Site Suitability Review of the Dickinson Municipal Landfill

by
Jeffrey Olson
North Dakota State Water Commission
and
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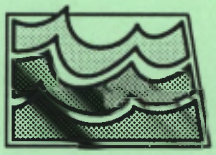

Prepared by the
North Dakota State Water Commission
and the
North Dakota Geological Survey

ND Landfill Site Investigation No. 30

SITE SUITABILITY REVIEW OF THE DICKINSON MUNICIPAL LANDFILL

By Jeffrey M. Olson, North Dakota State Water Commission,

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Bismarck, North Dakota
1994

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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 solid waste 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. A one time ground-water sampling event was performed at each site, and additional studies may be necessary to meet the requirements of the NDSDHCL for continued operation of solid waste landfills. The Dickinson municipal solid waste landfill is one of the landfills being evaluated.

Location of the Dickinson Landfill

The Dickinson municipal solid waste landfill is located five miles south of the City of Dickinson in Township 139 North, Range 95 West, SW 1/4, SE 1/4 Section 17 (Fig. 1). The landfill site encompasses approximately 45 acres of an abandoned lignite strip mine.

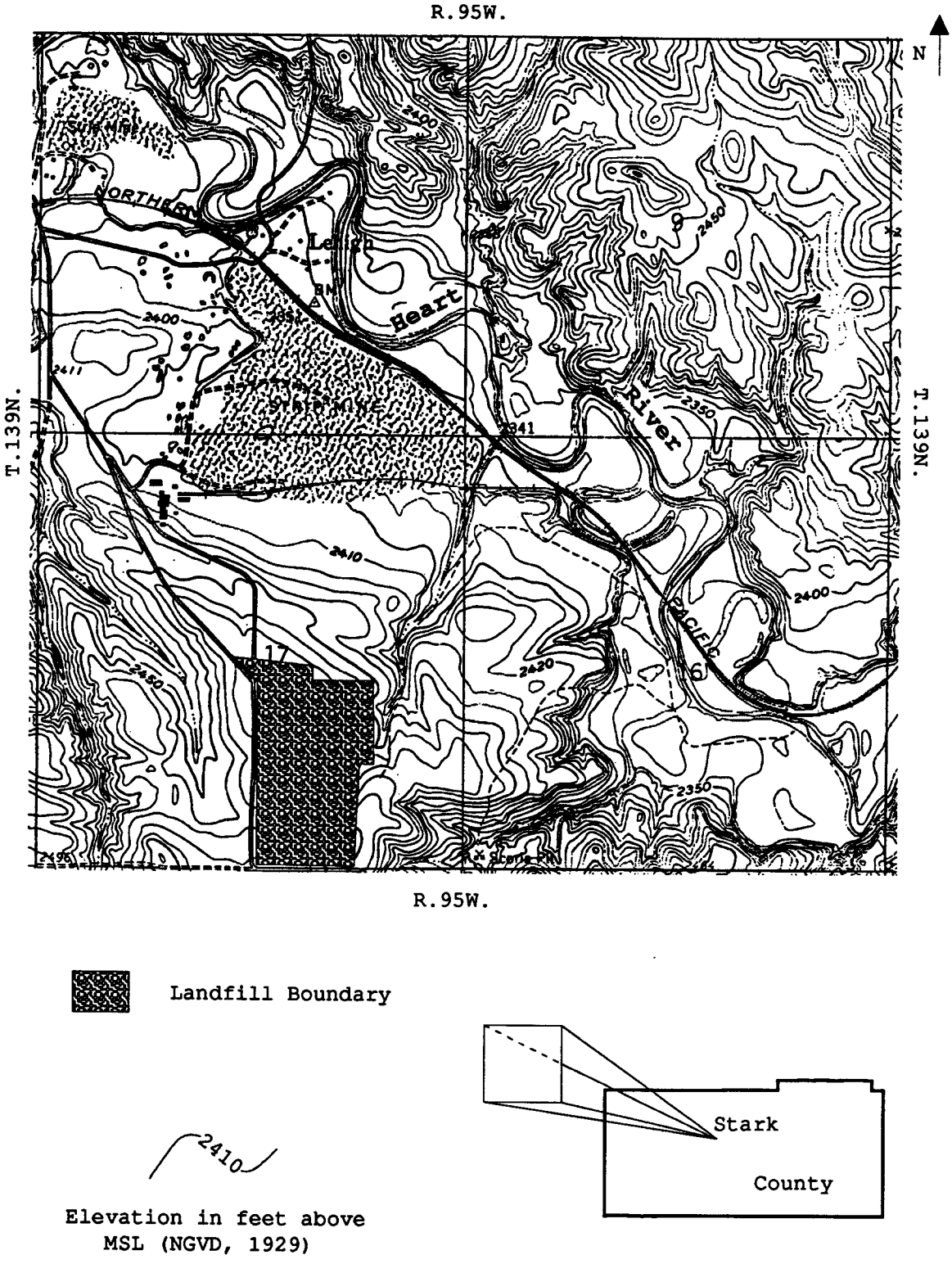

Figure 1. Location of the Dickinson municipal landfill in the SE 1/4 of section 17, T139N, R95W.

Previous Site Investigations

A geotechnical and hydrogeologic report by Braun Intertec was completed on February 3, 1992 with an addendum completed on January 18, 1993. Ten monitoring wells were installed around the perimeter of the landfill and two temporary monitoring wells were installed at the base of the strip mine. Four of the monitoring wells were screened within the Lehigh lignite bed, four were screened within the mine spoils, and four were screened in the bedrock sand beneath the Lehigh lignite. Three of the four wells screened in the Lehigh lignite were dry and three of the four monitoring wells screened in the mine spoils were also dry during Braun's study.

Conclusions drawn from Braun's report were: groundwater flow is to the east toward the Heart River, there is no apparent contaminant migration from the landfill, the bottom liner meets specifications, and the thickness of the clay liner is variable.

Water quality analyses were completed for major ions, trace elements, and VOC compounds. A pH of 9.3 was detected in well MW-30 (139-095-17DAC) during this study. No anomalously large concentrations of other analytes were detected in this study.

Methods of Investigation

The Dickinson study was accomplished by means of: 1) drilling test holes; 2) constructing and developing monitoring wells; 3) collecting and analyzing water samples; and 4) measuring water levels.

Test-Drilling Procedure

The drilling method at the Dickinson landfill was based on the site's geology and depth to ground water, as determined by the preliminary evaluation. A forward-rotary drill rig was used at the Dickinson landfill because the sediments were consolidated and because the depth to the water table was expected to be greater than 70 feet. The lithologic descriptions were determined from the drill cuttings.

Monitoring Well Construction and Development

Three test holes were drilled at the Dickinson landfill, and monitoring wells were installed in all of them. Four existing monitoring wells installed by Braun Intertec were also used in this study. The number of wells installed at the Dickinson 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 around 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 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.

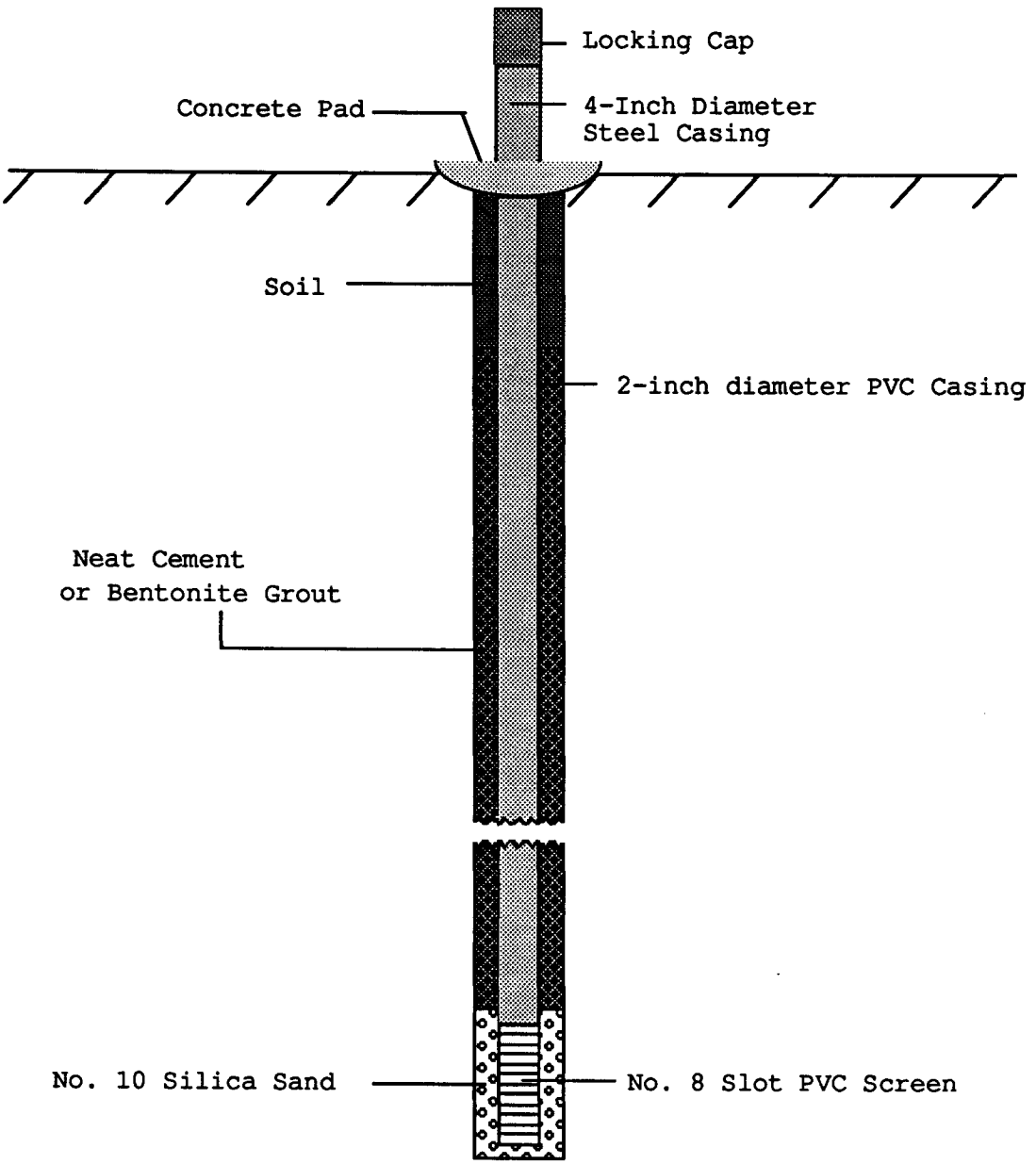

Figure 2. Construction design used for monitoring wells installed at the Dickinson landfill.

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 that 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, field 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 about 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.

* No special preservative techniques were applied to nitrate samples and as a result reported nitrate concentrations may be lower than actual.

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. 3). 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 139-095-17DAC would be located in the SW1/4, NE1/4, SE1/4, Section 17, Township 139 North, Range 95 West. Consecutive numbers are added following the three letters if more than one well is located in a 10-acre tract, e.g. 139-095-17DAC1 and 139-095-17DAC2.

GEOLOGY

Regional Geology

The Dickinson landfill is located in the former Husky Mine pit in section 17, T139N, R95W. The mine is south of the Heart River in an area of dissected bedrock. Several ravines drain toward the Heart River from the area surrounding the mine. Two ravines east of the site are

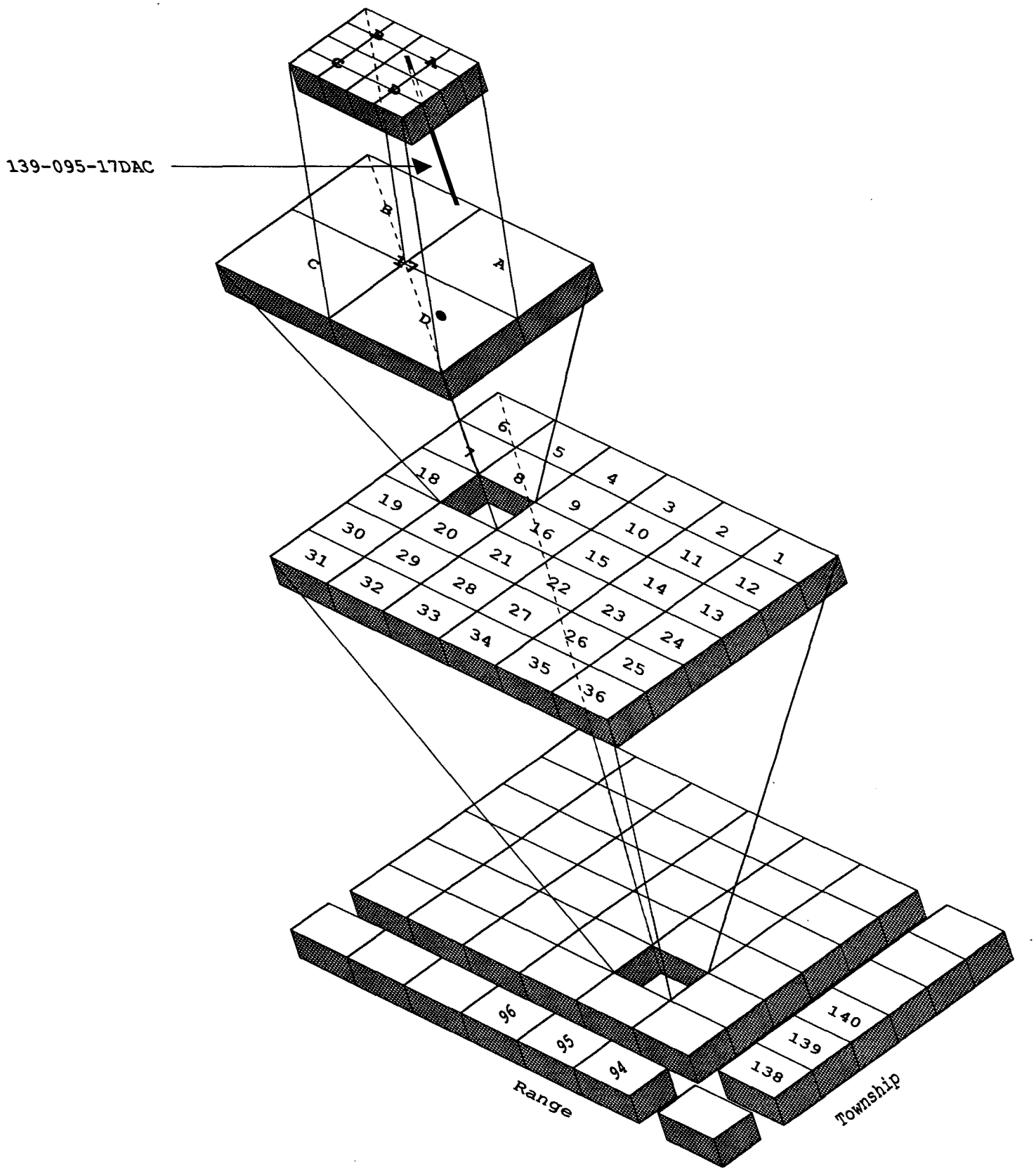

Figure 3. Location-numbering system for the Dickinson landfill.

eroding toward the mine (Fig. 4). The valley of the Heart River, located about three-fourths mile from the mine, contains alluvium, consisting of clay, silt, sand, and gravel.

Two lignite beds, the Dickinson and Lehigh, were mined at the site. These beds are part of the Sentinel Butte Formation, which also includes clay, silt, sand, sandstone, and limestone. The Sentinel Butte Formation is underlain by the Bullion Creek, Slope, Cannonball, Ludlow, Hell Creek, and Fox Hills Formations.

Schmid (1980) identified a north-south trending anticline by mapping the elevation of the Lehigh bed. The axis of the anticline is near the west side of the mine pit. The east limb dips about 150 feet per mile (1.6 degrees), while the west limb dips less than 1 degree. Schmid also observed a fault with a displacement of about 3 feet in the southeast corner of the pit. Additional faults may be present near the mine, but faults with minor displacement are difficult to define with subsurface data.

Local Geology

The mine pit is more than 100 feet deep. The walls of the pit consist of clay with interbedded sand and lignite. The Dickinson lignite is about 4 to 8 feet thick, and the Lehigh lignite is about 7 to 17 feet thick (Fig. 5). The mine operator spread and packed spoil material on the bottom

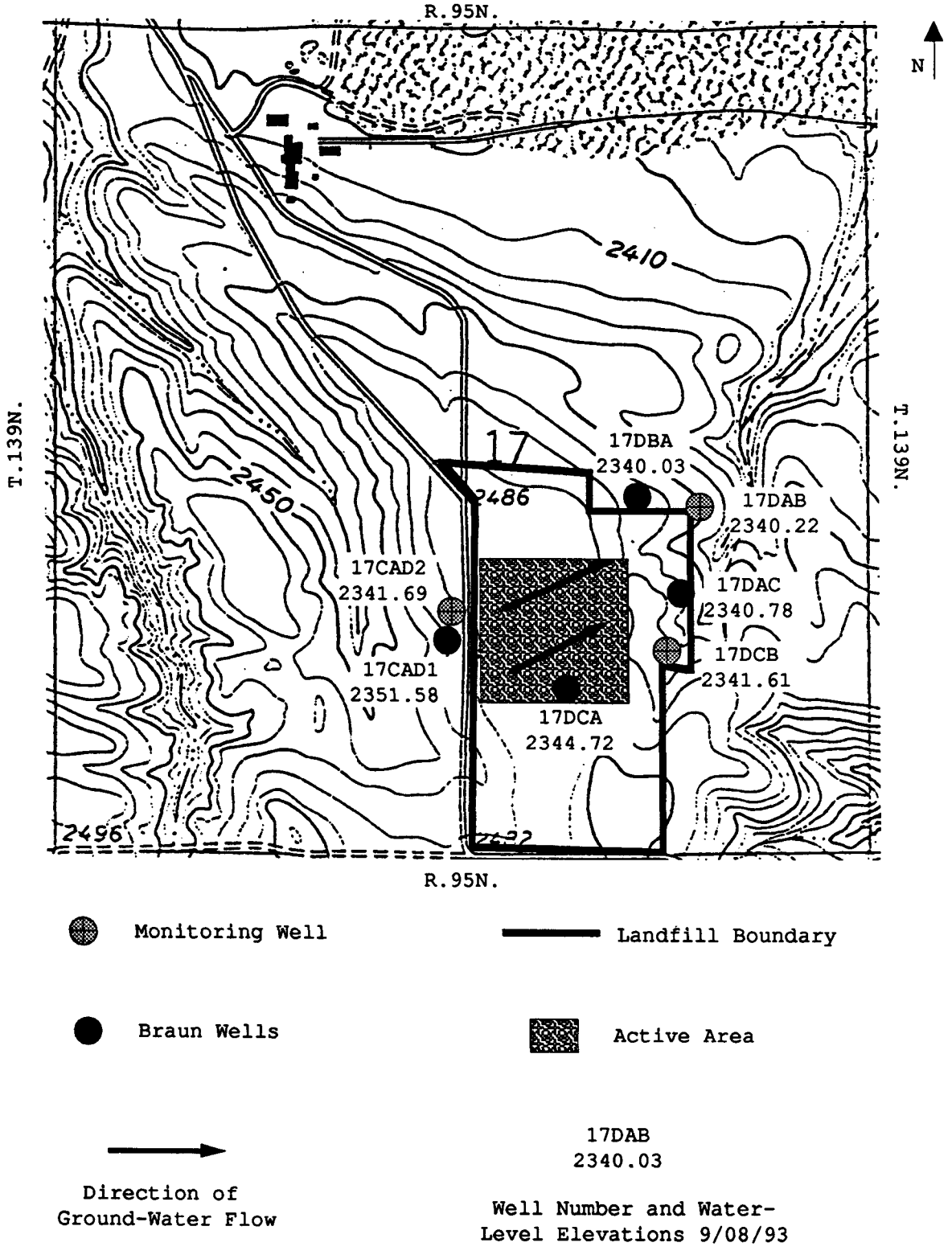

Figure 4. Location of monitoring wells at the Dickinson municipal landfill.

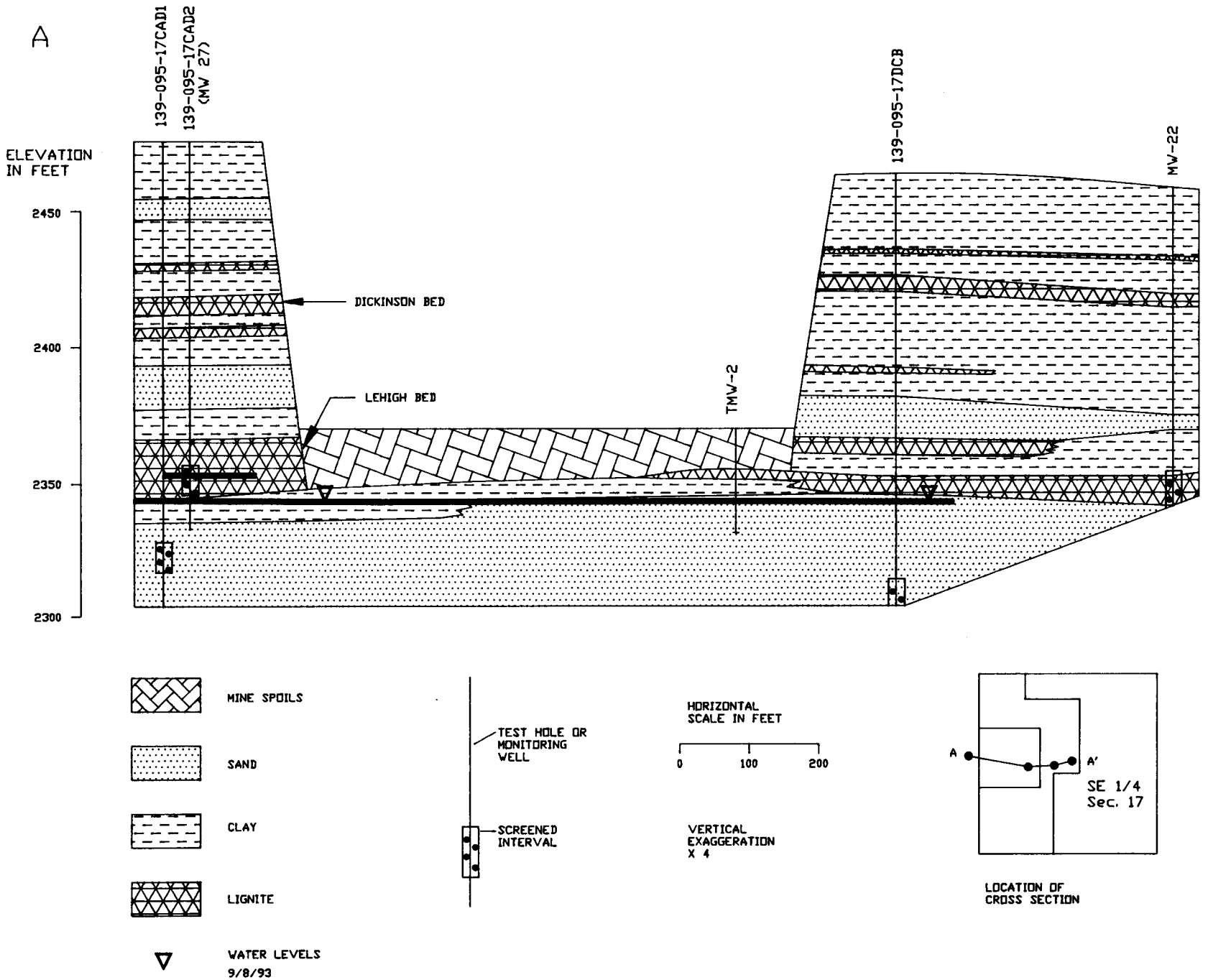

Figure 5. Geohydrologic section A-A' in the Dickinson landfill.

of the pit to serve as a liner. Soil borings drilled within the pit (Braun, 1992, 1993) indicate that the thickness of the spoil material varies from 1.5 feet to 15 feet.

The compacted spoils are underlain by a thin layer of clay that ranges from 3 feet in Braun SB-10 to 15 feet in Braun TMW-1. The clay is underlain by a thick layer of fine-grained to medium-grained, silty sand. The sand is at least 45 feet thick as indicated by test hole 139-095-17DCB (Fig. 5, lithologic logs in Appendix C). None of the test holes at the mine drilled through the sand layer.

Clinker beds are exposed in the ravines to the east and west of the mine. These beds are stratigraphically higher than the Lehigh bed, and likely represent outcrops of the Dickinson lignite bed.

The Lehigh lignite bed is exposed at the surface north of the Husky Mine in the Heart River valley. The Lehigh bed was mined along the Heart River in the Lehigh, Binek, and Pittsburgh mines in sections 7 and 8, T139N, R95W. Because of the structural dip the Lehigh bed is not exposed along the river to the east of the mine. Structure contours for this area (about the middle of section 16) indicate that the Lehigh bed is about 100 feet below the Heart River (Schmid, 1980).

HYDROLOGY

Surface-Water Hydrology

The Heart River is located about three-quarters of a mile north and east of the landfill (Fig. 1). The Heart River valley is the local drainage basin for the area surrounding the landfill. Ravines located on the east and the west sides of the landfill drain surface-water runoff toward the Heart River. The Heart River should not be affected by surface runoff from the landfill due to its distance from the landfill and the depth of the disposal pit.

A few stock dams are located within a two-mile radius of the landfill. These stock dams should not be affected by contaminant migration from the landfill due to their up-gradient location.

Regional Ground-Water Hydrology

The Dickinson landfill is located in an area of unglaciated topography and only bedrock aquifers exist beneath the landfill site. The uppermost aquifer is located in the Sentinel Butte Formation and occurs in undifferentiated lignite beds and in the fine to medium-grained sand layers throughout the formation. The Sentinel Butte aquifer is the main source of domestic water supply for the area. Locally, sand and fractured lignite layers beneath

the landfill may be susceptible to contaminant migration from the landfill.

The Bullion Creek aquifer underlies the Sentinel Butte aquifer in the area of the landfill. This aquifer is located at a depth of about 550 feet. The Bullion Creek aquifer is generally characterized by a sodium-bicarbonate type water. This aquifer should not be affected by contaminant migration from the landfill due its depth and the occurrence of intervening clay layers.

The Hell Creek aquifer underlies the Ludlow Formation and occurs at a depth of about 800 feet (Trapp, et al., 1975). The Hell Creek Formation overlies the Fox Hills aquifer, which is located at a depth of about 1,020 feet (Trapp, et al., 1975) These aquifers should not be affected by contaminant migration from the landfill due to their depth and the occurrence of intervening clay layers.

Local Ground-Water Hydrology

Three monitoring wells were installed to monitor the layer of bedrock sand of the Sentinel Butte Formation that underlies the Lehigh lignite layer. Four existing monitoring wells from Braun (1991) were also used to determine the occurrence and movement of ground water in this sand aquifer.

The Lehigh and Dakota lignite beds were penetrated during the drilling process. These lignite beds were dry during the time of drilling. A clay aquitard about 10 feet

thick occurs between the Lehigh lignite and the underlying sand aquifer.

Four water-level measurements were taken over about a seven-week period (Appendix E). Monitoring well 17CAD1 is completed in the Lehigh lignite and monitoring well 17CAD2 is completed in the underlying sand aquifer in the Sentinel Butte Formation (Fig. 4). Water-level measurements indicate downward ground-water flow from the Lehigh lignite to the Sentinel Butte sand (Fig. 5). The volume of downward flow probably is small due to the low intervening hydraulic conductivity clay layer. The direction of local ground-water flow is to the east toward the Heart River valley (Fig. 4).

Water Quality

Chemical analyses of water samples are shown in Appendix F. An anomalously high pH value of 9.97 was detected in well 17DBA. An elevated pH at this well was also detected by Braun (1993). The source of the high pH was not determined in this study. The water in the Sentinel Butte sand aquifer is characterized by a sodium-bicarbonate type water. Anomalously large concentrations of other analytes, including trace elements, were not detected in this study.

The results of the VOC analysis, from well 17DAB, are shown in Appendix G. The analysis detected the compounds tetrahydrofuran at a concentration of 140 µg/L and 2-Butanone (MEK) at a concentration of 228 µg/L. These compounds are

man-made compounds used in glues and liquid cements for fabricating packages and polyvinyl-chloride materials. The source of these compounds may to be due to well construction. A later sampling event by Braun Intertec on January 12, 1994, indicated a reduced tetrahydrofuran concentration (24 µg/L) and no detection of MEK. Periodic monitoring at this well may be appropriate to evaluate temporal fluctuations of these two compounds.

CONCLUSIONS

The Dickinson landfill is located in the former Husky Mine Pit. The Dickinson and Lehigh lignite beds were mined at this location. The landfill is situated within the Sentinel Butte Formation which also includes zones of sand, sandstone, silt, clay, and limestone. A previous investigation at the site indicates the bedrock forms a north-south trending anticline. The axis of the anticline is along the west side of the landfill. A fault observed in the pit had a displacement of about 3 feet.

The base of the pit was covered with spoil material ranging in thickness from 1.5 to 15 feet. The spoil material was used as the liner for the refuse cell. The spoil material is underlain by a layer of clay ranging in thickness from 3 feet to 15 feet. This layer of clay is underlain by a layer of fine to medium-grained silty sand that is at least

45 feet thick and appears to dip to the east towards the Heart River valley.

The Heart River is located about three-quarters of a mile north and east of the landfill and the Heart River watershed includes the area around the landfill. The Heart River should not be susceptible to contaminant migration from the landfill.

The uppermost aquifer in the study area occurs within the Sentinel Butte Formation. This aquifer occurs in undifferentiated lignite beds and in fine to medium-grained sand layers. This aquifer is the main source of domestic water supply for the area.

At the time of this study the Dickinson and Lehigh lignite beds appeared to be dry with the uppermost aquifer occurring in the fine to medium-grained sand beneath the lignite. Water-level measurements indicate downward ground-water flow from the Lehigh lignite to the Sentinel Butte sand. The volume of downward flow probably is small due to the low intervening hydraulic conductivity clay layer. The direction of local ground-water flow is to the east toward the Heart River valley. The Sentinel Butte sand aquifer may be susceptible to contaminant migration beneath the landfill due to the varying thickness of the overlying clay aquitard.

Chemical analyses indicated an anomalously high pH in well 17DBA. The high pH at this well was also detected in previous investigations. The source of this pH was not determined. Anomalously large concentrations of other

analytes, including trace elements, were not detected in this study. Therefore, contaminant migration from the landfill was not indicated.

The VOC analysis from well 17DAB detected the compounds tetrahydrofuran and 2-Butanone. The source of these compounds may to be due to well construction. Periodic monitoring at this well may be appropriate to evaluate temporal fluctuations of these compounds.

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APPENDIX A

WATER QUALITY STANDARDS AND CONTAMINANT LEVELS

Water Quality Standards and Contaminant Levels

Field Parameters	
appearance	color/odor
pH	6-9 (optimum)
specific conductance	-----
temperature	-----

Constituent	**MCL (µg/L)**
Arsenic	50
Cadmium	10
Lead	50
Molybdenum	100
Mercury	2
Selenium	10
Strontium	*

*EPA has not set an MCL for strontium. The median concentration for most U.S. water supplies is 100 µg/L (Hem, 1989).

	SMCL (mg/L)
Chloride	250
Iron	>0.3
Nitrate	50
Sodium	20-170
Sulfate	300-1000
Total Dissolved Solids	>1000

	Recommended Concentration Limits (mg/L)
Bicarbonate	150-200
Calcium	25-50
Carbonate	150-200
Magnesium	25-50
Hardness	>121 (hard to very hard)

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. Screw 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

139-095-17CAD2
NDSWC

Date Completed:	8/4/93	Purpose:	Observation Well
L.S. Elevation (ft):	2485.01	Well Type:	2" PVC
Depth Drilled (ft):	180	Aquifer:	UND
Screened Interval (ft):	158-168	Source:	
		Owner:	DICKINSON LANDFILL

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	SANDY	0-2
CLAY	STIFF, OXIDIZED, BEDROCK, OLIVE	2-15
CLAY	MOTTLED, REDDISH -BROWN, SILTY	15-16
CLAY	OXIDIZED, OLIVE	16-18
CLAY	MEDIUM GRAY	18-20
CLAY	OLIVE	20-29
LIGNITE		29-30
SAND	SILTY, YELLOWISH-BROWN	30-37
CLAY	OLIVE	37-57
LIGNITE		57-59
CLAY	MEDIUM GRAY	59-68
LIGNITE	DAKOTA BED	68-74
CLAY	LIGHT GREEN	74-80

LIGNITE		80-82
CLAY	DARK GRAY	82-90
CLAY	LIGHT GREEN	90-92
SAND	LIGHT GREEN, VERY FINE GRAIN	92-108
CLAY	SILTY, LIGHT GRAY	108-116
SANDSTONE		116-117
CLAY	LIGHT GRAY	117-122
LIGNITE	LEHIGH BED	122-142
CLAY	GRAYISH-GREEN	142-150
SAND	FINE GRAIN, LIGHT GREEN	150-152
SAND	MEDIUM GRAIN, GREEN	152-180

139-095-17DAB
NDSWC

Date Completed:	8/5/93	Purpose:	Observation Well
L.S. Elevation (ft):	2440.22	Well Type:	2" PVC
Depth Drilled (ft):	140	Aquifer:	UND
Screened Interval (ft):	122-132	Source:	
		Owner:	DICKINSON LANDFILL

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	SPOILS, MEDIUM GRAY, STIFF	1-14
LIGNITE		14-19
CLAY	MEDIUM GRAY, SPOILS	19-92
SAND	VERY FINE GRAIN, SILTY, LIGHT GRAY	92-113
SANDSTONE	HARD, FINE GRAIN	113-114
CLAY		114-124
SAND	MEDIUM GRAIN	124-140

139-095-17DCB
NDSWC

Date Completed:	8/5/93	Purpose:	Observation Well
L.S. Elevation (ft):	2463.51	Well Type:	2" PVC
Depth Drilled (ft):	160	Aquifer:	UND
Screened Interval (ft):	150-160	Source:	
		Owner:	DICKINSON LANDFILL

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	SILTY, LIGHT YELLOWISH-ORANGE, INTERMIXED MEDIUM GRAY CLAY	1-26
CLAY	MEDIUM GRAY	26-28
LIGNITE		28-29
CLAY	MEDIUM GRAY, STIFF	29-35
CLAY	BROWNISH-GRAY, WITH THIN TWO TO THREE INCH LAYER OF LIGNITE	35-38
LIGNITE		38-43
CLAY	SILTY, MEDIUM GRAY	43-46
CLAY	LIGHT GREEN, VERY FINE SAND	46-55
CLAY	GRAYISH-BROWN, LIGNITE CHIPS	55-72
LIGNITE	LIGNITE LAYER APPROX. SIX INCHES THICK	72-72.6
CLAY	GRAYISH-BROWN, LIGNITE CHIPS	72.6-82

SAND	FINE GRAIN, CLAYEY	82-98
LIGNITE	DAKOTA BED	98-102
CLAY		102-112
LIGNITE		112-115
SAND	FINE GRAIN, TRACE OF SILT	115-152
SANDSTONE	INDURATED	152-157
SAND	MEDIUM GRAIN	157-160

APPENDIX D

LITHOLOGIC LOGS OF WELLS AND TEST HOLES FROM PREVIOUS STUDIES.

LOG OF BORING

BRAUN INTERTEC

PROJECT: CFEX-91-007L

HYDROGEOLOGIC ASSESSMENT
CITY OF DICKINSON SANITARY LANDFILL
DICKINSON, NORTH DAKOTA

BORING: SB-10

LOCATION:
See Figure 5.

DATE: 8/30/91 | SCALE: 1" = 10'

(See Report and Standard Plates for evaluation and descriptive terminology.)

Elev.	Depth	ASTM Symbol	Description of Materials (ASTM D 2488)	BPF	WL	Tests or Notes
2365.6	0.0		SPOILS Consists mainly of clay, silt, and fine grained sand. The proportion, thickness, and depth of each constituent varies.			Sample #194(1-1.5)
						#195(7-7.5)
2352.6	13.0	SM	SILTY SAND very fine grained, dark greenish gray (5GY4/1), dense, damp.			#196(12-12.5)
						#197(20-20.5)
2342.6	23.0	CL	CLAY with silt, greenish gray (5GY6/1) little very fine grained sand, rather stiff, moist.			TWT-3(23-24.5)
2339.6	26.0					#198(25-25.5)
2337.6	28.0	SM	SILTY SAND fine to medium grained, dark greenish gray (5GY4/1), poorly graded, loose to medium dense, moist.			Water level at 25.5' (2340.1' elev.)
		SC	CLAYEY SAND little silt, dark greenish gray (5GY4/1), moist. wet to waterbearing			#199(29.5-30)
						#200(35.5-36)
						#201(42-42.5)
						#202(43.5-44)
2315.6	50.0		END OF BORING.			

MONITORING WELL FIELD DATA SHEET

Client: City of Dickinson | Proj. No.: BFAX-91-020A | Location: Dickinson, North Dakota

Well Number: MW-22 (SB-6) | Well Location: 139-95-17DAC | Date of Installation: 8-12-91

Date of Revision: | Crew: WS, EB, SB | B.M. Location & Elev. (±0.01):

Stick up above ground (to 0.1'): 2.4

Top of riser pipe (w/o cap) Elev. (±0.01'): 2461.19

Ground surface Elev. (±0.1'): 2458.8

Depth to bottom of surface seal: 2.5

Approximate water level before installation:

Approximate depth of first water encountered in drilling:

Depth to top of seal: 101

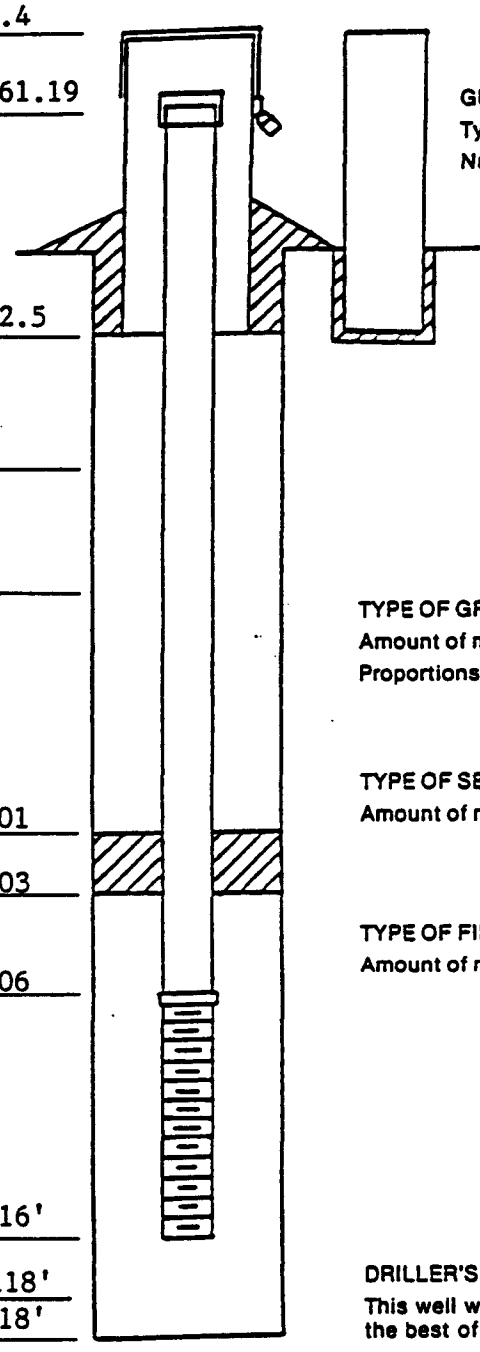
Depth to bottom of seal: 103

Depth to top of screen: 106

Depth to bottom of screen: 116'

Depth to bottom of Sump: 118'

Depth to bottom of boring: 118'



GUARD POST:
Type: T-Post
Number: 3

Protective Cover:
Type: Steel
Length: 5'
Lock #: 2106

Type of sealing material: Concrete

RISER PIPE:
Type: PVC
Diameter: 2"
Total Length: 108½
Sections Used: 11
Couplings: Flush Threaded
Cap: Yes X No

TYPE OF GROUT ABOVE SEAL: NEAT Cement
Amount of material used: Approx 180 gal.
Proportions: 6 water; 1 cement; 5# Bentonite Powder

TYPE OF SEALING MATERIAL: Bentonite Pellets
Amount of material used: 30#s

TYPE OF FILTER MATERIAL: Washed silica (12-30)
Amount of material used: 400#'s

SCREEN:
Type: Timco
Slot Size: PVC
Length: .010
Diameter: 10'
Plug/Point: 2"
Plug

Method of advance:
HSA X I.D. 3 3/4
Casing I.D.
Tricone O.D.

Method of development:
Air
Jet Surge Bail X

DRILLER'S CERTIFICATION

This well was drilled under my jurisdiction, and this report is true to the best of my knowledge.

Braun Intertec Engineering, Inc. 406
Driller's or Firm's Name Certificate No.

913 S. 18th Street, Bismarck, ND
Address

Signed by 11/12/91 Date

BRAUN

B112

LOG OF BORING

BRAUN INTERTEC

PROJECT: CFEX-91-007L HYDROGEOLOGIC ASSESSMENT CITY OF DICKINSON SANITARY LANDFILL DICKINSON, NORTH DAKOTA	BORING: SB-6 (cont.) LOCATION: MW-22: 139-95-17DAC DATE: 8/9/91 SCALE: 1" = 10'

(See Report and Standard Plates for evaluation and descriptive terminology.)

Elev.	Depth	ASTM Symbol	Description of Materials (ASTM D 2488)	BPF	WL	Tests or Notes
			SILT light gray (2.5YN6/).			#48(80-80.5)
2372.8	86.0					
		SM	SILTY SAND very fine to fine grained, light gray (2.5YN6/), some bedding apparent.			#49(86.5-87)
2369.8	89.0	CL	CLAY somewhat cemented.			#50(91-91.5)
2365.3	93.5					
		ML	SILT with very fine-grained sand, light gray (2.5YN6/).			#51(96-96.5)
2360.8	98.0		organic laminae from 97' to 98'			
		CL	CLAY dark gray (5Y4/1), with laminae of silt and fine sand, damp.			#52(101-101.5)
2352.8	106.0					
			LIGNITE black with iron-stained surfaces, dry, LEHIGH LIGNITE.			#53(107-107.5)
						#54(110-110.5)
2342.8	116.0					
2340.8	118.0	CH	CLAY dark gray (5Y4/1), with minor lenses of interbedded sand.			#55(116.5-117)
			END OF BORING.			
			Monitoring well MW-22 installed and screened from 106' to 116'.			

LOG OF BORING

BRAUN INTERTEC

PROJECT: CFEX-91-007L

HYDROGEOLOGIC ASSESSMENT
CITY OF DICKINSON SANITARY LANDFILL
DICKINSON, NORTH DAKOTA

BORING: SB-6

LOCATION:
MW-22: 139-95-17DAC

DATE: 8/9/91 SCALE: 1" = 10'

(See Report and Standard Plates for evaluation and descriptive terminology.)

Elev.	Depth	ASTM Symbol	Description of Materials (ASTM D 2488)	BPF	WL	Tests or Notes
2458.8	0.0	CL	CLAY with some interbedded silt, olive (5Y5/4), organic films common on bedding surfaces, dry, no HCl reaction on white crystallizations.			Sample #32(1.5-2)
			more clay and less silt, olive brown (2.5Y4/3) white crystallizations exhibit moderate reaction to HCl, damp.			#33(6-6.5)
						#34(16-16.5)
						#35(21-21.5)
2432.3	26.5		grades to a very dark gray (5Y3/1)			
2430.8	28.0		LIGNITE with carbonaceous clay, black, wet.			#36(26.5-28) (composite)
		CL	CLAY dark gray (2.5YN4/), minor silt, damp.			#37(32-32.5)
			2-inch thick carbonaceous clay at 34'			
2420.8	38.0					#38(36-36.5)
2417.3	41.5		LIGNITE black, fissile, dry, DICKINSON LIGNITE.			#39(38-41.5) (composite)
2415.3	43.5	CL	CLAY gray (10YR5/1), little silt, trace of very fine sand along bedding surfaces.			
2412.8	46.0	CL	CLAY geenish gray (5GY5/1), damp.			#40(44.5-45)
2411.3	47.5	SP	SAND very fine-grained, greenish gray (5GY5/1), damp to moist.			#41(46.5-47)
2408.3	50.5	CL	CLAY greenish gray (5GY5/1), damp.			#42(49-49.5)
		CL	CLAY very dark gray (5Y3/1), interbedded with abundant .5 to 1 inch thick carbonaceous layers, trace of pyrite within these layers.			#43a(52.5-53)
						#43b(56-56.5)
			carbonaceous clay from 61' to 64.5'			#44(60-60.5)
2394.3	64.5					
2390.8	68.0	CH	CLAY dark greenish gray (5GY4/1), very dense.			#45(65.5-66)
2388.3	70.5	CL	CLAY gray to dark gray (2.5YN5/ to N6/). transition from clay to very fine sand from 70' to 71'			#46(69-69.5)
		SC	SANDY CLAY very fine-grained with silt, light gray (2.5YN6/), minor laminae of clay.			#47(72-72.5)
2381.8	77.0	ML	interbedded with clay of same color, approxomately 75% sand and 25% clay			

MONITORING WELL FIELD DATA SHEET

Client: City of Dickinson | Proj. No.: BFAX-91-020A | Location: Dickinson, North Dakota

Well Number: MW-27 (SB-12) | Well Location: 139-95-17CAD | Date of Installation: 8-28-91

Date of Revision: | Crew: WS, EB, LM | B.M. Location & Elev. (±0.01):

Stick up above ground (to 0.1'): 2.2

Top of riser pipe (w/o cap) Elev. (±0.01'): 2487.01

Ground surface Elev. (±0.1'): 2484.8

Depth to bottom of surface seal: 2.5

Approximate water level before installation:

Approximate depth of first water encountered in drilling:

Depth to top of seal: 121

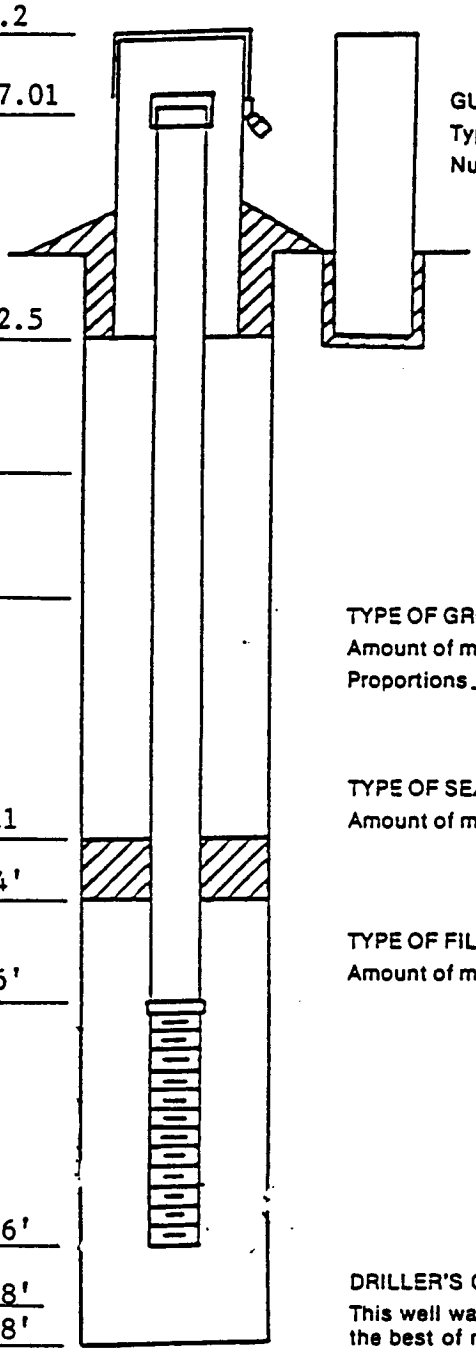
Depth to bottom of seal: 124'

Depth to top of screen: 126'

Depth to bottom of screen: 136'

Depth to bottom of sump: 138'

Depth to bottom of boring: 138'



GUARD POST:
Type: T-Posts
Number: 3

Protective Cover:
Type: Steel
Length: 5'
Lock #: 2106

Type of sealing material: Concrete

RISER PIPE:
Type: PVC
Diameter: 2"
Total Length: 128½
Sections Used: 13
Couplings: Flush Threaded
Cap: Yes X No

TYPE OF GROUT ABOVE SEAL: NEAT Cement
Amount of material used: Approx. 240 gals.
Proportions: 6 water; 1 cement; 5#'s Bentonite Powder

TYPE OF SEALING MATERIAL: Bentonite Pellets
Amount of material used: 50#'s

TYPE OF FILTER MATERIAL: Washed Silica (12-30)
Amount of material used: 360#'s

SCREEN:
Type: Timco
Slot Size: PVC
Length: .010
Diameter: 10'
Plug/Point: 2"
Plugs

Method of advance:
HSA: X I.D.: 3 3/4
Casing: I.D.:
Tricone: O.D.:

Method of development:
Jet: Surge: Air: Bail: X

DRILLER'S CERTIFICATION

This well was drilled under my jurisdiction, and this report is true to the best of my knowledge.

Braun Intertec Engineering, Inc. 406
Driller's or Firm's Name — Certificate No.

913 S. 18th Street, Bismarck, ND
Address

Signed by: 11/12/91 Date

BRAUN

B112

LOG OF BORING

BRAUN INTERTEC

PROJECT: CFEX-91-007L

HYDROGEOLOGIC ASSESSMENT
CITY OF DICKINSON SANITARY LANDFILL
DICKINSON, NORTH DAKOTA

BORING: SB-12

LOCATION:
MW-27: 139-95-17CAD

DATE: 8/20/91 | SCALE: 1" = 10'

(See Report and Standard Plates for evaluation and descriptive terminology.)

Elev.	Depth	ASTM Symbol	Description of Materials (ASTM D 2488)	BPF	WL	Tests or Notes
2484.8	0.0					
2483.8	1.0	ML	SILT brown (10YR4/3), some clay, roots.			
		CL	SILTY CLAY light yellowish brown (2.5Y6/4), calcareous, roots present, mottled.			Sample #119(2.5-3)
						#120(7-7.5)
						#121(11.5-12)
2467.8	17.0					
		CH	CLAY little silt, light olive gray (5Y5/3), dry			#122(16-16.5)
			vertical fractures evident, iron and manganese stained, damp			#123(19.5-20)
			very stiff and dense clay, olive (2.5Y5/4)			#124(26.5-27)
2452.8	32.0		1" soft lignite layer at 30.5'			
2449.8	35.0	SM	SILTY SAND fine grained, light gray (5Y6/1).			#125(32-32.5)
		CL	CLAY with silt, olive brown (2.5Y5/3), dense, trace of sand.			#126(35-35.5)
2446.3	38.5					
2444.3	40.5	ML	CLAYEY SILT with trace of fine grained sand, light gray and dark brown alternating laminae.			#127(38.5-39)
		CL	CLAY olive brown (2.5Y5/3), oxidized fractures present. gypsum crystals present			#128(45.5-46)
						#129(49-49.5)
2428.8	56.0					#130(54.5-55)
2427.8	57.0		LIGNITE			
		CL	CLAY carbonaceous, dark gray (7.5YR4/0), very stiff, damp. trace of lignite fragments			#131(60.5-61)
2417.8	67.0					
			LIGNITE DICKINSON LIGNITE			#132(66.5-67)
2413.8	71.0					
		CL	CLAY with little silt, dark gray (10YR6/1).			#133(72-72.5)
						#134(75-75.5)

LOG OF BORING

BRAUN INTERTEC

PROJECT: CFEX-91-007L

HYDROGEOLOGIC ASSESSMENT
CITY OF DICKINSON SANITARY LANDFILL
DICKINSON, NORTH DAKOTA

BORING: SB-12 (cont.)

LOCATION:
MW-27: 139-95-17CAD

DATE: 8/20/91 SCALE: 1" = 10'

(See Report and Standard Plates for evaluation and descriptive terminology.)

Elev.	Depth	ASTM Symbol	Description of Materials (ASTM D 2488)	BPF	WL	Tests or Notes
			4" lignite layer at 84'			#135(82-82.5)
						#136(84.5-85)
2396.8	88.0	SM	SILTY SAND fine grained, light gray (2.5Y6/0), dry.			
						#137(91.5-92)
2386.3	98.5	CL	CLAY and SILT alternating deposits of clay-rich and silt-rich sediments, some layers contain small amounts of fine grained sand, colors range between light and dark gray.			#138(96-96.5)
						#139(101-101.5)
						#140(104-104.5)
						#141(107.5-108)
						#142(111-111.5)
2365.3	119.5					#143(117-117.5)
2360.8	124.0	SM	SILTY SAND fine grained sand, light gray (5Y6/1), some silt, trace of clay, some carbonaceous laminae present.			#144(119-119.5)
2357.8	127.0	CH	CLAY some silt, gray (5Y5/1). grades into a dark gray (5Y4/1) carbonaceous clay at 126.5'			#145(125.5-126) #146(127-127.5)
			LIGNITE soft, dry, LEHIGH LIGNITE.			#147(129.5-130)
						#148(132.5-133)
2348.3	136.5	CH	CLAY some silt, dark greenish gray (5GY4/1), lignite fragments, dense, dry.			#149(139-139.5)
2345.3	139.5		END OF BORING.			
			Monitoring well MW-27 installed and screened from 126 to 136 feet.			

MONITORING WELL FIELD DATA SHEET

Client City of Dickinson | Proj. No. BFAX-91-020A | Location Dickinson, ND

Well Number MW-29 | Well Location 139-95-17DAC2 | Date of Installation 09/18/92

Date of Revision | Crew WS, PH, SB | B.M. Location & Elev. (±0.01)

Stick up above ground (to 0.1') 2.0

Top of riser pipe (w/o cap) Elev. (±0.01') 2448.85

Ground surface Elev. (±0.1') 2446.8

Depth to bottom of surface seal 2.5

Approximate water level before installation 104

Approximate depth of first water encountered in drilling 128

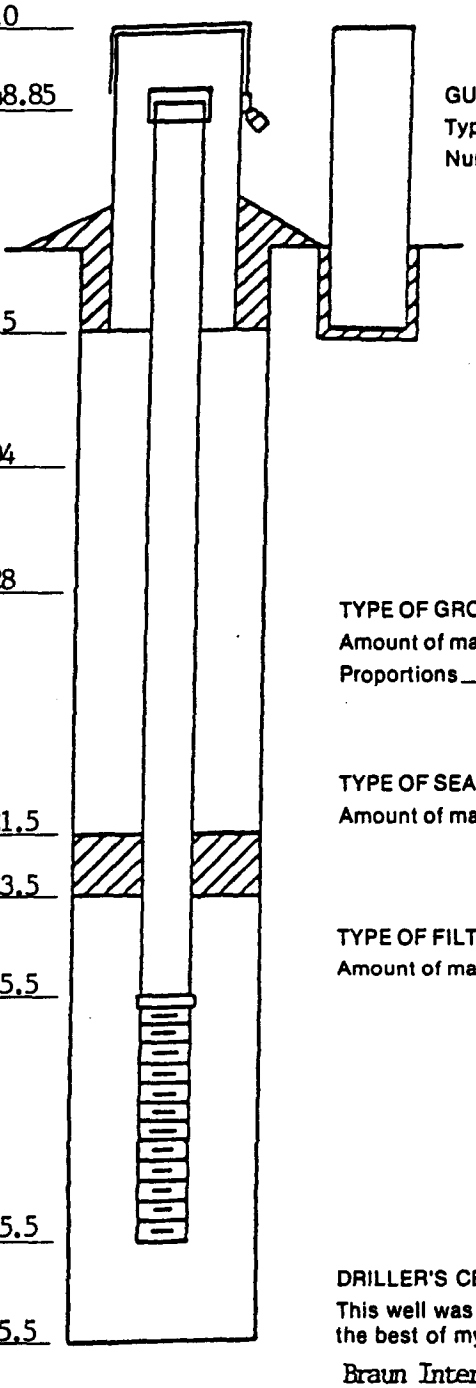
Depth to top of seal 121.5

Depth to bottom of seal 123.5

Depth to top of screen 125.5

Depth to bottom of screen 135.5

Depth to bottom of boring 135.5



GUARD POST:
Type T-Posts
Number 3

Protective Cover:
Type Steel
Length 5'
Lock # 2106

Type of sealing material Concrete

RISER PIPE:
Type PVC
Diameter 2"
Total Length 127.7
Sections Used 13 plus 16" coupler
Couplings Flush-Thread
Cap Yes X No

TYPE OF GROUT ABOVE SEAL: Neat Cement Grout
Amount of material used 200 gallons
Proportions 6 parts water to 1 cement; 5 lbs. bentonite powder

TYPE OF SEALING MATERIAL: Bentonite Pellets
Amount of material used 40 lbs. (4 gallons)

TYPE OF FILTER MATERIAL: Silica Sand
Amount of material used 3.5 bags (350 lbs)

SCREEN:
Type PVC
Slot Size 0.010
Length 10'
Diameter 2"
Plug/Point Plug

Method of advance:
HSA X I.D. 3 3/4"
Casing I.D.
Tricone O.D.

Method of development:
Air
Jet Surge Ball X

DRILLER'S CERTIFICATION

This well was drilled under my jurisdiction, and this report is true to the best of my knowledge.

Braun Intertec Environmental, Inc. 417
Driller's or Firm's Name Certificate No.

913 S. 18th St., P.O. Box 2379, Bismarck, ND 58502-2379
Address

Signed by Date

BRAUN

B112

LOG OF BORING

PROJECT: BFAX-91-020A HYDROGEOLOGIC ASSESSMENT CITY OF DICKINSON SANITARY LANDFILL DICKINSON, NORTH DAKOTA	BORING: MW-29
	LOCATION: 139-95-17DAC2
	DATE: 9/17/92 SCALE: 1" = 10'

(See Report and Standard Plates for evaluation and descriptive terminology.)

Elev.	Depth	ASTM Symbol	Description of Materials (ASTM D 2488)	BPF	WL	Tests or Notes
2446.8	0.0		SPOILS consists mainly of clay, silt, and fine grained sand, with proportions, thickness, and depth of each constituent variable.			

LOG OF BORING

PROJECT: BFAX-91-020A

HYDROGEOLOGIC ASSESSMENT
CITY OF DICKINSON SANITARY LANDFILL
DICKINSON, NORTH DAKOTA

BORING: MW-29 (cont.)

LOCATION:
139-95-17DAC2

DATE: 9/17/92

SCALE: 1" = 10'

(See Report and Standard Plates for evaluation and descriptive terminology.)

Elev.	Depth	ASTM Symbol	Description of Materials (ASTM D 2488)	BPF	WL	Tests or Notes
					▽	Water level at 2341.01 (105.79 BGS)
						#1(109-110.5)
						#2(114-115.5)
2327.8	119.0					
		CL	CLAY with silt, dark gray (5Y 4/1), some fine sand, moist.			#3(119-120.5)
						#4(124-125.5)
2318.8	128.0					SCREEN INSTALLED FROM 125.5 TO 135.5 FEET.
		SP	POORLY GRADED SAND medium grained, greenish gray (5GY 5/1), waterbearing.			#5(129-130.5)
2311.3	135.5					#6(134-135.5)
			END OF BORING			

MONITORING WELL FIELD DATA SHEET

Client: City of Dickinson | Proj. No.: BFAX-91-020A | Location: Dickinson, ND

Well Number: MW-30 | Well Location: 139-95-17DBA | Date of Installation: 09/22/92

Date of Revision: | Crew: WS, PH, SB | B.M. Location & Elev. (±0.01):

Stick up above ground (to 0.1'): 2.48

Top of riser pipe (w/o cap) Elev. (±0.01'): 2455.88

Ground surface Elev. (±0.1'): 2453.4

Depth to bottom of surface seal: 2.5

Approximate water level before installation: 113

Approximate depth of first water encountered in drilling: 122

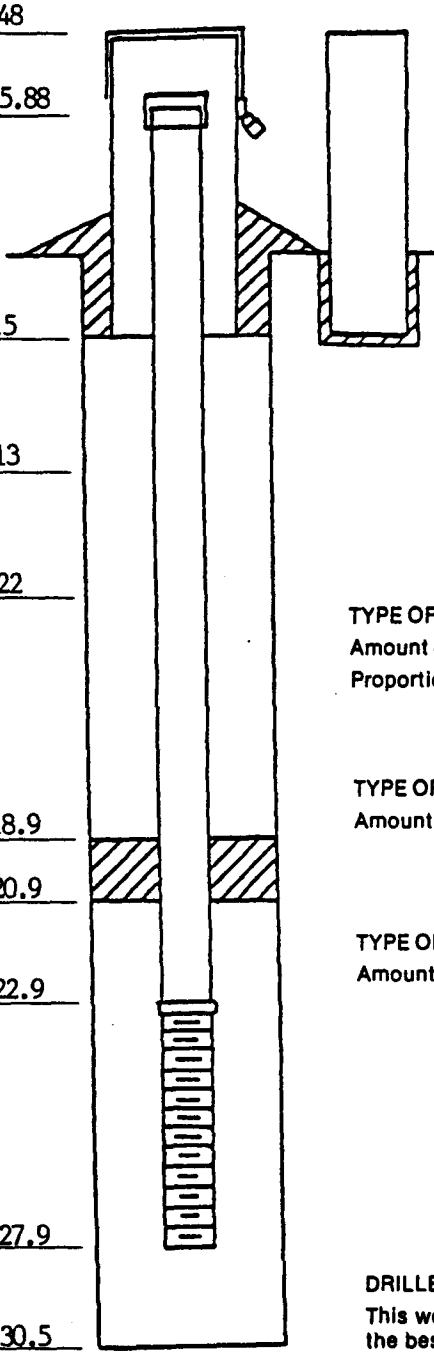
Depth to top of seal: 118.9

Depth to bottom of seal: 120.9

Depth to top of screen: 122.9

Depth to bottom of screen: 127.9

Depth to bottom of boring: 130.5



GUARD POST:
Type: T-Posts
Number: 3

Protective Cover:
Type: Steel
Length: 5'
Lock #: 2106

Type of sealing material: Concrete

RISER PIPE:
Type: PVC
Diameter: 2"
Total Length: 120.4
Sections Used: 12 plus 16" coupler
Couplings: Flush-Thread
Cap: Yes X No

TYPE OF GROUT ABOVE SEAL: Neat Cement
Amount of material used: 230 gallons
Proportions: 6 parts water to 1 cement; 5 lbs. bentonite powder

TYPE OF SEALING MATERIAL: Bentonite Pellets
Amount of material used: 40 lbs (4 gallons)

TYPE OF FILTER MATERIAL: Silica Sand
Amount of material used: 3.5 bags (350 lbs)

SCREEN:
Type: PVC
Slot Size: 0.010
Length: 10'
Diameter: 2"
Plug/Point: Plug

Method of advance:
HSA: X I.D.: 3 3/4"
Casing: I.D.:
Tricone: O.D.:

Method of development:
Air:
Jet: Surge: Bail: X

DRILLER'S CERTIFICATION

This well was drilled under my jurisdiction, and this report is true to the best of my knowledge.

Braun Intertec Environmental, Inc. 417
Driller's or Firm's Name Certificate No.

913 S. 18th St., P.O. Box 2379, Bismarck, ND 58502-2379
Address

Signed by Date

BRAUN

LOG OF BORING

PROJECT: BFAX-91-020A HYDROGEOLOGIC ASSESSMENT CITY OF DICKINSON SANITARY LANDFILL DICKINSON, NORTH DAKOTA	BORING: MW-30
	LOCATION: 139-95-17DBA
	DATE: 9/21/92 SCALE: 1" = 10'

(See Report and Standard Plates for evaluation and descriptive terminology.)

Elev.	Depth	ASTM Symbol	Description of Materials (ASTM D 2488)	BPF	WL	Tests or Notes
2453.4	0.0		SPOILS consists mainly of clay, silt, and feine grained sand, with proportions, thickness, and depth variable.			

LOG OF BORING

PROJECT: BFAX-91-020A

HYDROGEOLOGIC ASSESSMENT
CITY OF DICKINSON SANITARY LANDFILL
DICKINSON, NORTH DAKOTA

BORING: MW-30 (cont.)

LOCATION: 139-95-17DBA

DATE: 9/21/92 SCALE: 1" = 10'

(See Report and Standard Plates for evaluation and descriptive terminology.)

Elev.	Depth	ASTM Symbol	Description of Materials (ASTM D 2488)	BPF	WL	Tests or Notes
						#7(104-105.5 feet)
						#8(109-110.5)
						Water level at 2340.40 (113.0 feet BGS)
2335.4	118.0					#9(114-115.5)
		CL	CLAY with silt, gray (5Y 5/1), occassional organic blebs less than 1/2 inch diameter, damp.			SCREEN INSTALLED FROM 117.9 TO 127.9.
2331.4	122.0	SP	POORLY GRADED SAND medium grained, greenish gray (5GY 5/1), little clay, waterbearing.			#10(119-120.5)
						#11(124-125.5)
2322.9	130.5					#12(129-130.5)
			END OF BORING			

MONITORING WELL FIELD DATA SHEET

Client: City of Dickinson | Proj. No.: BFAX-91-020A | Location: Dickinson, ND

Well Number: TMW-1 | Well Location: 139-95-17DCA | Date of Installation: 09/24/92

Date of Revision: | Crew: WS, PH, SB | B.M. Location & Elev. (± 0.01):

Stick up above ground (to 0.1'): 2.12

Top of riser pipe (w/o cap) Elev. (± 0.01'): 2374.72

Ground surface Elev. (± 0.1'): 2372.6

Depth to bottom of surface seal: 2.5

Approximate water level before installation: 28

Approximate depth of first water encountered in drilling: 31

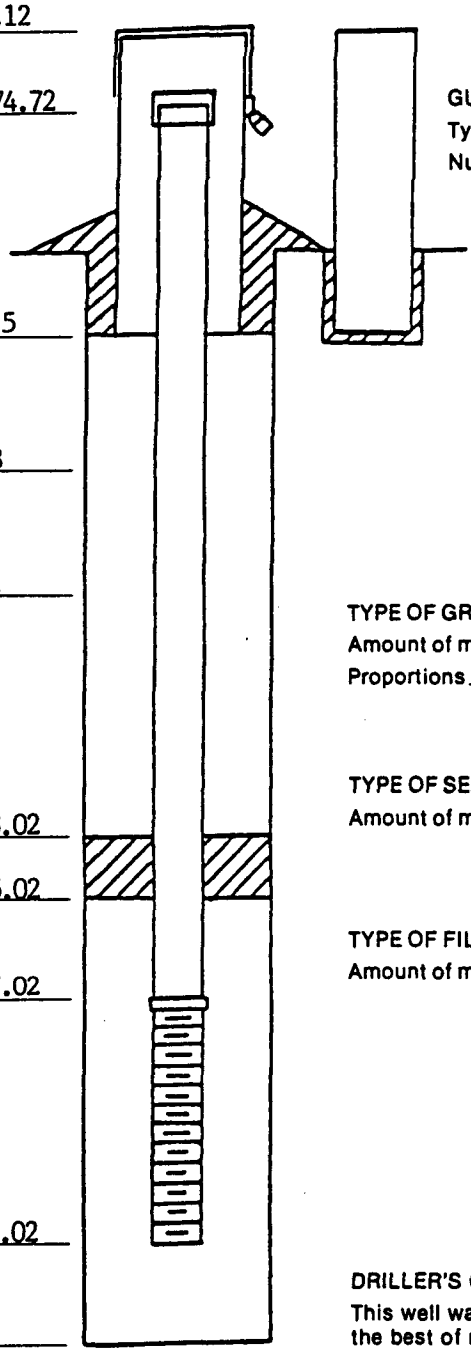
Depth to top of seal: 23.02

Depth to bottom of seal: 25.02

Depth to top of screen: 27.02

Depth to bottom of screen: 37.02

Depth to bottom of boring: 2



GUARD POST:
Type: T-Posts
Number: 3

Protective Cover:
Type: None
Length:
Lock #: 2106

Type of sealing material: Volclay Bentonite Grout

RISER PIPE:
Type: PVC
Diameter: 2"
Total Length: 27.52
Sections Used: 3 plus 16" coupler
Couplings: Flush-Thread
Cap: Yes X No

TYPE OF GROUT ABOVE SEAL: Volclay Bentonite Grout
Amount of material used: 50 gallon
Proportions: 25 gallons per 50 lb bag grout

TYPE OF SEALING MATERIAL: Bentonite Pellets
Amount of material used: 50 lbs (5 gallon bucket)

TYPE OF FILTER MATERIAL: Silica Sand (12-30)
Amount of material used: 4 bags (400 lbs)

SCREEN:
Type: PVC
Slot Size: 0.010
Length: 10'
Diameter: 2"
Plug/Point: Plug

Method of advance:
HSA: X I.D.: 3 3/4"
Casing: I.D.:
Tricone: O.D.:

Method of development:
Air:
Jet: Surge: Bail: X

DRILLER'S CERTIFICATION

This well was drilled under my jurisdiction, and this report is true to the best of my knowledge.

Braun Intertec Environmental, Inc. 417
Driller's or Firm's Name Certificate No.

913 S. 18th St., P.O. Box 2379, Bismarck, ND 58502-2379
Address

Signed by Date

BRAUN

B112

LOG OF BORING

PROJECT: BFAX-91-020A

HYDROGEOLOGIC ASSESSMENT
CITY OF DICKINSON SANITARY LANDFILL
DICKINSON, NORTH DAKOTA

BORING: TMW-1

LOCATION:
139-95-17DCA

DATE: 9/23/92

SCALE: 1" = 10'

(See Report and Standard Plates for evaluation and descriptive terminology.)

Elev.	Depth	ASTM Symbol	Description of Materials (ASTM D 2488)	BPF	WL	Tests or Notes
2372.6	0.0					
2371.1	1.5		SPOILS consists mainly of clay, silt, and fine-grained sand, with the proportion, thickness, and depth of each constituent variable.			PRP-2 (0 to 10 feet)
		CL	CLAY dark grayish brown (2.5Y 4/2), with some silt, with some organic blebs, very fine -grained sand laminae present.			TWT-3 (4-6)
						TWT-4 (9-11)
2356.6	16.0					
		SP	gradational contact with underlying clay, increasing sand percentage downward with an increase in grain size from very fine-grained to medium grained			
			POORLY GRADED SAND medium grained, greenish gray (5GY 5/1), little clay, moist.			
			wet to waterbearing sand encountered between 27 and 28.5 feet			INSTALLED SCREEN FROM 27 to 37 FEET.
			carbonaceous cly laminae at 30 feet and 30.5 feet, wet to waterbearing			Water level at 2344.58 (28.02 BGS)
2334.6	38.0					
			END OF BORING			

MONITORING WELL FIELD DATA SHEET

Client: City of Dickinson | Proj. No.: BFAX-92-020A | Location: Dickinson, ND

Well Number: TMW-2 | Well Location: 139-95-17DBD | Date of Installation: 09/24/92

Date of Revision: | Crew: WS, PH, SB | B.M. Location & Elev. (±0.01):

Stick up above ground (to 0.1'): 2.32

Top of riser pipe (w/o cap) Elev. (±0.01'): 2372.85

Ground surface Elev. (±0.1'): 2370.5

Depth to bottom of surface seal: 2.5

Approximate water level before installation: 32

Approximate depth of first water encountered in drilling: 23

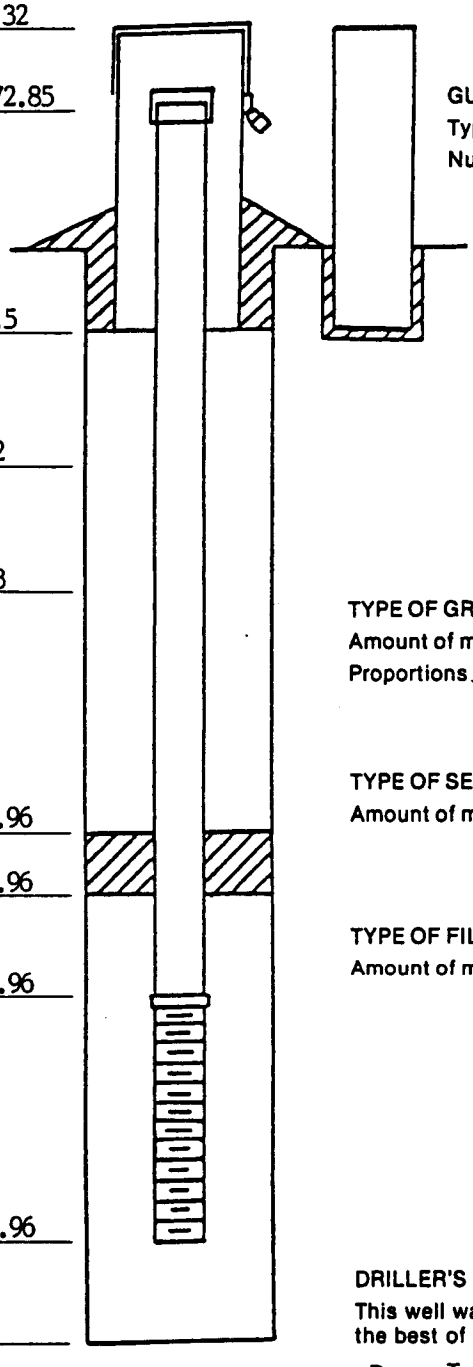
Depth to top of seal: 22.96

Depth to bottom of seal: 24.96

Depth to top of screen: 26.96

Depth to bottom of screen: 36.96

Depth to bottom of boring: 38



GUARD POST:
Type: T-Posts
Number: 3

Protective Cover:
Type: Steel
Length: 5'
Lock #: 2106

Type of sealing material: Volclay Bentonite Grout

RISER PIPE:
Type: PVC
Diameter: 2"
Total Length: 26.96
Sections Used: 3 plus 16" coupler
Couplings: Flush-Thread
Cap: Yes X No

TYPE OF GROUT ABOVE SEAL: Volclay Bentonite Grout
Amount of material used: 50 gallons
Proportions: 25 gallons per 50 lb bag grout

TYPE OF SEALING MATERIAL: Bentonite Pellets
Amount of material used: 50 lbs (5 gallon bucket)

TYPE OF FILTER MATERIAL: Silica Sand (12-30)
Amount of material used: 4 bags (400 lbs)

SCREEN:
Type: PVC
Slot Size: 0.010
Length: 10'
Diameter: 2"
Plug/Point: Plug

Method of advance:
HSA: X I.D.: 3 3/4"
Casing: I.D.:
Tricone: O.D.:

Method of development:
Air:
Jet: Surge: Ball: X

DRILLER'S CERTIFICATION

This well was drilled under my jurisdiction, and this report is true to the best of my knowledge.

Braun Intertec Environmental, Inc. 417
Driller's or Firm's Name Certificate No.

913 S. 18th St., P.O. Box 2379, Bismarck, ND 58502-2379
Address

Signed by Date

BRAUN

B112

LOG OF BORING

PROJECT: BFAX-91-020A

HYDROGEOLOGIC ASSESSMENT
CITY OF DICKINSON SANITARY LANDFILL
DICKINSON, NORTH DAKOTA

BORING: TMW-2

LOCATION: 139-95-17DBD

DATE: 9/23/92

SCALE: 1" = 10'

(See Report and Standard Plates for evaluation and descriptive terminology.)

Elev.	Depth	ASTM Symbol	Description of Materials (ASTM D 2488)	BPF	WL	Tests or Notes
2370.5	0.0		SPOILS consists mainly of clat, silt, and fine grained sand, proportion, thickness, and depth of each constituent varies.			PRP-1 (0-10 feet) TWT-1 (2-4) TWT-2 (8-10)
2355.5	15.0					
2353.5	17.0		LIGNITE brittle and flakey, moisture on fractures			
2352.0	18.5	CL	CARBONACEOUS CLAY dark gray to med gray, damp.			
		CL				
2347.5	23.0		CLAY dark gray (5Y 4/1), laminated, very fine-gtrained sand along laminae which causes horizontal partings to occur.			
		SP	POORLY GRADED SAND greenish gray (5GY 5/1 to 5G 5/1), medium grained, wet to waterbearing.			SCREEN INSTALLED FROM 27 TO 37 FEET. Water level at 2340.45 (30.02 BGS).
2332.5	38.0					
			END OF BORING			

APPENDIX E

WATER-LEVEL TABLES

DICKINSON LANDFILL WATER LEVELS
8/03/93 TO 9/21/93

139-095-17CAD2 LS Elev (msl,ft)=2485.01
Sentinel Butte Aquifer SI (ft.)=158-168

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/11/93	143.32	2341.69	09/08/93	143.32	2341.69
08/19/93	143.40	2341.61	09/21/93	143.31	2341.70
09/02/93	143.17	2341.84			

139-095-17CAD1 (MW-27) LS Elev (msl,ft)=2484.98
Sentinel Butte Aquifer SI (ft.)=126-136

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/11/93	132.39	2352.59	09/08/93	133.40	2351.58
08/19/93	133.46	2351.52	09/21/93	133.49	2351.49
09/02/93	133.49	2351.49			

139-095-17DAB LS Elev (msl,ft)=2440.22
Sentinel Butte Aquifer SI (ft.)=122-132

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/09/93	99.42	2340.80	09/08/93	100.19	2340.03
09/03/93	99.76	2340.46	09/21/93	99.74	2340.48

139-095-17DBA (MW-30) LS Elev (msl,ft)=2453.1
Sentinel Butte Aquifer SI (ft.)=122.9-127.9

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/10/93	112.82	2340.28	09/08/93	112.86	2340.24
09/02/93	112.83	2340.27	09/21/93	112.75	2340.35

139-095-17DCA (TMW-1) LS Elev (msl,ft)=2372.6
Sentinel Butte Aquifer SI (ft.)=27.02-37.02

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
09/03/93	27.92	2344.68	09/21/93	27.85	2344.75
09/08/93	27.88	2344.72			

139-095-17DCB LS Elev (msl,ft)=2463.51
Sentinel Butte Aquifer SI (ft.)=150-160

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/10/93	113.59	2349.92	09/08/93	121.90	2341.61
09/02/93	121.94	2341.57	09/21/93	121.86	2341.65

139-095-17DAC (MW-29) LS Elev (msl,ft)=2446.46

Sentinel Butte Aquifer SI (ft.)=125.5-135.5

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/10/93	105.65	2340.81	09/08/93	105.68	2340.78
09/02/93	105.60	2340.86	09/21/93	105.59	2340.87

APPENDIX F

MAJOR ION AND TRACE-ELEMENT CONCENTRATIONS

Dickinson Municipal Landfill
Major Ion Analyses

Location	Screened Interval (ft)	Date Sampled	(milligrams per liter) SiO_2	Fe	Mn	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl	F	NO_3	B	TDS	Hardness $CaCO_3$	as NCH	% Na	SAR	Spec Cond (µmho)	Temp (°C)	pH
139-095-17CAD2	158-168	09/02/93	16	0.31	0.1	9	3	340	6	778	36	150	16	2.5	4.3	0.45	967	35	0	95	25	1428	9	8.84
139-095-17CAD1	126-136	09/02/93	11	0.1	0.08	12	6	590	5.2	1290	0	160	11	2	4.3	0.55	1440	55	0	95	35	2160	9	7.55
139-095-17DAB	122-132	09/03/93	37	0.5	0.11	13	5	410	10	782	5	330	16	2	8.9	0.37	1220	53	0	93	24	1713	7	8.27
139-095-17DBA	122.9-127.9	09/02/93	34	0.72	0.03	6	1	390	7.2	804	200	110	14	2.9	15	0.53	1180	19	0	97	39	1625	9	9.97
139-095-17DCA	27.02-37.02	09/03/93	69	1.3	0.22	9	4	450	4.5	1270	0	76	18	1.6	10	0.67	1270	39	0	96	31	1792	9	7.47
139-095-17DCB	150-160	09/02/93	11	0.16	0.21	33	15	810	11	1690	0	600	20	1.2	8	1	2340	140	0	92	30	3370	10	7.34
139-095-17DAC	125.5-135.5	09/02/93	10	0.3	0.07	9	4	490	6.1	1260	20	110	13	2.6	3.8	0.58	1290	39	0	96	34	1928	8	8.33

Trace Element Analyses

Location	Date Sampled	(micrograms per liter) Selenium	Lead	Cadmium	Mercury	Arsenic	Molybdenum	Strontium
139-095-17CAD2	9/2/93	0	2	0	0	15	15	190
139-095-17CAD1	9/2/93	0	0	0	0	1	12	450
139-095-17DAB	9/2/93	0	1	0	0	9	9	470
139-095-17DBA	9/2/93	0	2	0	0	3	9	200
139-095-17DCA	9/2/93	0	1	0	0	1	11	440
139-095-17DCB	9/2/93	0	0	0	0	3	3	1100
139-095-17DAC	9/2/93	0	1	0	0	1	3	330

APPENDIX G

VOLATILE ORGANIC COMPOUNDS
FOR WELL 139-095-17DAB

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)	228*
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	140*
Pentachloroethane	<5
Trichlorotrofluoroethane	<5
Carbondisufide	<5
Ether	<5

* Constituent Detection