Site Suitability Review of the Bauer Landfill

by
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North Dakota State Water Commission
and
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North Dakota Geological Survey

Prepared by the
North Dakota State Water Commission
and the
North Dakota Geological Survey

ND Landfill Site Investigation No. 6

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BAUER LANDFILL

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TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

LIST OF FIGURES

INTRODUCTION

Purpose

The North Dakota State Engineer and the North Dakota State Geologist were instructed by the 52nd State Legislative Assembly to conduct site-suitability reviews of the municipal landfills in the state of North Dakota. These reviews are to be completed by July 1, 1995 (North Dakota Century Code 23-29-07.7). The purpose of this program is to evaluate site suitability of each landfill for disposal of solid waste based on geologic and hydrologic characteristics. Reports will be provided to the North Dakota State Department of Health and Consolidated Laboratories (NDSDHCL) for use in site improvement, site remediation, or landfill closure. Additional studies may be necessary to meet the requirements of the NDSDHCL for continued operation of municipal solid waste landfills. The Bauer solid waste landfill is one of the landfills being evaluated.

Location of the Bauer Landfill

The Bauer solid waste landfill is located one mile south and 1.5 miles east of the City of Wilton in Township 142 North, Range 79 West, SW 1/4 Section 6 (Fig. 1). The landfill site encompasses approximately 25 acres, all of which has been used.

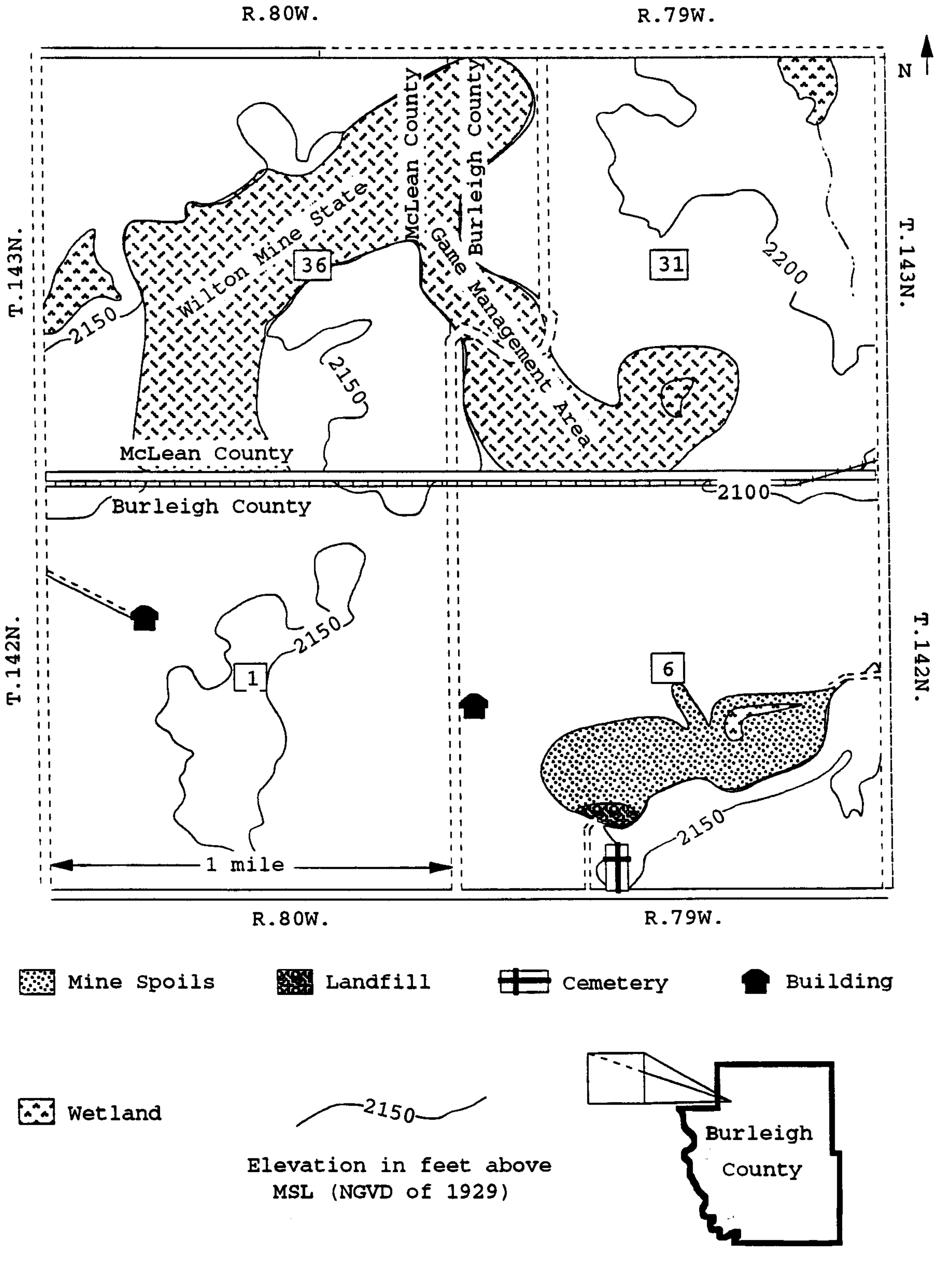

Figure 1. Location of the Bauer landfill in the SW 1/4 of section 6, T142N, R79W.

Previous Site Investigations

No previous geological or hydrological investigations have been completed at the Bauer landfill. Water-quality analyses were taken from surface-water impoundments in 1980 by the previous owner.

Methods of Investigation

The Bauer study was accomplished by means of: 1) test drilling; 2) construction and development of monitoring wells; 3) collecting and analyzing water samples; and 4) measuring water levels. Well abandonment procedures were followed for non-permanent monitoring wells.

Test Drilling Procedure

The drilling method at the Bauer landfill was based on the site's geology and depth to ground water, as determined by the preliminary evaluation. A hollow-stem auger was used at the Bauer landfill because the sediments were poorly consolidated and because the depth to the water table was expected to be less than 70 feet. The lithologic descriptions were determined from the drill cuttings.

Monitoring Well Construction and Development

Six test holes were drilled at the Bauer landfill, and monitoring wells were installed in five of the test holes. The number of wells installed at the Bauer landfill was based on the geologic and topographic characteristics of the site. The depth and intake interval of each well was selected to monitor the water level at the top of the uppermost aquifer. The wells were located near the active area of the landfill.

Wells were constructed following a standard design (Fig. 2) intended to comply with the construction regulations of the NDSDHCL and the North Dakota Board of Water Well Contractors (North Dakota Department of Health, 1986). The wells were constructed using a 2-inch diameter, SDR21, polyvinyl chloride (PVC) well casing and a PVC screen, either 5 or 10 feet long, with a slot-opening size of 0.012 or 0.013 inches. The screen was fastened to the casing with stainless steel screws (no solvent weld cement was used). After the casing and screen were installed into the drill hole, the annulus around the screen was filled with No. 10 (grain-size diameter) silica sand to a height of two feet above the top of the screen. High-solids bentonite grout and/or neat cement was placed above the silica sand to seal the annulus to approximately five feet below land surface. The remaining annulus was filled with drill cuttings. The permanent wells

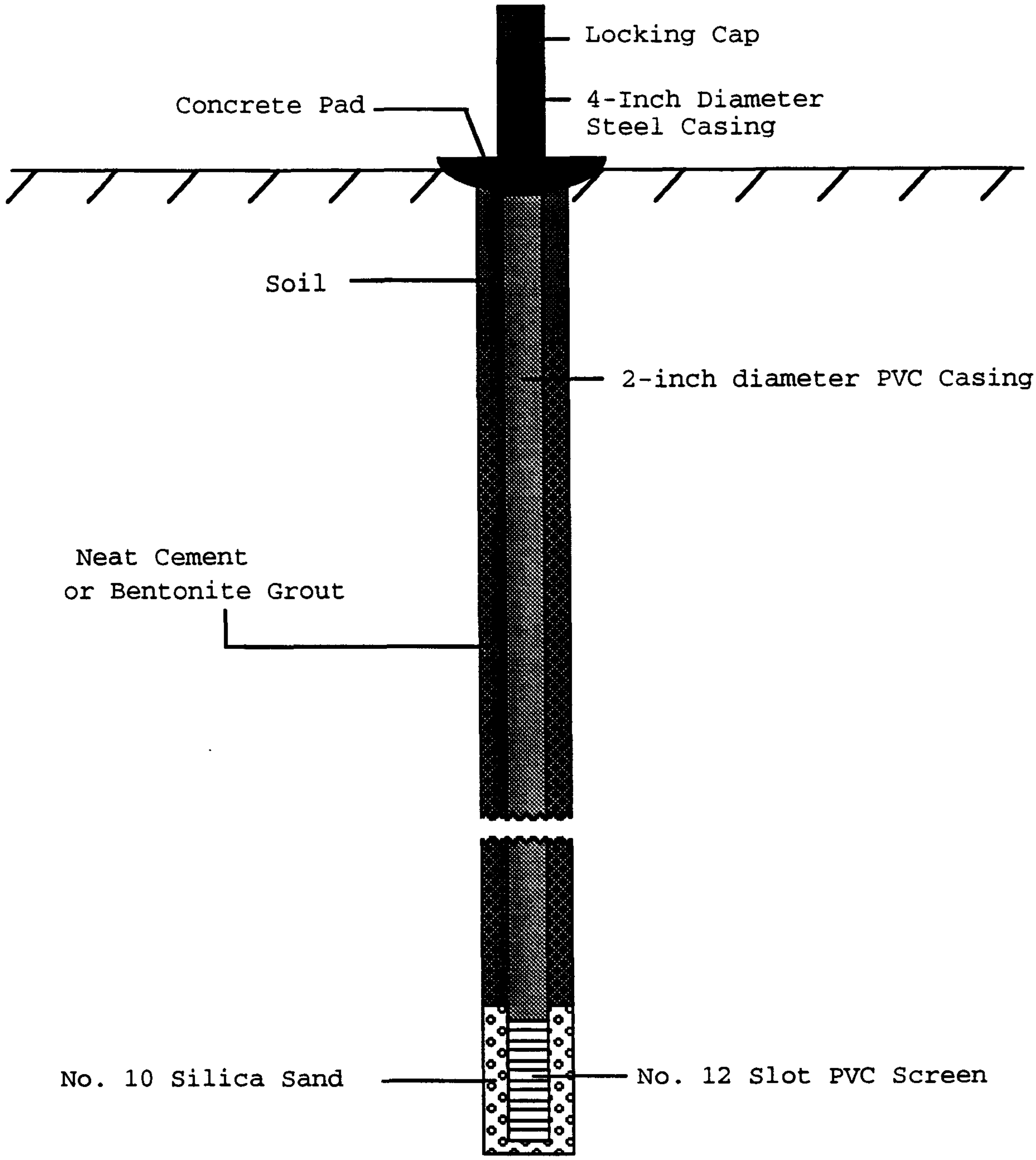

Figure 2. Construction design used for monitoring wells installed at the Bauer landfill.

were secured with a protective steel casing and a locking cover protected by a two-foot-square concrete pad.

All monitoring wells were developed using a stainless steel bladder pump or a teflon bailer. Any drilling fluid and fine materials present near the well were removed to insure movement of formation water through the screen.

The Mean Sea Level (MSL) elevation was established for each well by differential leveling to Third Order accuracy. The surveys established the MSL elevation at the top of the casing and the elevation of the land surface next to each well.

Collecting and Analyzing Water Samples

Water-quality analyses were used to determine if leachate is migrating from the landfill into the underlying ground-water system. Selected field parameters, major ions, and trace elements were measured for each water sample. These field parameters and analytes are listed in Appendix A with their Maximum Contaminant Levels (MCL). MCLs are enforcable drinking water standards and represent the maximum permissible level of a contaminant as stipulated by the U.S. Environmental Protection Agency (EPA).

Water samples were collected using a bladder pump constructed of stainless steel with a teflon bladder. A teflon bailer was used in monitoring wells with limited transmitting capacity. Before sample collection, three to four well volumes were extracted to insure that unadulterated formation water was sampled. Four samples from each well were collected in high density polyethylene plastic bottles as follows:

1) Raw (500 ml)
2) Filtered (500 ml)
3) Filtered and acidified (500 ml)
4) Filtered and double acidified (500 ml)

The following parameters were determined for each sample. Specific conductance, pH, bicarbonate, and carbonate were analyzed using the raw sample. Sulfate, chloride, nitrate, and dissolved solids were analyzed using the filtered sample. Calcium, magnesium, sodium, potassium, iron, and manganese were analyzed from the filtered, acidified sample. Cadmium, lead, arsenic, and mercury were analyzed using the filtered double-acidified samples.

One well was sampled for Volatile Organic Compounds (VOC) analysis. This sample was collected at a different time than the standard water quality sample. The procedure used for collecting the VOC sample is described in Appendix B. Each sample was collected with a plastic throw-away bailer and kept chilled. These samples were analyzed within the permitted 14-day holding period. The standard water-quality analyses were performed at the North Dakota State Water Commission (NDSWC) Laboratory and VOC analyses were performed by the NDSDHCL.

Water-Level Measurements

Water-level measurements were taken at least three times at a minimum of two-week intervals. The measurements were taken using a chalked-steel tape or an electronic (Solnist 10078) water-level indicator. These measurements were used to determine the shape and configuration of the water table.

Well-Abandonment Procedure

The test holes and monitoring wells that were not permanent were abandoned according to NDSDHCL and Board of Water Well Contractors regulations (North Dakota Department of Health, 1986). The soil around the well was dug to a depth of approximately three to four feet below land surface (Fig. 3) to prevent disturbance of the sealed wells. The screened interval of the well was plugged with bentonite chips to a height of approximately one foot above the top of the screen and the remaining well casing was filled with neat cement. The upper three to four feet was then filled with cuttings and the disturbed area was blended into the surrounding land surface. Test holes were plugged with high-solids bentonite grout and/or neat cement to a depth approximately five feet below land surface. The upper five feet of the test hole was filled with soil cuttings.

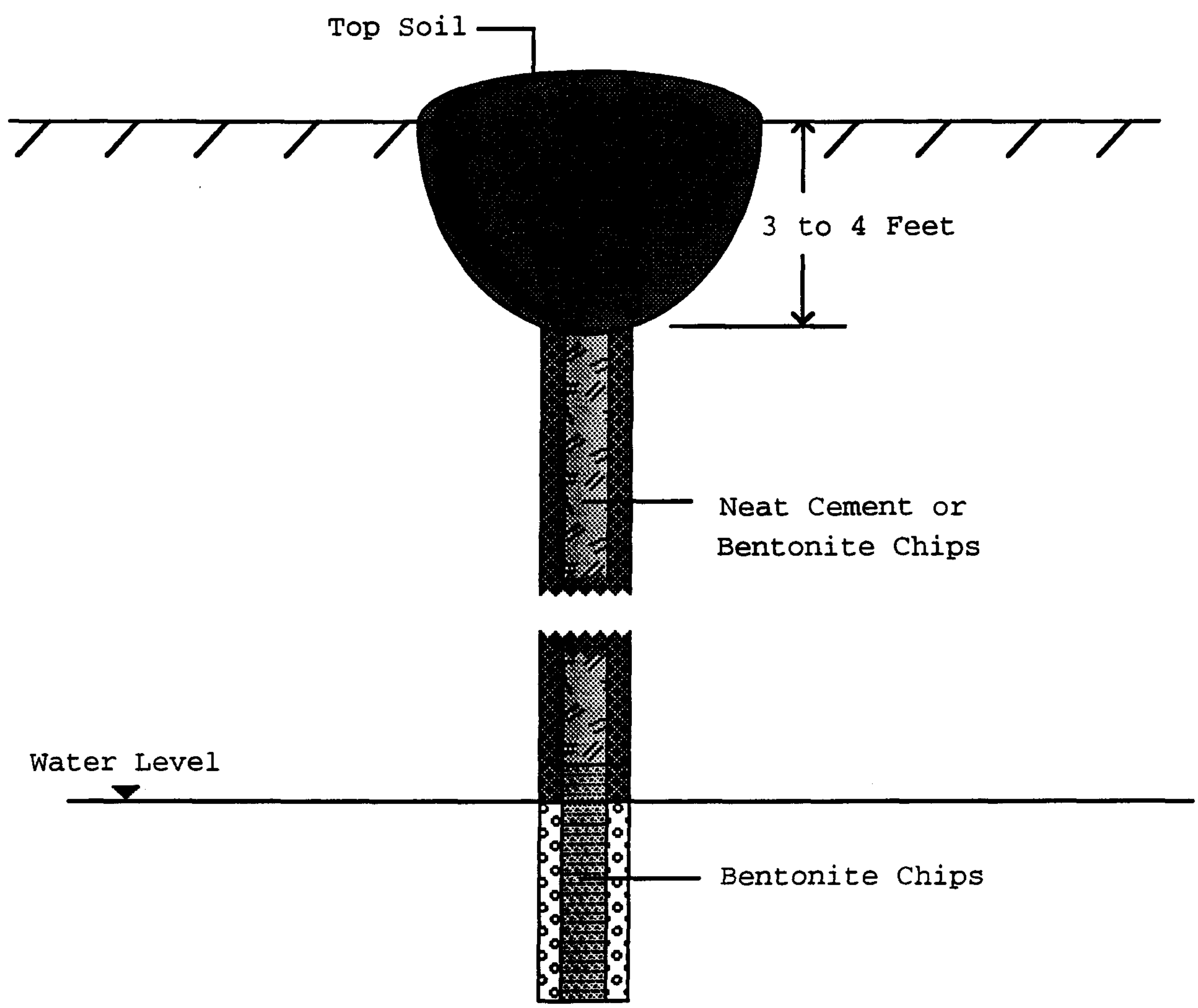

Figure 3. Monitoring well abandonment procedure.

Location-Numbering System

The system for denoting the location of a test hole or observation well is based on the federal system of rectangular surveys of public land. The first and second numbers indicate Township north and Range west of the 5th Principle Meridian and baseline (Fig. 4). The third number indicates the section. The letters A, B, C, and D designate, respectively, the northeast, northwest, southwest, and southeast quarter section (160-acre tract), quarter-quarter section (40-acre tract), and quarter-quarter-quarter section (10-acre tract). Therefore, a well denoted by 142-079-06CDD would be located in the SE1/4, SE1/4, SW1/4, Section 6, Township 142 North, Range 79 West. Consecutive numbers are added following the three letters if more than one well is located in a 10-acre tract, e.g. 142-079-06CDD1 and 142-079-06CDD2.

GEOLOGY

Regional Geology

The geologic materials in the Wilton area include glacial sediments and bedrock. A discontinuous layer of glacial drift, consisting mainly of till, is draped over the bedrock topography. The till is up to 80 feet thick and is

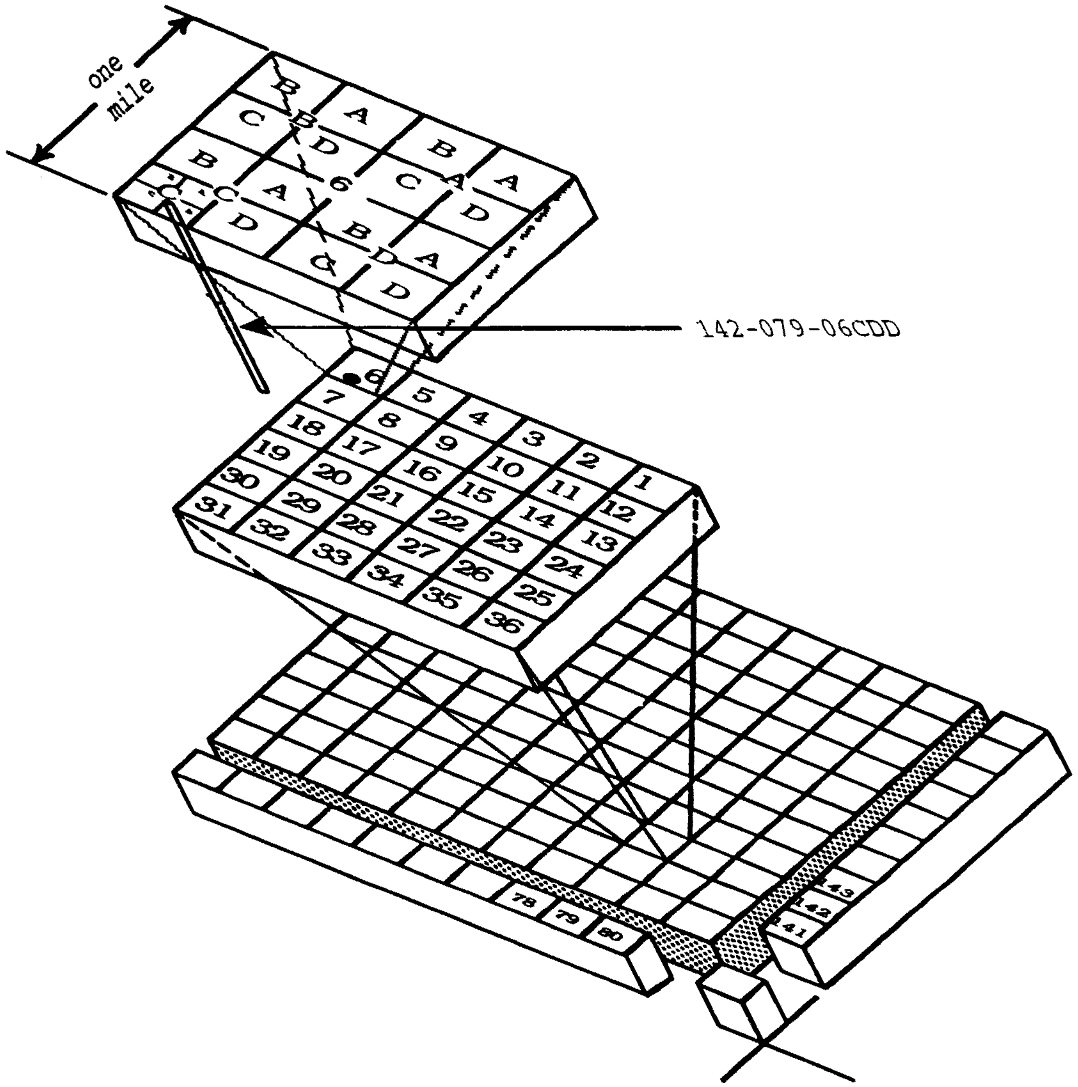

Figure 4. Location-Numbering system for the Bauer landfill.

composed of clay, silt, sand, pebbles, cobbles, and boulders. Pebble-sized and larger clasts make up about 5% of the till (Kume and Hansen, 1965).

The near-surface bedrock in the area is assigned to the Bullion Creek Formation. Although some publications (e.g., Naplin, 1979) identified the upper part of the bedrock as Sentinel Butte Formation, the latest information indicates that no Sentinel Butte sediments are present in the Wilton area (Clarence Carlson, personal communication). The Bullion Creek Formation was deposited during the Paleocene Epoch in a deltaic environment (Jacob, 1976). It is composed of sand, sandstone, silt, clay, lignite, and limestone.

Local Geology

The Bauer landfill is located in an abandoned lignite strip mine (Fig. 5). Abandoned underground mine tunnels also occur in areas surrounding the strip mine. A layer of till ranging from 40 to 60 feet thick occurs at the surface. The till is predominantly clay with varying proportions of sand, silt, pebbles, and cobbles. The till is underlain by lignite, clay, and sand of the Bullion Creek Formation.

Three test holes intersected the intact lignite bed around the perimeter of the strip mine. The lignite has an average thickness of 10 feet and is underlain by a layer of clay approximately 25 feet thick (Fig. 6). A layer of fine-

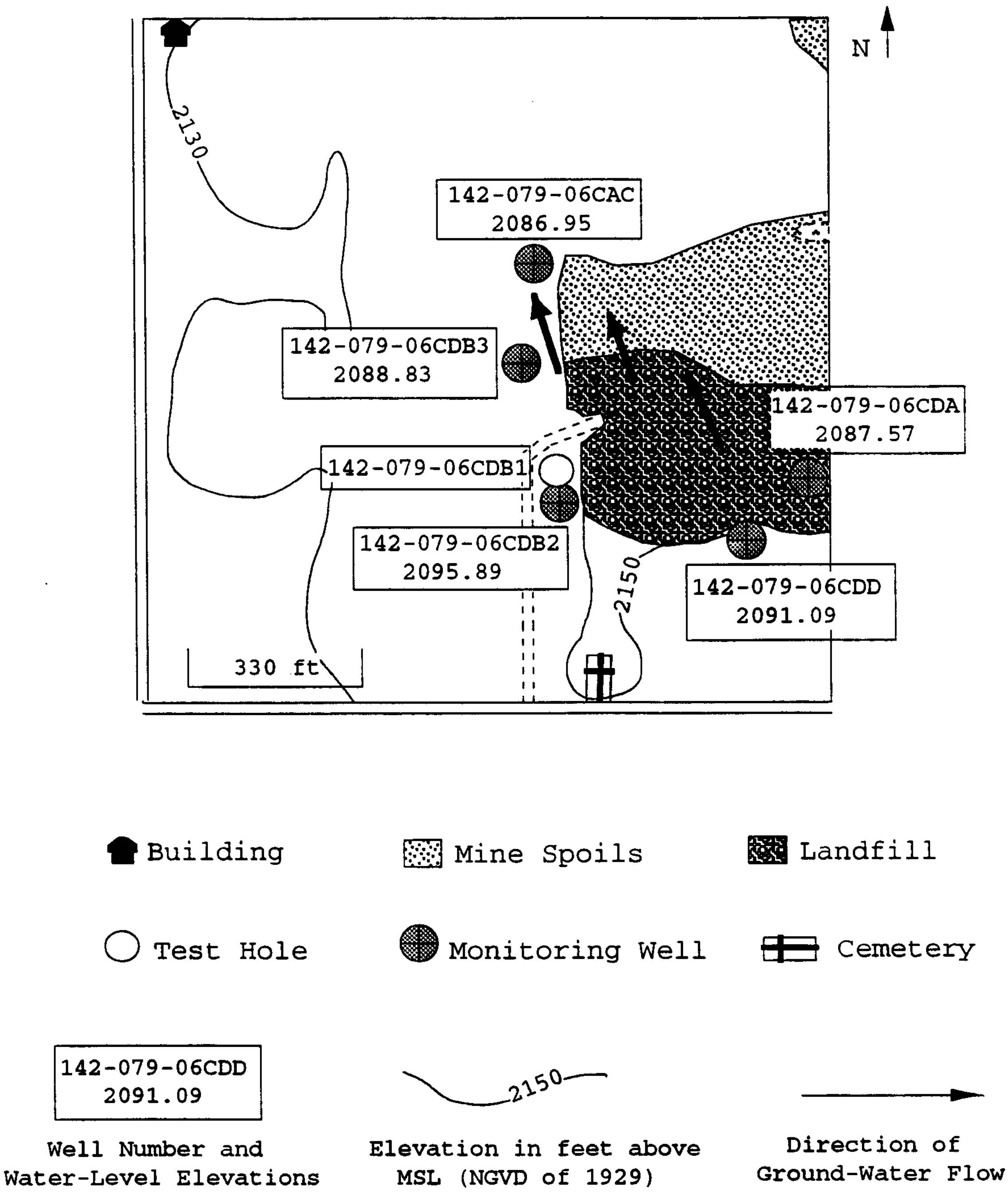

Figure 5. Location of monitoring wells and the direction of ground-water flow in the sand aquifer.

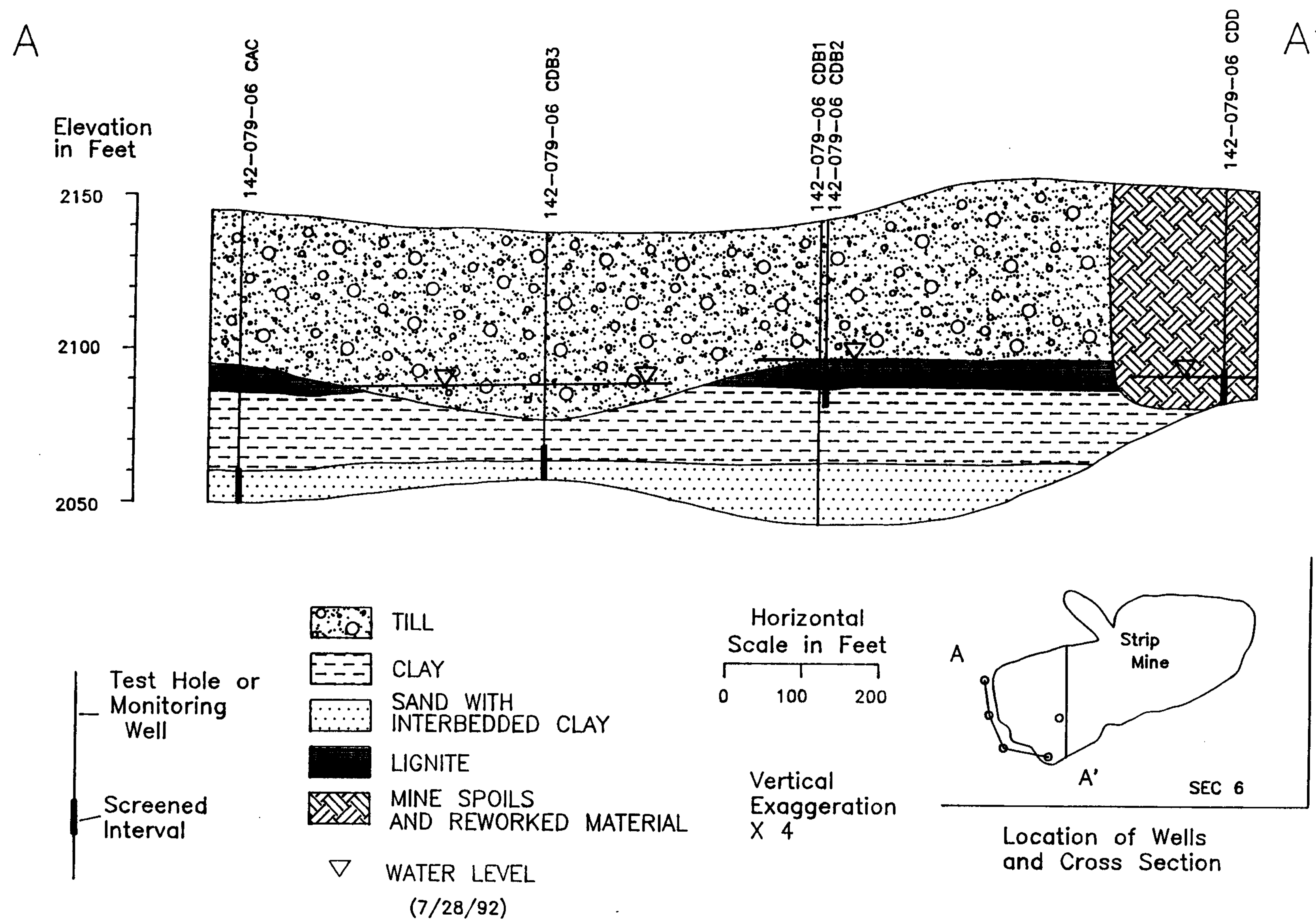

Figure 6. Geohydrologic section A–A' in the Bauer landfill

grained, silty sand with interbedded clay occurs 75 to 85 feet below the surface.

The lignite bed is absent in test hole 142-079-06CDB3 (lithologic logs in Appendix C). This hole appears to be outside of the strip mine. Apparently the lignite at this location has been removed either by pre-glacial erosion or by underground mining. Test holes 142-079-06CDA and 142-079-06CDD were drilled within the strip mine area. The spoil material in these test holes is a mixture of clay, silt, and sand with a trace of gravel and lignite fragments.

HYDROLOGY

Surface-Water Hydrology

Surface-water impoundments are located within the deep valleys created by the mine tailing piles. Runoff from the active landfill area does not appear to flow into these surface-water impoundments but rather appears to accumulate in small local depressions in the landfill cover material. Infiltration and associated leachate migration may be enhanced in these depression areas.

Regional Ground-Water Hydrology

The regional aquifers near the Bauer landfill are in bedrock formations. The domestic wells are screened in bedrock sands and lignite beds within the Bullion Creek Formation. The water from the Bullion Creek Formation is generally high in bicarbonate and sulfate (Randich, 1965). Total dissolved solids concentrations usually range from 500 to 2,000 mg/L.

In 1965 the city of Wilton drilled two wells about 1-mile northwest of the landfill that were completed in a 20-foot layer of bedrock sand. The cumulative well yield was insufficient in relation to the city's demand (Randich, 1965).

A domestic well, located 1/4 mile northwest of the landfill, is screened in the lignite bed 50 to 60 feet below land surface. This lignite bed appears to be at the same elevation as the lignite that was mined in the vicinity of the landfill.

Local Ground-Water Hydrology

Five monitoring wells were installed around the Bauer landfill boundary (Fig. 5). The well screens were placed in mine spoils, and lignite and sand of the Bullion Creek Fromation. Five water-level measurements were taken over an eight-week period (Appendix D). Wells 142-079-06CAC, 142-079-06CDA, and 142-079-06CDB3 were screened within a layer of bedrock sand about 75 feet below land surface. Water-level measurements from these wells indicated that the sand aquifer is confined and the direction of the ground-water flow is to the north-northwest.

Well 142-079-06CDB2 was screened within the layer of clay directly below a 12-foot thick lignite bed. This lignite bed did not appear to contain water at the time of drilling. There is not enough information to determine the flow direction in the clay.

Well 142-079-06CDD was screened within the mine tailings that surround the landfill. There is not enough information available to determine what hydraulic connection exists between the mine tailings and the bedrock clay. The ground-water flow direction within the mine tailings was not determined.

Water Quality

Chemical analyses of water samples are shown in Appendix E. The water quality results indicated high concentrations of sulfate, calcium, bicarbonate, and total dissolved solids (Appendix E). High concentrations of the above ions are not unusual for water in the Bullion Creek Formation.

Wells 142-079-06CDA and 142-079-06CDB3 screened in the sand aquifer, indicated high concentrations of sulfate (450 mg/L and 600 mg/L respectively), bicarbonate (767 mg/L and 306 mg/L respectively), and total dissolved solids (1220 mg/L and 1080 respectively). Well 142-079-06CAC, also screened in the sand, indicated concentrations of sulfate (190 mg/L), bicarbonate (711 mg/L), and total dissolved solids (810 mg/L). These wells range in water quality from a calcium-bicarbonate type to a calcium-bicarbonate-sulfate type. Increased sulfate may be caused by mobilization of sulfate from the mine tailings.

Well 142-079-06CDB2, screened in the clay, indicated high concentrations of calcium (310 mg/L), bicarbonate (501 mg/L), sulfate (1200 mg/L), and total dissolved solids (2,020 mg/L). The water is a calcium-sulfate type.

Well 142-079-06CDD, screened in the mine tailings, indicated concentrations of calcium (580 mg/L), sulfate (2,000 mg/L), and total dissolved solids (2,940 mg/L). The water is a calcium-sulfate type. This well also indicated increased concentrations of sodium (210 mg/L). These concentrations may be the result of weathering of the mine tailings which are predominantly comprised of sediments of the Bullion Creek Formation.

The trace element analyses indicated high strontium concentrations at all wells (>2,500 µg/L). Increased strontium can result from leaching of incineration ash, municipal waste ash, and burning pile ash. These ashes are usually found in municipal waste landfills. Well 142-079-06CDD also detected a molybdenum concentration of 118 µg/L. This concentration is 23 times higher than any other sample and above the MCL of 100 µg/L. The source of the molybdenum was not determined.

The results of the VOC analysis, from well 142-079-06CDD, are shown in Appendix F. This analysis did not detect any VOC compounds.

CONCLUSIONS

The Bauer landfill is situated in an area of glacial sediments and bedrock materials. The bedrock is assigned to the Bullion Creek Formation.

The Bauer landfill is located in an abandoned lignite strip mine. Abandoned underground mine tunnels also occur in areas surrounding the strip mine. A 40 to 60-foot thick layer of till occurs on the surface around the landfill. The till is underlain by lignite, clay and sand of the Bullion Creek Formation.

A 12-foot thick lignite bed occurs about 50 feet below land surface and overlies a layer of clay and fine-grained sand. The layer of sand appears to be saturated at three wells (142-079-06CAC, 142-079-06CDB3, and 142-079-06CDA). Water-level measurements indicated that the sand aquifer is confined and the direction of ground-water flow is to the north-northwest.

Water-level data also indicated that the clay is saturated and the mine tailings are partially saturated. The lignite layer around the landfill appeared to be unsaturated at the time of drilling.

Water-quality analyses indicated high concentrations of sulfate, calcium, bicarbonate, and total dissolved solids in the sand, clay , and mine tailing. High concentrations of the above ions are not unusual for water within the Bullion Creek Formation. Within the study area, the upper sand and clay of the Bullion Creek Formation is characterized by a calcium-bicarbonate and calcium-sulfate type water.

Trace element analyses indicated elevated concentrations of strontium and molybdenum. The source of these trace elements was not determined. No VOC's were detected in the VOC analysis from well 142-079-06CDD. These water quality results suggest that there has been no leachate migration downward from the landfill into the sand aquifer.

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APPENDIX A

WATER QUALITY STANDARDS
AND
MAXIMUM CONTAMINANT LEVELS

Water Quality Standards
and
Maximum Contaminant Levels

	MCL (mg/L)
Field Parameters	
appearance	color/odor
pH	6-8(optimum)
specific conductance	-----
temperature	-----
water level	-----
Geochemical Parameters	
iron	>0.3
calcium	25-50
magnesium	25-50
manganese	>0.05
potassium	------
total alkalinity	------
bicarbonate	150-200
carbonate	150-200
chloride	250
fluoride	0.7-1.2
nitrate+nitrite (N)	10
sulfate	300-1000
sodium	20-170
total dissolved solids (TDS)	>1000
cation/anion balance	------
hardness	>121 (hard to very hard)
Heavy Metals (µg/L)	
arsenic	50
cadmium	10
lead	50
molybdenum	100
mercury	2
selenium	10
strontium	*

* EPA has not set a MCL for strontium. The median concentration for most U.S. water supplies is 110 µg/L (Hem,1989).

APPENDIX B

SAMPLING PROCEDURE FOR VOLATILE ORGANIC COMPOUNDS

SAMPLING PROCEDURE FOR 40ML AMBER BOTTLES

Sample Collection for Volatile Organic Compounds

by
North Dakota Department of Health
and Consolidated Laboratories

1. Three samples must be collected in the 40ml bottles that are provided by the lab. One is the sample and the others are duplicates.

2. A blank will be sent along. Do Not open this blank and turn it in with the other three samples.

3. Adjust the flow so that no air bubbles pass through the sample as the bottle is being filled. No air should be trapped in the sample when the bottle is sealed. Make sure that you do not wash the ascorbic acid out of the bottle when taking the sample.

4. The meniscus of the water is the curved upper surface of the liquid. The meniscus should be convex (as shown) so that when the cover to the bottle is put on, no air bubbles will be allowed in the sample.

convex meniscus

5. Add the small vial of concentrated HCL to the bottle.

6. Scew the cover on with the white Teflon side down. Shake vigorously, turn the bottle upside down, and tap gently to check if air bubbles are in the sample.

7. If air bubbles are present, take the cover off the bottle and add more water. Continue this process until there are no air bubbles in the sample.

8. The sample must be iced after collection and delivered to the laboratory as soon as possible.

9. The 40 ml bottles contain ascorbic acid as a preservative and care must be taken not to wash it out of the bottles. The concentrated acid must be added after collection as an additional preservative.

APPENDIX C

LITHOLOGIC LOGS OF WELLS AND TEST HOLES

142-079-06CAC
NDSWC

Date Completed:	6/23/92	Well Type:	P2
Depth Drilled (ft):	95	Source of Data:	
Screened Interval (ft):	85-95	Principal Aquifer :	Undefined
Casing size (in) & Type:		L.S. Elevation (ft)	2145.08
Owner: BAUER			

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SILT	SANDY, TRACE PEBBLES, MODERATE YELLOWISH BROWN 10YR 5/4, (GLACIAL DRIFT)	1-4
CLAY	SANDY, TRACE PEBBLES AND COBBLES, MODERATE YELLOWISH BROWN 10YR 5/4	4-12
CLAY	TRACE PEBBLES AND COBBLES, MODERATE YELLOWISH BROWN 10YR5/4	12-23
CLAY	TRACE PEBBLES AND LIGNITE, OLIVE BLACK 5Y 2/1	23-48
CLAY	TRACE PEBBLES, MODERATE YELLOWISH BROWN 10YR 5/4	48-50
LIGNITE	(BULLION CREEK FORMATION)	50-58
CLAY	LIGHT GRAY N7	58-60
CLAY	GRAYISH GREEN 5G 5/2	60-80
CLAY	GRAYISH BROWN 5YR 3/2, MOIST	80-85
SAND	CLAYEY, GRAYISH BLUE GREEN 5BG 5/2	85-95

142-079-06CDA

NDSWC

Date Completed:	6/24/92	Well Type:	P2
Depth Drilled (ft):	95	Source of Data:	
Screened Interval (ft):	85-95	Principal Aquifer :	Undefined
Casing size (in) & Type:		L.S. Elevation (ft)	2141.86

Owner: BAUER

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SILT	SANDY, TRACE GRAVEL, MODERATE YELLOWISH BROWN 10YR 5/4 (MINE SPOILS)	1-3
SANDSTONE	LIGHT GRAY N7	3-6
SAND	CLAYEY, MODERATE YELLOWISH BROWN 10YR 5/4	6-11
SAND	LIGNITE FRAGMENTS, MODERATE YELLOWISH BROWN 10YR 5/4	11-15
SILT	SANDSTONE FRAGMENTS, MODERATE YELLOWISH BROWN 10YR 5/4	15-18
SILT	LIGNITE FRAGMENTS, DARK YELLOWISH BROWN 10YR 4/2	18-20
CLAY	TRACE OF GRAVEL, DARK YELLOWISH BROWN 10YR 4/2	20-24
CLAY	SANDY, TRACE GRAVEL AND LIGNITE, DARK YELLOWISH BROWN 10YR 4/2	24-41
CLAY	SANDY, DARK YELLOWISH-BROWN 10YR 4/2, DAMP	41-47
CLAY	TRACE SAND AND GRAVEL, OLIVE GRAY 5Y 4/1	47-52
CLAY	GRAYISH GREEN 5G 5/2, DAMP (BULLION CREEK FORMATION)	52-57
CLAY	GRAYISH GREEN 5G 5/2	57-65
SAND	FINE-GRAINED, MEDIUM GRAY N5	65-66
CLAY	TRACE SAND, OLIVE GRAY 5Y 4/1, DAMP	66-71

CLAY	SANDY, OLIVE GRAY 5Y 4/1	71-80
SAND	CLAYEY, GRAYISH BLUE GREEN 5BG 5/2	80-95

142-079-06CDB1

NDSWC

Date Completed:	6/22/92	Purpose:	Test Hole
Depth Drilled (ft):	95	Source of Data:	
L.S. Elevation (ft)	2142.11	Owner: BAUER	

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SILT	WITH PEBBLES AND COBBLES, MODERATE YELLOWISH BROWN (GLACIAL DRIFT)	1-3
CLAY	PALE YELLOWISH BROWN WITH WHITE MOTTLES	3-7
SILT	SANDY, MODERATE YELLOWISH BROWN 10YR 5/4	7-9
CLAY	SANDY, PALE YELLOWISH BROWN 10YR 6/2	9-13
CLAY	WITH GRAVEL AND SAND, DARK YELLOWISH BROWN 10YR 4/2	13-21
CLAY	TRACE SAND, PEBBLES, AND LIGNITE FRAGMENTS, DARK YELLOWISH BROWN 10YR 4/2	21-43
LIGNITE	(BULLION CREEK FORMATION)	43-52
CLAY	MODERATE YELLOWISH BROWN 10YR 5/4	52-54
CLAY	GREENISH GRAY 5G 6/1, DAMP	54-63
CLAY	OLIVE GRAY 5Y 2/1, DRY	63-71
CLAY	GRAYISH GREEN 5G 5/2	71-77
SAND	WITH INTERBEDDED CLAY, GRAYISH GREEN 5G 5/2	77-95

142-079-06CDB2

NDSWC

Date Completed:	6/22/92	Well Type:	P2
Depth Drilled (ft):	58	Source of Data:	
Screened Interval (ft):	53-58	Principal Aquifer :	Undefined
Casing size (in) & Type:		L.S. Elevation (ft)	2142.61

Owner: BAUER

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SILT	GRAVEL, MODERATE YELLOWISH BROWN 10YR 5/4 (GLACIAL DRIFT)	1-3
CLAY	PALE YELLOWISH BROWN WITH WHITE MOTTLES	3-7
SILT	SANDY, MODERATE YELLOWISH BROWN 10YR 5/4	7-9
CLAY	SANDY, PALE YELLOWISH BROWN 10YR 6/2	9-12
CLAY	SANDY, GRAVELLY, DARK YELLOWISH BROWN 10YR 4/2	12-20
CLAY	TRACE SAND AND PEBBLES, DARK YELLOWISH BROWN 10YR 4/2	20-41
LIGNITE	(BULLION CREEK FORMATION)	41-53
CLAY	GREENISH GRAY 5G 6/1	53-58

142-079-06CDB3

NDSWC

Date Completed:	6/24/92	Well Type:	P2
Depth Drilled (ft):	80	Source of Data:	
Screened Interval (ft):	70-80	Principal Aquifer :	Undefined
Casing size (in) & Type:		L.S. Elevation (ft)	2139.15

Owner: BAUER

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	SILTY, TRACE OF GRAVEL, MODERATE YELLOWISH BROWN 10YR 5/4 (GLACIAL DRIFT)	1-15
CLAY	SANDY, TRACE PEBBLES, MODERATE YELLOWISH BROWN 10YR 5/4	15-40
CLAY	TRACE SAND, GRAVEL, AND LIGNITE FRAGMENTS OLIVE GRAY 5Y 4/1	40-61
CLAY	TRACE SAND, OLIVE GRAY 5Y 4/1 (BULLION CREEK FORMATION)	61-68
CLAY	SANDY, OLIVE GRAY 5Y 4/1	68-74
SAND	CLAYEY, GRAYISH BLUE GREEN 5BG 5/2	74-80

142-079-06CDD

NDSWC

Date Completed:	6/23/92	Well Type:	P2
Depth Drilled (ft):	70	Source of Data:	
Screened Interval (ft):	60-70	Principal Aquifer :	Undefined
Casing size (in) & Type:		L.S. Elevation (ft)	2154.64
Owner: BAUER			

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SILT	CLAYEY, TRACE GRAVEL, MODERATE YELLOWISH BROWN 10YR 5/4 (MINE SPOILS)	1-5
SILT	TRACE GRAVEL, PALE YELLOWISH BROWN 10YR 6/2	5-9
SILT	SANDY, GRAVELLY, MODERATE YELLOWISH BROWN 10YR 5/4	9-13
CLAY	SANDY, TRACE PEBBLES, DARK YELLOWISH BROWN 10YR 4/2	13-18
SILT	CLAYEY, MODERATE YELLOWISH BROWN 10YR 5/4	18-26
CLAY	SILTY, MODERATE YELLOWISH BROWN 10YR 5/4	26-33
SILT	TRACE SAND AND CLAY, MODERATE YELLOWISH BROWN 10YR 5/4	33-37
SILTSTONE	WELL INDURATED, DARK YELLOWISH ORANGE 10YR 6/6	37-39
CLAY	SILTY, MODERATE YELLOWISH BROWN 10YR 5/4	39-48
CLAY	BROWNISH BLACK 5YR 2/1	48-50
CLAY	DUSKY YELLOW BROWN 10YR 2/2	50-56
CLAY	WITH GYPSUM CRYSTALS	56-58
CLAY	WITH IGNITE CHIPS, BLACK N1	58-63
CLAY	GRAYISH GREEN 10GY 5/2, LIGNITE CHIPS	63-66
CLAY	GREENISH GRAY 5GY 6/1, LIGNITE CHIPS	66-70

APPENDIX D

WATER-LEVEL TABLES

Bauer Water Levels
6/29/92 to 8/24/92

142-079-06CAC LS Elev (msl,ft)=2145.08

Undefined Aquifer SI (ft.)=85-95

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
06/29/92	55.42	2089.66	08/11/92	58.26	2086.82
07/07/92	57.70	2087.38	08/24/92	58.14	2086.94
07/28/92	58.13	2086.95			

142-079-06CDA LS Elev (msl,ft)=2141.86

Undefined Aquifer SI (ft.)=85-95

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
07/07/92	54.06	2087.80	08/11/92	54.43	2087.43
07/28/92	54.29	2087.57	08/24/92	53.94	2087.92

142-079-06CDB2 LS Elev (msl,ft)=2142.61

Undefined Aquifer SI (ft.)=53-58

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
06/29/92	46.60	2096.01	08/11/92	46.78	2095.83
07/07/92	46.64	2095.97	08/24/92	46.78	2095.83
07/28/92	46.72	2095.89			

142-079-06CDB3 LS Elev (msl,ft)=2139.15

Undefined Aquifer SI (ft.)=70-80

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
06/29/92	50.23	2088.92	08/11/92	50.46	2088.69
07/07/92	50.09	2089.06	08/24/92	50.34	2088.81
07/28/92	50.32	2088.83			

142-079-06CDD LS Elev (msl,ft)=2154.64

Undefined Aquifer SI (ft.)=60-70

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
06/29/92	56.15	2098.49	08/11/92	64.06	2090.58
07/07/92	59.47	2095.17	08/24/92	64.14	2090.50
07/28/92	63.55	2091.09			

APPENDIX E

MAJOR ION AND TRACE-ELEMENT CONCENTRATIONS

Bauer Water Quality

Major Ion Analyses

Location	Screened Interval (ft)	Date Sampled	SiO_2	Fe	Mn	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl	F	NO_3	B	TDS	Hardness as $CaCO_3$	NCH	% Na	SAR	Spec Cond (µmho)	Temp (°C)	pH
			(milligrams per liter)																					
142-079-06CAC	85-95	07/07/92	17	0.15	0.5	160	58	18	7.9	711	0	190	3.5	0.1	4.5	0.56	810	640	55	6	0.3	1822	12	6.86
142-079-06CDA	85-95	07/07/92	15	0.05	0.89	200	68	89	11	767	0	450	5	0.1	6.5	0.55	1220	780	150	20	1.4	1823	11	7.24
142-079-06CDB2	53-58	07/07/92	19	2	0.78	310	150	39	16	501	0	1200	13	0.1	19	1.7	2020	1400	980	6	0.5	1884	10	6.98
142-079-06CDB3	70-80	07/07/92	12	0.05	0.11	160	63	51	26	306	0	600	6.3	0.1	6.1	0.44	1080	660	410	14	0.9	1844	13	8.16
142-079-06CDD	60-70	07/07/92	4.9	0.04	0.02	580	38	210	34	45	23	2000	25	0.1	7.3	0.4	2940	1600	1500	22	2.3	3340	18	10.3

Trace Element Analyses

Location	Date Sampled	Selenium	Lead	Cadmium	Mercury	Arsenic	Molybdenum	Strontium
		(micrograms per liter)						
142-079-06CAC	7/7/92	0	0	0	0	2	4	2500
142-079-06CDA	7/7/92	0	0	0	0	3	0	2700
142-079-06CDB2	7/7/92	0	0	0	0	4	5	4300
142-079-06CDB3	7/7/92	1	0	0	0	3	0	2800
142-079-06CDD	7/7/92	3	1	0	0	7	118	6700

APPENDIX F

VOLATILE ORGANIC COMPOUNDS
FOR WELL 142-079-06CDD

Volatile Organic Compounds
and
Minimum Concentrations

Concentrations are based only on detection limits. Anything over the detection limit indicates possible contamination.

Constituent	Chemical Analysis µg/L
Benzene	<2
Vinyl Chloride	<1
Carbon Tetrachloride	<2
1,2-Dichlorethane	<2
Trichloroethylene	<2
1,1-Dichloroethylene	<2
1,1,1-Trichloroethane	<2
para-Dichlorobenzene	<2
Acetone	<50
2-Butanone (MEK)	<50
2-Hexanone	<50
4-Methyl-2-pentanone	<50
Chloroform	<5
Bromodichloromethane	<5
Chlorodibromomethane	<5
Bromoform	<5
trans1,2-Dichloroethylene	<2
Chlorobenzene	<2
m-Dichlorobenzene	<5
Dichloromethane	<5
cis-1,2-Dichloroethylene	<2
o-Dichlorobenzene	<2
Dibromomethane	<5
1,1-Dichloropropene	<5
Tetrachlorethylene	<2
Toluene	<2
Xylene(s)	<2
1,1-Dichloroethane	<5
1,2-Dichloropropane	<2
1,1,2,2-Tetrachloroethane	<5
Ethyl Benzene	<2
1,3-Dichloropropane	<5
Styrene	<2
Chloromethane	<5
Bromomethane	<5
1,2,3-Trichloropropane	<5
1,1,1,2-Tetrachloroethane	<5
Chloroethane	<5
1,1,2-Trichloroethane	<5

* Constituent Detection

VOC Constituents cont.

2,2-Dichloropropane	<5
o-Chloroluene	<5
p-Chlorotoluene	<5
Bromobenzene	<5
1,3-Dichloropropene	<5
1,2,4-Trimethylbenzene	<5
1,2,4-Trichlorobenzene	<5
1,2,3-Trichlorobenzene	<5
n-Propylbenzene	<5
n-Butylbenzene	<5
Naphthalene	<5
Hexachlorobutadiene	<5
1,3,5-Trimethylbenzene	<5
p-Isopropyltoluene	<5
Isopropylbenzene	<5
Tert-butylbenzene	<5
Sec-butylbenzene	<5
Fluorotrichloromethane	<5
Dichlorodifluoromethane	<5
Bromochloromethane	<5
Allylchloride	<5
2,3-Dichloro-1-propane	<5
Tetrahydrofuran	<50
Pentachloroethane	<5
Trichlorotrofluoroethane	<5
Carbondisufide	<5
Ether	<5

* Constituent Detection