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Progress Report

1996-1997



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February 1997





Minnesota Department of Natural Resources Division of Waters

> 1995 Minn. Laws Chap. 220 Sec. 5 Subd. 3

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Southwestern Minnesota Groundwater Exploration Project

Report 'ogiress

by James A. Berg February 1997

Report to the Minnesota Legislature by the Minnesota Department of Natural Resources Division of Waters St. Paul, MN

> The 1995 Minnesota Laws, Chapter 220, Section 5, Subdivision 3

This report was prepared by staff of the Department of Natural Resources, Division of Waters. It is intended to fulfill the requirement of the 1995 Minnesota Laws, Chapter 220, Section 5, Subdivision 3 to report on the progress of the Southwestern Minnesota Drilling Project. The cost to develop and duplicate this report was approximately **\$7,000.00**.

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Acknowledgments

We would like to thank members of the Minnesota Geological Survey (David Southwick, Dale Setterholm, Carrie Patterson, Bruce Bloomgren, and Emily Bauer) for suggestions made in the early stages of the project regarding general exploration areas, for their guidance during the drilling phase of the project, for reviewing the draft version of this report, and especially for completing gamma and resistivity logs of the test holes. Rick Lindgren of the U.S. Geological Survey also reviewed the draft report. We would also like to thank the cooperators (City of Worthington, City of Luverne, Rock County Rural Water, Lincoln County Rural Water, and the City of Marshall) for participating in the project and lending logistical support during the drilling portion of the project.

Department of Natural Resources/Division of Waters support that made this project possible includes: project management, mud logging, and report review by Tom Gullett and Brian Rongitsch; mud logging and report review by Evan Drivas, mud logging by Mike Liljegren; drafting by Jerry Johnson; geophysics and report review by Todd Petersen; and report review by Sarah Tufford, Jennie Leete, and Dave Leuthe. Finally, we also appreciated the dedicated drilling services provided by LTP Enterprises, Inc. and Don Hejtmanek.

Funding for this project was approved by the 1995 Minnesota Laws, Chapter 220, Section 5, Subdivision 3, as recommended by the Minnesota Legislative Water Commission.

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Summary

High quality/high capacity aquifers are difficult to find in many portions of southwestern Minnesota since the area is underlain by silt and clay rich Quaternary glacial sediments and shale rich Cretaceous bedrock. In cooperation with five major water appropriators in the region (City of Luverne, Rock County Rural Water, City of Worthington, Lincoln-Pipestone Rural Water, and the City of Marshall), the Minnesota Department of Natural Resources (DNR) has drilled 17 mud rotary test holes at selected locations in Rock, Nobles, Yellow Medicine, and Lincoln Counties. Ten additional test holes are planned for the 1997 field season. These test holes will be located in Yellow Medicine, Lyon, and Pipestone Counties. The purposes of these test holes include: 1) finding the most productive aquifers in areas closest to the major water appropriators, and 2) obtaining geological information to help predict the location² of the best aquifers for future use.

The test holes drilled during the summer and fall of 1996 ranged in depth from 400 to 979 feet. Most of the test holes penetrated both the Quaternary and Cretaceous sections. In the Worthington area (Nobles County), potentially productive sand layers (thickness of 20 feet or more) were found in the Quaternary section at depths of 134 to 426 feet below ground surface at thicknesses ranging from 20 to 37 feet. Maximum Cretaceous sandstone thicknesses ranged from 68 to 124 feet at depths of 363 to 744 feet below ground surface. The Worthington area appears to have several options for future groundwater exploration and development.

Rock County appears to have fewer options for groundwater supplies than Nobles County, since the area is underlain by a thinner section of Quaternary materials and Cretaceous bedrock. However, even with these limitations, this study has shown that additional groundwater resources may be available in this area. Two new potential large capacity aquifers were discovered by this project consisting of sand layers at the base of the Quaternary section. One aquifer was found in the area around the Rock River and Kanaranzi Creek valleys near the Iowa border at depths of approximately 200 to 250 feet. The other aquifer was found between Magnolia and Adrian at a depth of approximately 250 feet. The maximum sand thickness of these potential large capacity aquifers ranges from 38 to 46 feet. Aquifer testing, water quality testing, and additional drilling is required to determine if these units can supply the capacity and quality demands of the water producers in the area.

Shallow buried outwash units (Prairie Coteau aquifer) in the Lincoln-Pipestone Rural Water Burr Well Field area (Yellow Medicine County) have a dominant northwest-southeast orientation. Thick sections of these outwash units were found in DNR test holes 41-1 and 87-7, located 4-5 miles south-southeast of the Burr Well Field, at depths of 70 to 312 feet below ground surface. In addition, 35 to 38 foot thick accumulations of sand were found at the base of the Quaternary section (Altamont aquifer) in test holes 41-1 and 87-7. The depth to the top of the Altamont aquifer in this area ranges from 365 to 461 feet below ground surface.

The distribution and orientation of the deeper aquifers in the Burr Well Field/Lake Cochrane area (Unit 5 outwash and Altamont aquifer) are not known since very few boreholes penetrate these units in the area. The Altamont aquifer is an attractive target since it is relatively thick, widespread, and produces relatively good quality water. In addition, based on stratigraphic relationships, this aquifer appears to be hydraulically isolated from the overlying Prairie Coteau aquifer. Additional test drilling is required to locate the thickest portions of this aquifer.

1.0 Introduction

The 1995 legislature funded this project from a proposal that was initiated by the Minnesota Water Well Contractors Association. The purpose of the project is to help characterize the geologic and hydrologic conditions in southwestern Minnesota where water supplies are difficult to locate. The original name of the project was the "Grid Drilling Program". One of the exploration strategies considered during the early stages of the project was to drill test holes at regularly spaced intervals or in a grid pattern. However, the test holes were located based on available geologic information and the name has been changed to the Southwestern Minnesota Groundwater Exploration Project 1996-1997.

An amount of \$50,000 was appropriated from the General Fund to the DNR Division of Waters to be matched by an equal amount of money from non-state sources for a total program budget of \$100,000 for the biennium. The non-state sources included: the City of Worthington, City of Luverne, Rock County Rural Water System, Lincoln-Pipestone Rural Water System, and the City of Marshall. The study area (Figure 1) was defined based on regional geology and the locations of the water suppliers that chose to participate. Specifically the project was designed to: 1) find potentially productive aquifers near the major water appropriators, and 2) obtain geological information to help predict the locations of the best aquifers for future investigations.

The purpose of this progress report is to summarize information gathered during the 1996 field season from portions of Rock, Nobles, Yellow Medicine, and Lincoln Counties. The remainder of the project, including planned test drilling in portions of Pipestone, Lyon and Yellow Medicine Counties, will be completed during the 1997 field season.

The test hole drilling locations (Figure 2) were chosen based on regional subsurface geology that was researched and compiled by the DNR for this project. The Minnesota Geological Survey (MGS), the U.S. Geological Survey (USGS), the project participants, and a consulting firm representing three of the participants reviewed the drilling plan and provided suggestions. The regional subsurface geology and target areas were discussed with all of these parties in meetings during the spring of 1996.

2.0 Regional Geology

Previous work in the study area was reviewed prior to drilling in order to locate promising test hole sites. Understanding the regional geology of the area was important for locating areas suitable for test drilling and for interpreting the results of the test drilling.

2.1 Stratigraphy

2.1.1 Cretaceous

The general stratigraphy of the area is shown in Figure 3. The Precambrian basement consists of hard rock such as quartzite and other metamorphic rock types. The Precambrian basement is overlain by a softer bedrock layer composed of Cretaceous shale, sandstone and silty marlstone units. The Cretaceous bedrock is overlain by unconsolidated Pleistocene glacial sediments and

other Quaternary deposits. The Cretaceous sandstone and Quaternary sand layers are the primary aquifers in the area.

The Cretaceous sedimentary rocks of southwestern Minnesota were deposited near the eastern shore of a large inland sea (Setterholm, D.R., 1990). The floor of the inland sea had very little topographic relief. The east-west trending Sioux Ridge which occurs in the southwestern portion of the study area (Figure 4) was partly exposed during the Cretaceous period.

At least two sandstone units within the Cretaceous bedrock have important aquifer potential: the Split Rock Creek Formation and the Dakota Formation. The Split Rock Creek sandstone occurs in South Dakota and the southwestern portion of the study area. This unit was deposited in a marginal marine setting (beach and offshore sand bar) at the edge of the exposed Sioux Ridge. The Dakota Formation, which occurs at the base of the Cretaceous section, was deposited in marginal marine and non-marine settings. This unit appears to be widespread and has a highly variable thickness.

2.1.2 Quaternary

The Quaternary section consists of Pleistocene or glacial age sediments deposited from 8,000 years to 2 million years before the present (B.P.) and Holocene (recent post-glacial) unconsolidated sediments. The Quaternary sediments are separated from the Cretaceous bedrock by a long period during which no deposition occurred (unconformity). The Cretaceous deposits were exposed and eroded for a very long time, creating a distinctive layer just above the Cretaceous bedrock. This layer is referred to in this report as the basal Quaternary (BQ) because it is found at the base of the Quaternary. The exact age of this layer is unknown. The basal Quaternary sediments are composed of unconsolidated sand and clay deposited in non-marine fluvial (stream deposits) and lacustrine (lake deposits) settings.

The remaining overlying portions of the Quaternary sediments can be divided based on surface exposures and subsurface evidence indicating boundaries between till layers (Patterson, 1995). The upper two units of Quaternary sediments (Units 1 and 2) were deposited as silty clay tills and outwash sands from Wisconsin and Late Wisconsin advances of the Des Moines glacial lobe (Figure 5). These units were deposited over most of the study area with the exception of Rock County, southwestern Pipestone County, and extreme southwestern Lincoln County.

The Pre-Wisconsin till/outwash units have been divided based on evidence from drill cuttings indicating previous land surface exposure. Where driller's or geologist's logs noted a change from an unoxidized color (such as gray) to an oxidized color (such as yellow, yellow-brown or tan), the color change was interpreted as the upper contact of a glacial unit that had previously been exposed to the land surface. In addition, thick sand layers and boulder/cobble zones were interpreted as representing the top or near top of the glacial till/outwash unit. Three glacial till/outwash units (Units 3, 4 and 5) can be identified in the Pre-Wisconsin section within the areas investigated to date.

2.1.3 Area Type Logs

Gamma and resistivity logs that represent typical geologic conditions in the area (type logs) have been included from Rock and Nobles Counties (Figures 6 and 7) and the Burr Well Field/Lake Cochrane area (Figure 8). The stratigraphic designations were made by referring to the

geologist's mud logs and by comparing with other gamma and resistivity logs in the area. The gamma and resistivity logs are a continuous depth records of the natural radiation and electrical resistivity of the subsurface formations measured from inside the drill hole. The geologist's mud log is a depth record of the subsurface geology created by identifying pieces of rock and sediment in the drilling mud that are circulated to the surface from the bottom of the drill hole. The till unit tops were commonly identified by a lower gamma reading indicating a higher quartz sand content. The higher quartz sand content was interpreted as evidence of deposition in an exposed environment during a glacial recession.

The unit designations within Rock and Nobles Counties are considered equivalent since correlations were made across the area with a network of cross sections (Section 3.2). For instance, that portion of the glacial deposits in the Worthington area identified as Unit 5 was deposited by the same glaciation as a Unit 5 interval in Rock County. No attempt has been made at this stage of the project to correlate between Rock and Nobles Counties and the Burr Well Field/Lake Cochrane area.

2.2 Topography

Much of the study area topography is depicted in the top layer of Figure 4. The region consists of a topographically high surface to the west, called the Prairie Coteau, and a low relief, lower elevation surface in the eastern portion of the area where Marshall and Worthington are located. The Prairie Couteau strongly influences groundwater flow direction (Bradt, R., 1996). The Prairie Coteau was created by deposition from successive glaciations and erosion of the adjoining lowland to the northeast by glaciation (Patterson, C. J., 1995).

3.0 Rock and Nobles Counties

3.1 Summary of Test Hole Information

Tables 1 and 2 (pages 6 and 7) are a summary of the potentially productive sand and sandstone layers that were encountered in the Rock and Nobles County test holes. The locations of the Rock and Nobles County test holes are shown in Figure 2. These test hole locations were chosen based on sand thickness maps that were created by the DNR from available well logs and published information. Geophysical information was also used to help locate the test holes in Rock County. The strategy in this area was to try to locate low areas in the top of the Cretaceous bedrock surface on the assumption that these low areas may have been occupied by streams prior to glaciation. Low gravity areas from a published gravity survey of Rock County (Chandler, V. W., 1994) were used to help locate test holes. Refraction seismic data collected at three locations in Rock County by the DNR geophysicists, also influenced the locations of the test holes.

The depth ranges of these intervals were determined from drilling rates, lithology from cuttings (mud log or drillers log), resistivity log responses, and gamma log responses. A fast drilling rate is often a good indicator of sand, sandstone, and gravel layers. A low gamma response (recorded by the line on the right side of the log), interpreted in conjunction with the mud log, indicates a high quartz sand content. These characteristics often correspond to material with good aquifer potential. The electrical resistivity of the layers is recorded as the solid line on the left portion of

the log. The resistivity values are controlled by the groundwater chemistry and the permeability/porosity of the layers.

Due to scheduling and drilling problems we were unable to log test holes 67-4 and 67-5 for gamma and resistivity. In addition, due to hole obstructions, we were only able to obtain a partial log of 67-1. A partial gamma and resistivity log was also obtained for test hole 53-7 due to scheduling difficulties for the logging equipment. The logged segment from 320 to 430 feet in test hole 53-6 is inaccurate due to a logging tool malfunction.

Most of the test holes in Rock and Nobles Counties were drilled to hard rock (Precambrian basement). Only test holes 67-1, 67-2 and 53-7 were not. Test holes 67-1 and 67-2 were only drilled into the Cretaceous bedrock due to the budgetary limitations. The 53-7 test hole was drilled to a depth just short of the hard rock due to difficulties in interpreting the geology from drill cuttings.

Table 1 Quaternary Sand Layers - Rock and Nobles Counties

	Depth			
Test Hole #	Range (fact)	Thicknes	S Commonts	Unit
1101c π	(leet)	(leet)	Comments	Unit
53-2	134-154	20	Drilled very fast. Rough drilling indicated cobbles and gravel in this interval. Cuttings consisted of coarse to very coarse sand with gravel and rock fragments. Medium gamma response possibly due to a low quartz/high rock fragment composition of the sand and gravel.	2
53-2	224-261	37	Drilled very fast. Silty very fine to very coarse sand. Low gamma response, high resistivity.	3
53-3	400-426	26	Drilled fast. Silty medium to coarse sand. Medium to high gamma response, high resistivity.	BQ
53-4	320-346	26	Drilled fast. Silty very fine to very coarse sand. Low to medium gamma response, medium to high resistivity.	5
53-7	256-277	21	Drilled fast. Very fine to medium sand. Low gamma response, high resistivity.	BQ
67-5	176-198	22	Drilled fast. Medium to coarse sand. No gamma or resistivity log.	BQ
67-6	290-310	20	Drilled fast. Very fine to medium sand with some coarse sand. Low gamma response, medium resistivity.	BQ
67-7	260-284	24	Drilled very fast. Very fine to medium sand. Low gamma response, high resistivity.	BQ
67-8	204-232	28	Drilled very fast. Very fine to medium sand. Low gamma response, high resistivity.	BQ

Test Hole #	Depth Range (feet)	Thickness (feet)	Comments
53-3	620-744	124	Drilled very fast. Fine to medium sandstone with some coarse layers. Low gamma response, medium resistivity.
53-4	672-740	68	Drilled very fast. Fine to medium sandstone with some coarse layers. Low gamma response, medium resistivity.
53-6	456-508	52	Drilled very fast. Very fine to medium grained sandstone with some coarse sand. Low gamma response, medium resistivity.
67-6	395-455	60	Drilled very fast. Poor recovery, siltstone or very fine sandstone. Low gamma response, medium resistivity.
67-7	363-410	47	Drilled very fast. Poor recovery, some siltstone and very fine sandstone. Low gamma response, high resistivity.

Table 2 Cretaceous Sandstone Layers - Rock and Nobles Counties

3.2 Aquifer Distribution

The information from the test holes was used to revise and update maps (Figures 9 through 13) that were created at the beginning of the project. For each unit map all the available well logs in the area were used. The classification of the sand and sandstone layers (Units 1 through 5, BQ, and Cretaceous bedrock) from available well log data (driller, gamma and resistivity logs) were made by comparing each well log with an extensive system of geologic cross sections. Selected cross sections have been included in this report as Figures 14 through 19. Many Cretaceous bedrock classifications were obtained from the Minnesota Geological Survey (MGS) County Well Index database.

Cross section locations are shown on Figure 9. Prominent regional features are visible on the cross sections. The sloping Precambrian basement surface shown on Cross Sections A-A' (Figure 14), B-B'(Figure 15) and E-E' (Figure 18) is the southern slope of the buried Sioux Ridge. The Cretaceous section thins toward the north along this slope and is absent beneath the City of Luverne. Cross sections C-C' (Figure 16) and D-D' (Figure 17) are oriented perpendicular to the direction of lateral ice movement in the Wisconsin and Late Wisconsin, and perpendicular to the Bemis (Late Wisconsin) moraine. The highest topographic portions of these cross sections represent the Bemis moraine.

3.2.1 Quaternary Sand Thickness Maps

The general orientation of the subsurface sand units as drawn on these maps is based on a regional understanding of glacial ice movement and the associated sediment transport from the melting ice during glacial retreat (Wright, H.E., 1972). Glaciations that resulted in the deposition of the upper two units (Units 1 and 2) originated northwest of Minnesota and moved to the southeast. These ice movement directions are known from the orientation of surface exposures. Many of the major outwash channels, created during the recession of the glacier from the southeast to the northwest, probably had a similar northwest/southeast orientation. During glacial recession, outwash channels could have formed between the southwestern edge of the glacier and the northeastern slope of the topographically higher areas to the southwest (Southwick, D.L. et al., 1993). Schematic block diagrams illustrating this process are shown in Figure 20.

The orientation of basal Quaternary sand bodies in Rock County were derived by connecting sand thickness trends in southeastern South Dakota (Lindgren, R.J., 1992) with the Cretaceous bedrock topography trends of northwestern Iowa (Hansen, R.E., 1986). Less information is available regarding the orientation of Units 3, 4, and 5. Studies of Early Pleistocene deposits in Kansas, Nebraska, Iowa, and South Dakota, however, indicate significant glacial advances that affected southwestern Minnesota originated north and northwest of Minnesota (Patterson, C.J., 1993). Therefore, the dominant orientation of outwash units 3, 4, and 5 may also be northwest/southeast as suggested by the maps in this report.

The maps included in this report were created with this orientation information along with interpolations between data points. Therefore, the maps are interpretations from the drill hole data combined with the historical geology of the region. Actual subsurface conditions will be different in some areas, but the use of these maps for subsurface exploration should increase chances for success in finding productive sand layers.

3.2.2 Basal Quaternary (BQ)

The BQ sand occurs within an elevation range of 1,100 to 1,290 feet above the National Geodetic Vertical Datum (NGVD) in Rock and Nobles Counties (Figures 14 through 19). The known trend of the BQ in the Worthington area is shown in Figure 10. This unit was encountered in DNR test hole 53-3 and appears to have a northeast-southwest trend southeast of Worthington. Very little information exists regarding the width or maximum thickness of this unit.

More information on the BQ exists in Rock County which is mainly due to the 1996 DNR and the 1995 USGS test hole drilling programs. DNR test holes 67-4 through 67-8 in southeastern Rock County penetrated a laterally continuous BQ sand layer with an average thickness of 20 to 25 feet. Test holes 67-1 through 67-3 were drilled in an effort to find the northwesterly extension of this layer. Unfortunately, the thickest portion of this unit between Steen and Beaver Creek was not found. The maximum thickness of this unit along the Steen/Beaver Creek appears to be is at least 46 feet based on a domestic or farm well located approximately midway between test holes 67-2 and 67-3.

Test hole 53-7, located approximately 3 miles west of Adrian, penetrated 21 feet of BQ. A domestic or farm well located approximately 3.5 miles north-northwest of test hole 53-7 encountered 38 feet of BQ. This information suggests a general north-south trend of the BQ sand layer in this area.

3.2.3 Unit 5

The known trend of Unit 5 outwash in the Worthington area is shown in Figure 11. This unit was encountered in DNR test hole 53-4. This unit and Unit 4 have been objectives of a recent exploration and evaluation project northeast of Worthington completed by a Minneapolis consulting firm (B.A. Liesch and Associates, November 1996). Maximum sand thickness may range from 20 to 30 feet and the width of the thickest sandy intervals appear to be less than a half a mile.

Less information exists regarding this unit in Rock County. Thick intervals of this unit were not encountered in any of the DNR test holes in this area. The Unit 5 outwash occurs within an elevation range of 1,210 to 1,390 feet (NGVD) in Rock and Nobles Counties.

3.2.4 Unit 4

Unit 4 outwash in the Worthington area appears to have a maximum thickness of 20 feet and the width of the thickest sandy intervals is less than a half mile (Figure 12). Unit 4 outwash is thin or absent in the Rock County. A buried channel appears to exist just southwest of Luverne; however, the northwest and southeast ends of this channel terminate at the Beaver Creek and Rock River Valleys, respectively, limiting the extent of the aquifer. This outwash unit is found within an elevation range of 1,300 to 1,500 feet (NGVD) in Rock and Nobles Counties.

3.2.5 Unit 3

The data availability for Unit 3 outwash in the entire Worthington area is generally good (Figure 13). In the Worthington area, a buried system of channels exists which converge to the south.

This unit was encountered in test hole 53-1 with a thickness of 6 feet and in test hole 53-2 with a thickness of 37 feet. The maximum thickness of sand and gravel in this unit (72 feet) was encountered in a domestic well approximately one mile west of test hole 53-3. Typical of most of these Quaternary units, the width of the thickest sandy intervals is less than one half mile. Unit 3 outwash in Rock County and has been eroded or mixed with younger deposits. The elevation range of this unit in the area is 1,380 to 1,550 feet (NGVD).

3.2.6 Unit 2

Unit 2 has not been mapped but was encountered in test hole 53-2 with a thickness of 20 feet. In the Worthington area this unit has an elevation range of 1,440 to 1,650 feet (NGVD).

3.2.7 Cretaceous Sandstone

Some thick sandstone layers were encountered in five of the test holes. The thicker layers (greater than 20 feet) ranging from 47 feet (test hole 67-7) to 124 feet (test hole 53-3). These thick sandstone layers occur in the middle to lower portions of the Cretaceous bedrock. The sandstone layer at the base of the Cretaceous bedrock found in test holes 53-3 and 53-4 is the Dakota Formation (Figure 17, Cross Section D-D'). This unit was deposited predominantly in a stream environment (Setterholm, D.R., 1990). Therefore, sandstone bodies within the formation tend to be localized and do not extend over a wide area. For instance, the 124 foot thick sandstone layer penetrated in test hole 53-3 is mostly absent in wells or test holes approximately 2 miles to the north or south.

Some potential large capacity aquifers appear to exist in the Cretaceous sandstone in the vicinity of test holes 53-6, 67-6, and 67-7 (Figure 16, Cross Section C-C'). A 47-60 foot thick zone with a low gamma response exists in the middle portion of the Cretaceous section. The gamma log trace of this layer is very similar in each test hole. The unit may be marine in origin (deposited in a beach or sand bar setting) and, if so, would tend to be widespread or laterally continuous making it easier to find in the subsurface. In test hole 53-6, the unit was composed predominantly of medium sand grains. To the southwest, only small amounts of silt and very fine sand were recovered from this interval in test holes 67-6 and 67-7 indicating that the unit is very fine grained in this area.

3.3 **Pumping Capacity**

Evaluating maximum aquifer pumping rates and groundwater quality were not among the objectives of this project. However, for the participants in this project this information is obviously important for making decisions about the future development of these resources. None of the aquifers described in this report in Rock and Nobles Counties are used for municipal water supply by any of the larger communities or rural water companies. Major water appropriators in the area to date have been using shallower sources of groundwater. However, some information is available from Valley Springs, South Dakota; Rushmore, Minnesota; and the City of Worthington.

Valley Springs has two municipal wells in the BQ unit which is also called the Valley Springs aquifer in South Dakota (Lindgren, R.J., 1992). The maximum thickness of the Valley Springs aquifer occurs 1 to 2 miles northwest of the City of Valley Springs. The City of Valley Springs municipal wells produce from a medium to coarse sand with a thickness of 8 and 15 feet in wells

#1 and #2, respectively. Well #1 was tested for 12 hours at 200 gpm with 60 feet of drawdown. Well #2 was test pumped at 150 gpm for an unknown time period with a drawdown of 32 feet. Current production from municipal wells #1 and #2 is 88 gpm and 202 gpm, respectively.

The City of Rushmore has a well (Minnesota Unique #475657) that has been completed in a 31 foot Unit 4 sand layer. According to Larry Lupkas, the City of Rushmore Maintenance Supervisor, this well typically produces at a rate of 120 gallons per minute (gpm) which is all they need to meet their water supply needs. Mr. Lupkas indicted that this rate produces very little drawdown of the water level in the well. Water quality information was not available for samples from this well.

The City of Worthington contracted B.A. Liesch and Associates to evaluate buried Quaternary sand aquifers (Units 4 and 5) approximately 2 miles northeast of the city limits. A test production well, which was screened across 26 cumulative feet of medium to coarse sand, was pumped for approximately 4 days at 569 gpm. According to the report, the test could not run long enough to determine a long term sustainable yield due to farm well interferences. The drawdown data indicate a long term sustainable yield less than the 569 gpm test pumping rate.

This limited amount of information from these three municipalities seems to indicate sustainable yields from 20 to 30 foot thick buried Quaternary sand channels may range from 200 to 500 gpm.

3.4 Water Quality

Water quality information from Quaternary sand or Cretaceous sandstone aquifers was not generated as part of this project, however, limited water quality data were developed for another DNR project (Bradt, R., 1996) and from private sources (B.A. Liesch and Associates, 1996). The samples from both studies were analyzed for a wide range of chemical parameters. Only total dissolved solids (TDS) and sulfates have been summarized in this report. TDS was calculated by summing the reported constituents (total, as reported).

Six farm wells and five observation wells completed in buried Quaternary sand layers within a 2 mile radius of Worthington were sampled in the DNR and Liesch studies, respectively. Groundwater samples from the Units 2 through 5 are represented in these studies. The TDS concentrations ranged from 972 milligrams per liter (mg/l) to 2,591 mg/l. The average TDS concentration was 1,931 mg/l. Concentrations of sulfate ranged from 325 mg/l to 1,580 mg/l, with an average concentration of 1,150 mg/l.

Four Rock County samples were collected from buried Quaternary sand aquifers according to the Bradt report. Three of these samples were collected within a 2 mile radius of Luverne from the Unit 4, Unit 5, and BQ sand layers. The TDS concentrations of these samples ranged from 523 mg/l to 2,517 mg/l with an average concentration of 1,381 mg/l. The sulfate concentrations from these samples ranged from 37 mg/l to 1,217 mg/l with an average of 561 mg/l.

In addition, the City of Valley Springs supplied water quality information from their #1 municipal well at our request. The water sample from the BQ sand layer in this well contained 970 mg/l TDS and 105 mg/l sulfate.

Only one reliable Cretaceous sandstone groundwater sample was collected near the areas investigated in this drilling study. The sample was collected 3 miles east of Ellsworth and contained 2,988 mg/l TDS and 1,660 mg/l sulfate.

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Concentrations of TDS and sulfate from the buried Quaternary sand aquifers in the Worthington area are high and somewhat uniform. The water quality appears to improve some in Rock County and the variability appears to increase.

4.0 Burr Well Field/Lake Cochrane Area

4.1 Summary of Test Hole Information

Three test holes were drilled in this area at locations shown in Figure 2. Test hole depths ranged from 484 feet (87-8) to 724 feet (87-7). The test holes in this area were drilled to the base of the Quaternary section. Test holes 41-1 and 87-7 were drilled 102 to 259 feet, respectively, into the Cretaceous bedrock. The most promising sand layers in the glacial till, with a thickness of 20 feet or greater, are shown in Table 3.

The shallow sand layer in 87-7 (70-153 feet) correlates with the upper aquifer that is being pumped at the Burr Well Field. This aquifer is referred to in South Dakota, and locally, as the Prairie Coteau aquifer (Kame, Jack, 1985). According to South Dakota naming conventions, the Prairie Coteau aquifer consists of outwash deposits that are found between surface/near-surface aquifers and the Altamont aquifer at the base of the Quaternary section. In the Burr Well Field/Lake Cochrane area the Prairie Coteau aquifer is composed of four hydraulically connected outwash sand layers (Units 2, 3, 4a, and 4b) which are discussed in Sections 4.2 and 4.3.

The deepest sand layers in 41-1 (461-496 feet) and 87-7 (355-393 feet) are part of the basal Quaternary unit which locally, and in South Dakota, are referred to as the Altamont aquifer (Kame, Jack, 1985). The name of the Altamont aquifer has nothing to do with the Altamont phase of the Des Moines lobe glacier and no depositional relationship is suggested by this shared name. The Altamont is also being pumped at the Burr Well Field.

Many thin (less than 20 feet) sand layers were encountered in the 87-8 test hole; otherwise, there is nothing notable about the aquifer potential at this location. The deepest test hole, 87-7, penetrated 230 feet of the Cretaceous section. A unit with a low gamma response occurs from 600-630 feet. This unit is the Niobrara siltstone or a silty marlstone without any aquifer potential.

Table 3Quaternary Sand LayersBurr Well Field/Lake Cochrane Area

Test Hole #	Depth Range (feet)	Thicknes (feet)	s Comments	Unit
87-7	70-153	83	Drilled very fast. Complex layers of different grain sizes ranging from very fine to fine sand and coarse to very coarse sand. Low gamma response with a ragged appearance indicating thin clay interbedded layers. Medium to high resistivity.	3
87-7	180-202	22	Drilled very fast. Medium to very coarse sand overlying very fine to medium sand. Low gamma response, medium resistivity.	4a
87-7	355-393	38	Drilled very fast. Silty very fine to coarse sand. Low gamma response, medium to high resistivity.	BQ
41-1	277-312	35	Drilled fast. Medium sand. Low gamma response, medium to high resistivity.	4b
41-1	461-496	35	Drilled fast. Fine to coarse sand, predominantly medium grained. Low gamma response, medium to high resistivity.	BQ

4.2 Aquifer Distribution

Abundant high quality test hole information is available from South Dakota northwest of the DNR test hole locations (Figures 21 through 23). Information from DNR test holes 87-7, 87-8, and 41-1 was integrated with information from this area.

The orientation of the outwash units 4, 3, and 2, described in the following sections (Figures 21 through 23), is dominantly northwest-southeast and the thickest portions of these units occur within the same localized trend.

4.2.1 Basal Quaternary (Altamont aquifer)

Only a few boreholes in the Burr Well Field/Lake Cochrane Area have penetrated the basal Quaternary unit. Sand thicknesses range from 10 feet to 100 feet in the South Dakota test holes. Sand thicknesses in the basal Quaternary unit from the same general area in Minnesota range from approximately 10 to 35 feet. The thickest sand in South Dakota was encountered in DU-73A approximately 2 miles west-northwest of DNR test hole 41-1 (Cross Section D-D', Figure 27). The unit has an elevation range of approximately 1,200 to 1,300 feet (NGVD).

The basal Quaternary sand layers found in the DNR test holes were associated with a dark brown clay unit that is interpreted as lacustrine. Similar to the overlying outwash sand units, thick sand portions of the BQ may have a northwest - southeast orientation. Not enough information is available to create a useful sand thickness map. This unit appears to be hydraulically isolated from the overlying sand units according to stratigraphic relationships (Figures 24 through 27).

4.2.2 Unit 5

This unit has an elevation range of approximately 1,300-1,380 feet (NGVD). The maximum sand thickness in this unit (28 feet) is at a domestic well located approximately 3 miles east of DNR test hole 87-8 (Cross Section D-D', Figure 27). Not enough data were available to create a useful sand thickness map. No major water production occurs from this unit. This unit appears to be hydraulically isolated from the overlying sand layers (Figures 24 through 27). Unit 5 and all the overlying units are absent in the eastern portion of the mapped area due to erosion by subsequent glaciation.

4.2.3 Unit 4

Unit 4 appears to have two identifiable sections, Unit 4a and Unit 4b, in the central portion of the mapped area. The two sections are shown on cross-section D-D' (Figure 27) with the tops of the subunits occurring at the tops of sand layers. Elsewhere, the tops of these subunits have been interpreted to occur at the oxidized till layers. These two subunits appear to merge near the trace of cross section A-A' (Figure 21). No evidence of a division in Unit 4 exists in boreholes along Cross Section A-A'. This division of Unit 4 may be due to a minor advance and retreat of the glacier within a 6 to 7 mile central portion of the mapped area.

The maximum thickness of Unit 4a outwash is 40 feet at the Burr Well Field (Figure 26, Cross Section C-C'). The Unit 4 outwash units occur at an elevation range of approximately 1,400 to 1,530 feet (NGVD). These subunits and the overlying outwash units appear to be hydraulically connected.

4.2.4 Unit 3

Sand thicknesses of 80 feet and greater are common within the Unit 3 outwash (Figure 22). Two southeast trending channels converge southeast of Lake Cochrane and extend into Minnesota through the DNR 87-7 test hole location. The typical width of the thick sand and gravel portion of this unit (greater than 20 feet) is approximately 2.5 miles. Unit 3 outwash occurs at an elevation range of approximately 1,500 to 1,620 feet (NGVD).

4.2.5 Unit 2

Thick Unit 2 outwash exists along a northwest southeast trend southwest of Lake Cochrane and probably extends into Minnesota somewhere between DNR test holes 41-1 and 87-7 (Figure 23). While this outwash unit is somewhat thinner than the underlying Unit 3, the width of the thick outwash is approximately the same 2 to 2.5 miles. Unit 2 outwash has an elevation range of approximately 1,600 to 1,780 feet above sea level.

4.3 **Pumping Capacity**

The Prairie Coteau aquifer was tested from the Burr Well Field during January 1991 (B.A. Liesch and Associates, 1991) and again during July 1993 (B.A. Liesch and Associates, 1993). The first test consisted of pumping from Well No. 1 (MN Unique #440325) for 72 hours at 750 gpm. The late time transmissivity from this test averaged 51,000 gallons/day/ft. The second test consisted of pumping from the same well for 7 days with an average discharge of 818 gpm. The late time transmissivities from this test average approximately 56,000 gallons/day/ft. Using the 56,000 gallons/day/ft value and assuming an aquifer thickness of 160 feet, the Prairie Couteau aquifer in this area has a hydraulic conductivity of 350 gallons/day/foot squared.

The basal Quaternary sand layer is locally referred to as the Altamont aquifer. This aquifer was tested at the Burr Well Field for six days during November/December 1994 (B.A. Liesch and Associates, 1995). The test consisted of pumping from well ALT-TPW-94 (MN Unique #550052) at approximately 465 gpm. The average transmissivity from this test was approximately 8,700 gallons/day/ft. Using an aquifer thickness of 30 feet, the Altamont aquifer has a hydraulic conductivity of 290 gallons/day/foot squared. This value and the hydraulic conductivity value of the Prairie Coteau aquifer are about average for silty sand aquifers (Freeze and Cherry, 1979).

4.4 Water Quality

Water quality information is also available from the Burr Well Field wells. Water samples from the Prairie Coteau and Altamont aquifers were collected from the same production wells that were described in the previous section (B.A. Liesch and Associates, 1991 and B.A. Liesch and Associates, 1993). Water samples from Well #1 (Prairie Coteau aquifer) contained an average sulfate concentration of 370 mg/l and an average TDS concentration of 1,532 mg/l (total, as reported). Water samples collected from ALT-TPW-94 (Altamont aquifer) contained an average sulfate concentration of 284 mg/l and an average TDS of 1,442 mg/l (total, as reported).

5.0 **Recommendations**

5.1 Worthington Area

The Worthington area is underlain by at least one Cretaceous sandstone and five Quaternary outwash units with aquifer potential. The Quaternary units are attractive targets for groundwater development because they occur at relatively shallow depths and are typically composed of medium to coarse grained sand and gravel. In addition, the water quality in the Quaternary outwash units appears to be a little better than groundwater from the Cretaceous sandstone. The disadvantage of pursuing the buried Quaternary sand layers for municipal water supplies include the narrow width and thinness of some buried channel deposits, and the potential for interference with nearby farmstead wells. Pursuing the lower units (BQ, Unit 5, and Unit 4) in areas west and south of Worthington may help avoid well interference problems since few existing wells penetrate these units in this area.

The Unit 3 trends identified in this study west and south of Worthington may also be good exploration targets. A relatively thick sand (37 feet) in this unit was encountered in test hole 53-2 located approximately one mile west of Worthington. The few farm wells that penetrate Unit 3 combined with the recently drilled DNR test holes provide enough information to determine the general trend of this unit. Unit 3 is also a good development objective since it appears to have some of the thickest sands of all the buried Quaternary units in Rock and Nobles Counties.

The 124 foot thick sandstone layer at the base of the Cretaceous section in test hole 53-3 was also a significant discovery. The development of this aquifer will be determined by the extra cost caused by the greater depth of this sandstone and the limitations of it's poorer water quality.

5.2 Rock County

The Rock County Rural Water System and the City of Luverne have fewer options for groundwater supplies than the City of Worthington. Units 1 and 2 were never deposited in the area and Units 3 and 4 are highly eroded west of Adrian. In addition, the Precambrian Sioux Quartzite is exposed at the surface north of Luverne along the Sioux Ridge which eliminates the possibility of finding high capacity aquifers in that area. Even with these limitations, this study has shown that groundwater resources are available in this area.

One of the major objectives of this exploratory drilling project was to search for a basal Quaternary sand that we expected to be present in the area from southeast of Beaver Creek to west of Ellsworth. A new aquifer unit was discovered by this project in the basal Quaternary sand in the test hole 67-5 through 67-8 area. The aquifer at that location consists of 20 to 28 feet of predominantly medium grained sand which may not suit the high capacity (>500 gpm) needs of the City of Luverne and the Rock County Rural Water System. However, one farm well (Minnesota Unique #113705) located along the northwestern trend of this aquifer encountered 46 feet of sand. The driller's log did not specify the grain size of the sand. This information suggests that the thickest part of the aquifer has not yet been defined and the potential for finding a high capacity aquifer in this area may still exist.

Additional exploration, to better determine the potential of this unit, should be focused along the trend between Steen and Beaver Creek that is shown in Figure 10. Aquifer testing of the BQ in the vicinity of 67-5 through 67-8 could determine whether this portion of the aquifer can sustain the desired levels of pumping. Information from the Valley Springs municipal well #1 (105 mg/l sulfate) suggests that the water quality in this aquifer may be better than most in the area.

Another suspected basal Quaternary sand unit east of Magnolia appears to have been confirmed by test hole 53-7. This test hole encountered a 20 foot thick BQ sand approximately 3.5 miles south-southeast of a 38 foot BQ sand in a farm well. This sand unit may also have potential as a high capacity aquifer. Additional test drilling, to better define the potential of this unit, should be focused along the trend between Adrian and Magnolia shown in Figure 10.

Another potential aquifer of Cretaceous age appears to exist in the area around test holes 53-6, 67-6, and 67-7. The 47-60 foot thick zone appears to be laterally continuous but the unit appears to be very fine grained around test holes 67-6 and 67-7 which will limit the aquifer's capacity. No information is available regarding the quality of water in this unit.

5.3 Burr Well Field Area

The distribution of the deeper aquifers in this area (Unit 5 outwash and Altamont aquifer) is not known since very few boreholes penetrate these units. The Altamont aquifer is an attractive target since it is relatively thick, possibly widespread, and produces relatively good quality water. In addition, based on stratigraphic relationships, this aquifer appears to be hydraulically isolated from the overlying Prairie Coteau aquifer. This isolation should might prevent water level drawdown in nearby wetlands and other wells completed in shallower aquifers. Additional test drilling is required to define the thickest portions and extent of this aquifer.

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Glossary

Aquifer	A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield economical quantities of water to wells and springs.
Cretaceous	A period that lasted from 136 million years to 64 million years before the present.
Fluvial	Pertaining to streams and the deposits and landforms produced by streams.
Formation	A rock unit distinguished from adjacent deposits by some common character such as composition or origin.
Gamma/	
resistivity log	A continuous depth record of the natural radiation and electrical resistivity of the subsurface formations measured from inside the drill hole. Low gamma readings and higher resistivity readings together may suggest that an aquifer is present.
Glacial till	Unsorted and unstratified glacial material, generally unconsolidated, directly deposited by and underneath a glacier without subsequent reworking by meltwater. Consisting of a heterogeneous mixture of clay, silt, sand, gravel, and boulders ranging widely in size and shape.
Groundwater	The water contained in interconnected pores in an aquifer.
Hydraulic	
conductivity	A coefficient of proportionality describing the rate at which water can flow through a permeable medium. Specifically, the flow rate of a water volume per unit of time through a given cross sectional area (i.e. gallons/day/square foot). A larger number indicates a better aquifer.
Lacustrine	Pertaining to lakes and the deposits and landforms produced by lakes.
Lithology	The composition of a rock or formation.
Mud log	A depth record of the subsurface geology created by identifying pieces of rock and sediment in the drilling mud that are circulated to the surface from the bottom of the drill hole.
Outwash	Stratified sand and gravel removed or washed out from a glacier by meltwater streams and deposited in front of or beyond the end moraine or the margin of an active glacier.

Permeability	The property or capacity of porous rock, sediment, or soil for transmitting a fluid; it is a measure of the relative ease of fluid flow under unequal pressure. The more permeable the formation, the better it functions as an aquifer.
Porosity	The percentage of the bulk volume of a rock or soil that is occupied by interstices, whether isolated or connected. Higher porosity values that are connected indicate a better aquifer.
Pleistocene	The first epoch of the Quaternary Period. Characterized by the spreading and recession of continental ice sheets.
Precambrian	The earliest geologic era covering all the time before the Cambrian Period.
Quaternary	A latest period of time in the stratigraphic column occurring 0 to 2 million years before the present. This period consists of glacial (Pleistocene) and post-glacial (Holocene) deposits.
Sandstone	A bedded sedimentary rock composed largely of sand grains which are cemented together by various binding materials such as silica or calcite.
Shale	A fine grained sedimentary rock formed by the consolidation of clay, silt, or mud. It is characterized by finely laminated structure.
Sulfate	Dissolved mineral found in some groundwater composed of one sulfur atom and four oxygen atoms. Derived from the dissolution of gypsum or anhydrite. Higher values indicate water that is less desirable for general use without treatment.
Stratigraphy	The study of stratified rocks or sediments especially their sequence in time, the character of the rocks or sediments and the correlation of beds in different localities.
Topography	Representing the surface features of a region including its relief, lakes, and rivers etc.
Transmissivity	The rate at which water is transmitted through a unit width of an aquifer, under a unit hydraulic gradient, extending the full saturated height of the aquifer. A larger value indicates a better aquifer.
Wisconsin	The last glaciation of the Pleistocene Epoch.

Appendix 1 - Figures

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Figure 3 Stratigraphy of southwestern Minnesota (Modified from Setterholm, D.R. 1990)



Figure 4 Topography of land and bedrock surfaces in southwestern Minnesota and contiguous areas of South Dakota and Iowa (Patterson, C. 1995)



Figure 5 Des Moines lobe glacier in Minnesota during the Late Wisconsin (Modified from Wright, H.E. 1972)

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Figure 6 Type gamma/resistivity log - Worthington area

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Figure 7 Type gamma/resistivity log - Southern Rock County



Figure 8 Type gamma/resistivity log - Burr Well Field/Lake Cochrane Area





Pre-Quaternary topography and cross section location map Rock and Nobles Counties

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Note: South Dakota sand thickness data from Lindgren (1992)

Basal Quaternary sand thickness Rock and Nobles Counties

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Unit 5 sand thickness Rock and Nobles Counties ·* .

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Figure 20 Deposition of northwest-southeast oriented buried glacial outwash channels in southwestern Minnesota



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Appendix 2 Drilling Logs and Sealing Records

Drilling L	Log - Minnesota Department of Natu	Iral Kesources		Page I of 2
Site ID # :	Do-1	County: Nobles		
Geologist	: JIII Berg, Tom Gullett	Driller: Don Hejti	$\frac{\text{manek} - LIP}{6?' M = 1}$	
Date: $8/21$		Drilling Method:	o iviua rotar	y
Location:	1102N R41w Section 12 BDDCBB	· · · · · · · · · · · · · · · · · · ·		
Depth (π)	Description		Thickness	Drilling Notes
0	Clay, black		3	
3	Clay, sandy, gray		106	
109	Clay, sandy, yellow		10	
119	Clay, sandy, gray		5	Chatter @ 122' and 132-134'
204	Clay, sandy, gray, and some black shale		20	
224	Sand		6	Chatter @ 229'
230	Clay, sandy, gray and some black		19	
249	Clay, sandy, yellow and green		80	
329	Clay, sandy, gray		50	· · ·
379	Clay, sandy, yellow		130	Chatter @ 387- 388'
509	Clay, black		10	
519	Sand, clayey		5	· · · · · · · · · · · · · · · · · · ·
524	Clay, sandy, gray and black		55	Chatter @ 537'
579	Sandstone	······	2	
581	Shale, gray and black, soft		16	
597	Sandstone, silty very fine to medium		10	
607	Shale, gray and black, soft		12	
619	Shale with sandstone layers		15	
634	Shale, black and tan		54	Very slow
688	Sandstone, silty very fine to medium with s	hale layers	30	·
718	Shale		22	
740	Sandstone		34	Rough @ 754'
774	Shale with sandstone layers		106	
880	Sandstone, orangish-red at 884 feet		23	

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Drilling L	Drilling Log - Minnesota Department of Natural Resources Page 2 of 2			
Site ID # 5	53-1	County: Nobles		
Geologist:	Jim Berg, Tom Gullett	Driller: Don Hejtm	nanek - LTP	· · · · · · · · · · · · · · · · · · ·
Date: 8/21	/96	Drilling Method: 6	"Mud rotary	7
Location:	T102N R41W Section 12 BDDCBB			
Depth (ft)	Description		Thickness	Drilling Notes
903	Shale with sandstone layers		31	
934	Mudstone, orangish-red	999 k	9	
943	Hard rock		36	Very slow
979	Bottom of hole			
	Interpreted from geologist's mud log and ga	mma/resistivity log		

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Drilling l	Drilling Log - Minnesota Department of Natural Resources			Page 1 of 1
Site ID #	53-2	County: Nobles		
Geologist	: Jim Berg, Evan Drivas, Mike L.	Driller: Don Hejtr	nanek - LTP	
Date: 8/29	9/96	Drilling Method:	6" Mud rotary	¥
Location:	T102N R40W Section 32 AAAABA			
Depth (ft)	Description		Thickness	Drilling Not
0	Topsoil, black		4	
4	Clay, sandy, yellow	an a	5	
9	Clay, sandy, gray		92	Chatter @ 74'
101	Sand		3	
104	Clay, sandy, gray		30	
134	Sand, coarse to very coarse with gravel and	cobbles	20	Rough
154	Clay, sandy, gray		49	
203	Sand		2	
205	Clay, sandy, gray	annan	18	
223	Sand, silty, very fine to very coarse		36	
259	Clay, gray		129	Rough @ 339
388	Sand, medium to very coarse		7	
395	Clay, gray and clayey sand	AND	90	
485	Sandstone, medium, with shale layers		68	
553	Shale, black, with sandstone layers	· · · · · · · · · · · · · · · · · · ·	57	
610	Shale, black		25	
635	Shale, black, with sandstone layers and lign	ite	70	· · · · · · · · · · · · · · · · · · ·
705	Sandstone		11	
716	Shale with sandstone layers		93	
809	White clay with angular quartz grains		15	
824	Bottom of hole			
	Interpreted from the geologist's mud log ar	nd the		

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Drilling L	Drilling Log - Minnesota Department of Natural Resources Page 1 of 1			
Site ID # 5	53-3	County: Nobles		
Geologist:	Evan Drivas, Tom Gullett, Mike L.	Driller: Don Hejtm	nanek - LTP	
Date: 8/14	/96	Drilling Method: 6	" Mud rotary	7
Location:	T101N R40W Section 12 CBBCCD			
Depth (ft)	Description		Thickness	Drilling Notes
0	Sand with gravel		20	
20	Clay, sandy, gray	· · · · · · · · · · · · · · · · · · ·	32	
52	Sand		3	
55	Clay with sand and gravel lenses		41	
96	Clay, sandy, gray		38	
134	Gravel and cobbles		1	
135	Clay, sandy, gray		264	
399	Boulder	21 <u>89 17 1</u> 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1.	1	
400	Sand, clayey		5	
405	Sand, silty medium to coarse		22	
427	Shale		37	
484	Shale, with sandstone layers		82	
566	Sandstone, fine		34	Chatter
590	Shale		9	
599	Sandstone, fine		171	
770	Hard rock			
775	Bottom of hole			
	Interpreted from the geologist's mud log and gamma/resistivity log	l the		
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Site ID \neq 33.4County: NoblesGeologist: Jim Berg, Evan DrivasDriller: Don Hejtmanek - LTPDate: 87/96Drilling Method: 6° Mud RotaryLocation: T102N R 39W Section 32 ABAABAThicknessDepth (ħ)DescriptionThickness0Topsol44Clay, sandy, yellow37Sand, silty, fine29Clay, sindy, gray4161Clay, gray and sand lenses566Clay, sandy, gray41107Sand, silty very fine to coarse26125Clay, sandy, gray41107Sand, silty very fine to coarse26130Sand3133Clay, sandy, gray41146Sand8148Clay, sandy, gray118146Sand5156Sand1279Sand11280Clay, sandy, gray118281Clay, sandy25279Sand1280Clay, sandy25312Sand, silty, very fine to very coarse28346Clay, sandy97433Sandstone, very fine to medium21344Clay, sandy21287Clay, sandy25312Sand, silty, very fine to medium21346Clay, sandy37351Shale, soft with interbeded sandstone533517Shale, Satwith sandstone layers38357Sha	Drilling I	log - Minnesota Department of Natur	ral Resources	<u></u>	Page 1 of 2
Geologist. Jim Berg, Evan Drivas Driller: Don Hejtmanck - 1.TP Date: 8/7/96 Orilling Method: 6" Mud Rotary Location: T102N R 39W Section 32 ABAABA Thickness Drilling Notes 0 Topsoil 4 1 4 Clay, sandy, yellow 3 1 7 Sand, silty, fine 2 1 9 Clay, sandy, gray 41 1 61 Clay, sandy, gray 41 1 66 Clay, sandy, gray 41 1 107 Sand, silty very fine to coarse 5 1 118 Clay, sandy, gray 5 1 1 107 Sand, silty very fine to coarse 26 1 1 113 Clay, sandy, gray 5 1 1 130 Sand 3 1 1 146 Sand 8 1 1 148 Clay, sandy, gray 118 Rough @ 165' 1 148 Clay, sandy 6 1 1 </td <td>Site ID # :</td> <td>53-4</td> <td>County: Nobles</td> <td></td> <td></td>	Site ID # :	53-4	County: Nobles		
Date: Brilling Method: Wud Rotary Location: T102N R 39W Section 32 ABAABA Thickness Drilling Notes 0 Topsoil 4 Inickness Drilling Notes 1 Topsoil 4 Inickness Drilling Notes 2 Sand, silty, fine 2 Inickness Inickness 9 Clay, sandy, gray 41 Inickness Inickness 66 Clay, sandy, gray 41 Inickness Inickness 107 Sand, silty very fine to coarse 26 Inickness Inickness 113 Sand 3 Inickness Inickness Inickness 125 Clay, sandy, gray 5 Inickness Inickness Inickness 130 Sand 3 Inickness of sand 13 Inickness Inickness 146 Sand Sand Inickness Inickness Inickness 133 Clay, sandy, gray 11 Inickness Inickness Inicknes 148	Geologist	: Jim Berg, Evan Drivas	Driller: Don Hejtr	manek - LTP	
Location: 1102N R 39W Section 32 ABAABADepth (ft)DescriptionThicknessDrilling Notes0Topsoll444Clay, sandy, yellow317Sand, silty, fine219Clay, sandy, gray41120Clay, sandy, gray41161Clay, sandy, gray41166Clay, sandy, gray411107Sand, silty very fine to coarse261125Clay, sandy, gray51130Sand31133Clay, sandy util lenses of sand131146Sand81156Sand51161Clay, sandy gray118Rough @ 165'279Sand11280Clay, sandy61280Clay, sandy251286Sand11287Clay, sandy251312Sand, silty, very fine to very coarse281312Sand, silty, very fine to very coarse281346Clay, sandy97Chatter @ 370.407443Sandstone, very fine to medium21Rough @ 470464Shale, soft with interbedded sandstone531517Shale, black with sandstone layers38Very slow	Date: 8/7/	96	Drilling Method:	6" Mud Rotar	у
Depth (ft)DescriptionThicknessDrilling Notes0Topsoil444Clay, sandy, yellow317Sand, silty, fine219Clay, sandy, gray41120Clay, sandy, gray41161Clay, gray and sand lenses5166Clay, sandy, gray411107Sand, silty very fine to coarse261125Clay, sandy, gray51130Sand31144Sand81145Sand81146Sand51156Sand51161Clay, sandy gray61156Sand11279Sand11280Clay, sandy61280Clay, sandy251281Clay, sandy251312Sand, silty, very fine to very coarse283146Clay, sandy97Chatter @ 370,407443Sandstone, very fine to medium21Rough @ 470464Shale, soft with interbedded sandstone535517Shale, solt with interbedded sandstone531	Location:	T102N R 39W Section 32 ABAABA			
0 Topsoil 4 4 Clay, sandy, yellow 3 7 Sand, silty, fine 2 9 Clay, silty, yellow 11 20 Clay, sandy, gray 41 61 Clay, gray and sand lenses 5 66 Clay, sandy, gray 41 107 Sand, silty very fine to coarse 26 125 Clay, sandy, gray 5 130 Sand 3 133 Clay, sandy with lenses of sand 13 146 Sand 8 148 Clay, sandy 8 148 Clay, sandy mith lenses of sand 13 146 Sand 8 156 Sand 1 279 Sand 1 280 Clay, sandy 6 286 Sand 1 287 Clay, sandy 25 312 Sand, silty, very fine to very coarse 28 312 Sand, silty, very fine to medium 21	Depth (ft)	Description		Thickness	Drilling Notes
4 Clay, sandy, yellow 3 7 Sand, silty, fine 2 9 Clay, silty, yellow 11 20 Clay, sandy, gray 41 61 Clay, gray and sand lenses 5 66 Clay, sandy, gray 41 107 Sand, silty very fine to coarse 26 125 Clay, sandy, gray 5 130 Sand 3 133 Clay, sandy, gray 5 146 Sand 13 148 Clay, sandy with lenses of sand 13 148 Clay, sandy 8 156 Sand 5 161 Clay, sandy, gray 118 184 Clay, sandy, gray 118 280 Clay, sandy 6 279 Sand 1 280 Clay, sandy 6 286 Sand 1 287 Clay, sandy 25 312 Sand, silty, very fine to very coarse 28 346 Clay, sandy 97 Chatter @	0	Topsoil		4	
7 Sand, silty, fine 2 9 Clay, silty, yellow 11 20 Clay, sandy, gray 41 61 Clay, gray and sand lenses 5 66 Clay, sandy, gray 41 107 Sand, silty very fine to coarse 26 125 Clay, sandy, gray 5 130 Sand 3 133 Clay, sandy, gray 5 146 Sand 13 146 Sand 8 148 Clay, sandy 8 156 Sand 5 161 Clay, sandy, gray 118 148 Clay, sandy 8 156 Sand 5 161 Clay, sandy, gray 118 280 Clay, sandy 6 286 Sand 1 287 Clay, sandy 25 312 Sand, silty, very fine to very coarse 28 346 Clay, sandy 97 Chatter @ 370,407 443 Sandstone, very fine to medium 21 <t< td=""><td>4</td><td>Clay, sandy, yellow</td><td></td><td>3</td><td></td></t<>	4	Clay, sandy, yellow		3	
9 Clay, silly, yellow 11 20 Clay, sandy, gray 41 61 Clay, gray and sand lenses 5 66 Clay, sandy, gray 41 107 Sand, silly very fine to coarse 26 125 Clay, sandy, gray 5 130 Sand 3 133 Clay, sandy, gray 5 146 Sand 8 147 Sand 13 148 Clay, sandy 8 156 Sand 5 161 Clay, sandy, gray 118 280 Clay, sandy 6 286 Sand 1 287 Clay, sandy 25 312 Sand, silty, very fine to very coarse 28 346 Clay, sandy 97 Chatter @ 370,407 443 Sandstone, very fine to medium 21 Rough @ 470 444 Shale, soft with interbedded sandstone 53 53 517	7	Sand, silty, fine		2	
20 Clay, sandy, gray 41 61 Clay, gray and sand lenses 5 66 Clay, sandy, gray 41 107 Sand, silty very fine to coarse 26 125 Clay, sandy, gray 5 130 Sand 3 133 Clay, sandy with lenses of sand 13 146 Sand 8 148 Clay, sandy, gray 8 156 Sand 5 161 Clay, sandy, gray 118 162 Clay, sandy, gray 118 163 Clay, sandy, gray 11 280 Clay, sandy 6 286 Sand 1 287 Clay, sandy 25 312 Sand, silty, very fine to very coarse 28 346 Clay, sandy 97 Chatter @ 370,407 370,407 370,407 443 Sandstone, very fine to medium 21 Rough @ 470 444 Shale, soft with interbedded sandstone 53 53	9	Clay, silty, yellow		11	
61Clay, gray and sand lenses566Clay, sandy, gray41107Sand, silty very fine to coarse26125Clay, sandy, gray5130Sand3133Clay, sandy with lenses of sand13146Sand8148Clay, sandy8148Clay, sandy, gray118160Sand5161Clay, sandy, gray118279Sand1280Clay, sandy6286Sand1287Clay, sandy25312Sand, silty, very fine to very coarse28346Clay, sandy97Chatter @ 370,407443Sandstone, very fine to medium21Rough @ 470464Shale, soft with interbedded sandstone53517Shale, black with sandstone layers38Very slow	20	Clay, sandy, gray		41	
66Clay, sandy, gray41107Sand, silty very fine to coarse26125Clay, sandy, gray5130Sand3133Clay, sandy with lenses of sand13146Sand8148Clay, sandy8148Clay, sandy, gray118149Sand5161Clay, sandy, gray118162Clay, sandy, gray118279Sand1280Clay, sandy6286Sand1287Clay, sandy25312Sand, silty, very fine to very coarse28346Clay, sandy97Chatter @ 370,407443Sandstone, very fine to medium21Rough @ 470464Shale, soft with interbedded sandstone53517Shale, black with sandstone layers38Very slow	61	Clay, gray and sand lenses		5	
107Sand, silty very fine to coarse26125Clay, sandy, gray5130Sand3133Clay, sandy with lenses of sand13146Sand8148Clay, sandy8156Sand5161Clay, sandy, gray118162Rough @ 165'279Sand1280Clay, sandy6286Sand1287Clay, sandy25312Sand, silty, very fine to very coarse28346Clay, sandy97Chatter @ 370,407343Sandstone, very fine to medium21Rough @ 470443Sandstone, very fine to medium5353517Shale, black with sandstone layers38Very slow	66	Clay, sandy, gray		41	
125Clay, sandy, gray5130Sand3133Clay, sandy with lenses of sand13146Sand8148Clay, sandy8148Clay, sandy8156Sand5161Clay, sandy, gray118279Sand1280Clay, sandy6286Sand1287Clay, sandy25312Sand, silty, very fine to very coarse28346Clay, sandy97Chatter @ 370,407443Sandstone, very fine to medium21Rough @ 470464Shale, soft with interbedded sandstone5353517Shale, black with sandstone layers38Very slow	107	Sand, silty very fine to coarse		26	
130Sand3133Clay, sandy with lenses of sand13146Sand13146Sand8148Clay, sandy8156Sand5161Clay, sandy, gray118279Sand1280Clay, sandy6286Sand1287Clay, sandy25312Sand, silty, very fine to very coarse28346Clay, sandy97Chatter @ 370,407443Sandstone, very fine to medium21Rough @ 470464Shale, soft with interbedded sandstone53517Shale, black with sandstone layers38Very slow	125	Clay, sandy, gray		5	
133Clay, sandy with lenses of sand1313146Sand88148Clay, sandy8156Sand5161Clay, sandy, gray118Rough @ 165'279Sand11280Clay, sandy61286Sand11287Clay, sandy251312Sand, silty, very fine to very coarse28346346Clay, sandy97Chatter @ 370,407443Sandstone, very fine to medium21Rough @ 470464Shale, soft with interbedded sandstone53517517Shale, black with sandstone layers38Very slow	130	Sand		3	
146Sand8148Clay, sandy8156Sand5161Clay, sandy, gray118Rough @ 165'279Sand1280Clay, sandy6286Sand1287Clay, sandy25312Sand, silty, very fine to very coarse28346Clay, sandy97Chatter @ 370,407443Sandstone, very fine to medium21Rough @ 470464Shale, soft with interbedded sandstone53517517Shale, black with sandstone layers38Very slow	133	Clay, sandy with lenses of sand		13	
148Clay, sandy8156Sand5161Clay, sandy, gray118Rough @ 165'279Sand11280Clay, sandy61286Sand11287Clay, sandy251312Sand, silty, very fine to very coarse28346Clay, sandy97Chatter @ 370,407443Sandstone, very fine to medium21Rough @ 470464Shale, soft with interbedded sandstone53517517Shale, black with sandstone layers38Very slow	146	Sand	AL ANTINES,	8	
156Sand5161Clay, sandy, gray118Rough @ 165'279Sand11280Clay, sandy61286Sand11287Clay, sandy251312Sand, silty, very fine to very coarse2828346Clay, sandy97Chatter @ 370,407443Sandstone, very fine to medium21Rough @ 470464Shale, soft with interbedded sandstone53517517Shale, black with sandstone layers38Very slow	148	Clay, sandy	<u></u>	8	
161Clay, sandy, gray118Rough @ 165'279Sand11280Clay, sandy61286Sand11287Clay, sandy251312Sand, silty, very fine to very coarse2828346Clay, sandy97Chatter @ 370,407443Sandstone, very fine to medium21Rough @ 470464Shale, soft with interbedded sandstone53517517Shale, black with sandstone layers38Very slow	156	Sand		5	
279Sand1280Clay, sandy6286Sand1287Clay, sandy25312Sand, silty, very fine to very coarse28346Clay, sandy97443Sandstone, very fine to medium21464Shale, soft with interbedded sandstone53517Shale, black with sandstone layers38	161	Clay, sandy, gray		118	Rough @ 165'
280Clay, sandy6286Sand1287Clay, sandy25312Sand, silty, very fine to very coarse28346Clay, sandy97Chatter @ 370,407443Sandstone, very fine to medium21Rough @ 470464Shale, soft with interbedded sandstone53517517Shale, black with sandstone layers38Very slow	279	Sand		1	
286Sand1287Clay, sandy25312Sand, silty, very fine to very coarse28346Clay, sandy97443Sandstone, very fine to medium21464Shale, soft with interbedded sandstone53517Shale, black with sandstone layers38	280	Clay, sandy		6	
287Clay, sandy25312Sand, silty, very fine to very coarse28346Clay, sandy97Chatter @ 370,407443Sandstone, very fine to medium21Rough @ 470464Shale, soft with interbedded sandstone53517517Shale, black with sandstone layers38Very slow	286	Sand	1994, 200 Martin and a state of the second	1	
312Sand, silty, very fine to very coarse28346Clay, sandy97Chatter @ 370,407443Sandstone, very fine to medium21Rough @ 470464Shale, soft with interbedded sandstone53517517Shale, black with sandstone layers38Very slow	287	Clay, sandy		25	
346Clay, sandy97Chatter @ 370,407443Sandstone, very fine to medium21Rough @ 470464Shale, soft with interbedded sandstone53517517Shale, black with sandstone layers38Very slow	312	Sand, silty, very fine to very coarse		28	
443Sandstone, very fine to medium21Rough @ 470464Shale, soft with interbedded sandstone53517Shale, black with sandstone layers38Very slow	346	Clay, sandy		97	Chatter @ 370 407
464Shale, soft with interbedded sandstone53517Shale, black with sandstone layers38Very slow	443	Sandstone, very fine to medium		21	Rough @ 470
517Shale, black with sandstone layers38Very slow	464	Shale, soft with interbedded sandstone	<u> </u>	53	
	517	Shale, black with sandstone layers		38	Very slow

Drilling L	Drilling Log - Minnesota Department of Natural Resources Page 2 of 2			
Site ID # :	53-4	County: Nobles		
Geologist	Jim Berg, Evan Drivas	Driller: Don Hejtn	nanek - LTP	
Date: 8/7/	96	Drilling Method: 6	"Mud Rotar	у
Location:	T102N R 39W Section 32 ABAABA		<u> </u>	
Depth (ft)	Description		Thickness	Drilling Notes
555	Shale, dark gray, lignite, fossil @ 591		45	
600	Shale , black, with pieces of limestone		10	
610	Shale, black, with sandstone layers		25	Chatter @ 620
635	Sandstone, fine to medium	· · · ·	15	
650	Shale		18	
668	Sandstone, fine		56	
724	Hard rock		2	very slow
726	Bottom of hole			
	Interpreted from geologist's mud log and gan	mma/resistivity log		
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Drilling Log - Minnesota Department of Natural Resources			Р	age 1 of 1
Site ID # 5	53-6	County: Nobles		
Geologist:	Tom Gullett, Brian Rongitsch	Driller: Dan Hejtn	nanek - LTP	
Date: 9/11	/96	Drilling Method: 6	5" Mud rotary	/
Location:	T102N R43W Section 32 DDA			
Depth (ft)	Description		Thickness	Drilling Notes
0	Sand with small amount of clay		8	
8	Gravel, quartz and limestone		10	
18	Sand, coarse		6	
24	Gravel		25	
59	Clay, sandy, olive green		25	Chatter @ 69
84	Sand, medium		10	5. 5.
94	Sand and clay		5	
99	Clay, sandy, olive green		70	
169	Clay, medium dark gray, calcareous		160	Chatter @ 264'
329	Clay, medium dark gray, calcareous with se	ome white clay	10	
339	Shale, dark gray, soft, non-calcareous		26	
365	Sandstone		15	
380	Shale, dark gray		69	
449	Sandstone, medium		51	
500	Shale, dark gray and black	2000-101-1	34	
534	Shale, dark gray with bits of lignite		110	
644	Fragments of feldspar and quartz		5	
649	Bottom of hole			
	Interpreted from geologist's mud log and g	amma/resistivity log		
	merpretea nom geologist s mud log and g			

Drilling Log - Minnesota Department of Natural Resources				Page 1 of 1
Site ID # 5	53-7	County: Nobles		
Geologist:	Tom Gullett	Driller: Don Hejtm	anek - LTP	
Date: 9/9/	96	Drilling Method: 6	" Mud rotary	7
Location:	T102N R43W Section 17 ADD			
Depth (ft)	Description		Thickness	Drilling Notes
0	Clay, light olive brown		8	
8	Clay, yellow brown with pebbles		26	
34	Clay, sandy, gray		35	
69	Clay, sandy, yellow		17	
86	Sand		3	
89	Sand and clay		5	· · · · · · · · · · · · · · · · · · ·
94	Clay, sandy, yellow		15	Chatter @121-122
109	Clay, sandy, gray		35	
144	Sand		3	
147	Clay, sandy, gray		112	
259	Sand, medium		5	
279	Clay, dark reddish brown, non-calcareous		5	
284	Clay, gray		125	
409	Shale, dark gray and medium sandstone		11	
420	Sandstone		5	
425	Shale, dark gray		53	
478	Shale, dark gray, with sandstone layers		26	
504	Sandstone		15	
519	Shale, dark gray with some white clay		90	Chatter @ 568'
609	Sandstone, fine to coarse		15	
624	Sandstone and shale		20	
644	Shale, dark gray		15	
659	Bottom of hole			
	Interpreted from geologist's mud log and game	ma/resistivity log		

Drilling L	Drilling Log - Minnesota Department of Natural Resources Page 1 of 1			
Site ID # 67-1 County: Rock				
Geologist:	Evan Drivas`	Driller: Don Hejtn	nanek - LTP	
Date: 10/2	2/96	Drilling Method: 6	" Mud rotary	1
Location:	T102N R46W Section 35 CCC			
Depth (ft)	Description		Thickness	Drilling Notes
0	Clay, brown		8	
8	Clay, sandy, gray		5	
13	Sand, medium to coarse		18	
31	Clay, tan, sandy		13	
44	Clay, gray, sandy		100	Chatter @ 63'
144	Clay, light gray with some white		15	
159	Clay, light gray with sand		15	
174	Sand, very fine		10	
184	Clay, light gray		24	
208	Sand, silty, very fine		6	
214	Clay, light gray		5	
219	Clay, very sandy, gray		43	
262	Clay, sandy, gray		72	
334	Sand, medium		10	
344	Clay, sandy, gray		15	
359	Shale, gray		41	
400	Bottom of hole			

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Drilling Log - Minnesota Department of Natural Resources Page 1 of 1				
Site ID # 67-2 County: Rock				
Geologist	Tom Gullett	Driller: Don Hejtm	nanek	
Date: 10/1	6/96	Drilling Method: 6	" Mud rotary	/
Location:	T101N R46W Section 1 CCCB			
Depth (ft)	Description		Thickness	Drilling Notes
0	Soil, dark gray, organic		3	
3	Clay, sandy, olive green		5	
8	Clay, gray with pebbles		10	
18	Clay, olive brown, sandy		41	
59	Clay, sandy, gray		195	
254	Sand, very fine		4	
258	Clay, sandy, gray		24	
282	Sand		2	
284	Clay, ash gray, non-calcareous		50	
334	Shale, black		66	
400	Bottom of hole			

Drilling Log - Minnesota Department of Natural Resources				Page 1 of 1
Site ID # 6	57-3	County: Rock		
Geologist:	Tom Gullett	Driller: Don Hejtm	nanek - LTP	
Date: 10/1	4/96	Drilling Method: 6	" Mud rotary	1
Location:	T101N R45W Section 20 AAB			
Depth (ft)	Description		Thickness	Drilling Notes
0	Clay, sandy, brown		8	
8	Clay, sandy, olive green		15	
23	Sand, medium		1	
24	Clay, sandy, olive green		5	
29	Clay and sand		10	
39	Clay, sandy, olive green		123	Chatter @ 80-89'
160	Sand, medium		19	
179	Clay, sandy, dark gray		5	
186	Sand		7	
192	Clay, sandy, gray		152	
344	Shale, black		73	
417	Sandstone, fine to medium		12	
429	Shale, black		55	
484	Shale, black with abundant white clay		40	
524	Weathered metamorphic rock		36	Chatter @ 551'
560	Bottom of hole			
	Interpreted from geologist's mud log and ga	mma/resistivity log		
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Drilling L	Drilling Log - Minnesota Department of Natural Resources Page 1 of 1			
Site ID # 0	57-4	County: Rock		
Geologist	: Brian Rongitsch	Driller: Don Hejtn	nanek	
Date: 9/18	8/96	Drilling Method: 6	5" Mud rotary	4
Location:	T101N R45W Section 23 AAAAAD			
Depth (ft)	Description		Thickness	Drilling Notes
0	Sand, medium to coarse with gravel		21	
21	Clay, sandy, yellow		3	
24	Clay, gray, sandy		180	
204	Sand, fine to coarse		16	
220	Clay, gray, sandy	<u></u>	14	
234	Shale, dark gray, soft		84	
318	Sandstone, fine to medium		8	
326	Shale, dark gray with pieces of lignite		22	
349	Sandstone, fine to medium		8	
357	Shale, black, soft		12	
369	Shale and layers of sandstone		15	
384	Sandstone, fine to medium		10	
394	Clay, whitish		5	
399	Hard rock		3	Took 20 minutes to drill 2 feet
402	Bottom of hole			

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Drilling I	og - Minnesota Department of Natu	ral Resources		Page 1 of 1
Site ID # 6	57-5	County: Rock		
Geologist	Evan Drivas	Driller: Don Hejtm	nanek - LTP	
Date: 9/23	/96	Drilling Method: 6	" Mud rotary	1
Location:	T101N R 45W Section 25 CCCDDD			
Depth (ft)	Description		Thickness	Drilling Notes
0	Clay, brown		4	
4	Sand and gravel		19	Chatter @ 14-18'
23	Clay, light gray, sandy		20	Chatter @ 34-35'
43	Clay, sandy, tan		10	
53	Clay, sandy, gray		123	
176	Sand, medium		17	s.
193	Sand, medium to coarse		5	
198	Clay, sandy, gray		30	
228	Sand		3	
231	Clay, sandy, gray		25	
256	Sand		2	
258	Clay, sandy, gray		3	Chatter @ 258
261	Boulder		2	Very slow drilling
263	Clay, dark gray, calcareous		15	
278	Bottom of hole			

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Site ID #	20g - Minnesota Department of Natural	Resources		Page 1 01
Site ID # 67-6 County: Rock		unty: Rock	l- ITD	
Geologist: Evan Drivas Driller: Don Hej		iller: Don Hejtm	anek - LTP	
Date: 9/2.		lling Method: 6	Mud rotary	/
Location:	1101N R44 w Section 20 ABBBBC			
Depth (ft)	Description		Ihickness	Drilling N
0	Soil, dark brown, organic		ć	
3	Clay, brown, sandy		20	
23	Clay, gray, sandy		25	
48	Clay, brown, sandy		35	
83	Clay, gray, sandy		20	
103	Clay, olive-green, sandy		183	
286	Sand medium to coarse		7	
293	Sand, medium		17	
310	Clay, gray, sandy		3	
313	Shale, dark gray		81	
394	Sandstone, very fine		54	Chatter @ 39
448	Shale, dark gray with gypsum		5	
453	Sandstone		2	
455	Shale, dark gray		32	
487	Sandstone, very fine to fine		7	
494	Shale, dark gray		20	
514	Shale, dark gray with some white clay		10	
524	Hard rock		8	Very slow
532	Bottom of hole			
	Interpreted from geologist's mud log and gamma/	resistivity log		
				

Drilling Log - Minnesota Department of Natural Resources				Page 1 of 1
Site ID # 67-7County: Rock				
Geologist: Tom Gullett, Jim Berg Driller: Don Hejtm			nanek - LTP	
Date: 9/30	/96	Drilling Method: 6	" Mud rotary	7
Location:	T101N R 44W Section 32 BBBBB			
Depth (ft)	Description		Thickness	Drilling Notes
0	Clay, yellow-brown, sandy		13	
13	Clay, gray, sandy		25	
38	Clay, light brown, sandy		30	
68	Clay, gray, sandy		45	
113	Clay, olive-green, sandy		15	
128	Clay, yellow, sandy		30	~
153	Clay, reddish gray, sandy		15	Rock at 162'
168	Clay, gray, sandy		95	×
263	Sand, medium		25	
288	Clay, blue, sandy		15	
303	Clay, dark brown		60	Chatter @ 314'
363	Sandstone, fine		30	
393	Sandstone, medium		8	
401	Shale, black		4	
405	Sandstone, fine-medium		8	
413	Shale, black		45	
458	Clay, white		35	
445	Hard rock, weathered		10	498-503 took 35 minutes to drill
503	Bottom of hole			
	Interpreted from geologist's mud log and game	ma/resistivity log		
			,	
· · · · ·				

Drilling L	og - Minnesota Department of Natu	ral Resources		Page 1 of 1
Site ID # 6	57-8	County: Rock		
Geologist:	Jim Berg	Driller: Don Hejtn	nanek - LTP	
Date: 10/9	/96	Drilling Method: 6	" Mud rotary	7
Location:	T101N R 44W Section 32 DDDDDC			
Depth (ft)	Description		Thickness	Drilling Notes
0	Sand, coarse to very coarse		13	
13	Clay, yellow, sandy		5	
18	Clay, gray, sandy		24	
40	Clay, yellow, sandy		10	
50	Clay, gray, sandy		152	Rough @ 51'
202	Sand, very fine to medium		30	· · · · · · · · · · · · · · · · · · ·
232	Clay, dark brown, soft		68	
300	Shale, dark gray		20	· · · · · · · · · · · · · · · · · · ·
320	Shale and sandstone		30	
350	Sandstone, very fine		15	
362	Shale, dark gray		95	
450	Metamorphic rock, weathered, greenish-whit	e	40	
490	Bottom of hole			
		1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -		
	Interpreted from geologist's mud log and gar	nma/resistivity log		

She ILP # 41-1 County: Lincoln Geologist: Jim Berg, Tom Gullett Driller: Don Hejtmanek - LTP Dot: 10/3/96 Drilling Method: 6" Mud rotary Location: T113N R 47W Section 6 BAAADA 3 Depth (ft) Description Thickness Drilling Not 0 Topsoil, black 3 3 Clay, yellow with pebbles 26 29 Clay, gray, sandy 43 43 66 129 Clay, gray, sandy 46 12 129 Clay, gray, sandy 95 14 129 Clay, gray, sandy 95 14 219 Clay, gray, sandy 95 14 229 Clay, agray, sandy 95 14 229 Clay, dark brown, soft 25 15 250 Sand, fine to coarse 18 16 275 Sand, fine to coarse 12 12 382 Clay (no sample return) 7 12 382 Clay (no sample return) 35 14 461 Sand, fine to coarse 41 14 471 Clay (no sa	Drilling L	og - Minnesota Department of Nat	ural Resources	······	Page 1 of 1
Geologist: Jim Berg, Tom Gullett Driller: Don Hejtmanek - LTP Date: 10/31/96 Drilling Method: 6" Mud rotary Location: T113N R 47W Section 6 BAAADA Depth (ft) Description 0 Topsoil, black 3 Clay, yellow with pebbles 26 26 29 Clay, gray, sandy 43 67 Sand, medium to very coarse with some gravel 16 83 Clay, gray, sandy 46 129 Clay, gray, sandy 5 134 Clay, gray, sandy 95 229 Clay, gray, sandy 95 229 Clay, gray, sandy 95 229 Clay, dark brown, soft 25 229 Clay (ark brown, soft 25 229 Clay (no sample return) 7 275 Sand, fine to coarse 18 268 Clay (no sample return) 60 370 Sand, coarse to very coarse 12 382 Clay (no sample return) 35 418 Sand 3 421 Clay (no sample return) 40 <tr< td=""><td>Site ID # 4</td><td>41-1</td><td>County: Lincoln</td><td></td><td></td></tr<>	Site ID # 4	41-1	County: Lincoln		
Date: IDTilling Method: 6" Mud rotary Location: T113N R 47W Section 6 BAAADA Depth (ft) Description Thickness Drilling Not 0 Topsoil, black 3 26 29 Clay, gray, sandy 43 67 Sand, medium to very coarse with some gravel 16 6 83 Clay, gray, sandy 46 6 129 Clay, gray, sandy 46 6 129 Clay, dray, sandy 95 6 229 Clay, drak brown, soft 25 6 230 Sand, fine to coarse 18 6 241 Clay (no sample return) 7 7 255 Sand, coarse to very coarse 12 12 341 Clay (no sample return) 60 60 370 Sand, coarse to very coarse 12 12 382 Clay (no sample return) 35 14 401 Sand 3 14 14 418 Sand 3 14 14 421 Clay (no sample return)	Geologist: Jim Berg, Tom Gullett Driller: Don Hejtu		nanek - LTP	<u></u>	
Location: 1113N R 47W Section 6 BAAADA Depth (R) Topsoil, black 3 3 Clay, yellow with pebbles 26 29 Clay, gray, sandy 43 67 Sand, medium to very coarse with some gravel 16 83 Clay, gray, sandy 46 129 Clay, gray, sandy 46 129 Clay, gray, sandy 46 134 Clay, gray, sandy 95 229 Clay, dark brown, soft 25 250 Sand, fine to coarse 18 268 Clay (no sample return) 7 275 Sand, fine to coarse 35 310 Clay (no sample return) 60 370 Sand, coarse to very coarse 12 382 Clay (no sample return) 35 418 Sand 3 421 Clay (no sample return) 40 451 Sand, fine to coarse 41 464	Date: 10/3	1/96	Drilling Method: 6	" Mud rotary	/
Depth (ft)DescriptionThicknessDrilling Not0Topsoil, black333Clay, yellow with pebbles2629Clay, gray, sandy4367Sand, medium to very coarse with some gravel1683Clay, gray, sandy46129Clay, gray, sandy5134Clay, gray, sandy5134Clay, gray, sandy95229Clay, dark brown, soft25250Sand, fine to coarse18268Clay (no sample return)7275Sand, fine to coarse35310Clay (no sample return)60370Sand, coarse to very coarse12382Clay (no sample return)35418Sand3421Clay (no sample return)40461Sand, fine to coarse41496Clay (no sample return)8504Shale, dark gray55559Shale, black, soft with some lignite45604Bottom of hole1Lithologic interpretations from geologist's mud log and gamma/resistivity log14Lithologic interpretations from geologist's mud log and gamma/resistivity log1	Location:	T113N R 47W Section 6 BAAADA			
0 Topsoil, black 3 3 Clay, yellow with pebbles 26 29 Clay, gray, sandy 43 67 Sand, medium to very coarse with some gravel 16 83 Clay, gray, sandy 46 129 Clay, gray, sandy 46 129 Clay, gray, sandy 5 134 Clay, gray, sandy 95 229 Clay, dark brown, soft 25 250 Sand, fine to coarse 18 268 Clay (no sample return) 7 275 Sand, fine to coarse 35 310 Clay (no sample return) 60 370 Sand, coarse to very coarse 12 382 Clay (no sample return) 35 418 Sand 3 421 Clay (no sample return) 40 461 Sand, fine to coarse 41 496 Clay (no sample return) 8 504 Shale, dark gray 55 559 Shale, dark gray 55 559 Shale, koft with some lignite 45 <	Depth (ft)	Description		Thickness	Drilling Not
3 Clay, yellow with pebbles 26 29 Clay, gray, sandy 43 67 Sand, medium to very coarse with some gravel 16 83 Clay, gray, sandy 46 129 Clay, gray, sandy 46 129 Clay, gray, sandy 5 134 Clay, gray, sandy 95 229 Clay, dark brown, soft 25 250 Sand, fine to coarse 18 268 Clay (no sample return) 7 275 Sand, fine to coarse 35 310 Clay (no sample return) 60 370 Sand, coarse to very coarse 12 382 Clay (no sample return) 35 418 Sand 3 421 Clay (no sample return) 40 461 Sand, fine to coarse 41 496 Clay (no sample return) 8 504 Shale, dark gray 55 559 Shale, dark gray 55 559 Shale, black, soft with some lignite 45 604 Bottom of hole 1 </td <td>0</td> <td>Topsoil, black</td> <td></td> <td>3</td> <td></td>	0	Topsoil, black		3	
29Clay, gray, sandy4367Sand, medium to very coarse with some gravel1683Clay, gray, sandy46129Clay, gray, sandy5134Clay, gray, sandy95229Clay, dark brown, soft25250Sand, fine to coarse18268Clay (no sample return)7275Sand, fine to coarse35310Clay (no sample return)60370Sand, coarse to very coarse12382Clay (no sample return)35418Sand3421Clay (no sample return)40461Sand, fine to coarse41496Clay (no sample return)8504Shale, dark gray55559Shale, black, soft with some lignite45604Bottom of hole1Lithologic interpretations from geologist's mud log and gamma/resistivity log1	3	Clay, yellow with pebbles		26	
67Sand, medium to very coarse with some gravel1683Clay, gray, sandy46129Clay, yellow, sandy5134Clay, gray, sandy95229Clay, dark brown, soft25250Sand, fine to coarse18268Clay (no sample return)7275Sand, fine to coarse35310Clay (no sample return)60370Sand, coarse to very coarse12382Clay (no sample return)35418Sand3421Clay (no sample return)40461Sand, fine to coarse41496Clay (no sample return)8504Shale, dark gray55559Shale, black, soft with some lignite45604Bottom of hole1Lithologic interpretations from geologist's mud log and gamma/resistivity log1	29	Clay, gray, sandy		43	······································
83Clay, gray, sandy46129Clay, yellow, sandy5134Clay, gray, sandy95229Clay, dark brown, soft25250Sand, fine to coarse18268Clay (no sample return)7275Sand, fine to coarse35310Clay (no sample return)60370Sand, coarse to very coarse12382Clay (no sample return)35418Sand3421Clay (no sample return)40461Sand, fine to coarse41496Clay (no sample return)8504Shale, dark gray55559Shale, black, soft with some lignite45604Bottom of hole1Lithologic interpretations from geologist's mud log and gamma'resistivity log1	67	Sand, medium to very coarse with some gra	avel	16	
129Clay, yellow, sandy5134Clay, gray, sandy95229Clay, dark brown, soft25250Sand, fine to coarse18268Clay (no sample return)7275Sand, fine to coarse35310Clay (no sample return)60370Sand, coarse to very coarse12382Clay (no sample return)35418Sand3421Clay (no sample return)40461Sand, fine to coarse41476Clay (no sample return)8504Shale, dark gray55559Shale, dark gray55559Shale, soft with some lignite45604Bottom of hole1Lithologic interpretations from geologist's mud log and gamma/resistivity log1	83	Clay, gray, sandy		46	
134Clay, gray, sandy95229Clay, dark brown, soft25250Sand, fine to coarse18268Clay (no sample return)7275Sand, fine to coarse35310Clay (no sample return)60370Sand, coarse to very coarse12382Clay (no sample return)35418Sand3421Clay (no sample return)40461Sand, fine to coarse41496Clay (no sample return)8504Shale, dark gray55559Shale, dark gray55559Shale, soft with some lignite45604Bottom of hole1Lithologic interpretations from geologist's mud log and gamma/resistivity log1	129	Clay, yellow, sandy		5	-
229Clay, dark brown, soft25250Sand, fine to coarse18268Clay (no sample return)7275Sand, fine to coarse35310Clay (no sample return)60370Sand, coarse to very coarse12382Clay (no sample return)35418Sand3421Clay (no sample return)40461Sand, fine to coarse41496Clay (no sample return)8504Shale, dark gray55559Shale, black, soft with some lignite45604Bottom of hole1Lithologic interpretations from geologist's mud log and gamma/resistivity log1	134	Clay, gray, sandy		95	
250Sand, fine to coarse18268Clay (no sample return)7275Sand, fine to coarse35310Clay (no sample return)60370Sand, coarse to very coarse12382Clay (no sample return)35418Sand3421Clay (no sample return)40461Sand, fine to coarse41496Clay (no sample return)8504Shale, dark gray55559Shale, black, soft with some lignite45604Bottom of hole1Lithologic interpretations from geologist's mud log and gamma/resistivity log1	229	Clay, dark brown, soft	- 1 4 4 5 5 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	25	
268Clay (no sample return)7275Sand, fine to coarse35310Clay (no sample return)60370Sand, coarse to very coarse12382Clay (no sample return)35418Sand3421Clay (no sample return)40461Sand, fine to coarse41496Clay (no sample return)8504Shale, dark gray55559Shale, black, soft with some lignite45604Bottom of hole1Lithologic interpretations from geologist's mud log and gamma/resistivity log1	250	Sand, fine to coarse		18	
275Sand, fine to coarse35310Clay (no sample return)60370Sand, coarse to very coarse12382Clay (no sample return)35418Sand3421Clay (no sample return)40461Sand, fine to coarse41496Clay (no sample return)8504Shale, dark gray55559Shale, black, soft with some lignite45604Bottom of hole1Lithologic interpretations from geologist's mud log and gamma/resistivity log1	268	Clay (no sample return)		7	
310Clay (no sample return)60370Sand, coarse to very coarse12382Clay (no sample return)35418Sand3421Clay (no sample return)40461Sand, fine to coarse41496Clay (no sample return)8504Shale, dark gray55559Shale, black, soft with some lignite45604Bottom of hole1Lithologic interpretations from geologist's mud log and gamma/resistivity log1	275	Sand, fine to coarse		35	
370Sand, coarse to very coarse12382Clay (no sample return)35418Sand3421Clay (no sample return)40461Sand, fine to coarse41496Clay (no sample return)8504Shale, dark gray55559Shale, black, soft with some lignite45604Bottom of hole1Lithologic interpretations from geologist's mud log and gamma/resistivity log1	310	Clay (no sample return)		60	
382Clay (no sample return)35418Sand3421Clay (no sample return)40461Sand, fine to coarse41496Clay (no sample return)8504Shale, dark gray55559Shale, black, soft with some lignite45604Bottom of holeLithologic interpretations from geologist's mud log and gamma/resistivity log	370	Sand, coarse to very coarse		12	
418 Sand 3 421 Clay (no sample return) 40 461 Sand, fine to coarse 41 496 Clay (no sample return) 8 504 Shale, dark gray 55 559 Shale, black, soft with some lignite 45 604 Bottom of hole 1 Lithologic interpretations from geologist's mud log and gamma/resistivity log 1	382	Clay (no sample return)		35	
421Clay (no sample return)40461Sand, fine to coarse41496Clay (no sample return)8504Shale, dark gray55559Shale, black, soft with some lignite45604Bottom of hole	418	Sand		3	
461Sand, fine to coarse41496Clay (no sample return)8504Shale, dark gray55559Shale, black, soft with some lignite45604Bottom of hole1Lithologic interpretations from geologist's mud log and gamma/resistivity log1	421	Clay (no sample return)		40	
496Clay (no sample return)8504Shale, dark gray55559Shale, black, soft with some lignite45604Bottom of hole	461	Sand, fine to coarse		41	
504 Shale, dark gray 55 559 Shale, black, soft with some lignite 45 604 Bottom of hole 1 Lithologic interpretations from geologist's mud log and gamma/resistivity log 1	496	Clay (no sample return)		8	
559 Shale, black, soft with some lignite 45 604 Bottom of hole 1 Lithologic interpretations from geologist's mud log and gamma/resistivity log 1	504	Shale, dark gray		55	
604 Bottom of hole Lithologic interpretations from geologist's mud log and gamma/resistivity log Image: Comparison of the second se	559	Shale, black, soft with some lignite		45	
Lithologic interpretations from geologist's mud log and gamma/resistivity log	604	Bottom of hole			
		Lithologic interpretations from geologist's gamma/resistivity log	mud log and		
Drilling L	Log - Minnesota Department of Natu	ral Resources		Page 1 of 2	
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Site ID # 8	87-7	County: Yellow M			
Geologist	: Jim Berg, Evan Drivas	Driller: Don Hejtn	nanek - LTP		
Date: 10/2	24/96	Drilling Method: 6	"Mud rotary	7	
Location:	T114N R 46W Section 28 CCBBBA				
Depth (ft)	Description		Thickness	Drilling Notes	
0	Clay, brown, sandy		3		
3	Clay, gray, sandy	-	5	Chatter @ 9-10'	
8	Clay, tan, sandy		5		
13	Clay, gray, sandy		29		
36	Sand, coarse to very coarse		9		
45	Clay, gray, sandy	1. / · · · · · · · · · · · · · · · · · ·	23		
68	Sand, coarse to very coarse	4. · · · · · · · · · · · · · · · · · · ·	34		
99	Sand, medium to very coarse	<u></u>	55		
154	Sand, fine to medium		10		
164	Sand, fine		5		
169	Sand, very fine		10		
179	Sand, fine to medium		5		
184	Sand, medium to very coarse		15		
199	Sand, very fine to medium		5		
204	Clay, gray, sandy		10		
214	Clay, brown, sandy		25		
239	Clay, light gray, sandy		22		
250	Sand, silty fine to medium		20		
270	Clay, brown, sandy		55		
339	Clay, medium gray, sandy		15		
354	Sand, silty, very fine to fine	· · · · · · · · · · · · · · · · · · ·	10		
374	Sand, silty, very fine to coarse		19		
393	Clay, dark brown, soft		52		
449	Clay, dark brown with sand layers		5		

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Drilling I	Drilling Log - Minnesota Department of Natural Resources Page 2 of 2					
Site ID # 8	37-7	County: Yellow M	ledicine			
Geologist	Jim Berg, Evan Drivas	Driller: Don Hejtm	nanek - LTP			
Date: 10/2	24/96	Drilling Method: 6	"Mud rotary	r		
Location:	T114N R 46W Section 28 CCBBBA					
Depth (ft)	Description		Thickness	Drilling Notes		
454	Clay, dark brown, soft		40			
494	Shale, medium gray		15			
509	Shale with sand layers (no sample return)		20			
529	Shale, black, soft		75			
604	Shale, medium gray, hard		5			
609	Siltstone, marl? (no sample return)		21			
630	Siltstone and shale (no sample return)		15			
645	Shale, medium gray, hard		79			
724	Bottom of hole					
	Lithologic interpretations from geologist's m gamma/resistivity log	ud log and				
	:					

Drilling L	Drilling Log - Minnesota Department of Natural Resources Page 1 of 1				
Site ID # 8	37-8	County: Yellow M	ledicine		
Geologist:	Jim Berg, Tom Gullett	Driller: Don Hejtn	nanek - LTP		
Date: 11/1	3/96	Drilling Method: 6	" Mud rotary	7	
Location:	T114N R 46W Section 34 ADADAD				
Depth (ft)	Description		Thickness	Drilling Notes	
0	Topsoil, brown		3		
3	Clay, olive brown, sandy		51		
54	Clay, gray, sandy		80	Chatter @116'	
134	Sand, fine to very coarse with gravel		19		
153	Clay, gray, sandy		16		
169	Clay, gray with sand layers		30		
199	Clay, yellow, sandy	· · · ·	43		
242	Boulder		2		
244	Clay, yellow-brown, sandy with sand layers		26		
270	Clay, gray, sandy		134	Chatter @275'	
404	Sand		4		
408	Clay, yellow-brown sandy		10		
418	Sand, fine to coarse		16		
434	Sand and yellow brown clay		5		
439	Clay, dark brown, soft		45		
484	Bottom of hole				
	Lithologic interpretations from geologists mogamma/resistivity	ud log and			

Well Drilling			SW	- SE
		Sec 12	T 102	R41
DRILL	ERS LOG			
Drilled for DNR Div. of Waters		By <u>Pa</u>	ige 1	Office
ocation of Test Hole see map T 102 R41 Sec	.12			
	. Test	Hole No. 53-	1Well No	
$6 \frac{1}{4}$ Data started $8 - 21 - 96 3:1$	0 Date completed 8-	28-96		N: 1)*E
			(U.21) (C	2015
FORMATIC	ONS DRILLED		-	
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Top Soil	Black	G.L.	4 '	4 '
Clay	Brown	4 '	8'	4 '
Sand	Brown	8'	11'	3'
Clay	Brown	11'	15'	4 '
Clay (soft)	Grev	15'	59 1/2'	44 1/2
Sand	Grey	59 1/2'	60 1/2'	1'
very soft sandy clay	Grev	60 1/2'	108'	47 1/2
Clay	Yellow	108'	124'	80'
Clay	Grey	124'	204'	80'
Clay & Shale	Blk,Grey	204'	226'	22'
Sand & Shale	Grey,Blk	226'	233'	7'
Clay & Shale	Grey,Blk	233'	240'	7'
Clay & Shale	light gree	n240'	334'	94'
Clay & Shale	Grey,Blk	334'	387'	53'
Rock	foregrue Ella	387'	388'	1'
Clay & Shale	Grey,Blk	388'	486'	98'
very Sandy Clay & Shale	Grey,Blk	486'	510'	24'
Lenses of Sand & Shale	Tan,Grey,B	lk510'	516'	6'
Very sandy Shale	Grey,Blk	516'	519'	3'
Very dirty sand (120)	Tan,Grey,B	lk 519'	524'	5'
Harder Shale	Grey,Blk	524'	579'	55'
Sand	Grey	579'	581'	3'
Very soft sandy clay or shale	Grey	581'	597 1/2	' 16 1/2
Sand (drilled good)	Grey	597 1/2	605 1/2	5'

FARGO, N.D.

HUTCHINSON, MN.

Enterprises, Inc.

Driller

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TVell I	Enterprises. Onc. Drilling

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Sec. 12	

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Drilled for _____ DNR Div. of Waters _____ By Page 2 Office Location of Test Hole See map T 102 R41 Sec. 12

Size of test hole <u>64</u> Date started <u>8-21-96</u> Date completed <u>8-28-96</u> Total Hours

FORMATIONS	DRILLED			
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Rock	Gray	602 <u>1</u> '	603'	$\frac{1}{2}$
Sand (drilled good)	Gray	603'	607 '	4 '
Sandy Clay & Shale (soft)	Gray,tan	607'	646'	39'
Hard sandy clay & shale	Græy,tan	646'	676'	30'
Lenses of shale, clay & dirty sa	nd Gray, tan	676'	688'	12'
Very sandy clay & shale (firm)	Grav,tan	688'	703'	15'
Sand (drilled dirty)	Gray,tan	703'	717'	14'
Dirty sand stone w/lenses of	Gray,tan	717 '	755 <u>1</u> '	38 <u>1</u> '
shale (not sticky)				
Rock		755 <u>1</u> '	756'	$\frac{1}{2}$
Stocky Shale	Gray,tan	756'	779'	43'
Hard Shale	Gray	779'	804'	25'
Shale w/lenses of sand	Gray	804'	809'	5'
Very soft dirty sand & shale	Gray	809'	843'	34'
Cleanersand	Gray	843'	849'	6'
Lenses of dirty sand & shale	Gray	849'	864'	15'
Very soft sand stone	Gray	864'	883'	19'
sandy shale hole started taking	water Gray	,blk 883'	893'	10'
Hard shale (mud turned reddish)	Tan,Org.Gr	een ay, 893'	914'	21'
Shale (brittle)	Orange,li	^{me} 914'	924'	10'
Shale (brittle)	Green Grav.Org.	924'	980'	56'
				1

	FARGO, N.D.
Enterprises, Inc.	HUTCHINSON, MN.

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Geo. 32	1 <u>120</u> _R	40w

By Page 1 Office

DRILLERS LOG

Drilled for ______ DNR Div of Waters Location of Test Hole T 102 R 40w

Well

Drilling

	Test Hole No. 53-2Well	No
Size of test hole $63/4$ Date started $8-29-96$	_Date completed9-5-96	Hours

			r	
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Top Soil	Black	GL	2	2
Clay	Brown	2	19	17
Clay	Gray	19	$24\frac{1}{2}$	$5\frac{1}{2}$
Rock	Colored	$24\frac{1}{2}$	25	$\frac{1}{2}$
Clay	Blue,Gray	25	101	76
sand w/lenses of clay	Gray	101	104	3
Soft sand clay	Gray	104	134	30
Sand, gravel & cobbles	Colored	134	$144\frac{1}{2}$	10 <u>1</u>
lenses of clay & gravel	Colored	$144\frac{1}{2}$	149 1	$4\frac{1}{2}$
Sand and light gravel (drilled dirty)	Colored	149 1	154	5
Sandy Clay (soft)	Gray	154	203	49
Sand	Gray	203	205 <u>1</u>	$2\frac{1}{2}$
Sandy clay	Gray	205 <u>1</u>	223	17 <u>1</u>
Sand	Gray	223	259 1	36 <u>1</u>
Sandy clay	Gray	259 <u>1</u>	383	123 ¹ / ₂
Sand	Gray	383	391	8
Sandy clay & shale Tan	,Blk,Gray	391	479	88
Very sandy clay & shale Tan	,Blk,Gray	479	489	10
Very dirty sand w/shale	Gray,Tan	489	504	15
Sand (drilled good)	Gray	504	514	10
Sand (drilled dirty)	Gray	514	532	18
Very sandy clay-shale	Gray,Tan	532	549	17
Sand (drilled good)	Gray	549	553	4
Soft sandy clay-shale w/small lenses	Gray,Blk,	553	580	27
of sand	Tan			

of sand

Signed___

Enterprises. Gnc. Well Drilling	FARGO, HUTCHIN	N.D. NSON, MN.	sec - 3	† N sw B212	NE SE 0 R 40 W
DR	ILLERS	LOG			
Drilled for DNR Div. of Waters		-	Ву		Office
Location of Test Hole					
		Test	Hole No. <u>53</u>	<u>-2</u> Well N	0
Size of test hele $6\frac{1}{4}$ Date started $8-29-96$	Date	completed		Total H	lours
FORM	ATIONS D	DRILLED			
TYPE OF FORMATION		COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Sandy clay & shale (soft)		Blk,Gray,	580	654	74
Very hard shale		Tan,Gray,	654	671	17
Shale & Clay		Tan,Gray	671	734	63
Sand (drilled Good)		Gray	734	737	3
Sandy Clay -Shale	Blk	Gray,Tan	737	800	63
Soft shale	White	,Gray,Blk	800	824	24
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t NE FARGO, N.D. Ν Enterprises, Inc. HUTCHINSON, MN. Vell Drilling - SW -- SE -Sec. 3 101 T 40 R-DRILLERS LOG Drilled for DNR Div. of Waters _{By} Page 1 __Office Location of Test Hole <u>T 101 R 40 Sec. 3</u> Test Hole No. <u>53-3</u> Well No. _____ Size of test hole <u>6 3/4</u> Date started <u>8-14-96</u> (3:30) are completed ______ Total Hours _____ FORMATIONS DRILLED THICKNESS COLOR STARTED ENDED AT WHAT TYPE OF FORMATION AT WHAT DEPTH OF FORMATION OF FORMATION Top Soil 2' 2' Black GL 2' Sand and gravel 16' 18' Brown 18' 50' Sandy clay 32' Gray 31 Sand 50' 53' Gray 6' Lenses of sandy clay & sand <u>5</u>3' 59' Grav Lenses of sand &gravel &clay (no water Gray, Col 14' 59' 73' 73' 92' 19' sandy clay w/pebbles <u>Gray</u> Gray,Blk 92' 96' 4 ' Sand w/lenses of clay (washed) sandv clay Gray 96' 134' 38' 1' Colored gravel & rock 134' 135' Gray 60' Sandy clay 135' 195' 47' Yellow 195' 242' sandy clay 41' Blk.Yellow very sandy clay w/shale 242' 283' 3991 116' soft sandy clay & shale Blk.Gray 283' <u>1</u> 399닃' 399' soft rock Gray 20' Sand (drilled fair) took a little water Gray 399날' 419불' 419불 421불 2' Gray rock sandy clay (soft) Gray 421날' 466' 4412' hard sticky clay -shale Gray 466' 506' 40' 44' Softer sandy clay shale 508' 55**0'** Grav.Blk 19' soft sandy shale Gray, Blk, red 550' 569' very soft shale (sandy) 90 sec. 20' Blk.Gray 569' 589' very dirty sand stone 589' 604' 15' Gray 35' 604' 639' fine sand (drilled good) Gray

Signed_

Driller

FARG Enterprises, Onc. HUTCH IVell Dhilling	° O, N.D. HINSON, MN.	Sec -	↑ N O(NE SE SE
DRILLER	IS LOG	Ву	page 2	Office
Location of Test Hole			-	· · · · · · · · · · · · · · · · · · ·
Size of test hole $6\frac{1}{4}$ Date started $8-14-96$	Test	Hole No. <u>53</u>	<u>.3 </u> Well N Total H	0 tours
FORMATION	S DRILLED			
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Dirty Sand	Gray,Blk	639	649	10
Lenses of dirty sand and shale	Gray,Blk	649	664	15
Fine sand (drilled good)	Gray,Blk	664	669	5
Lenses of dirty sand & shale(poor	Gray,Blk	669 [′]	684	15
sample)				
Sandy Shale	Gray, Blk	684	704	20
Sand (drilled good)	Gray	704	710	6
Lenses of sand & shale	Gray	710	724	14
Very sandy shale	Gray,Blk	724	744	20
Hard shale	Gray	744	755	11
Shale	Grn, Gray,	755	775	20
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STP Enterprises, Onc. Well Drilling	FARGO, N.D. HUTCHINSON, MN.	Sec 🗸 ć	↑ N 02_T_3	×
	DRILLERS LOG			
Drilled for DNR Div. of Waters		Ву_ра	age 1	Office
Location of Test Hole 102 39 32 (see ma	ıp)			
		Hole No. 53	-4Well N	0
Size of test hole $63/4$ Date started $8-7-96$	Date completed_8 – 1	3-96	Total H	lours <u>33</u>
FOF	RMATIONS DRILLED		~	
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Top soil	Black	GL	3	3
	_		1	1

	Top soil	Black	GL	3	3
	Clay	Brown	3	7	4
	Sand	Brown	7	9	2
	Clay	Brown	9	18	9
	Clay (sticky)	Grav	18	33	15
	Softer sandy clay	Gray	33	46	13
	very sandy clay	Gray	46	61	15
	Lenses of sand & clay	Gray	61	66	5
	Soft sandy clay	Gray	66	88	22
	Very soft sandy clay	Gray	88	107	19
	clay Very dirty sand(70 sec) w/lenses of	Gray	107	130	23
	Sand (fine)	Gray	130	133	3
	Very sandy_clay w/lenses of fine sand	Gray	133	146	13
	Sand	Gray	146	148	2
	Very sandy clay	Gray	148	156	8
	Sand (came in over night)	Gray	156	161 1	5 1
	Sandy clay w/pebbles	Gray	161 1	207	45 1
	Sandy clay (hard)	Gray	207	209	2
	Sandy clay	Gray	209	279	70
	Sand	Gray	279	280	1
	Sandy clay	Gray	280	286	6
	Sand	Gray	286	287	1
en. 2945 2955 2955	Sandy clay	Gray	287	304	17
	Very soft sandy clay	Gray	304	312 ¹ / ₂	81/2

Signed_

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	Enterprises, Onc.
Well I	Drilling



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		DRILLERS LUG		
Drilled for DNR Div. of	E Waters		_{Bv} Page 2	Office
		· · · · · · · · · · · · · · · · · · ·	- /	
Location of Test Hole -102	2 39-32			

Size of test hole <u>6 3/4</u> Date started <u>8-7-96</u> Date completed <u>8-13-96</u> Total Hours <u>33</u>

______Test Hole No. _____Well No. _____

FORMATIONS DRILLED									
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION					
Sand (drilled good) took a Little water	Gray	312 1	340	27 <u>1</u>					
Sandy clay	Gray	340	443	103					
Very fine sand (poor sample) dilled	Gray	443	464	21					
Lenses of sand (fine) and clay	Gray,Tan	464	474	10					
Hard sandy clay	Gray,Tan	474	488	14					
Lenses of sand & clay	Gray, Tan	488	501 <u>1</u>	131/2					
Rock	Gray	501 <u>1</u>	502	$\frac{1}{2}$					
Lenses of dirty sand &clay	Gray,Tan	502	517	15					
Hard clay - shale	Gray,Tan	517	525	8					
Sandy clay	Gray	525	555	30					
Hard sticky clay w/shale - coal	Gray,Blk	555	610	55					
Very sandy clay - shale	Gray	610	639	29					
Sandy clay - shale	Gray	639	659	20					
Dirty sand (fine)	Gray	659	665	6					
Very dirty sand (fine)	Gray	665	671	6					
Very sandy clay- shale	Gray,Blk	671	724	53					
Hard shale 1hr. last 2' Blk	Gray,Grn	724	726	2					

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FARGO, N.D. HUTCHINSON, MN.



DRILLERS LOG

Drilled for <u>I</u>	<u>DNR</u>	Div.	of	Wate	ers						E	Βγ			 Office	
Location of Te	est Hol	e <u>61</u>	mi.	s.	of	Luverne,	MN	on	Hwy	75	xoqqA	31/2	mi.	Ε.	 	

______ Test Hole No. <u>67-6</u>____Well No. ______

Size of test hole <u>6 3/4</u> Date started <u>10-2-96</u> Date completed <u>10-8-96</u> Total Hours

FORMATIONS DRILLED								
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION				
Top Soil	Black	GL	2	2				
Sandy clay w/lenses of gravel	Brown	2	23	21				
Sandy clay	Brown,Gray	23	84	61				
Sandy Clay	Brown,Gray	84	2113	1275				
Rock	Pink	2115	212	15				
Sandy clay	Gray	212	286	74				
Sand (fair)	Gray	286	290	4				
Very sandy clay w/lenses of sand	Gray	290	297	7				
Fine sand (drilled dirty) looked clean	Gray	297	3105	135				
Sandy shale firm	Gray	3101/2	386	751				
Soft sandy shale	Blk,Gray	386	396	10				
Fine sand (drilled fair)(poor sample)	Gray	396	448	52				
Sandy shale Blk	,Brown,Gra	y 448	453	5				
Fine sand	Gray	453	455	2				
Firm shale	Blk,Gray	455	487	32				
Sandstone	Gray	487	494	7				
Sandy shale	B1k,Gray	494	510	16				
Sandy shale w/layers of rock	White,Gray		524	14				
Rock	White,Gray	524	532	8				
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DRILLERS LOG

Drilled for DNR	Div. of Wa	iter				Ву		Offic	ce
Location of Test Hole	Approx 6 ¹	S. of Li	uverne,	MN on H	wy 75,	<u>3 E,</u>	2,5,		
				·····	Test Hole I	No. <u>67</u>	7Well No		
Size of test hole <u>6</u> 3,	<u></u> Date started .	9-30-96	Date	e completed.	10-2-9	16	Total Hours	23	3/4

FORMATIONS I	DRILLED			
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION
Top Soil	Brown	GL	1	1
Soft clay	Brown	1	15	14
Clay	Gray	15	113	98
Soft sandy clay	Gray	113	162	49
Rock		162	162 ¹ / ₂	1
Soft Clay	Gray, Brown	1623	263	100 ¹ 2
Fine sand (drilled good) TALW 6-8-10	Gray	263	288	25
Sandy shale Blk	,Brown,Gra	y 288	346	58
ine sand stone TW (drilled good)	White	346	401	55
Shale	Blk, Gray	401	405	4
Shale lenses Fine sandstone (drilled good) w/small	Gray	405	413	8
Shale	Brown Blk,Gray,	413	439	26
Very soft sandy shale	Brown Blk,Gray,	439	445	6
Hard shale	Blk, Brown	463	484	21
Rock (very hard at bottom)	Red,Gray	484	503	19

Uell Drilling

FARGO, N.D. HUTCHINSON, MN.



DRILLERS LOG

Drilled for DNR Div of Waters	Ву	Office
Location of Test Hole <u>Approx 3¹</u> S. of Luverne MN on	Hwy 75, 5 3/4 W on Co 1	5
	Test Hole No. <u>67–1</u> Well No	
Size of test hole $63/4$ Date started $10-22-96$ Date complet	red_1 <u>0-23-96</u> Total Hour	s <u>14 3/</u> 4

FORMATIONS DRILLED								
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION				
Top soil	Black	GL	2	2				
Clay	Brown	2	15	13				
Sand	Brown		31	16				
Sandy clay	Brown	31	59	28				
Sandy clay	Gray	59	132	73				
Very soft sandy clay w/dirt fine sand	Grn,Gray	132	174	42				
Very fine sand	Gray	174	184	10				
Sandy clay 1t.	Gray, Brown	184	208	24				
Very dirty sand (fine)	Gray, Brown	208	214	6				
Sandy clay	Gray, Brown	214	219	5				
Very fine dirty sand (drilled good)	Gray	219	262	43				
Sandy clay	Gray	262	321	.59				
Sticky clay - shale	Gray, Brown	321	389	68				
	Gray,Brown	389	400	11				

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	Enterprises, Inc.
Well I	Drilling



DRILLERS LOG

Drilled for DNR Div of Waters

By _____Office

Location of Test Hole Approx 53 of Luverne on 75, 5 W, 12 N.

______.Test Hole No. <u>67–2</u>____Well No. _____

Size of test hole <u>6 3/4</u> Date started <u>10-16-96</u> Date completed <u>10-17-96</u> Total Hours

FORMATIONS DRILLED							
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION			
Top soil	Black	GL	2	2			
Clay	Brown	2	7	5			
Gravel	Brown	7	11	4			
Sandy clay w/lenses of sand	Gray	11	17	6			
Clay	Brown	17	60	43			
Clay	Gray	60	190	130			
Softer clay	Gray	190	221	31			
Very sandy clay w/lenses of sand	Gray	221	227	6			
Very sandy clay (soft)	Gray,Blk '	227	254	27			
Sand (drilled good)	Gray	254	258	4			
Very sandy clay	Gray,B1k	258	282	24			
Sand (drilled good) w/lenses of clay	Gray,Grn	282	293	11			
Sandy shale and clay	Gray,Grn	293	334	41			
Sandy clay and brittle shale	Gray,B1k	334	400	66			
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DRILLERS LOG

Drilled for <u>DNR Div of Waters</u>	ByOffice
Location of Test Hole Approx 6 5. of Luverne, MN on	n Hwy 75, W 2½ mi.
	Test Hole No 67-3 Well No

Size of test hole 63/4 Date started 10-14-96 Date completed 10-16-96 Total Hours 21

FORMATIONS DRILLED								
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION				
Top soil	Black	GL	1	1				
Clay	Brown	1	18	17				
Sandy Clay	Brown	18	124	106				
Silty Clay (soft)	Tan	124	162	38				
Fine sand 8-10 (drilled good) took wate	r Gray	162	179	17				
Shale	Grn, Brown	179	188	9				
Fine sand	Gray	188	192 ¹ / ₂	4 ¹ / ₂				
	Gray, Brown	192 ¹ 5	224	31 ¹ / ₂				
Hard clay - shale	Brown, Gray	224	265	41				
Very sandy clay-shale (much softer)	Gray, Brown	265	324	59				
Hard shale (stocky)	Gray, Brown	324	384	60				
Sandy shale	Gray, Brown	384	417	33				
Very fine sand (poor sample)	Gray,B1k	417	429	12				
Very soft sandy shale	Blk,Gray	429	449	20				
Very fine sand (no sample) drilled quict	B1k,Gray	449	462	<u> 13</u>				
Shale (soft)	Black	462	494	32				
Shale de-comp.	B1k, white	494	519	2.5				
De-comprock-shale	Blk, white	519	560	41				
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DRILLERS LOG

Drilled for <u>DNR Div. of Waters</u>	ByOffice
Location of Test Hole Approx 6 ¹ / ₂ mi S. of Luverne on 75,	1 E see map
	Test Hole No. 67-4 Well No.

Size of test hole <u>6 3/4</u> Date started <u>9-18-96</u> Date completed <u>9-19-96</u> Total Hours

FORMATIONS DRILLED								
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION				
Top soil	Black	GL	1	1				
Sand & gravel	Brown	1	21	20				
Sandy clay	Brown	21	24	3				
Sandy clay	Gray	24	196	172				
Very sandy clay (soft)	Gray	196	204	8				
Very fine sand (drilled good)	Gray	204	209	5				
Sand (drilled good) took water	Blue	209	220 ¹ / ₅	1115				
Sandy clay-shale	Gray, Tan	220 ¹ /2	318	97 ¹ /2				
Very fine sand	Gray	318	326 ¹ / ₂	8 ¹ / ₂				
Sandy shale Blk	,Gray,Tan	326 ¹ / ₂	348	21 ¹ /2				
Fine sandstone	Gray	348	357	9				
Sandy shale Blk	.Gray,Tan	357	372	15				
Fine sandstone	Gray	372	374	2				
Sandy shale w/lenses of sandstone (fin	Gray e)Blk,Whit	<u>= 374</u>	382	8				
Sandstone	White	382	390	8				
Hard decomp. & solid granite	White,Pink	390	403	13				
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DRILLERS LOG

Drilled for <u>DNR</u> Di	v. of Wa	aters				By			Office
Location of Test Hole	Approx	8½ S.	of Luverne,	MN on	Hwy 75	1.1	mi. E	•	
					Test Ho	le No	67-5	_Well No	

Size of test hole <u>6 3/4</u> Date started <u>9-23-96</u> Date completed <u>9-24-96</u> Total Hours _____

FORMATIONS DRILLED							
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION			
Top soil	Black	GL	4	4			
Sand & gravel	Brown	4	16	12			
Rock	Brown	16	165	13			
Sand & gravel	Brown	16 ¹ / ₂	24	7 ¹ / ₅			
Rock		24	24 ¹ / ₂	1/3			
Sandy clay	Brown	24 ¹ / ₂	60	35 ¹ / ₂			
Clay	Gray	60	136	76			
Clay	Tan,Gray	136	176	40			
Dirty sand	Gary	176	181	5			
Fine sand (drilled good) took a little	Gray	181	200	19			
<u>Clay-shale</u>	Gray,B1k	200	227	27			
Dirty sand	Gray	227	230	3			
Clay-shale	Blk,Gray	230	261	31			
Rock (hard)	Red	261	262 ¹ /2	11/2			
	White	262 ¹ /2	267	4 ¹ / ₂			
Rock	White,Pink	267	278	9			
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Enterprises, Inc.	HUT
Well Drilling	

GO, N.D. CHINSON, MN.



DRILLERS LOG

Drilled for <u>DIR DIV.</u> O	WALEIS	ByOffice
Location of Test Hole <u>T 10</u>	2 N R 43 W, S 32, N 4, SE 4, SE	1 ₄ DDA

______Test Hole No. <u>53-6</u>____Well No. ______

Size of test hole <u>64</u> ______Date started <u>9-11-96</u> _______Date completed ________Total Hours ______

FORMATIONS DRILLED							
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION			
Top Soil	Black	GL	1	1			
Sand	Brown	1	8	7			
Gravel	Brown	8	24	16			
Sand	Brown	24	42	18			
Dirty sand & clay	Brown	42	49	7			
Sand	Brown	49	54	5			
Very sandy clay	Brown	54	76	22			
Harder clay	Brown	76	84	8			
Sand	Brown	84	94	10			
Sandy clay	Brown	94	105	11			
Sandy Clay	Gray, Brn	105	188	83			
Sandy Clay	Gray,Tan	188	302	114			
Soft sandy clay	Gray,Tan	302	352	50			
Hard clay-shale	Gray,Blk	352	448	96			
Sand stone (drilled good) took a littl	eGray,white	<u> </u>	500	5.2			
Hard sticky shale	Blk, Gray	500	578	78			
Hard shale Tan	Gray, Blk	578	649	71			
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C		En	terprises, Inc.	



DRILLERS LOG

Drilled for <u>DNR</u> D	<u>iv. of</u>	Wat	ers				ByOffice
Location of Test Hole	<u>T 10</u>	2 R	43 W	517 SE	1, SE1,	NE 4 ADD	

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______Test Hole No. <u>53-7</u>___Well No. _____

Size of test hole $6\frac{1}{2}$ Date started 9-9-96 Date completed 9-11-96 Total Hours

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FORMATIONS DRILLED								
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION				
Top soil	Black	GL	2	2				
Clay	Brown	2	60	58				
Clay Brn	Drk Gray	60	74	14				
Soft sand clay	Brn,Gray	74	86	12				
Sand	Brown	86	90	4				
Sandy clay	Gray	90	121	31				
Rock	Red	121	122	1				
Sandy clay	Gray	122	143	21				
Sand	Gray	143	1475	4 ¹ / ₂				
Sandy clay	Gray	1475	197	49 ¹ / ₅				
Sandy clay	Tan,Gray	197	260	63				
Sand (drilled fair) (60)	Gray	260	276	16				
Sandy clay	Gray	276	324	48				
Very soft sandy clay	Gray	324	352	28				
Sandy clay	Gray	352	404	52				
Shale	Drk Gray	404	480	76				
Very sandy shale Tan	Drk Gray	480	495	15				
Sample Very fine sand (drilled good) poor	Gray	495	510½	15½				
Sticky hard shale Tan	B1k,Gray	510 ¹ 5	588	77 ¹ / ₅				
Sandy shale w/lenses of sand	Blk,Gray	588	602	14				
Sand (drilled good)	Gray	602	606 ¹ 5	4 ¹ / ₅				
Sandy shale	Gray	606 ¹ 5	609	2 ¹ /2				
Sandstone	White, Grn	609	624	15				
Very sandy shale Tan,	Gray, B1k	624	651	47				
Quarsite Signed	Pink	651	659	8 Driller				

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DRILLERS LOG Drilled for __DNR_Div of waters __pq1 _____By ______Office Location of Test Hole __7 mi. W of Canby, 4 3/4 mi. S. east side of rd. _______Test Hole No. <u>87-7</u> Well No. ______

Size of test hole <u>6 3/4</u> Date started <u>10-24-96</u> Date completed <u>10-31-96</u> Total Hours

FORMATIONS DRILLED								
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION				
Top soil	Black	GL	2	2				
Soft clay w/pebbles	Brown	2	10	8				
Rock	Red	10	101/2	1				
Soft clay	Gray	1.015	41	30 ¹ / ₂				
Sand and light gravel	Gray	41	50	9				
Sandy clay	Gray	50	65	15				
Lenses of sand and clay	Gray	65	74	8				
Sandy clay	Gray	74	78	4				
Sand	Gray	78	8.2	4				
Dirty fine sand and clay	Gray	82	99	17				
Sand (took water) drilled fair	Gray	99	157	58				
Very fine sand (drilled fair)Poor sampl	eGray	157	179	22				
Coarse sand	Gray	179	199	20				
Very fine sand (no sample)	Gray	199	205	6				
Sandy clay	Gray	205	256	51				
Lenses of sand and clay	Gray	256	2.6.2	6				
Sand (drilled good)	Gray	262	266	4				
Fine dirty sand	Brown, Tan	266	278	12				
Sandy clay	Brown, Gray	278	364	86				
_Dirty sand	Gray	364	374	10				
Fine sand (drilled fair)	Gray	374	384	10				
Very fine sand (poor sample)	Gray	384	397	13				
Sandy clay-shale w/small lenses of sand	Gray	397	500	103				
Very softsandy shale	Gray	500	517	17				

UTP Enterprises. Gnc. Well Drilling	∝ FARGO, N.D. HUTCHINSON, MN.	↑ N	NWNE
		Sec	TR
	DRILLERS LOG		
Drilled for DNR Div of waters p	age 2	Ву	Office

Location of Test Hole 7 mi. W of Canby, 4 3/4 mi. S. east side of rd.

______.Test Hole No. <u>87–7</u>____Well No. ______

Size of test hole <u>6 3/4</u> Date started <u>10-24-96</u> Date completed <u>10-31-96</u> Total Hours

FORMATIONS DRILLED									
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION					
Sandy shale	Gray,B1k	577	597	80					
Very fine sand (poor sample)	Gray	597	635	38					
Lenses of very fine sand and shale	Gray,B1k	635	659	24					
Shale -rock (drilled slow) Gray,	Cologed	659	724	65					
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]-	Enterprises	v. Enc.
Well	Dr	illing	



DRILLERS LOG

Drilled for <u>DNR</u>	Div. of	Water				Ву			Office
Location of Test Hole	Approx	6 ¹ ₂ S. o	f Luverne,	MN on	Нжу	75, 4E,	35.	<u></u>	,
						Fest Hole No.	67-8	Well No	

Size of test hole 63/4 Date started 10-9-96 Date completed 10-9-96 Total Hours

FORMATIONS DRILLED								
TYPE OF FORMATION	COLOR OF FORMATION	STARTED AT WHAT DEPTH	ENDED AT WHAT DEPTH	THICKNESS OF FORMATION				
Top soil	Black	GL	2	2				
Clay	Brown	2	10	8				
Sand	Brown	10	16	6				
Sandy clay	Gray	16	48	32				
Sandy clay	Brown	48	101	53				
Sandy clay	Gray		140	39				
Hard sticky clay	Gray	140	171	31				
Soft sandy clay	Gray, Brow	<u>n 171</u>	207	36				
Lenses of clay and sand	Gray	207	219	12				
Fine sand (drilled good) THLW 6-8	Gray	219	236	17				
Sandy shale	Blk,Gray	236	326	90				
Sandy shale w/small lenses of sand	Gray,B1k	326	336	10				
Fine sand	Gray	336	340	4				
Sandy Shale	Gray,B1k	344	354	14				
Fine sand (drilled fair)	Gray	354	364	10				
Sandy shale	Gray	364	400	36				
Very soft sandy shale (brittle shale)	Gray,B1k	400	451					
Sandy Shale Gray	.Grn,White	451	489	38				

WELL OR BCRING LOCATION County Name NORCES		WELL	MINNESOTA D AND BOR Minnesota	DEPARTMENT OF HEALTH NING SEALING RECORD Statutes, Chapter 1031 Minnesota Well and Boring Sealing No. Minnesota Unique No. or W-series No. (Leave blank if not known)
Township Name Township No.	Range No.	Section No. Fr	action (sm> Ig.)	Date Sealed Date Well or Boring Constructed
DEMALD 102	41	121	1 W AL	8-28-76 8-21.96
Numerical Street Address or Fire Num	mber and City	of Well or Boring	Location	
				Depth Before Sealing 780ft. Original Depth 780ft.
Show exact location of well or boring	and and the second s	Sketch ma	p of well or boring	AQUIFER(S) STATIC WATER LEVEL
in section grid with "X".		location, s lines, road	showing property s, and buildings.	Single Aquifer I Multiaquifer
N				WELL/BORING Li Measured Li Estimated
┝╍┿╍┿╍┿╍┿╍┿╍┥	-	TIT	HOLE	
	1	IRSC	//0	
W	F	# 5.	3-1	CASING TYPE(S)
▲ → → → → → → → → → → → → → → → → → → →				Steel Plastic Tile Other
	mile			CASING
	2			Diameter Depth Set in oversize hole? Annualar space initially grouted?
S 1 mile				in. from to ft.
PROPERTY OWNER'S NAME	SF 1	nx,		In. trom to ft. U Yes U No U Yes U No U Unknown
Property owner's mailing address if differ	rent than well lo	ocation address inc	licated above.	in. from to ft. Yes No Yes No Unknown
MINN	DN	R		SCREEN/OPEN HOLE
con la		ETTE		
500 20	· · · · ·	·	/	Screen from to ft. Open Hole from to ft.
57. PA	AUC,	, MIN	1.5519	COPSTRUCTION/DEBRIS/FILL
WELL OWNER'S NAME	OF	han x .		Obstruction Debris Fill No Obstruction
Well owner's mailing address if different t	than property o	wner's address inc	licated above.	Type of Obstruction/Debris/Fill
				POMP
				Type
GEOLOGICAL MATERIAL	COLOR	HARDNESS OF FORMATION	FROM TO	Removed I Not Present I Other
If not known, indicate estimated formation	n log from near	by well or boring.		METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:
				No Annular Space Exits
<u>)</u> N			+	Annular space grouted with tremie pipe
				Casing Perforation/Removal
				in. from to ft.
· · · · · · · · · · · · · · · · · · ·				
				to ft. Perforated Hemoved
				Type of perforator
				U Other
				AIRAI A BEAGE
				Grouting Material from to to ft yards bags
		ing and a second se		from to ft, vards baos
<u>e</u>				
				from to ft yards bags
1	3. A.			from to ft varies base
				von vo vo vo va vo
REMARKS, SOURCE OF DATA, DIF	FFICULTIES I	N SEALING		UNSEALED WELLS AND BORINGS
				Other unsealed well or boring on property?
				LICENSED OR REGISTERED CONTRACTOR CERTIFICATION
				This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.
				ITPANTODISE THE QUIDE
				Contractor Business Name
				1/100 1/100 4-12.76
				Authorized Bepresentative Signature Date
				HON HEITMANEK
MPORTANT-FILE WITH PROPER	ATY H	101	116	rvame or rerson Sealing Well of Boring
HE 01404 00				1000

WELL OR BORING L	OCATION		WEU			EPARTMENT OF HEALTH Minnesota Well and Boring Sealing No. H 101117
NDBL	LS			Minnes	onin sota Sta	Statutes, Chapter 103I Minnesota Unique No. or W-series No. (leave blank if not known)
Township Name	Township N	lo. Range No.	Section No. Fr	action (sm>	lg.) D	Date Sealed Date Well or Boring Constructed
WORTH INGTON	107	2 40	29 1	GNE	NE	9-5-96 8-29-96
Numerical Street Addre		lumber and City	NE NE	NE	D	Depth Before Sealing 824ft. Original Depth 824ft.
Show exact location of in section grid with "X"	f well or borir '.	ıg	Sketch may location, s lines, roads	o of well or bo howing prop s, and building	oring A perty C gs.	AQUIFER(S) STATIC WATER LEVEL
N	X	,			° ₩ □	WELL/BORING Image: Measured imag
			1. 7	11/1	- 0	Env. Bore Hole Other ft. below above land surface
w 3			TES!	7065		
		¼ mile 7	F 53	- 2	Ļ	
	-++					CASING Diameter Denth Set in oversize hole? Appublic space initially arouted?
S 1 mile	e الج	6			_	in. from to ft.
PROPERTY OWNER		100	EM	<u>.</u>		in. from to ft. Yes No Yes No Unknown
Property owner's mailing	address if dif	ferent than well lo	ocation address ind	icated above.		in. from to ft.
50	20 6	AFAY	L++E		S	SCREEN/OPEN HOLE
- i	On.	ot in		~ ~ ~	- Lª	
			INIS	ردرد		
Well owner's mailing add	TA7		wher's address inc	V /	`_	
Well owner a mailing add		ni inan property o	wher a duress inc	icaled above.		
					- -	Turo
GEOLOGICAL MAT	TERIAL	COLOR	FORMATION	FROM 1	머니	
If not known, indicate est	timated forma	tion log from near	by well or boring.		M	METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:
						No Annular Space Exits
						Annular space grouted with tremie pipe
					C	Casing Perforation/Removal
					-	in. from to ft. Perforated Removed
						in, from to ft.
						Type of perforator
					—- <u> </u> _	U Other
					G	
					G	Grouting Material CEAREAT from C to 824 ft. 8.5 vards bags
						itom to it yatus bags
						trom to ft yards bags
		14 - 163 -				from to ft yards bags
REMARKS, SOURCE	OF DATA, I	DIFFICULTIES	N SEALING		Ū	UNSEALED WELLS AND BORINGS
					0	Other unsealed well or boring on property? 🖸 Yes 🛛 No
					l	LICENSED OR REGISTERED CONTRACTOR CERTIFICATION
		1			т tr	This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.
						170 FUXEDADISE THE SUPER
						Contractor Business Name License or Registration No.
						()m (l. 9.12.94
					A	Authorized Representative Signature Date
						Dave WEIt - AUGK
			X A A	а "а — «	\dashv	Name of Person Sealing Well or Bung
PAPERS-WELL OWN	NER COPY	H	101	117		
L						

THE OR BORING LOCATION	MINNESCTA D	EPARTMENT OF HEALTH Minnesota Weilland Borng
Tourn Name	WELL AND BOR	
1. RICE	Minnesota	Statutes, Chapter 103I or W-series No.
LOUDELS		
Dwnship Name Township No Hange		Date Well of Boning Constructed
B19160 101 46) 3 MINNUS	8-20-76 8-14-76
Numerical Street Address or Fire Number and	City of Well or Bonng Location	שרה ארה
	NW ANN SW	Depth Before Sealingft. Original Deptht
Snow exact ocation of well or bonng	Sketch map of well or boring	AQUIFER(S) STATIC WATER LEVEL
in section grid with "X"	location, showing property lines roads and buildings	Single Aquifer 🔄 Multiaquifer
<u>N</u>		WELL/BORING
		Water Supply Well C Monit Well
		Senv Bore Hole Other It Delow above land surface
Ν Ε	TESTAULE	CASING TYPE(S)
X		
	# 53-5	Steel Plastic Tile Other
<u></u>		CASING
· · · · · · · · · · · · · · · · · · ·		Diameter Depth Set in oversize hole? Annualar space initially grouted?
тіlе Ко		in from to ttYesNoYesNoUnknown
PROPERTY OWNER'S NAME	E AMAI	I IN, from to tt, Yes No Yes No Shknown
Property owner's mailing address if different than 4	vell location address indicated above	n from to # TYes No Yes No Johnown
AGIALAL DA	R	
NULLAN CIT	5 ++ 5	SCREEN/OPEN HOLE
500 CATAY		Screen from to ft. Open Hole from to ft.
ra Dal	and Same	
WELL OWNER'S NAME		
STATE OF	E ATN.	
Well owner's mailing address if different than prope	arty owner's address indicated above.	Type of Obstruction/Debns/Fill
		Obstruction/Debns/Fill removed? Yes No
		PUMP
		Туре
	HARDNESS OF	Removed Not Present Other
GEOLOGICAL MATERIAL COLOR	FORMATION FHOM TO	METHOD USED TO SEAL ANNULLAD SPACE BETWEEN 2 CASINGS OF CASING AND BORE HOLE.
If not known, indicate estimated formation log from	nearby well or boring.	
		C No Annular Space Exits
		Annular space grouted with tremie pipe
		Casing Perforation/Removal
		in. from to tt. Perforated Removed
		in. from to ft. Perforated Removed
		lype of perforator
		GROUTING MATERIAL(S)
		NEAT D DDS 9
	- <u> </u> <u> </u> <u> </u>	Grouning Material from to It yards bags
		from to ft varie base
		yarus Dags
		from to ft yards bags
	F. Fel	from to ft yards bags
REMARKS, SOURCE OF DATA DEFECT		LINDEALED WELLS AND BORINGS
		I LIVENDER UM MENND I EMER UM I MAG I UM GENTI MUCHT
		This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is
		true to the best of my knowledge.
		ITO & scoop's + Ques
		LITERDRIES INC 71686
		(1) (1)
		Autorized Representative Schedure
		Due the THANSK
		The of Person Section Well or Blanding
MPORTANT-FILE WITH PROPERTY	I 101118	
HE 01424 CO		
		10/95R

	, vontre_00 - A 0	EPARTMENT OF HEALTH Minnesota Weilland Bonnd
County Name	WELL AND BOR	ING SEALING RECORD Sealing No. H 101119
2155	Minnesota	Statutes, Chapter 103I or W-series No
NUBLES		28849 biank fror krown.
Township No Range No.	Section NC =raction sm → ig.)	Date Sealed Date Well of Bonng Constructed
LCRAIN 102 39	52 NOUNEN	<u>x-14-76</u> x-6-76
Numerical Street Address or Fire Number and City	of Well or Boring Location	77/ 77/
		Depth Before Sealingft. Original Depthft
Show exact location of well or boring	Sketch map of weil or boring	AQUIFER(S) STATIC WATER LEVEL
in section grid with "X"	location, showing property lines roads and buildings	Single Aquifer 🔄 Multiaguifer
N	in ea, roada, and bonango	WELL/BORING
6 X		🖸 Water Supply Well 🔄 Monit: Well
	$L_{-} \neq L/I_{E}$	Env. Bore Hole Cother t. Colection Surface
w	Est role	CASING TYPE(S)
•	(~ 7 1)	
#	:53.7	Steel Plastic Tile Other
····	· ·	CASING
		Diameter Depth Set in oversize noie? Annualar space initially grouted?
5 1 mile 4		in, from to ft;Yes NoYes NoUnknown
PROPERTY OWNER'S NAME	~ ~ ~ · ·	In from to ft.
Property owner's mailing address if different than well 's	cation address indicated above	In from to ft 🗌 Yes 🗍 No 🗍 Yes 💭 No 🗍 Unknown
	A	
	++5	SCREENOPEN HOLE
SOU LAFAYE		Screen from to ft. Open Hole from to ft.
ST Part A	AL EFIC	OBSTRUCTION/DEBRIS/FILL
	(1) (2) (1)	
State of	IN.	
Well owner's mailing address if different than property o	wner's address indicated above.	Type of Obstruction/Debns/Fill
		PUMP
		Туре
	HARDNESS OF FROM TO	Removed Not Present Other
	FORMATION FROM TO	METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE:
If not known, indicate estimated formation log from near	by well or boring.	
		Annular space grouted with treme pipe
		Casing Perforation/Removal
		in. from to ft. Perforated Removed
		in. from to ft. Perforated [] Removed
		Time of partnerster
		GROUTING MATERIAL(S)
		GROUTING MATERIAL(S) MEAT GROUTING MATERIAL(S) MEAT Grouting Material CENTERNAL IN DIA Statement CENTERNAL IN DIA MEAT
		GROUTING MATERIAL(S) GROUTING MATERIAL(S) Grouting Material CEMERT from to 226 ft. 7.5 yards bags
		Other GROUTING MATERIAL(S) GROUTING Material CEMERT from to 726 tt. 7,5 yards bags from to tt. yards bags
		Other GROUTING MATERIAL(S) GROUTING MATERIAL(S) Grouting Material CEMENT from to tt yards bags from to tt yards bags
		GROUTING MATERIAL(3) Grouting Material
		GROUTING MATERIAL(S) Grouting Material MEAT from to tt. yards bags
		GROUTING MATERIAL(S) Grouting Material MEAT from to tt. yards bags
REMARKS, SOURCE OF DATA, DIFFICULTER		GROUTING MATERIAL(S) GROUTING MATERIAL(S) Grouting Material NEAT from to 10 7.5 yards bags
REMARKS, SOURCE OF DATA, DIFFICULTIES		GROUTING MATERIAL(S) GROUTING MATERIAL(S) Grouting Material CLARKAT from to To to to tt. yards bags trom to tt. yards bags UNSEALED WELLS AND BORINGS Other unsealed well or boring on property? Yee No
REMARKS, SOURCE OF DATA, DIFFICULTIES		GROUTING MATERIAL(S) GROUTING MATERIAL(S) Grouting Material CLARKAT from to 7_5 yards bags from to ft yards bags ft yards bags ft yards bags to ft yards bags to ft yards bags to ft yards bags to ft bags to
REMARKS, SOURCE OF DATA, DIFFICULTIES		GROUTING MATERIAL(S) GROUTING MATERIAL(S) Grouting Material CLARKAT from to to Z_6 ft yards bags from to ft bags
REMARKS, SOURCE OF DATA, DIFFICULTIES		Other GROUTING MATERIAL(S) GROUTING MATERIAL(S) Grouting Material CELECAT from to Tt. Yards bags from to ft. yards bags from ft. yards bags from ft. yards bags from to ft. yards bags from ft. yards bags ft. yards ft. yards ft. yards ft.
REMARKS, SOURCE OF DATA, DIPFICULTIES		GROUTING MATERIAL(S) GROUTING MATERIAL(S) Grouting Material
REMARKS, SOURCE OF DATA, DIPFICULTIES		
REMARKS, SOURCE OF DATA, DIFFICULTIES		Other GROUTING MATERIAL(S) GROUTING MATERIAL(S) GROUTING MATERIAL(S) Grouting Material CLARKAT from to T
REMARKS, SOURCE OF DATA, DIFFICULTIES		Other GROUTING MATERIAL(S) GROUTING MATERIAL(S) Grouting Material CLARKAT from to 26 ft. 75 yards bags from to ft. yards bags from ft. yards bags ft. yards ft. yards ft. yards bags ft. yards ft.
REMARKS, SOURCE OF DATA, DIFFICULTIES		Contractor Busineer from Line Contractor Central Contractor Busineer from Line Contractor Registration No.
REMARKS, SOURCE OF DATA, DIFFICULTIES		Other GROUTING MATERIAL(3) Grouting Material CEMPERAT from to 226 ft. 7.5 yards bags from to ftyardsbags to
REMARKS, SOURCE OF DATA, DIFFICULTIES		GROUTING MATERIAL(S) GROUTING MATERIAL(S) Grouting Meterial CEPTERT from
REMARKS. SOURCE OF DATA, DIFFICULTIES		GROUTING MATERIAL(S) GROUTING MATERIAL(S) Grouting Material CEREAT from to 226 ft. 7_5 yards bags from to ft yards bags from to ft yards bags from to ft yards bags from to ft yards bags UNNEALED WELLS AND BORENGE Other unsessied well or boring on property? Yes No LICENSED ON REGENTERED CONTRACTOR CERTIFICATION This well or boring was asseled in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge. L.T.P. ENTERPORISES FINE License or Registration No. Contractor Busineer Normal Authorized Replectifiers Signater Date Date
REMARKS, SOURCE OF DATA, DEFICULTIES		GROUTING MATERIAL(8) GROUTING MATERIAL(8) Grouting Material CEREAT from to 226 ft. 7_5 yards bags from to ft yards bags from to ft yards bags from to ft yards bags from to ft yards bags UNSEALED WELLS AND BORENOG Other unisested well or boring on property? Yes No LICENSED ON REGISTERED CONTRACTOR CERTIFICATION This well or boring was esseled in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge. <i>L.T.P. E.N.T.E.D.P.R.S.L.S. J.N.C.</i> <i>License or Registration No.</i> <i>License or Registration No.</i> <i>Date</i> <i>Date</i> <i>Date</i> <i>Method Person Sealing Well or Bring</i>
REMARKS, SOURCE OF DATA, DEFICULTIES		GROUTING MATERIAL(S) GROUTING Material GROUTING Material GENERAT from to t. 7, 5 yards bags from to ft yards bags from to ft yards bags from to ft yards bags UNGEALED WELLS AND BORINGS Other unsealed will or boring on property? Yes No LICENSED ON REGENTENED CONTRACTOR CENTERCATION This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is rue to the best of my knowledge. <i>L</i>

		-, ·	MINNESOTA D	FPARTMENT OF HEALTH	Menancia Menand Rossa
WELL OR BORING LOCATION	N	WEII			Sealing No. H 101139
Sounty Name		WELL		ING SEALING RECORD	Minnesota Unique No
Knck			Minnesota	Statutes. Chapter 103/	
Township Name Township	o No. Range No	Section No. Fra	action (sm> ig.)	Date Sealed	Date Well or Bonng Constructed
Bibhan	2 111	200	مذرس علا و مر علام	10 22 51	10 22 96
CRILK 10	<u> 76</u>		E Yu Su	10-23-16	10-22-70
Numerical Street Address of Fire	e Number and City	of Well or Boring	Location	1100	400
	-			Depth Before Sealing	ft Orginal Depthft.
Show exact location of well or bo	onng	Sketch map	o of well or boring	AQUIFER(S)	STATIC WATER LEVEL
in section grid with "X"		location. s	howing property	📃 Single Aquifer 📃 Multiaquifer	
×i		11 63. 10463	, and bandings.	WELL/BORING	Measured Estimated
				📃 Water Supply Weii 📃 Monit. Weii	
	,	~ ,	111	Env Bore Hole Other	ft. 🔤 below 📃 above land surface
		es/ /	uce	CASING TYPE(S)	
W			,		
	- 1	± 6 /	-1	Steel C Plastic Tile C Other	
				CASING	
X				Diameter Depth	Set in oversize hole? Annualar space initially grouted?
S					
1 mile	- 4 %			to to	
PROPERTY OWNER'S NAME				in from to	ft Tyes No Yes No Unknown
STATE	OF	MIN	A.		
Property owner's mailing address if	different than well i	ocation address indi	cated above	in. from to	ft. 🗌 Yes 📄 No 📄 Yes 📄 No 📃 Unknown
min	4. DI	$\langle \mathcal{R} \rangle$		SCREEN/OPEN HOLE	
can 1	AFAL	ETTE			
200 5	· · · · · · · · · · · · · · · · ·	_		Screen from to	ft. Open Hole from to ft.
57 L	PAUC.	MAN	55155	OBSTRUCTION/DEBRIS/FILL	· · · · · · · · · · · · · · · · · · ·
WELL OWNER'S NAME	1/1				
STATE	OFI	A inins	•		: No Obstruction /
Well owner's mailing address if diffe	erent than property of	wher's address indi	cated above.	Type of Obstruction/Debris/Fill	
					2
				Obstruction/Debris/Fill removed?	es 📋 No
				PUMP	
				Туре	
· · · · · · · · · · · · · · · · · · ·		HARDNESS OF			Dther
GEOLOGICAL MATERIAL	COLOR	FORMATION	FROM TO		
If not known, indicate estimated for	mation log from nea	rby well or boring.		THE INUU USED TO SEAL ANNULAR SP	AUE DE I WEEN 2 CASINGS, UN CASING AND BURE HOLE:
				No Annular Space Exits	
· · · · · · · · · · · · · · · · · · ·				Annular space grouted with tremie pip	e
				Casing Perforation/Removal	
				in from	
				in. from	to ft.
				in. from	to ft.
				in. from	to ft.
				in. from in. from Type of perforator	to ft.
				in. from in. from Type of perforator	to ft. Perforated Removed ft. Perforated Removed
				in. from in. from Type of perforator	to ft. Perforated Removed to ft. Perforated Removed
				in. from in. from Type of perforator Other GROUTING MATERIAL(S)	to ft. Perforated Removed to ft. Perforated Removed
				in. from in. from Type of perforator Other GROUTING MATERIAL(3) N € D ↑	
				in. from Type of perforator Other GROUTING MATERIAL(S)	to ft.
				in. from Type of perforator Other GROUTING MATERIAL(S)	to ft.
				in. from Type of perforator Other GROUTING MATERIAL(S) MEAT Grouting Material Grouting Material	to ft.
				in. from Type of perforator Other GROUTING MATERIAL(S) MEAT Grouting Material Grouting Material	to ft.
				in. from	to ft.
				in. from	to ft.
				in. from Type of perforator Other GROUTING MATERIAL(S) MEAT Grouting Material 	to ft.
				in. from Type of perforator Other GROUTING MATERIAL(S)	to ft.
REMARKS, SOURCE OF DATA	A, DIFFICULTIES	N SEALMQ		in. from Type of perforator Grouting Material Grouting Material UNSEALED WELLS AND BORENGS	to ft.
REMARKS, SOURCE OF DATA	A, DIFFICULTIES	N SEALMQ		in. from Type of perforator GROUTING MATERIAL(S) Grouting Material UNSEALED WELLS AND BORENGS Other unsealed well or boring on property	to ft.
REMARKS, SOURCE OF DATA	A, DIFFICULTIES	N SEALING		in. from Type of perforator GROUTING MATERIAL(S) M & A T Grouting Material UNSEALED WELLS AND BORENGS Other unsealed well or boring an propertif LICENSED OR INCONSTRACE	to ft.
REMARKS, SOURCE OF DATA	A, DIFFICULTIES	N SEALING		in. from Type of perforator GROUTING MATERIAL(S) M & A T Grouting Material UNSEALED WELLS AND SORINGS Other unsealed well or boring an property LICENSED OR INCONSTRACE This well or boring was sealed in according	to
REMARKS, SOURCE OF DATA	A, DIFFICULTIES	N SEALMQ		in. from	to ft.
REMARKS, SOURCE OF DATA	A, DIFFICULTIES	N SEALING		in. from Type of perforator Grouting Material Grouting Material UNSEALED WELLS AND SORINGS Other unsealed well or boring an property LICENSED OR INCLISTICATION This well or boring was sealed in accordiat true to the bast of my knowledge.	to ft.
REMARKS, SOURCE OF DATA	A, DIFFICULTIES	N SEALMQ			to ft.
REMARKS, SOURCE OF DATA	A, DIFFICULTIES	N SEALING			to ft.
REMARKS, SOURCE OF DATA	A, DIFFICULTIES	N SEALING			to ft.
REMARKS, SOURCE OF DATA	A, DIFFICULTIES	N SEALMQ			to ft. \Box Perforated \Box Removed to ft. \Box Perforated \Box Removed T from to $\underline{4000}$ ft. $\underline{33}^{2}$ Hyards bags \Box from to $\underline{4000}$ ft. $\underline{33}^{2}$ Hyards bags \Box from to $\underline{4000}$ ft. $\underline{33}^{2}$ Hyards bags \Box from to $\underline{11}$ H yards bags \Box TOR CENTRECATION Ince with Minnesota Rules, Chapter 4725. The information contained in this report is \Box \Box \Box \Box \Box \Box \Box \Box \Box \Box
REMARKS, SOURCE OF DATA	A, DIFFICULTIES	N SEALMQ			to
REMARKS, SOURCE OF DATA	A, DIFFICULTIES	N SEALING			tott. \Box Perforated \Box Removed tott. \Box Perforated \Box Removed page fromttott. \Box page fromttott. \Box page fromttott. \Box page tott. \Box page TOR CENTIFICATION nce with Minnesota Rules, Chapter 4725. The information contained in this report is Define \Box tottotteres for the performation NO . \Box \Box \Box \Box \Box \Box \Box \Box \Box \Box
REMARKS, SOURCE OF DATA	A, DIFFICULTIES	N SEALING			to ft. \Box Perforated \Box Removed to ft. \Box Perforated \Box Removed Throw \Box to $\underline{1000}$ ft. $\underline{3^{3}}$ Hyards $\underline{}$ bags \Box from $\underline{}$ to $\underline{1000}$ ft. $\underline{3^{3}}$ Hyards $\underline{}$ bags \Box from $\underline{}$ to $\underline{100}$ ft. $\underline{}$ yards $\underline{}$ bags \Box from $\underline{}$ to $\underline{}$ ft. $\underline{}$ yards $\underline{}$ bags \Box from $\underline{}$ to $\underline{}$ ft. $\underline{}$ yards $\underline{}$ bags \Box from $\underline{}$ to $\underline{}$ ft. $\underline{}$ yards $\underline{}$ bags \Box from $\underline{}$ to $\underline{}$ ft. $\underline{}$ yards $\underline{}$ bags \Box from $\underline{}$ to $\underline{}$ ft. $\underline{}$ yards $\underline{}$ bags \Box TOR CENTIFICATION Ince with Minnesota Rules, Chapter 4725. The information contained in this report is Datis f f f f f f f f f f f f f f f f f f f
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Township Name Township	No. Range No	Section No. Fra	action (sm. 🔶 ig.)	Date Sealed Date Well or Boring Constructed
UDWARNK' IC	1:44	32 5	eses z	c 10-10-76 10-9-76
Nomenca: Street Address or Fire	Number and City	y of Well or Boring	Location	
Show exact location of well or boil	ng	Sketch mar	of well or bonng	AQUIFER(S) STATIC WATER LEVEL
Sector give with A		ines, roads	, and buildings.	WELL/BORING
	_			Water Supply Well Monit, Well
		· · ·	4.16	Serv Bore Hole G Other ft G below G above land surface
w	<u>i</u> 1	151 1	TCLE	CASING TYPE(S)
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STATE	OF	Min	N.	
Property owner's mailing address if o	interent than well I		cated above.	
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				Other unsealed well or boring on property? Yes No
				LICENSED OR REGISTERED CONTRACTOR CERTIFICATION
				This well or boring was seeled in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.
,				LTP ENTERPRISES, INC. 91686
				Contractor dusinees Name / License or Registration No.
				1' 1/a Pun - 11-11-96
				Authorized Representative Signature Date
				1), ble it an auge
				Hernard Person Seeling Well or Bortrag
PAPERS-WELL OWNER COP	YEH: 7 H	1011	136	· · ·
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