Site Suitability Review of the Geving Sanitation Landfill

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

ND Landfill Site Investigation No. 32

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OF THE
GEVING SANITATION LANDFILL

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Bismarck, North Dakota
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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 Geving solid waste landfill is one of the landfills being evaluated.

Location of the Geving Landfill

The Geving municipal solid waste landfill is located about 5 miles north-northwest of the City of Parshall in Township 152 North, Range 90 West, NW 1/4 Section 14 (Fig. 1). The landfill site encompasses approximately 30 acres.

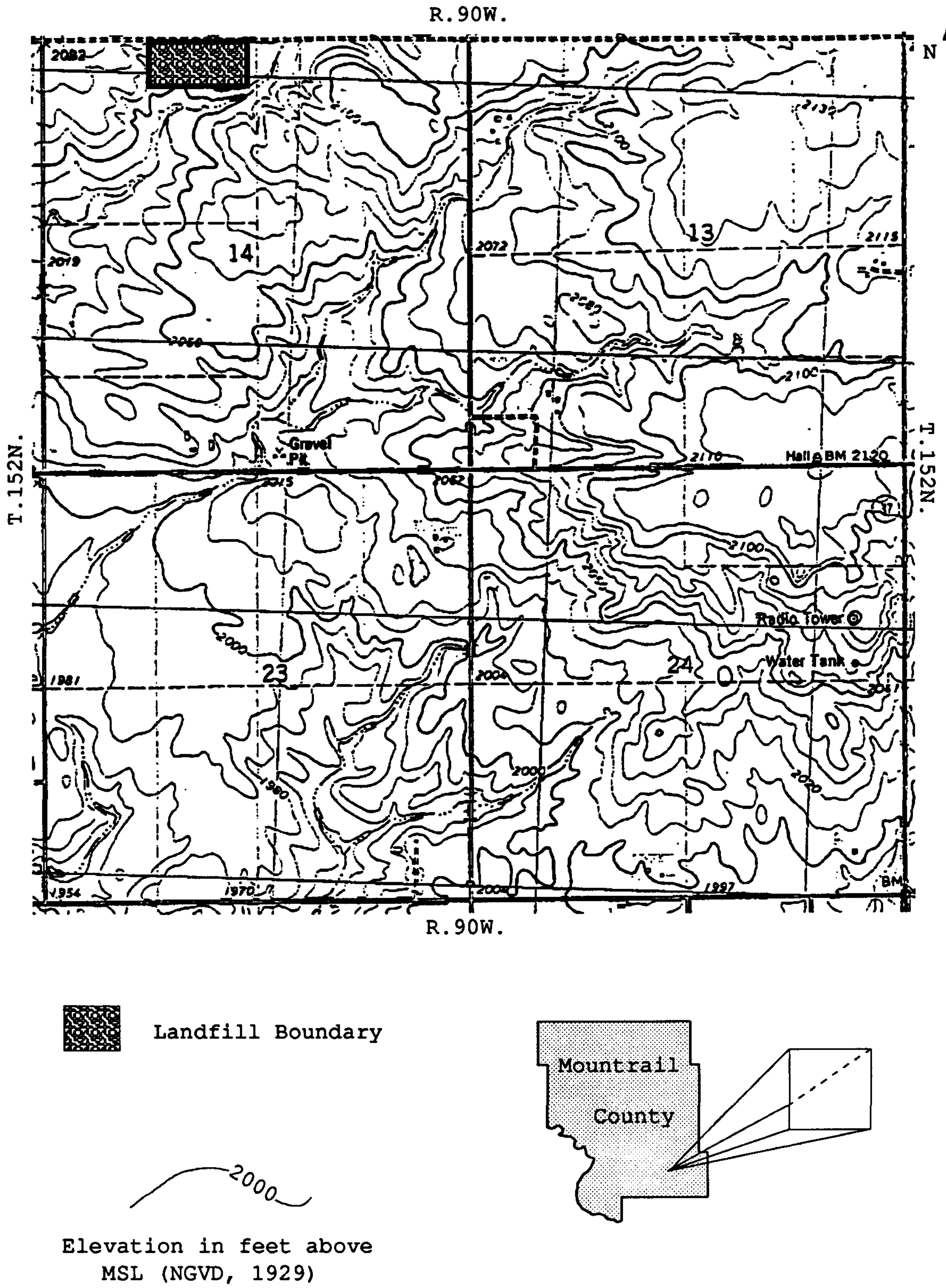

Figure 1. Location of the Geving Sanitation landfill in the NW 1/4, section 14, T.152N., R.90W.

Previous Site Investigations

No previous hydrogeologic investigations have been completed at the Geving solid-waste landfill.

Methods of Investigation

The Geving 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. Well abandonment procedures were followed for non-permanent monitoring wells.

Test-Drilling Procedure

The drilling method at the Geving 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 Geving 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

Six test holes were drilled at the Geving landfill, and monitoring wells were installed in all of them. The number of wells installed at the Geving 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 boundaries 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.

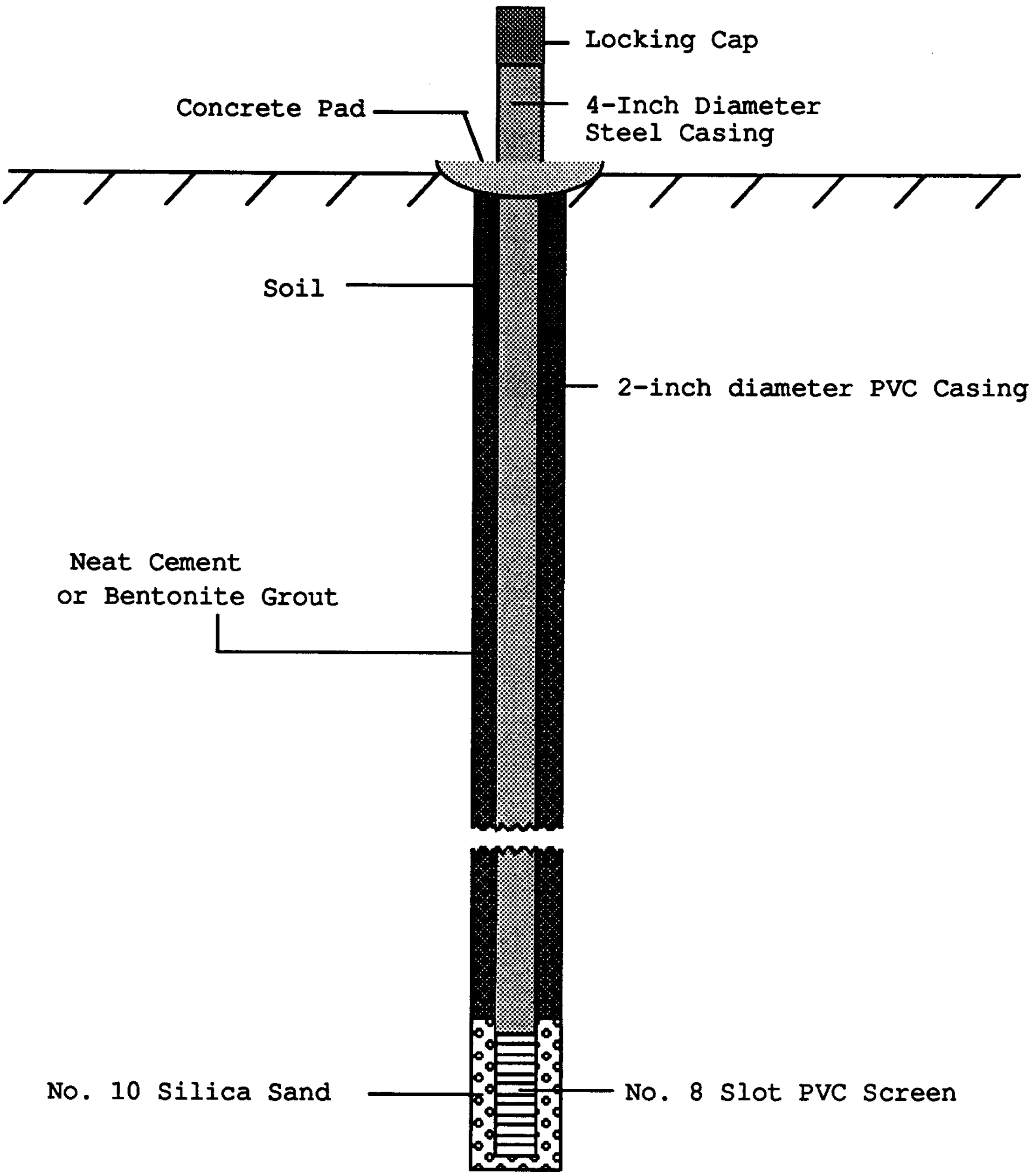

Figure 2. Construction design used for monitoring wells installed at the Geving landfill.

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 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.

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

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.

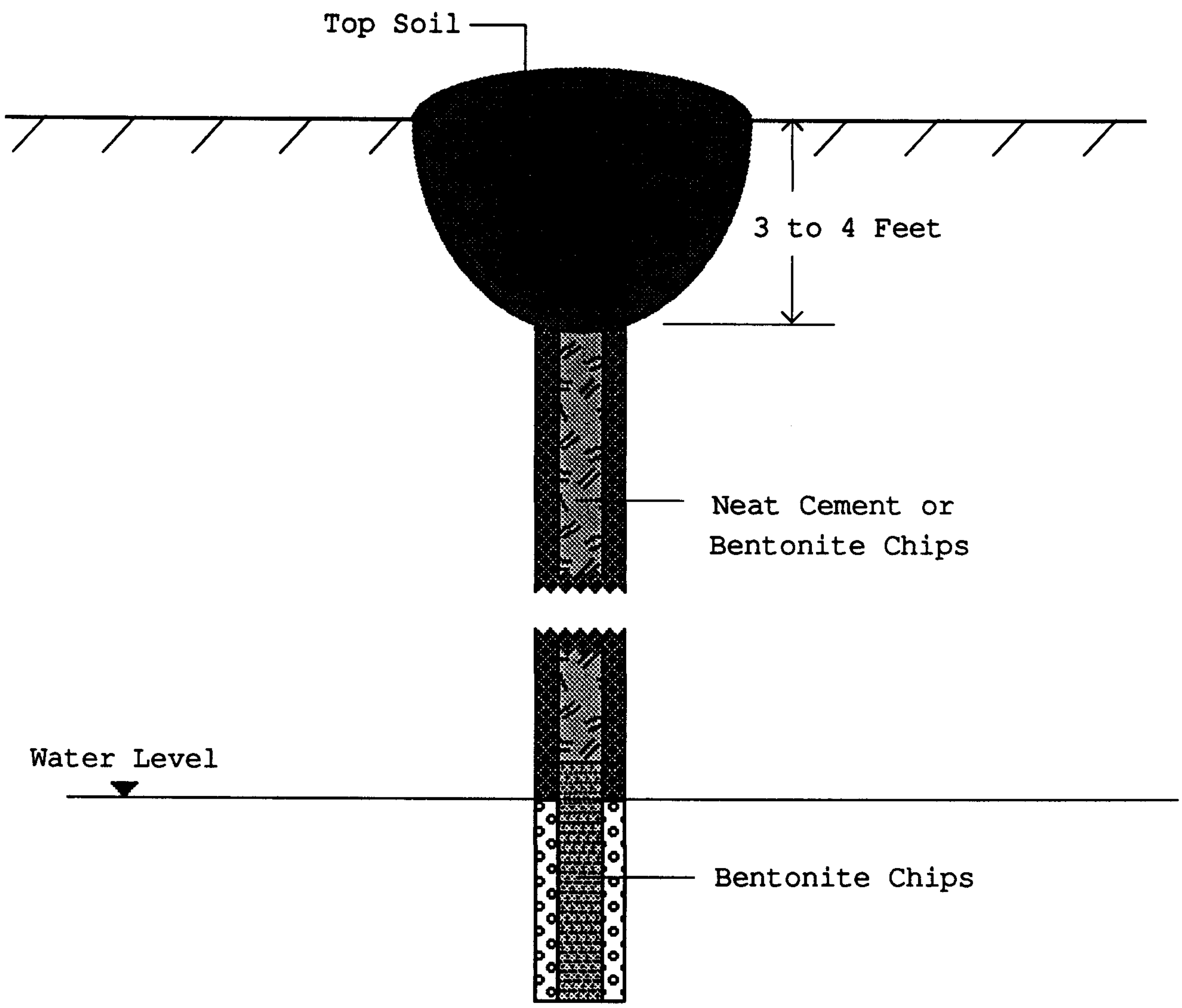


Figure 3. Monitoring well abandonment procedures.

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 152-090-14BAD would be located in the SE1/4, NE1/4, NW1/4, Section 14, Township 152 North, Range 90 West. Consecutive numbers are added following the three letters if more than one well is located in a 10-acre tract, e.g. 152-090-14BAA1 and 152-090-14BAA2.

Geology

The Geving landfill is located on the south slope of a hill (Fig. 5). The surficial geologic materials in the area consist of collapsed glacial sediments and glaciofluvial sediments of the Coleharbor Group. The glaciofluvial sediments occur mainly along stream channels, such as Shell Creek, 2 1/2 miles northwest of the landfill, and East Fork

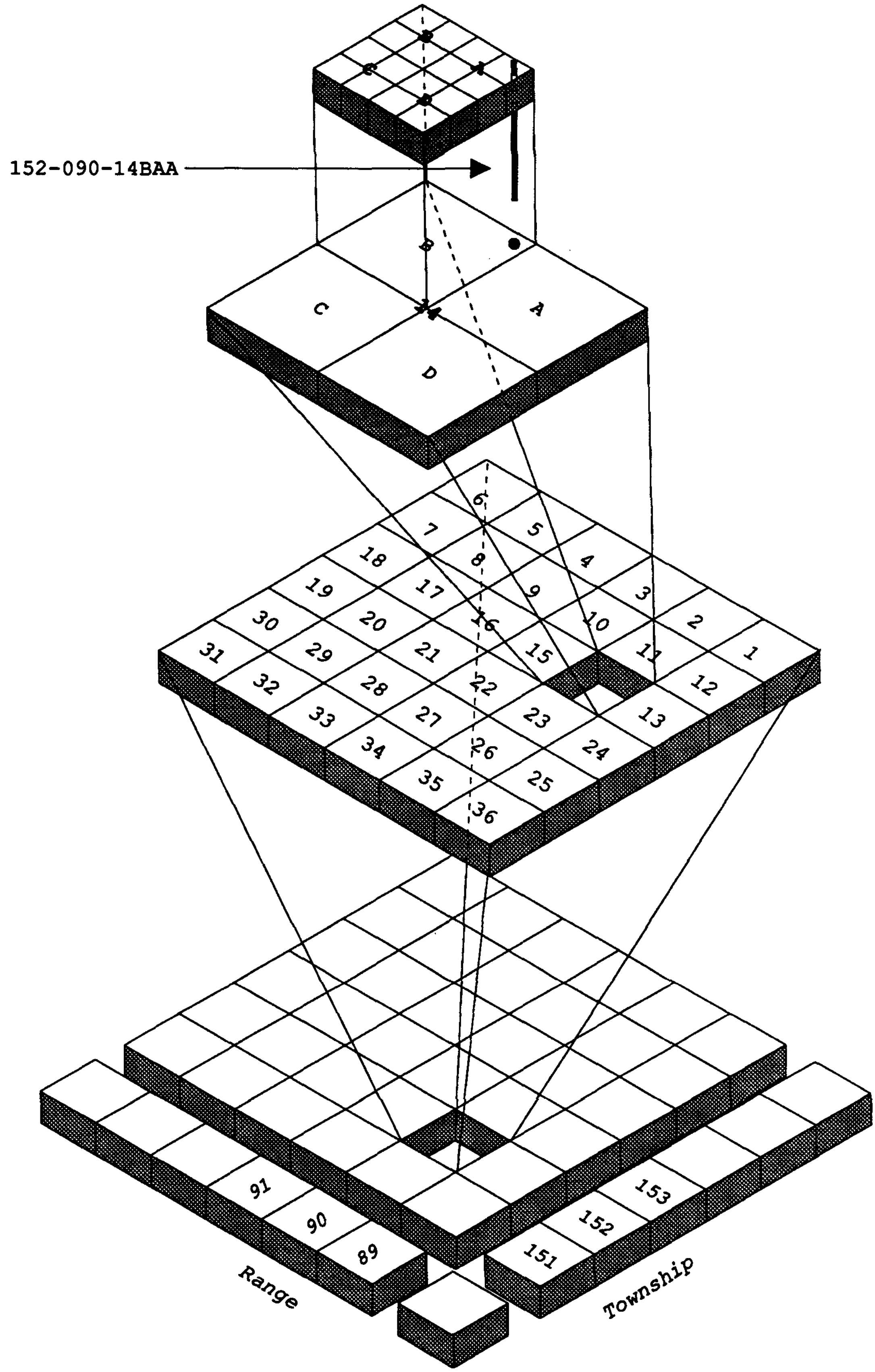
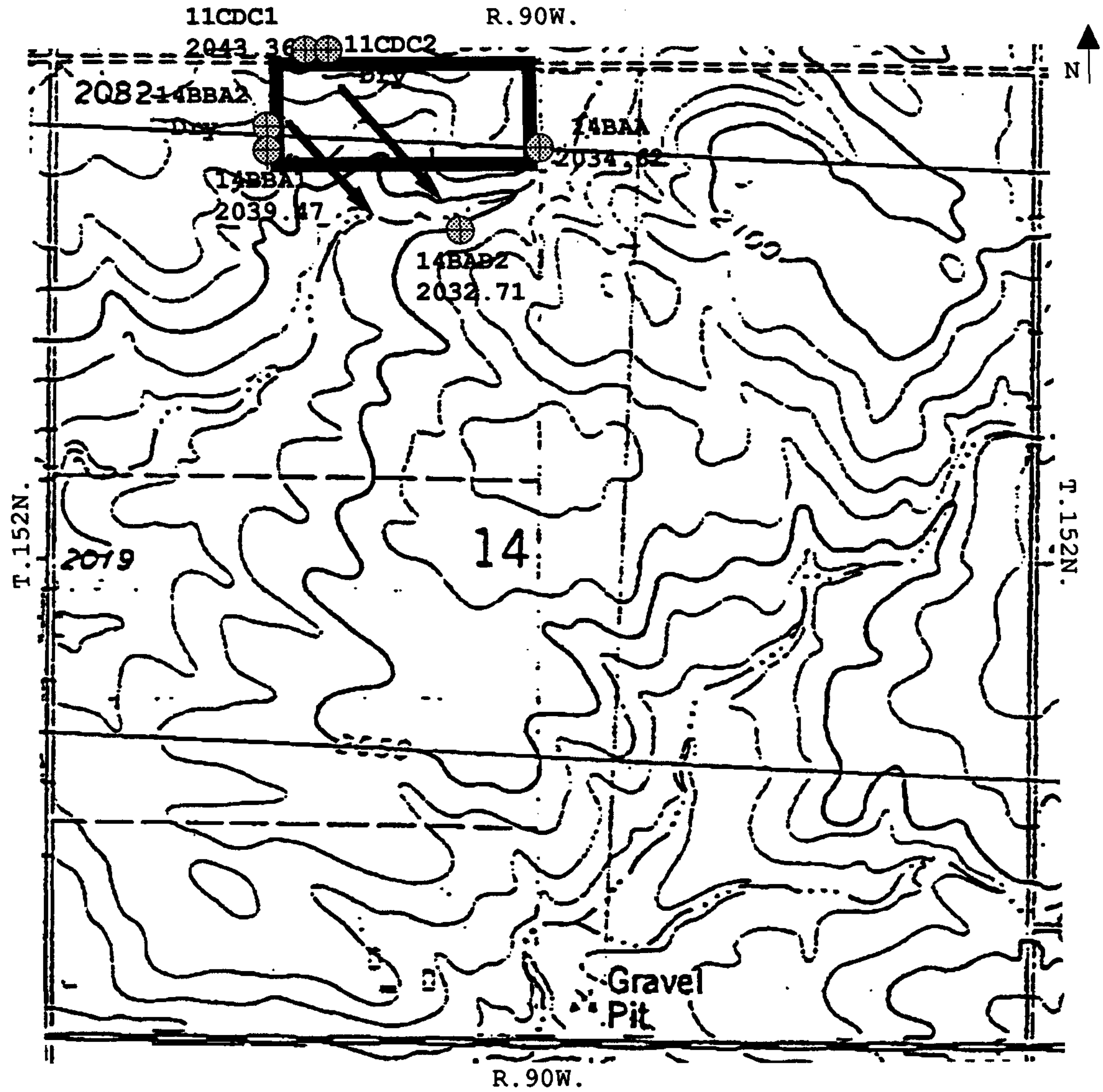


Figure 4. Location-numbering system for the Geving landfill.



SWC/NDGS Monitoring Wells

Direction of Ground-Water Flow

Landfill Boundary

2000

Elevation in feet above MSL (NGVD, 1929)

14BAD2
2032.71

Well Number and Water-Level Elevation on 9/8/93

Figure 5. Location of monitoring wells at the Geving Sanitation landfill.

Shell Creek, 2 1/2 miles south of the landfill. An intermittent stream valley just south of the landfill also contains minor glaciofluvial sediments according to maps of the area (Armstrong, 1971, Clayton, 1972).

The Coleharbor Group in the area is generally less than 50 feet thick (Clayton, 1972). The Sentinel Butte Formation (Paleocene) underlies the Coleharbor Group and is composed of clay, silt, sand, sandstone, lignite, and limestone.

Test holes drilled around the perimeter of the landfill for this study encountered between 7 feet and 23 feet of Coleharbor Group sediments (lithologic logs are shown in Appendix C). A layer of sand occurs at the surface in three of the six test holes (152-090-11CDC1, 11CDC2, and 14BAA). In test hole 14BAA the sand is underlain by 2 feet of gravel (Fig. 6). This sand and gravel may be part of the glaciofluvial valley fill deposits associated with the intermittent stream channel to the south. Till occurs at the surface in the other three test holes.

The Sentinel Butte Formation at the site contains two layers of sand separated by clay and lignite (Fig. 6). The upper sand is fine-grained to medium-grained, while the lower sand is very fine-grained to fine-grained. Only three of the test holes encountered lignite.

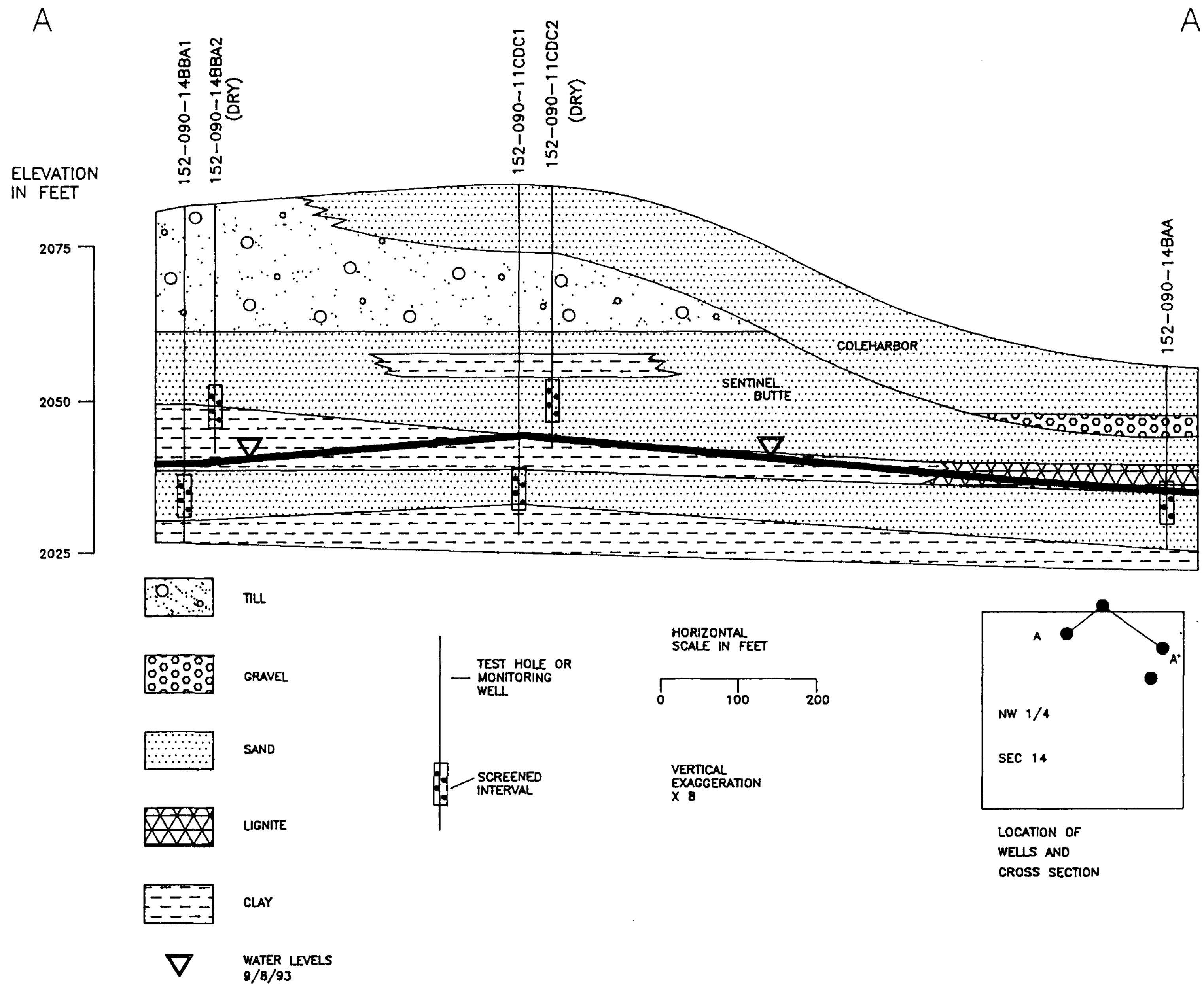


Figure 6. Geohydrologic section A–A' in the Geving landfill.

HYDROLOGY

Surface-Water Hydrology

An intermittent stream occurs along the eastern boundary of the landfill. This stream flows to the southwest and discharges into a small wetland located southwest of the landfill. An intermittent stream only flows during periods of snow melt or heavy precipitation. This stream may be susceptible to contaminant migration from landfill surface runoff or lateral ground-water flow through the buried refuse.

Another intermittent stream is located about one-half mile east of the landfill. This stream flows to the south and discharges into East Fork Shell Creek. This stream should not be susceptible to contaminant migration from the landfill.

Shell Creek is located about 2.5 miles west of the landfill. This creek is the regional discharge area for local streams and shallow ground waters. Shell Creek should not be affected by the landfill operation due to its distance and up-gradient location from the landfill.

Lake Sakakawea is located about five miles southwest of the landfill. Lake Sakakawea is the regional discharge area for all the streams and creeks around the landfill. Lake Sakakawea should not be affected by contaminant migration from the landfill.

Regional Ground-Water Hydrology

Major aquifers in the area of the Geving landfill consist of glacial and bedrock lithologies. The Shell Creek aquifer, located about two miles west of the landfill, occurs in sand and gravel outwash-alluvium deposits in the Shell Creek valley (Armstrong, 1971). The extent of this aquifer is not completely known. The depth of the Shell Creek aquifer ranges from land surface to about 250 feet (Armstrong, 1971). Recharge to the Shell Creek aquifer is by precipitation, lateral flow from adjacent glacial outwash sediments, and lateral flow from the undifferentiated Sentinel Butte aquifer system. The Shell Creek aquifer water quality varies from a mixed cation-bicarbonate type at shallow depths to a sulfate type water at greater depths.

The East Fork Shell Creek aquifer is located about 2.5 miles south of the landfill. This aquifer occurs in surficial fluvial sand and gravel within the East Fork Shell Creek valley (Armstrong, 1971). The aquifer is recharged by precipitation, seepage from streams, and lateral flow from the Sentinel Butte aquifer system. The City of Parshall obtains its water supply from this aquifer. The East Fork Shell Creek aquifer is characterized by a sodium-bicarbonate, sulfate type water.

Undifferentiated sand and gravel aquifers are found throughout the region. These aquifers are not extensive and as a result are characterized by limited recharge. However, these aquifers commonly are a source for domestic and stock supplies. These aquifers are generally characterized by a mixed cation-bicarbonate-sulfate type water (Armstrong, 1971). The glacial aquifers should not be affected by contaminant migration from the landfill.

The uppermost bedrock aquifer is found in the Sentinel Butte Formation and occurs in zones of unconsolidated sandstone and fractured lignite that directly underlie the glacial drift in the vicinity of the landfill. Recharge to this aquifer is generally from precipitation and from lateral flow from adjacent glacial aquifers. The Sentinel Butte aquifer is characterized by a sodium-bicarbonate type water.

The Bullion Creek Formation underlies the Sentinel Butte aquifer and occurs in areas of unconsolidated sandstone and fractured lignite. This aquifer is characterized by a sodium-sulfate type water (Armstrong, 1971).

It is not known if the Cannonball/Ludlow aquifer exists in the vicinity of the landfill. The Fox Hills-Hell Creek aquifer underlies the Cannonball Formation. This aquifer occurs within unconsolidated sandstone at a depth ranging from 1,450 to 2,100 feet (Armstrong, 1971). The Fox Hills-Hell Creek aquifer is characterized by a sodium-bicarbonate type water. None of the bedrock aquifers, except the Sentinel Butte aquifer, should be affected by contaminant migration from the landfill.

Local Ground-Water Hydrology

Six monitoring wells were installed at the Geving landfill. Wells 14BAA and 14BAD2 were screened in a lignite bed of the Sentinel Butte Formation and the other four wells were screened in a layer of bedrock sand of the Sentinel Butte Formation. Two shallow wells (11CDC2 and 14BBA2), screened in the shallow bedrock sand, were dry during this study (Fig. 6).

Four water-level measurements were taken over a five week period (Appendix D). A confined aquifer was located in a layer of bedrock sand underlying a thin layer of clay. The flow of this aquifer appears to be to the south-southeast following the topographic slope toward the valley occupied by an intermittent stream (Fig. 5).

Water Quality

Chemical analyses of water samples are shown in Appendix E. The major ion analysis indicated anomalously high nitrate concentrations of 170 mg/L in well 14BAA and 68 mg/L in well 11CDC1 which are above the SMCL of 50 mg/L. Well 14BAA is screened in bedrock sand and lignite along the eastern boundary of the landfill (Fig. 5). Well 11CDC1 is located in a road ditch along the north side of the landfill next to an agricultural field screened in bedrock sand. The source of the nitrate concentrations was not determined. As compared to other wells, well 14BAA had significantly larger concentrations of many major analytes. These included: total dissolved solids (1900 mg/L), sulfate (1700 mg/L), calcium (440 mg/L), magnesium (190 mg/L), and sodium (230 mg/L).

Trace element analyses indicated a selenium concentration of 11 µg/L in well 14BAA. This concentration exceeds the MCL of 10 µg/L. The source of the selenium concentration was not determined. The elevated nitrate and selenium concentrations along with the other elevated analytes may be indicative of leachate migration from the landfill at well 14BAA.

The results of the VOC analysis, from well 152-090-14BAA, are shown in Appendix F. There were no VOC compounds detected at this well.

CONCLUSIONS

The Geving landfill is located on the south slope of a hill consisting of collapsed glacial sediments and glaciofluvial sediments of the Coleharbor Group. The Coleharbor Group is generally less than 50 feet thick in the area of the landfill. The Sentinel Butte Formation underlies the Coleharbor Group and consists of silt, sand, sandstone, lignite, and limestone. The Sentinel Butte Formation at the site contains two layers of sand separated by clay and lignite layers.

The uppermost aquifer beneath the landfill occurs in the Sentinel Butte Formation. Recharge to this aquifer is by precipitation and lateral flow from undifferentiated glacial aquifers. Water-level measurements indicated a confined aquifer located in a layer of sand underlying a thin layer of clay. The flow of this aquifer appears to be to the south-southeast following the topographic slope toward the valley occupied by the intermittent stream.

An intermittent stream is located along the eastern boundary of the landfill and flows to the southwest. This stream may be susceptible to contaminant migration from landfill surface runoff or lateral ground-water flow through the buried refuse.

The water-quality analyses indicated anomalously high nitrate concentrations from wells 14BAA and 11CDC1. These concentrations exceeded the MCL for nitrate. Well 14BAA also indicated elevated concentrations of total disolved solids, sulfate, calcium, magnesium, and sodium compared to the other wells in this study. Well 14BAA is located down-gradient of the buried refuse and is screened in bedrock sand and lignite. The trace-element analyses also indicated an anomalously high selenium concentration that exceeds the MCL in well 14BAA. The elevated nitrate, selenium, and other major analyte concentrations may be indicative of leachate migration from the landfill at well 14BAA. A VOC analysis from this well did not detect any VOC compounds.

REFERENCES

Armstrong, C.A., 1971, Ground-water resources of Burke and Mountrail Counties: North Dakota Geological Survey, Bulletin 55, North Dakota State Water Commission, County Ground Water Studies 14, Part III, 86 p.

Clayton, L., 1972, Geology of Mountrail County, North Dakota: North Dakota Geological Survey, Bulletin 55, North Dakota State Water Commission, County Ground Water Studies 14, Part IV, 70 p.

Hem, J.D., 1989, Study and interpretation of the chemical characteristics of natural water: United States Geological Survey Water-Supply Paper 2254, 263 p.

North Dakota Department of Health, 1986, Water well construction and well pump installation: Article 33-18 of the North Dakota Administrative Code.

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

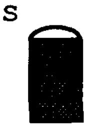
1. Three samples must be collected in the 40ml bottles that are provided by the lab. One is the sample and the others are duplicates.

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

152-090-11CDC1

NDSWC

Date Completed:	8/10/93	Purpose:	Observation Well
L.S. Elevation (ft):	2085.36	Well Type:	2" PVC
Depth Drilled (ft):	56	Aquifer:	UND
Screened Interval (ft):	47-52	Source:	
		Owner:	HERB GEVING

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND	FINE GRAINED, YELLOWISH-BROWN, TILL	1-11
SAND	CLAYEY, TRACE OF GRAVEL, FINE TO MEDIUM GRAIN, YELLOWISH-BROWN	11-23
SAND	FINE TO MEDIUM GRAIN, YELLOWISH-BROWN, BEDROCK	23-28
CLAY	LIGHT GRAY, BEDROCK	28-31
SAND	GREENISH, FINE TO MEDIUM GRAIN	31-41
CLAY	YELLOWISH-ORANGE	41-42
CLAY	SANDY, BROWNISH-BLACK	42-47
SAND	CLAYEY, SILTY, YELLOWISH-GREEN, FINE GRAINED	47-53
CLAY	MEDIUM GRAY, STIFF	53-56

152-090-11CDC2

NDSWC

Date Completed:	8/10/93	Purpose:	Observation Well
L.S. Elevation (ft):	2085.15	Well Type:	2" PVC
Depth Drilled (ft):	40	Aquifer:	UND
Screened Interval (ft):	33-38	Source:	
		Owner:	HERB GEVING

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND	FINE GRAIN, YELLOWISH-BROWN, TILL	1-13
SAND	CLAYEY, TRACE OF GRAVEL, FINE TO MEDIUM GRAIN, YELLOWISH-BROWN	13-23
SAND	FINE TO MEDIUM GRAIN, YELLOWISH-BROWN, BEDROCK	23-28
CLAY	LIGHT GRAY, BEDROCK	28-30
SAND	GREENISH, FINE TO MEDIUM GRAIN	30-38
SAND	FINE GRAIN, REWORKED SANDSTONE, WHITEISH	38-40

152-090-14BAA

NDSWC

Date Completed:	8/10/93	Purpose:	Observation Well
L.S. Elevation (ft):	2055	Well Type:	2" PVC
Depth Drilled (ft):	33	Aquifer:	UND
Screened Interval (ft):	17-27	Source:	
		Owner:	HERB GEVING

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND	FINE TO MEDIUM GRAIN, YELLOWISH-ORANGE	1-9
GRAVEL	MEDIUM TO COARSE GRAIN YELLOWISH-ORANGE	9-11
SAND	VERY FINE TO FINE GRAIN, OLIVE	11-16
LIGNITE		16-21
SAND	VERY FINE GRAINED, SILTY, YELLOWISH-GREEN	21-31
CLAY	LIGHT GRAY, SILTY	31-33

152-090-14BAD
NDSWC

Date Completed:	8/10/93	Purpose:	Test Hole
L.S. Elevation (ft):	2043		
Depth Drilled (ft):	32	Aquifer:	UND
		Source:	
		Owner:	HERB GEVING

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	SILTY, ROCKY, LIGHT YELLOW, TILL	1-7
LIGNITE	BEDROCK	7-11
CLAY	BROWNISH-BLACK	11-13
CLAY	YELLOWISH-BROWN, STIFF	13-17
CLAY	MEDIUM-GRAY, STIFF	17-19
CLAY	SILTY, SANDY, BLUEISH-GRAY, STIFF	19-32

152-090-14BAD2
NDSWC

Date Completed:	8/10/93	Purpose:	Observation Well
L.S. Elevation (ft):	2043.17	Well Type:	2" PVC
Depth Drilled (ft):	14	Aquifer:	UND
Screened Interval (ft):	7-12	Source:	
		Owner:	HERB GEVING

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	SILTY, ROCKY, YELLOWISH-BROWN, TILL	1-7
LIGNITE	BEDROCK	7-11
CLAY	SILTY, BROWNISH-BLACK.	11-13
CLAY	YELLOWISH-ORANGE.	13-14

152-090-14BBA1
NDSWC

Date Completed:	8/10/93	Purpose:	Observation Well
L.S. Elevation (ft):	2082.7	Well Type:	2" PVC
Depth Drilled (ft):	55	Aquifer:	UND
Screened Interval (ft):	46-51	Source:	
		Owner:	HERB GEVING

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	SANDY, GRAVELLY, YELLOWISH-BROWN, TILL	1-16
CLAY	REDDISH-BROWN	16-17
CLAY	SANDY, GRAVELLY, YELLOWISH-BROWN, TILL	17-22
SAND	FINE TO MEDIUM GRAIN, YELLOWISH-GREEN, BEDROCK	22-34
CLAY	SANDY, OLIVE	34-37
CLAY	OLIVE, STIFF	37-40
CLAY	BROWNISH-BLACK, SOFT LIGNITE	40-41
CLAY	SILTY, SANDY, OLIVE	41-45
SAND	VERY FINE TO FINE GRAIN, SILTY, OLIVE	45-53
CLAY	MEDIUM GRAY, STIFF	53-55

152-090-14BBA2
NDSWC

Date Completed:	8/10/93	Purpose:	Observation Well
L.S. Elevation (ft):	2083.38	Well Type:	2" PVC
Depth Drilled (ft):	38	Aquifer:	UND
Screened Interval (ft):	31-36	Source:	
		Owner:	HERB GEVING

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	SANDY, GRAVELLY, YELLOWISH-BROWN, TILL	1-16
CLAYSTONE	YELLOWISH-ORANGE, INDURATED	16-17
CLAY	SANDY, GRAVELLY, YELLOWISH-BROWN, TILL	17-22
SAND	FINE TO MEDIUM GRAIN, GREEN, BEDROCK	22-32
SANDSTONE	VERY FINE GRAIN, INDURATED	32-33
SAND	FINE TO MEDIUM GRAIN, GREENISH	33-37
CLAY	LIGHT YELLOWISH-GREEN	37-38

APPENDIX D

WATER-LEVEL TABLES

Geving Landfill Water Levels
8/18/93 to 9/21/93

152-090-11CDC1 LS Elev (msl,ft)=2085.36
UND Aquifer SI (ft.)=47-52

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/18/93	42.29	2043.07	09/08/93	41.83	2043.53
08/24/93	42.20	2043.16	09/21/93	41.89	2043.47

152-090-14BAA LS Elev (msl,ft)=2055
UND Aquifer SI (ft.)=17-27

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/18/93	20.78	2034.22	09/08/93	20.38	2034.62
08/24/93	20.53	2034.47	09/21/93	20.72	2034.28

152-090-14BAD2 LS Elev (msl,ft)=2043.17
UND Aquifer SI (ft.)=7-12

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/18/93	9.54	2033.63	09/08/93	10.46	2032.71
08/23/93	9.71	2033.46	09/21/93	11.10	2032.07

152-090-14BBA1 LS Elev (msl,ft)=2082.7
UND Aquifer SI (ft.)=46-51

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/18/93	43.45	2039.25	09/08/93	43.23	2039.47
08/23/93	43.39	2039.31	09/21/93	43.31	2039.39

APPENDIX E

MAJOR ION AND TRACE-ELEMENT CONCENTRATIONS

Geving Landfill Water Quality
Major Ions

			(milligrams per liter)																					
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
152-090-11CDC1	47-52	08/24/93	18	0.02	0.01	75	25	41	3.1	325	0	55	15	0.5	68	0.12	461	290	24	23	1	679		7.02
152-090-14BAA	17-27	08/24/93	53	0.05	0.04	440	190	230	10	393	0	1700	14	0.5	170	0.72	3000	1900	1600	21	2.3	3160	9	7.04
152-090-14BAD2	7-12	08/23/93	11	0.03	0.01	87	43	14	2.3	343	0	68	27	0.2	41	0.03	463	390	110	7	0.3	775	10	7.25
152-090-14BBA1	46-51	08/23/93	20	0.17	0.04	97	46	19	3.2	301	0	150	30	0.3	46	0.04	560	430	180	9	0.4	837	11	7.56

Trace Element Analyses

Location	Date Sampled	Selenium	Lead	Cadmium	Mercury	Arsenic	Molybdenum	Strontium
		(micrograms per liter)						
152-090-11CDC1	8/23/93	1	0	0	0	1	6	280
152-090-14BAA	8/23/93	11	0	0	0	0	8	3500
152-090-14BAD2	8/23/93	1	0	0	0	1	1	430
152-090-14BBA1	8/23/93	7	0	0	0	1	2	490

APPENDIX F

VOLATILE ORGANIC COMPOUNDS
FOR WELL 152-090-14BAA

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