Sand, medium to coarse	26	68
Sand, coarse, and fine gravel	12	80
Sand, coarse, with lignite	15	95

TABLE 2.--Logs of test holes -- Continued

137-80-3abb
Test hole 1852

Formation	Material	Thickness (feet)	Depth (feet)
Alluvium:			
	Roadfill, gravel, sand and clay	10	10
	Sand, medium-gray, very fine to fine, clayey	11	21
	Sand, dark-gray, fine to medium, rounded, lignite fragments	21	42
Hell Creek Formation:			
	Sandstone, greenish-gray, very fine to fine-grained; clay, greenish-gray, silty; interbedded	21	63
	Sandstone, light-greenish-gray, fine to medium-grained, glauconitic (?)	11	74
	Sandstone, greenish-gray, glauconitic (?); shale, brownish-gray, silty, lignitic	5	79
	Sandstone, greenish-gray, very fine to fine-grained, silty to clayey, glauconitic (?)	5	84

137-80-3dab
Test hole 1851

Formation	Material	Thickness (feet)	Depth (feet)
Alluvium:			
	Topsoil, medium-gray, sandy	5	5
	Clay, brown, silty	11	16
	Clay, medium-gray, silty	5	21
	Sand, medium-gray, very fine to fine, silty	10	31

137-80-3dab, Continued
Test hole 1851

Formation	Material	Thickness (feet)	Depth (feet)
Hell Creek Formation:			
	Sandstone, medium to greenish-gray, fine to medium-grained, friable----	26	57
	Shale, medium-gray, silty; sandstone, greenish-gray, fine-grained, friable, abundant dark grains----------------	6	63

137-80-24abc
Test hole 1949

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, pale-yellowish-brown, silty, cohesive, oxidized, calcareous------	11	11
	Clay, light-olive-gray, silty, very cohesive, lignitic, calcareous------	10	21
	Sand, very fine to coarse, unsorted, subrounded to rounded, abundant lignite fragments, scattered snail shells------------------------	60	81
	Gravel, fine to medium, sandy, unsorted, subangular to subrounded, lignite fragments-------------------	9	90
	Gravel, fine to coarse, sandy, subrounded to well-rounded, abundant brown pebbles, lignite fragments----	14	104
	Sand, medium to very coarse, gravelly, subrounded, lignite fragments, abundant brown grains----------------	11	115
Fox Hills Sandstone:			
	Clay, bluish-gray, silty--------------	11	126

TABLE 2.--Logs of test holes -- Continued

138-75-5ddd
Test hole 2046

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Till, moderate-olive-brown, oxidized	50	50
	Till, moderate-olive-brown, sandy, contains lignite smears, oxidized	16	66
	Till, light-olive-gray, sandy	27	93
	Till, medium-dark-gray	31	122
Hell Creek Formation:			
	Sand, grayish-green, fine to medium, clayey, with brown carbonaceous particles	14 1/2	136 1/2

138-75-8cdd
Test hole 2021

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Till, moderate-yellowish-brown, lignite fragments, oxidized, highly calcareous	55	55
	Till, dark-yellowish-orange, highly-oxidized	13	68
	Till, dark-greenish-gray, silty, lignite fragments, calcareous	23	91
	Till, olive-gray, silty, lignite fragments, calcareous	13	104

TABLE 2.--Logs of test holes -- Continued

138-75-8cdd, Continued
Test hole 2021

Formation	Material	Thickness (feet)	Depth (feet)
Hell Creek Formation:			
	Sandstone, dark-yellowish-orange, fine-grained, silty, oxidized	4	108
	Sandstone, yellowish-brown, partially-oxidized	6	114
	Sandstone, greenish-gray, abundant glauconite	6	120

138-75-9bcb
Auger hole 18

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, dusky-yellow	2	2
	Clay, moderate-olive-brown, silty, thinnly-bedded	8	10
	Till, olive-gray, oxidized	6	16

138-75-16bbb
Auger hole 17

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, brownish-gray, sandy to gravelly	2	2
	Clay, yellowish-gray, silty, very thinnly-bedded	10	12
	Clay, moderate-yellowish-brown silty, thinnly bedded	3	15
	Till, moderate-yellowish-brown, oxidized	7	22

TABLE 2.--Logs of test holes -- Continued

138-75-20aaa
Test hole 2025

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, light-olive-gray, cohesive, scattered carbonaceous particles----	20	20
	Till, olive-gray, scattered lignite fragments, abundant shale pebbles, oxidized----------------------------	88	108
	Till, medium-bluish-gray, abundant shale pebbles, thin interbedded gravel layers----------------------	25	137
	Gravel, fine to medium, abundant shale and limestone pebbles---------	8	145
	Till, medium-bluish-gray, abundant shale and limestone pebbles---------	28	173
Fox Hills Sandstone:			
	Sand, moderate-yellowish-brown, very fine to fine, silty to clayey, black carbonaceous particles, oxidized------------------------------	26 1/2	199 1/2

138-76-7add
Test hole 1942

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, dark-yellowish-brown, silty, cohesive, oxidized, calcareous------	6	6
	Clay, moderate-yellowish-brown, silty, cohesive, oxidized, calcareous------	11	17
	Clay, light-olive-gray, silty to sandy, cohesive, calcareous---------	20	37
	Gravel, fine to medium, sandy, unsorted, rounded, abundant shale pebbles and lignite fragments-------	11	48

TABLE 2.--Logs of test holes -- Continued

138-76-7add, Continued
Test hole 1942

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Clay, light-olive-gray, silty, cohesive, calcareous	2	50
	Gravel, fine to medium, unsorted, sandy, rounded, abundant shale and lignite	2	52
	Sand, fine to coarse, poorly-sorted, subrounded, abundant shale and lignite	22	74
	Sand, coarse to very coarse, poorly-sorted, angular, abundant shale and lignite grains	6	80
	Sand, greenish-gray, very fine to fine, lignitic in places	42	122
	Gravel, medium, well-sorted, subangular to well-rounded	5	127
Hell Creek Formation:			
	Sandstone, medium-bluish-gray to greenish-gray, fine to medium, oxidized, lignite specks; shale, moderate-yellowish-brown, silty	20	147

138-76-8abb
U.S.B.R. drill hole 27

Material	Thickness (feet)	Depth (feet
Topsoil, black, organic sandy clay	1.5	1.
Clay, brown, plastic, stiff, moist (Lacustrine?)	24.5	26
Clay, gray, plastic, soft, moist, (Lacustrine?)	6	32
Sand, gray, fine, with fine to medium gravels, dense	8	40

TABLE 2.--Logs of test holes -- Continued

138-76-8bab
U.S.B.R. drill hole 26

Material	Thickness (feet)	Depth (feet)
Topsoil, black, organic, sandy clay	2	2
Clay, brown, plastic, soft	14	16
Clay, gray, plastic, soft	12	28
Sand and gravel, fairly well graded sand, silty, clayey lenses, with fine to medium gravels	7	35

138-76-19abb
Auger hole 11

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, dusky-yellowish-brown	2	2
	Sand, moderate-brown, fine to medium	7	9
	Clay, moderate-yellowish-brown, plastic	14	23
	Clay, moderate-yellowish-brown, silty, plastic	7	30
	Clay, light-olive-gray, silty, plastic	20	50
	Sand, fine to medium	2	52
	Clay, light-olive-gray, plastic, cohesive	9	61
	Sand, fine to medium	3	64
	Clay, light-olive-gray, sandy	31	95
	Gravel, fine to medium; sand, coarse	6	101
	Clay, light-olive-gray, plastic	6	107

138-76-19a
Clyde Monroe test hole 1
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Sand	4	6
Brown clay (caving)	18	24
Blue clay	19	43
Fine gravel	10	53
Clay	5	58
Coarse gravel	11	69
Clay	1	70

Remarks: Water samples taken at 63 feet.

138-76-19b
Clyde Monroe test hole 2
Log by Schnell, Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	4	4
Brown clay	24	28
Blue clay	48	76
Sand	2	78
Clay, gray	22	100

138-77-20aaa
Test hole 1867

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, yellowish-brown, very fine to fine, very clayey, oxidized	11	11
	Clay, yellowish-brown, silty	4	15
	Clay, light-brownish-gray, silty	6	21

138-76-20aaa, Continued
Test hole 1867

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Clay, medium-gray, silty, lignite fragments	31	52
	Clay, light-brownish-gray, silty	11	63
	Clay, light-brownish-gray, silty, lignite fragments	41	104
	Gravel, medium; sand, very coarse	6	110
	Clay, light-brownish-gray, silty	40	150
	Gravel, medium; sand, very coarse	1	151
	Clay, light-brownish-gray, silty	20	171
Fox Hills Sandstone:			
	Shale, medium-gray, silty, carbonaceous streaks	18	189
	Shale, medium-gray, silty; sandstone, dark-greenish-gray, very fine to fine-grained, friable, glauconitic	42	231

138-76-20bbb
Auger hole 12

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, moderate-yellowish-brown; sand, fine to coarse; oxidized	10	10
	Clay, moderate-yellowish-brown, plastic, silty, oxidized	8	18
	Gravel, fine to coarse	4	22
	Sand, fine to coarse	39	61
	Clay, light-olive-gray; sand, fine to medium	10	71
	Gravel, medium	12	83
	Clay, light-olive-gray, sandy	4	87

TABLE 2.--Logs of test holes -- Continued

138-76-26aaa
Test hole 2032

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	1	1
	Till, dark-yellowish-orange, abundant limestone and shale pebbles, lignite fragments, calcareous, oxidized	17	18
	Gravel, fine to coarse, sandy, unsorted, subangular to subrounded, abundant limestone pebbles	8	26
	Clay, dark-greenish-gray, silty, cohesive, calcareous	8	34
	Till, dark-greenish-gray, lignite fragments, calcareous	36	70
Fox Hills Sandstone:			
	Sandstone, dark-yellowish-orange, fine to very fine-grained, clayey, oxidized	4	74
	Sandstone, medium-bluish-gray, fine to very fine-grained, with clay and lignite	16	90

138-76-31aab
Test hole 2029

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Roadfill	5	5
	Clay, light-olive-gray, silty, highly-calcareous, oxidized	12	17
	Clay, dark-gray, very silty, cohesive, lignite fragments	10	27
	Silt, medium-bluish-gray, cohesive, abundant lignite chips, few fossils, highly-calcareous	8	35

138-76-31aab, Continued
Test hole 2029

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Silt, moderate-olive-brown, hard, fossil fragments, calcareous, oxidized	7	42
	Silt, light-olive-gray, cohesive, lignite flecks, calcareous, oxidized	20	62
	Silt, olive-gray, occassional greenish-black areas, cohesive, tiny lignite flecks	72	134
	Sand, very fine to coarse, clayey to gravelly, unsorted, subangular, lignite fragments	24	158
	Gravel, medium to very coarse; boulders; angular to subrounded	8	164
Fox Hills Sandstone:			
	Clay, dark-greenish-gray, silty, indurated, mica flecks	16	180

138-76-33bbb
Test hole 2022

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil	1 1/2	1 1/2
	Silt, moderate-yellowish-brown, clayey, cohesive, abundant lignite flecks, oxidized, highly-calcareous	9 1/2	11
	Silt, light-olive-gray, very clayey, cohesive, lignite flecks, calcareous	20	31
	Silt, dark-greenish-gray, cohesive, very calcareous	59	90

TABLE 2.--Logs of test holes -- Continued

138-76-33bbb, Continued
Test hole 2022

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Gravel, fine, sandy, unsorted, angular to rounded, abundant shale-----	21	111
Fox Hills Sandstone:			
	Sand, dusky-yellow-green, fine to very fine, silty, some black and green grains-----------------------	3	114
	Sand, olive-black, fine to very fine, abundant lignite, some mica flakes----------------------------	3	117
	Clay, dark-greenish-gray, silty, mica and lignite flakes-----------------	3	120

138-76-36aaa
Auger hole 16

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, brown-----------------------	1	1
	Till, moderate-yellowish-brown, oxidized------------------------------	23	24
	Till, olive-gray, sandy---------------	52	76
	Sand, olive-gray, fine to medium, saturated, poorly-sorted, abundant shale-----------------------------	13	89
	Sand, olive-gray, very poorly sorted, very coarse to medium, gravelly-----	23	112

TABLE 2.--Logs of test holes -- Continued

138-77-2abb, Continued
Auger hole 7

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, yellowish-brown	2	2
	Till, light-brown, shale pebbles, oxidized	3	5
	Sand, light-brown, fine to medium, oxidized	1	6
	Clay, moderate-yellowish-brown, with gray streaks, plastic, a few scattered lignite smears, oxidized	12	18
	Clay, moderate-yellowish-brown, silty	10	28
	Gravel, fine to medium	1	29
	Till, moderate-yellowish-brown, sandy	10	38
	Sand, moderate-yellowish-brown, fine to medium	4	42
	Clay, moderate-yellowish-brown	4	46
	Sand, moderate-yellowish-brown, fine to medium, clayey	19	65
Hell Creek Formation:			
	Clay, dark-greenish-gray, sandy; sand, fine to medium	12	77

138-77-3abb
Auger hole 8

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	2	2
	Clay, moderate-yellowish-brown; sand, fine to medium; oxidized	8	10
	Clay, grayish-brown; sand, fine to medium	4	14
	Clay, light-olive-gray; sand, fine to medium	13	27
	Clay, light-olive-gray, plastic, cohesive	5	32

138-77-3ccd
Test hole 1944

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black-------------------------	1	1
	Clay, moderate-yellowish-brown, silty, cohesive, oxidized, calcareous-------	23	24
	Clay, light-olive-gray, silty, cohesive, oxidized, calcareous---------	57	81
	Gravel, fine to coarse, sandy, subangular to rounded, unsorted---------	3	84
	Clay, light-olive-gray, silty, cohesive, calcareous-------------------	29	113
	Sand, medium to coarse, sorted, angular, abundant shale and lignite fragments----------------------------	43	156
	Sand, coarse to very coarse, gravelly, poorly-sorted, subangular to rounded, abundant shale and lignite fragments-----------------------	22	178
Fox Hills Sandstone:			
	Shale, dark-greenish-gray, silty, indurated----------------------------	11	189

138-77-4acc
U.S.B.R. drill hole 21

Material	Thickness (feet)	Depth (feet)
Topsoil, brown, clayey-----------------	1.5	1.5
Clay, brown and gray, plastic, fairly stiff, with trace of silt (lacustrine)	24.5	26
Clay, gray, silty, plastic, soft lacustrine---------------------------	9	35
Clay, gray, silty, plastic, soft becoming stiff at 60' (lacustrine)-----	65	100

TABLE 2.--Logs of test holes -- Continued

138-77-4adc
U.S.B.R. drill hole 22

Material	Thickness (feet)	Depth (feet)
Clay, brown and gray, plastic, trace of silt (lacustrine)----------------	27	27
Clay, gray, silty, soft, sticky (lacustrine)------------------------	5	32
Sand, gray, very fine, silty----------	5	37
Clay, gray, silty, plastic (lacustrine)	8	45
Clay, gray, moderately plastic, stiff (lacustrine)------------------------	25	70

138-77-4add
U.S.B.R. drill hole 23

Material	Thickness (feet)	Depth (feet)
Topsoil, black, organic, clayey-------	1	1
Clay, grayish-brown, silty, stiff, plastic, (lacustrine)---------------	25	26
Silt, gray, with thin sand and clay zones------------------------------	5	31
Clay, gray, silty, plastic, stiff (lacustrine)------------------------	16	47
Sand, gray, fine, silty, soft---------	8	55
Clay, gray, stiff, very plastic (lacustrine)------------------------	14	69
Sand, brown, fine to coarse, dense----	1	70

138-77-5cbb
U.S.B.R. drill hole 18

Material	Thickness (feet)	epth (feet)
Topsoil, brown, organic, sandy clay---	3	3
Clay, brown, plastic, stiff, moist----	8	11
Sand, tan, very fine, dry, trace of silt-------------------------------	10	21
Sand and gravel, brown, coarse sand with fine to medium gravel, silty, clayey-----------------------------	14	35

TABLE 2.--Logs of test holes -- Continued

138-77-5dab
U.S.B.R. drill hole 20

Material	Thickness (feet)	Depth (feet)
Topsoil, black, organic clay-----------	1.5	1.5
Clay, brown, plastic, stiff, gypsum concentrations throughout------------	10.5	12
Sand, brown, fine, silty, soft---------	5	17
Clay, brown, plastic, soft-------------	6	23
Clay, gray, very plastic, soft becoming stiff at approx. 47'----------	37	60

Note: Above materials are of lacustrine origin.

138-77-5dbb
U.S.B.R. drill hole 19

Material	Thickness (feet)	Depth (feet)
Topsoil, black, organic clay-----------	2	2
Clay, brown, plastic, stiff, gypsum concentrations throughout (lacustrine)--------------------------------	21	23
Clay, gray, plastic, stiff (lacustrine)--------------------------------	4	27
Clay (till?), gray, sandy, soft, with fine gravels throughout--------------	22.5	49.5
Clay, gray, plastic, stiff (lacustine)--------------------------------	10.5	60

138-77-6ccd
U.S.B.R. drill hole 15

Material	Thickness (feet)	Depth (feet)
Clay, gray, firm, occasional gravels---	3	3
Clay, brown, soft, plastic, with concentrations of gypsum----------------	8	11
Sand, brown, fine, silty, soft---------	6	17

TABLE 2.--Logs of test holes -- Continued

138-77-6ccd, Continued
U.S.B.R. drill hole 15

Material	Thickness (feet)	Depth (feet)
Clay, gray, soft, plastic	14	31
Sand, gray, fine, silty, soft	5.5	36.5
Clay, gray, soft, plastic	18	54.5
Sand, gray, medium to coarse, with fine gravels, clayey	5.4	59.8

Note: Above materials from 0 to 54.5' are of lacustrine origin.

138-77-6cda
U.S.B.R. drill hole 16

Material	Thickness (feet)	Depth (feet)
Topsoil, brown, organic, silty, clay	1.5	1.5
Clay, brown, soft, plastic	14.5	16
Clay, gray, soft, plastic	6	22
Sand, gray, fine, very silty, soft	5	27
Clay, gray, plastic, soft to stiff	33	60

Note: Above materials are of lacustrine origin.

138-77-6daa
Test hole 1945

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	1	1
	Clay, dark-yellowish-brown, silty, calcareous	27	28
	Sand, coarse to very coarse, gravelly, abundant shale particles	8	36

138-77-6daa, Continued
Test hole 1945

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Sand, gray, medium to very coarse, poorly-sorted, abundant shale and lignite	17	53
	Sand, medium to very coarse; gravel, fine to medium; silty to clayey, abundant lignite fragments	6	59
	Gravel, medium to coarse, sandy, abundant lignite fragments	5	64
Hell Creek Formation:			
	Shale, grayish-brown, silty, carbonaceous	8	72
	Shale, greenish-gray, silty to sandy	12	84

138-77-6dbd
U.S.B.R. drill hole 17

Material	Thickness (feet)	Depth (feet)
Clay, brown, soft, sandy in zones, gypsum concentrations throughout	21	21
Clay, gray, plastic, soft to stiff	39	60

Note: Above materials are of lacustrine origin.

TABLE 2.--Logs of test holes -- Continued

138-77-9bdb
Test hole 1831

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black, sandy	5	5
	Sand, yellowish-brown, very fine to fine, clayey	5	10
	Clay, yellowish-brown, silty	21	31
	Clay, medium-gray	12	43
	Clay, medium-gray; sand, very coarse; abundant shale pebbles	5	48
	Clay, medium-gray, silty	76	124
	Sand, medium-gray, fine to medium, clayey, lignite fragments	29	153
Hell Creek Formation:			
	Shale, medium-gray, silty, lignitic	5	158
Fox Hills Sandstone:			
	Shale, medium-gray, silty	37	195
	Sandstone, dark-greenish-gray, fine to medium-grained, glauconitic; shale, medium-gray, silty; interbedded	25	220
	Sandstone, greenish-gray, fine to medium-grained, clayey, friable, abundant quartz grains	11	231

138-77-10d
Bill McDonald test hole 1
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Sand	4	6
Brown clay	11	17
Blue clay	81	98
Gravel	10	108

138-77-10d, Continued
Bill McDonald test hole 1
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Sandy clay	14	122
Sand	24	146
Coal	1	147
Gravel	6	153
Sand	7	160

138-77-10dca
Bill McDonald test hole 6
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Brown clay	35	35
Blue clay	61	96
Sand	5	101
Clay	6	107
Sand	33	140
Coarse gravel	15	155
Fine gravel	5	160

138-77-10dcd
Bill McDonald test hole 5
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Sand	6	6
Brown clay	18	24
Blue clay	83	107
Gravel	2	109
Clay	25	136
Fine sand	15	151
Coarse gravel	18	169
Medium gravel	29	198

TABLE 2. Logs of test holes -- Continued

138-77-11aaa
Test hole 1943

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	1	1
	Clay, moderate-yellowish-brown, silty, cohesive, oxidized, calcareous	15	16
	Sand, fine to very coarse; gravel, fine to coarse; angular to subrounded, oxidized	3	19
	Clay, moderate-yellowish-brown, silty, cohesive, oxidized, calcareous	8	27
	Sand, fine to coarse, poorly-sorted, subangular to well-rounded, abundant shale pebbles	3	30
	Clay, light-olive-gray, silty, cohesive, calcareous	7	37
	Sand, fine to coarse, poorly-sorted, subangular to well-rounded, silty, cohesive	2	39
	Clay, light-olive-gray, silty, cohesive, calcareous	51	90
Hell Creek Formation:			
	Shale, brownish-gray, silty, lignitic	20	110
	Sandstone, dark-yellowish-orange, very fine to medium-grained, silty, clayey, oxidized	6	116
	Sandstone, light-bluish-gray, very fine to medium-grained, oxidation spots	10	126

TABLE 2.--Logs of test holes -- Continued

138-77-13aaa
Test hole 2028

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Silt, yellowish-gray, sandy, slightly, cohesive, calcareous, oxidized-------	3	3
	Silt, moderate-yellowish-brown, cohesive, calcareous, oxidized---------	4	7
	Silt, medium-bluish-gray, sandy, cohesive, calcareous------------------	4	11
	Silt, olive-gray, very cohesive, calcareous---------------------------	33	44
	Sand, fine to very coarse, gravelly, unsorted, rounded--------------------	7	51
	Silt, dark-greenish-gray; sand, very fine; lignite fragments, calcareous--	41	92
	Gravel, fine to coarse, sandy, unsorted, subangular, abundant lignite fragments-----------------------	8	100
Hell Creek Formation:			
	Sandstone, dusky-yellow, very fine to fine-grained, clayey, indurated, oxidized-----------------------------	15 1/2	115 1
	Sandstone, medium-bluish-gray, fine-grained, clayey, indurated-----------	4 1/2	120

138-77-14add
Test hole 1940

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black-------------------------	1	1
	Clay, pale-yellowish-brown, silty, cohesive, oxidized, calcareous-------	8	9
	Clay, dark-yellowish-orange, silty, cohesive, oxidized, calcareous-------	16	25

TABLE 2.--Logs of test holes -- Continued

138-77-14add, Continued
Test hole 1940

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Clay, pale-yellowish-brown, silty, cohesive, oxidized, calcareous-----	5	30
	Clay, light-olive-gray, silty, cohesive, calcareous------------------	31	61
	Gravel, fine to medium, sandy, unsorted, angular to subrounded, abundant carbonates------------------	3	64
	Clay, light-olive-gray, silty, cohesive, calcareous------------------	66	130
	Sand, very fine to coarse, subangular to rounded, abundant shale and lignite pebbles----------	31	161
	Sand, coarse to very coarse; gravel, granule; unsorted, rounded, abundant quartz and lignite------------	5	166
	Clay, light-olive-gray, silty, cohesive, calcareous------------------	7	173
	Sand, fine to coarse, poorly-sorted, angular to rounded, lignite fragments, snail shells----------------	27	200
	Gravel, fine to medium, clayey, subangular to rounded; sand, coarse to very coarse, mostly quartz; abundant brown granules, lignite and shell fragments----------------	31	231

138-77-14ccc
Test hole 1941

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	2	2
	Clay, dark-yellowish-brown, very silty, oxidized, calcareous	9	11
	Clay, moderate-yellowish-brown, silty, cohesive, oxidized, calcareous	16	27
	Clay, dark-yellowish-brown, silty, cohesive, oxidized, calcareous	5	32
	Clay, light-olive-gray, silty, cohesive, calcareous	69	101
	Gravel, fine to medium, subangular to rounded; sand, fine to very coarse; lignite fragments	13	114
	Sand, medium to very coarse, well-sorted, angular to rounded, shale granules, lignite fragments	12	126
Fox Hills Sandstone:			
	Sand, medium-bluish-gray, very fine to fine, silty, biotite flakes	10	136

138-77-15aaa
Test hole 2023

Formation	Material	Thickness (feet)	Depth (feet
Glacial drift:			
	Topsoil	1	1
	Sand, very fine to fine, silty, poorly-sorted, subrounded	15	16
	Sand, very fine to very coarse, silty, unsorted, subrounded to well-rounded	3	19
	Silt, dark-greenish-gray, clayey, calcareous	13	32
	Clay, light-olive-gray, silty, cohesive, lignite flecks	80	112
	Silt, olive-gray, clayey, some laminations, calcareous	18	130

138-77-15aaa, Continued
Test hole 2023

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Gravel, fine, sandy, unsorted, lignite fragments	1	131
	Sand, very fine to very coarse, unsorted, subrounded to well-rounded, lignite fragments	16	147
	Gravel, fine to coarse, sandy, unsorted, rounded, abundant limestone and granitic rocks	13	160
	Gravel, fine to medium, unsorted, subrounded, predominantly shale, abundant limestone and lignite	29	189
	Silt, olive-gray, clayey, abundant lignite fragments	15	204
	Gravel, fine to medium, sandy unsorted, rounded, abundant red, green and brownish pebbles (preglacial ?)	9	213
Fox Hills Sandstone:			
	Clay, dark-greenish-gray, silty, indurated, mica flakes	12	225

138-77-15bbb
Auger hole 13

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, moderate-brown, silty	1	1
	Clay, moderate-yellowish-brown, silty, plastic, oxidized	21	22
	Clay, light-olive-gray, silty	11	33
	Clay, light-olive-gray; sand, fine to medium	16	49

TABLE 2.--Logs of test holes -- Continued

138-77-15bbb, Continued
Auger hole 13

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Sand, fine to medium	4	53
	Clay, light-olive-gray, sandy	59	112

138-77-15caa
Bill Anderson test hole 1
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Sand	3	5
Clay, brown	26	31
Clay, blue	67	98
Sand	11	109
Clay	3	112
Coal	2	114
Sand	25	139
Gravel	5	144
Clay	6	150

138-77-15dcb
Bill Anderson Irrigation well 1
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	3	3
Sand	4	7
Clay, brown	26	33
Clay, blue	75	108
Sand and gravel	28	136
Coal	1	137
Clay	3	140

TABLE 2.--Logs of test holes -- Continued

138-77-22aad
Test hole 1955

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	1	1
	Clay, yellowish-brown, silty, oxidized	39	40
	Clay, olive-gray, silty	49	89
	Gravel, medium to coarse; sand, coarse to very coarse; abundant lignite and shale fragments	5	94
	Sand, gray, fine to medium, gravelly, lignite and shale fragments	12	106
	Sand, fine to medium; gravel, fine to medium; abundant lignite and shale fragments	8	114
	Gravel, medium to coarse, abundant lignite and shale granules	8	122
Fox Hills Sandstone:			
	Sandstone, greenish-gray, very fine to fine, silty, friable	4	126

138-77-22bdd
Bill Anderson test hole 5
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Sand	2	4
Clay, brown	29	33
Clay, blue	10	43
Gravel	1	44
Clay, sandy	6	50
Clay, black	5	55
Shale	75	130

TABLE 2.--Logs of test holes -- Continued

138-77-22cac
Bill Anderson test hole 6
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Sand	4	6
Clay, brown	11	17
Sand	14	31
Clay, blue	18	49
Clay, sandy	7	56
Clay	50	106
Sand	3	109
Gravel	5	114
Clay	16	130

138-77-22dda
Auger hole 15

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, moderate-yellowish-brown, plastic, silty, oxidized	21	21
	Clay, moderate-brown, silty, plastic	12	33
	Clay, light-olive-gray, silty, plastic	56	89
	Sand, fine to very coarse; gravel, fine to medium	21	110

TABLE 2.--Logs of test holes -- Continued

138-77-23aac
Test hole 1979

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black, silty to sandy--------	2	2
	Sand, fine to medium, oxidized--------	12	14
	Clay, yellowish-brown, silty to sandy, cohesive, unoxidized beyond 20 feet----------------------------	8	22
	Clay, gray, silty, cohesive-----------	28	50
	Sand, fine to medium, abundant lignite	1/2	50 1/2
	Clay, olive-gray, silty, cohesive, lignite flakes---------------------	50 1/2	101
	Gravel, fine to coarse, cobbles; sand, very coarse; subangular to rounded, lignite fragments------------------	18	119
	Lignite------------------------------	1	120
	Sand, fine to coarse, subrounded------	2	122
Hell Creek (?) Formation:			
	Clay, grayish-brown, very sandy-------	8	130

138-77-23ddb
Ray Baeth Irrigation well 1
Log by Ben Hasz

Material	Thickness (feet)	Depth (feet)
Topsoil------------------------------	2	2
Sand---------------------------------	5	7
Brown clay---------------------------	21	28
Blue clay----------------------------	48	76
Fine gravel--------------------------	22	98
Coarse gravel------------------------	9	107
Fine gray sand-----------------------	2	109
Sandy gray clay----------------------	6	115

TABLE 2.--Logs of test holes -- Continued

138-77-23ddb2
Baeth Screen test

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, dark-brown	1	1
	Clay, yellowish-brown, oxidized	7	8
	Clay, yellowish-brown, silty, slightly-oxidized	19	27
	Clay, olive-gray, silty to sandy, cohesive, calcareous	28	55
	Clay, light-olive-gray, silty, cohesive, dense, calcareous	17	72
	Sand, coarse to granule, subrounded, abundant lignite and shale	6	78
	Gravel, coarse to very coarse, rounded	5	83
	Lignite	1	84
	Gravel, coarse to very coarse; sand, medium to very coarse, subrounded	6	90

138-77-23ddb3
Baeth pumping observation test hole

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, brownish-black, sandy	2	2
	Clay, yellowish-brown, silty, cohesive, oxidized, calcareous	19	21
	Clay, medium to olive-gray, silty, cohesive, calcareous	49	70
	Sand, yellowish-gray, fine, gravelly, abundant lignite and shale fragments	10	80
	Gravel, coarse to very coarse; sand, coarse; subrounded	27	107

TABLE 2.--Logs of test holes -- Continued

138-77-24bbb
Auger hole 14

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, moderate-yellowish-brown, fine to medium, oxidized-----------------	5	5
	Clay, moderate-yellowish-brown; sand fine to medium; oxidized------------	6	11
	Clay, moderate-yellowish-brown, silty, oxidized----------------------------	13	24
	Clay, grayish-brown, silty------------	14	38
	Clay, light-olive-gray, silty---------	16	54
	Sand, fine to medium, clayey----------	6	60
	Clay, light-olive-gray, silty; sand, fine--------------------------------	8	68
	Sand, fine to medium------------------	9	77
	Clay, light-olive-gray, silty---------	14	91
	Gravel, fine to coarse; sand, medium to coarse--------------------------	21	112

138-77-24ccc
Test hole 1939

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, brown------------------------	1	1
	Sand, light-olive-gray, fine to medium, silty and clayey------------	5	6
	Clay, light-olive-gray, and pale-yellowish-brown, silty and sandy----	10	16
	Clay, light-olive-gray to medium-gray, smooth------------------------	1	17
	Clay, light-olive-gray, silty, co-hesive------------------------------	48	65
	Gravel, fine to very coarse, abundant lignite, shale, igneous and carbonate pebbles-------------------	23	88
	Clay, olive-gray, silty; sand, very coarse; shale fragments-------------	17	105

TABLE 2.--Logs of test holes -- Continued

138-77-24ccc, Continued
Test hole 1939

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Clay, olive-gray, very silty, sandy---	52	157
	Clay, olive-gray, very silty, sandy to gravelly------------------------	3	160
Fox Hills Formation:			
	Sandstone, medium-light-gray, very fine to fine-grained, friable; shale, medium-light-gray------------	8	168

138-77-24dcc
Auger hole 9

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, dusky-brown, sandy-----------	1	1
	Sand, light-olive-gray, fine to medium, becoming more clayey from 10 - 15 feet------------------------------	19	20
	Sand, olive-gray, clayey, fine to medium------------------------------	9	29
	Clay, light-olive-gray; sand, fine to medium ------------------------------	41	70
	Clay, olive-gray, dense, harder drilling than above-----------------------	18	88
	Clay, olive-gray, plastic, cohesive----	24	112

TABLE 2.--Logs of test holes -- Continued

138-77-24dd
Auger hole 10

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, moderate-yellowish-brown, sandy	2	2
	Clay, moderate-yellowish-brown, silty; sand, fine	28	30
	Clay, moderate-yellowish-brown, silty	4	34
	Clay, light-olive-gray, silty, plastic, cohesive	38	72
	Clay, olive-gray, silty, plastic, cohesive	30	102

138-77-25a
Bill McDonald test hole 3
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	3	3
Sand	7	10
Brown clay	10	20
Blue clay	65	85
Gravel	1	86
Sandy clay	14	100

TABLE 2.--Logs of test holes -- Continued

138-77-25bbd2
Adams Screen test

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black, sandy	1	1
	Clay, yellowish-brown, silty, calcareous, oxidized	17	18
	Clay, olive-gray, cohesive, calcareous	35	53
	Gravel, fine to very coarse, subrounded; sand, fine to coarse; abundant shale and carbonates	27	80

138-77-25d
Bill McDonald test hole 2
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Sand	6	8
Brown clay	13	21
Blue clay	18	39
Gravel	9	48
Clay	9	57
Gravel	2	59
Clay	1	60

138-77-25daa
Bill McDonald service well
Log by Schnell, Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	1	1
Sand	15	16
Brown clay	8	24
Blue clay	5	29
Gravel	27	56

TABLE 2.--Logs of test holes -- Continued

138-77-26adc
Test hole 1954

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	1	1
	Clay, dark-yellowish-orange, silty, cohesive, lignite fragments, oxidized, calcareous	19	20
	Clay, dark-yellowish-brown, silty, cohesive, lignite fragments, oxidized, calcareous	5	25
	Clay, olive-gray, silty, cohesive, lignite fragments, calcareous	8	33
	Gravel, fine to coarse, sandy, subrounded, unsorted	8	41
	Sand, very fine to coarse, silty, unsorted, subangular to rounded, abundant shale and lignite fragments	12	53
	Sand, coarse to very coarse; gravel, granule; poorly sorted, subangular to well rounded	5	58
	Gravel, fine; sand, fine to very coarse; unsorted, subrounded, lignite and shale pebbles	5	63
	Clay, olive-gray, silty to sandy	11	74
Hell Creek Formation:			
	Shale, light-bluish-gray, silty to sandy	4 3/4	78 3/4

138-77-26dda
Test hole 1869

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	1	1
	Clay, yellowish-brown, silty	20	21
	Clay, light to medium-gray, silty to sandy. lignite fragments	42	63
	Clay, medium-brownish-gray, silty	41	104
	Sand, medium to very coarse	11	115
	Gravel, medium to coarse; sand, medium to very coarse	9	124
	Clay, medium-gray, silty	13	137
	Clay, medium-gray, silty; sand, gray, fine to medium	11	148
	Sand, gray, fine to medium, silty, gravelly, lignite fragments; clay, medium-gray; interbedded	20	168
	Sand, medium to very coarse; gravel, fine to medium	11	179
Fox Hills Sandstone:			
	Sandstone, greenish-gray, very fine to fine-grained, silty and clayey, abundant glauconite	4	183
	Sandstone, greenish-gray, very fine to fine-grained, silty and clayey, glauconitic; shale, medium gray, silty and sandy	7	192
	Sandstone, greenish-gray, silty and clayey, friable, abundant glauconite, some specks of carbonaceous material	18	210
	Sandstone, greenish-gray, friable, glauconitic, indurated; shale, medium to greenish-gray; silty	21	231

TABLE 2.--Logs of test holes -- Continued

138-77-32daa
Test hole 1868

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black and dark-brown	2	2
	Till, brown and buff, sandy, shale pebbles, lignite smears	20	22
Hell Creek Formation:			
	Shale, dark-brownish-gray; silty, very carbonaceous	5	27
	Shale, brown, silty	4	31
	Sandstone, yellowish-brown, fine to medium-grained, friable, clayey, abundant dark minerals	6	37
	Sandstone, light-brownish-gray, fine to medium-grained, friable, clayey	5	42
	Shale, medium-gray, silty and sandy; sandstone, light-bluish-gray, very fine to fine-grained, glauconitic; interbedded	5	47
	Shale, brownish-gray to medium-gray, carbonaceous; sandstone, medium to light-greenish-gray, very fine to fine-grained, glauconitic	37	84
	Shale, green to dark-grayish-brown, silty, lignite seams interbedded	16	100
	Shale, dark-grayish-brown, silty very carbonaceous; sandstone, greenish-gray, very fine to fine-grained, friable, silty to clayey, glauconitic	5	105
	Sandstone, dark-greenish-gray, very fine to fine-grained, friable, silty and clayey	11	116
	Sandstone, dark-greenish-gray, very fine to fine-grained, friable; shale, grayish-brown, carbonaceous, silty; interbedded	10	126
	Shale, dark-grayish-brown, silty, abundant lignite and peat	10	136

TABLE 2.--Logs of test holes -- Continued

138-77-32daa, Continued
Test hole 1868

Formation	Material	Thickness (feet)	Depth (feet)
Fox Hills Sandstone:			
	Sandstone, light-bluish and light-greenish-gray, friable, silty and clayey, glauconitic, some indurated layers------------------------------	32	168
	Shale, light to medium-gray, silty, carbonaceous streaks----------------	31	199
	Sandstone, light-bluish and light-greenish-gray, friable, silty and clayey, glauconitic-------------	11	210

138-77-35bbb
Test hole 2030

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, very fine to fine, silty, unsorted, oxidized------------------	10	10
	Silt, dark-yellowish-orange, cohesive, lignite flecks, oxidized----	25	35
	Sand, fine to medium	1/2	35 1
	Clay, dark-greenish-gray, silty, cohesive, calcareous----------------	4 1/2	40
Hell Creek Formation:			
	Sand, very fine to fine, silty, lignite fragments, oxidized---------	11	51
	Sand, medium-bluish-gray, very fine to fine, clayey, abundant glauconite grains---------------------	4	55
	Clay, olive-gray, silty, lignite fragments, indurated-----------------	5	60

TABLE 2.--Logs of test holes -- Continued

138-78-1abb
Test hole 1952

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	1	1
	Clay, light-olive-gray; sand, fine to medium; calcareous	5	6
	Clay, pale-yellowish-brown, calcareous	10	16
	Clay, dusky-brown, silty, calcareous	4	20
	Clay, olive-gray, silty, lignite fragments, calcareous	26	46
	Clay, olive-gray, silty, calcareous	68	114
	Sand, olive-gray, fine to medium, silty, poorly-sorted, calcareous	11	125
	Gravel, fine, sandy, poorly-sorted, subrounded to rounded; clay, olive-gray, silty; abundant shale pebbles, interbedded	31	156
	Sand, fine to coarse, angular to subrounded, shale and lignite fragments, rounded; clay, olive-gray, very silty, calcareous	16	172
	Clay, light-olive-gray, very silty, lignite fragments, calcareous	16	188
	Gravel, fine, sandy, subrounded to rounded, unsorted, lignite fragments	10	198
Fox Hills Sandstone:			
	Clay, light-olive to greenish-gray, silty to sandy, calcareous	12	210

TABLE 2.--Logs of test holes -- Continued

138-78-1ddd
U.S.B.R. drill hole 14

Material	Thickness (feet)	Depth (feet)
Clay, gray, plastic, firm, numerous concentrations of gypsum and probable alkaline salts	6	6
Clay, gray and brown, soft, plastic, occasional salt concentrations	6	12
Sand, brown, fine, very silty, soft	5	17
Clay, gray, silty, soft, moderately plastic, silty and sandy 30' to 52' with silt and sand content decreaseing 52' to 60'	43	60

Note: Above materials of lacustrine origin.

138-78-2cdd
U.S.B.R. drill hole 12

Material	Thickness (feet)	Depth (feet)
Clay (glacial till), brown, sandy, with gravels throughout, occasional boulders	3	3
Sand, tan, fine, dry, dense(Fort Union Group)	15	18
Clay (shale), gray, very firm, dry	6.7	24.7

138-78-7cbb
Test hole 1946

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	3	3
	Clay, light-olive-gray, silty, calcareous	13	16

138-78-7cbb, Continued
Test hole 1946

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Clay, grayish-black, silty----------	6	22
	Clay, dark-greenish-gray, silty, calcareous------------------------	3	25
	Clay, light-olive-gray, silty, calcareous------------------------	7	32
	Clay, olive-gray, silty to sandy in parts, lignite fragments, calcareous--------------------------	68	100
	Silt, olive-gray, clayey, sandy, lignite fragments, calcareous-----	30	130
	Gravel, medium to coarse; sand, medium to very coarse; poorly-sorted, clayey, lignite and shale pebbles---------------------	5	135
	Silt, gray; clay, gray; sand, fine; lignite fragments-----------------	35	170
	Gravel, medium to coarse; sand, very coarse----------------------	14	184
Fox Hills Sandstone:			
	Siltstone, olive-gray, clayey, slightly calcareous---------------	8	192
	Shale, olive-gray, silty------------	6	206
	Sandstone, dusky-blue-green, very fine to fine-grained, friable, silty, very glauconitic-----------	14	220

138-78-19abb
Test hole 1948

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black----------------------	3	3
	Clay, dark-yellowish-orange, silty, cohesive, oxidized, calcareous----	15	18

138-78-19abb, Continued
Test hole 1948

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Clay, dark-yellowish-brown, silty, cohesive, lignite fragments, oxidized, calcareous	7	25
	Sand, very fine to medium, very angular to rounded, lignite fragments	13	38
	Clay, light-olive-gray, cohesive, lignite fragments, calcareous	22	60
Hell Creek Formation:			
	Sand, medium-bluish-gray, very fine to medium, silty, abundant lignite, shale and green grains; shale, brownish-gray, interbedded	24	84

138-78-21ccc
Test hole 2041

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	2	2
	Sand, dusky-yellowish-brown, fine to medium, unsorted, oxidized	6	8
	Sand, very fine to medium, poorly-sorted	13	21
	Silt, dark-greenish-gray, clayey to sandy, cohesive, lignite flecks, calcareous	31	52
	Clay, dark-greenish-gray, silty, lignite flecks, cohesive	4	56
	Silt, dark-greenish-gray, clayey, to sandy, cohesive, lignite flecks, calcareous	27	83

TABLE 2.-- Logs of test holes -- Continued

138-78-21ccc, Continued
Test hole 2041

Formation	Material	Thickness (feet)	Depth (feet)
Hell Creek Formation:			
	Sandstone, medium-bluish-gray, very fine to fine, silty, soft, lignite fragments	22	105

138-78-23aaa
Test hole 1947

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	1	1
	Clay, medium-light-gray, silty to sandy, cohesive, oxidized, calcareous	5	6
	Clay, dark-yellowish-orange, silty, cohesive, oxidized, calcareous	7	13
	Clay, light-olive-gray, very silty, cohesive, calcareous	6	19
	Silt, light-olive-gray, clayey, sandy, calcareous	25	44
	Clay, light-olive-gray, silty, cohesive, calcareous	70	114
	Clay, light-olive-gray, silty, cohesive; sand, very fine to coarse, unsorted, angular; abundant shale and lignite fragments	10	124
	Sand, fine to medium, well-sorted, subangular to well-rounded, shale pebbles	33	157
	Gravel, fine to medium, sandy, angular to rounded	16	173
Fox Hills Sandstone:			
	Clay, light-bluish-gray, silty to sandy	5	178

TABLE 2.--Logs of test holes -- Continued

138-78-23bbb
Test hole 1870

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	1	1
	Clay, dark-gray, silty	10	11
	Clay, brownish-gray, silty	4	15
	Clay, yellowish-brown, silty	6	21
	Clay, medium-brownish-gray, silty	15	36
	Clay, medium-brownish-gray, silty, lignite fragments	27	63
	Clay, medium-brownish-gray, silty	41	104
	Sand, medium to very coarse; gravel, medium to coarse; clayey, lignite fragments	23	127
	Gravel, medium to coarse; sand, medium to coarse	5	132
Hell Creek Formation:			
	Sandstone, light-greenish-gray, very fine to fine-grained, friable, silty to clayey, glauconitic (?)	12	144
	Shale, light-brown, silty	4	148
Fox Hills Sandstone:			
	Sandstone, light-greenish-gray, very fine to fine-grained, friable, slightly silty and clayey, glauconitic (?)	10	158
	Shale, brownish-gray, silty, carbonaceous streaks	10	168
	Shale, brownish-gray and medium-gray	15	183
	Shale, brownish-gray, and medium-gray, silty and sandy, scattered brown carbonaceous specks	37	220
	Shale, dark-gray; sandstone at 231 feet, indurated	11	231

TABLE 2.--Logs of test holes -- Continued

138-78-27ccd
Test hole 2042

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	2	2
	Clay, medium-light-gray, very sandy, cohesive, highly-calcareous	4	6
	Sand, fine to coarse, fair sorting, angular to rounded, lignite fragments, oxidized	4	10
	Sand, medium-light-gray, angular to rounded, abundant lignite fragments	20	30
	Sand, fine to medium, fair sorting, angular to rounded, abundant lignite	74	104
	Clay, olive-gray, silty, cohesive, lignite fragments, calcareous	32	136
	Sand, fine to very coarse, granular, unsorted, angular to rounded, lignite fragments	8	144
	Clay, olive-gray, silty, cohesive	4	148
	Gravel, fine, sandy, unsorted	6	154
	Clay, olive-gray, silty, cohesive	6	160
	Sand, medium, silty	6	166
	Silt, olive-gray, clayey	4	170
	Sand, medium	2	172
	Silt, dark-greenish-gray, clayey, sandy	15	187
	Clay, dark-greenish-gray, silty, cohesive	11	198
	Gravel, fine to medium, sandy, unsorted, very angular to rounded, lignite and shale pebbles	22	220
Fox Hills Sandstone:			
	Clay, dark-greenish-gray, silty to sandy, cohesive, indurated	10	230

TABLE 2.--Logs of test holes -- Continued

138-78-32daa
Test hole 2012

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Silt, dark-yellowish-orange, clayey, cohesive, highly-calcareous--------	9	9
	Sand, fine to medium, sorted, rounded, abundant lignite-------------------	13	22
	Clay, dark-greenish-gray, silty, cohesive, calcareous, very small lignite and mica flakes---------------	10	32
	Silt, dark-greenish-gray, sandy, highly-calcareous, abundant lignite fragments--------------------	21	53
	Silt, olive-gray, clayey to sandy, lignite and mica flakes------------	9	62
	Sand, very fine to fine, silty, abundant carbonates, some glauconite and lignite fragments-------	68	130
	Clay, olive-gray, silty, lignite flecks----------------------------	11	141
	Sand, very fine to very coarse, very granular, unsorted, angular to rounded, abundant limestone and lignite------------------------	13	154
	Silt, dark-greenish-gray, clayey to sandy, lignite chips, calcareous---	34	178
	Gravel, fine to medium, sandy, subrounded, unsorted, abundant limestone, few lignite fragments---	9	187
	Silt, dark-greenish-gray to olive-gray, clayey to sandy, cohesive, sparse lignite flecks, calcareous--	9	196
	Gravel, fine to medium, sandy, subrounded, unsorted, abundant limestone, some lignite----------------	2 1/2	198 1/2
Fox Hills Sandstone:			
	Silt, olive-gray, indurated, small laminations, abundant green grains-	11 1/2	210

TABLE 2.--Logs of test holes -- Continued

138-79-2aaa
Test hole 2053

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	1	1
	Clay, moderate-yellowish-brown, silty, highly-calcareous	11	12
	Sand, very fine to medium, angular to rounded; clay layers, grayish-orange, very silty, highly-calcareous	14	26
	Till, moderate-yellowish-brown, silty, calcareous, oxidized	8	34
	Gravel, fine, very sandy, unsorted, subangular to subrounded	2	36
	Silt; moderate-yellowish-orange, lignite particles, highly-calcareous, oxidized	12	48
	Silt, greenish to dark-greenish-gray, calcareous, soft, sandy, abundant lignite and shale fragments	14	62
Hell Creek Formation:			
	Sandstone, light-olive-gray, very fine to fine	3	65
	Silt, dark-gray, clayey, indurated, lignite chips; sand, very fine	10	75

138-79-3cac
Auger hole 5

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, brownish-black	2	2
	Clay, moderate-yellowish-brown, oxidized	5	7
	Till, moderate-yellowish-brown, sandy, shale pebbles, oxidized	30	37

TABLE 2.--Logs of test holes -- Continued

138-79-3cac, Continued
Auger hole 5

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Clay, brownish-gray, sandy	12	49
	Clay, olive-gray, sandy	15	64
	Sand, greenish-gray, clayey	43	107

138-79-8aaa
Test hole 1860

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	2	2
	Clay, yellowish-brown, silty and sandy	9	11
	Clay, brownish-gray, cohesive	10	21
	Clay, medium-gray, silty and sandy	11	32
	Sand, light-gray, very fine to fine, silty	11	43
	Silt, dark-gray, clayey	14	57
	Gravel, medium to coarse, abundant lignite and shale pebbles	6	63
	Clay, medium-gray, very sandy	5	68
	Sand, light-to-medium-gray, very fine to medium, poorly-sorted, silty, abundant lignite fragments	16	84
	Clay, medium-gray, silty, lignite fragments	21	105
	Sand, light-gray, very fine to fine, silty, to clayey, poorly-sorted	11	116

138-79-8aaa, Continued
Test hole 1860

Formation	Material	Thickness (feet)	Depth (feet)
Hell Creek Formation:			
	Shale, brownish-gray, silty, very carbonaceous to lignitic----------	2	118
	Shale, brownish-gray, silty and sandy, carbonaceous streaks-------	5	123
	Shale, medium-gray, silty and sandy, carbonaceous; sandstone, medium-gray, very fine to fine-grained---	3	126
	Shale, light to medium-gray, silty--	5	131
	Shale, greenish to brownish-gray, silty and sandy, carbonaceous streaks; sandstone, greenish-gray, friable, glauconitic (?)----	10	141
	Sandstone, light to bluish-gray, silty to clayey, friable, glauconitic (?)-----------------------	6	147
	Shale, brownish-gray, carbonaceous, abundant lignite (Peat like material-------------------------	5	152
Fox Hills (?) Sandstone:			
	Sandstone, light-greenish-gray, very fine to fine-grained, silty to clayey, glauconite (?) grains; lignite---------------------------	6	158

TABLE 2.--Logs of test holes -- Continued

138-79-9abb
Test hole 1861

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	2	2
	Clay, yellowish-brown, silty	14	16
	Sand, dark-gray, fine to medium, very fossiliferous (pelecypod and gastropod shells), lignite fragments	6	22
	Clay, medium-gray, fossil and lignite fragments	4	26
	Clay, greenish-gray, silty and sandy	13	39
	Gravel, medium; sandy, very coarse	4	43
	Clay, medium-gray, silty	5	48
	Sand, gray to brown, fine to coarse, poorly-sorted	5	53
	Sand, light-gray, fine to medium, silty, poorly-sorted	27	80
	Gravel, medium to very coarse; sand, very coarse; abundant lignite fragments	25	105

TABLE 2.--Logs of test holes -- Continued

138-79-19dcd
Auger hole 4

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, moderate-yellowish-brown, very fine, oxidized	3	3
	Clay, moderate-yellowish-brown, plastic, oxidized	14	17

138-79-20ccc
Auger hole 3

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, moderate-yellowish-brown very fine to medium	1	1
	Clay, moderate-yellowish-brown, plastic	6	7

TABLE 2.--Logs of test holes -- Continued

138-80-1dcc
Auger hole 1

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, brownish-gray, plastic, sand, very fine, silty	12	12
	Clay, bluish-gray, plastic, silty; sand, very fine	14	26
	Clay, dark-greenish-gray, smooth, plastic, cohesive	21	47
	Clay, olive-gray; sand, very fine, silty	5	52
	Sand, fine to medium, clayey	32	84
	Gravel, very coarse; sand, fine to coarse, (rough drilling)	8	92
	Clay, olive-gray, smooth	5	97

TABLE 2.--Logs of test holes -- Continued

138-80-2bbc
Test hole 2058

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, brown, sandy	2	2
	Clay, very dark-yellowish-brown, silty and sandy, oxidized, calcareous	9	11
	Sand, dark-yellowish-brown, subrounded to rounded, well-sorted, oxidized	20	31
	Clay, olive-gray, silty, with very fine sand, smooth, plastic, micaceous, calcareous	16	47
Hell Creek Formation:			
	Clay, light-olive-gray to light-greenish-gray, some lignite, very micaceous, smooth, cohesive	47	84

138-80-2ccc
Test hole 2057

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, brownish-black, sandy	1	1
	Sand, brown, oxidized, fine to medium, some coarse, subrounded, well-sorted, calcareous	14	15
	Clay, moderate-olive-brown, silty, smooth, plastic, highly calcareous	4	19

TABLE 2.--Logs of test holes -- Continued

138-80-2ccc, Continued
Test hole 2057

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Clay, light-olive-gray, silty, with very fine sand, lignite chips, soft, highly-calcareous----------------------------	22	41
	Clay, light-olive-gray, silty, smooth, very plastic, highly-calcareous----------------------	5	46
	Gravel, fine to coarse; sand, coarse----------------------------	2	48
	Clay, light-olive-gray, silty, smooth, very plastic, highly-calcareous----------------------	8	56
	Gravel, fine to coarse, predominantly limestone; sand, coarse---------------------------	4	60
	Clay, light-olive-gray, silty, smooth, soft, plastic, calcareous--------------------------	30	90
	Clay, light-olive-gray, sandy, cohesive, micaceous, calcareous--------------------------	24	114
	Clay, light-olive-gray, silty; till, silty, calcareous----------	15	129
	Gravel, fine to coarse, subrounded to rounded, well-sorted---------------------------	18	147
	Gravel, very coarse; pebbles, cobbles and small boulders-------	23	170
Hell Creek Formation:			
	Clay, brownish-black, silty, very micaceous, small particles of lignite, noncalcareous; contains orange scoria specks-------	4	174

TABLE 2.--Logs of test holes -- Continued

138-80-8ddd
Test hole 1863

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	1	1
	Clay, brown, silty to sandy	14	15
	Sand, brown, fine to medium, clayey and silty	6	21
	Sand, brown, fine to medium; clay, brownish-gray; interbedded, scattered lignite fragments	11	32
	Sand, brown, fine to very coarse, clayey, rounded, abundant lignite	4	36
	Sand, brown, medium to very coarse, abundant lignite fragments	6	42
	Sand, brown, fine to very coarse, gravelly, poorly-sorted, lignite fragments	16	58
	Gravel, fine to medium; sand, brown, medium to very coarse; clay, interbedded, silty	5	63
	Gravel, fine to very coarse; sand, very coarse; abundant lignite fragments	42	105
	Sand, medium to very coarse; gravel, medium; abundant lignite fragments	9	114
Hell Creek Formation:			
	Sandstone, light-greenish-gray, fine to very fine-grained, clayey, carbonaceous, abundant glauconite grains	12	126
	Sandstone, light-greenish-gray, very fine to fine-grained, very shaley, glauconitic	10	136
	Shale, greenish-gray, silty to sandy; siltstone, greenish-gray; glauconitic	16	152

138-80-8ddd, Continued
Test hole 1863

Formation	Material	Thickness (feet)	Depth (feet)
Hell Creek Formation-Continued:			
	Shale, brown, carbonaceous----------	10	162
	Shale, brownish-gray, silty and sandy, glauconite (?) grains------	6	168

138-80-9bcd
Paul Wachter irrigation well 1
Log by Schnell, Inc.

Material	Thickness (feet)	Depth (feet)
Sandy topsoil-----------------------	2	2
Sandy clay loam---------------------	11	13
Fine sand---------------------------	6	19
Sand with lignite-------------------	6	25
Sand and wood-----------------------	2	27
Sand--------------------------------	2	29
Sand, lignite, and wood-------------	9	38
Sandy clay--------------------------	6	44
Lignite and sand--------------------	9	53
Clay with lignite layers------------	9	62
Rice gravel and lignite-------------	7	69
Clay--------------------------------	2	71
Gravel------------------------------	15	86
Clay--------------------------------	1	87
Lignite and sand--------------------	4	91
Gravel------------------------------	13	104
Clay--------------------------------	1	105

TABLE 2.--Logs of test holes -- Continued

138-80-11ddd
Test hole 1858

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, brown, fine to medium, carbonaceous	10	10
	Clay, buff, cohesive	11	21
	Clay, brown, silty to sandy	10	31
Hell Creek Formation:			
	Shale, light-gray, silty	16	47
	Shale, yellowish-brown, and gray, silty	5	52
	Shale, medium-gray, silty	11	63
	Sandstone, light-gray, very fine to fine-grained, silty, friable, scattered glauconitic grains	15	78
	Shale, light to medium-gray, silty; sandstone, light-gray, friable	6	84

138-80-12bbc
Test hole 1859

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, dark-brown, fine to medium	5	5
	Clay, light-brown, silty	5	10
	Clay, brownish-gray, silty to sandy	11	21
	Clay, light to medium-gray, silty	21	42
	Gravel, coarse; sand, very coarse	1	43
	Clay, medium-gray, silty	20	63
	Sand, gray, fine to medium	4	67
	Clay, gray, silty, lignite fragments	7	74
	Clay, medium-gray, silty and sandy	20	94
	Gravel, medium to very coarse, lignite fragments	21	115

TABLE 2.--Logs of test holes -- Continued

138-80-13cbb
C. P. Yegen test hole 1
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Sand loam topsoil------------------	2	2
Sand-------------------------------	25	27
Blue clay--------------------------	31	58
Sandy clay-------------------------	4	62
Medium sand and gravel with lignite lenses---------------------------	6	68
Clay, sandy------------------------	13	81
Tough clay-------------------------	90	171

138-80-13ccb
C. P. Yegen test hole 7
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil----------------------------	3	3
Clay-------------------------------	14	17
Sand-------------------------------	6	23
Clay--------------------------------	24	47
Sand-------------------------------	20	67
Clay and shale---------------------	13	80
Shale------------------------------	10	90

TABLE 2.--Logs of test holes -- Continued

138-80-13ccc
Test hole 1857

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, brown, sandy and clayey----	5	5
	Sand, brown, fine to medium clayey--	5	10
	Sand, brown, fine to medium, poorly-sorted---------------------------	11	21
	Sand, medium-gray, very fine to fine, silty to clayey; clay, medium-gray, silty and sandy; interbedded------	21	42
	Sand, medium-gray, very fine to fine, silty to clayey; clay, medium-gray, silty and sandy; interbedded; lignite fragments-----------------	36	78
	Sand, medium-gray, fine to coarse, gravelly, abundant lignite--------	6	84
Hell Creek Formation:			
	Shale, light-greenish-gray, silty and sandy; sandstone, light-brown, indurated------------------------	15	99
	Sandstone, bluish-gray, silty and clayey, friable-------------------	6	105
	Shale, bluish-gray, silty and sandy-	10	115
	Shale, bluish-gray, silty; shale, brownish-gray, silty; interbedded-	6	121
	Sandstone, bluish-gray, very fine to fine-grained, silty and clayey, friable---------------------------	5	126
	Sandstone, bluish-gray, very fine to fine-grained, silty, friable; shale, dark-greenish-gray, silty; interbedded-----------------------	15	141
	Sandstone, dark-greenish-gray, very fine to fine-grained, friable, silty and clayey, abundant glauconite grains---------------------	6	147

TABLE 2.--Logs of test holes -- Continued

138-80-13ccc, Continued
Test hole 1857

Formation	Material	Thickness (feet)	Depth (feet)
Fox Hills Sandstone:			
	Shale, dark-brown, carbonaceous	19	166
	Sandstone, dark-greenish-gray, very fine to fine-grained, friable, glauconitic(?)	2	168
	Shale, brownish-gray, silty, carbonaceous	5	173
	Shale, medium-gray, silty; sandstone, medium-gray, silty and clayey, interbedded	58	231
	Shale, medium-gray, silty, carbonaceous streaks	47	278
	Sandstone, dark-greenish-gray, friable, abundant glauconite, shaley, scattered carbonized wood fragments	16	294
	Sandstone, dark-greenish-gray, friable, very abundant glauconite, carbonized wood fragments	21	315
	Sandstone, dark-greenish-gray, very fine to fine-grained, friable, abundant glauconite; shale, grayish-green; interbedded	78	393
	Sandstone, dark-greenish-gray, very fine to fine-grained, friable, silty and clayey, very abundant glauconite	6	399
	Sandstone, dark-greenish-gray, very fine to fine-grained, silty and clayey, very abundant glauconite; shale, greenish-gray; black carbonaceous specks	22	421
	Shale, dark-gray, silty; sandstone, greenish-gray; interbedded	20	441
Pierre Shale:			
	Shale, grayish-black, silty in part	52	493

TABLE 2.--Logs of test holes -- Continued

138-80-13cdd
C. P. Yegen test hole 8
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Yellow clay------------------------	20	20
Gray clay--------------------------	40	60
Fine sand with clay layers---------	23	83
Good gravel with boulders----------	6	89
Gray clay (Fort Union Group)-------	1	90

138-80-15bbd
Fort Lincoln Nursery irrigation well 2
Log by Soil Conservation Service

Material	Thickness (feet)	Depth (feet)
Topsoil----------------------------	3	3
Sand and gravel--------------------	13	16
Very fine sand---------------------	10	26
Boulder----------------------------	11	27
Clay-------------------------------	10	37
Clay-------------------------------	10	47
Clay-------------------------------	10	57
Clay-------------------------------	3	60
Fine and medium sand---------------	2	62
Very fine sand---------------------	5	67
Very fine sand---------------------	1	68
Boulder----------------------------	1	69
Fine sand--------------------------	8	77
Lignite and gray clay--------------	3	87
Lignite----------------------------	6	93
Lignite and fine and medium sand---	4	97
Lignite and medium sand------------	10	107
Lignite and medium sand------------	10	117
Lignite and sand-------------------	12	129
Boulders (ended hole)--------------		129

TABLE 2.--Logs of test holes -- Continued

138-80-15cba
Fort Lincoln Nursery irrigation well 1
Log by Soil Conservation Service

Material	Thickness (feet)	Depth (feet)
Topsoil	4	4
Gravel	20	24
Clay	9	33
Fine sand	7	40
Blue clay	30	70
Fine sand	35	105
Fair sand	9	114
Fair gravel	26	140
Fine sand	23	163
Bedrock	1	164

138-80-15cdd
Test hole 1956

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, dark-yellowish-brown, very silty to sandy, oxidized, calcareous	7	7
	Gravel, fine to coarse, unsorted, subrounded; sand, coarse to very coarse; lignite fragments, oxidized	13	20
	Clay, moderate-yellowish-brown, silty to sandy; gravel, fine, poorly-sorted, subangular, interbedded, calcareous, oxidized	10	30
	Clay, grayish-olive-green, silty to sandy, cohesive, lignite fragments, calcareous	29	59
	Sand, very fine to fine, poorly-sorted, subangular, lignite fragments	20	79
	Lignite, detrital, rounded	4	83
	Clay, light-olive-gray, silty, cohesive, calcareous	10	93

TABLE 2.--Logs of test holes -- Continued

138-80-15cdd, Continued
Test hole 1956

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Gravel, fine to medium, subrounded; sand, medium to very coarse, rounded, lignite fragments----------------------------	63	156
Hell Creek Formation:			
	Clay, brownish-gray, very silty to sandy, cohesive, lignite fragments----------------------------	12	168

138-80-17aca
Auger hole 22

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, pale-yellowish-brown, clay--	4	4
	Clay, moderate-yellowish-brown; sand, fine to medium; silty-------------	15	19
	Sand, moderate-yellowish-brown, fine to medium, lignite fragments-------	15	34
	Sand, olive-gray, fine to medium, lignite fragments------------------	32	66
	Gravel, fine to coarse; sand, fine to very coarse---------------------	6	72

TABLE 2.--Logs of test holes -- Continued

138-80-17acb1
John Petersen irriation well 1
Log by Schnell, Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil----------------------------	3	3
Brown sandy soil--------------------	10	13
Fine sand--------------------------	27	40
Sand and coal (stratified)----------	13	53
Blue clay--------------------------	5	58
Gravel-----------------------------	31	89
Clay (Fort Union (?) Group)----------	1	90

138-80-17acb2
Auger hole 21

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, pale-yellowish-brown, clayey to silty-------------------	4	4
	Clay, moderate-yellowish-brown, silty----------------------------	16	20
	Sand, moderate-yellowish-brown, fine to medium, lignite fragments-	18	38
	Sand, light-olive-gray, fine to medium, clayey, lignite fragments-	13	51
	Gravel, medium, sandy, lignite fragments------------------------	2	53
	Clay, light-olive-gray; sand, fine to medium------------------------	6	59
	Gravel, fine to very coarse; sand, fine to very coarse---------------	8	67

TABLE 2.- Logs of test holes -- Continued

138-80-21ccc
Test hole 1854

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	1	1
	Clay, buff, silty and sandy	20	21
	Clay, brownish-gray, silty	6	27
	Sand, light-brown, very fine to fine	5	32
	Sand, light-brown, fine to medium, clayey, lignite fragments	17	49
	Gravel, medium to very coarse, lignite fragments	12	61
	Gravel, medium, sandy, abundant lignite fragments	63	124
Hell Creek Formation:			
	Sandstone, medium-gray, very fine to fine-grained, friable; shale, greenish-gray to dark-brown, lignitic	18	142
	Sandstone, greenish-gray, fine-grained, friable, clayey and silty, glauconitic (?)	5	147

138-80-22aac
Dan McDonald irrigation well 1
Log by Burgess Co.

Material	Thickness (feet)	Depth (feet)
Topsoil and clay	6	6
Sand	2	2
Gravel	10	18
Clay and gravel mixed	10	28
Clay	11	39
Sandy clay	35	74
Sand	2	76

TABLE 2.--Logs of test holes -- Continued

138-80-22aac, Continued
Dan McDonald irrigation well 1
Log by Burgess Co.

Material	Thickness (feet)	Depth (feet)
Sandy clay------------------------	8	84
Fine sand with lignite and clay layers--------------------------	9	93
Medium sand with lignite-----------	5	98
Rice gravel------------------------	20	118
Coarse gravel with lignite layers--	13	131

138-80-22abd1
Test hole 1958

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, yellowish-brown, silty-------	4	4
	Sand, very fine to coarse, unsorted, subangular, lignite fragments, oxidized--------------	7	11
	Sand, fine to very coarse, gravelly, subrounded, lignite fragments, oxidized--------------	6	17
	Gravel, fine to medium, sandy, subrounded, oxidized-------------	4	21
	Clay, pale-yellowish-brown, silty to sandy, cohesive, lignite fragments, oxidized, calcareous--	19	40
	Clay, light-olive-gray, silty to sandy, cohesive, lignite fragments, calcareous----------------	34	74
	Clay, light-olive-gray, silty, cohesive, sand, very fine to medium, unsorted, subrounded; lignite fragments----------------	11	85

TABLE 2.--Logs of test holes -- Continued

138-80-22abd1, Continued
Test hole 1958

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Clay, olive-gray, silty to sandy, cohesive; gravel, fine, rounded; interbedded, lignite fragments	18	103
	Gravel, very coarse, rounded, lignite fragments	49	152
Hell Creek Formation:			
	Claystone, medium-bluish-gray, silty	5	157

138-80-22abd2
Test hole 1957

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	1	1
	Sand, very fine to coarse, silty to clayey, oxidized	3	4
	Gravel, fine to coarse, sandy, unsorted, rounded, oxidized	16	20
	Sand, fine to very coarse, well-sorted, angular, oxidized	5	25
	Clay, yellowish-brown, sandy, cohesive, lignite fragments	7	32
	Clay, light-olive-gray, very silty to sandy, cohesive, lignite fragments	30	62

TABLE 2.--Logs of test holes -- Continued

138-80-22abd2, Continued
Test hole 1957

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Clay, light-olive-gray, silty to sandy, cohesive; sand, fine; interbedded, lignite fragments----	28	90
	Sand, fine to medium, well-sorted, angular to subrounded, lignite fragments------------------------	4	94
	Sand, fine to medium, well sorted; clay, olive-gray, cohesive, in terbedded------------------------	6	100
	Gravel, fine to coarse, sandy, unsorted, angular to rounded, lignite fragments-----------------	52	152
Hell Creek Formation:			
	Clay, light-olive-gray, silty to sandy, indurated-----------------	5 1/2	157 1/2

138-80-22bbc
Dan McDonald test hole
Log by Schnell, Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil-------------------------------	5	5
Sand----------------------------------	13	18
Clay----------------------------------	3	21
Blue sandy clay-----------------------	14	35
Sand with clay lenses-----------------	5	40
Blue sand-----------------------------	15	55
Gravel--------------------------------	9	64
Clay----------------------------------	1	65
Lignite-------------------------------	2	67
Coarse sand with lignite fragments--	16	83
Lignite-------------------------------	1	84
Nice gravel---------------------------	3	87
Coarse gravel-------------------------	11	98
Gravel,and lignite--------------------	2	100
Sand and gravel with lignite----------	20	120
Lignite-------------------------------	2	122
Nice gravel---------------------------	8	130

TABLE 2.--Logs of test holes -- Continued

138-80-23aab
Dennis Solberg test hole 3
Log by Schnell, Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	4	4
Sand and coal	13	17
Brown clay	3	20
Blue clay	18	38
Sandy clay	13	51
Fine sand	33	84
Coal	2	86
Medium gravel	9	95
Clay	5	100

138-80-23aba
Dennis Solberg test hole 2
Log by Schnell, Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	3	3
Sand and gravel	7	10
Brown clay	10	20
Blue clay	12	32
Sand	14	46
Sandy clay	7	53
Fine sand with coal layers	32	85
Medium gravel with coal at 90 feet	10	95
Clay	5	100

TABLE 2.--Logs of test holes -- Continued

138-80-23bdc
Dennis Solberg irrigation well 1
Log by Ben Hasz

Material	Thickness (feet)	Depth (feet)
Topsoil	1	1
Clay	4	5
Sand	8	13
Yellow clay	12	25
Sand	4	29
Blue clay	9	38
Blue sand	60	98
Sand and gravel	4	102
Boulders (gravel)	8	110

138-80-23ccc
Test hole 1855

Formation	Material	Thickness (feet)	Depth (feet)
	Topsoil, black	1	1
	Sand, brown, fine to medium, gravelly	15	16
	Clay, brown, silty and sandy	4	20
	Clay, medium-gray, silty and sandy	17	37
	Sand, medium-gray, very fine to medium, lignite fragments; clay, medium-gray; interbedded	11	48
	Sand, medium-gray, very fine to medium	9	57
	Clay, medium-gray; sand, fine to medium, lignite fragments	10	67
	Sand, medium-gray, fine to medium; clay, medium-gray; interbedded	26	93
	Lignite	2	95
	Gravel, medium to coarse, clay, gray; interbedded; lignite fragments	3	98

TABLE 2.--Logs of test holes -- Continued

138-80-23ccc, Continued
Test hole 1855

Formation	Material	Thickness (feet)	Depth (feet)
Hell Creek Formation:			
	Shale, brownish-black, carbonaceous	8	106
	Sandstone, greenish-gray, very fine to fine-grained, silty and clayey, glauconitic (?), friable	9	115
	Shale, medium to brownish-gray, silty and sandy	11	126
	Sandstone, greenish-gray, very fine to fine-grained, glauconitic (?), carbonaceous streaks	16	142
	Sandstone, greenish-gray, very fine to fine-grained, glauconitic (?), friable; shale, greenish-gray, silty; interbedded	6	148
	Sandstone, greenish-gray, very fine to fine-grained, friable, clayey, silty, glauconitc (?)	10	158
	Sandstone, greenish-gray, very fine to fine-grained, friable, silty; shale, brownish-gray, carbonaceous; interbedded	4	162
	Shale, brownish-gray, lignite fragments, very carbonaceous	17	179
Fox Hills Sandstone:			
	Sandstone, greenish-gray, very fine to fine-grained, friable, shaley and silty	62	241
	Shale, greenish-gray, silty and sandy	32	273

TABLE 2.--Logs of test holes -- Continued

138-80-24cac1
C. P. Yegen irrigation well 1
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	3	3
Clay	9	12
Sandy clay	5	17
Fine sand	7	24
Blue clay with sandy clay layers	41	65
Sand and lignite	1	66
Sandy clay	1	67
Sand and lignite	2	69
Rice gravel and lignite	3	72
Coarse gravel	8	80
Sandy clay	2	82
Lignite	1	83
Sandy clay	1	84
Tough clay	1	85

138-80-24cac2
53' SE of irrigation well 1
C. P. Yegen Observation Well
Log by Schnell, Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Sandy clay	5	7
Fine brown sand	7	14
Fine gray sand	5	19
Gray clay	24	44
Fine sand	3	47
Clay with streaks of fine sand at 56 feet	15	62
Fine sand	7	69
Medium sand and gravel with boulders (drilled tight)	7	76
Tight sandy clay	14	90

(Water level 5.91 feet below land surface)

TABLE 2.--Logs of test holes -- Continued

138-80-24cac3
C. P. Yegen Observation well
(160 feet SE of irrigation well 1)
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Yellow sandy clay	9	11
Gray clay	13	24
Fine sand	2	26
Gray clay	45	71
Medium gravel with boulders	3	74
Sandy clay	16	90

(Water level 7.83 feet below land suface)

138-80-24cbd
C. P. Yegen test hole 2
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	3	3
Yellow clay	11	14
Sand	4	18
Blue clay with sand lenses	21	39
Sand with clay layers	15	54
Clay	18	72
Sand and lignite	2	74
Gravel	4	78
Coarse sand with lignite	13	91

TABLE 2.--Logs of test holes -- Continued

138-80-24cca
C. P. Yegen test hole 3
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	3	3
Yellow clay	6	9
Sand	10	19
Clay	11	30
Sand	18	48
Clay	19	67
Sand, medium to coarse with lignite	11	78
Rock layers	3	81
Shale	9	90

138-80-24daa
Auger hole 2

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, moderate-yellowish-brown, very fine to medium, lignite fragments	7	7
	Sand, dusky-brown, very fine to medium, gravelly	3	10
	Sand, grayish-brown, fine to coarse, lignite fragments	11	21
	Clay, light-olive-gray, plastic, smooth, cohesive	6	27

TABLE 2.--Logs of test holes -- Continued

138-80-24dac
C. P. Yegen test hole 5
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Sandy loam topsoil------------------	3	3
Yellow sandy clay-------------------	6	9
Sand--------------------------------	25	34
Blue clay with traces of sand layers----------------------------	46	80
Fine sand with lignite--------------	3	83
Sandy blue clay---------------------	4	87
Fine sand with lignite (not good)---	12	99
Clay--------------------------------	6	105
Sand (fair)-------------------------	3	108
Sandy clay--------------------------	8	116
Medium sand-------------------------	4	120
Sand with clay layers---------------	4	124
Gravel------------------------------	11	135
Green tough clay with gravel mixed (not good)------------------------	5	140
Shale-------------------------------	10	150

138-80-24ddc
C. P. Yegen test hole 6
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil-----------------------------	2	2
Sand--------------------------------	27	29
Clay--------------------------------	13	42
Sandy clay--------------------------	22	64
Sand--------------------------------	4	68
Sandy clay--------------------------	30	98
Fine sand (fair)--------------------	26	124
Sandy clay--------------------------	4	128
Fine sand with traces of lignite----	15	143
Fine sand with cemented sand layers (tight)---------------------------	67	210
Shale-------------------------------	1	211

TABLE 2.--Logs of test holes -- Continued

138-80-25ddd
(566 feet SE of irrigation well 3)
C. P. Yegen observation well
Log by Schnell, Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	1	1
Brown sand	26	27
Sandy clay	16	43
Gravel	1	44
Sandy clay	8	52
Fine blue sand (tight)	11	63
Dark clay	1	64
Fine sand with lignite	16	80
Sticky clay	3	83
Fine to coarse sand	2	85
Sticky clay	41	126
Fine blue sand (tight)	8	134
Hard coal	1	135
Fine sand with clay streaks	2	137
Clay	3	140
Fine sand	3	143
Clay	10	153
Very fine sand (tight)	30	183
Coal	1	184
Clay	10	194
Rock layer and clay	1	195

(Water level 40.00 feet below land surface)

138-80-25bab
C. P. Yegen irrigation well 2
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	4	4
Sand	5	9
Clay	8	17
Sand	11	28
Clay	33	61
Fine sand, gray	19	80
Coarse sand and fine gravel	13	93
Coarse gravel	5	98
Clay	2	100

TABLE 2.--Logs of test holes -- Continued

138-80-25bba
C. P. Yegen test hole 4
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Yellow clay	6	8
Sand	10	18
Clay	50	68
Sand and gravel	7	75
Coarse sand with boulders	6	81

138-80-25cda
C. P. Yegen test hole 10
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Sandy clay	8	10
Dark Clay	7	17
Green-blue clay	15	32
Black clay	8	40
Brown clay	6	46
Sand blue clay	12	58
Lignite	1	59
Green sandstone	1	60

138-80-25dac
C. P. Yegen irrigation well 3
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Brown sand	14	16
Blue sand and coal	9	25
Coal	7	32
Sand and coal	14	46
Sticky clay	34	80

TABLE 2.--Logs of test holes -- Continued

138-80-25dac, Continued
C. P. Yegen irrigation well 3
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Sandy clay with gravel and coal	12	92
Sticky clay	10	102
Blue sand	2	104
Coal	1	105
Blue sand	1	106
Coal	1	107
Sand and coal	9	116
Clay	1	117
Silty clay	6	123
Sand and coal	3	126
Clay	16	142
Sand and coal	13	155

138-80-25dbd
C. P. Yegen test hole 3
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Sandy clay	28	30
Clay with sand layers	45	75
Clay (Fort Union Group)	5	80

138-80-25dda1
C. P. Yegen test hole 11
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Dry sand	8	10
Yellow clay	2	12
Sand	4	16
Clay	1	17
Sand	21	38

TABLE 2.--Logs of test holes -- Continued

138-80-25dda1, Continued
C. P. Yegen test hole 11
Log by Schnell Inc.

Material-Continued:	Thickness (feet)	Depth (feet)
Medium sand with lignite	47	85
Sticky gray clay	45	130
Sand and gravel cemented	24	155
Sand with lignite layers	44	199
Rock	2	201

138-80-25dda2
(150 feet SE of irrigation well 3)
C. P. Yegen observation well
Log by Schnell, Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	1	1
Brown sand	23	24
Gravel and coal streaks	2	26
Fine to medium sand	29	55
Coal	2	57
Sandy clay	5	62
Sticky gray clay (sand from 73-81 feet)	41	103
Coal	2	105
Fine sand with coal	11	116
Clay	1	117
Fine sand with coal (tight)	8	125
Clay	1	126
Fine sand with coal (tight)	2	128
Clay	3	131
Fine sand (drills tight)	3	134
Sticky clay	11	145
Fine sand with coal	14	159
Rock	1	160
Gray clay	4	164
Rock	1	165
Solid clay	15	180

(Water level 23.69 feet below land surface)

TABLE 2.--Logs of test holes -- Continued

138-80-25dda3
C. P. Yegen test hole 11a

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, yellowish-brown	2	2
	Sand, very fine to medium, oxidized, silty to clayey	40	42
	Gravel, fine to medium, mostly limestone and shale	2	44
	Clay, light-olive-gray	1	45
	Sand, very fine to medium, silty, a trace of lignite at 56 feet	9	64
	Sand, very fine to medium, subrounded to angular, silty	25	89
	Clay, light-olive-gray, silty	4	93
	Sand, fine to medium	5	98
	Clay, dark-olive-gray, plastic	8	106
	Silt, olive-gray, clayey, calcareous	21	127
	Peat and lignite	1	128
	Silt, clayey; sand, fine to medium	3	131
	Sand, medium to very coarse	5	136
	Gravel, fine to coarse, angular with streaks of clay	3	139
	Silt, sandy	7	146
	Clay, light-olive-gray, silty	10	156
	Silt, light-olive-gray; sand, fine, angular	1	157
	Clay, light-olive-gray, silty	2	159
	Sand, very fine to medium, angular, silty	8	167
	Clay, light-olive-gray, plastic	3	170
	Sand, very fine to medium, angular, silty; lignite fragments from 173 to 175 feet; clay, olive-gray, plastic	16	186

TABLE 2.--Logs of test holes -- Continued

138-80-25ddb
C. P. Yegen test hole 12
Log by Schnell, Inc.

Material	Thickness (feet)	Depth (feet)
Sandy clay------------------------	9	9
Sand------------------------------	29	38
Lignite---------------------------	1	39
Sand and gravel-------------------	27	66
Clay------------------------------	49	115
Medium sand-----------------------	25	140
Coarse sand (still in sand but lost circulation)---------------	20	160

138-80-27cdc
Test hole 1929

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, dark-yellowish-brown, silty, cohesive, lignite fragments, oxidized, calcareous------------	12	12
	Sand, very fine to fine, silty, poorly sorted, angular to rounded, lignite fragments, oxidized------------------------	5	17
	Sand, very fine to fine, well-sorted, angular to rounded, lignite fragments---------------	9	26
	Sand, very fine to coarse, poorly-sorted, subangular to rounded, lignite fragments------	15	41
Hell Creek Formation:			
	Clay, greenish-gray to yellowish-orange, silty to sandy, indurated, snail shells, lignite fragments------------------------	11 1/2	52 1/2

TABLE 2.--Logs of test holes -- Continued

138-80-27dda
Test hole 1856

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, dark-brown, sandy---------	5	5
	Clay, buff, silty to sandy---------	16	21
	Clay, medium-gray, silty; sand, very fine to fine; interbedded---	22	43
Hell Creek Formation:			
	Shale, medium-gray, silty, carbonaceous------------------------	4	47
	Shale, light-greenish-gray, silty and sandy, glauconitic (?)-------	5	52
	Sandstone, greenish-gray, very fine to fine-grained, friable, silty and clayey-----------------------	11	63
	Shale, brownish-black, very carbonaceous--------------------------	5	68
	Shale, medium-gray, silty----------	5	73
	Shale, light-greenish-gray, silty to sandy, glauconitic (?)--------	5	78
	Shale, medium-gray, silty; sandstone, greenish-gray, friable; interbedded----------------------	11	89
	Sandstone, light-greenish-gray, very fine to fine-grained, silty and clayey, friable, glauconitic-	16	105
	Shale, brownish-gray, carbonaceous, lignite seams--------------------	16	121
	Sandstone, light-greenish-gray, very fine to fine-grained, silty and clayey-----------------------	5	126
	Shale, medium-gray, silty; sandstone, dark-greenish-gray, friable, very glauconitic-----------	5	131
	Sandstone, dark-greenish-gray, friable, very glauconitic--------	5	136
	Shale, brownish-gray, carbonaceous; lignite seams; interbedded-------	5	141

138-80-27dda, Continued
Test hole 1856

Formation	Material	Thickness (feet)	Depth (feet)
Fox Hills Sandstone:			
	Sandstone, light-greenish-gray, very fine to fine, silty and clayey, scattered glauconite grains-------------------------	6	147

138-80-29bab
Test hole 1013

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, fine, clayey-----------------	7	7
	Sand, fine to medium, lignite and wood fragments-------------------	25	32
	Sand, fine to medium; gravel, fine; lignite and wood fragments-	20	52
	Clay, light-gray-------------------	5	57
	Sand, fine to medium, silty--------	4	61
	Gravel, medium to coarse-----------	9	70

138-80-29bad
State Prison Farm irrigation well 1
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil----------------------------	4	4
Sand-------------------------------	4	8
Brown clay-------------------------	11	19
Gray fine sand---------------------	13	32
Gray clay--------------------------	2	34
Sand, medium, coal-----------------	18	52
Sand and clay layers (stratified)--	11	63

TABLE 2.--Logs of test holes -- Continued

138-80-29bad, Continued
State Prison Farm irrigation well 1
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Fine gravel	7	70
Medium and coarse gravel	23	93
Clay, sandy	3	96
Medium sand	10	106
Clay	4	110

138-80-29bbb1
Test hole 1012

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, brown, sandy	2	2
	Clay, brown, smooth	6	8
	Sand, fine to coarse, lignite fragments	82	90
	Gravel, fine to coarse, rounded	30	120
	Gravel, coarse, sandy; clay, gray	5	125
Hell Creek Formation:			
	Clay, light-gray; sandy, fine to coarse	5	130

TABLE 2.--Logs of test holes -- Continued

138-80-29bbb2
Test hole 1853

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, brown, silty	5	5
	Clay, yellowish-brown, silty; sand, light-gray, very fine to fine	5	10
	Sand, medium-gray, very fine to fine, clayey	11	21
	Sand, medium-gray, fine to medium, well-rounded, lignite fragments	10	31
	Sand, medium-gray, medium to coarse, well-rounded, poorly-sorted, lignite fragments	23	54
	Gravel, medium to coarse, clayey to silty, abundant lignite fragments	9	63
	Gravel, medium to coarse; sand, gray, medium to coarse; interbedded, abundant lignite fragments	10	73
	Sand, medium-gray, fine to medium, abundant lignite fragments	19	92
	Gravel, coarse to very coarse, abundant lignite fragments	19	111
Hell Creek Formation:			
	Shale, greenish-gray to brownish-black, lignitic, sandstone, greenish-gray, clayey, glauconitic (?), friable	25	136
	Shale, brown and brownish-gray, lignitic, very carbonaceous	6	142
	Sandstone, greenish-gray, very fine to fine-grained, friable, clayey, glauconitic (?)	5	147

TABLE 2.--Logs of test holes -- Continued

139-75-3ddd
Test hole 1977

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil	1	1
	Gravel, fine to medium, subangular to rounded, oxidized	3	4
	Clay, moderate-yellowish-brown	16	20
	Till, olive-gray, silty to sandy, lignite fragments, calcareous	54	74
Hell Creek Formation:			
	Sandstone, grayish-green, mica and lignite fragments, glauconitic	11	85
	Sandstone, grayish-blue-green, friable, lignite flakes, glauconitic	15	100
	Clay, dusky-yellowish-brown, silty, carbonaceous	13	113
	Sandstone, grayish-blue-green, medium-grained, glauconitic	29	142
Fox Hills Sandstone:			
	Sandstone, medium-bluish-gray, clayey, lignite flakes, glauconitic; shale, olive-gray	16	158
	Sandstone, light-gray, very fine grained, well-indurated, calcareous	3	161
	Clay, olive-gray, silty, well-indurated; sandstone, medium-bluish-gray, glauconitic	2	163
	Shale, olive-gray, silty, indurated	7	170
	Sandstone, olive to greenish-gray, clayey, glauconitic	17	187
	Sandstone, light-gray, very fine-grained	1	188
	Sandstone, dark-greenish-gray, lignite fragments, glauconitic	32	220

TABLE 2.--Logs of test holes -- Continued

139-75-3ddd, Continued
Test hole 1977

Formation	Material	Thickness (feet)	Depth (feet)
	Sandstone, dark-greenish-gray, very fine to fine-grained, lignite and mica flakes, glauconitic-------------------------	32	252
	Sandstone, moderate-bluish-green, very fine to fine-grained, abundant glauconite; shale, light-olive-gray, sandy, abundant lignite-------------------------	32	284

139-75-19caa
Test hole 2049D

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil---------------------------	1	1
	Clay, gray, silty, highly-calcareous-------------------------	4	5
	Gravel, medium to very coarse; sand, coarse; subrounded, unsorted, oxidized-----------------	10	15
	Till, dark-greenish-gray, abundant shale, calcareous--------	26	41
	Gravel, granular, sand, medium to coarse; subangular to subrounded----------------------	5	46
Hell Creek Formation:			
	Shale, dusky-brown, lignitic, silty, oxidized-----------------	3	49
	Shale, dark-greenish-gray, very silty, some lignite--------------	3 1/2	52 1/2

TABLE 2.--Logs of test holes -- Continued

139-75-22ccb
Test hole 2020

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Till, moderate-yellowish-brown, silty, lignite fragments, oxidized, highly-calcareous	10	10
	Till, dark-yellowish-orange, silty, lignite fragments, oxidized, highly-calcareous	22	32
	Till, dark-greenish-gray, abundant shale, lignite and boulders	25	57
Hell Creek Formation:			
	Sandstone, medium-bluish-gray, very fine to fine-grained, silty, indurated, black and green grains, some organic material	3	60

139-76-20abb
Test hole 2017

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	1 1/2	1 1/
	Sand, very fine to coarse, silty to clayey, unsorted, calcareous, oxidized	10 1/2	12
	Till, moderate-yellowish-brown, highly-calcareous, oxidized	13	25
	Till, moderate-yellowish-brown, rusty streaks, highly calcareous, oxidized	17	42
Cannonball Formation:			
	Silt, olive-black, clayey to sandy, indurated, mica flakes, oxidized	8	50

TABLE 2.--Logs of test holes -- Continued

139-76-26dda
Test hole 2034

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Till, yellowish-brown, silty	1	1
	Gravel, medium to coarse, subangular to subrounded, poorly-sorted	4	5
Hell Creek Formation:			
	Sand, light-olive-gray, fine, silty to clayey, plastic, partially-oxidized	9	14
	Sand, olive-gray, fine, silty to clayey, plastic	2	16
	Shale, olive-gray, sandy, indurated	4	20
	Shale, brownish-gray, silty to sandy	9	29
	Shale, bluish-olive-gray, silty to sandy, smooth, indurated	13	42

139-77-1bbb
Test hole 2055

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, sandy	1	1
	Sand, gray to black, fine, clayey and silty, calcareous	4	5
	Sand, clayey, some gravel	1	6
	Till, moderate-olive-brown, very sandy, leached, oxidized	11	17
	Till, olive-gray, silty, calcareous	22	39
	Till, olive-gray, very sandy, calcareous, much reworked bedrock	11	50
	Gravel, fine to medium, oxidized	1	51

TABLE 2.--Logs of test holes -- Continued

139-77-1bbb, Continued
Test hole 2055

Formation	Material	Thickness (feet)	Depth (feet)
Cannonball Formation:			
	Sand, moderate-olive-brown, fine, loosely-consolidated, oxidized---	12	63

139-77-6aaa
Test hole 1934

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift;			
	Topsoil, black---------------------	2	2
	Clay, dark-brown, sand, carbonaceous--------------------------	4	6
	Sand, gray, fine to very coarse, gravelly, abundant shale---------	11	17
	Clay, greenish-gray, silty---------	3	20
	Gravel, fine to medium, sandy, lignite fragments------------------	2	22
	Clay, olive-gray, silty and sandy--	10	32
	Clay, olive-gray, very silty; sand, fine to very coarse; interbedded-	21	53
	Clay, medium to olive-gray, silty and sandy------------------------	6	59
	Sand, very coarse, gravelly--------	9	68
Hell Creek Formation:			
	Shale, grayish-brown, silty and sandy; sandstone, medium-dark-gray, abundant green grains------	15	83
	Shale, medium-gray, silty and sandy----------------------------	11	94

139-77-8cbc
Test hole 1953

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil----------------------------	1	1
	Gravel, fine, sandy, unsorted, subrounded, oxidized-----------------	2	3
	Clay, pale yellowish-brown, silty, cohesive, lignite fragments, calcareous, oxidized-----------------	16	19
	Sand, fine to coarse, poorly-sorted, angular to rounded, lignite fragments, oxidized----------	21	40
	Sand, fine to coarse, poorly-sorted, angular to rounded, lignite fragments----------------------------	6	46
	Clay, light-olive-gray, silty, cohesive, highly calcareous---------	6	52
	Clay, dark-greenish-gray, silty to sandy, slightly cohesive, lignite fragments, calcareous-------------	16	68
	Clay, light-olive-gray, silty, cohesive, highly-calcareous---------	36	104
Hell Creek Formation:			
	Clay, greenish-gray, silty to sandy, cohesive, black specks------------	11	115

139-77-15ccc
Test hole 2016

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, moderate-yellowish-brown, silty, calcareous, oxidized-------	12	12
	Clay, moderate-yellowish-brown, silty, cohesive, calcareous, oxidized-------------------------	8	20

TABLE 2.--Logs of test holes -- Continued

139-77-15ccc, Continued
Test hole 2016

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued			
	Gravel, fine to medium, sandy, unsorted, subrounded, abundant carbonates----------------------	2 1/2	22 1/2
	Till, dark-greenish-gray, very sandy, lignite fragments, calcareous-------------------------	8	30 1/2
Cannonball Formation:			
	Sand, greenish-gray, silty to clayey, abundant black and green grains, some mica and lignite flecks---------------------	14 1/2	45

139-77-20ccc
Test hole 2036

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black---------------------	7	7
	Silt, moderate-yellowish-brown, cohesive, calcareous, oxidized---	6	13
	Silt, dark-greenish-gray, lignite fragments, calcareous------------	27	40
	Silt, dark-greenish-gray, clayey, tiny lignite flecks, calcareous--	15	65
	Gravel, fine to coarse, sandy, unsorted, subrounded, predominately carbonates----------------------	3	68
	Silt, light-olive-gray, cohesive, calcareous----------------------	39	107

TABLE 2.--Logs of test holes -- Continued

139-77-20ccc, Continued
Test hole 2036

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Sand, very fine to fine, silty to clayey, unsorted, abundant lignite fragments----------------	45	152
	Sand, medium, silty to clayey, unsorted abundant, carbonates and lignite----------------------	56	208
	Boulder, limestone-----------------	1 1/2	209 1/2
Fox Hills Sandstone:			
	Silt, dark-greenish-gray, clayey, indurated, mica flakes-----------	15 1/2	225

139-77-32aaa
Test hole 1866

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black---------------------	1	1
	Clay, light-brown to light-gray, silty----------------------------	25	26
	Clay, medium-gray, silty-----------	16	42
	Clay, brownish-gray, cohesive-------	48	90
	Gravel, medium; sand, very coarse--	1	91
	Clay, medium-gray, silty in part---	35	126
	Clay, medium-gray; sand, fine to medium; silty--------------------	63	189
	Gravel, medium to coarse; sand, coarse; abundant lignite---------	11	200
Fox Hills Sandstone:			
	Shale, medium-gray, silty, carbonaceous------------------------	31	231

TABLE 2.--Logs of test holes -- Continued

139-77-32aaa, Continued
Test hole 1866

Formation	Material	Thickness (feet)	Depth (feet)
Fox Hills Sandstone-Continued:			
	Shale, greenish-gray, silty, sandstone, fine to very fine-grained, friable, abundant green grains----	21	252

139-77-34bbb
Test hole 2035

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, grayish-orange, silty, highly-calcareous, oxidized----------	5	5
	Clay, moderate to dark-yellowish-brown, silty, highly-calcareous, oxidized-------------------------	22	27
Hell Creek Formation:			
	Sand, dusky-yellow, very fine to fine, clayey, cohesive, oxidized--	8	35
	Sand, dark-greenish-gray, very fine to fine, clayey, lignite fragments-------------------------	6	41
	Clay, dark-yellowish-brown, silty, indurated, abundant lignite fragments------------------------	4	45

TABLE 2.--Logs of test holes -- Continued

139-78-8aaa
Test hole 1950

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, light-olive-gray, silty and sandy, calcareous	6	6
	Clay, medium-dark-gray, very sandy, silty, calcareous	1	7
	Gravel, fine; sand, coarse to very coarse	2	9
	Clay, medium-dark-gray, very sandy, silty, calcareous	8	17
	Gravel, fine to medium	3	20
	Till, olive to greenish-gray, sandy, lignite and shale particles	26	46
	Clay, olive-gray, very sandy, silty, lignite flakes	30	76
	Clay, brownish-gray to olive-black, sandy and silty, carbonaceous, calcareous	8	84
	Clay, olive-gray, sandy, silty, calcareous	8	92
	Shale, brownish-gray to greenish-gray, silty	13	105

139-78-11aaa
Test hole 1951

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, light-olive-gray, clayey, silty, calcareous	10	10
	Gravel, fine to medium; sand, medium to very coarse; clay, olive-gray, silty	5	15
	Clay, olive-gray, silty, lignite fragments	20	35

139-78-11aaa, Continued
Test hole 1951

Formation	Material	Thickness (feet)	Depth (feet)
Hell Creek Formation:			
	Sandstone, greenish-gray, medium to very fine grained, silty and clayey, friable, abundant dark grains-----------------------	7	42
	Shale, brownish-gray, silty, carbonaceous, lignite fragments------	11	53
	Sandstone, greenish-gray, very fine to fine-grained, friable, silty and clayey, mica flakes, scattered dark minerals, glauconitic-	10	63

139-78-11abb
Test hole 1932

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black----------------------	1	1
	Clay, dark-yellowish-orange, silty to sandy, calcareous, oxidized----	6	7
	Clay, moderate-yellowish-brown, silty, cohesive, calcareous, oxidized--------------------------	9	16
	Clay, dark-yellowish-orange, very silty, cohesive, calcareous, oxidized--------------------	18	34
Hell Creek Formation:			
	Sand, greenish-gray to brownish-gray, silty to clayey, lignite fragments, abundant green grains--	29	63

TABLE 2.--Logs of test holes -- Continued

139-78-16ccc
Test hole 1865

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	2	2
	Clay, brown to buff, silty and sandy	13	15
	Gravel, medium; sand, medium to very coarse	2	17
	Clay, light to medium-gray, silty and sandy	5	22
	Gravel, fine; sand, very coarse	4	26
	Clay, brownish-gray, silty	10	36
	Clay, medium-gray, silty	6	42
	Sand, gray, very fine to medium, silty, poorly-sorted, well-rounded, abundant lignite fragments	21	63
	Sand, gray, very fine to medium, silty, rounded; clay, medium-gray, silty, interbedded with sand	31	94
	Clay, medium-gray, silty to sandy	11	105
	Sand, gray, very fine to medium, silty; clay, medium-gray; abundant lignite; interbedded sand and clay	43	148
	Gravel, medium to coarse; sand, medium to very coarse; abundant lignite from 148-153 feet	11	159
Hell Creek Formation:			
	Shale, light-bluish-gray, silty, sandy in part, abundant glauconite grains	14	173
	Sandstone, greenish-gray, fine to very fine-grained, friable, abundant glauconite grains, specks of black and brown, carbonaceous	10	183

TABLE 2.--Logs of test holes -- Continued

139-78-16ccc, Continued
Test hole 1865

Formation	Material	Thickness (feet)	Depth (feet)
Fox Hills (?) Sandstone:			
	Shale, light-greenish-gray, silty; sandstone, greenish-gray, fine to very fine grained, silty, abundant glauconite grains; interbedded	27	210

139-78-19ddd
Test hole 2011

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	2	2
	Silt, dark-yellowish-orange, slightly-cohesive, abundant lignite fragments, highly-calcareous, oxidized	10	12
	Silt, dark-yellowish-brown, cohesive, lignite fragments, highly-calcareous, oxidized	24	36
	Clay, dark-greenish-gray, silty, cohesive, lignite fragments, calcareous	4	40
	Gravel, fine, sandy, subrounded to well-rounded, unsorted, abundant carbonates	4	44
	Sand, very fine to medium, silty, unsorted, angular to subangular, abundant lignite fragments	10	54
	Clay, greenish-gray, silty, cohesive, calcareous	6	60
	Silt, greenish-gray, sandy, unsorted, cohesive, lignite and mica flakes, calcareous	30	90

TABLE 2.--Logs of test holes -- Continued

139-78-19ddd, Continued
Test hole 2011

Formation	Material	Thickness (feet)	Depth (feet)
Hell Creek Formation:			
	Sand, dark-greenish-gray, very fine to fine, cohesive, abundant lignite, changing to dark-yellowish-green	45	135

139-78-22bb
T. C. Casey test hole 10
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Sandy clay loam	16	18
Sand, gravel, and clay	5	23
Sand and gravel	9	32
Gravel,with clay, blue	10	42
Blue clay	55	97
White rock chips and gravel	3	100
Fine sand with sandy clay layers	40	140
Soft sand rock with clay layers	12	152
Sand rock	15	167
Gravel	28	195

TABLE 2.--Logs of test holes -- Continued

139-78-22bd
T. C. Casey test hole 13
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	4	4
Fine sand	9	13
Blue sandy clay	60	73
Gravel	3	76
Soft blue clay	64	140
Sand	20	160
Gravel	6	166
Bedrock	14	180

139-78-22cc
T. C. Casey test hole 12
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	3	3
Sand and small gravel	22	25
Blue clay	3	28
Sand and lignite	3	31
Blue clay	12	43
Sand layer	1	44
Clay with thin sand and lignite layers	44	88
Sand and gravel	4	92
Clay, sand and gravel in layers	57	149
Bedrock (Fort Union Group)	31	180

139-78-22cd
T. C. Casey test hole 11
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Topsoil	2	2
Dry sand	5	7

139-78-22cd, Continued
T. C. Casey test hole 11
Log by Schnell Inc.

Material	Thickness (feet)	Depth (feet)
Yellow clay	25	32
Gray clay	12	44
Gravelly clay	1	45
Gray clay, sandy	23	68
Gravel with boulders	4	72
Sandy clay with sand lenses	50	122
Tough clay with some sandy clay layers	52	174
Sand	4	178
Clay	2	180
Soft sandstone	25	205
Sandy clay	1	206
Sand	5	211
Sandy clay layers and sandstone (thin lenses)	5	216

139-78-23cda
Test hole 2010

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil	1	1
	Silt, dark-yellowish-orange, clayey, cohesive, lignite flecks, highly-calcareous, oxidized	11	12
	Clay, light-olive-gray, very silty, cohesive, highly-calcareous, oxidized	15	27
	Silt, dark-greenish-gray, cohesive, abundant lignite flecks, calcareous	5	32
	Sand, very fine to fine, silty to clayey, abundant lignite	7	39
	Silt, dark-greenish-gray, clayey, very cohesive, lignite flecks, calcareous	23	62

TABLE 2.--Logs of test holes -- Continued

139-78-23cda, Continued
Test hole 2010

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Gravel, fine to medium, sandy, angular to well-rounded, abundant carbonates, lignite and fossil fragments	2	64
	Clay, dark-greenish-gray, silty, very cohesive, calcareous	5	69
	Gravel, fine to medium sandy	1	70
	Till, dark-greenish-gray, silty to sandy, lignite fragments, calcareous	13	83
	Sand, fine, gravelly, unsorted, angular to rounded, abundant carbonates and shale, some lignite	5	88
	Till, dark-greenish-gray, silty to gravelly, lignite fragments, calcareous	44	132
	Silt, dark-greenish-gray, clayey to sandy, lignite flakes, calcareous	47	179
	Sand, very fine to medium, silty, unsorted, lignite fragments	47	226
	Gravel, fine to coarse, sandy, unsorted, angular to well-rounded, abundant brownish pebbles, some carbonates	34	260
Fox Hills Sandstone:			
	Clay, dark-greenish-gray, very silty, cohesive, lignite fragments	5	265

TABLE 2.--Logs of test holes -- Continued

139-78-24dcd
Test hole 1933

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	1	1
	Clay, light-olive-gray, silty to sandy, cohesive, abundant organic material, calcareous, oxidized	10	11
	Clay, medium-dark-gray, silty to sandy, cohesive, calcareous	12	23
	Clay, light-olive-gray, silty, co hesive, lignite flakes, calcareous	44	67
	Gravel, fine to coarse, sandy, subangular to subrounded	5	72
	Clay, light-olive-gray, silty, cohesive, lignite fragments, calcareous	2	74
	Gravel, fine to coarse, sandy, subangular to subrounded	3	77
	Clay, light-olive-gray, silty, cohesive, lignite fragments, calcareous	6	83
	Gravel, fine to coarse, sandy, subangular to subrounded	5	88
	Clay, light-olive-gray, silty, cohesive, lignite fragments, calcareous	26	114
	Gravel, fine to medium, sandy, subangular to rounded; clay, light-olive-gray, silty; interbedded	7	141
	Gravel, fine, sandy, angular to well-rounded, lignite fragments	32	173
	Sand, fine to very coarse, angular to well-rounded, abundant quartz	38	211
Fox Hills Sandstone:			
	Sandstone, medium-gray, very fine to fine-grained, friable, silty and clayey, abundant dark grains	20	231

TABLE 2.--Logs of test holes -- Continued

139-78-27cbb
Test hole 2037

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Silt, dark-yellowish-orange, clayey, cohesive, lignite fragments, calcareous	20	20
	Silt, dark-yellowish-brown; sand, very fine to medium, oxidized	5	25
	Silt, dark-greenish-gray, sandy, lignite fragments, calcareous	15	40
	Clay, olive to greenish-black, silty, cohesive, slightly-calcareous	10	50
	Silt, olive-gray, sandy, lignite fragments, calcareous	30	80
	Silt, olive-gray, very sandy, abundant quartz and lignite	24	104
	Till, olive-gray, calcareous	7	111
	Till, olive-to dark-greenish-gray, silty to very sandy, lignite fragments, calcareous	34	145
	Silt, light-olive to greenish-gray, clayey, cohesive, abundant lignite, calcareous	55	200
	Gravel, fine to coarse, sandy, angular to rounded, unsorted	45	245
Fox Hills Sandstone:			
	Clay, greenish-gray, very silty, cohesive, indurated, mica flakes	10	255

TABLE 2.--Logs of test holes -- Continued

139-78-30cdd
Test hole 2054

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	3	3
	Till, moderate-yellowish-brown, oxidized, calcareous	14	17
Hell Creek Formation:			
	Sandstone, very fine to medium, slightly-calcareous, some lignite	15	32
	Sandstone, very fine to medium, clayey, oxidized	5	37
	Clay, olive-gray, silty, indurated	5	42
	Sandstone, dark-greenish-gray, clayey	3	45

139-78-31ddb
Test hole 1864

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	2	2
	Clay, yellowish-brown, silty	13	15
	Clay, medium-gray, silty, homogenious	130	145
	Gravel, medium to coarse	2	147
Hell Creek Formation:			
	Shale, dark-brown, silty and sandy, carbonaceous, lignite seams; sandstone, very fine to fine-grained, friable, glauconitic (?)	5	1522
	Shale, dark-brownish-gray, silty and sandy, carbonaceous; sandstone, bluish-gray, very fine to fine-grained, clayey, friable	16	168

TABLE 2.--Logs of test holes -- Continued

139-78-31ddb, Continued
Test hole 1864

Formation	Material	Thickness (feet)	Depth (feet)
Fox Hills Sandstone:			
	Sandstone, light-bluish-gray, very fine to fine-grained, friable, scattered glauconite (?) grains---	31	199
	Sandstone, light-bluish-gray, very fine to fine-grained, friable, glauconitic (?), scattered carbonaceous specks------------------	6	205
	Shale, light-gray, silty and sandy, interbedded brown fiverous carbonaceous material----------------	5	210
	Sandstone, light-gray, very fine to fine-grained, friable, glauconitic (?); shale, light-gray, silty------	10	220
	Shale, light-gray, silty------------	11	231
	Sandstone, light-gray, very fine to fine-grained, friable, clayey and silty, glauconitic (?)------------	10	241
	Shale, light to medium-gray, silty; shale, dark-brownish-gray---------	37	278
	Shale, light to medium-gray, silty, thin brown carbonaceous streaks---	5	283
	Shale, light to medium-gray, silty; sandstone, dark-greenish-gray, very fine to fine-grained, friable, glauconitic-----------------------	5	288
	Shale, light to medium-gray, silty--	21	309
	Sandstone, dark-greenish-gray, very fine to fine-grained, clayey and silty, friable; shale, medium-gray, silty, indurated from 383-386 feet--------------------------	79	388
	Sandstone, light to dark-greenish-gray, friable, some indurated layers, abundant glauconite grains----------------------------	16	404
	Shale, dark-greenish-gray, very sandy and silty, abundant glauconite----------------------------	5	409

TABLE 2.--Logs of test holes -- Continued

139-78-31ddb, Continued
Test hole 1864

Formation	Material	Thickness (feet)	Depth (feet)
Fox Hills Sandstone-Continued:			
	Shale, dark-greenish-gray, sandy and silty; sandstone, very fine to fine-grained, friable, indurated from 426-428 feet; abundant glauconite----------------	19	428
Pie re Shale:			
	Shale, dark-gray, silty in parts	44	472

139-78-33bbc
Auger hole 6

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, light-olive-gray; sand, fine to medium--------------------------	14	14
	Clay, olive-gray, sandy---------------	3	17
	Sand, dark-gray, very fine to medium---------------------------------	4	21
	Clay, dark-gray, sandy, silty, lignitic------------------------------	36	57

139-79-18dad
Shot Point 121
Log by Magnolia Petroleum Co.

Material	Thickness (feet)	Depth (feet)
Clay, some gravel and sandstone------	10	10
Brown clay---------------------------	18	28
Blue clay----------------------------	10	38
Hard sandstone-----------------------	2	40
Blue clay----------------------------	40	80

TABLE 2.--Logs of test holes -- Continued

139-79-19aab
Shot Point 39
Log by Magnolia Petroleum Co.

Material	Thickness (feet)	Depth (feet)
Clay	4	4
Sand gravel and small boulders	10	14
Blue shale	45	59
Very hard shale	2	61
Blue shale	9	70
Sandy blue clay	10	80

139-79-22aaa
Shot Point 55
Log by Magnolia Petroleum Co.

Material	Thickness (feet)	Depth (feet)
Brown clay	7	7
Yellow clay	9	16
Blue clay	4	20
Sandy blue clay	10	30
Blue clay	10	40
White, brown, and black clay	5	45
Sandy clay	5	50
Blue clay	24	74
Coal	1	75
Blue clay	5	80

TABLE 2.--Logs of test holes -- Continued

139-79-24bcc
Test hole 1930

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, dark-yellowish-brown, silty, oxidized, calcareous	5	5
	Clay, olive-gray, silty to sandy, lignite fragments, calcareous	5	10
	Sand, fine to medium; gravel, fine; unsorted, angular to well-rounded, lignite fragments	5	15
	Gravel, fine to medium, sandy, poorly-sorted, subrounded to rounded	11	26
Hell Creek Formation:			
	Clay, greenish-gray; sand, fine, angular; abundant lignite and glauconite	11	37
	Clay, moderate-yellowish-brown, sandy, abundant lignite, glauconite and shale	5	42

139-79-33aad
U. S. B. R. drill hole 5

Material	Thickness (feet)	Depth (feet)
Topsoil, brown, organic, sandy	1	1
Sand, tan, fine, silty, dry, dense	14	15
Clay (shale) (Fort Union Group) gray, very tough and firm, dry	19.6	34.6

TABLE 2.--Logs of test holes -- Continued

139-79-35aad1
Test hole 1862

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	1	1
	Clay, brown, silty and sandy	14	15
	Sand, medium-gray, fine to medium; clay, gray, silty	7	22
	Sand, medium-gray, very fine to fine	4	26
	Sand, medium to very coarse; gravel, fine to medium; clayey, pelecypod shells	6	32
	Clay, medium-gray, gastropod shells	31	63
	Clay, light to medium-gray, silty	21	84
	Clay and sand, interbedded. Clay, medium-gray, silty; sand, gray, very fine to fine	21	105
	Sand, medium-gray, very fine to fine; clay, medium-gray, silty, interbedded with sand	21	126
	Sand, gray, fine to medium, clayey, abundant lignite fragments	16	142
	Gravel, medium to very coarse, abundant lignite (lost circulation abandoned hole)	5	147

139-79-35aad2
Test hole 1862 A
(50 feet south of aad1)

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	1	1
	Clay, brown, silty to sandy	20	21
	Sand gravel. Sand, medium to very coarse; gravel, fine to medium	10	31
	Clay, light to medium-gray	11	42

139-79-35aad2, Continued
Test hole 1862 A
(50 feet south of aad1)

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Clay, light-medium-gray, silty, lignite fragments----------------	21	63
	Clay, medium to brownish-gray, silty----------------------------	21	84
	Clay, medium-gray, silty-----------	10	94
	Clay and sand, interbedded. Clay, medium-gray, silty; sand, medium-gray, very fine to fine----------	11	105
	Sand, medium-gray, very fine to fine, silty to clayey------------------	21	126
	Sand, fine to medium, clayey, abundant lignite fragments--------	16	142
	Gravel and sand. Gravel, medium to very coarse; sand, medium to very coarse----------------------	10	152

139-79-35ca
U. S. B. R. drill hole 8

Material	Thickness (feet)	Depth (feet)
Clay, brown and gray, plastic, soft--------------------------------	13	13
Sand, gray, fine, silty-------------	4	17
Clay, gray, silty, firm------------	3	20
Sand, gray, fine, silty, dense-----	10	30

139-79-35cba
U.S.B.R. drill hole 7

Material	Thickness (feet)	Depth (feet)
Clay, brown, plastic, soft	11	11
Clay, gray, organic, plastic, soft	4	15
Sand, gray, fine to coarse, fine gravels	3	18
Sand, gray, fine, silty	8	26
Sand, gray, fine, few gravels	9	35
Sand, gray, fine with lignite particles, dense	14.8	49.8

139-80-2bba
Shot Point 201
Log by Magnolia Petroleum Co.

Material	Thickness (feet)	Depth (feet)
Yellow clay	24	24
Sandy clay	45	69
Sand	9	78
Blue clay	12	90

139-80-3abb
Test hole 1981

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil	2	2
	Gravel, fine to medium, sandy, unsorted, subrounded, to rounded	3	5
	Till, grayish-orange, silty to sandy, lignite fragments, calcareous, oxidized	15	20
	Till, dark-greenish-gray, silty to sandy, lignite fragments, calcareous	7	27

TABLE 2.--Logs of test holes -- Continued

139-80-3abb, Continued
Test hole 1981

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Sand, very fine to coarse, silty to gravelly, predominately quartz	4	31
	Till, dark-greenish-gray, shale and lignite, calcareous	8	39
Cannonball Formation:			
	Sand, very fine to medium, predominately quartz, lignite fragments	6	45
	Sand, very fine to fine, clayey, predominately quartz, some lignite	10	55

139-80-4bab
Shot Point 159
Log by Magnolia Petroleum Co.

Material	Thickness (feet)	Depth (feet)
Clay	3	3
Sand and gravel	12	15
Yellow sandy clay	13	28
Sand with gravel streaks	37	65
Blue sandy clay	15	80

139-80-9ada
Shot Point 63
Log by Magnolia Petroleum Co.

Material	Thickness (feet)	Depth (feet)
Clay, some gravel and small boulders	10	10
Yellow sandy clay	17	27

TABLE 2.--Logs of test holes -- Continued

139-80-9ada, Continued
Shot Point 63
Log by Magnolia Petroleum Co.

Material	Thickness (feet)	Depth (feet)
Blue clay	15	42
Hard ledge	2	44
Sandy blue clay	21	65
Blue clay	15	80

139-80-10aaa2
Shot Point 75
Log by Magnolia Petroleum Co.

Material	Thickness (feet)	Depth (feet)
Sandy clay	20	20
Sand and gravel	21	41
Blue clay	39	80

139-80-22abb
Shot Point 129
Log by Magnolia Petroleum Co.

Material	Thickness (feet)	Depth (feet)
Clay	8	8
Yellow clay, some sand and gravel	7	15
Blue clay, scattered gravel	25	40
Firm blue clay	40	80

TABLE 2.--Logs of test holes -- Continued

139-80-22ddd
Test hole 2059

Formation	Material	Thickness (feet)	Depth (feet)
Colluvium:			
	Topsoil, sandy	1	1
	Clay, yellowish-brown, sandy, highly-oxidized, calcareous	6	7
Glacial drift:			
	Gravel, fine to medium with a little coarse material, rounded	5	12
Cannonball Formation:			
	Sand, dark-greenish-gray, fine, clayey and silty	9	21

139-80-28aad
Shot Point 148
Log by Magnolia Petroleum Co.

Material	Thickness (feet)	Depth (feet)
Sandy clay	6	6
Gravel and small boulders	2	8
Clay	14	22
Blue clay	21	43
Very hard clay	2	45
Blue sand	5	50
Blue clay	30	80

TABLE 2.--Logs of test holes -- Continued

139-80-35ddd
Test hole 2060

Formation	Material	Thickness (feet)	Depth (feet)
Alluvium:			
	Topsoil, black, clayey	1	1
	Clay, yellowish-brown, silty	10	11
	Clay dark-greenish-gray, silty and sandy, calcareous	5	17
Glacial drift:			
	Gravel, fine to medium, rounded	1	18
	Clay, dark-greenish-gray, sandy, soft, calcareous	6	24
	Clay, olive-gray, smooth, plastic, calcareous	42	68
	Gravel, fine to medium, rounded	2	70
Hell Creek Formation:			
	Clay, dark-greenish-gray, silty to sandy, micaceous	14	84

139-80-36bcd
U.S.B.R. drill hole 2

Material	Thickness (feet)	Depth (feet)
Topsoil	1	1
Sand, brown, clayey, dense	5	6
Clay, gray, sandy	4	10
Clay, brown, and gray, soft, plastic	9	19
Clay, brown and gray, sandy, soft	13	32
Clay, gray, plastic	3	35
Silt, gray, clayey, soft	8	43
Clay, gray, sandy	10	53
Sandy clay (till?), gray and brown with coarse gravel	10.5	63.5
Shale, gray, sandy	1.5	65

TABLE 2.--Logs of test holes -- Continued

139-81-2cbb
Test hole 1980

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, sandy	7	7
	Sand, moderate-yellowish-brown, very fine to medium, silty to clayey, oxidized	5	12
	Sand, fine to coarse, lignite fragments	16	28
	Clay, dark-greenish-gray, very silty, cohesive, lignite flecks, calcareous	4	32
	Sand, fine to coarse, lignite flakes	20	52
	Sand, fine to very coarse, clayey, lignite and shale fragments	7	59
	Sand, fine to coarse, angular to rounded, lignite wood and fossil fragments	6	65
	Sand, fine to coarse, clayey	3	68
	Sand, fine to coarse, silty, angular to rounded	9	77
	Clay, light-olive-gray, silty	17	94
	Boulders and cobbles	12	106
Hell Creek Formation:			
	Clay, greenish-gray, silty, cohesive, lignite and mica flakes	4	110

TABLE 2.--Logs of test holes -- Continued

140-75-1aaa
Test hole 2049A

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil	1	1
	Till, grayish-black, predominately shale	4	5
	Till, dusky-yellow, highly-calcareous, oxidized	6	11
	Till, moderate-yellowish-brown, calcareous, oxidized	13	24
	Till, olive-gray, calcareous	45	69
	Sand, coarse	1	70
	Till, olive-gray, lignite fragments, calcareous	7	77
	Gravel, fine to coarse, subrounded	8	85
	Gravel, fine to coarse; sand, medium to coarse; subrounded	37	122
	Silt, olive-gray, clayey; sand, very fine; calcareous	16	138
	Gravel, fine to coarse, subrounded	12	138
	Gravel, fine to coarse, subrounded	12	150
	Sand, medium to coarse, some granules subrounded	19	169
	Gravel, granular to cobbles, rounded	10	179
Hell Creek Formation:			
	Shale, dusky-yellowish-brown, lignitic, oxidized	5	184
	Sandstone, dark-greenish-gray, very fine to fine	5	189

TABLE 2.--Logs of test holes -- Continued

140-75-12cdd
Test hole 2049

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Till, moderate-olive-brown, sandy, oxidized, calcareous	17	17
	Till, olive-gray, abundant sandstone and shale fragments	29	46
	Silt, olive-gray, very clayey, plastic	4	50
	Gravel, fine to medium, subrounded; sand, coarse; poorly-sorted	10	60
	Silt, olive-black, clayey, plastic, cohesive	3	63
	Sand, olive-gray, fine to medium, subangular to subrounded	17	80
	Silt, olive-gray, very clayey, smooth, plastic	29	109
	Gravel, fine to very coarse; sand, medium to coarse; subangular to subrounded; organic soil zone around 150 feet	71	180
	Gravel, very coarse; sand, very coarse; subangular to subrounded	4	184
Fox Hills Sandstone:			
	Silt, bluish-green, clayey	5	189

140-75-21ddd
Test hole 2003

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Till, moderate-yellowish-brown, lignite fragments, oxidized, highly-calcareous	22	22

TABLE 2.--Logs of test holes --Continued

140-75-21ddd, Continued
Test hole 2003

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Till, dark-greenish-gray, lignite fragments, calcareous-------------	34	56
	Clay, dark-greenish-gray, silty, cohesive, calcareous--------------	9	65
	Sand, very fine to coarse, oxidized, abundant lignite------------------	1	66
Hell Creek Formation:			
	Sandstone, moderate-yellowish-brown, silty; clay, dark-yellowish-orange, silty, oxidized-----------	17	83
	Clay, grayish-green, sandy, indurated, black and green grains------------	7	90

140-75-24ddd
Test hole 2049B

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, medium; gravel, coarse; angular to subrounded----------------	9	9
	Till, dark-greenish-gray, abundant shale and lignite calcareous------	26	35
	Silt, dark-greenish-gray, clayey to sandy, highly-calcareous----------	5	40
	Till, dark-greenish-gray, with minor layers of medium to coarse sand, calcareous-----------------------	13	53
	Till, dark-greenish-gray, abundant shale and lignite, calcareous-----	39	92
	Gravel, coarse; sand, medium to coarse; angular to rounded--------	14	106
	Till, dark-greenish-gray, abundant gravel, calcareous----------------	20	126

TABLE 2.--Logs of test holes -- Continued

140-75-24ddd, Continued
Test hole 2049B

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Gravel, fine to coarse, clayey, abundant shale pebbles	10	136
Hell Creek Formation:			
	Shale, dusky-brown, silty to sandy, lignitic	6	142
	Shale, grayish-olive, very silty to sandy, partially-indurated	5	147

140-75-32dcc
Test hole 2049C

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	3	3
	Clay, light-olive-gray, sandy, highly-calcareous, oxidized	3	6
	Gravel, very coarse; sand, medium to coarse; rounded, oxidized	2	8
	Silt, dark-yellowish-brown, some lignite specks, calcareous, oxidized	1	9
	Till, moderate-yellowish-brown, abundant shale pebbles, calcareous, oxidized	13	22
	Till, dark-greenish-gray, abundant shale pebbles, calcareous	20	42
	Sand, very fine to very coarse	2	44
	Till, dark-greenish-gray, abundant shale, calcareous	20	64

140-75-32dcc, Continued
Test hole 2049C

Formation	Material	Thickness (feet)	Depth (feet)
Hell Creek Formation:			
	Shale, grayish-brown, silty, lignitic, oxidized	5	69
	Siltstone, olive-gray, sandy, some lignite fragments	4 1/2	73 1/2

140-75-35add
Test hole 2033

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil	3	3
	Till, olive-gray, gravelly, oxidized	4	7
	Till, dark-greenish-gray, gravelly, lignite fragments, calcareous	16	23
	Sand, fine to very coarse, gravelly, unsorted, rounded, abundant shale pebbles	7	30
	Till, dark-greenish-gray, gravelly, lignite fragments, calcareous	28	58
Hell Creek Formation:			
	Sandstone, olive-gray, very fine grains, silty, indurated, contains some mica and lignite flakes	4	62
	Sandstone, dark-yellowish-brown, very fine-grained, silty, indurated, abundant lignite grains	8	70
	Claystone, grayish-blue-green, silty, indurated, lignite fragments	5	75

TABLE 2.--Logs of test holes -- Continued

140-76-14daa
Test hole 2019

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	2	2
	Clay, grayish-orange, silty, oxidized, calcareous	3	5
	Till, moderate-yellowish-brown, abundant shale, lignite fragments, oxidized, calcareous	15	20
	Till, dark-greenish-gray, abundant shale, limestone and lignite, calcareous	10	30
	Silt, olive-gray, cohesive, lignite fragments, calcareous	5	35
	Silt, dark-greenish-gray, clayey, calcareous	16	51
	Till, dark-greenish-gray, abundant shale and limestone, lignite fragments, calcareous	35	86
	Sand, very fine to medium, silty, unsorted, abundant lignite	20	106
Hell Creek Formation:			
	Sandstone, grayish-blue-green, silty, abundant black and green grains	14	120

140-76-18bbc
Test hole 1935

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, brownish-gray, silty and sandy	5	5
	Clay, medium to dark-gray, sandy and silty	4	9
	Gravel, medium to coarse; sand, coarse to very coarse; shale fragments	14	23

TABLE 2.--Logs of test holes -- Continued

140-76-18bbc, Continued
Test hole 1935

Formation	Material	Thickness (feet)	Depth (feet)
Cannonball Formation:			
	Claystone, dusky-blue-green, silty and sandy, mica flakes, glauconite grains	8	31
	Claystone, brownish-gray, silty, carbonaceous	21	52
Hell Creek Formation:			
	Sandstone, light-gray, friable, lignitic layers	12	64
	Claystone, brownish-gray, silty	20	84
	Sandstone, dark-greenish-gray, mica flakes, carbonaceous, abundant glauconite grains	10	94

140-76-25ccc
Test hole 2018

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, brownish-black, very silty	4	4
	Silt, medium-light-gray, cohesive, abundant snail shells, highly-calcareous	2	6
	Till, moderate-yellowish-orange, abundant limestone and shale, lignite fragments, oxidized, calcareous	14	20
	Till, dark-greenish-gray, predominately limestone and shale, abundant lignite fragments, calcareous	38	58
	Sand, fine to very coarse, gravelly, subangular to rounded	25	83

TABLE 2.--Logs of test hole -- Continued

140-76-25ccc, Continued
Test hole 2018

Formation	Material	Thickness (feet)	Depth (feet)
Hell Creek Formation:			
	Sandstone, medium-bluish-gray, very fine to fine-grained, silty, some lignite and glauconite grains------	7	90

140-76-32aaa
Test hole 2026

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Till, dusky-yellow, sandy, calcareous, oxidized---------------------	5	5
	Gravel, fine to medium, abundant limestone, oxidized----------------	6	11
	Sand, very fine to fine, silty-------	12	23
	Clay, olive-gray, very silty, plastic, cohesive, calcareous---------------	18	41
	Till, olive-gray, silty to sandy, calcareous------------------------	7	48
Cannonball Formation:			
	Shale, olive-gray, fissile to compact------------------------------	15	63
	Shale, olive-black, silty, fissile---	32	95
	Sandstone, dark-greenish-gray, fine grained, silty and clayey, scattered blue-green grains, carbonaceous material--------------------	5	100
	Sandstone, dark-greenish-gray, friable, silty, abundant green grains-------	5	105
	Shale, greenish-gray, sandy, cohesive, plastic; sandstone, friable--------	26	131
	Shale, greenish-gray to brownish-black, silty----------------------	9	140

140-76-32aaa, Continued
Test hole 2026

Formation	Material	Thickness (feet)	Depth (feet)
Cannonball Formation-Continued:			
	Shale, light-olive-gray, silty, cohesive	21	161
	Sandstone, greenish-gray, fine to very fine grained, some dark-grains, abundant blue-green grains	16	177
	Shale, brownish-black, carbonaceous, lignitic, silty	7	184
	Shale, greenish-gray, silty, cohesive, plastic	4	188
	Shale, brownish-black, carbonaceous, lignitic, abundant wood material	6	194
Hell Creek Formation:			
	Sandstone, greenish-gray, fine to very fine-grained, silty and clayey, scattered blue-green grains	6	200
	Sandstone, medium-bluish-gray, fine-grained, friable, silty, clayey, scattered carbonaceous material and blue-green grains	10	210

140-78-14aaa
Test hole 2008

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	2	2
	Till, moderate-yellowish-brown, oxidized, very calcareous	4	6
	Gravel, fine to coarse, sandy, subrounded to rounded, unsorted, oxidized	7	13

TABLE 2.--Logs of test holes -- Continued

140-78-14aaa, Continued
Test hole 2008

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Gravel, fine to coarse, sandy, subrounded to well-rounded, unsorted, fossil shell fragments------------	6 1/2	19 1/2
Cannonball Formation:			
	Sand, greenish-black, indurated; white, green, and black grains------------	10 1/2	30

140-78-32ddd
Test hole 1931

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil-----------------------------	1	1
	Clay, dark-yellowish-brown, silty to sandy, oxidized, calcareous----	41	42
Hell Creek Formation:			
	Clay, light-olive-gray, very silty, indurated, lignite chips----------	12	54
	Clay, greenish-gray, silty to sandy, indurated, abundant lignite-------	9	63

TABLE 2.--Logs of test holes -- Continued

140-78-34acd
Test hole 2027

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, sandy, black	2	2
	Sand, very fine to very coarse, unsorted, subrounded, oxidized	4	6
	Silt, dark-yellowish-orange, mica and lignite flakes, highly-calcareous, oxidized	21	27
	Clay, olive-gray, silty, cohesive, calcareous	9	36
Hell Creek Formation:			
	Sand, fine to medium, well-sorted, abundant green and black grains	24	60

140-78-36bba
Test hole 2009

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	2	2
	Sand, medium to very coarse, gravelly, unsorted, angular to subrounded, oxidized	8	10
	Gravel, fine to medium, sandy, subangular to well-rounded, oxidized	2	12
	Silt, moderate-yellowish-brown, cohesive, lignite flecks, calcareous	1	13
	Silt, dark-greenish-gray, cohesive, lignite fragments, calcareous	3	16
	Clay, dark-greenish-gray, cohesive, calcareous	17	33
	Sand, fine to very coarse, unsorted, angular to rounded, abundant shale, limestone and lignite, some shell fragments	6	39

140-78-36bba, Continued
Test hole 2009

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Gravel, fine to medium, sandy, unsorted, rounded; clay layers----	5	44
	Clay, light-olive-gray, silty, cohesive, calcareous--------------	32	76
	Gravel, fine to medium, sandy, unsorted, subrounded to well-rounded--------------------------	1	77
	Sand, fine to coarse, subangular to subrounded, poorly-sorted, lignite fragments-----------------	7	84
	Cobbles and boulders----------------	2	86
Hell Creek Formation:			
	Sandstone, olive-gray, mica flakes, glauconitic-----------------------	19	105

140-79-10cbb
Test hole 2038

Formation	Material	Thickness (feet)	Depth (feet)
Tongue River Formation:			
	Sandstone, moderate-yellowish-brown, and moderate-olive-brown, medium-grained, some coarse sand grains in the first five feet, abundant dark heavy minerals, oxidized, friable-------	24	24
	Shale, moderate-yellowish-brown, and light-olive-gray, silty, cohesive, calcareous--------------	18	42
	Shale and sand interbedded, light-olive-gray, silty-----------------	21	63
	Shale, dark-yellowish-orange, silty, compact--------------------------	10	73

TABLE 2.--Logs of test holes -- Continued

140-79-10cbb, Continued
Test hole 2038

Formation	Material	Thickness (feet)	Depth (feet)
Tongue River Formation-Continued:			
	Sandstone, light-olive-gray, indurated, medium to fine-grained, mostly quartz, abundant dark heavy minerals	1	74
	Shale, dark-yellowish-orange, silty	10	84
	Sandstone; grayish-olive, medium-grained, friable; sand, fine to coarse; abundant carbonate and dark minerals, scattered yellow-green grains	16	100
Cannonball Formation:			
	Siltstone, dark-gray to olive-gray, sandy, interbedded, very fine grained, sand and lignite particles	15	115

140-80-29cbb
Test hole 1982

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, fine to very fine, silty, lignite fragments, oxidized, highly-calcareous	11	11
	Gravel, fine to medium, sandy, angular to rounded, abundant snail shells, oxidized	3	14
Cannonball Formation:			
	Shale, olive-gray, very silty, mica flakes	6	20

TABLE 2.--Logs of test holes -- Continued

140-81-5aaa
Test hole 1983

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, dark-yellowish-brown, sandy to silty	4	4
	Sand, light-olive-gray, very fine to medium; silt, clayey in layers; lignite fragments, calcareous	16	20
	Sand, medium to coarse, sorted, subangular, lignite fragments	13	33
	Lignite, rounded, wood fragments	1	34
	Sand, medium to very coarse, sorted, subangular, lignite fragments	19	53
	Sand, very fine to medium, sorted, subangular, lignite fragments	29	82
	Gravel, fine to medium, sandy, unsorted, abundant yellowish pebbles, possibly preglacial	23	105

141-75-21ddd
Test hole 2002

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	6	6
	Clay, yellowish-gray, very silty, cohesive, oxidized, highly-calcareous	4	10
	Silt, dark-yellowish-orange, oxidized, highly-calcareous	7	17
	Silt, dark-greenish-gray, highly calcareous	6	23
	Sand, very fine to coarse, silty, subrounded to well-rounded, lignite fragments, highly-calcareous	3	26
	Till, dark-greenish-gray, abundant shale and lignite fragments, calcareous	64	90

TABLE 2.--Logs of test holes -- Continued

141-75-21ddd, Continued
Test hole 2002

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Gravel, fine to medium, sandy, angular to rounded, oxidized------	3	93
Cannonball Formation:			
	Silt, dusky-yellow to brownish-black, sandy, abundant lignite, oxidized-------------------------	12	105

141-76-16bba
Test hole 1998

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Gravel, fine to medium, very sandy, subangular to rounded, unsorted, oxidized--------------------------	13	13
	Sand, fine to very coarse, gravelly, poorly-sorted, subrounded, lignite fragments-------------------------	10	23
	Till, olive-black, slightly-calcareous, lignite fragments--------	20	43
Cannonball Formation:			
	Clay, dusky-yellowish-green to greenish-black, very sandy, cohesive, mica flakes---------------	17	60

TABLE 2.--Logs of test holes -- Continued

141-76-28ada
Test hole 2000

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Till, olive-gray, sandy, highly-calcareous	9	9
	Sand, very fine to very coarse, clayey, unsorted; gravel, fine	12	21
	Till, dark-greenish-gray, lignite fragments, calcareous	35	56
Cannonball Formation:			
	Silt, dark-greenish-gray, sandy, cohesive, abundant very fine sand grains (glauconitic)	4	60

141-76-29ccd
Test hole 2001

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, yellowish-gray, silty, cohesive, highly-calcareous, oxidized	4	4
	Gravel, fine to medium, sandy, unsorted, subrounded, abundant carbonates	9	13
	Sand, fine to very coarse, gravelly, unsorted, subangular to rounded, abundant shale, some lignite	29	42
	Clay, light-olive-gray, silty, cohesive, calcareous	13	55
Cannonball Formation:			
	Sandstone, very fine-grained, silty to clayey, glauconite grains	20	75

TABLE 2.--Logs of test holes -- Continued

141-77-1cdd
Test hole 1999

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, fine to very coarse, gravelly, unsorted, angular to rounded, some shell fragments, oxidized---------	12	12
	Gravel, fine to medium, sandy, unsorted, subrounded to rounded, abundant carbonates, oxidized-----	15	27
	Gravel, fine to very coarse, sandy, unsorted, angular to rounded, abundant shale and carbonates------	3	30
Cannonball Formation:			
	Shale, dark-greenish-gray, very silty, slightly indurated---------	15	45

141-77-26aaa
Shot Point 30
Log by Magnolia Petroleum Co.

Material	Thickness (feet)	Depth (feet)
Yellow clay and boulders------------	28	28
Hard ledge--------------------------	2	30
Yellow clay-------------------------	6	36
Blue shale--------------------------	14	50
Hard ledge--------------------------	4	54
Blue shale--------------------------	26	80

TABLE 2.--Logs of test holes -- Continued

141-78-5ddd
Test hole 2006

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Gravel, fine to coarse, sandy, unsorted, subangular to subrounded, abundant carbonates and fossil shells, oxidized-------------------	4	4
Cannonball Formation:			
	Clay, grayish-orange, very silty, cohesive, mica flakes, oxidized------	2	6
	Clay, greenish-gray, very silty to sandy, indurated, mica flakes, lignite in streaks-----------------	9	15

141-78-35bbb
Test hole 2007

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black-----------------------	1	1
	Sand, very fine to medium, clayey, fossil fragments, oxidized---------	2	3
	Gravel, fine to medium, sandy, subrounded to angular, calcareous, oxidized---------------------------	6	9
	Gravel, fine to medium, very silty, abundant organic material----------	3	12
Cannonball Formation:			
	Clay, dark-greenish-gray, silty, indurated, abundant mica flakes----	3	15

TABLE 2.--Logs of test holes -- Continued

141-80-36abd
Test hole 2004

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, very fine to medium, very clayey, highly-calcareous, oxidized------------------------------	4	4
	Gravel, fine to medium, very sandy, unsorted, abundant fossil shells---	5	9
Cannonball Formation:			
	Siltstone, greenish to dark-greenish-gray, indurated, lignite fragments------------------------------	6	15

142-75-15cda
Test hole 1994

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, fine to coarse, clayey to gravelly, well-sorted, subrounded; cobble and boulders; oxidized--------------------------	15	15
	Till, olive-gray, silty to very sandy, calcareous-----------------	22	37
	Till, dark-greenish-gray, silty to gravelly, lignite fragments, calcareous------------------------	59	96
	Sand, fine, silty to clayey, lignite fragments--------------------	16	112
Cannonball Formation:			
	Clay, brownish-black, silty to sandy, lignite and organic material--------------------------	2	114
	Sand, grayish-blue-green, very fine to medium, quartz and green grains---------------------------	6	120

TABLE 2.--Logs of test holes -- Continued

142-75-19ccb
Test hole 1995

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	2	2
	Till, light-olive-gray, silty to sandy, highly-calcareous, oxidized	6	8
	Clay, medium-bluish-gray, very silty, cohesive, highly-calcareous, some snail shells	4	12
	Peat, brownish-black, predominately organic material, abundant snail shells	16	28
	Gravel, fine to medium, very sandy, unsorted, subangular to rounded; sand, medium to very coarse	14	42
	Till, olive-gray, silty to sandy, highly-calcareous	16	58
	Sand, fine to coarse, unsorted, subrounded, some clay	70	128
	Sand, very fine to very coarse, clayey, angular to rounded, lignite fragments	45	173
	Till, olive-gray, very sandy	8	181
	Gravel, granular, subrounded, sandy	15	196
Hell Creek Formation:			
	Clay, brownish-black, silty, cohesive, mica flakes	14	210

TABLE 2.--Logs of test holes -- Continued

142-75-22acc
Test hole 2045

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, very fine to very coarse, clayey; gravel, medium, oxidized	11	11
	Silt, medium-bluish-gray, cohesive, lignite flecks, calcareous	19	30
	Silt, medium-bluish-gray; sand, very fine, calcareous	33	63
	Silt, medium-bluish-gray, sandy, calcareous, cohesive between 75-77 and 82-120 feet	57	120
	Till, dark-greenish-gray, silty, lignite fragments, calcareous	42	162
	Gravel, fine to medium, poorly-sorted, angular to rounded, sandy	8	170
	Till, olive-gray, sandy, calcareous	1	171
	Gravel, fine to medium, poorly-sorted, angular to rounded, sandy	1	172
Hell Creek Formation:			
	Sandstone, grayish-blue-green, very fine to medium-grained, clayey matrix, unsorted, becoming darker with depth and containing more lignite	23	195

TABLE 2.--Logs of test holes -- Continued

142-76-3dda
Test hole 1997

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black	1	1
	Clay, dusky-yellow, silty, cohesive, oxidized, highly-calcareous	5	6
	Gravel, fine, very sandy, unsorted, angular to rounded, abundant shale	14	20
	Till, dark-greenish-gray, lignite fragments, slightly-calcareous	25	45
	Gravel, fine to coarse, angular to subangular, unsorted, abundant limestone	12	57
Cannonball Formation:			
	Clay, light-olive-gray, silty, cohesive to indurated	18	75

142-76-7aaa
Test hole 1978

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil	1	1
	Sand, medium to very coarse, unsorted, subrounded; gravel, granular	3	4
	Till, moderate-yellowish-brown, silty to sandy, lignite fragments, oxidized, calcareous	10	14
	Till, olive-gray, silty to sandy, lignite fragments, calcareous	22	36

TABLE 2.--Logs of test holes -- Continued

142-76-7aaa, Continued
Test hole 1978

Formation	Material	Thickness (feet)	Depth (feet)
Cannonball Formation:			
	Shale, olive-gray, calcareous	7	43
	Shale, olive-gray, silty	10	53
	Sandstone, greenish-gray, very fine to fine-grained, lignite and mica flakes, calcareous	22	75
	Shale, olive-gray, silty, calcareous	6	81
	Sandstone, dark-greenish-gray, very fine to medium-grained, silty, glauconitic	4	85
	Shale, olive-gray, very silty to sandy	10	95
	Sandstone, dark-greenish-gray, very fine to medium-grained, silty, glauconitic	10	105

142-76-22ddd
Test hole 2024

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, dark-yellowish-orange, silty, calcareous	4	4
	Sand, very fine to very coarse, unsorted, gravel, fine to medium, subrounded; clay, yellowish-orange; lignite fragments	8	12
	Clay, yellowish-orange, sandy	11	23
	Sand, very fine to medium, silty, rounded, abundant shale, limestone and lignite flecks	34	57
Cannonball Formation:			
	Clay, dark-greenish-gray, silty, indurated, highly-calcareous	18	75

TABLE 2.--Logs of test holes -- Continued

142-76-23bcb
Test hole 1996

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, yellow-orange---------------	1	1
	Clay, olive-black, silty, cohesive---	5	6
	Gravel, fine to medium, sandy, subangular, predominately limestone; sand, fine to very coarse, subrounded, predominately quartz------	17	23
Cannonball Formation:			
	Clay, brownish-black, silty, cohesive to indurated----------------	7	30

142-79-26ddd
Test hole 2005

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil------------------------------	1	1
	Gravel, fine to medium, very sandy, unsorted, abundant carbonate, oxidized-----------------------------	2	3
	Till, dark-yellowish-orange, calcareous, oxidized------------------	11	14
	Gravel, fine to coarse, sandy, unsorted, angular to rounded, fossil shell fragments, oxidized; minor layers of silt, lignitic-----------	6	20
Tongue River Formation:			
	Sand, very fine to medium, subangular, sorted, lignite fragments----------	11	31
	Sand, very fine to medium, subangular, sorted, predominately quartz with black and green grains-------------	10	41

TABLE 2.--Logs of test holes -- Continued

142-79-26ddd, Continued
Test hole 2005

Formation	Material	Thickness (feet)	Depth (feet)
Cannonball Formation:			
	Clay, olive-gray, cohesive, silty----	4	45

142-80-2abb
City of Wilton Test well 1
Log by C. A. Simpson and Son

Material	Thickness (feet)	Depth (feet)
Topsoil-------------------------------	1	1
Brown clay and rock-------------------	6	7
Yellow clay---------------------------	20	27
Blue clay-----------------------------	25	52
Hardpan and rock----------------------	5	57
Slightly gravelly clay----------------	23	80
Sandy clay----------------------------	22	102
Coal----------------------------------	5	107
Sandy gray clay-----------------------	1	108
Fine loose sand-----------------------	5	113
Soft gray clay------------------------	29	142
Coal and brown clay-------------------	3	145
Blue shale----------------------------	17	162
Coal----------------------------------	1	163
Gray shale----------------------------	40	203
Dark shale with little coal-----------	17	220

Remarks: About the only water was that from the 107-113 ft. layer. Water level was 60 feet from the surface.

TABLE 2.--Logs of test holes -- Continued

142-80-3aaa
Test hole 1985

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Till, moderate-yellowish-brown, lignite fragments, highly-calcareous, oxidized	7	7
Tongue River Formation:			
	Clay, moderate-yellowish-brown, silty, cohesive, oxidized	4	11
	Clay, dusky-yellow, silty, cohesive, calcareous	7	18
	Clay, dusky-yellowish-brown, silty, cohesive, oxidized	4	22
	Lignite, hard, sharp fragments	4	26
	Clay, medium-bluish-gray, silty, indurated, lignite smears	11	37
	Sand, medium-bluish-gray, very fine, silty, lignite and mica flakes	14	51
	Clay, medium-bluish-gray, silty, cohesive, lignite flecks, highly-calcareous	8	59
	Lignite, hard	3	62
	Clay, light-bluish-gray, silty, minor lignite flecks	3	65
	Lignite, hard	1/2	65 1/2
	Clay, pale-blue-green, slightly-silty	7 1/2	73
	Clay, light-olive-gray, silty, cohesive, highly-calcareous	2	75
	Silt, brownish-black, cohesive, abundant lignite fragments, highly-calcareous	6	81
	Clay, dark-greenish-gray, silty, indurated, calcareous	16	97
	Clay, greenish-gray, silty, indurated, white calcareous layers	9	106
	Lignite	1	107
	Silt, light-olive-gray, clayey, lignite flecks, calcareous	11	118
	Sandstone, olive-gray, very hard, indurated, calcareous	1	119

TABLE 2.--Logs of test holes -- Continued

142-80-3aaa, Continued
Test hole 1985

Formation	Material	Thickness (feet)	Depth (feet)
Tongue River Formation-Continued:			
	Silt, olive-gray, clayey, very fossiliferous, calcareous---------	19	138
	Lignite-----------------------------	1	139
	Silt, olive-black; sand, very fine--	6	145
	Silt, grayish-blue-green, clayey, occasional lignite chips----------	7	152
	Sand, very fine, clayey, calcareous-	4	156
	Clay, light-olive-gray, silty, lignite fragments, calcareous--------	7	163
	Lignite-----------------------------	1	164
	Sand, light-olive-gray, lignitic----	58	222
Cannonball Formation:			
	Silt, olive-gray to olive-black, very clayey-----------------------	3	225

142-81-4adc
Test hole 1984

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, yellowish-orange, sandy, oxidized-----------------------------	4	4
	Gravel, fine to medium, sandy, oxidized-----------------------------	3	7
Cannonball Formation:			
	Sand, very fine to fine, silty to clayey, lignite fragments, oxidized----------------------------	33	40
	Sand, fine, silty to clayey, lignite fragments -------------------	13	53
	Sandstone, friable, highly-calcareous--------------------------	5	58

TABLE 2.--Logs of test holes -- Continued

142-81-4adc, Continued
Test hole 1984

Formation	Material	Thickness (feet)	Depth (feet)
Cannonball Formation:			
	Sand, fine, silty to clayey, unsorted, abundant lignite and mica, (glauconitic)	5	63
	Sand, greenish-black, silty, (glauconitic)	25	88
	Silt, olive-gray, sandy, lignite and mica flakes, slightly-calcareous	1	89
	Limestone, olive-gray, sandy	2	91
	Silt, olive-gray, clayey to sandy, harder than above, slightly-calcareous	26	117
	Sand, olive-gray, abundant lignite and green specks (glauconitic)	2	119
	Limestone, sandy, very hard	4	123
	Silt, olive-gray, sandy, mica flakes	13	136
	Sand, grayish-blue-green, very fine to fine, (abundant glauconite)	9	145
Hell Creek Formation:			
	Sand, olive-gray, very silty, lignite and mica flakes	17	162
	Silt, olive-black, clayey, lignite and mica flakes	8	170
	Silt, olive-black, pyrites	18	188
	Silt, light-olive-gray, pyrite, mica, and lignite	9	197
	Sand, grayish-blue-green, very fine to medium, angular, abundant green grains (glauconitic)	12	209
	Silt, olive-gray, sandy	6	215
	Sand, light-olive-gray, very fine to medium, green grains, (glauconitic)	19	234

TABLE 2.--Logs of test holes -- Continued

142-81-4adc, Continued
Test hole 1984

Formation	Material	Thickness (feet)	Depth (feet)
Hell Creek Formation-Continued:			
	Silt, greenish-gray, sandy to clayey, lignitic	16	250
	Sand, olive-black, very fine to fine, abundant green grains (glauconite)	13	263
	Sand, clayey, mostly quartz, some mica and greenish grains	5	268
	Limestone, sandy	3	271
	Sand, olive-gray, very fine to medium, clayey	16	287
	Silt, dark-greenish-gray; sand, very fine; mica and lignite flakes, abundant light-bluish to greenish grains	47	334
	Sand, very fine to fine, silty, black and green grains	14	348
	Lignite	5	353
	Clay, olive-gray, silty	11	364
Fox Hills Sandstone:			
	Clay, greenish-gray, silty to sandy, (glauconitic)	16	380
	Sand, greenish-gray, fine to medium, abundant green and black grains (glauconitic)	15	395
	Sand, greenish-gray, fine to medium clayey, (glauconitic)	5	400
	Sand, greenish-gray, fine to medium, clayey (glauconitic)	35	435

TABLE 2.--Logs of test holes -- Continued

143-75-16acc
U. S. B. R. drill hole 41

Material	Thickness (feet)	Depth (feet)
Clay, brown, wet, sandy------------	3.1	3.1
Gravel, brown, dry, silty, sandy----------------------------	3.5	6.6
Clay (glacial till), brown, wet, color changing to gray at 7.5', sandy, silty, gravels throughout, occasional cobbles and boulders, moderately plastic, soft----------------------------	21.5	28.1
Sand, dark-gray, moist, very fine, clayey---------------------------	11.9	40

143-75-16bdd
U. S. B. R. drill hole 40

Material	Thickness (feet)	Depth (feet)
Clay, brown, moist, sandy----------	2.8	2.8
Clay (glacial till), brown, dry, color changing to gray and becoming moist to wet at 7.3', silty, sandy, soft, moderately plastic, occasional cobble and boulder, gravels throughout------	23.7	26.5
Sand, dark-gray, moist, clayey, poorly-graded, fine--------------	18.5	45

TABLE 2.--Logs of test holes -- Continued

143-75-17aac
U.S.B.R. drill hole 39

Material	Thickness (feet)	Depth (feet)
Clay (glacial till), brown, wet, soft, color changing to gray at 7.5', silty, sandy, moderately plastic, occasional cobble and boulder, gravels through	18.2	18.2
Shale, (Fort Union Group), black, wet, sandy, lignite stained	5.6	23.8
Sandstone, gray, dirty, hard, dry	0.4	24.2
Shale (Fort Union Group), black, sandy, wet	2.8	27
Sandstone, gray, dirty, hard, wet	0.5	27.5
Shale, (Fort Union Group), black, sandy, wet, lignite stained	2.5	30

143-75-19daa
Test hole 2056

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Silt and clay, moderate-olive-brown, sandy, lacustrine	11	11
	Sand, very coarse; gravel, fine to medium	2	13
	Till, light-olive-gray, sandy, calcareous, oxidized	7	20
	Till, olive-gray to medium-gray, sandy to gravelly, calcareous	10	30
	Till, medium-dark-gray; sandy to gravelly, calcareous	27	57
	Sand, coarse to very coarse, gravelly, abundant limestone particles	1	58
	Till, medium-dark-gray, sandy to gravelly, calcareous	17	75
	Sand, gravel, clay, reworked bedrock, angular fragments	6	81

TABLE 2.--Logs of test holes -- Continued

143-75-19daa, Continued
Test hole 2056

Formation	Material	Thickness (feet)	Depth (feet)
Cannonball Formation:			
	Shale, olive-gray, soft, silty	9	90
	Sandstone, olive-black, friable, poorly-sorted, blue-green grains	10	100
	Siltstone, olive-black to olive-gray, few blue-green grains	5	105

143-75-24dad
U.S.B.R. drill hole 42

Material	Thickness (feet)	Depth (feet)
Clay (glacial till), brown, wet, color changing to gray at 11.8', sandy, silty, stiff, gravels throughout; moderately plastic, occasional cobbles and boulders	60	60

143-76-7baa
Test hole 1991

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil	1	1
	Sand, medium to very coarse, well-sorted, subrounded to well-rounded	7	8
	Sand, medium to very coarse, gravelly, unsorted, subrounded, abundant limestone	9	17

143-76-7baa, Continued
Test hole 1991

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Sand, medium to very coarse; gravel, medium; unsorted, subrounded--------	6	23
	Sand, fine to coarse, well-sorted, subrounded to well-rounded, abundant shale-----------------------	7	30
Cannonball Formation:			
	Clay, olive-gray, silty---------------	45	75

143-76-12da
U.S.B.R. drill hole 38

Material	Thickness (feet)	Depth (feet)
Silt, black, organic, wet topsoil----	1	1
Silt, gray and brown, moist----------	6.2	7.2
Clay (glacial till), moist, stiff, brown, becoming wet and changing color to gray at 12.7', sandy, silty, occassional cobbles and boulders, moderately plastic--------	32.8	40

143-78-7cbb
Auger hole 26

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, dusky-brown, clayey---------	2	2
	Till, moderate-yellowish-brown, sandy, shale pebbles----------------------	42	44

TABLE 2.--Logs of test holes -- Continued

143-78-7cbb, Continued
Auger hole 26

Formation	Material	Thickness (feet)	Depth (feet)
Tongue River Formation:			
	Clay, dusky-brown, silty, carbonaceous, tough	8	52

143-78-18bbb
Auger hole 20

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, dusky-brown, sandy	2	2
	Till, moderate-yellowish-brown, sandy, oxidized, calcareous	23	25

143-78-35ccc
Test hole 1990

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil	2	2
	Till, moderate-yellowish-brown, silty to sandy, highly-calcareous, oxidized	30	32
Tongue River Formation:			
	Silt, light-olive-gray, clayey, lignitic	3	35
	Clay, dark-yellowish-orange, silty, oxidized	1	36
	Silt, dusky-yellow, clayey, lignite flecks, oxidized	4	40

TABLE 2.--Logs of test holes -- Continued

143-78-35ccc, Continued
Test hole 1990

Formation	Material	Thickness (feet)	Depth (feet)
Tongue River Formation-Continued:			
	Lignite, soft, (saturated)	1	41
	Clay, dark-gray, silty, lignite	2	43
	Lignite, soft	1	44
	Clay, dark- gray, silty	3	47
	Sand, very fine to coarse, subrounded to well-rounded, lignite	13	60
	Sand, very fine to medium, clayey, abundant mica and lignite flecks, and green grains (glacuonitic)	40	100
Cannonball Formation:			
	Silt, brownish-black, clayey, lignite fragments	3	103
	Sandstone, very fine to fine-grained, mica flakes, calcareous	16	119
	Silt, olive-gray, clayey, cohesive; sand, fine; mica and lignite fragments	16	135

143-79-10baa
Auger hole 19

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, dusky-brown, clayey	2	2
	Till, moderate-yellowish-brown, sandy, shale pebbles, oxidized	31	33
	Till, light-olive-gray, sandy, shale pebbles	25	58
	Sand, fine to coarse, lignite fragments	21	79

TABLE 2.--Logs of test holes -- Continued

143-79-10baa, Continued
Auger hole 19

Formation	Material	Thickness (feet)	Depth (feet)
Tongue River Formation:			
	Clay, grayish-green; sand, fine to medium	10	89
	Sandstone, grayish-green, fine grained	1/2	89 1/2

143-79-11aad
Auger hole 25

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Clay, moderate-yellowish-brown, silty, occasional pebbles	31	31
	Clay, grayish-brown, silty	8	39
	Clay, light-olive-gray, silty	6	45
	Sand, gray, fine to medium	1	46
Tongue River Formation:			
	Shale, dusky-brown, carbonaceous	6	52

143-79-14dad
Auger hole 27

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, dusky- brown, silty	2	2
	Clay, moderate-yellowish-brown; sand, fine to very coarse	12	14
	Clay, light-olive-gray; sand, fine to very coarse	7	21

TABLE 2.--Logs of test holes -- Continued

143-79-14dad, Continued
Auger hole 27

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Gravel, fine to coarse; sand, fine to very coarse	36	57
	Clay, light-olive-gray; sand, fine; interbedded	22	79
	Clay, light-olive-gray; sand, fine; interbedded	22	79
	Clay, light-olive-gray, silty	6	95
Cannonball Formation:			
	Sand, greenish-gray, fine to medium	2	97

143-80-35daa2
City of Wilton test well 2
Log by C. A. Simpson and son

Material	Thickness (feet)	Depth (feet)
Topsoil	1	1
Yellow clay	29	30
Firm sandy yellow clay	46	76
Fine clayey sand with water	8	84
Sand and coal	4	88
Gray clay or shale with traces of coal	40	128
Dark gray shale, rather tough	20	148
Light gray shale	6	154
Light gray shale with a trace of coal	10	164

Remarks: The principal source of water is from 68-88 feet. Water level was 62 feet from the surface.

TABLE 2.--Logs of test holes -- Continued

143-80-36cbb2
City of Wilton test well 3
Log by C. A. Simpson and son

Material	Thickness (feet)	Depth (feet)
Topsoil-------------------------------	1	1
Yellow clay and large boulder----------	3	4
Dark clay and rocks--------------------	8	12
Gray and slightly sandy gray clay------	22	34
Sandy yellow clay (apparently water-bearing when below the water level)--	36	70
Consolidated clayey yellow sand--------	23	93
Yellow clay----------------------------	5	98
Dark clay------------------------------	6	104

Remarks: Water-bearing formation from 70-93 feet. Water level 64 feet below the surface.

144-75-15aaa
Test hole 1993

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Till, dusky-yellow, silty to gravelly, lignite fragments, highly-calcareous-	15	15
	Till, dark-greenish-gray, silty to gravelly, abundant shale grains, some lignite fragments, calcareous---	91	106
	Till, dark-greenish-gray, very gravelly--------------------------------	4	110
Cannonball Formation:			
	Silt, olive-gray, very sandy to clayey, rounded (glauconitic)----------------	2	112
	Sandstone, fine-grained, abundant angular grains-----------------------		112

TABLE 2.--Logs of test holes -- Continued

144-76-7dad
Test hole 2052

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Gravel, fine to very coarse, sandy, cobbles, unsorted, subangular to rounded	15	15
	Till, moderate-yellowish-brown, calcareous	3	18
	Till, dark-greenish-gray, abundant shale, limestone, and lignite fragments, calcareous	40	58
	Gravel, fine to coarse, very sandy, unsorted, rounded, abundant lignite	43	101
	Till, dark-greenish-gray, abundant shale, limestone, and lignite fragments, calcareous	34	135
Cannonball Formation:			
	Clay, moderate-yellowish-brown, silty, indurated, mica flecks, oxidized	1	136
	Clay, light-olive-gray, silty to sandy, indurated, mica flakes	9	145
	Clay, olive-gray, very silty, indurated, mica flakes, lignite seams, calcareous	5	150

144-76-12bbb
Test hole 2044

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Gravel, brown, medium; sand, very coarse, rounded, some lignite particles	31	31
	Till, olive-gray, sandy, cohesive, calcareous	4	35

TABLE 2.--Logs of test holes -- Continued

144-76-12bbb, Continued
Test hole 2044

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Gravel, medium to coarse, sandy--------	8	43
	Till, olive-gray, calcareous, interbedded gravel layers, lignite fragments--------------------------------	17	60
	Till, olive-gray, sandy, oxidized, calcareous----------------------------	92	152
	Gravel, medium------------------------	4	156
	Till, light-olive-gray, sandy, calcareous----------------------------	8	164
	Gravel, medium, angular, mostly reworked bedrock, oxidzed-----------	1	165
Cannonball Formation:			
	Shale, olive-black, silty; siltstone, sandy, soft, bluish-green grains-----	15	180

144-76-29aaa
Test hole 1992

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, fine to very coarse, gravelly, unsorted, angular to rounded, lignite fragments-----------------------	34	34
	Gravel, medium to coarse---------------	3	37
	Till, dark-greenish-gray, lignite fragments, calcareous----------------	20	57
	Sand, very fine to coarse, clayey, unsorted, angular to rounded---------	10	67
Cannonball Formation:			
	Silt, dark-greenish-gray, cohesive, lignite and mica flakes--------------	8	75

TABLE 2.--Logs of test holes -- Continued

144-76-31bcd
U.S.B.R. drill hole 36

Material	Thickness (feet)	Depth (feet)
Sand, brown, dry, silty, with few gravels	6.8	6.8
Sand, brown, moist, fine to medium, silty, color changes to gray at 18.8'	18.2	25

144-76-31dbb
U.S.B.R. drill hole 37

Material	Thickness (feet)	Depth (feet)
Gravel, brown, wet, poorly graded, lacks coarse and fine sizes, silty	12.2	12.2
Sand, brown, wet, medium to coarse, few small gravels	5.8	18
Sand, gray, wet, fine to medium, small gravel seams and lignite particles	17	35

144-77-8aab
Auger hole 23

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Till, moderate-yellowish-brown, shale pebbles, oxidized, calcareous	32	32
Cannonball Formation:			
	Clay, moderate-brown; sand, fine to medium, rounded, silty	53	85
	Clay, light-olive-gray; sand, fine; interbedded	2	87
	Sand, light-olive-gray, fine to medium, lignitic	25	112

TABLE 2.--Logs of test holes -- Continued

144-77-18daa
Test hole 1988

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Silt, moderate-yellowish-brown; sand, fine, highly-calcareous, oxidized	8	8
	Sand, fine to very coarse, gravelly, unsorted, angular to subrounded, partially-oxidized	4	12
	Till, dark-greenish-gray, lignite fragments, calcareous	1	13
	Sand, medium to very coarse; gravel, granule; poorly-sorted, subrounded to rounded	9	22
	Till, dark-greenish-gray, calcareous	20	42
Cannonball Formation:			
	Silt, light-olive-gray, mica and lignite fragments	18	60

144-77-23cac
Test hole 2043

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, very fine to very coarse, clayey, unsorted	7	7
	Till, light-olive-gray, very silty, calcareous	4	11
	Gravel, medium	1	12
	Till, moderate-yellowish-brown, lignite fragments, calcareous	11	23
	Till, dark-greenish-gray, very silty, lignite fragments, calcareous	41	64
	Gravel, fine to coarse, sandy, unsorted, rounded	11	75

TABLE 2.--Logs of test holes -- Continued

144-77-23cac, Continued
Test hole 2043

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift-Continued:			
	Till, dark-greenish-gray, very silty, lignite fragments, calcareous------	7	82
	Clay, dark-greenish-gray, calcareous, hard------------------------------	11	93
	Silt, dark-greenish-gray, cohesive, tiny lignite flecks, calcareous----	8	101
	Till, dark-greenish-gray, very silty, lignite fragments, calcareous------	15	116
	Sand, very fine to coarse, gravelly, unsorted--------------------------	1 1/2	117 1/2
	Till, dark-greenish-gray, silty, shale pebbles, lignite fragments, calcareous-----------------------------	16 1/2	134
	Till, dark-yellowish-orange, silty to sandy, oxidized, lignite fragments------------------------------	15	149
Cannonball Formation:			
	Silt, dusky-yellow, sandy, indurated, some lignite-----------------------	26	175
	Sand, moderate-olive-brown, very fine to fine, clayey, slightly-oxidized-	4	179
	Sand, dark-greenish-gray, very fine to fine, glauconitic, silty--------	1	180

144-77-36acb
U.S.B.R. drill hole 35

Material	Thickness (feet)	Depth (feet)
Clay, black, wet, plastic, organic---	3.2	3.2
Clay (glacial till), brown, stiff, wet, silty, sandy, gravels, throughout, occasional cobbles and boulders, moderately plastic, color changes to gray at 16.8'----------------------	24	27.2

TABLE 2.--Logs of test holes -- Continued

144-77-36acb, Continued
U.S.B.R. drill hole 33

Material	Thickness (feet)	Depth (feet)
Sand, gray, wet, silty, with few gravels, dense	7.8	35

144-77-36bac
U.S.B.R. drill hole 34

Material	Thickness (feet)	Depth (feet)
Clay (glacial till), brown, moist, stiff, silty, sandy, cobbles and boulders, gravels throughout, moderately plastic	12.8	12.8
Clay (glacial till), same as above but gray	9.7	22.5
Sand, gray, fine, silty, moist	4.6	27.1
Gravel, medium to fine, brown, sandy, many shale particles	2.9	30

144-77-36bbd
U.S.B.R. drill hole 33

Material	Thickness (feet)	Depth (feet)
Topsoil, silty sand, tan	1.5	1.5
Clay, brown, moist, highly alkaline	2.1	3.6
Clay (glacial till), brown, moist, stiff, moderately plastic, sandy, silty, occasional cobbles and boulders, gravels throughout, color changes to gray at 16.2', occasional sand seams 16.2' to 40'	36.4	40

TABLE 2.--Logs of test holes -- Continued

144-78-3cdd
Test hole 1987

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Road fill	7	7
	Silt, dark-greenish-gray, very fossiliferous, highly-calcareous	10	17
	Sand, medium to very coarse, gravelly, poorly-sorted, subrounded to rounded	7	24
Cannonball Formation:			
	Clay, olive-gray, very silty, indurated	16	40

144-78-14ccc
U.S.B.R. drill hole 28

Material	Thickness (feet)	Depth (feet)
Topsoil, sandy silt, tan, organic	0.6	0.6
Gravel, brown, moist, sandy and silty, gravel, medium to coarse	24.4	25

144-78-14cdc
U.S.B.R. drill hole 29

Material	Thickness (feet)	Depth (feet)
Topsoil, dark-brown, organic silty clay	1	1
Silt, brown frozen	2.2	3.2
Gravel, brown, medium	8.1	11.3
Silty sand, gray, fine silty, sand, low density	4.2	15.5
Silt, gray, stiff	8	23.5
Clay (glacial till), brown, silty, sandy, gravels throughout, occasional cobbles and boulders, stiff, moderately plastic	6.5	30

TABLE 2.--Logs of test holes -- Continued

144-78-15ddd
U.S.B.R. drill hole 27a

Material	Thickness (feet)	Depth (feet)
Silt, black, moist, sandy, organic----	1.8	1.8
Gravel, brown, moist, medium to coarse, sandy------------------------	14.8	16.6
Gravel, brown, moist, coarse, clayey--	1.6	18.2
Shale (Tongue River Formation), gray, moist, sandy------------------------	6.8	25

144-78-21aaa
Auger hole 24

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Till, moderate-yellowish-brown, sandy, shale pebbles, oxidized, calcareous-	28	28
	Till, light-olive-gray, shale pebbles, calcareous--------------------------	44	72
Cannonball Formation:			
	Clay, greenish-gray; sand, fine to medium------------------------------	8	80

144-78-23aa
U.S.B.R. drill hole 31

Material	Thickness (feet)	Depth (feet)
Topsoil, sandy, silt, tan, organic----	1	1
Clay (glacial till), brown, sandy, silty, gravels throughout, occasional cobbles and boulders, moist, stiff------------------------	6.8	7.8
Silty sand, gray, wet, fine to medium---------------------------------	5.4	13.2

TABLE 2.--Logs of test holes -- Continued

144-78-23aa, Continued
U.S.B.R. drill hole 31

Material	Thickness (feet)	Depth (feet)
Silt, gray, wet, small sand seams	13.5	26.7
Shale (Tongue River Formation), a light-blue, moist, hard, silty, clay shale	3.3	30

144-78-23abb
U.S.B.R. drill hole 30

Material	Thickness (feet)	Depth (feet)
Topsoil, dark-brown, organic silty sand	1.6	1.6
Sand and gravel, brown and gray, medium to coarse sand, fine to medium gravel, saturated below 7.5' (Penetration test 14'-20' indicates loose condition)	31.8	33.4
Clay (glacial till) brown, very stiff silty, sandy, gravels throughout, occasional cobbles and boulders, medium plasticity	6.6	40

144-78-26cdc
Test hole 1989

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil, black, silty	1	1
	Sand, fine to very coarse, gravelly, unsorted, subangular to rounded	12	13
	Gravel, fine, sandy, unsorted, rounded, lignite fragments	13	26

TABLE 2.--Logs of test holes -- Continued

144-78-26cdc, Continued
Test hole 1989

Formation	Material	Thickness (feet)	Depth (feet)
Cannonball Formation:			
	Shale, olive-gray, silty, lignite fragments--------------------------	4	30

144-79-1ccb
Test hole 2051

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Sand, very fine to very coarse, clayey, unsorted, subrounded, calcareous, oxidized-------------------	13	13
	Sand and clay, dark-greenish-gray, calcareous, unoxidized--------------	10	23
	Till, olive-gray, abundant shale, limestone and lignite fragments, calcareous--------------------------	8	31
	Sand, unsorted, rounded; gravel, fine--------------------------------	4	35
Cannonball Formation:			
	Clay, olive-gray, silty, indurated, abundant lignite fragments----------	25	60

TABLE 2.--Logs of test hole -- Continued

144-79-25bcc
Test hole 1986

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Topsoil-------------------------------	2	2
	Till, yellowish to light-olive-gray, highly-calcareous-------------------	4	6
	Gravel, fine to medium, sandy, sub-rounded to rounded, unsorted--------	17	23
	Clay, dark-greenish-gray, very silty, cohesive, calcareous----------------	43	66
Cannonball Formation:			
	Shale, greenish-black, silty, dark-greenish-gray, abundant lignite-----	9	75

144-79-29ccb
Test hole 2050

Formation	Material	Thickness (feet)	Depth (feet)
Glacial drift:			
	Till, light-olive-gray, silty to sandy-------------------------------	5	5
	Gravel, stained black, fine to coarse, unsorted----------------------------	5	10
	Gravel, fine to coarse, sandy, un-sorted-------------------------------	10	20
Cannonball Formation:			
	Silt, greenish-gray, mica and lignite flakes, slightly-calcareous---------	10	30

TABLE 4.--Chemical analyses of ground water from Quaternary aquifers showing trace or minor constituents

Results in parts per million

Location	Depth	Date of collection	Iron: Ferrous (Fe)	Iron: Ferric (Fe)	Iron: Total (Fe)	Manganese (Mn)	Copper (Cu)	Zinc (Zn)	Nitrite (NO_2)	Orthophosphate (PO_4)
137-78-8bcb	216	7-18-62	....	....	2.1	.84	....	....	....	....
137-78-33aba	185	8-6-62	....	....	.27	.84	....	....	....	....
137-79-26cbb	86	8-6-62	....	....	.86	.00	....	....	....	....
138-76-33bbb	110	8-6-62	....	....	.17	1.6	....	....	....	....
138-77-15aaa	210	8-6-62	....	....	2.3	.05	....	....	....	....
138-77-15dcb	138.4	9-8-61 a/	1.9	2.5	4.4	.39	.10	4.1	.03	.05
138-77-25bbd1	78.2	9-9-61 a/	.53	.64	1.2	.60	.34	.00	.00	.27
138-78-27ccd	210	8-3-62	....	....	.26	.48	....	....	....	....
138-78-32daa	185	8-3-62	....	....	.58	.43	....	....	....	....
138-80-9bcd	105	9-8-61 a/	4.5	6.1	11	.44	.06	.34	.01	.04
138-80-15bbd	129	9-7-61 a/	3.8	3.6	7.4	.16	.13	.23	.05	.04
138-80-15cba	164	9-7-61 a/	3.2	3.6	6.8	.07	.10	.98	.04	.36
138-80-17acb1	190	9-8-61 a/	3.7	4.6	8.3	.35	.17	.34	.08	.09
138-80-22aac	131	9-8-61 a/	1.9	2.9	4.8	.09	.05	.66	.01	.18
138-80-23bdc	110	9-8-61 a/	1.7	2.2	3.9	.09	.05	.44	.01	.26
138-80-24cac1	80	9-9-61 a/	.02	.36	.38	.00	.03	.04	.02	.27
139-78-27cbb	225	8-3-62	....	....	.36	.01	....	....	....	....
139-81-11adc	104	9-8-61 a/	4.3	4.9	9.2	.59	.11	1.6	.01	.10
140-75-12cdd	167	8-2-62	....	....	.11	1.3	....	....	....	....
140-76-25ccc	70	8-6-62	....	....	.29	1.4	....	....	....	....
140-78-36bba	86	7-8-62	....	....	.84	.00	....	....	....	....
140-81-5aaa	90	8-62	....	....	1.6	.14	....	....	....	....

a/ Selenium (Se) 0.00, and Sulfide (S) 0.0.

TABLE 5.--Water-level measurements in selected wells in Burleigh County, North Dakota

137-76-32bbb
Paul McCay, stock well

Date	Water level	Date	Water level	Date	Water level
Sept. 13, 1960	98.11	Mar. 8, 1963	97.18	Sept. 6, 1963	96.54
Sept. 11, 1962	97.50	Apr. 17,	97.17	Oct. 2.	99.51
Dec. 10,	98.89	May 7,	99.04b	Nov. 1,	96.59
Jan. 3, 1963	97.08	June 24,	97.45		
Feb. 7,	96.90	Aug. 9,	100.25b		

b= well pumped recently

137-78-8bcb
Test hole 2014

Date	Water level	Date	Water level	Date	Water level
Aug. 16, 1962	47.41	Jan. 3, 1963	47.70	Aug. 9, 1963	47.60
31,	47.53	Feb. 7,	47.58	Sept. 6,	47.76
Sept. 11,	47.52	Mar. 8,	47.48	Oct. 2,	47.73
Oct. 3,	47.65	Apr. 16,	47.38	Nov. 1,	47.95
26,	47.69	May 7,	47.40	Dec. 3,	47.97
Dec. 10,	47.73	June 24	47.48	Jan. 2, 1964	47.93

TABLE 5.--Water-level measurements in selected wells in Burleigh County, North Dakota -- Continued

137-78-33aba
Test hole 2039

Date	Water level	Date	Water level	Date	Water level
Aug. 16, 1962	66.35	Jan. 3, 1963	66.46	Aug. 9, 1963	66.61
31,	66.51	Feb. 7,	66.26	Sept. 6,	66.71
Sept. 11,	66.50	Mar. 8,	66.08	Oct. 2,	66.81
Oct. 3,	66.64	Apr. 16,	66.15	Nov. 1,	66.91
26,	66.61	May 7,	65.93	Dec. 3,	66.84
Dec. 10,	66.59	June 24,	66.23	Jan. 2, 1964	66.58

137-79-26cbb
Test hole 2015

Date	Water level	Date	Water level	Date	Water level
Aug. 16, 1962	13.24	Jan. 3, 1963	13.17	Aug. 9, 1963	12.96
31,	13.70	Feb. 7,	12.19	Sept. 6,	13.67
Sept. 11	13.97	Mar. 8,	11.63	Oct. 2,	13.91
Oct. 3,	14.19	Apr. 16,	12.15	Nov. 1,	13.60
26,	14.23	May 7,	12.24	Dec. 3,	13.02
Dec. 10,	14.04	June 24,	12.41	Jan. 2, 1964	11.90

TABLE 5.--Water-level measurements in selected wells in Burleigh County, North Dakota -- Continued

138-76-33bbb
Test hole 2022

Date		Water level	Date		Water level	Date		Water level
Aug.	16, 1962	5.72	Jan.	3, 1963	5.98	Aug.	9, 1963	6.19
	29,	5.99	Feb.	7,	5.85	Sept.	6,	6.52
Sept.	11,	6.12	Mar.	8,	5.74	Oct.	2,	6.98
Oct.	4,	6.30	Apr.	17,	5.61	Nov.	1,	6.88
	26,	6.22	May	7,	5.59	Dec.	3,	6.96
Dec.	10,	6.11	June	24,	5.73	Jan.	2, 1964	6.79

138-77-15aaa
Test hole 2023

Date		Water level	Date		Water level	Date		Water level
Aug.	14, 1962	14.33	Oct.	10, 1962	12.93	Jan.	1, 1963	11.56
	16,	14.96		16,	12.79	Feb.	7,	11.20
	23,	14.64		21,	12.63	Mar.	8,	11.02
	28,	15.43d		26,	12.50	Apr.	16,	10.76
Sept.	2,	16.34c		31,	12.46	May	6,	10.73
	7,	15.37d	Nov.	3,	12.44	June	24,	11.63
	11,	14.77		9,	12.38	July	12,	12.41
	16,	14.24		15,	12.23	Aug.	9,	14.97d
	21,	13.88		20,	12.16	Sept.	6,	13.29
	24,	13.62		25,	12.09	Oct.	2,	14.30d
Oct.	3,	13.25		30,	12.01	Nov.	1,	15.45d
	8,	13.01	Dec.	10,	11.89	Dec.	3,	13.60

c= nearby well being pumped d=nearby well pumped recently

TABLE 2.--Water-level measurements in selected wells in Burleigh County, North Dakota -- Continued

138-77-15dcb
W. Anderson, irrigation well no. 1

Date	Water level	Date	Water level	Date	Water level
Sept. 21, 1961	12.19b	Aug. 23, 1962	13.72b	Feb. 8, 1963	9.06
Oct. 26,	9.79	Sept. 11,	12.85	Apr. 16,	8.74
Nov. 8,	9.85	12,	12.73	May 6,	8.66
17,	9.66	24,	11.58	June 24,	9.41
Dec. 6,	9.27	Oct. 26,	10.33	Aug. 9,	13.61b
May 1, 1962	8.29	Nov. 16,	10.04	Sept. 6,	11.18
15,	11.88b	Dec. 10,	9.65	Oct. 3,	11.15
June 27,	9.12	Jan. 2, 1963	9.42	Nov. 1,	13.72b
July 28,	8.70	Feb. 7,	9.28	Dec. 3,	11.49
				Jan. 2, 1964	10.62

b= well pumped recently

TABLE 5.--Water-level measurements in selected wells in Burleigh County, North Dakota -- Continued

138-77-22aad
Test hole 1955

Lowest water level for the day from recorder graph

1961

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5										13.19d.	12.40	12.24
10										13.05	12.38	12.15
15										12.87	12.35	12.08
20										12.77	12.34	12.01
25									14.14d.	12.56	12.32	11.94
Eom									13.87d.	12.42	12.29	11.73

1962

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5	11.38	10.59	10.38	10.18	15.33d.	12.01	11.01	16.71d.	18.56	13.45	12.64	11.87
10	11.15	10.55e.	10.33e.	10.20	16.39d.	11.74	10.95	16.78d.	16.07	13.26	12.45	11.78
15	10.90e.	10.51	10.30	10.20	16.00d.	11.59	10.91	18.10d.	15.18	13.01	12.32	11.73
20	10.72	10.47	10.26	10.25	13.70	11.40	10.80	19.09d.	14.52	12.87	12.15	11.69
25	10.67h.	10.43h.	10.23	10.40	13.42	11.35	10.80	18.93d.	14.11	12.72	12.14	11.62
Eom	10.62	10.42	10.21h.	10.53h.	12.25	11.21	11.95d.	19.49d.	13.58	12.75	12.00	11.54

1963

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5	11.41	11.25	10.97	10.58	10.40	12.65	11.33	17.54d.	13.75	14.15	16.95	13.99
10	11.36	11.24	10.77	10.51	14.02d.	12.04	12.84	17.80d.	13.48	17.04d.	16.34	13.75
15	11.36	11.24	10.72	10.48	13.30d.	11.75	14.68d.	17.95d.	13.52	19.35d.	-----	13.65
20	11.34	11.20	10.70	10.46	11.25	11.72	15.15d.	15.60	13.66	20.05d.	15.71	13.62
25	11.30	11.10	10.66	10.45	14.01d.	11.66	17.61d.	14.81	13.80	19.85d.	-----	13.57
Eom	11.28	11.06	10.61	10.38	15.22d.	11.36	18.20d.	14.16	13.97	17.13	-----	13.56

d=nearyby well pumped recently e=estimated h=tape measurment

TABLE 5.--Water-level measurements in selected wells in Burleigh County, North Dakota -- Continued

138-77-23ddb
R. Baeth, irrigation well no. 1

Date	Water level	Date	Water level	Date	Water level
Sept. 14, 1961	36.70d	May 28, 1962	33.54	Jan. 2, 1963	29.60
21,	32.74	June 20,	30.62	Feb. 7,	29.38
26,	31.41	27,	30.14	Mar. 8,	29.35
Oct. 31,	31.18	July 5,	29.67	Apr. 16,	27.85
Nov. 8,	33.71b	27,	28.71	May 6,	27.75
17,	31.86	Aug. 14,	38.64b	June 24,	31.90
Dec. 6,	30.33	23,	36.28d	Aug. 9,	41.77b
Jan. 25, 1962	28.49	Sept. 11,	38.58b	Sept. 6,	34.22
Mar. 30,	27.58	24,	35.21	Oct. 2,	45.15b
May 1,	33.31	Oct. 26,	32.18	Dec. 3,	36.28
10,	64.89a	Nov. 16,	31.90	Jan. 2, 1964	32.26
15,	40.00b	Dec. 10,	30.56		

a= well being pumped b= well pumped recently d= nearby well pumped recently

TABLE 5.--Water-level measurements in selected wells
in Burleigh County, North Dakota -- Continued

138-77-23aac
Test hole 1979

Date		Water level	Date		Water level	Date		Water level
June	19, 1962	26.95	Oct.	5, 1962	30.48	Dec.	5, 1962	28.97
	27,	28.17		8,	30.23		10,	28.89
Aug.	14,	31.86		12,	30.11	Jan.	2, 1963	28.28
	17,	32.78		16,	30.03	Feb.	7,	27.86
	19,	32.86		21,	29.86	Mar.	8,	27.60
	23,	33.24		26,	29.64	Apr.	16,	27.30
	25,	34.27d		30,	29.85	May	6,	27.33
	28,	35.12c	Nov.	2,	29.91		27,	28.20
	31,	34.42d		5,	29.60	July	12,	28.18
Sept.	5,	34.10		9,	29.44	Aug.	9,	33.45d
	11,	32.72		12,	29.20	Sept.	6,	30.56
	16,	31.57		16,	29.15	Oct.	2,	31.72
	21,	31.38		20,	29.11	Meas. discontinued		
	28,	31.01		25,	29.06			
Oct.	1	30.70		30,	29.02			

c= nearby well being pumped   d= nearby well pumped recently

TABLE 5.--Water-level measurements in selected wells in Burleigh County, North Dakota -- Continued

138-77-25bbd1
G. D. Adams, irrigation well no. 1

Date		Water level	Date		Water level	Date		Water level
Sept.	7, 1961	39.20b	May	27, 1962	36.30	Feb.	7, 1963	31.27
	23,	37.58	June	27,	32.61	Mar.	8,	30.86
Oct.	31,	32.71	July	27,	32.83	Apr.	17,	30.42
Nov.	8,	36.09d	Aug.	16,	45.46d	May	6,	30.32
	17,	34.39		23,	38.63	Aug.	9,	44.60d.
Jan.	25, 1962	30.98	Sept.	11,	41.09	Sept.	6,	37.00
Apr.	27,	30.10		24,	37.81	Oct.	2,	65.00a
May	2,	60.67a	Oct.	25,	34.72		21,	66.50a
	4,	68.33a	Nov.	16,	34.54	Nov.	1,	47.25b
	10,	69.61a	Dec.	10,	33.15	Dec.	3,	37.00
	15,	42.59b	Jan.	2, 1963	32.14	Jan.	2, 1964	35.93

a= well being pumped b= well pumped recently d= nearby well pumped recently

TABLE 5.--Water-level measurements in selected wells in Burleigh County, North Dakota -- Continued

138-77-26adc
Test hole 1954

Date		Water level	Date		Water level	Date		Water level
Sept.	22, 1961	34.87d	Mar.	26, 1962	27.80	Jan.	2, 1963	39.77
Oct.	31,	31.94	Apr.	1,	27.60	Feb.	7,	28.63
Nov.	8,	34.39d	May	1,	31.74	Mar.	8,	28.30
	17,	32.83		9,	40.17d	Apr.	17,	27.80
Dec.	4,	30.80		15,	38.99	May	6,	27.33
Jan.	5, 1962	29.51	June	27,	30.48	June	26,	32.15
Feb.	5,	29.20	Aug.	16,	37.60d	Aug.	9,	40.15d
	12,	28.80		23,	36.38d	Sept.	6,	34.99
	19,	28.20	Sept.	24,	36.69d	Oct.	2,	40.70d
Mar.	12,	28.00	Oct.	26,	33.10		21,	43.22d
	19,	27.90	Dec.	10,	31.18	Nov.	1,	42.61d

d= nearby well pumped recently.

138-78-27ccd
Test hole 2042

Date		Water level	Date		Water level	Date		Water level
Aug.	16, 1962	42.35	Jan.	3, 1963	42.49	Aug.	9, 1963	42.14
	31,	42.42	Feb.	7,	42.55	Sept.	6,	42.76
Sept.	11,	42.48	Mar.	8,	42.49	Oct.	2,	42.92
Oct.	3,	42.54	Apr.	16,	42.37	Nov.	1,	42.83
	26,	42.53	May	7,	42.35	Dec.	3,	43.07
Dec.	10,	42.50	June	24,	42.35	Jan.	2, 1964	42.92

TABLE 5.--Water-level measurements in selected wells in Burleigh County, North Dakota -- Continued

138-78-32daa
Test hole 2012

Date	Water level	Date	Water level	Date	Water level
Aug. 16, 1962	48.46	Jan. 3, 1963	48.44	Aug. 9, 1963	48.41
31,	48.22	Feb. 7,	48.47	Sept. 6,	48.68
Sept. 11,	48.26	Mar. 8,	48.34	Oct. 2,	48.79
Oct. 3,	48.44	Apr. 16,	48.18	Nov. 1,	48.80
26,	48.48	May 7,	48.18	Dec. 3,	48.85
Dec. 10,	48.47	June 24,	48.21	Jan. 2, 1964	48.74

138-80-2ccc
Test hole 2057

Date	Water level	Date	Water level	Date	Water level
Sept. 11, 1962	21.13	Jan. 2, 1963	21.17	June 24, 1963	20.74
25,	21.45	Feb. 7,	21.11	Aug. 9,	21.15
Oct. 25,	21.35	Mar. 7,	21.02	Sept. 6,	21.37
Nov. 16,	21.20	Apr. 16,	20.88	Oct. 2,	21.45
Dec. 7,	21.19	May 6,	20.86	Nov. 1,	21.57
				Jan. 2, 1964	21.24

TABLE 5.--Water level measurements in selected wells
in Burleigh County, North Dakota -- Continued

138-80-9bcc
P. Wachter, irrigation well no. 1

Date	Water level	Date	Water level	Date	Water level
Sept. 8, 1961	19.70	Nov. 26, 1962	18.74	June 24, 1963	16.51
June 27, 1962	15.35	Dec. 7,	18.57	July 8,	16.34
27,	49.50a	Jan. 2, 1963	18.05	Aug. 9,	16.89
Aug. 23,	17.39	Feb. 7,	17.51	Sept. 6,	17.89
Sept. 11,	17.48	Mar. 7,	16.12	Nov. 1,	55.00a
Nov. 5,	23.66b	Apr. 16,	15.93	Dec. 3,	18.78
8,	20.57b	May 7,	15.85	Jan. 2,1964	16.97

a= well being pumped b= well pumped recently

TABLE 5.--Water-level measurements in selected wells in Burleigh County, North Dakota -- Continued

138-80-15cdd
Test hole 1956

Lowest water level for the day from recorder graph

1961

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5										35.45	39.88	38.85
10										39.78h.	39.43h.	38.75
15										40.15	39.29	38.64
20										40.85d.	39.14	38.53
25										40.70d.	39.04	38.45
Eom										40.49d.	38.94	38.33

1962

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5	38.31			36.45	37.34d.	36.55	36.83	39.00d.	38.77	39.18d.	38.80	38.74
10	38.09		36.90e.	36.50	38.20d.	36.50	37.05	38.97d.	38.76	3 .89	38.70	38.73
15	37.98			36.55	37.29	36.43	37.13	38.56h.	38.85	39.43	38.68	38.73e.
20	37.85	37.21e.		36.61	36.87	36.48	37.19	38.58d.	39.07d.	39.51	38.71	38.72
25	37.70			36.66	36.71h.	36.72	38.27d.	38.62	39.25d.	39.42	38.69	3 .71e.
Eom	37.59e.		36.57	36.77	36.64	37.00	38.95d.	38.75h.	39.15..	39.30	38.70	38.70

1963

Day	Jan	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5	38.60	37.59	37.16	36.80	37.11	37.51	37.70	39.46	38.93	40.62d.	41.60d.	39.60
10	38.43	37.50	36.89	36.94	37.19	37.49	38.69	39.15	39.12	40.14	40.26	39.40
15	38.31	37.48	36.84	36.89	37.26	37.63	39.18d.	39.16	39.31	40.50d.	40.05	-----
20	38.08	37.27	36.80	36.98	37.33	38.78d.	39.25	39.12	39.53	39.86	39.74	-----
25	37.98	37.28	36.75	36.98	37.61	37.77	39.31	38.98	39.38	40.31d.	39.65	-----
Eom	37.80	37.27	36.83	36.97	37.58	37.60	39.57	38.96	39.94	40.37d.	39.62	38.15

d=nearby well pumped recently   e=estimated   h=tape measurement

TABLE 5.--Water-level measurements in selected wells in Burleigh County, North Dakota -- Continued

138-80-17acb
J. Peterson, irrigation well no. 1

Date		Water level	Date		Water level	Date		Water level
Sept.	8, 1961	14.42	Nov.	6, 1962	17.98	May	7, 1963	15.36
May	1, 1962	14.85		14,	31.82a	June	5,	15.39
June	27,	14.90		19,	18.00	July	8,	15.85
July	27,	15.79	Dec.	7,	17.94	Aug.	9,	16.69b
Aug.	23,	16.96d	Jan.	2, 1963	17.26	Sept.	6,	17.14b
Sept.	11,	17.19d	Feb.	7,	16.57	Oct.	2,	17.77d
Oct.	25,	17.95d	Mar.	7,	15.22	Nov.	1,	18.39d
Nov.	5,	18.06d	Apr.	16,	15.32	Dec.	2,	17.93

a= well being pumped b= well pumped recently d= nearby well being pumped

138-80-22aac
D. McDonald, irrigation well no. 1

Date		Water level	Date		Water level	Date		Water level
Sept.	23, 1961	43.27	Aug.	24, 1962	43.00	Mar.	12, 1963	41.17
Oct.	10,	43.07	Sept.	11,	43.08	Apr.	16,	41.32
	19,	44.14b	Oct.	25,	44.66c	Aug.	9,	43.43c
May	1, 1962	41.08	Dec.	7,	43.57	Sept.	6,	43.23c
June	27,	41.02	Jan.	2, 1963	42.92	Oct.	8,	43.55c
July	27,	43.16c	Feb.	7,	41.77	Nov.	1,	55.72b

b= well pumped recently c= nearby well pumped recently

TABLE 5.--Water-level measurements in selected wells
in Burleigh County, North Dakota -- Continued

138-80-23bdc
D. Solberg, irrigation well no. 1

Date	Water level	Date	Water level	Date	Water level
Sept. 7, 1961	35.93	Sept. 11, 1962	35.78	May 17, 1963	34.16
Oct. 10,	35.22	Oct. 25,	36.40b	June 24,	34.93
14,	36.98d	Dec. 7,	35.73	Aug. 9,	78.18a
19,	35.37	Jan 2, 1963	35.60	Sept. 6,	35.97
May 1, 1962	33.45	Feb. 7,	34.50	Oct. 2,	80.14a
June 27,	32.98	Mar. 7,	33.68	Nov. 1,	38.36b
Aug. 23,	35.94b	Apr. 16,	34.07		

a= well being pumped b= well pumped recently d= nearby well pumped recently

138-80-24cac
Yegen Dairy, irrigation well no. 1

Date	Water level	Date	Water level	Date	Water level
Sept. 9, 1961	12.00b	Jan. 2, 1963	9.54	May 8, 1963	8.99
Oct. 12,	7.40	Feb. 7,	9.09	June 24,	11.82b
May 1, 1962	6.54	Mar. 7,	8.74	Aug. 8	10.43
Aug. 24,	28.79a	Apr. 5,	8.48	Sept. 6,	9.10
Oct. 25,	6.85	18,	8.69		
Dec. 7,	10.01	May 6,	6.94		

a= well being pumped b= well pumped recently

TABLE 5.--Water-level measurements in selected wells in Burleigh County, North Dakota -- Continued

138-80-25bab
Yegen Dairy, irrigation well no. 2

Date	Water level	Date	Water level	Date	Water level
May 6, 1963	8.99	Aug. 8, 1963	12.99b	Oct. 2, 1963	10.84
June 24,	12.63b	Sept. 6,	11.19	Nov. 1,	37.70a

a= well being pumped b= well pumped recently

139-75-19caa
Test hole 2049-D

Date	Water level	Date	Water level	Date	Water level
Mar. 28, 1963	10.79	May 7, 1963	10.75	Sept. 6, 1963	9.96
Apr. 5,	10.82	Aug.9,	10.69	Oct. 2,	10.10

139-78-27cbb
Test hole 2037

Date	Water level	Date	Water level	Date	Water level
Aug. 17, 1962	24.34	Jan. 2, 1963	24.30	Aug. 9, 1963	23.92
30,	24.22	Feb. 7,	24.28	Sept. 6,	24.13
Sept. 11,	24.27	Mar. 8,	24.30	Oct. 2,	24.12
Oct. 3,	24.29	Apr. 17,	23.97	Nov. 1,	24.24
26,	24.34	May 6,	24.23	Jan. 2, 1964	24.18
Dec. 10,	24.35	June 25,	23.75		

TABLE 5.--Water-level measurements in selected wells in Burleigh County, North Dakota -- Continued

139-81-11bdd
R. Ward, irrigation well no. 1

Date	Water level	Date	Water level	Date	Water level
May 1, 1961	15.45b	Mar. 12, 1963	14.02	Sept. 17, 1963	14.70
Sept. 8,	15.00	Apr. 16,	12.98	Oct. 2,	14.55
Dec. 10, 1962	15.04	May 7,	12.94	Nov. 1,	32.28a
Jan. 2, 1963	14.99	June 24,	13.70		

a= well being pumped b= well pumped recently

140-75-1aaa
Test hole 2049-A

Date	Water level	Date	Water level	Date	Water level
Mar. 28, 1963	51.65	June 25, 1963	52.30	Oct. 2, 1963	52.27
Apr. 5,	52.24	Aug. 9,	52.52	Nov. 1,	52.62
May 7,	51.96	Sept. 6,	52.34	Jan. 2, 1964	51.87

140-75-12cdd
Test hole 2049

Date	Water level	Date	Water level	Date	Water level
Aug. 17, 1962	13.26	Jan. 3, 1963	13.33	June 25, 1963	13.46
29,	13.26	Feb. 7,	13.37	Aug. 9,	13.65
Sept. 24,	13.35	Mar. 8,	13.44	Sept. 6,	13.63
Oct. 4,	13.26	28,	13.35	Oct. 2,	13.72
26,	13.28	Apr. 5,	13.47	Nov. 1,	13.76
Dec. 10,	13.37	May 7,	13.52	Jan. 2, 1964	13.65

TABLE 5.--Water-level measurements in selected wells in Burleigh County, North Dakota -- Continued

140-75-24ddd
Test hole 2049-B

Date	Water level	Date	Water level	Date	Water level
Mar. 28, 1963	4.61	June 25, 1963	4.66	Oct. 2, 1963	4.87
Apr. 5,	4.67	Aug. 9,	4.75	Nov. 1,	4.81
May 7,	4.76	Sept. 6,	4.77	Jan. 2, 1964	4.77

140-76-33bbb
Test hole 2018

Date	Water level	Date	Water level	Date	Water level
Aug. 15, 1962	1.8 gpm	Jan. 2, 1963	1.4 gpm	Aug. 9, 1963	1.2 gpm
29,	1.1 gpm	Feb. 7,	1.4 gpm	Sept. 6,	1.3 gpm
Sept. 24,	1.2 gpm	Mar. 8,	Frozen	Oct. 2,	1.1 gpm
Oct. 26,	1.3 gpm	Apr. 16,	1.2 gpm	Nov. 1,	1.2 gpm
Dec. 10,	1.5 gpm	June 24,	1.0 gpm	Jan. 2, 1964	0.2 gpm

gpm= gallons per minute flow.

140-78-36bba
Test hole 2009

Date	Water level	Date	Water level	Date	Water level
Aug. 17, 1962	12.81	Jan. 2, 1963	12.99	Aug. 9, 1963	12.80
30,	12.88	Feb. 7,	12.95	Sept. 6,	12.90
Sept. 11,	12.90	Mar. 8,	12.90	Oct. 2,	12.97
Oct. 3,	12.98	Apr. 17,	12.88	Nov. 1,	12.95
26,	13.02	May 6,	12.94		
Dec. 10,	13.04	June 25,	12.52		

TABLE 5.--Water-level measurements in selected wells
in Burleigh County, North Dakota -- Continued

140-81-5aaa
Test hole 1983

Date	Water level	Date	Water level	Date	Water level
June 21, 1962	7.84	Oct. 26, 1962	8.36	May 7, 1963	7.05
July 20,	7.49	Dec. 7,	9.37	June 24,	6.35
Aug. 15,	7.39	Jan. 2, 1963	8.34	Aug. 9,	7.35
30	7.77	Feb. 6,	7.23	Sept. 6,	8.07
Sept. 12,	7.58	Mar. 7,	6.55	Oct. 3,	8.54
25,	8.67	Apr. 17,	6.89	Nov. 1	7.76
				Jan. 2, 1964	6.74

141-80-35cc
C. Delong

Date	Water level	Date	Water level	Date	Water level
Nov. 21, 1940	15.90	Sept. 10, 1949	15.58	Sept. 16, 1954	13.79
Apr. 4,	15.33	Nov. 25,	14.82	Apr. 21, 1955	13.60
Nov. 20,	15.65	25, 1950	13.22	Oct. 25, 1955	14.50
Aug. 12, 1942	15.61	June 25, 1951	14.04	May 4, 1956	13.28
May 23, 1943	14.47	Nov. 10,	13.85	Nov. 14,	17.14
8, 1944	14.47	Apr. 25, 1952	13.33	May 2, 1957	13.77
Sept. 3,	14.86	Aug. 3,	14.95	Sept. 4, 1958	15.75
May 12, 1945	14.29	9,	15.00	No. meas. 1959	
18, 1946	14.34	Sept. 24,	15.04	Meas. discontinued	
Oct. 2,	15.17	May 5, 1953	13.42		
No meas. 1947		Nov. 19,	14.32		
Sept. 13, 1948	15.85	Apr. 30, 1954	13.77		

TABLE 5.--Water-level measurement in selected wells in Burleigh County, North Dakota -- Continued

142-75-19ccb
Test hole 1995

Date	Water level	Date	Water level	Date	Water level
Aug. 14, 1962	5.75	Jan. 3, 1963	5.91	June 25, 1963	5.96
29,	5.59	Feb. 7,	5.95	Aug. 9,	6.25
Sept. 20,	5.81	Mar. 8,	6.03	Sept. 6,	6.32
Oct. 26,	5.66	28,	5.96	Oct. 2,	6.39
Dec. 10	5.92	May 7,	5.94	Nov. 1,	6.38

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Bismarck AASF #1
3410 Yegen Road
Bismarck, ND 58504
EDR Inquiry # 5872123.6

Client Name:

AECOM
12120 Shamrock Plaza
Omaha, NE 68154
Contact: Hans Sund

Environmental Data Resources, Inc. (EDR) Aerial Photo Decade Package is a screening tool designed to assist environmental professionals in evaluating potential liability on a target property resulting from past activities. EDR's professional researchers provide digitally reproduced historical aerial photographs, and when available, provide one photo per decade.

Search Results:

Year	Scale	Details	Source
2017	1"=500'	Flight Year: 2017	USDA/NAIP
2014	1"=500'	Flight Year: 2014	USDA/NAIP
2010	1"=500'	Flight Year: 2010	USDA/NAIP
2006	1"=500'	Flight Year: 2006	USDA/NAIP
1997	1"=500'	Acquisition Date: September 23, 1997	USGS/DOQQ
1992	1"=750'	Flight Date: September 28, 1992	USGS
1984	1"=500'	Flight Date: April 19, 1984	USDA
1979	1"=1000'	Flight Date: May 16, 1979	USGS
1976	1"=500'	Flight Date: May 28, 1976	USGS
1961	1"=500'	Flight Date: October 26, 1961	USGS
1959	1"=500'	Flight Date: May 24, 1959	USGS
1957	1"=500'	Flight Date: August 13, 1957	USDA
1938	1"=500'	Flight Date: July 15, 1938	USDA

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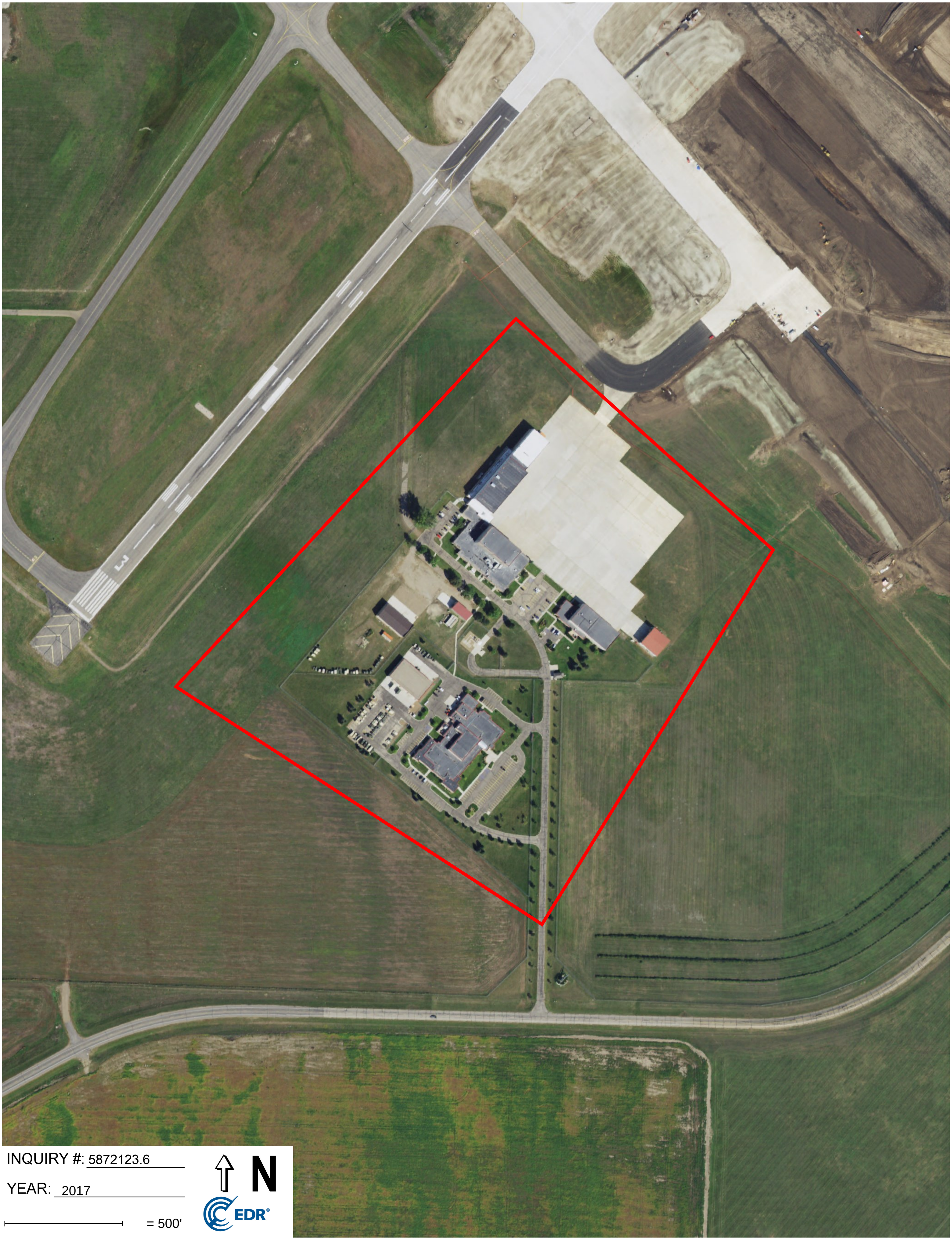
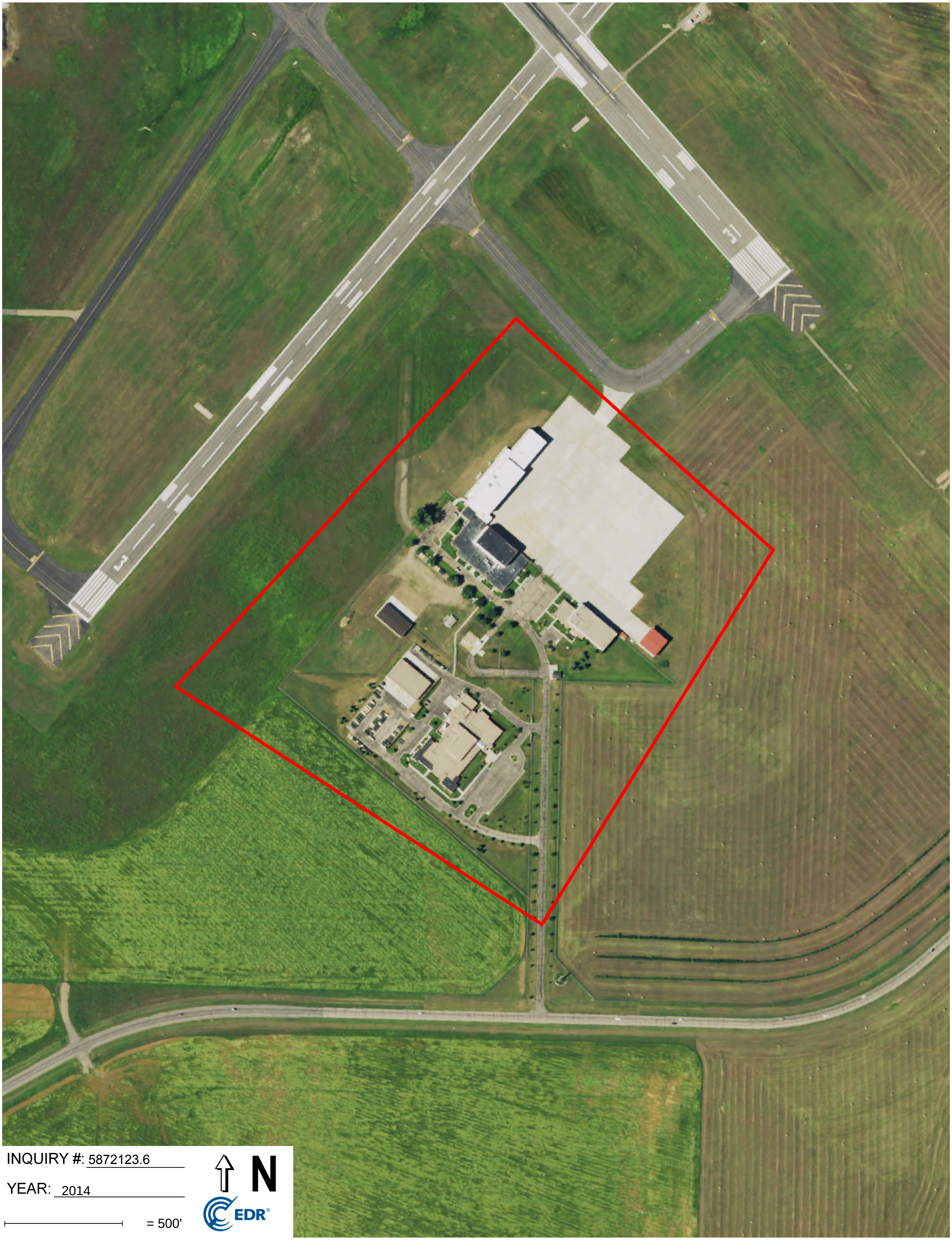


INQUIRY #: 5872123.6

YEAR: 2017

= 500'

N



INQUIRY #: 5872123.6

YEAR: 2014

= 500'

N

INQUIRY #: 5872123.6

YEAR: 2010

= 500'

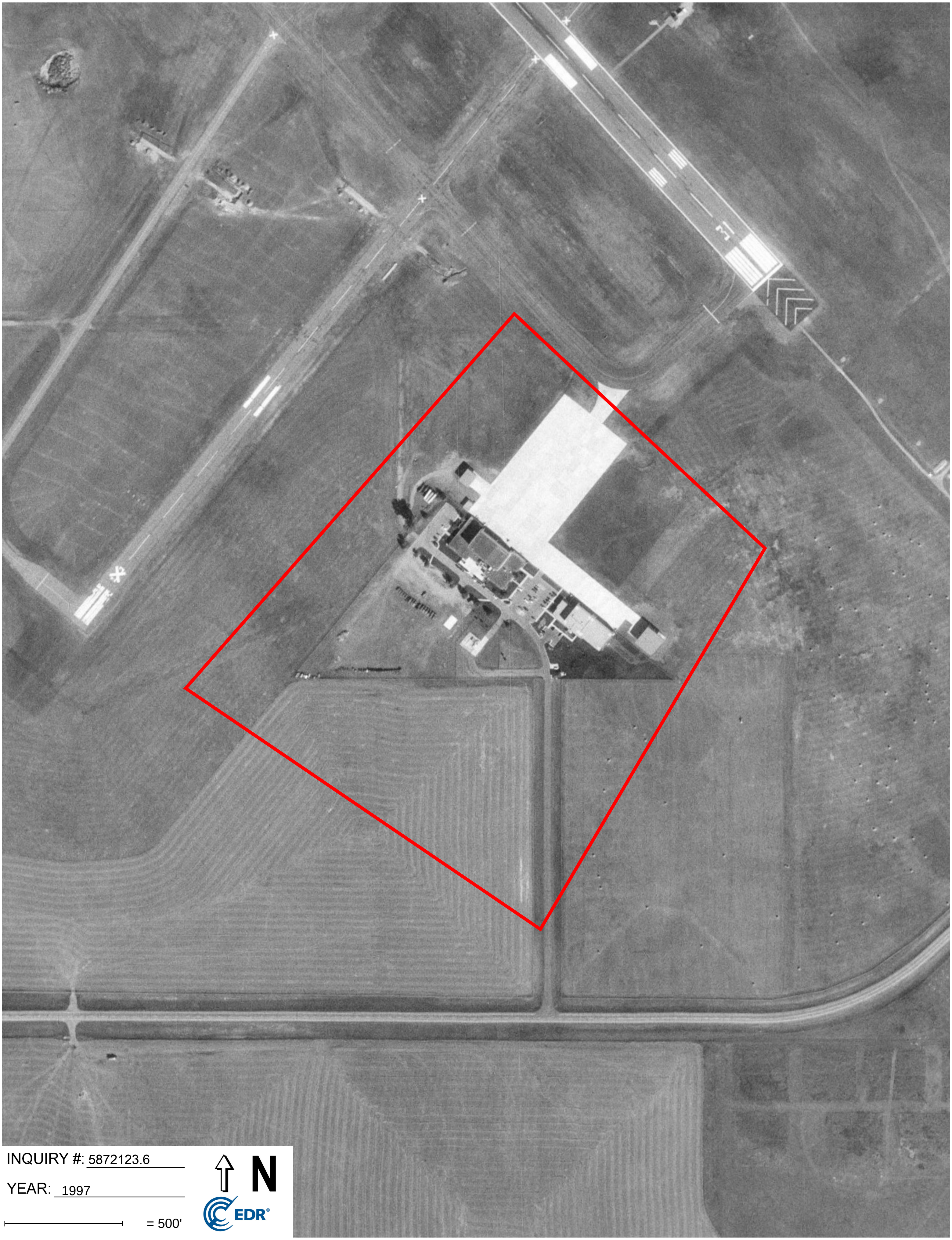
N

INQUIRY #: 5872123.6

YEAR: 2006

= 500'

N



INQUIRY #: 5872123.6

YEAR: 1997

= 500'

N

EDR

INQUIRY #: 5872123.6

YEAR: 1992

= 750'

N

EDR

Subject boundary not shown because it exceeds image extent or image is not georeferenced.

INQUIRY #: 5872123.6

YEAR: 1984

= 500'

N

EDR

INQUIRY #: 5872123.6

YEAR: 1979

= 1000'

N

Subject boundary not shown because it exceeds image extent or image is not georeferenced.

INQUIRY #: 5872123.6

YEAR: 1976

= 500'

N

EDR

INQUIRY #: 5872123.6

YEAR: 1961

= 500'

N

EDR


INQUIRY #: 5872123.6
YEAR: 1959
= 500'
N
EDR

INQUIRY #: 5872123.6

YEAR: 1957

= 500'

N

EDR

INQUIRY #: 5872123.6

YEAR: 1938

= 500'

N

EDR

Bismarck AASF #1
3410 Yegen Road
Bismarck, ND 58504

Inquiry Number: 5872123.2s
November 15, 2019

The EDR Radius Map™ Report with GeoCheck®

6 Armstrong Road, 4th floor
Shelton, CT 06484
Toll Free: 800.352.0050
www.edrnet.com

TABLE OF CONTENTS

Thank you for your business.
Please contact EDR at 1-800-352-0050
with any questions or comments.

EXECUTIVE SUMMARY

A search of available environmental records was conducted by Environmental Data Resources, Inc (EDR). The report was designed to assist parties seeking to meet the search requirements of EPA's Standards and Practices for All Appropriate Inquiries (40 CFR Part 312), the ASTM Standard Practice for Environmental Site Assessments (E 1527-13), the ASTM Standard Practice for Environmental Site Assessments for Forestland or Rural Property (E 2247-16), the ASTM Standard Practice for Limited Environmental Due Diligence: Transaction Screen Process (E 1528-14) or custom requirements developed for the evaluation of environmental risk associated with a parcel of real estate.

TARGET PROPERTY INFORMATION

ADDRESS

3410 YEGEN ROAD
BISMARCK, ND 58504

COORDINATES

Latitude (North):	46.7631010 - 46˚ 45' 47.16''
Longitude (West):	100.7409150 - 100˚ 44' 27.29''
Universal Tranverse Mercator:	Zone 14
UTM X (Meters):	367059.2
UTM Y (Meters):	5180092.0
Elevation:	1645 ft. above sea level

USGS TOPOGRAPHIC MAP ASSOCIATED WITH TARGET PROPERTY

Target Property Map:	6050163 MENOKEN SW, ND
Version Date:	2014
Southeast Map:	6050191 SUGARLOAF BUTTE, ND
Version Date:	2014
Southwest Map:	6050171 SCHMIDT, ND
Version Date:	2014
Northwest Map:	6050091 BISMARCK, ND
Version Date:	2014

AERIAL PHOTOGRAPHY IN THIS REPORT

Portions of Photo from:	20150927
Source:	USDA

MAPPED SITES SUMMARY

Target Property Address:
3410 YEGEN ROAD
BISMARCK, ND 58504

Click on Map ID to see full detail.

MAP ID	SITE NAME	ADDRESS	DATABASE ACRONYMS	RELATIVE ELEVATION	DIST (ft. & mi.) DIRECTION
1	BISMARCK MUNICIPAL A		FUDS	Lower	3652, 0.692, NNW

EXECUTIVE SUMMARY

TARGET PROPERTY SEARCH RESULTS

The target property was not listed in any of the databases searched by EDR.

DATABASES WITH NO MAPPED SITES

No mapped sites were found in EDR's search of available ("reasonably ascertainable ") government records either on the target property or within the search radius around the target property for the following databases:

STANDARD ENVIRONMENTAL RECORDS

Federal NPL site list

NPL - National Priority List
Proposed NPL - Proposed National Priority List Sites
NPL LIENS - Federal Superfund Liens

Federal Delisted NPL site list

Delisted NPL - National Priority List Deletions

Federal CERCLIS list

FEDERAL FACILITY - Federal Facility Site Information listing
SEMS - Superfund Enterprise Management System

Federal CERCLIS NFRAP site list

SEMS-ARCHIVE - Superfund Enterprise Management System Archive

Federal RCRA CORRACTS facilities list

CORRACTS - Corrective Action Report

Federal RCRA non-CORRACTS TSD facilities list

RCRA-TSDF - RCRA - Treatment, Storage and Disposal

Federal RCRA generators list

RCRA-LQG - RCRA - Large Quantity Generators
RCRA-SQG - RCRA - Small Quantity Generators
RCRA-VSQG - RCRA - Very Small Quantity Generators (Formerly Conditionally Exempt Small Quantity Generators)

Federal institutional controls / engineering controls registries

LUCIS - Land Use Control Information System

US ENG CONTROLS.......... Engineering Controls Sites List
US INST CONTROL.......... Sites with Institutional Controls

Federal ERNS list

ERNS.......................... Emergency Response Notification System

State- and tribal - equivalent CERCLIS

SHWS.......................... This state does not maintain a SHWS list. See the Federal CERCLIS list and Federal NPL list.

State and tribal landfill and/or solid waste disposal site lists

SWF/LF........................ Solid Waste Landfills/Special Use Landfills

State and tribal leaking storage tank lists

LUST.......................... Leaking Underground Storage Tank List
INDIAN LUST................... Leaking Underground Storage Tanks on Indian Land

State and tribal registered storage tank lists

FEMA UST...................... Underground Storage Tank Listing
UST........................... Underground Storage Tank Data
AST........................... Aboveground Storage Tank Listing
INDIAN UST.................... Underground Storage Tanks on Indian Land

State and tribal institutional control / engineering control registries

AUL........................... Land Use Controls Listing

State and tribal voluntary cleanup sites

INDIAN VCP.................... Voluntary Cleanup Priority Listing

State and tribal Brownfields sites

BROWNFIELDS................... List of Brownfields Sites

ADDITIONAL ENVIRONMENTAL RECORDS

Local Brownfield lists

US BROWNFIELDS................ A Listing of Brownfields Sites

Local Lists of Landfill / Solid Waste Disposal Sites

SWRCY......................... Recycling Centers
INDIAN ODI.................... Report on the Status of Open Dumps on Indian Lands
ODI........................... Open Dump Inventory
DEBRIS REGION 9............... Torres Martinez Reservation Illegal Dump Site Locations
IHS OPEN DUMPS................ Open Dumps on Indian Land

Local Lists of Hazardous waste / Contaminated Sites

US HIST CDL................... Delisted National Clandestine Laboratory Register

EXECUTIVE SUMMARY

CDL	Clandestine Drug Lab Location Listing
US CDL	National Clandestine Laboratory Register

Local Land Records

LIENS 2	CERCLA Lien Information

Records of Emergency Release Reports

HMIRS	Hazardous Materials Information Reporting System
SPILLS	State Spills

Other Ascertainable Records

RCRA NonGen / NLR	RCRA - Non Generators / No Longer Regulated
DOD	Department of Defense Sites
SCRD DRYCLEANERS	State Coalition for Remediation of Drycleaners Listing
US FIN ASSUR	Financial Assurance Information
EPA WATCH LIST	EPA WATCH LIST
2020 COR ACTION	2020 Corrective Action Program List
TSCA	Toxic Substances Control Act
TRIS	Toxic Chemical Release Inventory System
SSTS	Section 7 Tracking Systems
ROD	Records Of Decision
RMP	Risk Management Plans
RAATS	RCRA Administrative Action Tracking System
PRP	Potentially Responsible Parties
PADS	PCB Activity Database System
ICIS	Integrated Compliance Information System
FTTS	FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fungicide, & Rodenticide Act)/TSCA (Toxic Substances Control Act)
MLTS	Material Licensing Tracking System
COAL ASH DOE	Steam-Electric Plant Operation Data
COAL ASH EPA	Coal Combustion Residues Surface Impoundments List
PCB TRANSFORMER	PCB Transformer Registration Database
RADINFO	Radiation Information Database
HIST FTTS	FIFRA/TSCA Tracking System Administrative Case Listing
DOT OPS	Incident and Accident Data
CONSENT	Superfund (CERCLA) Consent Decrees
INDIAN RESERV	Indian Reservations
FUSRAP	Formerly Utilized Sites Remedial Action Program
UMTRA	Uranium Mill Tailings Sites
LEAD SMELTERS	Lead Smelter Sites
US AIRS	Aerometric Information Retrieval System Facility Subsystem
US MINES	Mines Master Index File
ABANDONED MINES	Abandoned Mines
FINDS	Facility Index System/Facility Registry System
ECHO	Enforcement & Compliance History Information
UXO	Unexploded Ordnance Sites
DOCKET HWC	Hazardous Waste Compliance Docket Listing
FUELS PROGRAM	EPA Fuels Program Registered Listing
AIRS	Permitted Airs Facility Listing
ASBESTOS	Asbestos Notification Listing
DRYCLEANERS	Drycleaner Facility Listing
NPDES	Wastewater Facility Listing

TIER 2 - - - - - Tier 2 Information Listing
UIC - - - - - Underground Injection Wells
MINES MRDS - - - - - Mineral Resources Data System

EDR HIGH RISK HISTORICAL RECORDS

EDR Exclusive Records

EDR MGP - - - - - EDR Proprietary Manufactured Gas Plants
EDR Hist Auto - - - - - EDR Exclusive Historical Auto Stations
EDR Hist Cleaner - - - - - EDR Exclusive Historical Cleaners

EDR RECOVERED GOVERNMENT ARCHIVES

Exclusive Recovered Govt. Archives

RGA LUST - - - - - Recovered Government Archive Leaking Underground Storage Tank

SURROUNDING SITES: SEARCH RESULTS

Surrounding sites were identified in the following databases.

Elevations have been determined from the USGS Digital Elevation Model and should be evaluated on a relative (not an absolute) basis. Relative elevation information between sites of close proximity should be field verified. Sites with an elevation equal to or higher than the target property have been differentiated below from sites with an elevation lower than the target property.
Page numbers and map identification numbers refer to the EDR Radius Map report where detailed data on individual sites can be reviewed.

Sites listed in ***bold italics*** are in multiple databases.

Unmappable (orphan) sites are not considered in the foregoing analysis.

ADDITIONAL ENVIRONMENTAL RECORDS

Other Ascertainable Records

FUDS: The Listing includes locations of Formerly Used Defense Sites Properties where the US Army Corps Of Engineers is actively working or will take necessary cleanup actions.

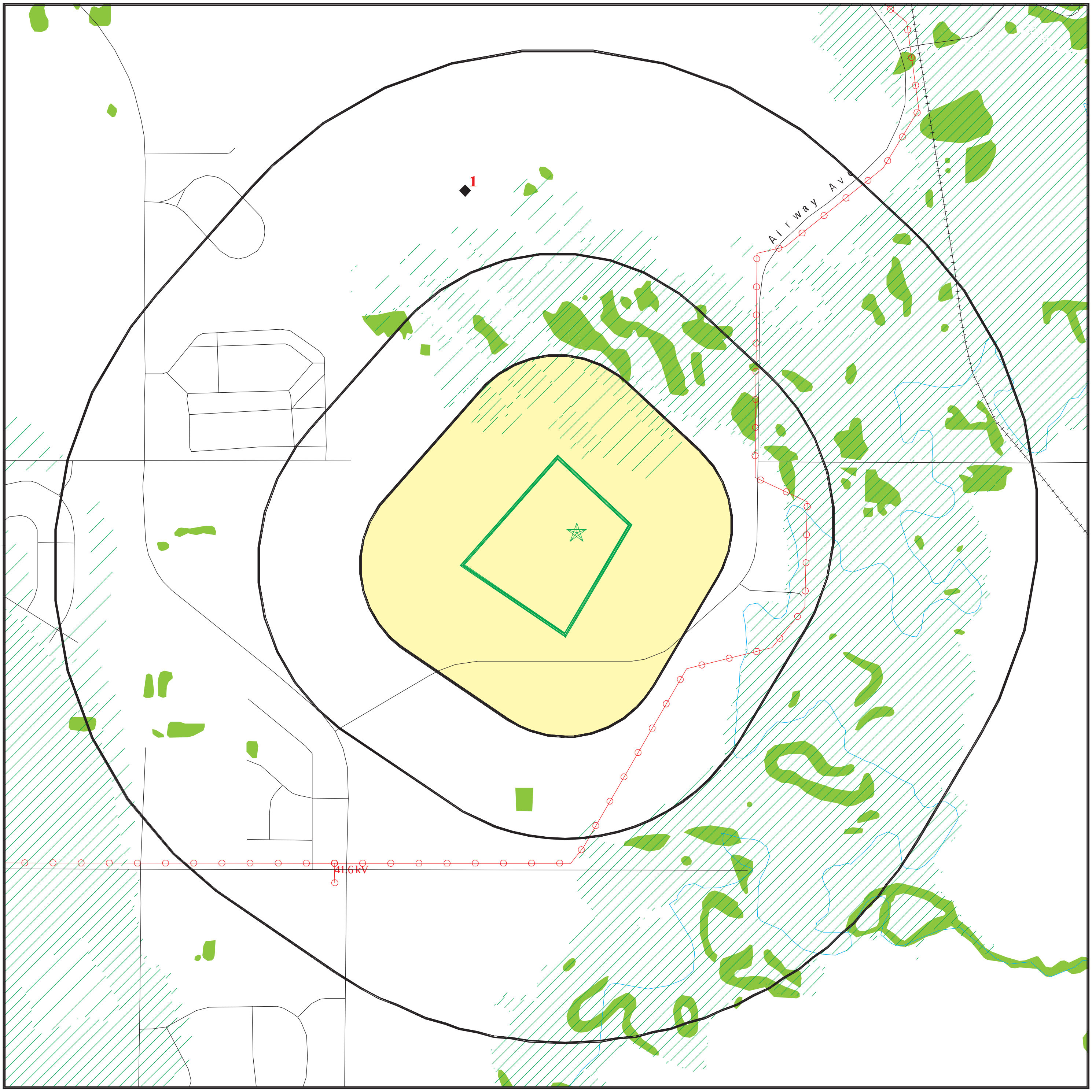
A review of the FUDS list, as provided by EDR, and dated 05/15/2019 has revealed that there is 1 FUDS site within approximately 1 mile of the target property.

Lower Elevation	Address	Direction / Distance	Map ID	Page
BISMARCK MUNICIPAL A		NNW 1/2 - 1 (0.692 mi.)	1	8

EXECUTIVE SUMMARY

There were no unmapped sites in this report.

OVERVIEW MAP - 5872123.2S



Target Property

Sites at elevations higher than or equal to the target property

Sites at elevations lower than the target property

Manufactured Gas Plants

National Priority List Sites

Dept. Defense Sites

0 1/4 1/2 1 Miles

Indian Reservations BIA

Power transmission lines

Special Flood Hazard Area (1%)

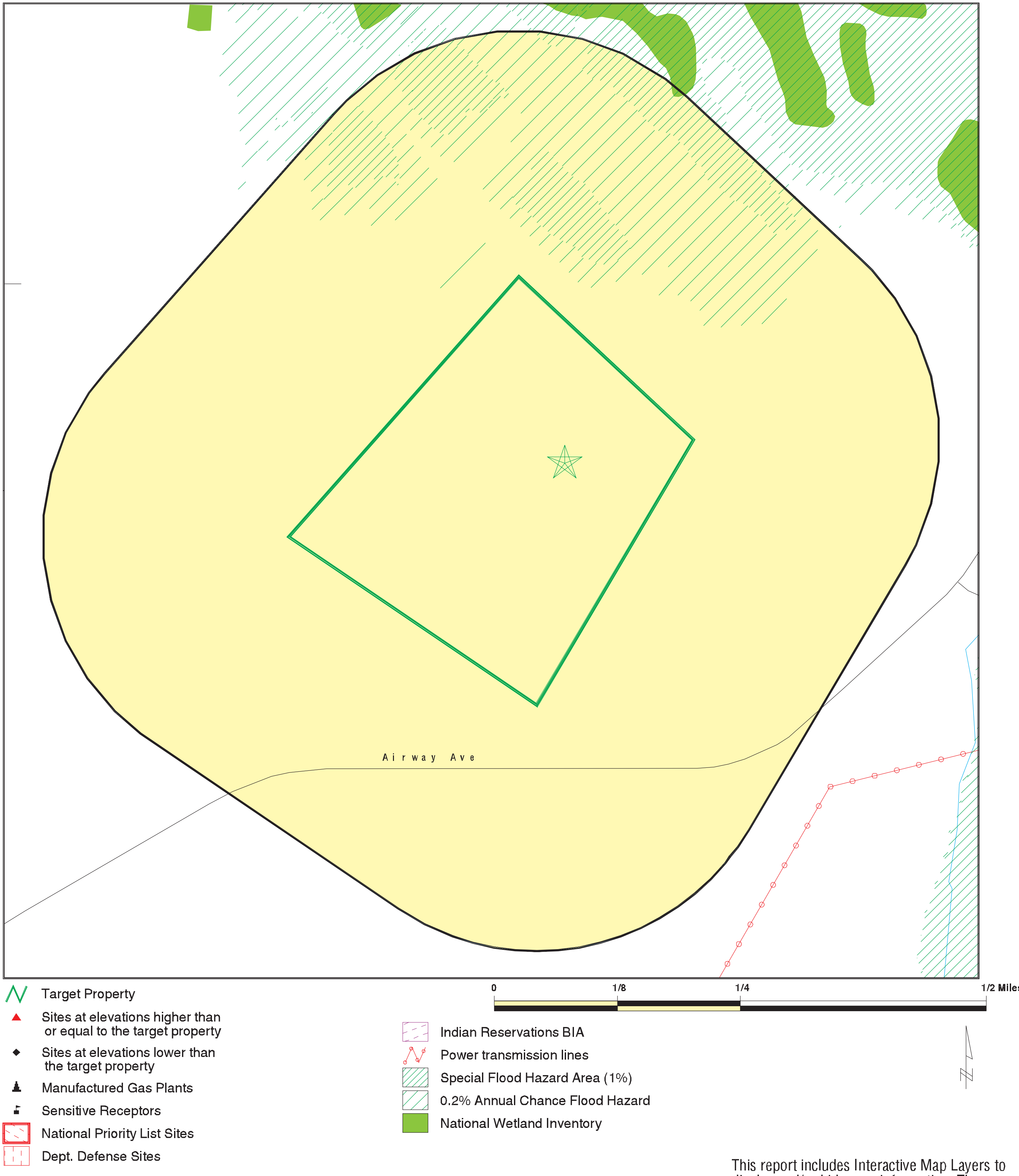
0.2% Annual Chance Flood Hazard

National Wetland Inventory

This report includes Interactive Map Layers to display and/or hide map information. The legend includes only those icons for the default map view.

SITE NAME: Bismarck AASF #1	CLIENT: AECOM
ADDRESS: 3410 Yegen Road Bismarck ND 58504	CONTACT: Hans Sund
	INQUIRY #: 5872123.2s
LAT/LONG: 46.763101 / 100.740915	DATE: November 15, 2019 4:14 pm

DETAIL MAP - 5872123.2S



This report includes Interactive Map Layers to display and/or hide map information. The legend includes only those icons for the default map view.

SITE NAME:	Bismarck AASF #1	CLIENT:	AECOM
ADDRESS:	3410 Yegen Road	CONTACT:	Hans Sund
	Bismarck ND 58504	INQUIRY #:	5872123.2s
LAT/LONG:	46.763101 / 100.740915	DATE:	November 15, 2019 4:15 pm

MAP FINDINGS SUMMARY

Database	Search Distance (Miles)	Target Property	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
STANDARD ENVIRONMENTAL RECORDS								
Federal NPL site list								
NPL	1.000		0	0	0	0	NR	0
Proposed NPL	1.000		0	0	0	0	NR	0
NPL LIENS	1.000		0	0	0	0	NR	0
Federal Delisted NPL site list								
Delisted NPL	1.000		0	0	0	0	NR	0
Federal CERCLIS list								
FEDERAL FACILITY	0.500		0	0	0	NR	NR	0
SEMS	0.500		0	0	0	NR	NR	0
Federal CERCLIS NFRAP site list								
SEMS-ARCHIVE	0.500		0	0	0	NR	NR	0
Federal RCRA CORRACTS facilities list								
CORRACTS	1.000		0	0	0	0	NR	0
Federal RCRA non-CORRACTS TSD facilities list								
RCRA-TSDF	0.500		0	0	0	NR	NR	0
Federal RCRA generators list								
RCRA-LQG	0.250		0	0	NR	NR	NR	0
RCRA-SQG	0.250		0	0	NR	NR	NR	0
RCRA-VSQG	0.250		0	0	NR	NR	NR	0
Federal institutional controls / engineering controls registries								
LUCIS	0.500		0	0	0	NR	NR	0
US ENG CONTROLS	0.500		0	0	0	NR	NR	0
US INST CONTROL	0.500		0	0	0	NR	NR	0
Federal ERNS list								
ERNS	TP		NR	NR	NR	NR	NR	0
State- and tribal - equivalent CERCLIS								
SHWS	N/A		N/A	N/A	N/A	N/A	N/A	N/A
State and tribal landfill and/or solid waste disposal site lists								
SWF/LF	0.500		0	0	0	NR	NR	0
State and tribal leaking storage tank lists								
LUST	0.500		0	0	0	NR	NR	0
INDIAN LUST	0.500		0	0	0	NR	NR	0
State and tribal registered storage tank lists								
FEMA UST	0.250		0	0	NR	NR	NR	0

MAP FINDINGS SUMMARY

Database	Search Distance (Miles)	Target Property	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
UST	0.250		0	0	NR	NR	NR	0
AST	0.250		0	0	NR	NR	NR	0
INDIAN UST	0.250		0	0	NR	NR	NR	0
State and tribal institutional control / engineering control registries								
AUL	0.500		0	0	0	NR	NR	0
State and tribal voluntary cleanup sites								
INDIAN VCP	0.500		0	0	0	NR	NR	0
State and tribal Brownfields sites								
BROWNFIELDS	0.500		0	0	0	NR	NR	0
ADDITIONAL ENVIRONMENTAL RECORDS								
Local Brownfield lists								
US BROWNFIELDS	0.500		0	0	0	NR	NR	0
Local Lists of Landfill / Solid Waste Disposal Sites								
SWRCY	0.500		0	0	0	NR	NR	0
INDIAN ODI	0.500		0	0	0	NR	NR	0
ODI	0.500		0	0	0	NR	NR	0
DEBRIS REGION 9	0.500		0	0	0	NR	NR	0
IHS OPEN DUMPS	0.500		0	0	0	NR	NR	0
Local Lists of Hazardous waste / Contaminated Sites								
US HIST CDL	TP		NR	NR	NR	NR	NR	0
CDL	TP		NR	NR	NR	NR	NR	0
US CDL	TP		NR	NR	NR	NR	NR	0
Local Land Records								
LIENS 2	TP		NR	NR	NR	NR	NR	0
Records of Emergency Release Reports								
HMIRS	TP		NR	NR	NR	NR	NR	0
SPILLS	TP		NR	NR	NR	NR	NR	0
Other Ascertainable Records								
RCRA NonGen / NLR	0.250		0	0	NR	NR	NR	0
FUDS	1.000		0	0	0	1	NR	1
DOD	1.000		0	0	0	0	NR	0
SCRD DRYCLEANERS	0.500		0	0	0	NR	NR	0
US FIN ASSUR	TP		NR	NR	NR	NR	NR	0
EPA WATCH LIST	TP		NR	NR	NR	NR	NR	0
2020 COR ACTION	0.250		0	0	NR	NR	NR	0
TSCA	TP		NR	NR	NR	NR	NR	0
TRIS	TP		NR	NR	NR	NR	NR	0

MAP FINDINGS SUMMARY

Database	Search Distance (Miles)	Target Property	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
SSTS	TP		NR	NR	NR	NR	NR	0
ROD	1.000		0	0	0	0	NR	0
RMP	TP		NR	NR	NR	NR	NR	0
RAATS	TP		NR	NR	NR	NR	NR	0
PRP	TP		NR	NR	NR	NR	NR	0
PADS	TP		NR	NR	NR	NR	NR	0
ICIS	TP		NR	NR	NR	NR	NR	0
FTTS	TP		NR	NR	NR	NR	NR	0
MLTS	TP		NR	NR	NR	NR	NR	0
COAL ASH DOE	TP		NR	NR	NR	NR	NR	0
COAL ASH EPA	0.500		0	0	0	NR	NR	0
PCB TRANSFORMER	TP		NR	NR	NR	NR	NR	0
RADINFO	TP		NR	NR	NR	NR	NR	0
HIST FTTS	TP		NR	NR	NR	NR	NR	0
DOT OPS	TP		NR	NR	NR	NR	NR	0
CONSENT	1.000		0	0	0	0	NR	0
INDIAN RESERV	1.000		0	0	0	0	NR	0
FUSRAP	1.000		0	0	0	0	NR	0
UMTRA	0.500		0	0	0	NR	NR	0
LEAD SMELTERS	TP		NR	NR	NR	NR	NR	0
US AIRS	TP		NR	NR	NR	NR	NR	0
US MINES	0.250		0	0	NR	NR	NR	0
ABANDONED MINES	0.250		0	0	NR	NR	NR	0
FINDS	TP		NR	NR	NR	NR	NR	0
ECHO	TP		NR	NR	NR	NR	NR	0
UXO	1.000		0	0	0	0	NR	0
DOCKET HWC	TP		NR	NR	NR	NR	NR	0
FUELS PROGRAM	0.250		0	0	NR	NR	NR	0
AIRS	TP		NR	NR	NR	NR	NR	0
ASBESTOS	TP		NR	NR	NR	NR	NR	0
DRYCLEANERS	0.250		0	0	NR	NR	NR	0
NPDES	TP		NR	NR	NR	NR	NR	0
TIER 2	TP		NR	NR	NR	NR	NR	0
UIC	TP		NR	NR	NR	NR	NR	0
MINES MRDS	TP		NR	NR	NR	NR	NR	0

EDR HIGH RISK HISTORICAL RECORDS

EDR Exclusive Records

Database	Search Distance (Miles)	Target Property	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
EDR MGP	1.000		0	0	0	0	NR	0
EDR Hist Auto	0.125		0	NR	NR	NR	NR	0
EDR Hist Cleaner	0.125		0	NR	NR	NR	NR	0

EDR RECOVERED GOVERNMENT ARCHIVES

Exclusive Recovered Govt. Archives

Database	Search Distance (Miles)	Target Property	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
RGA LUST	TP		NR	NR	NR	NR	NR	0
- Totals --		0	0	0	0	1	0	1

MAP FINDINGS SUMMARY

Database	Search Distance (Miles)	Target Property	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted

NOTES:

TP = Target Property

NR = Not Requested at this Search Distance

Sites may be listed in more than one database

N/A = This State does not maintain a SHWS list. See the Federal CERCLIS list.

MAP FINDINGS

Map ID Direction Distance Elevation	Site	Database(s)	EDR ID Number EPA ID Number
1 **NNW** **1/2-1** **0.692 mi.** **3652 ft.**	**BISMARCK MUNICIPAL AIRPORT** **BISMARCK, ND**	**FUDS**	**1024898913** **N/A**

Relative:
Lower

Actual:
1643 ft.

FUDS:

EPA Region:	8
Installation ID:	ND89799F070500
Congressional District Number:	0
Facility Name:	BISMARCK MUNICIPAL AIRPORT
FUDS Number:	B08ND0399
City:	BISMARCK
State:	ND
County:	BURLEIGH
Telephone:	402-995-2416
USACE Division:	Northwestern Division (NWD)
USACE District:	Omaha District (NWO)
Status:	Properties without projects
Current Owner:	Local Government
X Coord:	-100.74666667003
Y Coord:	46.775277780046402
Latitude:	46.775277780000003
Longitude:	-100.74666667

Count: 0 records.

ORPHAN SUMMARY

City	EDR ID	Site Name	Site Address	Zip	Database(s)
		NO SITES FOUND			

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

To maintain currency of the following federal and state databases, EDR contacts the appropriate governmental agency on a monthly or quarterly basis, as required.

Number of Days to Update: Provides confirmation that EDR is reporting records that have been updated within 90 days from the date the government agency made the information available to the public.

STANDARD ENVIRONMENTAL RECORDS

Federal NPL site list

NPL: National Priority List

National Priorities List (Superfund). The NPL is a subset of CERCLIS and identifies over 1,200 sites for priority cleanup under the Superfund Program. NPL sites may encompass relatively large areas. As such, EDR provides polygon coverage for over 1,000 NPL site boundaries produced by EPA's Environmental Photographic Interpretation Center (EPIC) and regional EPA offices.

Date of Government Version: 07/19/2019
Date Data Arrived at EDR: 07/30/2019
Date Made Active in Reports: 09/03/2019
Number of Days to Update: 35

Source: EPA
Telephone: N/A
Last EDR Contact: 11/07/2019
Next Scheduled EDR Contact: 01/13/2020
Data Release Frequency: Quarterly

NPL Site Boundaries

Sources:

EPA's Environmental Photographic Interpretation Center (EPIC)
Telephone: 202-564-7333

EPA Region 1
Telephone 617-918-1143

EPA Region 3
Telephone 215-814-5418

EPA Region 4
Telephone 404-562-8033

EPA Region 5
Telephone 312-886-6686

EPA Region 10
Telephone 206-553-8665

EPA Region 6
Telephone: 214-655-6659

EPA Region 7
Telephone: 913-551-7247

EPA Region 8
Telephone: 303-312-6774

EPA Region 9
Telephone: 415-947-4246

Proposed NPL: Proposed National Priority List Sites

A site that has been proposed for listing on the National Priorities List through the issuance of a proposed rule in the Federal Register. EPA then accepts public comments on the site, responds to the comments, and places on the NPL those sites that continue to meet the requirements for listing.

Date of Government Version: 07/19/2019
Date Data Arrived at EDR: 07/30/2019
Date Made Active in Reports: 09/03/2019
Number of Days to Update: 35

Source: EPA
Telephone: N/A
Last EDR Contact: 11/07/2019
Next Scheduled EDR Contact: 01/13/2020
Data Release Frequency: Quarterly

NPL LIENS: Federal Superfund Liens

Federal Superfund Liens. Under the authority granted the USEPA by CERCLA of 1980, the USEPA has the authority to file liens against real property in order to recover remedial action expenditures or when the property owner received notification of potential liability. USEPA compiles a listing of filed notices of Superfund Liens.

Date of Government Version: 10/15/1991
Date Data Arrived at EDR: 02/02/1994
Date Made Active in Reports: 03/30/1994
Number of Days to Update: 56

Source: EPA
Telephone: 202-564-4267
Last EDR Contact: 08/15/2011
Next Scheduled EDR Contact: 11/28/2011
Data Release Frequency: No Update Planned

Federal Delisted NPL site list

Delisted NPL: National Priority List Deletions

The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) establishes the criteria that the EPA uses to delete sites from the NPL. In accordance with 40 CFR 300.425.(e), sites may be deleted from the NPL where no further response is appropriate.

Date of Government Version: 07/19/2019
Date Data Arrived at EDR: 07/30/2019
Date Made Active in Reports: 09/03/2019
Number of Days to Update: 35

Source: EPA
Telephone: N/A
Last EDR Contact: 11/07/2019
Next Scheduled EDR Contact: 01/13/2020
Data Release Frequency: Quarterly

Federal CERCLIS list

FEDERAL FACILITY: Federal Facility Site Information listing

A listing of National Priority List (NPL) and Base Realignment and Closure (BRAC) sites found in the Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) Database where EPA Federal Facilities Restoration and Reuse Office is involved in cleanup activities.

Date of Government Version: 04/03/2019
Date Data Arrived at EDR: 04/05/2019
Date Made Active in Reports: 05/14/2019
Number of Days to Update: 39

Source: Environmental Protection Agency
Telephone: 703-603-8704
Last EDR Contact: 10/04/2019
Next Scheduled EDR Contact: 01/13/2020
Data Release Frequency: Varies

SEMS: Superfund Enterprise Management System

SEMS (Superfund Enterprise Management System) tracks hazardous waste sites, potentially hazardous waste sites, and remedial activities performed in support of EPA's Superfund Program across the United States. The list was formerly know as CERCLIS, renamed to SEMS by the EPA in 2015. The list contains data on potentially hazardous waste sites that have been reported to the USEPA by states, municipalities, private companies and private persons, pursuant to Section 103 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This dataset also contains sites which are either proposed to or on the National Priorities List (NPL) and the sites which are in the screening and assessment phase for possible inclusion on the NPL.

Date of Government Version: 07/19/2019
Date Data Arrived at EDR: 07/30/2019
Date Made Active in Reports: 09/03/2019
Number of Days to Update: 35

Source: EPA
Telephone: 800-424-9346
Last EDR Contact: 11/07/2019
Next Scheduled EDR Contact: 01/27/2020
Data Release Frequency: Quarterly

Federal CERCLIS NFRAP site list

SEMS-ARCHIVE: Superfund Enterprise Management System Archive

SEMS-ARCHIVE (Superfund Enterprise Management System Archive) tracks sites that have no further interest under the Federal Superfund Program based on available information. The list was formerly known as the CERCLIS-NFRAP, renamed to SEMS ARCHIVE by the EPA in 2015. EPA may perform a minimal level of assessment work at a site while it is archived if site conditions change and/or new information becomes available. Archived sites have been removed and archived from the inventory of SEMS sites. Archived status indicates that, to the best of EPA's knowledge, assessment at a site has been completed and that EPA has determined no further steps will be taken to list the site on the National Priorities List (NPL), unless information indicates this decision was not appropriate or other considerations require a recommendation for listing at a later time. The decision does not necessarily mean that there is no hazard associated with a given site; it only means that. based upon available information, the location is not judged to be potential NPL site.

Date of Government Version: 07/19/2019
Date Data Arrived at EDR: 07/30/2019
Date Made Active in Reports: 09/03/2019
Number of Days to Update: 35

Source: EPA
Telephone: 800-424-9346
Last EDR Contact: 11/07/2019
Next Scheduled EDR Contact: 01/27/2020
Data Release Frequency: Quarterly

Federal RCRA CORRACTS facilities list

CORRACTS: Corrective Action Report
CORRACTS identifies hazardous waste handlers with RCRA corrective action activity.

Date of Government Version: 06/24/2019
Date Data Arrived at EDR: 06/26/2019
Date Made Active in Reports: 10/17/2019
Number of Days to Update: 113

Source: EPA
Telephone: 800-424-9346
Last EDR Contact: 10/28/2019
Next Scheduled EDR Contact: 01/06/2020
Data Release Frequency: Quarterly

Federal RCRA non-CORRACTS TSD facilities list

RCRA-TSDF: RCRA - Treatment, Storage and Disposal
RCRAInfo is EPA's comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Transporters are individuals or entities that move hazardous waste from the generator offsite to a facility that can recycle, treat, store, or dispose of the waste. TSDFs treat, store, or dispose of the waste.

Date of Government Version: 06/24/2019
Date Data Arrived at EDR: 06/26/2019
Date Made Active in Reports: 10/17/2019
Number of Days to Update: 113

Source: Environmental Protection Agency
Telephone: 303-312-6149
Last EDR Contact: 10/28/2019
Next Scheduled EDR Contact: 01/06/2020
Data Release Frequency: Quarterly

Federal RCRA generators list

RCRA-LQG: RCRA - Large Quantity Generators
RCRAInfo is EPA's comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Large quantity generators (LQGs) generate over 1,000 kilograms (kg) of hazardous waste, or over 1 kg of acutely hazardous waste per month.

Date of Government Version: 06/24/2019
Date Data Arrived at EDR: 06/26/2019
Date Made Active in Reports: 10/17/2019
Number of Days to Update: 113

Source: Environmental Protection Agency
Telephone: 303-312-6149
Last EDR Contact: 10/28/2019
Next Scheduled EDR Contact: 01/06/2020
Data Release Frequency: Quarterly

RCRA-SQG: RCRA - Small Quantity Generators

RCRAInfo is EPA's comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Small quantity generators (SQGs) generate between 100 kg and 1,000 kg of hazardous waste per month.

Date of Government Version: 06/24/2019
Date Data Arrived at EDR: 06/26/2019
Date Made Active in Reports: 10/17/2019
Number of Days to Update: 113

Source: Environmental Protection Agency
Telephone: 303-312-6149
Last EDR Contact: 10/28/2019
Next Scheduled EDR Contact: 01/06/2020
Data Release Frequency: Quarterly

RCRA-VSQG: RCRA - Very Small Quantity Generators (Formerly Conditionally Exempt Small Quantity Generators)

RCRAInfo is EPA's comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Very small quantity generators (VSQGs) generate less than 100 kg of hazardous waste, or less than 1 kg of acutely hazardous waste per month.

Date of Government Version: 06/24/2019
Date Data Arrived at EDR: 06/26/2019
Date Made Active in Reports: 10/17/2019
Number of Days to Update: 113

Source: Environmental Protection Agency
Telephone: 303-312-6149
Last EDR Contact: 10/28/2019
Next Scheduled EDR Contact: 01/06/2020
Data Release Frequency: Quarterly

Federal institutional controls / engineering controls registries

LUCIS: Land Use Control Information System

LUCIS contains records of land use control information pertaining to the former Navy Base Realignment and Closure properties.

Date of Government Version: 08/13/2019
Date Data Arrived at EDR: 08/20/2019
Date Made Active in Reports: 08/26/2019
Number of Days to Update: 6

Source: Department of the Navy
Telephone: 843-820-7326
Last EDR Contact: 11/07/2019
Next Scheduled EDR Contact: 02/24/2020
Data Release Frequency: Varies

US ENG CONTROLS: Engineering Controls Sites List

A listing of sites with engineering controls in place. Engineering controls include various forms of caps, building foundations, liners, and treatment methods to create pathway elimination for regulated substances to enter environmental media or effect human health.

Date of Government Version: 08/19/2019
Date Data Arrived at EDR: 08/20/2019
Date Made Active in Reports: 08/26/2019
Number of Days to Update: 6

Source: Environmental Protection Agency
Telephone: 703-603-0695
Last EDR Contact: 08/20/2019
Next Scheduled EDR Contact: 12/09/2019
Data Release Frequency: Varies

US INST CONTROL: Sites with Institutional Controls

A listing of sites with institutional controls in place. Institutional controls include administrative measures, such as groundwater use restrictions, construction restrictions, property use restrictions, and post remediation care requirements intended to prevent exposure to contaminants remaining on site. Deed restrictions are generally required as part of the institutional controls.

Date of Government Version: 08/19/2019
Date Data Arrived at EDR: 08/20/2019
Date Made Active in Reports: 08/26/2019
Number of Days to Update: 6

Source: Environmental Protection Agency
Telephone: 703-603-0695
Last EDR Contact: 08/20/2019
Next Scheduled EDR Contact: 12/09/2019
Data Release Frequency: Varies

Federal ERNS list

ERNS: Emergency Response Notification System
Emergency Response Notification System. ERNS records and stores information on reported releases of oil and hazardous substances.

Date of Government Version: 09/09/2019	Source: National Response Center, United States Coast Guard
Date Data Arrived at EDR: 09/09/2019	Telephone: 202-267-2180
Date Made Active in Reports: 09/23/2019	Last EDR Contact: 09/09/2019
Number of Days to Update: 14	Next Scheduled EDR Contact: 01/06/2020
	Data Release Frequency: Quarterly

State- and tribal - equivalent CERCLIS

SHWS: This state does not maintain a SHWS list. See the Federal CERCLIS list and Federal NPL list.
State Hazardous Waste Sites. State hazardous waste site records are the states' equivalent to CERCLIS. These sites may or may not already be listed on the federal CERCLIS list. Priority sites planned for cleanup using state funds (state equivalent of Superfund) are identified along with sites where cleanup will be paid for by potentially responsible parties. Available information varies by state.

Date of Government Version: N/A	Source: Department of Environmental Quality
Date Data Arrived at EDR: N/A	Telephone: 701-328-5166
Date Made Active in Reports: N/A	Last EDR Contact: 11/14/2019
Number of Days to Update: N/A	Next Scheduled EDR Contact: 03/02/2020
	Data Release Frequency: N/A

State and tribal landfill and/or solid waste disposal site lists

SWF/LF: Solid Waste Landfills/Special Use Landfills
Solid Waste Facilities/Landfill Sites. SWF/LF type records typically contain an inventory of solid waste disposal facilities or landfills in a particular state. Depending on the state, these may be active or inactive facilities or open dumps that failed to meet RCRA Subtitle D Section 4004 criteria for solid waste landfills or disposal sites.

Date of Government Version: 07/23/2019	Source: Department of Environmental Quality
Date Data Arrived at EDR: 07/29/2019	Telephone: 701-328-5166
Date Made Active in Reports: 10/04/2019	Last EDR Contact: 10/23/2019
Number of Days to Update: 67	Next Scheduled EDR Contact: 02/03/2020
	Data Release Frequency: Quarterly

State and tribal leaking storage tank lists

LUST: Leaking Underground Storage Tank List
Leaking Underground Storage Tank Incident Reports. LUST records contain an inventory of reported leaking underground storage tank incidents. Not all states maintain these records, and the information stored varies by state.

Date of Government Version: 08/26/2019	Source: Department of Environmental Quality
Date Data Arrived at EDR: 08/27/2019	Telephone: 701-328-5166
Date Made Active in Reports: 10/04/2019	Last EDR Contact: 08/27/2019
Number of Days to Update: 38	Next Scheduled EDR Contact: 12/09/2019
	Data Release Frequency: Quarterly

INDIAN LUST R4: Leaking Underground Storage Tanks on Indian Land
LUSTs on Indian land in Florida, Mississippi and North Carolina.

Date of Government Version: 04/12/2019	Source: EPA Region 4
Date Data Arrived at EDR: 07/29/2019	Telephone: 404-562-8677
Date Made Active in Reports: 10/17/2019	Last EDR Contact: 10/25/2019
Number of Days to Update: 80	Next Scheduled EDR Contact: 02/03/2020
	Data Release Frequency: Varies

INDIAN LUST R5: Leaking Underground Storage Tanks on Indian Land
Leaking underground storage tanks located on Indian Land in Michigan, Minnesota and Wisconsin.

Date of Government Version: 04/08/2019
Date Data Arrived at EDR: 07/30/2019
Date Made Active in Reports: 10/17/2019
Number of Days to Update: 79

Source: EPA, Region 5
Telephone: 312-886-7439
Last EDR Contact: 10/25/2019
Next Scheduled EDR Contact: 02/03/2020
Data Release Frequency: Varies

INDIAN LUST R1: Leaking Underground Storage Tanks on Indian Land
A listing of leaking underground storage tank locations on Indian Land.

Date of Government Version: 04/11/2019
Date Data Arrived at EDR: 07/29/2019
Date Made Active in Reports: 10/17/2019
Number of Days to Update: 80

Source: EPA Region 1
Telephone: 617-918-1313
Last EDR Contact: 10/25/2019
Next Scheduled EDR Contact: 02/03/2020
Data Release Frequency: Varies

INDIAN LUST R8: Leaking Underground Storage Tanks on Indian Land
LUSTs on Indian land in Colorado, Montana, North Dakota, South Dakota, Utah and Wyoming.

Date of Government Version: 05/02/2019
Date Data Arrived at EDR: 10/22/2019
Date Made Active in Reports: 11/11/2019
Number of Days to Update: 20

Source: EPA Region 8
Telephone: 303-312-6271
Last EDR Contact: 10/25/2019
Next Scheduled EDR Contact: 02/03/2020
Data Release Frequency: Varies

INDIAN LUST R10: Leaking Underground Storage Tanks on Indian Land
LUSTs on Indian land in Alaska, Idaho, Oregon and Washington.

Date of Government Version: 04/16/2019
Date Data Arrived at EDR: 07/29/2019
Date Made Active in Reports: 10/17/2019
Number of Days to Update: 80

Source: EPA Region 10
Telephone: 206-553-2857
Last EDR Contact: 10/25/2019
Next Scheduled EDR Contact: 02/03/2020
Data Release Frequency: Varies

INDIAN LUST R6: Leaking Underground Storage Tanks on Indian Land
LUSTs on Indian land in New Mexico and Oklahoma.

Date of Government Version: 05/01/2019
Date Data Arrived at EDR: 07/29/2019
Date Made Active in Reports: 10/17/2019
Number of Days to Update: 80

Source: EPA Region 6
Telephone: 214-665-6597
Last EDR Contact: 10/25/2019
Next Scheduled EDR Contact: 02/03/2020
Data Release Frequency: Varies

INDIAN LUST R9: Leaking Underground Storage Tanks on Indian Land
LUSTs on Indian land in Arizona, California, New Mexico and Nevada

Date of Government Version: 04/08/2019
Date Data Arrived at EDR: 07/29/2019
Date Made Active in Reports: 10/17/2019
Number of Days to Update: 80

Source: Environmental Protection Agency
Telephone: 415-972-3372
Last EDR Contact: 10/25/2019
Next Scheduled EDR Contact: 02/03/2020
Data Release Frequency: Varies

INDIAN LUST R7: Leaking Underground Storage Tanks on Indian Land
LUSTs on Indian land in Iowa, Kansas, and Nebraska

Date of Government Version: 07/02/2019
Date Data Arrived at EDR: 10/16/2019
Date Made Active in Reports: 10/24/2019
Number of Days to Update: 8

Source: EPA Region 7
Telephone: 913-551-7003
Last EDR Contact: 10/25/2019
Next Scheduled EDR Contact: 02/03/2020
Data Release Frequency: Varies

State and tribal registered storage tank lists

FEMA UST: Underground Storage Tank Listing
A listing of all FEMA owned underground storage tanks.

Date of Government Version: 08/27/2019
Date Data Arrived at EDR: 08/28/2019
Date Made Active in Reports: 11/11/2019
Number of Days to Update: 75

Source: FEMA
Telephone: 202-646-5797
Last EDR Contact: 10/11/2019
Next Scheduled EDR Contact: 01/20/2020
Data Release Frequency: Varies

UST: Underground Storage Tank Data
Registered Underground Storage Tanks. UST's are regulated under Subtitle I of the Resource Conservation and Recovery Act (RCRA) and must be registered with the state department responsible for administering the UST program. Available information varies by state program.

Date of Government Version: 08/26/2019
Date Data Arrived at EDR: 08/27/2019
Date Made Active in Reports: 10/04/2019
Number of Days to Update: 38

Source: Department of Environmental Quality
Telephone: 701-328-5166
Last EDR Contact: 08/27/2019
Next Scheduled EDR Contact: 12/09/2019
Data Release Frequency: Quarterly

AST: Aboveground Storage Tank Listing
Registered Aboveground Storage Tanks.

Date of Government Version: 07/22/2019
Date Data Arrived at EDR: 07/29/2019
Date Made Active in Reports: 10/04/2019
Number of Days to Update: 67

Source: Department of Insurance
Telephone: 701-328-3246
Last EDR Contact: 10/21/2019
Next Scheduled EDR Contact: 02/03/2020
Data Release Frequency: Semi-Annually

INDIAN UST R5: Underground Storage Tanks on Indian Land
The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 5 (Michigan, Minnesota and Wisconsin and Tribal Nations).

Date of Government Version: 04/08/2019
Date Data Arrived at EDR: 07/29/2019
Date Made Active in Reports: 10/17/2019
Number of Days to Update: 80

Source: EPA Region 5
Telephone: 312-886-6136
Last EDR Contact: 10/25/2019
Next Scheduled EDR Contact: 02/03/2020
Data Release Frequency: Varies

INDIAN UST R6: Underground Storage Tanks on Indian Land
The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 6 (Louisiana, Arkansas, Oklahoma, New Mexico, Texas and 65 Tribes).

Date of Government Version: 05/01/2019
Date Data Arrived at EDR: 07/29/2019
Date Made Active in Reports: 10/17/2019
Number of Days to Update: 80

Source: EPA Region 6
Telephone: 214-665-7591
Last EDR Contact: 10/25/2019
Next Scheduled EDR Contact: 02/03/2020
Data Release Frequency: Varies

INDIAN UST R8: Underground Storage Tanks on Indian Land
The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 8 (Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming and 27 Tribal Nations).

Date of Government Version: 05/02/2019
Date Data Arrived at EDR: 10/22/2019
Date Made Active in Reports: 11/11/2019
Number of Days to Update: 20

Source: EPA Region 8
Telephone: 303-312-6137
Last EDR Contact: 10/25/2019
Next Scheduled EDR Contact: 02/03/2020
Data Release Frequency: Varies

INDIAN UST R9: Underground Storage Tanks on Indian Land

The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 9 (Arizona, California, Hawaii, Nevada, the Pacific Islands, and Tribal Nations).

Date of Government Version: 04/08/2019	Source: EPA Region 9
Date Data Arrived at EDR: 07/29/2019	Telephone: 415-972-3368
Date Made Active in Reports: 10/17/2019	Last EDR Contact: 10/25/2019
Number of Days to Update: 80	Next Scheduled EDR Contact: 02/03/2020
	Data Release Frequency: Varies

INDIAN UST R4: Underground Storage Tanks on Indian Land

The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 4 (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee and Tribal Nations)

Date of Government Version: 04/12/2019	Source: EPA Region 4
Date Data Arrived at EDR: 07/29/2019	Telephone: 404-562-9424
Date Made Active in Reports: 10/17/2019	Last EDR Contact: 10/25/2019
Number of Days to Update: 80	Next Scheduled EDR Contact: 02/03/2020
	Data Release Frequency: Varies

INDIAN UST R10: Underground Storage Tanks on Indian Land

The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 10 (Alaska, Idaho, Oregon, Washington, and Tribal Nations).

Date of Government Version: 04/16/2019	Source: EPA Region 10
Date Data Arrived at EDR: 07/30/2019	Telephone: 206-553-2857
Date Made Active in Reports: 10/17/2019	Last EDR Contact: 10/25/2019
Number of Days to Update: 79	Next Scheduled EDR Contact: 02/03/2020
	Data Release Frequency: Varies

INDIAN UST R7: Underground Storage Tanks on Indian Land

The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 7 (Iowa, Kansas, Missouri, Nebraska, and 9 Tribal Nations).

Date of Government Version: 05/02/2019	Source: EPA Region 7
Date Data Arrived at EDR: 07/29/2019	Telephone: 913-551-7003
Date Made Active in Reports: 10/17/2019	Last EDR Contact: 10/25/2019
Number of Days to Update: 80	Next Scheduled EDR Contact: 02/03/2020
	Data Release Frequency: Varies

INDIAN UST R1: Underground Storage Tanks on Indian Land

The Indian Underground Storage Tank (UST) database provides information about underground storage tanks on Indian land in EPA Region 1 (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont and ten Tribal Nations).

Date of Government Version: 04/11/2019	Source: EPA, Region 1
Date Data Arrived at EDR: 07/30/2019	Telephone: 617-918-1313
Date Made Active in Reports: 10/17/2019	Last EDR Contact: 10/25/2019
Number of Days to Update: 79	Next Scheduled EDR Contact: 02/03/2020
	Data Release Frequency: Varies

State and tribal institutional control / engineering control registries

AUL: Land Use Controls Listing

Land-Use Controls (LUCs) are defined broadly as legal measures that limit human exposure by restricting activity, use, and access to properties with residual contamination.

Date of Government Version: 07/15/2019	Source: Department of Environmental Quality
Date Data Arrived at EDR: 08/27/2019	Telephone: 701-328-5158
Date Made Active in Reports: 10/04/2019	Last EDR Contact: 08/27/2019
Number of Days to Update: 38	Next Scheduled EDR Contact: 12/09/2019
	Data Release Frequency: Semi-Annually

State and tribal voluntary cleanup sites

INDIAN VCP R1: Voluntary Cleanup Priority Listing
A listing of voluntary cleanup priority sites located on Indian Land located in Region 1.

Date of Government Version: 07/27/2015
Date Data Arrived at EDR: 09/29/2015
Date Made Active in Reports: 02/18/2016
Number of Days to Update: 142

Source: EPA, Region 1
Telephone: 617-918-1102
Last EDR Contact: 09/19/2019
Next Scheduled EDR Contact: 01/06/2020
Data Release Frequency: Varies

INDIAN VCP R7: Voluntary Cleanup Priority Lisitng
A listing of voluntary cleanup priority sites located on Indian Land located in Region 7.

Date of Government Version: 03/20/2008
Date Data Arrived at EDR: 04/22/2008
Date Made Active in Reports: 05/19/2008
Number of Days to Update: 27

Source: EPA, Region 7
Telephone: 913-551-7365
Last EDR Contact: 04/20/2009
Next Scheduled EDR Contact: 07/20/2009
Data Release Frequency: Varies

State and tribal Brownfields sites

BROWNFIELDS: List of Brownfields Sites
The concept of the Brownfields Program is to take contaminated or potentially contaminated, underdeveloped, unproductive property and convert it into productive real estate. Brownfield sites are defined as abandoned, idled or underused industrial or commercial properties whose redevelopment is complicated by real or perceived environmental contamination.

Date of Government Version: 05/10/2019
Date Data Arrived at EDR: 05/21/2019
Date Made Active in Reports: 06/26/2019
Number of Days to Update: 36

Source: Department of Environmental Quality
Telephone: 701-328-5166
Last EDR Contact: 08/23/2019
Next Scheduled EDR Contact: 12/02/2019
Data Release Frequency: Semi-Annually

ADDITIONAL ENVIRONMENTAL RECORDS

Local Brownfield lists

US BROWNFIELDS: A Listing of Brownfields Sites
Brownfields are real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. Cleaning up and reinvesting in these properties takes development pressures off of undeveloped, open land, and both improves and protects the environment. Assessment, Cleanup and Redevelopment Exchange System (ACRES) stores information reported by EPA Brownfields grant recipients on brownfields properties assessed or cleaned up with grant funding as well as information on Targeted Brownfields Assessments performed by EPA Regions. A listing of ACRES Brownfield sites is obtained from Cleanups in My Community. Cleanups in My Community provides information on Brownfields properties for which information is reported back to EPA, as well as areas served by Brownfields grant programs.

Date of Government Version: 06/03/2019
Date Data Arrived at EDR: 06/04/2019
Date Made Active in Reports: 08/26/2019
Number of Days to Update: 83

Source: Environmental Protection Agency
Telephone: 202-566-2777
Last EDR Contact: 09/19/2019
Next Scheduled EDR Contact: 12/30/2019
Data Release Frequency: Semi-Annually

Local Lists of Landfill / Solid Waste Disposal Sites

SWRCY: Recycling Centers
A listing of recycling center locations.

Date of Government Version: 04/12/2019
Date Data Arrived at EDR: 09/10/2019
Date Made Active in Reports: 10/07/2019
Number of Days to Update: 27

Source: Department of Environmental Quality
Telephone: 701-328-5266
Last EDR Contact: 09/06/2019
Next Scheduled EDR Contact: 12/16/2019
Data Release Frequency: Varies

INDIAN ODI: Report on the Status of Open Dumps on Indian Lands
Location of open dumps on Indian land.

Date of Government Version: 12/31/1998
Date Data Arrived at EDR: 12/03/2007
Date Made Active in Reports: 01/24/2008
Number of Days to Update: 52

Source: Environmental Protection Agency
Telephone: 703-308-8245
Last EDR Contact: 10/28/2019
Next Scheduled EDR Contact: 02/10/2020
Data Release Frequency: Varies

ODI: Open Dump Inventory
An open dump is defined as a disposal facility that does not comply with one or more of the Part 257 or Part 258 Subtitle D Criteria.

Date of Government Version: 06/30/1985
Date Data Arrived at EDR: 08/09/2004
Date Made Active in Reports: 09/17/2004
Number of Days to Update: 39

Source: Environmental Protection Agency
Telephone: 800-424-9346
Last EDR Contact: 06/09/2004
Next Scheduled EDR Contact: N/A
Data Release Frequency: No Update Planned

DEBRIS REGION 9: Torres Martinez Reservation Illegal Dump Site Locations
A listing of illegal dump sites location on the Torres Martinez Indian Reservation located in eastern Riverside County and northern Imperial County, California.

Date of Government Version: 01/12/2009
Date Data Arrived at EDR: 05/07/2009
Date Made Active in Reports: 09/21/2009
Number of Days to Update: 137

Source: EPA, Region 9
Telephone: 415-947-4219
Last EDR Contact: 10/17/2019
Next Scheduled EDR Contact: 02/03/2020
Data Release Frequency: No Update Planned

IHS OPEN DUMPS: Open Dumps on Indian Land
A listing of all open dumps located on Indian Land in the United States.

Date of Government Version: 04/01/2014
Date Data Arrived at EDR: 08/06/2014
Date Made Active in Reports: 01/29/2015
Number of Days to Update: 176

Source: Department of Health & Human Serivces, Indian Health Service
Telephone: 301-443-1452
Last EDR Contact: 11/01/2019
Next Scheduled EDR Contact: 02/10/2020
Data Release Frequency: Varies

Local Lists of Hazardous waste / Contaminated Sites

US HIST CDL: National Clandestine Laboratory Register
A listing of clandestine drug lab locations that have been removed from the DEAs National Clandestine Laboratory Register.

Date of Government Version: 06/11/2019
Date Data Arrived at EDR: 06/13/2019
Date Made Active in Reports: 09/03/2019
Number of Days to Update: 82

Source: Drug Enforcement Administration
Telephone: 202-307-1000
Last EDR Contact: 08/21/2019
Next Scheduled EDR Contact: 12/09/2019
Data Release Frequency: No Update Planned

CDL: Clandestine Drug Lab Location Listing
A listing of clandestine drug lab locations in North Dakota.

Date of Government Version: 05/16/2018
Date Data Arrived at EDR: 08/28/2018
Date Made Active in Reports: 09/24/2018
Number of Days to Update: 27

Source: Bureau of Criminal Investigation
Telephone: 701-328-8171
Last EDR Contact: 09/05/2019
Next Scheduled EDR Contact: 12/09/2019
Data Release Frequency: Varies

US CDL: Clandestine Drug Labs

A listing of clandestine drug lab locations. The U.S. Department of Justice ("the Department") provides this web site as a public service. It contains addresses of some locations where law enforcement agencies reported they found chemicals or other items that indicated the presence of either clandestine drug laboratories or dumpsites. In most cases, the source of the entries is not the Department, and the Department has not verified the entry and does not guarantee its accuracy. Members of the public must verify the accuracy of all entries by, for example, contacting local law enforcement and local health departments.

Date of Government Version: 06/11/2019
Date Data Arrived at EDR: 06/13/2019
Date Made Active in Reports: 09/03/2019
Number of Days to Update: 82

Source: Drug Enforcement Administration
Telephone: 202-307-1000
Last EDR Contact: 08/21/2019
Next Scheduled EDR Contact: 12/09/2019
Data Release Frequency: Quarterly

Local Land Records

LIENS 2: CERCLA Lien Information

A Federal CERCLA ('Superfund') lien can exist by operation of law at any site or property at which EPA has spent Superfund monies. These monies are spent to investigate and address releases and threatened releases of contamination. CERCLIS provides information as to the identity of these sites and properties.

Date of Government Version: 07/30/2019
Date Data Arrived at EDR: 07/30/2019
Date Made Active in Reports: 09/03/2019
Number of Days to Update: 35

Source: Environmental Protection Agency
Telephone: 202-564-6023
Last EDR Contact: 11/07/2019
Next Scheduled EDR Contact: 01/13/2020
Data Release Frequency: Semi-Annually

Records of Emergency Release Reports

HMIRS: Hazardous Materials Information Reporting System

Hazardous Materials Incident Report System. HMIRS contains hazardous material spill incidents reported to DOT.

Date of Government Version: 06/24/2019
Date Data Arrived at EDR: 06/26/2019
Date Made Active in Reports: 09/23/2019
Number of Days to Update: 89

Source: U.S. Department of Transportation
Telephone: 202-366-4555
Last EDR Contact: 09/24/2019
Next Scheduled EDR Contact: 01/06/2020
Data Release Frequency: Quarterly

SPILLS: State Spills

A listing of Department of Health spill records.

Date of Government Version: 01/02/2019
Date Data Arrived at EDR: 01/04/2019
Date Made Active in Reports: 01/17/2019
Number of Days to Update: 13

Source: Department of Environmental Quality
Telephone: 701-328-5150
Last EDR Contact: 10/02/2019
Next Scheduled EDR Contact: 01/20/2020
Data Release Frequency: Varies

Other Ascertainable Records

RCRA NonGen / NLR: RCRA - Non Generators / No Longer Regulated

RCRAInfo is EPA's comprehensive information system, providing access to data supporting the Resource Conservation and Recovery Act (RCRA) of 1976 and the Hazardous and Solid Waste Amendments (HSWA) of 1984. The database includes selective information on sites which generate, transport, store, treat and/or dispose of hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). Non-Generators do not presently generate hazardous waste.

Date of Government Version: 06/24/2019
Date Data Arrived at EDR: 06/26/2019
Date Made Active in Reports: 10/17/2019
Number of Days to Update: 113

Source: Environmental Protection Agency
Telephone: 303-312-6149
Last EDR Contact: 10/28/2019
Next Scheduled EDR Contact: 01/06/2020
Data Release Frequency: Quarterly

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

FUDS: Formerly Used Defense Sites

The listing includes locations of Formerly Used Defense Sites properties where the US Army Corps of Engineers is actively working or will take necessary cleanup actions.

Date of Government Version: 05/15/2019
Date Data Arrived at EDR: 05/21/2019
Date Made Active in Reports: 08/08/2019
Number of Days to Update: 79

Source: U.S. Army Corps of Engineers
Telephone: 202-528-4285
Last EDR Contact: 08/23/2019
Next Scheduled EDR Contact: 12/02/2019
Data Release Frequency: Varies

DOD: Department of Defense Sites

This data set consists of federally owned or administered lands, administered by the Department of Defense, that have any area equal to or greater than 640 acres of the United States, Puerto Rico, and the U.S. Virgin Islands.

Date of Government Version: 12/31/2005
Date Data Arrived at EDR: 11/10/2006
Date Made Active in Reports: 01/11/2007
Number of Days to Update: 62

Source: USGS
Telephone: 888-275-8747
Last EDR Contact: 10/11/2019
Next Scheduled EDR Contact: 01/20/2020
Data Release Frequency: Semi-Annually

FEDLAND: Federal and Indian Lands

Federally and Indian administrated lands of the United States. Lands included are administrated by: Army Corps of Engineers, Bureau of Reclamation, National Wild and Scenic River, National Wildlife Refuge, Public Domain Land, Wilderness, Wilderness Study Area, Wildlife Management Area, Bureau of Indian Affairs, Bureau of Land Management, Department of Justice, Forest Service, Fish and Wildlife Service, National Park Service.

Date of Government Version: 04/02/2018
Date Data Arrived at EDR: 04/11/2018
Date Made Active in Reports: 11/06/2019
Number of Days to Update: 574

Source: U.S. Geological Survey
Telephone: 888-275-8747
Last EDR Contact: 10/07/2019
Next Scheduled EDR Contact: 01/20/2020
Data Release Frequency: N/A

SCRD DRYCLEANERS: State Coalition for Remediation of Drycleaners Listing

The State Coalition for Remediation of Drycleaners was established in 1998, with support from the U.S. EPA Office of Superfund Remediation and Technology Innovation. It is comprised of representatives of states with established drycleaner remediation programs. Currently the member states are Alabama, Connecticut, Florida, Illinois, Kansas, Minnesota, Missouri, North Carolina, Oregon, South Carolina, Tennessee, Texas, and Wisconsin.

Date of Government Version: 01/01/2017
Date Data Arrived at EDR: 02/03/2017
Date Made Active in Reports: 04/07/2017
Number of Days to Update: 63

Source: Environmental Protection Agency
Telephone: 615-532-8599
Last EDR Contact: 11/11/2019
Next Scheduled EDR Contact: 02/24/2020
Data Release Frequency: Varies

US FIN ASSUR: Financial Assurance Information

All owners and operators of facilities that treat, store, or dispose of hazardous waste are required to provide proof that they will have sufficient funds to pay for the clean up, closure, and post-closure care of their facilities.

Date of Government Version: 06/24/2019
Date Data Arrived at EDR: 06/26/2019
Date Made Active in Reports: 09/23/2019
Number of Days to Update: 89

Source: Environmental Protection Agency
Telephone: 202-566-1917
Last EDR Contact: 09/24/2019
Next Scheduled EDR Contact: 01/06/2020
Data Release Frequency: Quarterly

EPA WATCH LIST: EPA WATCH LIST

EPA maintains a "Watch List" to facilitate dialogue between EPA, state and local environmental agencies on enforcement matters relating to facilities with alleged violations identified as either significant or high priority. Being on the Watch List does not mean that the facility has actually violated the law only that an investigation by EPA or a state or local environmental agency has led those organizations to allege that an unproven violation has in fact occurred. Being on the Watch List does not represent a higher level of concern regarding the alleged violations that were detected, but instead indicates cases requiring additional dialogue between EPA, state and local agencies - primarily because of the length of time the alleged violation has gone unaddressed or unresolved.

Date of Government Version: 08/30/2013
Date Data Arrived at EDR: 03/21/2014
Date Made Active in Reports: 06/17/2014
Number of Days to Update: 88

Source: Environmental Protection Agency
Telephone: 617-520-3000
Last EDR Contact: 10/31/2019
Next Scheduled EDR Contact: 02/17/2020
Data Release Frequency: Quarterly

2020 COR ACTION: 2020 Corrective Action Program List

The EPA has set ambitious goals for the RCRA Corrective Action program by creating the 2020 Corrective Action Universe. This RCRA cleanup baseline includes facilities expected to need corrective action. The 2020 universe contains a wide variety of sites. Some properties are heavily contaminated while others were contaminated but have since been cleaned up. Still others have not been fully investigated yet, and may require little or no remediation. Inclusion in the 2020 Universe does not necessarily imply failure on the part of a facility to meet its RCRA obligations.

Date of Government Version: 09/30/2017
Date Data Arrived at EDR: 05/08/2018
Date Made Active in Reports: 07/20/2018
Number of Days to Update: 73

Source: Environmental Protection Agency
Telephone: 703-308-4044
Last EDR Contact: 11/08/2019
Next Scheduled EDR Contact: 02/17/2020
Data Release Frequency: Varies

TSCA: Toxic Substances Control Act

Toxic Substances Control Act. TSCA identifies manufacturers and importers of chemical substances included on the TSCA Chemical Substance Inventory list. It includes data on the production volume of these substances by plant site.

Date of Government Version: 12/31/2016
Date Data Arrived at EDR: 06/21/2017
Date Made Active in Reports: 01/05/2018
Number of Days to Update: 198

Source: EPA
Telephone: 202-260-5521
Last EDR Contact: 09/19/2019
Next Scheduled EDR Contact: 12/30/2019
Data Release Frequency: Every 4 Years

TRIS: Toxic Chemical Release Inventory System

Toxic Release Inventory System. TRIS identifies facilities which release toxic chemicals to the air, water and land in reportable quantities under SARA Title III Section 313.

Date of Government Version: 12/31/2016
Date Data Arrived at EDR: 01/10/2018
Date Made Active in Reports: 01/12/2018
Number of Days to Update: 2

Source: EPA
Telephone: 202-566-0250
Last EDR Contact: 08/23/2019
Next Scheduled EDR Contact: 12/02/2019
Data Release Frequency: Annually

SSTS: Section 7 Tracking Systems

Section 7 of the Federal Insecticide, Fungicide and Rodenticide Act, as amended (92 Stat. 829) requires all registered pesticide-producing establishments to submit a report to the Environmental Protection Agency by March 1st each year. Each establishment must report the types and amounts of pesticides, active ingredients and devices being produced, and those having been produced and sold or distributed in the past year.

Date of Government Version: 09/30/2018
Date Data Arrived at EDR: 04/24/2019
Date Made Active in Reports: 08/08/2019
Number of Days to Update: 106

Source: EPA
Telephone: 202-564-4203
Last EDR Contact: 10/23/2019
Next Scheduled EDR Contact: 02/03/2020
Data Release Frequency: Annually

ROD: Records Of Decision

Record of Decision. ROD documents mandate a permanent remedy at an NPL (Superfund) site containing technical and health information to aid in the cleanup.

Date of Government Version: 07/19/2019
Date Data Arrived at EDR: 07/30/2019
Date Made Active in Reports: 09/03/2019
Number of Days to Update: 35

Source: EPA
Telephone: 703-416-0223
Last EDR Contact: 11/07/2019
Next Scheduled EDR Contact: 02/17/2020
Data Release Frequency: Annually

RMP: Risk Management Plans

When Congress passed the Clean Air Act Amendments of 1990, it required EPA to publish regulations and guidance for chemical accident prevention at facilities using extremely hazardous substances. The Risk Management Program Rule (RMP Rule) was written to implement Section 112(r) of these amendments. The rule, which built upon existing industry codes and standards, requires companies of all sizes that use certain flammable and toxic substances to develop a Risk Management Program, which includes a(n): Hazard assessment that details the potential effects of an accidental release, an accident history of the last five years, and an evaluation of worst-case and alternative accidental releases; Prevention program that includes safety precautions and maintenance, monitoring, and employee training measures; and Emergency response program that spells out emergency health care, employee training measures and procedures for informing the public and response agencies (e.g the fire department) should an accident occur.

Date of Government Version: 04/25/2019
Date Data Arrived at EDR: 05/02/2019
Date Made Active in Reports: 05/23/2019
Number of Days to Update: 21

Source: Environmental Protection Agency
Telephone: 202-564-8600
Last EDR Contact: 10/21/2019
Next Scheduled EDR Contact: 02/03/2020
Data Release Frequency: Varies

RAATS: RCRA Administrative Action Tracking System

RCRA Administration Action Tracking System. RAATS contains records based on enforcement actions issued under RCRA pertaining to major violators and includes administrative and civil actions brought by the EPA. For administration actions after September 30, 1995, data entry in the RAATS database was discontinued. EPA will retain a copy of the database for historical records. It was necessary to terminate RAATS because a decrease in agency resources made it impossible to continue to update the information contained in the database.

Date of Government Version: 04/17/1995
Date Data Arrived at EDR: 07/03/1995
Date Made Active in Reports: 08/07/1995
Number of Days to Update: 35

Source: EPA
Telephone: 202-564-4104
Last EDR Contact: 06/02/2008
Next Scheduled EDR Contact: 09/01/2008
Data Release Frequency: No Update Planned

PRP: Potentially Responsible Parties

A listing of verified Potentially Responsible Parties

Date of Government Version: 08/20/2019
Date Data Arrived at EDR: 09/05/2019
Date Made Active in Reports: 09/23/2019
Number of Days to Update: 18

Source: EPA
Telephone: 202-564-6023
Last EDR Contact: 11/07/2019
Next Scheduled EDR Contact: 02/17/2020
Data Release Frequency: Quarterly

PADS: PCB Activity Database System

PCB Activity Database. PADS Identifies generators, transporters, commercial storers and/or brokers and disposers of PCB's who are required to notify the EPA of such activities.

Date of Government Version: 03/20/2019
Date Data Arrived at EDR: 04/10/2019
Date Made Active in Reports: 05/14/2019
Number of Days to Update: 34

Source: EPA
Telephone: 202-566-0500
Last EDR Contact: 10/11/2019
Next Scheduled EDR Contact: 01/20/2020
Data Release Frequency: Annually

ICIS: Integrated Compliance Information System

The Integrated Compliance Information System (ICIS) supports the information needs of the national enforcement and compliance program as well as the unique needs of the National Pollutant Discharge Elimination System (NPDES) program.

Date of Government Version: 11/18/2016
Date Data Arrived at EDR: 11/23/2016
Date Made Active in Reports: 02/10/2017
Number of Days to Update: 79

Source: Environmental Protection Agency
Telephone: 202-564-2501
Last EDR Contact: 10/07/2019
Next Scheduled EDR Contact: 01/20/2020
Data Release Frequency: Quarterly

GOVERNMENT RECORDS SEARCHED / DATA CURRENCY TRACKING

FTTS: FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fungicide, & Rodenticide Act)/TSCA (Toxic Substances Control Act)
FTTS tracks administrative cases and pesticide enforcement actions and compliance activities related to FIFRA, TSCA and EPCRA (Emergency Planning and Community Right-to-Know Act). To maintain currency, EDR contacts the Agency on a quarterly basis.

Date of Government Version: 04/09/2009
Date Data Arrived at EDR: 04/16/2009
Date Made Active in Reports: 05/11/2009
Number of Days to Update: 25

Source: EPA/Office of Prevention, Pesticides and Toxic Substances
Telephone: 202-566-1667
Last EDR Contact: 08/18/2017
Next Scheduled EDR Contact: 12/04/2017
Data Release Frequency: No Update Planned

FTTS INSP: FIFRA/ TSCA Tracking System - FIFRA (Federal Insecticide, Fungicide, & Rodenticide Act)/TSCA (Toxic Substances Control Act)
A listing of FIFRA/TSCA Tracking System (FTTS) inspections and enforcements.

Date of Government Version: 04/09/2009
Date Data Arrived at EDR: 04/16/2009
Date Made Active in Reports: 05/11/2009
Number of Days to Update: 25

Source: EPA
Telephone: 202-566-1667
Last EDR Contact: 08/18/2017
Next Scheduled EDR Contact: 12/04/2017
Data Release Frequency: No Update Planned

MLTS: Material Licensing Tracking System
MLTS is maintained by the Nuclear Regulatory Commission and contains a list of approximately 8,100 sites which possess or use radioactive materials and which are subject to NRC licensing requirements. To maintain currency, EDR contacts the Agency on a quarterly basis.

Date of Government Version: 06/20/2019
Date Data Arrived at EDR: 06/20/2019
Date Made Active in Reports: 08/08/2019
Number of Days to Update: 49

Source: Nuclear Regulatory Commission
Telephone: 301-415-7169
Last EDR Contact: 10/25/2019
Next Scheduled EDR Contact: 02/03/2020
Data Release Frequency: Quarterly

COAL ASH DOE: Steam-Electric Plant Operation Data
A listing of power plants that store ash in surface ponds.

Date of Government Version: 12/31/2005
Date Data Arrived at EDR: 08/07/2009
Date Made Active in Reports: 10/22/2009
Number of Days to Update: 76

Source: Department of Energy
Telephone: 202-586-8719
Last EDR Contact: 11/06/2019
Next Scheduled EDR Contact: 12/16/2019
Data Release Frequency: Varies

COAL ASH EPA: Coal Combustion Residues Surface Impoundments List
A listing of coal combustion residues surface impoundments with high hazard potential ratings.

Date of Government Version: 01/12/2017
Date Data Arrived at EDR: 03/05/2019
Date Made Active in Reports: 11/11/2019
Number of Days to Update: 251

Source: Environmental Protection Agency
Telephone: N/A
Last EDR Contact: 09/03/2019
Next Scheduled EDR Contact: 12/16/2019
Data Release Frequency: Varies

PCB TRANSFORMER: PCB Transformer Registration Database
The database of PCB transformer registrations that includes all PCB registration submittals.

Date of Government Version: 05/24/2017
Date Data Arrived at EDR: 11/30/2017
Date Made Active in Reports: 12/15/2017
Number of Days to Update: 15

Source: Environmental Protection Agency
Telephone: 202-566-0517
Last EDR Contact: 11/06/2019
Next Scheduled EDR Contact: 02/17/2020
Data Release Frequency: Varies

RADINFO: Radiation Information Database
The Radiation Information Database (RADINFO) contains information about facilities that are regulated by U.S. Environmental Protection Agency (EPA) regulations for radiation and radioactivity.

Date of Government Version: 07/01/2019	Source: Environmental Protection Agency
Date Data Arrived at EDR: 07/01/2019	Telephone: 202-343-9775
Date Made Active in Reports: 09/23/2019	Last EDR Contact: 11/12/2019
Number of Days to Update: 84	Next Scheduled EDR Contact: 01/13/2020
	Data Release Frequency: Quarterly

HIST FTTS: FIFRA/TSCA Tracking System Administrative Case Listing

A complete administrative case listing from the FIFRA/TSCA Tracking System (FTTS) for all ten EPA regions. The information was obtained from the National Compliance Database (NCDB). NCDB supports the implementation of FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act) and TSCA (Toxic Substances Control Act). Some EPA regions are now closing out records. Because of that, and the fact that some EPA regions are not providing EPA Headquarters with updated records, it was decided to create a HIST FTTS database. It included records that may not be included in the newer FTTS database updates. This database is no longer updated.

Date of Government Version: 10/19/2006	Source: Environmental Protection Agency
Date Data Arrived at EDR: 03/01/2007	Telephone: 202-564-2501
Date Made Active in Reports: 04/10/2007	Last EDR Contact: 12/17/2007
Number of Days to Update: 40	Next Scheduled EDR Contact: 03/17/2008
	Data Release Frequency: No Update Planned

HIST FTTS INSP: FIFRA/TSCA Tracking System Inspection & Enforcement Case Listing

A complete inspection and enforcement case listing from the FIFRA/TSCA Tracking System (FTTS) for all ten EPA regions. The information was obtained from the National Compliance Database (NCDB). NCDB supports the implementation of FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act) and TSCA (Toxic Substances Control Act). Some EPA regions are now closing out records. Because of that, and the fact that some EPA regions are not providing EPA Headquarters with updated records, it was decided to create a HIST FTTS database. It included records that may not be included in the newer FTTS database updates. This database is no longer updated.

Date of Government Version: 10/19/2006	Source: Environmental Protection Agency
Date Data Arrived at EDR: 03/01/2007	Telephone: 202-564-2501
Date Made Active in Reports: 04/10/2007	Last EDR Contact: 12/17/2008
Number of Days to Update: 40	Next Scheduled EDR Contact: 03/17/2008
	Data Release Frequency: No Update Planned

DOT OPS: Incident and Accident Data

Department of Transporation, Office of Pipeline Safety Incident and Accident data.

Date of Government Version: 07/01/2019	Source: Department of Transporation, Office of Pipeline Safety
Date Data Arrived at EDR: 07/31/2019	Telephone: 202-366-4595
Date Made Active in Reports: 10/24/2019	Last EDR Contact: 10/29/2019
Number of Days to Update: 85	Next Scheduled EDR Contact: 02/10/2020
	Data Release Frequency: Quarterly

CONSENT: Superfund (CERCLA) Consent Decrees

Major legal settlements that establish responsibility and standards for cleanup at NPL (Superfund) sites. Released periodically by United States District Courts after settlement by parties to litigation matters.

Date of Government Version: 06/30/2019	Source: Department of Justice, Consent Decree Library
Date Data Arrived at EDR: 07/16/2019	Telephone: Varies
Date Made Active in Reports: 10/02/2019	Last EDR Contact: 10/02/2019
Number of Days to Update: 78	Next Scheduled EDR Contact: 01/20/2020
	Data Release Frequency: Varies

BRS: Biennial Reporting System

The Biennial Reporting System is a national system administered by the EPA that collects data on the generation and management of hazardous waste. BRS captures detailed data from two groups: Large Quantity Generators (LQG) and Treatment, Storage, and Disposal Facilities.

Date of Government Version: 12/31/2015	Source: EPA/NTIS
Date Data Arrived at EDR: 02/22/2017	Telephone: 800-424-9346
Date Made Active in Reports: 09/28/2017	Last EDR Contact: 09/16/2019
Number of Days to Update: 218	Next Scheduled EDR Contact: 01/06/2020
	Data Release Frequency: Biennially

INDIAN RESERV: Indian Reservations

This map layer portrays Indian administered lands of the United States that have any area equal to or greater than 640 acres.

Date of Government Version: 12/31/2014
Date Data Arrived at EDR: 07/14/2015
Date Made Active in Reports: 01/10/2017
Number of Days to Update: 546

Source: USGS
Telephone: 202-208-3710
Last EDR Contact: 10/06/2019
Next Scheduled EDR Contact: 01/19/2020
Data Release Frequency: Semi-Annually

FUSRAP: Formerly Utilized Sites Remedial Action Program

DOE established the Formerly Utilized Sites Remedial Action Program (FUSRAP) in 1974 to remediate sites where radioactive contamination remained from Manhattan Project and early U.S. Atomic Energy Commission (AEC) operations.

Date of Government Version: 08/08/2017
Date Data Arrived at EDR: 09/11/2018
Date Made Active in Reports: 09/14/2018
Number of Days to Update: 3

Source: Department of Energy
Telephone: 202-586-3559
Last EDR Contact: 11/04/2019
Next Scheduled EDR Contact: 02/17/2020
Data Release Frequency: Varies

UMTRA: Uranium Mill Tailings Sites

Uranium ore was mined by private companies for federal government use in national defense programs. When the mills shut down, large piles of the sand-like material (mill tailings) remain after uranium has been extracted from the ore. Levels of human exposure to radioactive materials from the piles are low; however, in some cases tailings were used as construction materials before the potential health hazards of the tailings were recognized.

Date of Government Version: 08/01/2019
Date Data Arrived at EDR: 08/21/2019
Date Made Active in Reports: 11/11/2019
Number of Days to Update: 82

Source: Department of Energy
Telephone: 505-845-0011
Last EDR Contact: 08/21/2019
Next Scheduled EDR Contact: 12/02/2019
Data Release Frequency: Varies

LEAD SMELTER 1: Lead Smelter Sites

A listing of former lead smelter site locations.

Date of Government Version: 07/19/2019
Date Data Arrived at EDR: 07/30/2019
Date Made Active in Reports: 09/03/2019
Number of Days to Update: 35

Source: Environmental Protection Agency
Telephone: 703-603-8787
Last EDR Contact: 11/07/2019
Next Scheduled EDR Contact: 01/13/2020
Data Release Frequency: Varies

LEAD SMELTER 2: Lead Smelter Sites

A list of several hundred sites in the U.S. where secondary lead smelting was done from 1931and 1964. These sites may pose a threat to public health through ingestion or inhalation of contaminated soil or dust

Date of Government Version: 04/05/2001
Date Data Arrived at EDR: 10/27/2010
Date Made Active in Reports: 12/02/2010
Number of Days to Update: 36

Source: American Journal of Public Health
Telephone: 703-305-6451
Last EDR Contact: 12/02/2009
Next Scheduled EDR Contact: N/A
Data Release Frequency: No Update Planned

US AIRS (AFS): Aerometric Information Retrieval System Facility Subsystem (AFS)

The database is a sub-system of Aerometric Information Retrieval System (AIRS). AFS contains compliance data on air pollution point sources regulated by the U.S. EPA and/or state and local air regulatory agencies. This information comes from source reports by various stationary sources of air pollution, such as electric power plants, steel mills, factories, and universities, and provides information about the air pollutants they produce. Action, air program, air program pollutant, and general level plant data. It is used to track emissions and compliance data from industrial plants.

Date of Government Version: 10/12/2016
Date Data Arrived at EDR: 10/26/2016
Date Made Active in Reports: 02/03/2017
Number of Days to Update: 100

Source: EPA
Telephone: 202-564-2496
Last EDR Contact: 09/26/2017
Next Scheduled EDR Contact: 01/08/2018
Data Release Frequency: Annually

US AIRS MINOR: Air Facility System Data
A listing of minor source facilities.

Date of Government Version: 10/12/2016
Date Data Arrived at EDR: 10/26/2016
Date Made Active in Reports: 02/03/2017
Number of Days to Update: 100

Source: EPA
Telephone: 202-564-2496
Last EDR Contact: 09/26/2017
Next Scheduled EDR Contact: 01/08/2018
Data Release Frequency: Annually

US MINES: Mines Master Index File
Contains all mine identification numbers issued for mines active or opened since 1971. The data also includes violation information.

Date of Government Version: 08/01/2019
Date Data Arrived at EDR: 08/27/2019
Date Made Active in Reports: 11/11/2019
Number of Days to Update: 76

Source: Department of Labor, Mine Safety and Health Administration
Telephone: 303-231-5959
Last EDR Contact: 08/27/2019
Next Scheduled EDR Contact: 12/09/2019
Data Release Frequency: Semi-Annually

MINES VIOLATIONS: MSHA Violation Assessment Data
Mines violation and assessment information. Department of Labor, Mine Safety & Health Administration.

Date of Government Version: 06/06/2019
Date Data Arrived at EDR: 06/06/2019
Date Made Active in Reports: 10/24/2019
Number of Days to Update: 140

Source: DOL, Mine Safety & Health Admi
Telephone: 202-693-9424
Last EDR Contact: 09/12/2019
Next Scheduled EDR Contact: 12/16/2019
Data Release Frequency: Quarterly

US MINES 2: Ferrous and Nonferrous Metal Mines Database Listing
This map layer includes ferrous (ferrous metal mines are facilities that extract ferrous metals, such as iron ore or molybdenum) and nonferrous (Nonferrous metal mines are facilities that extract nonferrous metals, such as gold, silver, copper, zinc, and lead) metal mines in the United States.

Date of Government Version: 12/05/2005
Date Data Arrived at EDR: 02/29/2008
Date Made Active in Reports: 04/18/2008
Number of Days to Update: 49

Source: USGS
Telephone: 703-648-7709
Last EDR Contact: 08/30/2019
Next Scheduled EDR Contact: 12/09/2019
Data Release Frequency: Varies

US MINES 3: Active Mines & Mineral Plants Database Listing
Active Mines and Mineral Processing Plant operations for commodities monitored by the Minerals Information Team of the USGS.

Date of Government Version: 04/14/2011
Date Data Arrived at EDR: 06/08/2011
Date Made Active in Reports: 09/13/2011
Number of Days to Update: 97

Source: USGS
Telephone: 703-648-7709
Last EDR Contact: 08/30/2019
Next Scheduled EDR Contact: 12/09/2019
Data Release Frequency: Varies

ABANDONED MINES: Abandoned Mines
An inventory of land and water impacted by past mining (primarily coal mining) is maintained by OSMRE to provide information needed to implement the Surface Mining Control and Reclamation Act of 1977 (SMCRA). The inventory contains information on the location, type, and extent of AML impacts, as well as, information on the cost associated with the reclamation of those problems. The inventory is based upon field surveys by State, Tribal, and OSMRE program officials. It is dynamic to the extent that it is modified as new problems are identified and existing problems are reclaimed.

Date of Government Version: 09/10/2019
Date Data Arrived at EDR: 09/10/2019
Date Made Active in Reports: 10/17/2019
Number of Days to Update: 37

Source: Department of Interior
Telephone: 202-208-2609
Last EDR Contact: 09/10/2019
Next Scheduled EDR Contact: 12/23/2019
Data Release Frequency: Quarterly

FINDS: Facility Index System/Facility Registry System

Facility Index System. FINDS contains both facility information and 'pointers' to other sources that contain more detail. EDR includes the following FINDS databases in this report: PCS (Permit Compliance System), AIRS (Aerometric Information Retrieval System), DOCKET (Enforcement Docket used to manage and track information on civil judicial enforcement cases for all environmental statutes), FURS (Federal Underground Injection Control), C-DOCKET (Criminal Docket System used to track criminal enforcement actions for all environmental statutes), FFIS (Federal Facilities Information System), STATE (State Environmental Laws and Statutes), and PADS (PCB Activity Data System).

Date of Government Version: 05/03/2019
Date Data Arrived at EDR: 06/05/2019
Date Made Active in Reports: 09/03/2019
Number of Days to Update: 90

Source: EPA
Telephone: (303) 312-6312
Last EDR Contact: 09/04/2019
Next Scheduled EDR Contact: 12/16/2019
Data Release Frequency: Quarterly

DOCKET HWC: Hazardous Waste Compliance Docket Listing

A complete list of the Federal Agency Hazardous Waste Compliance Docket Facilities.

Date of Government Version: 05/31/2018
Date Data Arrived at EDR: 07/26/2018
Date Made Active in Reports: 10/05/2018
Number of Days to Update: 71

Source: Environmental Protection Agency
Telephone: 202-564-0527
Last EDR Contact: 08/21/2019
Next Scheduled EDR Contact: 12/09/2019
Data Release Frequency: Varies

UXO: Unexploded Ordnance Sites

A listing of unexploded ordnance site locations

Date of Government Version: 12/31/2017
Date Data Arrived at EDR: 01/17/2019
Date Made Active in Reports: 04/01/2019
Number of Days to Update: 74

Source: Department of Defense
Telephone: 703-704-1564
Last EDR Contact: 10/10/2019
Next Scheduled EDR Contact: 01/27/2020
Data Release Frequency: Varies

ECHO: Enforcement & Compliance History Information

ECHO provides integrated compliance and enforcement information for about 800,000 regulated facilities nationwide.

Date of Government Version: 07/06/2019
Date Data Arrived at EDR: 07/09/2019
Date Made Active in Reports: 10/02/2019
Number of Days to Update: 85

Source: Environmental Protection Agency
Telephone: 202-564-2280
Last EDR Contact: 10/08/2019
Next Scheduled EDR Contact: 01/20/2020
Data Release Frequency: Quarterly

FUELS PROGRAM: EPA Fuels Program Registered Listing

This listing includes facilities that are registered under the Part 80 (Code of Federal Regulations) EPA Fuels Programs. All companies now are required to submit new and updated registrations.

Date of Government Version: 08/19/2019
Date Data Arrived at EDR: 08/20/2019
Date Made Active in Reports: 11/11/2019
Number of Days to Update: 83

Source: EPA
Telephone: 800-385-6164
Last EDR Contact: 08/20/2019
Next Scheduled EDR Contact: 12/02/2019
Data Release Frequency: Quarterly

AIRS: Permitted Airs Facility Listing

A listing of permitted airs facility locations.

Date of Government Version: 07/23/2019
Date Data Arrived at EDR: 07/29/2019
Date Made Active in Reports: 10/04/2019
Number of Days to Update: 67

Source: Department of Environmental Quality
Telephone: 701-328-5188
Last EDR Contact: 10/23/2019
Next Scheduled EDR Contact: 02/03/2020
Data Release Frequency: Semi-Annually

ASBESTOS: Asbestos Notification Listing
A listing of asbestos notification site locations

Date of Government Version: 08/28/2019
Date Data Arrived at EDR: 09/03/2019
Date Made Active in Reports: 10/04/2019
Number of Days to Update: 31

Source: Department of Environmental Quality
Telephone: 701-328-5188
Last EDR Contact: 11/14/2019
Next Scheduled EDR Contact: 02/17/2020
Data Release Frequency: Varies

DRYCLEANERS: Drycleaner facilities
A listing of drycleaner facility locations.

Date of Government Version: 07/23/2019
Date Data Arrived at EDR: 07/29/2019
Date Made Active in Reports: 10/04/2019
Number of Days to Update: 67

Source: Department of Environmental Quality
Telephone: 701-328-5188
Last EDR Contact: 10/23/2019
Next Scheduled EDR Contact: 02/03/2020
Data Release Frequency: Semi-Annually

NPDES: Wastewater Facility Listing
A listing of wastewater facility locations.

Date of Government Version: 07/11/2019
Date Data Arrived at EDR: 07/18/2019
Date Made Active in Reports: 09/13/2019
Number of Days to Update: 57

Source: Department of Environmental Quality
Telephone: 701-328-5260
Last EDR Contact: 10/02/2019
Next Scheduled EDR Contact: 01/20/2020
Data Release Frequency: Semi-Annually

TIER 2: Tier 2 Information Listing
Tier 2 information listing.

Date of Government Version: 12/31/2016
Date Data Arrived at EDR: 06/27/2017
Date Made Active in Reports: 10/05/2017
Number of Days to Update: 100

Source: Department of Emergency Services
Telephone: 701-328-8263
Last EDR Contact: 09/19/2019
Next Scheduled EDR Contact: 01/06/2020
Data Release Frequency: Annually

UIC: Underground Injection Wells
A listing of underground injection control wells.

Date of Government Version: 07/23/2019
Date Data Arrived at EDR: 07/31/2019
Date Made Active in Reports: 10/04/2019
Number of Days to Update: 65

Source: Department of Environmental Quality
Telephone: 701-328-5217
Last EDR Contact: 11/01/2019
Next Scheduled EDR Contact: 02/10/2020
Data Release Frequency: Quarterly

MINES MRDS: Mineral Resources Data System
Mineral Resources Data System

Date of Government Version: 04/06/2018
Date Data Arrived at EDR: 10/21/2019
Date Made Active in Reports: 10/24/2019
Number of Days to Update: 3

Source: USGS
Telephone: 703-648-6533
Last EDR Contact: 08/30/2019
Next Scheduled EDR Contact: 12/09/2019
Data Release Frequency: Varies

EDR HIGH RISK HISTORICAL RECORDS

EDR Exclusive Records

EDR MGP: EDR Proprietary Manufactured Gas Plants

The EDR Proprietary Manufactured Gas Plant Database includes records of coal gas plants (manufactured gas plants) compiled by EDR's researchers. Manufactured gas sites were used in the United States from the 1800's to 1950's to produce a gas that could be distributed and used as fuel. These plants used whale oil, rosin, coal, or a mixture of coal, oil, and water that also produced a significant amount of waste. Many of the byproducts of the gas production, such as coal tar (oily waste containing volatile and non-volatile chemicals), sludges, oils and other compounds are potentially hazardous to human health and the environment. The byproduct from this process was frequently disposed of directly at the plant site and can remain or spread slowly, serving as a continuous source of soil and groundwater contamination.

Date of Government Version: N/A
Date Data Arrived at EDR: N/A
Date Made Active in Reports: N/A
Number of Days to Update: N/A

Source: EDR, Inc.
Telephone: N/A
Last EDR Contact: N/A
Next Scheduled EDR Contact: N/A
Data Release Frequency: No Update Planned

EDR Hist Auto: EDR Exclusive Historical Auto Stations

EDR has searched selected national collections of business directories and has collected listings of potential gas station/filling station/service station sites that were available to EDR researchers. EDR's review was limited to those categories of sources that might, in EDR's opinion, include gas station/filling station/service station establishments. The categories reviewed included, but were not limited to gas, gas station, gasoline station, filling station, auto, automobile repair, auto service station, service station, etc. This database falls within a category of information EDR classifies as "High Risk Historical Records", or HRHR. EDR's HRHR effort presents unique and sometimes proprietary data about past sites and operations that typically create environmental concerns, but may not show up in current government records searches.

Date of Government Version: N/A
Date Data Arrived at EDR: N/A
Date Made Active in Reports: N/A
Number of Days to Update: N/A

Source: EDR, Inc.
Telephone: N/A
Last EDR Contact: N/A
Next Scheduled EDR Contact: N/A
Data Release Frequency: Varies

EDR Hist Cleaner: EDR Exclusive Historical Cleaners

EDR has searched selected national collections of business directories and has collected listings of potential dry cleaner sites that were available to EDR researchers. EDR's review was limited to those categories of sources that might, in EDR's opinion, include dry cleaning establishments. The categories reviewed included, but were not limited to dry cleaners, cleaners, laundry, laundromat, cleaning/laundry, wash & dry etc. This database falls within a category of information EDR classifies as "High Risk Historical Records", or HRHR. EDR's HRHR effort presents unique and sometimes proprietary data about past sites and operations that typically create environmental concerns, but may not show up in current government records searches.

Date of Government Version: N/A
Date Data Arrived at EDR: N/A
Date Made Active in Reports: N/A
Number of Days to Update: N/A

Source: EDR, Inc.
Telephone: N/A
Last EDR Contact: N/A
Next Scheduled EDR Contact: N/A
Data Release Frequency: Varies

EDR RECOVERED GOVERNMENT ARCHIVES

Exclusive Recovered Govt. Archives

RGA LUST: Recovered Government Archive Leaking Underground Storage Tank

The EDR Recovered Government Archive Leaking Underground Storage Tank database provides a list of LUST incidents derived from historical databases and includes many records that no longer appear in current government lists. Compiled from Records formerly available from the Department of Health in North Dakota.

Date of Government Version: N/A
Date Data Arrived at EDR: 07/01/2013
Date Made Active in Reports: 01/04/2014
Number of Days to Update: 187

Source: Department of Environmental Quality
Telephone: N/A
Last EDR Contact: 06/01/2012
Next Scheduled EDR Contact: N/A
Data Release Frequency: Varies

OTHER DATABASE(S)

Depending on the geographic area covered by this report, the data provided in these specialty databases may or may not be complete. For example, the existence of wetlands information data in a specific report does not mean that all wetlands in the area covered by the report are included. Moreover, the absence of any reported wetlands information does not necessarily mean that wetlands do not exist in the area covered by the report.

CT MANIFEST: Hazardous Waste Manifest Data

Facility and manifest data. Manifest is a document that lists and tracks hazardous waste from the generator through transporters to a tsd facility.

Date of Government Version: 05/14/2019
Date Data Arrived at EDR: 05/14/2019
Date Made Active in Reports: 08/05/2019
Number of Days to Update: 83

Source: Department of Energy & Environmental Protection
Telephone: 860-424-3375
Last EDR Contact: 11/11/2019
Next Scheduled EDR Contact: 02/24/2020
Data Release Frequency: No Update Planned

NY MANIFEST: Facility and Manifest Data

Manifest is a document that lists and tracks hazardous waste from the generator through transporters to a TSD facility.

Date of Government Version: 01/01/2019
Date Data Arrived at EDR: 05/01/2019
Date Made Active in Reports: 06/21/2019
Number of Days to Update: 51

Source: Department of Environmental Conservation
Telephone: 518-402-8651
Last EDR Contact: 10/29/2019
Next Scheduled EDR Contact: 02/10/2020
Data Release Frequency: Quarterly

WI MANIFEST: Manifest Information

Hazardous waste manifest information.

Date of Government Version: 05/31/2018
Date Data Arrived at EDR: 06/19/2019
Date Made Active in Reports: 09/03/2019
Number of Days to Update: 76

Source: Department of Natural Resources
Telephone: N/A
Last EDR Contact: 09/06/2019
Next Scheduled EDR Contact: 12/23/2019
Data Release Frequency: Annually

Oil/Gas Pipelines

Source: Endeavor Business Media

Petroleum Bundle (Crude Oil, Refined Products, Petrochemicals, Gas Liquids (LPG/NGL), and Specialty Gases (Miscellaneous)) N = Natural Gas Bundle (Natural Gas, Gas Liquids (LPG/NGL), and Specialty Gases (Miscellaneous)). This map includes information copyrighted by Endeavor Business Media. This information is provided on a best effort basis and Endeavor Business Media does not guarantee its accuracy nor warrant its fitness for any particular purpose. Such information has been reprinted with the permission of Endeavor Business Media.

Electric Power Transmission Line Data

Source: Endeavor Business Media

This map includes information copyrighted by Endeavor Business Media. This information is provided on a best effort basis and Endeavor Business Media does not guarantee its accuracy nor warrant its fitness for any particular purpose. Such information has been reprinted with the permission of Endeavor Business Media.

Sensitive Receptors: There are individuals deemed sensitive receptors due to their fragile immune systems and special sensitivity to environmental discharges. These sensitive receptors typically include the elderly, the sick, and children. While the location of all sensitive receptors cannot be determined, EDR indicates those buildings and facilities - schools, daycares, hospitals, medical centers, and nursing homes - where individuals who are sensitive receptors are likely to be located.

AHA Hospitals:
Source: American Hospital Association, Inc.
Telephone: 312-280-5991
The database includes a listing of hospitals based on the American Hospital Association's annual survey of hospitals.

Medical Centers: Provider of Services Listing
Source: Centers for Medicare & Medicaid Services
Telephone: 410-786-3000
A listing of hospitals with Medicare provider number, produced by Centers of Medicare & Medicaid Services, a federal agency within the U.S. Department of Health and Human Services.

Nursing Homes
Source: National Institutes of Health
Telephone: 301-594-6248
Information on Medicare and Medicaid certified nursing homes in the United States.

Public Schools
Source: National Center for Education Statistics
Telephone: 202-502-7300
The National Center for Education Statistics' primary database on elementary and secondary public education in the United States. It is a comprehensive, annual, national statistical database of all public elementary and secondary schools and school districts, which contains data that are comparable across all states.

Private Schools
Source: National Center for Education Statistics
Telephone: 202-502-7300
The National Center for Education Statistics' primary database on private school locations in the United States.

Daycare Centers: Child Care List
Source: Department of Human Services
Telephone: 701-328-2316

Flood Zone Data: This data was obtained from the Federal Emergency Management Agency (FEMA). It depicts 100-year and 500-year flood zones as defined by FEMA. It includes the National Flood Hazard Layer (NFHL) which incorporates Flood Insurance Rate Map (FIRM) data and Q3 data from FEMA in areas not covered by NFHL.
Source: FEMA
Telephone: 877-336-2627
Date of Government Version: 2003, 2015

NWI: National Wetlands Inventory. This data, available in select counties across the country, was obtained by EDR in 2002, 2005 and 2010 from the U.S. Fish and Wildlife Service.

Current USGS 7.5 Minute Topographic Map
Source: U.S. Geological Survey

STREET AND ADDRESS INFORMATION

GEOCHECK ®- PHYSICAL SETTING SOURCE ADDENDUM

TARGET PROPERTY ADDRESS

BISMARCK AASF #1
3410 YEGEN ROAD
BISMARCK, ND 58504

TARGET PROPERTY COORDINATES

Latitude (North):	46.763101 - 46˚ 45’ 47.16’’
Longitude (West):	100.740915 - 100˚ 44’ 27.29’’
Universal Tranverse Mercator:	Zone 14
UTM X (Meters):	367059.2
UTM Y (Meters):	5180092.0
Elevation:	1645 ft. above sea level

USGS TOPOGRAPHIC MAP

Target Property Map:	6050163 MENOKEN SW, ND
Version Date:	2014
Southeast Map:	6050191 SUGARLOAF BUTTE, ND
Version Date:	2014
Southwest Map:	6050171 SCHMIDT, ND
Version Date:	2014
Northwest Map:	6050091 BISMARCK, ND
Version Date:	2014

EDR’s GeoCheck Physical Setting Source Addendum is provided to assist the environmental professional in forming an opinion about the impact of potential contaminant migration.

Assessment of the impact of contaminant migration generally has two principle investigative components:

1. Groundwater flow direction, and
2. Groundwater flow velocity.

Groundwater flow direction may be impacted by surface topography, hydrology, hydrogeology, characteristics of the soil, and nearby wells. Groundwater flow velocity is generally impacted by the nature of the geologic strata.

GEOCHECK® - PHYSICAL SETTING SOURCE SUMMARY

GROUNDWATER FLOW DIRECTION INFORMATION

Groundwater flow direction for a particular site is best determined by a qualified environmental professional using site-specific well data. If such data is not reasonably ascertainable, it may be necessary to rely on other sources of information, such as surface topographic information, hydrologic information, hydrogeologic data collected on nearby properties, and regional groundwater flow information (from deep aquifers).

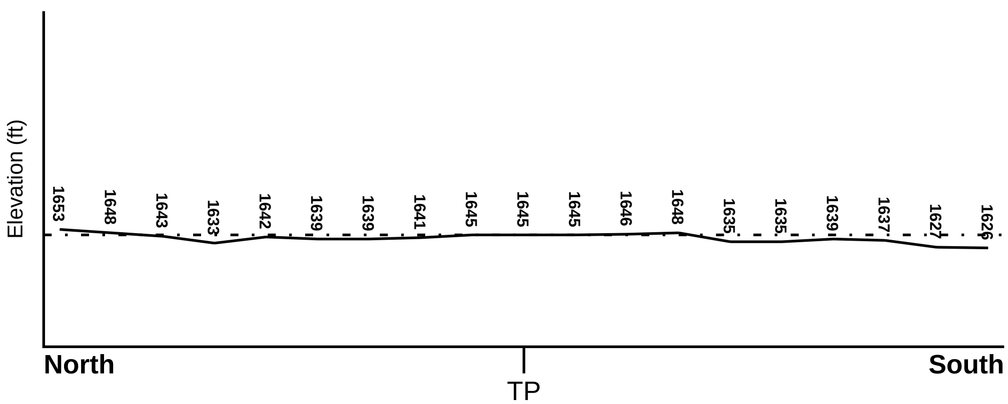
TOPOGRAPHIC INFORMATION

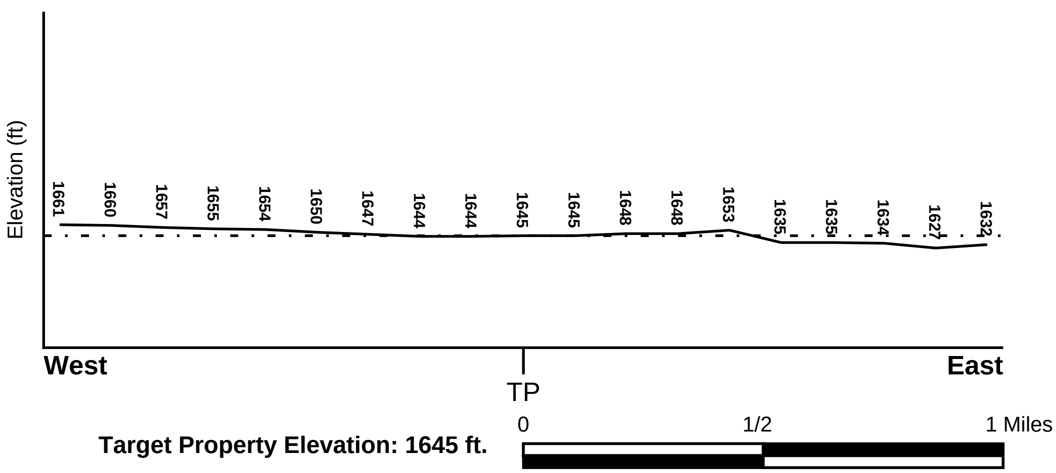
Surface topography may be indicative of the direction of surficial groundwater flow. This information can be used to assist the environmental professional in forming an opinion about the impact of nearby contaminated properties or, should contamination exist on the target property, what downgradient sites might be impacted.

TARGET PROPERTY TOPOGRAPHY

General Topographic Gradient: General NW

SURROUNDING TOPOGRAPHY: ELEVATION PROFILES





Target Property Elevation: 1645 ft.

Source: Topography has been determined from the USGS 7.5' Digital Elevation Model and should be evaluated on a relative (not an absolute) basis. Relative elevation information between sites of close proximity should be field verified.

GEOCHECK® - PHYSICAL SETTING SOURCE SUMMARY

HYDROLOGIC INFORMATION

Surface water can act as a hydrologic barrier to groundwater flow. Such hydrologic information can be used to assist the environmental professional in forming an opinion about the impact of nearby contaminated properties or, should contamination exist on the target property, what downgradient sites might be impacted.

Refer to the Physical Setting Source Map following this summary for hydrologic information (major waterways and bodies of water).

FEMA FLOOD ZONE

Flood Plain Panel at Target Property	FEMA Source Type
38015C0815D	FEMA FIRM Flood data

Additional Panels in search area:	FEMA Source Type
38015C0795D	FEMA FIRM Flood data
38059C0805E	FEMA FIRM Flood data

NATIONAL WETLAND INVENTORY

NWI Quad at Target Property	NWI Electronic Data Coverage
MENOKEN SW	YES - refer to the Overview Map and Detail Map

HYDROGEOLOGIC INFORMATION

Hydrogeologic information obtained by installation of wells on a specific site can often be an indicator of groundwater flow direction in the immediate area. Such hydrogeologic information can be used to assist the environmental professional in forming an opinion about the impact of nearby contaminated properties or, should contamination exist on the target property, what downgradient sites might be impacted.

AQUIFLOW®

Search Radius: 1.000 Mile.

EDR has developed the AQUIFLOW Information System to provide data on the general direction of groundwater flow at specific points. EDR has reviewed reports submitted by environmental professionals to regulatory authorities at select sites and has extracted the date of the report, groundwater flow direction as determined hydrogeologically, and the depth to water table.

MAP ID	LOCATION FROM TP	GENERAL DIRECTION GROUNDWATER FLOW
Not Reported		

GEOCHECK® - PHYSICAL SETTING SOURCE SUMMARY

GROUNDWATER FLOW VELOCITY INFORMATION

Groundwater flow velocity information for a particular site is best determined by a qualified environmental professional using site specific geologic and soil strata data. If such data are not reasonably ascertainable, it may be necessary to rely on other sources of information, including geologic age identification, rock stratigraphic unit and soil characteristics data collected on nearby properties and regional soil information. In general, contaminant plumes move more quickly through sandy-gravelly types of soils than silty-clayey types of soils.

GEOLOGIC INFORMATION IN GENERAL AREA OF TARGET PROPERTY

Geologic information can be used by the environmental professional in forming an opinion about the relative speed at which contaminant migration may be occurring.

ROCK STRATIGRAPHIC UNIT

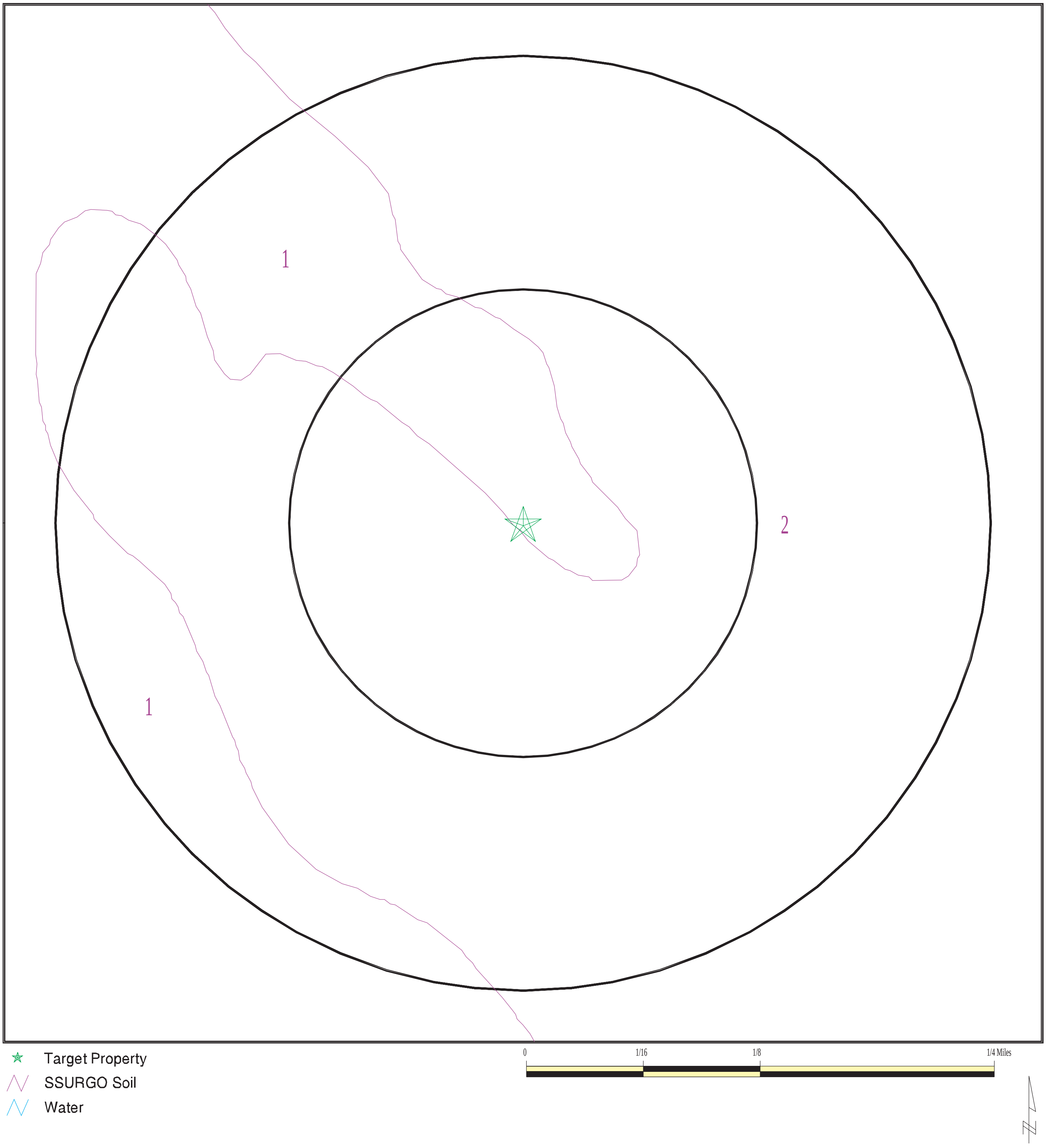
Era:	Mesozoic
System:	Cretaceous
Series:	Navarro Group
Code:	uK4 *(decoded above as Era, System & Series)*

GEOLOGIC AGE IDENTIFICATION

Category: Stratified Sequence

Geologic Age and Rock Stratigraphic Unit Source: P.G. Schruben, R.E. Arndt and W.J. Bawiec, Geology of the Conterminous U.S. at 1:2,500,000 Scale - a digital representation of the 1974 P.B. King and H.M. Beikman Map, USGS Digital Data Series DDS - 11 (1994).

SSURGO SOIL MAP - 5872123.2s



SITE NAME:	Bismarck AASF #1
ADDRESS:	3410 Yegen Road Bismarck ND 58504
LAT/LONG:	46.763101 / 100.740915

CLIENT:	AECOM
CONTACT:	Hans Sund
INQUIRY #:	5872123.2s
DATE:	November 15, 2019 4:15 pm

DOMINANT SOIL COMPOSITION IN GENERAL AREA OF TARGET PROPERTY

The U.S. Department of Agriculture's (USDA) Soil Conservation Service (SCS) leads the National Cooperative Soil Survey (NCSS) and is responsible for collecting, storing, maintaining and distributing soil survey information for privately owned lands in the United States. A soil map in a soil survey is a representation of soil patterns in a landscape. The following information is based on Soil Conservation Service SSURGO data.

Soil Map ID: 1

Soil Component Name: PARSHALL

Soil Surface Texture: fine sandy loam

Hydrologic Group: Class B - Moderate infiltration rates. Deep and moderately deep, moderately well and well drained soils with moderately coarse textures.

Soil Drainage Class: Well drained

Hydric Status: Not hydric

Corrosion Potential - Uncoated Steel: Moderate

Depth to Bedrock Min: > 0 inches

Depth to Watertable Min: > 0 inches

Soil Layer Information							
	Boundary			Classification		Saturated hydraulic conductivity micro m/sec	
Layer	Upper	Lower	Soil Texture Class	AASHTO Group	Unified Soil		Soil Reaction (pH)
1	0 inches	18 inches	fine sandy loam	Not reported	Not reported	Max: 42 Min: 14	Max: 8.4 Min: 7.4
2	18 inches	25 inches		Not reported	Not reported	Max: 42 Min: 14	Max: 8.4 Min: 7.4
3	25 inches	59 inches		Not reported	Not reported	Max: 42 Min: 14	Max: 8.4 Min: 7.4

Soil Map ID: 2

Soil Component Name: LIHEN

Soil Surface Texture: loamy fine sand

Hydrologic Group: Class A - High infiltration rates. Soils are deep, well drained to excessively drained sands and gravels.

Soil Drainage Class: Well drained

GEOCHECK® - PHYSICAL SETTING SOURCE SUMMARY

Hydric Status: Partially hydric

Corrosion Potential - Uncoated Steel: High

Depth to Bedrock Min: > 0 inches

Depth to Watertable Min: > 0 inches

Soil Layer Information

	Boundary			Classification			
Layer	**Upper**	**Lower**	**Soil Texture Class**	**AASHTO Group**	**Unified Soil**	**Saturated hydraulic conductivity micro m/sec**	**Soil Reaction (pH)**
1	0 inches	20 inches	loamy fine sand	Not reported	Not reported	Max: 141 Min: 42	Max: 8.4 Min: 7.4
2	20 inches	59 inches		Not reported	Not reported	Max: 141 Min: 42	Max: 8.4 Min: 7.4

LOCAL / REGIONAL WATER AGENCY RECORDS

EDR Local/Regional Water Agency records provide water well information to assist the environmental professional in assessing sources that may impact ground water flow direction, and in forming an opinion about the impact of contaminant migration on nearby drinking water wells.

WELL SEARCH DISTANCE INFORMATION

DATABASE	SEARCH DISTANCE (miles)
Federal USGS	1.000
Federal FRDS PWS	Nearest PWS within 1 mile
State Database	1.000

FEDERAL USGS WELL INFORMATION

MAP ID	WELL ID	LOCATION FROM TP
1	USGS40000913898	1/8 - 1/4 Mile ENE
4	USGS40000913897	1/4 - 1/2 Mile ENE
8	USGS40000913737	1/4 - 1/2 Mile SSW
12	USGS40000913795	1/2 - 1 Mile ESE
13	USGS40000913932	1/2 - 1 Mile ENE
14	USGS40000913954	1/2 - 1 Mile ENE
C16	USGS40000913859	1/2 - 1 Mile West
18	USGS40000914011	1/2 - 1 Mile NE
D20	USGS40000913847	1/2 - 1 Mile West
D21	USGS40000913848	1/2 - 1 Mile West
F23	USGS40000913662	1/2 - 1 Mile SE
27	USGS40000913546	1/2 - 1 Mile South

GEOCHECK® - PHYSICAL SETTING SOURCE SUMMARY

FEDERAL USGS WELL INFORMATION

MAP ID	WELL ID	LOCATION FROM TP
29	USGS40000913571	1/2 - 1 Mile SSW
31	USGS40000913931	1/2 - 1 Mile ENE
32	USGS40000913616	1/2 - 1 Mile SE
G35	USGS40000913659	1/2 - 1 Mile ESE
G36	USGS40000913660	1/2 - 1 Mile ESE
G37	USGS40000913661	1/2 - 1 Mile ESE

FEDERAL FRDS PUBLIC WATER SUPPLY SYSTEM INFORMATION

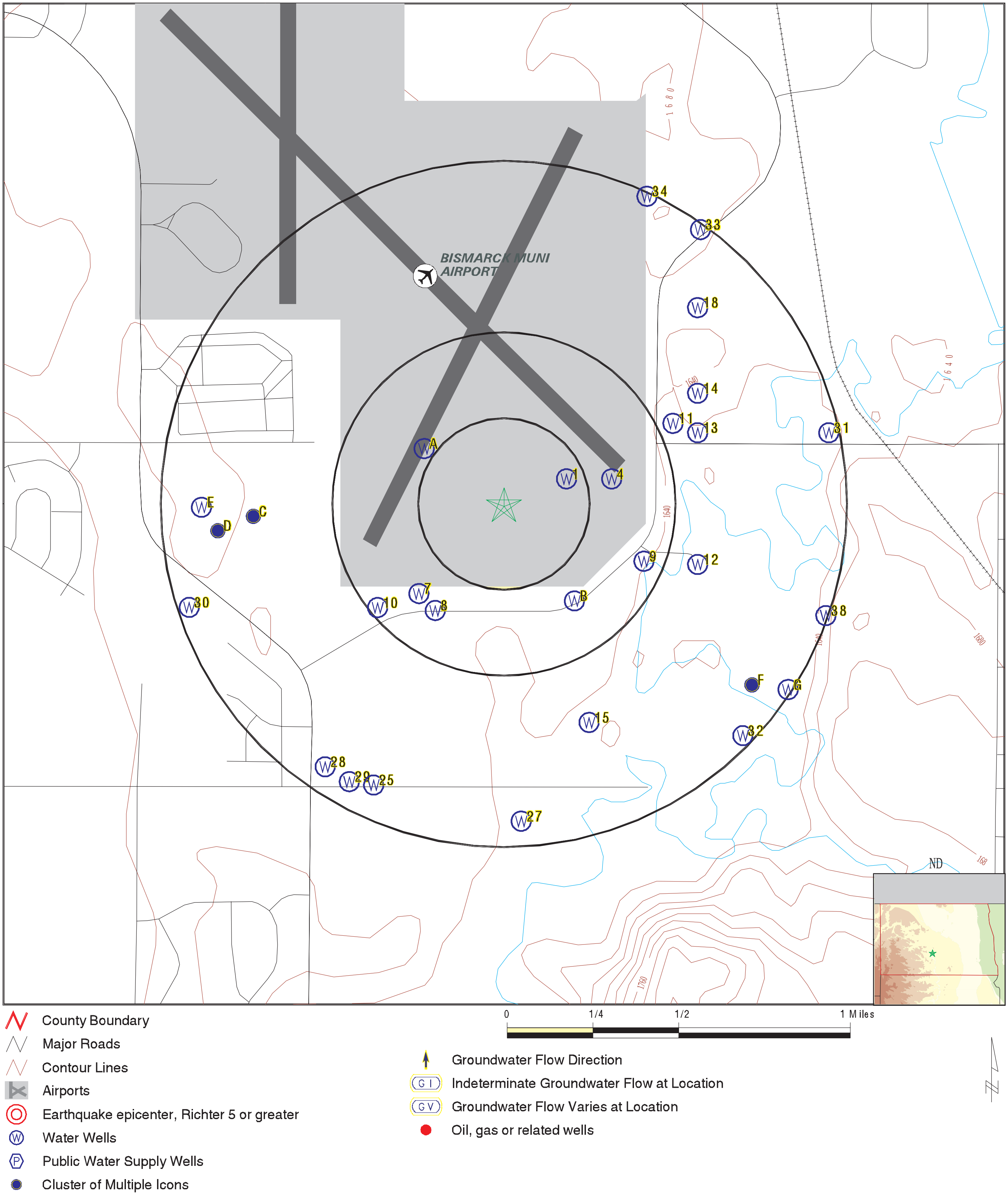
MAP ID	WELL ID	LOCATION FROM TP
No PWS System Found		

Note: PWS System location is not always the same as well location.

STATE DATABASE WELL INFORMATION

MAP ID	WELL ID	LOCATION FROM TP
A2	ND7000000012413	1/4 - 1/2 Mile NW
A3	ND7000000012414	1/4 - 1/2 Mile WNW
B5	ND7000000012411	1/4 - 1/2 Mile SE
B6	ND7000000012412	1/4 - 1/2 Mile SE
7	ND7000000012416	1/4 - 1/2 Mile SW
9	ND7000000012410	1/4 - 1/2 Mile ESE
10	ND7000000012415	1/4 - 1/2 Mile SW
11	ND7000000012299	1/2 - 1 Mile ENE
15	ND7000000012419	1/2 - 1 Mile SSE
C17	ND7000000012399	1/2 - 1 Mile West
D19	ND7000000012398	1/2 - 1 Mile West
E22	ND7000000012401	1/2 - 1 Mile West
E24	ND7000000012400	1/2 - 1 Mile West
25	ND7000000012418	1/2 - 1 Mile SSW
F26	ND7000000012421	1/2 - 1 Mile SE
28	ND7000000012417	1/2 - 1 Mile SW
30	ND7000000012407	1/2 - 1 Mile WSW
33	ND7000000012296	1/2 - 1 Mile NE
34	ND7000000012300	1/2 - 1 Mile NNE
38	ND7000000012420	1/2 - 1 Mile ESE

PHYSICAL SETTING SOURCE MAP - 5872123.2s



SITE NAME: Bismarck AASF #1	CLIENT: AECOM
ADDRESS: 3410 Yegen Road	CONTACT: Hans Sund
Bismarck ND 58504	INQUIRY #: 5872123.2s
LAT/LONG: 46.763101 / 100.740915	DATE: November 15, 2019 4:15 pm

Map ID Direction Distance Elevation	Database	EDR ID Number
1 **ENE** **1/8 - 1/4 Mile** **Higher**	**FED USGS**	**USGS40000913898**

Organization ID:	USGS-ND		
Organization Name:	USGS North Dakota Water Science Center		
Monitor Location:	138-080-23ABA	Type:	Well
Description:	Not Reported	HUC:	10130103
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported
Aquifer:	Not Reported	Formation Type:	Not Reported
Aquifer Type:	Not Reported	Construction Date:	19610101
Well Depth:	Not Reported	Well Depth Units:	Not Reported
Well Hole Depth:	100	Well Hole Depth Units:	ft

A2 **NW** **1/4 - 1/2 Mile** **Lower**	**ND WELLS**	**ND7000000012413**

Well Index:	4294	Basin:	Apple Creek
Aquifer:	Bismarck	Purpose:	Observation Well
Casing Type:	PVC	Diameter:	0
Surface Elevation:	0	Drill Date:	197910 5
Total Depth:	60	Bedrock Depth:	0

A3 **WNW** **1/4 - 1/2 Mile** **Lower**	**ND WELLS**	**ND7000000012414**

Well Index:	4295	Basin:	Apple Creek
Aquifer:	Bismarck	Purpose:	Observation Well
Casing Type:	PVC	Diameter:	0
Surface Elevation:	0	Drill Date:	197910 5
Total Depth:	50	Bedrock Depth:	0

4 **ENE** **1/4 - 1/2 Mile** **Higher**	**FED USGS**	**USGS40000913897**

Organization ID:	USGS-ND		
Organization Name:	USGS North Dakota Water Science Center		
Monitor Location:	138-080-23AAB	Type:	Well
Description:	Not Reported	HUC:	10130103
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported
Aquifer:	Not Reported	Formation Type:	Not Reported
Aquifer Type:	Not Reported	Construction Date:	19610101
Well Depth:	Not Reported	Well Depth Units:	Not Reported
Well Hole Depth:	100	Well Hole Depth Units:	ft

Map ID
Direction
Distance
Elevation | Database | EDR ID Number

B5
SE
1/4 - 1/2 Mile
Higher

ND WELLS **ND7000000012411**

Well Index:	4292	Basin:	Apple Creek
Aquifer:	Bismarck	Purpose:	Observation Well
Casing Type:	PVC	Diameter:	0
Surface Elevation:	0	Drill Date:	197910 3
Total Depth:	100	Bedrock Depth:	92

B6
SE
1/4 - 1/2 Mile
Higher

ND WELLS **ND7000000012412**

Well Index:	4293	Basin:	Apple Creek
Aquifer:	Bismarck	Purpose:	Observation Well
Casing Type:	PVC	Diameter:	0
Surface Elevation:	0	Drill Date:	1980 423
Total Depth:	100	Bedrock Depth:	93

7
SW
1/4 - 1/2 Mile
Higher

ND WELLS **ND7000000012416**

Well Index:	4297	Basin:	Apple Creek
Aquifer:	Unknown	Purpose:	Irrigation Well
Casing Type:	Unknown	Diameter:	15
Surface Elevation:	0	Drill Date:	1961 8 1
Total Depth:	110	Bedrock Depth:	0

8
SSW
1/4 - 1/2 Mile
Higher

FED USGS **USGS40000913737**

Organization ID:	USGS-ND		
Organization Name:	USGS North Dakota Water Science Center		
Monitor Location:	138-080-23BDC	Type:	Well
Description:	Not Reported	HUC:	10130103
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported
Aquifer:	Not Reported	Formation Type:	Not Reported
Aquifer Type:	Not Reported	Construction Date:	19610101
Well Depth:	110	Well Depth Units:	ft
Well Hole Depth:	Not Reported	Well Hole Depth Units:	Not Reported

Ground water levels,Number of Measurements:	1	Level reading date:	1961-08-01
Feet below surface:	37.43	Feet to sea level:	Not Reported
Note:	Not Reported		

Map ID Direction Distance Elevation	Database	EDR ID Number
9 **ESE** **1/4 - 1/2 Mile** **Lower**	**ND WELLS**	**ND7000000012410**

Well Index:	4291	Basin:	Apple Creek
Aquifer:	Unknown	Purpose:	Observation Well
Casing Type:	PVC	Diameter:	0
Surface Elevation:	0	Drill Date:	197910 3
Total Depth:	80	Bedrock Depth:	0

10 **SW** **1/4 - 1/2 Mile** **Higher**	**ND WELLS**	**ND7000000012415**

Well Index:	4296	Basin:	Apple Creek
Aquifer:	Bismarck	Purpose:	Observation Well
Casing Type:	PVC	Diameter:	0
Surface Elevation:	0	Drill Date:	197910 3
Total Depth:	110	Bedrock Depth:	97

11 **ENE** **1/2 - 1 Mile** **Lower**	**ND WELLS**	**ND7000000012299**

Well Index:	23909	Basin:	Apple Creek
Aquifer:	No Obs Well Installed	Purpose:	Test Hole
Casing Type:	None	Diameter:	0
Surface Elevation:	1631	Drill Date:	19601031
Total Depth:	0	Bedrock Depth:	0

12 **ESE** **1/2 - 1 Mile** **Lower**	**FED USGS**	**USGS40000913795**

Organization ID:	USGS-ND		
Organization Name:	USGS North Dakota Water Science Center		
Monitor Location:	138-080-24BCB	Type:	Well
Description:	Not Reported	HUC:	10130103
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported
Aquifer:	Not Reported	Formation Type:	Not Reported
Aquifer Type:	Not Reported	Construction Date:	1959
Well Depth:	97	Well Depth Units:	ft
Well Hole Depth:	Not Reported	Well Hole Depth Units:	Not Reported

Ground water levels,Number of Measurements:	1	Level reading date:	1960-09-14
Feet below surface:	30	Feet to sea level:	Not Reported
Note:	Not Reported		

Map ID
Direction
Distance
Elevation | Database | EDR ID Number

13
ENE
1/2 - 1 Mile
Lower | **FED USGS** | **USGS40000913932**

Organization ID:	USGS-ND		
Organization Name:	USGS North Dakota Water Science Center		
Monitor Location:	138-080-13CCC	Type:	Well
Description:	Not Reported	HUC:	10130103
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported
Aquifer:	Not Reported	Formation Type:	Not Reported
Aquifer Type:	Not Reported	Construction Date:	19600101
Well Depth:	Not Reported	Well Depth Units:	Not Reported
Well Hole Depth:	493	Well Hole Depth Units:	ft

14
ENE
1/2 - 1 Mile
Lower | **FED USGS** | **USGS40000913954**

Organization ID:	USGS-ND		
Organization Name:	USGS North Dakota Water Science Center		
Monitor Location:	138-080-13CCB	Type:	Well
Description:	Not Reported	HUC:	10130103
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported
Aquifer:	Not Reported	Formation Type:	Not Reported
Aquifer Type:	Not Reported	Construction Date:	19610101
Well Depth:	Not Reported	Well Depth Units:	Not Reported
Well Hole Depth:	90	Well Hole Depth Units:	ft

15
SSE
1/2 - 1 Mile
Lower | **ND WELLS** | **ND7000000012419**

Well Index:	4300	Basin:	Apple Creek
Aquifer:	Unknown	Purpose:	Unknown
Casing Type:	Unknown	Diameter:	0
Surface Elevation:	0	Drill Date:	0
Total Depth:	0	Bedrock Depth:	0

C16
West
1/2 - 1 Mile
Higher | **FED USGS** | **USGS40000913859**

Organization ID:	USGS-ND		
Organization Name:	USGS North Dakota Water Science Center		
Monitor Location:	138-080-22AAC	Type:	Well
Description:	Not Reported	HUC:	10130103
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported

Aquifer:	Not Reported	Formation Type:	Not Reported
Aquifer Type:	Not Reported	Construction Date:	19600101
Well Depth:	131	Well Depth Units:	ft
Well Hole Depth:	Not Reported	Well Hole Depth Units:	Not Reported

Ground water levels,Number of Measurements:	1	Level reading date:	1960-10-01
Feet below surface:	45.64	Feet to sea level:	Not Reported
Note:	Not Reported		

C17
West
1/2 - 1 Mile
Higher

ND WELLS **ND7000000012399**

Well Index:	4287	Basin:	Apple Creek
Aquifer:	Unknown	Purpose:	Irrigation Well
Casing Type:	Unknown	Diameter:	17
Surface Elevation:	0	Drill Date:	196010 1
Total Depth:	131	Bedrock Depth:	0

18
NE
1/2 - 1 Mile
Higher

FED USGS **USGS40000914011**

Organization ID:	USGS-ND		
Organization Name:	USGS North Dakota Water Science Center		
Monitor Location:	138-080-13CBB	Type:	Well
Description:	Not Reported	HUC:	10130103
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported
Aquifer:	Not Reported	Formation Type:	Not Reported
Aquifer Type:	Not Reported	Construction Date:	19610101
Well Depth:	Not Reported	Well Depth Units:	Not Reported
Well Hole Depth:	171	Well Hole Depth Units:	ft

D19
West
1/2 - 1 Mile
Higher

ND WELLS **ND7000000012398**

Well Index:	13061	Basin:	Apple Creek
Aquifer:	Unknown	Purpose:	Irrigation Well
Casing Type:	Unknown	Diameter:	0
Surface Elevation:	0	Drill Date:	0
Total Depth:	0	Bedrock Depth:	0

D20
West
1/2 - 1 Mile
Higher

FED USGS **USGS40000913847**

Organization ID:	USGS-ND
Organization Name:	USGS North Dakota Water Science Center

Monitor Location:	138-080-22ABD1	Type:	Well
Description:	Not Reported	HUC:	10130103
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported
Aquifer:	Not Reported	Formation Type:	Not Reported
Aquifer Type:	Not Reported	Construction Date:	19610101
Well Depth:	Not Reported	Well Depth Units:	Not Reported
Well Hole Depth:	157	Well Hole Depth Units:	ft

Ground water levels,Number of Measurements:	1	Level reading date:	1961-10-01
Feet below surface:	44.65	Feet to sea level:	Not Reported
Note:	Not Reported		

D21
West
1/2 - 1 Mile
Higher

FED USGS **USGS40000913848**

Organization ID:	USGS-ND		
Organization Name:	USGS North Dakota Water Science Center		
Monitor Location:	138-080-22ABD2	Type:	Well
Description:	Not Reported	HUC:	10130103
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported
Aquifer:	Sand and gravel aquifers (glaciated regions)		
Formation Type:	Glacial Drift, Undifferentiated - Pleistocene		
Aquifer Type:	Not Reported	Construction Date:	19610101
Well Depth:	Not Reported	Well Depth Units:	Not Reported
Well Hole Depth:	158	Well Hole Depth Units:	ft

Ground water levels,Number of Measurements:	1	Level reading date:	1961-10-01
Feet below surface:	41.82	Feet to sea level:	Not Reported
Note:	Not Reported		

E22
West
1/2 - 1 Mile
Higher

ND WELLS **ND7000000012401**

Well Index:	13060	Basin:	Apple Creek
Aquifer:	Unknown	Purpose:	Observation Well
Casing Type:	Unknown	Diameter:	0
Surface Elevation:	0	Drill Date:	196110 4
Total Depth:	0	Bedrock Depth:	152

F23
SE
1/2 - 1 Mile
Lower

FED USGS **USGS40000913662**

Organization ID:	USGS-ND		
Organization Name:	USGS North Dakota Water Science Center		
Monitor Location:	138-080-24CBD	Type:	Well
Description:	Not Reported	HUC:	10130103
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported

Aquifer:	Not Reported	Formation Type:	Not Reported
Aquifer Type:	Not Reported	Construction Date:	19610101
Well Depth:	Not Reported	Well Depth Units:	Not Reported
Well Hole Depth:	91	Well Hole Depth Units:	ft

E24
West
1/2 - 1 Mile
Higher

ND WELLS **ND7000000012400**

Well Index:	23901	Basin:	Apple Creek
Aquifer:	Unknown	Purpose:	Observation Well
Casing Type:	Unknown	Diameter:	0
Surface Elevation:	1662	Drill Date:	196110 4
Total Depth:	157	Bedrock Depth:	152

25
SSW
1/2 - 1 Mile
Higher

ND WELLS **ND7000000012418**

Well Index:	4299	Basin:	Apple Creek
Aquifer:	Bismarck	Purpose:	Observation Well
Casing Type:	PVC	Diameter:	0
Surface Elevation:	0	Drill Date:	197910 5
Total Depth:	120	Bedrock Depth:	110

F26
SE
1/2 - 1 Mile
Lower

ND WELLS **ND7000000012421**

Well Index:	4302	Basin:	Apple Creek
Aquifer:	Unknown	Purpose:	Irrigation Well
Casing Type:	Unknown	Diameter:	17
Surface Elevation:	0	Drill Date:	1960 9 1
Total Depth:	85	Bedrock Depth:	0

27
South
1/2 - 1 Mile
Lower

FED USGS **USGS40000913546**

Organization ID:	USGS-ND		
Organization Name:	USGS North Dakota Water Science Center		
Monitor Location:	138-080-26ABB	Type:	Well
Description:	Not Reported	HUC:	10130103
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported
Aquifer:	Not Reported	Formation Type:	Not Reported
Aquifer Type:	Not Reported	Construction Date:	1955
Well Depth:	186	Well Depth Units:	ft
Well Hole Depth:	Not Reported	Well Hole Depth Units:	Not Reported

Map ID Direction Distance Elevation	Database	EDR ID Number
28 **SW** **1/2 - 1 Mile** **Higher**	**ND WELLS**	**ND7000000012417**

Well Index:	23902	Basin:	Apple Creek
Aquifer:	No Obs Well Installed	Purpose:	Test Hole
Casing Type:	None	Diameter:	0
Surface Elevation:	1656	Drill Date:	19601028
Total Depth:	273	Bedrock Depth:	106

Map ID Direction Distance Elevation	Database	EDR ID Number
29 **SSW** **1/2 - 1 Mile** **Higher**	**FED USGS**	**USGS40000913571**

Organization ID:	USGS-ND		
Organization Name:	USGS North Dakota Water Science Center		
Monitor Location:	138-080-23CCC	Type:	Well
Description:	Not Reported	HUC:	10130103
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported
Aquifer:	Not Reported	Formation Type:	Not Reported
Aquifer Type:	Not Reported	Construction Date:	19600101
Well Depth:	Not Reported	Well Depth Units:	Not Reported
Well Hole Depth:	273	Well Hole Depth Units:	ft

Map ID Direction Distance Elevation	Database	EDR ID Number
30 **WSW** **1/2 - 1 Mile** **Higher**	**ND WELLS**	**ND7000000012407**

Well Index:	127245	Basin:	Missouri River
Aquifer:	Bismarck	Purpose:	Observation Well
Casing Type:	PVC	Diameter:	0
Surface Elevation:	0	Drill Date:	2005 418
Total Depth:	0	Bedrock Depth:	0

Map ID Direction Distance Elevation	Database	EDR ID Number
31 **ENE** **1/2 - 1 Mile** **Lower**	**FED USGS**	**USGS40000913931**

Organization ID:	USGS-ND		
Organization Name:	USGS North Dakota Water Science Center		
Monitor Location:	138-080-13CDD	Type:	Well
Description:	Not Reported	HUC:	10130103
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported
Aquifer:	Not Reported	Formation Type:	Not Reported
Aquifer Type:	Not Reported	Construction Date:	19610101
Well Depth:	Not Reported	Well Depth Units:	Not Reported
Well Hole Depth:	90	Well Hole Depth Units:	ft

Map ID Direction Distance Elevation	Database	EDR ID Number
32 **SE** **1/2 - 1 Mile** **Lower**	**FED USGS**	**USGS40000913616**

Organization ID:	USGS-ND		
Organization Name:	USGS North Dakota Water Science Center		
Monitor Location:	138-080-24CCA	Type:	Well
Description:	Not Reported	HUC:	10130103
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported
Aquifer:	Not Reported	Formation Type:	Not Reported
Aquifer Type:	Not Reported	Construction Date:	19610101
Well Depth:	Not Reported	Well Depth Units:	Not Reported
Well Hole Depth:	90	Well Hole Depth Units:	ft

33 **NE** **1/2 - 1 Mile** **Higher**	**ND WELLS**	**ND7000000012296**

Well Index:	4255	Basin:	Apple Creek
Aquifer:	Unknown	Purpose:	Unknown
Casing Type:	Unknown	Diameter:	4
Surface Elevation:	0	Drill Date:	1965 9 1
Total Depth:	0	Bedrock Depth:	0

34 **NNE** **1/2 - 1 Mile** **Higher**	**ND WELLS**	**ND7000000012300**

Well Index:	4258	Basin:	Apple Creek
Aquifer:	Unnamed	Purpose:	Observation Well - Plugged
Casing Type:	PVC	Diameter:	0
Surface Elevation:	0	Drill Date:	197910 3
Total Depth:	40	Bedrock Depth:	0

G35 **ESE** **1/2 - 1 Mile** **Lower**	**FED USGS**	**USGS40000913659**

Organization ID:	USGS-ND		
Organization Name:	USGS North Dakota Water Science Center		
Monitor Location:	138-080-24CAC1	Type:	Well
Description:	Not Reported	HUC:	10130103
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported
Aquifer:	Not Reported	Formation Type:	Not Reported
Aquifer Type:	Not Reported	Construction Date:	19600101
Well Depth:	80	Well Depth Units:	ft
Well Hole Depth:	Not Reported	Well Hole Depth Units:	Not Reported

Ground water levels,Number of Measurements:	1	Level reading date:	1960-09-01
Feet below surface:	13.48	Feet to sea level:	Not Reported
Note:	Not Reported		

G36
ESE
1/2 - 1 Mile
Lower

FED USGS **USGS40000913660**

Organization ID:	USGS-ND		
Organization Name:	USGS North Dakota Water Science Center		
Monitor Location:	138-080-24CAC2	Type:	Well
Description:	Not Reported	HUC:	10130103
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported
Aquifer:	Not Reported	Formation Type:	Not Reported
Aquifer Type:	Not Reported	Construction Date:	19620101
Well Depth:	Not Reported	Well Depth Units:	Not Reported
Well Hole Depth:	90	Well Hole Depth Units:	ft

G37
ESE
1/2 - 1 Mile
Lower

FED USGS **USGS40000913661**

Organization ID:	USGS-ND		
Organization Name:	USGS North Dakota Water Science Center		
Monitor Location:	138-080-24CAC3	Type:	Well
Description:	Not Reported	HUC:	10130103
Drainage Area:	Not Reported	Drainage Area Units:	Not Reported
Contrib Drainage Area:	Not Reported	Contrib Drainage Area Unts:	Not Reported
Aquifer:	Not Reported	Formation Type:	Not Reported
Aquifer Type:	Not Reported	Construction Date:	19610101
Well Depth:	Not Reported	Well Depth Units:	Not Reported
Well Hole Depth:	90	Well Hole Depth Units:	ft

38
ESE
1/2 - 1 Mile
Higher

ND WELLS **ND7000000012420**

Well Index:	4301	Basin:	Apple Creek
Aquifer:	Unknown	Purpose:	Unknown
Casing Type:	Unknown	Diameter:	2
Surface Elevation:	0	Drill Date:	0
Total Depth:	0	Bedrock Depth:	0

GEOCHECK® - PHYSICAL SETTING SOURCE MAP FINDINGS
RADON

AREA RADON INFORMATION

State Database: ND Radon

Radon Test Results

Source	Total Sites	Average	Std. Dev.	Pct > 4 Pci/L	Pct > 20 Pci/L
wic	2	3.40	0.60	0.0	0.0
home	2	4.5	1.7	50.0	0.0
daycare	26	2.13	1.31	11.5	0.0
wic	57	3.04	2.69	33.3	0.0
school	609	1.01	0.84	1.0	0.0
home	87	4.9	4.2	44.8	1.1
daycare	1	2.70	0.00	0.0	0.0
daycare	385	3.77	3.68	29.9	1.0
cluster	14	10.00	10.14	64.3	14.3

Federal EPA Radon Zone for BURLEIGH County: 1

Note: Zone 1 indoor average level > 4 pCi/L.
: Zone 2 indoor average level >= 2 pCi/L and <= 4 pCi/L.
: Zone 3 indoor average level < 2 pCi/L.

Federal Area Radon Information for Zip Code: 58504

Number of sites tested: 21

Area	Average Activity	% <4 pCi/L	% 4-20 pCi/L	% >20 pCi/L
Living Area - 1st Floor	2.600 pCi/L	100%	0%	0%
Living Area - 2nd Floor	Not Reported	Not Reported	Not Reported	Not Reported
Basement	4.762 pCi/L	57%	43%	0%

PHYSICAL SETTING SOURCE RECORDS SEARCHED

TOPOGRAPHIC INFORMATION

USGS 7.5' Digital Elevation Model (DEM)
Source: United States Geologic Survey
EDR acquired the USGS 7.5' Digital Elevation Model in 2002 and updated it in 2006. The 7.5 minute DEM corresponds to the USGS 1:24,000- and 1:25,000-scale topographic quadrangle maps. The DEM provides elevation data with consistent elevation units and projection.

Current USGS 7.5 Minute Topographic Map
Source: U.S. Geological Survey

HYDROLOGIC INFORMATION

Flood Zone Data: This data was obtained from the Federal Emergency Management Agency (FEMA). It depicts 100-year and 500-year flood zones as defined by FEMA. It includes the National Flood Hazard Layer (NFHL) which incorporates Flood Insurance Rate Map (FIRM) data and Q3 data from FEMA in areas not covered by NFHL.
Source: FEMA
Telephone: 877-336-2627
Date of Government Version: 2003, 2015

NWI: National Wetlands Inventory. This data, available in select counties across the country, was obtained by EDR in 2002, 2005 and 2010 from the U.S. Fish and Wildlife Service.

HYDROGEOLOGIC INFORMATION

AQUIFLOW^{R} Information System
Source: EDR proprietary database of groundwater flow information
EDR has developed the AQUIFLOW Information System (AIS) to provide data on the general direction of groundwater flow at specific points. EDR has reviewed reports submitted to regulatory authorities at select sites and has extracted the date of the report, hydrogeologically determined groundwater flow direction and depth to water table information.

GEOLOGIC INFORMATION

Geologic Age and Rock Stratigraphic Unit
Source: P.G. Schruben, R.E. Arndt and W.J. Bawiec, Geology of the Conterminous U.S. at 1:2,500,000 Scale - A digital representation of the 1974 P.B. King and H.M. Beikman Map, USGS Digital Data Series DDS - 11 (1994).

STATSGO: State Soil Geographic Database
Source: Department of Agriculture, Natural Resources Conservation Service (NRCS)
The U.S. Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS) leads the national Conservation Soil Survey (NCSS) and is responsible for collecting, storing, maintaining and distributing soil survey information for privately owned lands in the United States. A soil map in a soil survey is a representation of soil patterns in a landscape. Soil maps for STATSGO are compiled by generalizing more detailed (SSURGO) soil survey maps.

SSURGO: Soil Survey Geographic Database
Source: Department of Agriculture, Natural Resources Conservation Service (NRCS)
Telephone: 800-672-5559
SSURGO is the most detailed level of mapping done by the Natural Resources Conservation Service, mapping scales generally range from 1:12,000 to 1:63,360. Field mapping methods using national standards are used to construct the soil maps in the Soil Survey Geographic (SSURGO) database. SSURGO digitizing duplicates the original soil survey maps. This level of mapping is designed for use by landowners, townships and county natural resource planning and management.

PHYSICAL SETTING SOURCE RECORDS SEARCHED

LOCAL / REGIONAL WATER AGENCY RECORDS

FEDERAL WATER WELLS

PWS: Public Water Systems
Source: EPA/Office of Drinking Water
Telephone: 202-564-3750
Public Water System data from the Federal Reporting Data System. A PWS is any water system which provides water to at least 25 people for at least 60 days annually. PWSs provide water from wells, rivers and other sources.

PWS ENF: Public Water Systems Violation and Enforcement Data
Source: EPA/Office of Drinking Water
Telephone: 202-564-3750
Violation and Enforcement data for Public Water Systems from the Safe Drinking Water Information System (SDWIS) after August 1995. Prior to August 1995, the data came from the Federal Reporting Data System (FRDS).

USGS Water Wells: USGS National Water Inventory System (NWIS)
This database contains descriptive information on sites where the USGS collects or has collected data on surface water and/or groundwater. The groundwater data includes information on wells, springs, and other sources of groundwater.

STATE RECORDS

Water Well Locations
Source: State Water Commission
Telephone: 701-328-2754

OTHER STATE DATABASE INFORMATION

Oil and Gas Well Locations Listing
Source: North Dakota Industrial Commission
Telephone: 701-328-8020
A listing of oil and gas well locations in the state.

RADON

State Database: ND Radon
Source: Dept of Health
Telephone: 701-328-5188
Radon Surveys in North Dakota. Includes cluster, day care, school, home, and women with infant children

Area Radon Information
Source: USGS
Telephone: 703-356-4020
The National Radon Database has been developed by the U.S. Environmental Protection Agency (USEPA) and is a compilation of the EPA/State Residential Radon Survey and the National Residential Radon Survey. The study covers the years 1986 - 1992. Where necessary data has been supplemented by information collected at private sources such as universities and research institutions.

EPA Radon Zones
Source: EPA
Telephone: 703-356-4020
Sections 307 & 309 of IRAA directed EPA to list and identify areas of U.S. with the potential for elevated indoor radon levels.

OTHER

Airport Landing Facilities: Private and public use landing facilities
Source: Federal Aviation Administration, 800-457-6656

Epicenters: World earthquake epicenters, Richter 5 or greater
Source: Department of Commerce, National Oceanic and Atmospheric Administration

Earthquake Fault Lines: The fault lines displayed on EDR’s Topographic map are digitized quaternary faultlines, prepared in 1975 by the United State Geological Survey

PHYSICAL SETTING SOURCE RECORDS SEARCHED

STREET AND ADDRESS INFORMATION

Bismarck AASF #1

3410 Yegen Road

Bismarck, ND 58504

Inquiry Number: 5872123.3

November 15, 2019

Certified Sanborn® Map Report

6 Armstrong Road, 4th floor
Shelton, CT 06484
Toll Free: 800.352.0050
www.edrnet.com

Certified Sanborn® Map Report

11/15/19

Site Name:

Bismarck AASF #1
3410 Yegen Road
Bismarck, ND 58504
EDR Inquiry # 5872123.3

Client Name:

AECOM
12120 Shamrock Plaza
Omaha, NE 68154
Contact: Hans Sund

The Sanborn Library has been searched by EDR and maps covering the target property location as provided by AECOM were identified for the years listed below. The Sanborn Library is the largest, most complete collection of fire insurance maps. The collection includes maps from Sanborn, Bromley, Perris & Browne, Hopkins, Barlow, and others. Only Environmental Data Resources Inc. (EDR) is authorized to grant rights for commercial reproduction of maps by the Sanborn Library LLC, the copyright holder for the collection. Results can be authenticated by visiting www.edrnet.com/sanborn.

The Sanborn Library is continually enhanced with newly identified map archives. This report accesses all maps in the collection as of the day this report was generated.

Certified Sanborn Results:

Certification # 1B4B-488E-BF0C

PO # NA

Project Bismarck AASF #1

UNMAPPED PROPERTY

This report certifies that the complete holdings of the Sanborn Library, LLC collection have been searched based on client supplied target property information, and fire insurance maps covering the target property were not found.

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Appendix B
Preliminary Assessment Documentation

Appendix B.1
Interview Records

PA Interview Questionnaire - Other

Facility: Bismarck AASF
Interviewer: [redacted]
Date/Time: 9/13/19 at 0800

Interviewee: [redacted] **Title: Former AASF Shop Supervisor** **Phone Number:** [redacted] **Email:** [redacted]	Can your name/role be used in the PA Report? **Y** or N Can you recommend anyone we can interview? Y or **N** ___________________________
Roles or activities with the Facility/Years working at the Facility:	
20+ years as AASF shop supervisor	
PFAS Use: Identify accidental/intentional release locations, time frame of release, frequency of releases, storage container size (maintenance, fire training, firefighting, buildings with suppression systems (as builts), fueling stations, crash sites, pest management, recreational, dining facilities, metals plating, or waterproofing). How are materials ordered/purchased/disposed/shared with others?	

- Fire Suppression System
  - Full system release that resulted the hangar to fill ¾ of the way up the walls with foam
  - Hangar doors were closed
  - Hangar outfitted with trench drains that lead to an oil/water separator then to a city sewer system
  - Annual testing includes testing just the pressure in the system without a release of foam. This is completed by a contractor.
  - System installed in 2006
  - 300-gallon tank filled with 2% C2 High Expansion Foam
- The fire suppression system supplies foam to both hangars. There is an additional hangar (cold storage hangar) to the southeast that doesn't have a fire suppression system.
- 2 55-gallon drums of 2% C2 high expansion foam (bulk concentrate)

Known Uses
Use
Procurement
Disposition
Storage (Mixed)
Storage (Solution)
Inventory, Off-Spec
Containment
SOP on Filling
Leaking Vehicles
Nozzle and Suppression System Testing
Dining Facilities
Vehicle Washing
Ramp Washing
Fuel Spill Washing and Fueling Stations
Chrome Plating or Waterproofing

PA Interview Questionnaire - Other

Facility: Bismarck AASF
Interviewer: [redacted]
Date/Time: 9/13/19 at 0800

Interviewee: [redacted] **Title: NDARNG** **Phone Number:** [redacted] **Email:**	Can your name/role be used in the PA Report? **Y** or N Can you recommend anyone we can interview? Y or **N** ___________________________

Roles or activities with the Facility/Years working at the Facility:

19 years at the NDARNG

PFAS Use: Identify accidental/intentional release locations, time frame of release, frequency of releases, storage container size (maintenance, fire training, firefighting, buildings with suppression systems (as builts), fueling stations, crash sites, pest management, recreational, dining facilities, metals plating, or waterproofing). How are materials ordered/purchased/disposed/shared with others?

- TriMax30™ Fire Extinguishers
  - They received the TriMax Units in approximately 2004 and are still the main types of fire extinguishers at the AASF. They are placed in the ramp area, hangars, and on small vehicles
  - There is one that has only been filled with soap for fire training exercises
  - Every 5 years, the TriMax units were emptied into polyethylene tanks and empty TriMax extinguishers were sent to a contractor to undergo hydrostatic testing. Would then refill the fire extinguishers at the maintenance room south of the new hangar located in between the two hangars
- Never actually dispensed AFFF
- No spills or leaking occurred during emptying or refilling the TriMax units
- Prior to TriMax, they had Halon and purple k mobile fire extinguishers

Known Uses
Use
Procurement
Disposition
Storage (Mixed)
Storage (Solution)
Inventory, Off-Spec
Containment
SOP on Filling
Leaking Vehicles
Nozzle and Suppression System Testing
Dining Facilities
Vehicle Washing
Ramp Washing
Fuel Spill Washing and Fueling Stations
Chrome Plating or Waterproofing

PA Interview Questionnaire - Other

Facility: Bismarck AASF
Interviewer: [redacted]
Date/Time: 9/13/19 at 0800

Interviewee: [redacted] **Title: Bismarck Airport Fire Chief** **Phone Number:** **Email: [redacted]**	Can your name/role be used in the PA Report? **Y** or N Can you recommend anyone we can interview? Y or **N** ___________________________
Roles or activities with the Facility/Years working at the Facility:	
16 years at the Bismarck Airport Fire Department and current fire chief	

PFAS Use: Identify accidental/intentional release locations, time frame of release, frequency of releases, storage container size (maintenance, fire training, firefighting, buildings with suppression systems (as builts), fueling stations, crash sites, pest management, recreational, dining facilities, metals plating, or waterproofing). How are materials ordered/purchased/disposed/shared with others?

- Airport FD has 3 firetrucks with AFFF tanks with a capacity of 400-gallons, 200-gallons and 200-gallons
- They keep approximately 800-1,000 gallons of bulk 6% AFFF at the fire department at a time
- Have never responded to a fire or crash at the airport
- Trucks require nozzle testing annually where4 they containerize the AFFF
- Annual fire training is currently conducted using water only, but it is unknown how long water-only training occurred for
- Airport FD provides emergency response to AASF
- Located upgradient

Known Uses
Use
Procurement
Disposition
Storage (Mixed)
Storage (Solution)
Inventory, Off-Spec
Containment
SOP on Filling
Leaking Vehicles
Nozzle and Suppression System Testing
Dining Facilities
Vehicle Washing
Ramp Washing
Fuel Spill Washing and Fueling Stations
Chrome Plating or Waterproofing

Appendix B.2
Visual Site Inspection Checklists

Visual Site Inspection Checklist

Names(s) of people performing VSI: [redacted]

Recorded by: [redacted]

ARNG Contact: [redacted]

Date and Time: 9/13/2019 8am

Method of visit (walking, driving, adjacent): walking, driving

Source/Release Information

Site Name / Area Name / Unique ID: Bismarck AASF

Site / Area Acreage: approximately 33.65 acres

Historic Site Use (Brief Description):

The original 33.65 acre property was acquired in 1996 and is under contract for the next 50 years to be owned and operated by the NDARNG. The Bismarck AASF is adjacent to the Bismarck Regional Airport. The Bismarck AASF North Hangar is approximately 11,730 square feet of commercial hangar and will be under contract through September of 2020.

Current Site Use (Brief Description):

The AASF supports the North Dakota Army National Guard (NDARNG).

Physical barriers or access restrictions:

Access to the area is restricted to NDARNG.

1. Was PFAS used (or spilled) at the site/area? **Y / N**

1a. If yes, document how PFAS was used and usage time (e.g., fire fighting training 2001 to 2014):

Hangar fire suppression system full release 2006, 2007-present contractor tests the pressure of the system with no release

2. Has usage been documented? **Y / N**

2a. If yes, keep a record (place electronic files on a disk):

Documented in interview documents

3. What types of businesses are located near the site? **Industrial / Commercial / Plating / Waterproofing / Residential**

3a. Indicate what businesses are located near the site

Bismarck Municipal Airport, neighborhood and elementary school

4. Is this site located at an airport/flightline? **Y / N**

4a. If yes, provide a description of the airport/flightline tenants:

Bismarck Municipal Airport

Visual Site Inspection Checklist

Other Significant Site Features:

1. Does the facility have a fire suppression system? **Y** / N

1a. If yes, indicate which type of AFFF has been used:

The fire suppression systems have 2% AFFF tanks.

1b. If yes, describe maintenance schedule/leaks:

Hangar fire suppression system full release 2006, 2007-present pressure is tested with no release

1c. If yes, how often is the AFFF replaced:

TriMax30™ fire extinguishers replaced every 5 years

1d. If yes, does the facility have floor drains and where do they lead? Can we obtain an as built drawing?

The floor drains lead to an oil/water separator then to the City of Bismarck wastewater treatment plant.

Transport / Pathway Information

Migration Potential:

1. Does site/area drainage flow off installation? **Y** / N

1a. If so, note observation and location:

Surface water flows to the south to the Apple Creek which travels southeast to the Missouri River.

2. Is there channelized flow within the site/area? Y / **N**

2a. If so, please note observation and location:

3. Are monitoring or drinking water wells located near the site? **Y** / N

3a. If so, please note the location:

No potable water wells are located within the boundary of the Bismarck AASF; however, two domestic, seven irrigation, thirteen monitoring and four unknown wells were located within a two-mile radius of the site.

4. Are surface water intakes located near the site? Y / **N**

4a. If so, please note the location:

5. Can wind dispersion information be obtained? Y / **N**

5a. If so, please note and observe the location.

N/A

6. Does an adjacent non-ARNG PFAS source exist? **Y** / N

6a. If so, please note the source and location.

Yes, Bismarck Airport Fire Department and the corportate hangar are potential sources of PFAS ajacent to the AASF.

6b. Will off-site reconnaissance be conducted? Y / **N**

Visual Site Inspection Checklist

Significant Topographical Features:

1. Has the infrastructure changed at the site/area? **Y** / N

1a. If so, please describe change (ex. Structures no longer exist):

In 2006 the new AASF hangars were built.

2. Is the site/area vegetated? Y / **N**

2a. If not vegetated, briefly describe the site/area composition:

3. Does the site or area exhibit evidence of erosion? Y / **N**

3a. If yes, describe the location and extent of the erosion:

4. Does the site/area exhibit any areas of ponding or standing water? Y / **N**

4a. If yes, describe the location and extent of the ponding:

Receptor Information

1. Is access to the site restricted? **Y** / N

1a. If so, please note to what extent:

The facility has controlled access

2. Who can access the site? **Site Workers / Construction Workers / Trespassers / Residential / Recreational Users / Ecological**

2a. Circle all that apply, note any not covered above:

3. Are residential areas located near the site? **Y** / N

3a. If so, please note the location/distance:

Residents to the northeast

4. Are any schools/day care centers located near the site? Y / **N**

4a. If so, please note the location/distance/type:

An elementary school within a mile to the northeast

5. Are any wetlands located near the site? Y / **N**

5a. If so, please note the location/distance/type:

Visual Site Inspection Checklist

Additional Notes

Photographic Log

Photo ID/Name	Date & Location	Photograph Description
1	9/13/19, hangar	The hangar fire suppression system containing one 300-gallon tank filled with 2 percent C2 High Expansion Foam.
2	9/13/19, hangar, ramp area and small vehicles	The TriMax30™ fire extinguishers are located within the hangars, ramp area and small vehicles. There is 14 in total on site.
3	9/13/19, fire suppression room	This is the 300-gallon tank filled with 2 percent C2 High Expansion Foam.
4	9/13/19, fire suppression room	There are 2 55-gallon drums of bulk 2% C2 High Expansion Foam located within the fire suppression room.
5	Hazardous Materials Room	Bulk AFFF located in the Hazardous Materials Room used for overland firefighting only. Photo curtesy of NDARNG
6	Hazardous Materials Room	55-gallon drum with pumping system to fill smaller containers with AFFF. Photo curtesy of NDARNG.
7	Hazardous Materials Room	Bulk 6% AFFF concentrate located in the Hazardous Materials room used for overland fire fighting only. Photo curtesy of NDARNG.
8	Main Hangar	Hoses used in the Bambi Bucket® dispensing system for overland firefighting. Photo curtesy of NDARNG.

Appendix B.3
Conceptual Site Model Information

Preliminary Assessment – Conceptual Site Model Information

Site Name: Bismarck Army Aviation Support Facility

Why has this location been identified as a site?
Facility is an aviation support site with an aircraft hangar, high probability of release due to asset type and historical site usage.

Are there any other activities nearby that could also impact this location?
Yes, the potential adjacent sources include the Bismarck Fire Department at Bismarck Regional Airport and the corporate hangar at Bismarck Regional Airport.

Training Events

Have any training events with AFFF occurred at this site? *Yes*

If so, how often? *A full hangar release in 2006.*

How much material was used? Is it documented*? Yes, one 300-gallon tank dumped in 2006.*

Identify Potential Pathways: Do we have enough information to fully understand over land surface water flow, groundwater flow, and geological formations on and around the facility? Any direct pathways to larger water bodies?

Surface Water:

Surface water flow direction? *To the south and east towards Apple Creek*

Average rainfall? *17.82 inches*

Any flooding during rainy season? *unknown*

Direct or indirect pathway to ditches? *Direct*

Direct or indirect pathway to larger bodies of water? *Indirect to Apple Creek; Apple Creek discharges to Missouri River.*

Does surface water pond any place on site? *No*

Any impoundment areas or retention ponds? *No*

Any NPDES location points near the site? *unknown*

How does surface water drain on and around the flight line? *Around the flight line, the surface water ultimately drains southeast to Apple Creek.*

Groundwater:

Groundwater flow direction? *To the southeast and east towards recharge areas and the Missouri River*

Depth to groundwater? *Unknown*

Uses (agricultural, drinking water, irrigation)? *Not used.*

Any groundwater treatment systems? *No*

Any groundwater monitoring well locations near the site? *Yes*

Is groundwater used for drinking water? *Drinking water is supplied by the City of Bismarck Public*

Works, which receives water from groundwater sources.

Are there drinking water supply wells on installation? *No*

Do they serve off-post populations? *No*

Are there off-post drinking water wells downgradient? *No potable water wells are located within the boundary of the AASF; however, wells exist within two miles of the facility.*

Waste Water Treatment Plant:

Has the installation ever had a WWTP, past or present? *No*

If so, do we understand the process and which water is/was treated at the plant? *N/A*

Do we understand the fate of sludge waste? *N/A*

Is surface water from potential contaminated sites treated? *N/A*

Equipment Rinse Water

1. Is firefighting equipment washed? Where does the rinse water go?
No

2. Are nozzles tested? How often are nozzles tested? Where are nozzles tested? Are nozzles cleaned after use? Where does the rinse water flow after cleaning nozzles?
Yes, the AFFF is containerized.

3. Other?
Firefighting services for the AASF are provided by the Bismarck Airport Fire Department.

Identify Potential Receptors:

Site Worker *Yes*

Construction Worker *Yes*

Recreational User *No*

Residential *No*

Child *No*

Ecological *No*

Note what is located near by the site (e.g. daycare, schools, hospitals, churches, agricultural, livestock)?
Residential area is within one mile of the facility along with an elementary school.

Documentation

Ask for Engineering drawings (if applicable). Has there been a reconstruction or changes to the drainage system? When did that occur? *The AASF has a drainage system, where surface water drains to the Bismarck city sewer system, which leads to the city wastewater treatment plant.*

Appendix C
Photographic Log

APPENDIX C – Photographic Log

Army National Guard, Preliminary Assessment for PFAS	Bismarck AASF #1	Bismarck, ND

Photograph No. 1

Description:

The hangar fire suppression system containing one 300-gallon tank filled with 2 percent C2 High Expansion Foam.

Photograph No. 2

Description:

The TriMax30^{TM} fire extinguishers are located within the hangars, ramp area and small vehicles (14 in total on site).

APPENDIX C – Photographic Log

Army National Guard, Preliminary Assessment for PFAS	Bismarck AASF #1	Bismarck, ND

Photograph No. 3

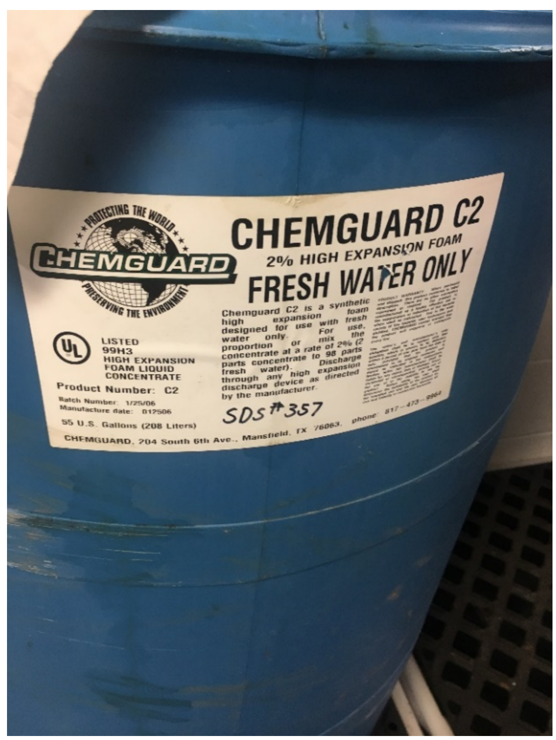
Description:

This is the 300-gallon tank filled with 2 percent C2 High Expansion Foam.

Photograph No. 4

Description:

There are two 55-gallon drums of bulk 2% C2 High Expansion Foam located within the fire suppression room.



APPENDIX C – Photographic Log

Army National Guard, Preliminary Assessment for PFAS	Bismarck AASF #1	Bismarck, ND

Photograph No. 5

Description:

Bulk AFFF located in the Hazardous Materials Room used for overland firefighting only.

Photo curtesy of NDARNG.

Photograph No. 6

Description:

55-gallon drum with pumping system to fill smaller containers with AFFF.

Photo curtesy of NDARNG.

APPENDIX C – Photographic Log

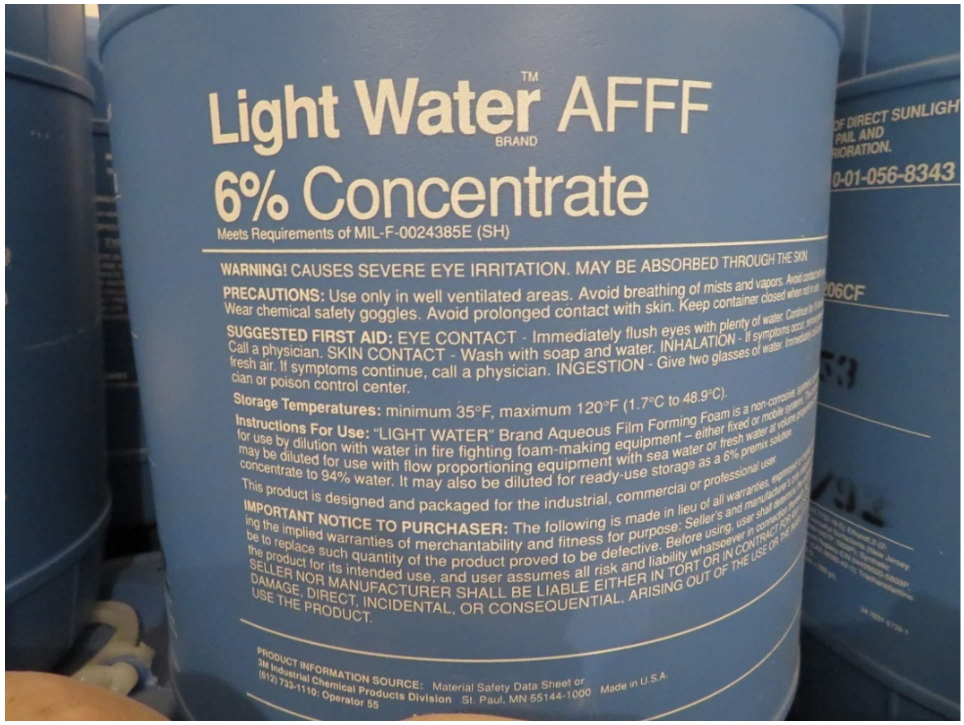
Army National Guard, Preliminary Assessment for PFAS	Bismarck AASF #1	Bismarck, ND

Photograph No. 7

Description:

Bulk 6% AFFF concentrate located in the Hazardous Materials room used for overland fire fighting only.

Photo curtesy of NDARNG.



Photograph No. 8

Description:

Hoses used in the Bambi Bucket® dispensing system for overland firefighting.

Photo curtesy of NDARNG.