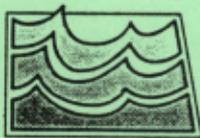


Site Suitability Review of the Dakota Landfill

by
Jeffrey Olson
North Dakota State Water Commission
and
Phillip L. Greer
North Dakota Geological Survey



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

ND Landfill Site Investigation No. 20

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OF THE
DAKOTA LANDFILL

By Jeffrey M. Olson, North Dakota State Water Commission,
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North Dakota Landfill Site Investigation 20

Prepared by the NORTH DAKOTA STATE WATER COMMISSION
and the NORTH DAKOTA GEOLOGICAL SURVEY

Bismarck, North Dakota
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TABLE OF CONTENTS

	Page
INTRODUCTION.....	1
Purpose.....	1
Location of the Dakota Landfill.....	1
Previous Site Investigations.....	2
Methods of Investigation.....	3
Test Drilling Procedure.....	3
Monitoring Well Construction and Development...	3
Collecting and Analyzing Water Samples.....	6
Water-Level Measurements.....	8
Well-Abandonment Procedure.....	8
Location-Numbering System.....	10
GEOLOGY.....	10
Distribution and Origin of Shale Blocks.....	12
Distribution of Sand.....	13
HYDROLOGY.....	16
Surface-Water Hydrology.....	16
Regional Ground-Water Hydrology.....	17
Local Ground-Water Hydrology.....	22
WATER QUALITY.....	24
CONCLUSIONS.....	29
REFERENCES.....	33
APPENDIX A. Well identification tables.....	34
APPENDIX B. Water quality standards and contamination levels.....	36
APPENDIX C. Sampling procedure for volatile organic compounds.....	38

TABLE OF CONTENTS (cont.)

	Page
APPENDIX D. NDSWC and NDGS lithologic logs.....	40
APPENDIX E. Lithologic logs from previous studies.....	108
APPENDIX F. NDSWC and NDGS water-level tables.....	148
APPENDIX G. NDSWC and NDGS major ion and trace element concentrations.....	162
APPENDIX H. Major ion and trace element concentrations from previous studies.....	168
APPENDIX I. Volatile organic compounds from well 132- 056-10BBC2.....	200
APPENDIX J. Volatile organic compounds from well 132- 056-10CBAC.....	203

LIST OF FIGURES

	Page
Figure 1. Construction design used for monitoring wells installed at the Dakota landfill.....	5
Figure 2. Monitoring well abandonment procedure.....	9
Figure 3. Location-numbering system for the Dakota landfill.....	11
Figure 4. Locations and elevations of the shale blocks.....	14
Figure 5. Piper diagram showing relative concentrations of major ions for ground water in the Gwinner aquifer and the undifferentiated aquifers underlying the Dakota landfill.....	26
Figure 6. Piper diagram showing relative concentrations of major ions for ground water in the unconfined and confined undifferentiated aquifers underlying the Dakota landfill.....	27

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 (NDS DHCL) for use in site improvement, site remediation, or landfill closure. Additional studies may be necessary to meet the requirements of the NDS DHCL for continued operation of municipal solid waste landfills. The Dakota solid waste landfill is one of the landfills being evaluated.

Location of the Dakota Landfill

The Dakota solid waste landfill is located three miles north and 2 miles west of the City of Gwinner in Township 132 North, Range 56 West, W 1/2 Section 10 (Plate 1). The landfill site encompasses approximately 320 acres, of which 33 acres has been used.

Previous Site Investigations

Six hydrogeologic investigations were conducted within the Dakota landfill between 1980 and 1993. Subsurface investigations were performed by Browning-Ferris Industries (1981), Braun Engineering (1985), Water Supply Inc. (1986), and two separate reports by Foth and Van Dyke (1990, 1993). All but the most recent study were completed for the previous owner (Big Dipper Landfill). A total of thirty-two soil borings and twenty-five monitoring wells were installed within the landfill property as part of the above investigations. There were no previous investigations beyond the landfill property.

Foth and Van Dyke (1993) concluded that the site geology was complex and included two or more sand/gravel intervals of variable thickness that extended toward the southwest corner of the property. The depth of these two intervals ranged from 45 to 80 feet and 100 to 140 feet. The study also concluded that the upper 25 feet of glacial till was well-suited for clay-liner construction.

Foth and Van Dyke (1993) further concluded that for the most part ground water in the study area was characterized by high dissolved solid concentrations and hardness. The low arsenic, barium, and selenium concentrations were considered as natural background concentrations. Tetrahydrofuran was detected in three wells and was attributed to glue used in the well construction.

For continuity in this report, well numbers from previous investigations were converted to the SWC/NDGS well numbering system. A conversion table is presented in Appendix A.

Methods of Investigation

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

Monitoring Well Construction and Development

Thirty-two test holes were drilled at the Dakota landfill, and monitoring wells were installed in seventeen of the test holes. The number of wells installed at the Dakota

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 in a sand body with a thickness greater than ten feet. All wells were located in a 1.5 mile radius of the landfill property.

Wells were constructed following a standard design (Fig. 1) intended to comply with the construction regulations of the NDSHCL 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 on wells next to the active area of the landfill. Glue was used on wells located one-half mile or more from the landfill. 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 or natural sands were collapsed to a height of at least two feet above the top of the screen. High-solids bentonite grout and/or neat cement was placed above the sand to seal the annulus to approximately two feet below land surface. The remaining annulus was filled with bentonite chips. The permanent wells were secured with a protective steel casing and a locking cover protected by a two-foot-square concrete pad.

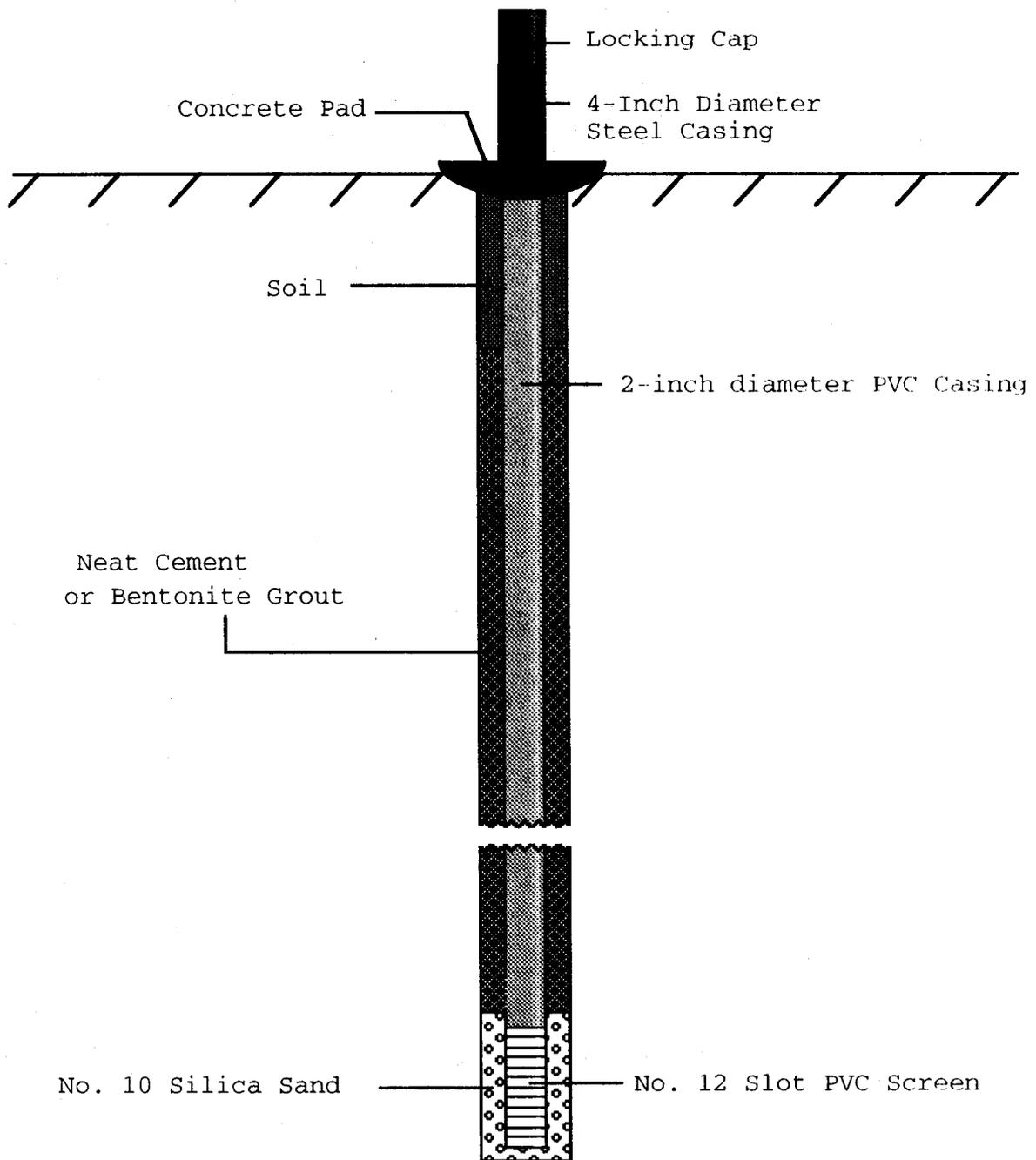


Figure 1. Construction design used for monitoring wells installed at the Dakota landfill.

All monitoring wells were developed using an air compressor 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 B with their water quality standards and contamination levels. The enforceable drinking water standards represent the maximum permissible level of a contaminant (MCL) as stipulated by the U.S. Environmental Protection Agency (EPA).

Water samples were collected using a bladder pump constructed of stainless steel or 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.

Two wells were sampled for Volatile Organic Compounds (VOC) analyses. These samples were collected at a different time than the standard water quality sample. The procedure used for collecting the VOC sample is described in Appendix C. 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 NDS DHCL.

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. 2) 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.

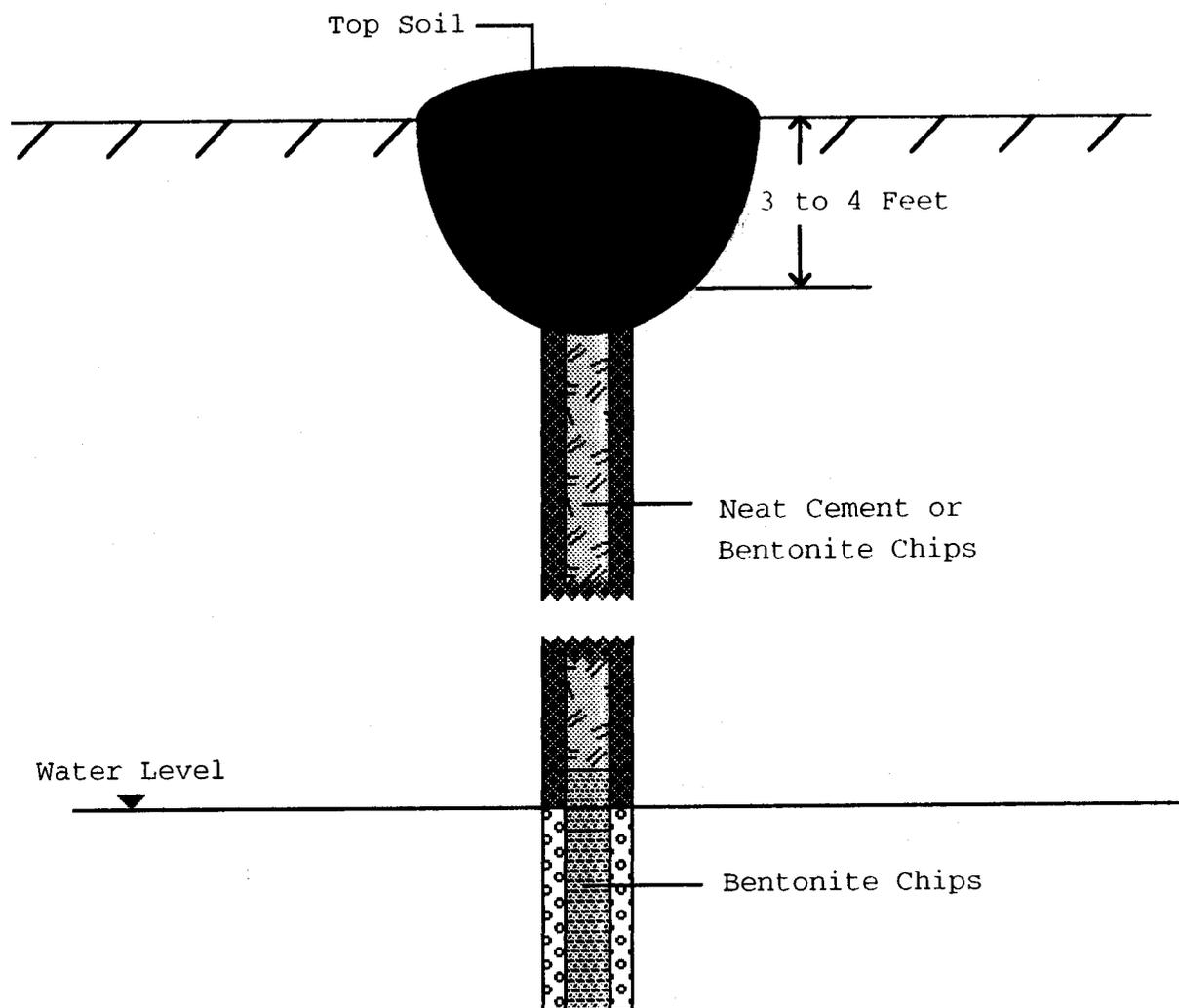


Figure 2. Monitoring well abandonment procedure.

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. 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 132-056-10BCD would be located in the SE1/4, SW1/4, NW1/4, Section 10, Township 132 North, Range 56 West. Consecutive numbers are added following the three letters if more than one well is located in a 10-acre tract, e.g. 132-056-10BCD1 and 132-056-10BCD2.

GEOLOGY

The Dakota landfill is located on the Whitestone Hills, which stand about 150 feet above the surrounding countryside and have a maximum elevation of about 1420 feet. The hills have gentle slopes on the west side and steep slopes on the east side, where they rise 100 feet in about one-half mile.

The stratigraphy of the Whitestone Hills consists of

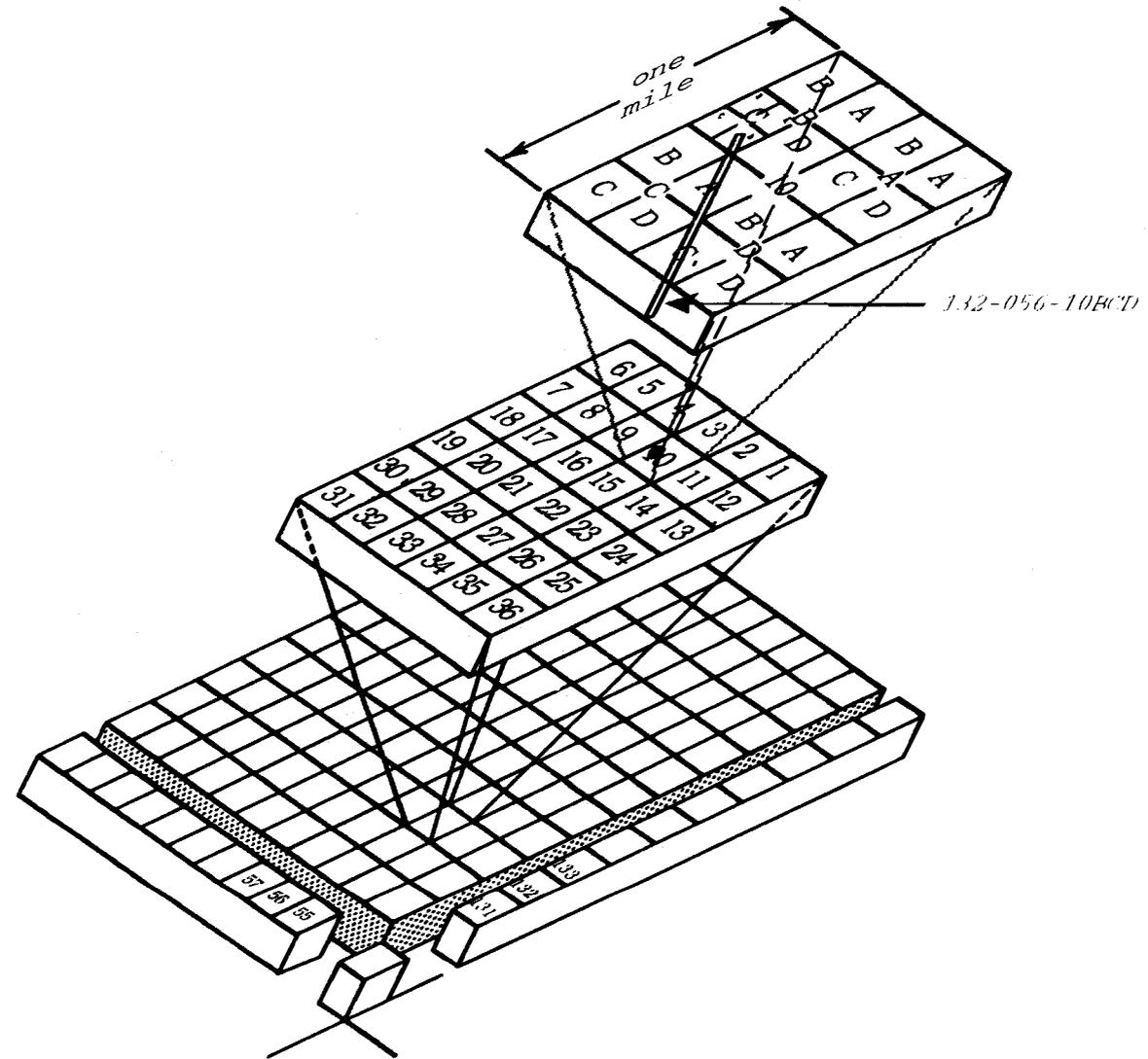


Figure 3. Location-numbering system for the Dakota landfill.

glacial till interbedded with layers and lenses of glaciofluvial sediment. The till is a mixture of clay, silt, sand, and rocks, whereas the glaciofluvial sediment consists mainly of sand and gravel. The hills also contain blocks of Cretaceous shale that were emplaced by glacial thrusting. The shale blocks were incorporated into the glacial material when the hill was thrust into its present position by the shearing action of an advancing glacier.

The elevation of the bedrock surface in the study area ranges from 1075 feet to 1115 feet. The uppermost bedrock unit is the Cretaceous Carlile Formation except on the western edge of the study area (test holes 132-056-04CCC, 09CCC, and 21BBC, lithologic logs in Appendix D) where the Cretaceous Niobrara Formation is the uppermost bedrock unit. The Carlile Formation is composed of soft, dark gray, waxy non-calcareous shale. The Niobrara Formation is composed of light gray, silty, calcareous shale (Bluemle, 1979).

Distribution and Origin of Shale Blocks

The deep test holes drilled for this study encountered numerous blocks of shale within the glacial sediments. The blocks ranged in thickness from a few feet to 50 feet. A test hole drilled in a previous study penetrated a 67-foot-thick block of shale. All of the shale blocks were derived from the Carlile Formation.

Figure 4 shows the locations and elevations of the shale blocks. Thirteen of twenty-one deep test holes within the study area penetrated shale blocks. The shale blocks are concentrated near the center and on the east side of the Whitestone Hills. The elevations of the shale blocks are very consistent. Nine of the test holes penetrated blocks with lower elevations between 1143 feet and 1167 feet, and another three test holes penetrated blocks with lower elevations between 1244 feet and 1272 feet.

The Whitestone Hills have been interpreted as an ice-thrust feature based on their topographic character (Bluemle, 1979). The presence of the shale blocks confirms this interpretation. The two sets of shale blocks may belong to separate thrust sheets. The lowermost blocks are on the east side of the Whitestone Hills, indicating that the material was thrust from east to west. The upper shale blocks have a vertical displacement of approximately 200 feet above the bedrock surface. The two levels of shale blocks are shown on Plates 3, 4, and 8.

Distribution of Sand

As noted in other reports, two or more sand layers occur beneath the landfill. The upper sand occurs at an elevation of about 1330 to 1370 feet. This sand ranges from a few feet to about 40 feet in thickness. It is interbedded with clay

or silt at some locations. The upper sand is illustrated in Plates 6, 7, and 8.

In the vicinity of the landfill, the depth from the ground surface to the top of the upper sand is typically between 40 feet and 60 feet. However, in one area near the southwest corner of section 10 the sand is as shallow as 19 feet (test hole 132-056-10CCCD, Plate 7). Test holes from previous studies encountered the upper sand over most of the southwest quarter of section 10 (Foth and Van Dyke, 1993). The upper sand has not been observed in test holes to the west or south of this quarter section. However, the upper sand appears to correlate with a sand in test hole 132-056-11CBB1, located one-half mile east of the landfill (Plate 6).

Another sand layer occurs at an elevation of about 1260 to 1310 feet. This lower sand was encountered sporadically in the deep test holes beneath the landfill. Sand intervals occur at a similar elevation one-half mile southwest of the landfill in test hole 132-056-16BAA (Plate 6) and one-half mile southeast of the landfill in test hole 132-056-11CCC1 (Plate 8). The lateral continuity of these sands is uncertain because of the distance between test holes. The cross sections suggest that the lower sand consists of several separate lobes rather than being a continuous unit.

On the north side of the study area (one-half mile north of the landfill) a sand occurs generally between the 1260-foot and 1330-foot elevations (Plate 2). The stratigraphic relationship between this sand and the sands beneath the

landfill has not been determined. Two test holes - 132-056-10BBC1 (Plate 7) and 132-056-10BDA (not shown on cross sections) - have been drilled in the area between the landfill and the sand shown in Plate 2. These two test holes contain some intervals of sand, but the sand layers are thinner than in test holes to the north or south.

HYDROLOGY

Surface-Water Hydrology

The Dakota landfill is located at the top of the Whitestone Hills, north of Gwinner, North Dakota. The relatively steep slopes along the eastern and southern sides of the Whitestone Hills are conducive to the development of springs. A spring located at the southwest corner of section 11, T. 132 N., R. 56 W was the only spring found flowing at the time of this study. A dam at this location created a surface water pond. Other seasonal or ephemeral springs may be located along the eastern and southern flanks of the hill. An ephemeral spring is one that may flow only during periods of high precipitation or heavy snow melt. Other small surface-water impoundments have been created by slow-flowing, shallow wells that have not been properly abandoned.

Numerous wetland depressions occur within a one-mile radius of the landfill. These wetlands appear to have seasonal or semi-permanent characteristics. Most of the

wetlands are poorly integrated and appear to be fed by surface water runoff. Seepage of water from shallow lenses of permeable glacial sediment may also support some wetlands.

Two abandoned gravel pits are also located at the southwest corner of section 15 and the southwest corner of section 16. These gravel pits are not within the area of influence of the landfill. The Gwinner city sewage lagoons are located about one mile southeast of the landfill.

Regional Ground-Water Hydrology

Regional aquifers near the Dakota landfill consist of bedrock and glacial aquifers. The bedrock aquifer underlying the Dakota landfill is known as the Dakota aquifer system. This aquifer occurs from about 500 to 1000 feet below land surface (Armstrong, 1982). The Dakota aquifer system is characterized by a sodium-sulfate type water. Recharge to the Dakota aquifer system is by infiltration and percolation on outcrops along the Black Hills uplift in South Dakota and by upward leakage from underlying bedrock formations (Armstrong, 1982). Discharge from this aquifer system is by well pumping. This aquifer should not be affected by the landfill operation due to its depth and intervening low hydraulic conductivity Cretaceous shales and glacial till.

Five major glacial aquifers occur within a ten-mile radius of the landfill. The closest is the Gwinner aquifer located about one mile southeast of the landfill. The

Gwinner aquifer extends southeastward from Gwinner to Richland County. The aquifer consists of lenticular deposits of sand and gravel interbedded with silt and clay (Armstrong, 1982). These materials were deposited in a valley and later covered by glacial till. Near the city of Gwinner the sand and gravel deposits of the Gwinner aquifer are generally 30 to 60 feet thick and the base of the aquifer is near the bedrock surface.

The deep test holes drilled for this study did not encounter the Gwinner aquifer within at least a one-mile radius of the landfill (Plates 2 through 8). The Gwinner aquifer can be identified along the east side of the city of Gwinner and extending northward to test hole 132-056-14CDA1, which is located on the east end of the sewage lagoons. This test hole is the most northerly occurrence of the aquifer that has been identified in any of the test drilling to date. Table 1 shows the test holes in the vicinity of Gwinner which contain sand and gravel deposits of the Gwinner aquifer.

The Gwinner aquifer is absent in test hole 132-056-14CCC, located on the west end of the sewage lagoons (Plate 5). It is also absent in the other deep test holes drilled south of the landfill (Plate 3). If the aquifer had extended northwestward from the City of Gwinner toward the landfill, it should have occurred at some of the test holes south of the landfill.

Test hole 132-056-02DCC1, which is located at the

Table 1. Depths to top and bottom of sand and gravel layers of the Gwinner aquifer.

Test Hole	Depth to top and bottom of Sand and Gravel layer
132-055-31BCC	134-173
132-055-31CCCB	143-189
132-056-14CDA1	138-168
132-056-24BCC	144-177
132-056-24CCCB	132-182
132-056-24CDD	154-172
132-056-25BBC	139-184
132-056-25DAA	156-172
132-056-26DAD	121-182
132-056-36AAA	131-172
132-056-36BBB	150-188

northeast corner of the study area, penetrated a layer of sand and gravel at a similar depth (148 feet to 191 feet) of the Gwinner aquifer. However, the two test holes to the south (132-056-11DBB and 11DCC) penetrated little sand or gravel in this interval. The aquifer may be to the east of these test holes, or it may have been removed by the thrusting which produced the Whitestone Hills.

The direction of ground-water flow in this aquifer is to the southeast. Pumping of the Gwinner municipal wells has changed the local flow direction near Gwinner by creating a

ground-water divide. Recharge to the Gwinner aquifer is by infiltration of precipitation and snow-melt through the overlying till or through the sandy materials near the Richland County line (Armstrong, 1982). The only known discharge from this aquifer is by well pumping. This aquifer is characterized by a sodium sulfate type water.

The Elliot aquifer is located about six miles northwest of the landfill. The depth of this aquifer ranges from 66 to 119 feet below land surface (Armstrong, 1982). Recharge to the Elliot aquifer is by infiltration of precipitation and snow melt through the overlying and adjacent till. The only known discharge is by well pumping. This aquifer is characterized by a calcium-sodium sulfate to a sodium sulfate type water.

The Englevale aquifer is located about nine miles west of the landfill. The depth of this aquifer ranges from land surface to 81 feet below land surface (Armstrong, 1982). Recharge to the Englevale aquifer occurs predominantly by direct infiltration of precipitation and snow-melt. Discharge from the Englevale aquifer is mainly by evapotranspiration and well pumping. This aquifer is characterized by a calcium bicarbonate type water.

The Spiritwood aquifer is located about ten miles south, southwest of the landfill. The depth of the Spiritwood aquifer ranges from 80 to 283 feet below land surface (Armstrong, 1982). Recharge to the Spiritwood aquifer is by infiltration of precipitation and snow-melt through the

overlying and adjacent till. Recharge to the Spiritwood aquifer also occurs by lateral flow from the Englevale aquifer. Discharge of the Spiritwood aquifer is by well pumping and upward movement into topographic low areas (James River, Bear Creek, Measaros Slough). This aquifer is characterized by a sodium-calcium sulfate type water.

The Milnor Channel aquifer is located about ten miles east of the landfill. The depth of the Milnor Channel aquifer ranges from 3 to 77 feet below land surface. Recharge to the Milnor Channel aquifer is by infiltration of precipitation and snow-melt through the overlying and adjacent till. High water levels in local wetlands may contribute to the recharge of the Milnor Channel aquifer. Discharge from the Milnor Channel aquifer is by well pumping, evapotranspiration, and leakage into wetlands and into the Sheyenne and Wild Rice Rivers. This aquifer is characterized by a calcium-sodium bicarbonate type water.

Undifferentiated sand and gravel aquifers are found throughout the region. These aquifers are not extensive and vary in depth and as a result yield small quantities of water. Undifferentiated aquifers within the immediate area of the landfill may be susceptible to leachate migration from the landfill.

This study did not identify a direct hydraulic connection between the undifferentiated aquifers underlying the landfill and the Gwinner, Elliot, Englevale, Spiritwood

and Milnor Channel aquifers. Therefore, contamination of these aquifers from the landfill is not considered likely.

Local Ground-Water Hydrology

A conceptual model of the local ground-water hydrology is developed using data collected from; 1) previous investigations within the landfill boundaries, 2) an areal study within a one and one-half mile radius of the landfill, and 3) the Gwinner aquifer study. The Gwinner aquifer study is an unpublished-ongoing investigation of the Gwinner aquifer being conducted by the North Dakota State Water Commission.

Monitoring wells were installed at twenty-four of the forty-eight test hole sites within the landfill property. (Plate 1). Twenty-two of the monitoring wells and 16 of the soil borings were installed during previous investigations. Monitoring wells were installed at fifteen of the twenty-two test holes drilled within a one and one-half mile radius of the landfill property. The Gwinner aquifer study included eleven additional monitoring wells. Water levels were measured once a week for a period of at least five weeks from wells installed for the areal investigation and wells from the Gwinner aquifer study (Appendix F). Water levels from an ongoing investigation (Foth and Van Dyke, 1993) were also

used to evaluate hydraulic continuity (if any) between the various hydrologic units (Appendix G).

The overall direction of ground-water flow in the undifferentiated aquifers near the landfill is assumed to be to the east, southeast toward the flank of the Whitestone Hills. The spatial distribution and geometry of these undifferentiated sand and gravel aquifers is complex. The interconnectedness of individual sand and gravel layers is virtually impossible to determine. Therefore it was not practical to show a potentiometric surface map(s) of the undifferentiated aquifers. An aquifer testing program may be useful to evaluate hydrologic continuity.

Water occurs in the undifferentiated aquifers under both unconfined and confined conditions. Examples of the unconfined occurrence of ground water are indicated in the upper sand layers shown in plates 6, 7, and 8. For the most part, the undifferentiated aquifers are confined and the confining lithology (aquitar) primarily consists of till. Foth and Van Dyke (1993) report vertical till hydraulic conductivities ranging from 10^{-7} to 10^{-8} cm/sec.

Hydraulic gradient analysis can be useful for evaluating hydraulic continuity in a complex hydrogeologic setting such as occurs beneath the Dakota landfill. If the difference in water levels between sand layers is small (small hydraulic gradient) determination of hydraulic continuity is inconclusive. On the other hand, the lack of hydraulic continuity between sand layers can often be inferred when

differences in water levels are large (large hydraulic gradient). For example, the water level in the sand layer at well 132-056-09ADD2 (Plate 4) is about 50 feet below the water level at well 132-056-10CBB (Plate 4). The large vertical hydraulic gradient indicates there is no direct hydraulic connection between the sand layers. Another example demonstrating a lack of hydraulic continuity between sand layers is shown by the large vertical hydraulic gradient between wells 132-056-02DCC1 and 132-056-02DCC2 (Plate 2). Differences in water chemistry can also indicate a lack of hydraulic continuity. For example, ground water in well 132-056-09ADD2 is a sodium-bicarbonate type while the ground water in well 132-056-10CBB is a calcium-bicarbonate type.

WATER QUALITY

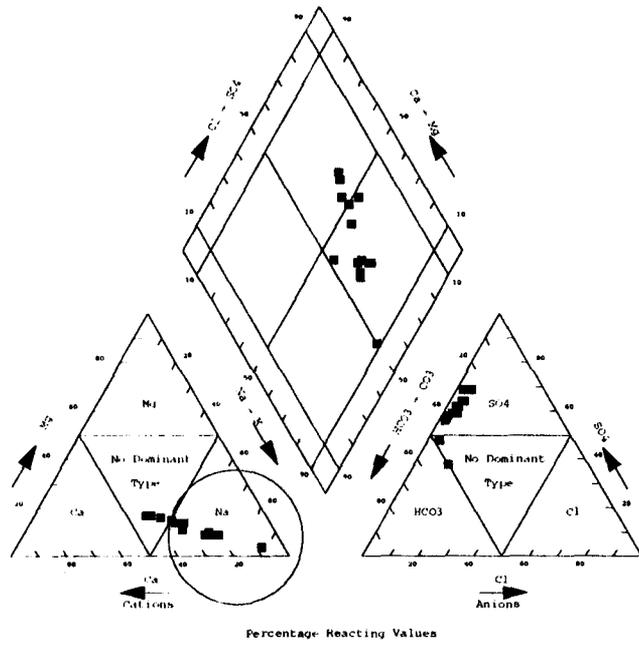
Chemical analyses of water samples taken from the undifferentiated aquifer monitoring wells, and Gwinner aquifer study are shown in Appendix H. Water quality analyses from previous investigations are shown in Appendix I. These water quality results were used to evaluate hydrochemical patterns in the Gwinner aquifer and the undifferentiated aquifers surrounding the landfill.

The relative distribution of major cations and anions in the Gwinner aquifer and undifferentiated aquifers are shown by the Piper diagram in figure 5. The Gwinner aquifer is

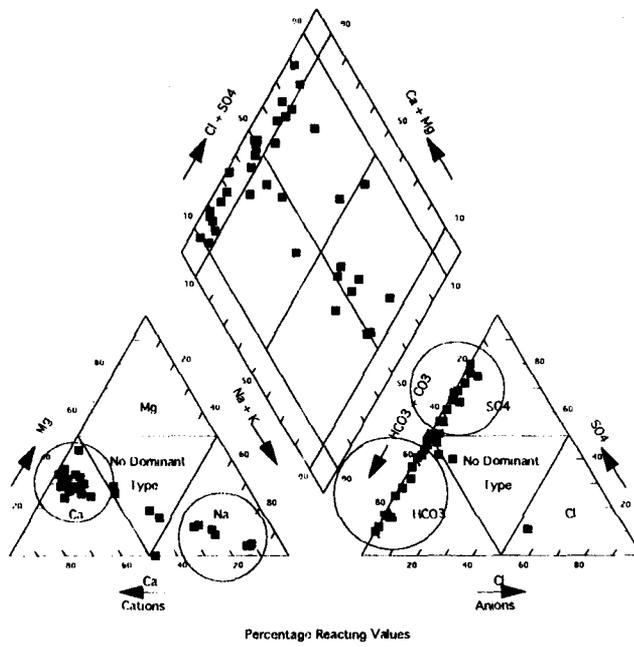
characterized by a high dissolved-solids, mixed cation-to-sodium-sulfate type water. Ground water in the undifferentiated aquifer is characterized by both a calcium-bicarbonate and a sodium-sulfate type.

A comparison of the relative cation and anion concentrations in the shallow unconfined/confined undifferentiated aquifers underlying the landfill and the deep confined undifferentiated aquifers in the area surrounding the landfill is shown in figure 6. The water chemistry is highly variable in the undifferentiated aquifers surrounding the landfill and includes a calcium-bicarbonate, a calcium-sulfate, and a sodium-sulfate type. The shallow unconfined/confined undifferentiated aquifers underlying the landfill are characterized by a calcium-bicarbonate to calcium-sulfate type water. All of the wells screened near the bedrock shale or large blocks of bedrock shale are characterized by a sodium-sulfate type water. The bedrock shales (Carlisle, Niobrara Formations) probably contribute additional sodium and sulfate to the ground-water flow system in the glacial drift. Lower relative sodium concentrations in the shallow unconfined/confined undifferentiated aquifers are probably indicative of both a lack of bedrock shale influence and decreased residence time which reduces the effects of cation exchange.

The water quality results for the undifferentiated wells, within the landfill, were obtained in June, 1993

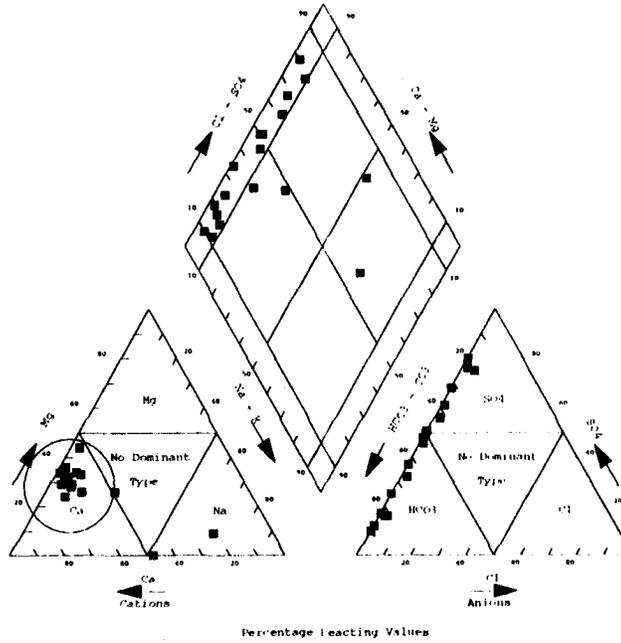


Gwinner Aquifer Piper Diagram

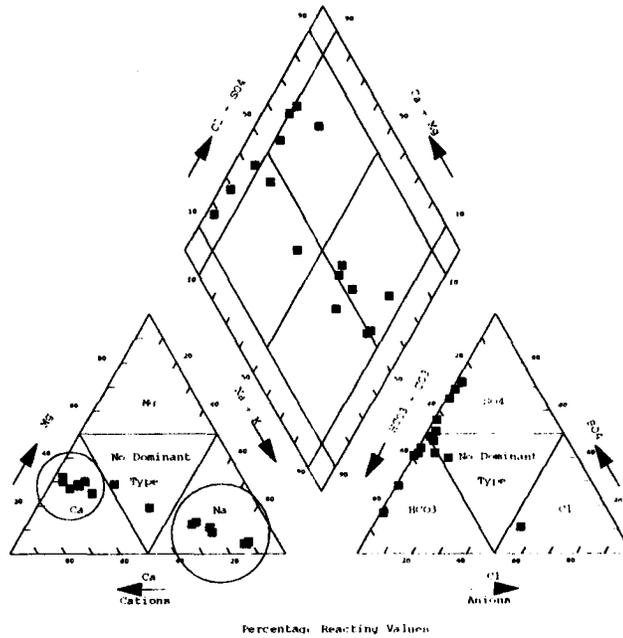


Undifferentiated Aquifer Piper Diagram

Figure 5. Piper diagram showing the general ground-water chemistry for the Gwinner aquifer and undifferentiated aquifers underlying the Dakota landfill.



Shallow Unconfined/confined Undifferentiated Aquifer Piper Diagram



Deep Confined Undifferentiated Aquifer Piper Diagram

Figure 6. Piper diagram showing water the general ground-water chemistry for the unconfined and confined undifferentiated aquifers underlying the Dakota landfill.

(Appendix J) and also from the Foth and Van Dyke study (November, 1993; Appendix K). The results from the June, 1993 sampling indicated elevated concentrations of calcium, magnesium, and sulfate in a number of wells. These concentrations are typical for glaciated environment in North Dakota. These results also indicated varied concentrations of arsenic. Wells 132-056-10BCCC (70 µg/L) and 132-056-10CAAD (86 µg/L) exceeded the MCL of 50 µg/L, and well 132-056-10BCCCD (45 µg/L) approached the MCL. Roberts, et al. (1985) indicated arsenic concentrations in ground water may have originated from Cretaceous shales and/or from arsenic-laced grasshopper bait applied during the 1930's and 1940's. The elevated arsenic concentrations do not appear to be caused by leachate migration from the landfill. No other constituents were above MCL.

VOC analyses from wells 132-056-10BBC2 and 132-056-10CBAC are shown in Appendix I and J. The results indicated a detection of tetrahydrofuran (61 µg/L) in well 132-056-10CBAC. Tetrahydrofuran is a man-made compound used in glues and liquid cement for fabricating packages and polyvinyl-chloride materials. The completion report for this well indicated glue was not used in its construction. Given that the well construction process did not use glue, the source of tetrahydrofuran may be from leachate migration from the landfill. No VOC's were detected in well 132-056-10BBC2.

Water quality samples from the undifferentiated wells surrounding the landfill were obtained on October 5, 1993.

The results indicated elevated concentrations of calcium, magnesium, and sulfate in some of the wells. These concentrations are typical in glaciated environments in North Dakota. Well 132-056-09ADD1 indicated a concentration of chloride (580 mg/L) above the SMCL (250 mg/L). The Carlile Shale is probably the source of this elevated chloride. These results also indicated varied concentrations of arsenic. The arsenic probably originated from previously described sources. No VOC analyses were performed due to the distance and depth of the water tables from the landfill.

CONCLUSIONS

The Dakota landfill is located in the Whitestone Hills, in the north half of the southwest quarter of section 10, T132N, R56W. The stratigraphy of the Whitestone Hills consists of glacial till interbedded with layers and lenses of sand and gravel. Numerous blocks of Cretaceous shale encountered in the recent test drilling confirm the ice-thrust origin of the Whitestone Hills. The distribution of the shale blocks indicates that the hills were thrust from the east.

Two or more sand layers occur beneath the landfill. The upper sand is present in most of the southwest quarter of section 10 and it appears to extend eastward some distance from the landfill to test hole 132-056-11-CBB1.

The lower sand may extend southwest from the landfill to test hole 132-056-16BAA and southeast from the landfill to test hole 132-056-11CCC1. However, the continuity of the lower sand cannot be established with confidence from the existing data.

The deep test holes drilled for this study did not encounter the Gwinner aquifer within a one-mile radius of the landfill. The nearest occurrence of the aquifer identified in the test drilling to date is in test hole 132-056-14CDA1, located on the east end of the sewage lagoons.

Ground-water springs may occur along the eastern slopes of the Whitestone Hills. One spring located at the southwest corner of section 11 appeared to flow during this study. This spring discharges into a water impoundment created by a dam at this site.

Numerous wetlands and abandoned gravel pits are located in the area of the Dakota landfill. The wetlands adjacent to the active area may be susceptible to contamination by surface-water runoff from the landfill.

There are five glacial aquifers and one bedrock aquifer within a ten mile radius of the landfill. No direct hydraulic connection was indicated between the undifferentiated aquifers and the Dakota, Elliot, Engelvale, Spiritwood, Milnor Channel, and Gwinner aquifers. Therefore contamination of these aquifers from the landfill is not considered likely.

The spatial distribution and geometry of the undifferentiated aquifers is complex and is typical of a depositional environment characterized by ice thrusting. The interconnectedness of individual sand and gravel layers is virtually impossible to determine. An aquifer testing program may be a useful approach to evaluate hydraulic continuity.

Water occurs in the undifferentiated aquifers under unconfined and confined conditions. In proximity to the landfill, the shallow unconfined/confined aquifers may be susceptible to contamination. The deeper confined aquifers do not appear to be susceptible to contamination due to their depth and the low hydraulic conductivity of the overlying aquitards which consist predominantly of till.

The Gwinner aquifer is characterized by a sodium-sulfate type water while the shallow unconfined/confined undifferentiated aquifers are characterized by a calcium-bicarbonate type water. The water chemistry is highly variable in the deeper confined undifferentiated aquifers and is characterized by a calcium-bicarbonate, calcium-sulfate, and a sodium-sulfate type.

The major ion analyses in the undifferentiated aquifers detected elevated concentrations of sulfate, calcium, and magnesium. These concentrations are typical for ground water in glacial environments of North Dakota. Trace element analysis detected elevated concentrations of arsenic in three wells. These concentrations do not appear to originate from

the landfill. Arsenic may have originated from the Cretaceous shales and/or from arsenic-based grasshopper bait applied during the 1930's and 1940's.

A VOC analysis from two wells detected a concentration of tetrahydrofuran in well 132-056-10CBAC. Given that the well construction process did not use glue, the source of tetrahydrofuran may be from leachate migration from the landfill. No VOC detection was found in well 132-056-10BBC2.

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APPENDIX A

WELL IDENTIFICATION TABLES

WELL IDENTIFICATION TABLE

SWC/NDGS #	WELL #	Well #	SWC/NDGS #
13205609DAA	MW-3	BFI-1	13205610BBC1
13205610BBC1	BFI-1	BFI-1A	13205610BBC2
13205610BBC2	BFI-1A	BFI-2	13205610CAC2
13205610BCCC	MW-4	BFI-2A	13205610CAC1
13205610BCCD	MW-18	BFI-3	13205610BDCC
13205610BCD	MW-19A	BFI-4	13205610CBCD
13205610BDA	BFI-5	BFI-5	13205610BDA
13205610BDCC	BFI-3	MW-3	13205609DAA
13205610BDD	WSI-5	MW-4	13205610BCCC
13205610BDDD	MW-12	MW-5	13205610CBB
13205610CAAA1	WSI-4	MW-12	13205610BDDD
13205610CAAA2	MW-15	MW-15	13205610CAAA2
13205610CAAD	WSI-6	MW-16A	13205610CBAD
13205610CAC1	BFI-2A	MW-17	13205610CBAC
13205610CAC2	BFI-2	MW-18	13205610BCCD
13205610CBAC	MW-17	MW19A	13205610BCD
13205610CBAD	MW-16A	MW-20	13205610CBC1
13205610CBB	MW-5	MW-21	13205610CCCB
13205610CBC1	MW-20	MW-23	13205610CBC2
13205610CBC2	MW-23	MW-26	13205610CDA
13205610CBCD	BFI-4	MW-33	13205610CDC
13205610CCAB	B-13	MW-35	13205610CDD1
13205610CCAC	B-28	WSI-4	13205610CAAA1
13205610CCAD	B-29	WSI-5	13205610BDD
13205610CCCB	MW-21	WSI-6	13205610CAAD
13205610CCCD	B-32	B-13	13205610CCAB
13205610CDA	MW-26	B-14	13205610CDB
13205610CDB	B-14	B-22	13205610CDCA
13205610CDC	MW-33	B-28	13205610CCAC
13205610CDCA	B-22	B-29	13205610CCAD
13205610CDD1	MW-35	B-32	13205610CCCD
13205610CDDC	B-34	B-34	13205610CDDC

APPENDIX B

WATER QUALITY STANDARDS
AND
CONTAMINANT LEVELS

**Water Quality Standards
and
Contaminant Levels**

Field Parameters

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

<u>Constituent</u>	<u>MCL (µg/L)</u>
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).

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

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

APPENDIX C

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 D

NDSWC/NDGS LITHOLOGIC LOGS
OF WELLS AND TEST HOLES

132-056-02CCC1

NDSWC

Date Completed: 9/22/93
 L.S. Elevation (ft): 1377.73
 Depth Drilled (ft): 320
 Screened Interval (ft): 221-226

Purpose: Observation Well
 Well Type: 2" PVC
 Aquifer: UND
 Source:
 Owner: NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
SAND	MEDIUM GRAINED	2-4
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	4-13
BOULDER		13-14
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	14-23
CLAY	SANDY WITH A TRACE OF PEBBLES, YELLOWISHBROWN.	23-30
SILT	YELLOWISHBROWN.	30-38
SAND	FINE TO MEDIUM GRAINED, YELLOWISHBROWN.	38-64
SAND	INTERBEDDED SANDYCLAY, YELLOWISHBROWN.	64-69
ROCK		69-70
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	70-83
SAND	MEDUM GRAINED.	83-84
CLAY	SANDY WITH A TRACE OF PEBBLES, YELLOWISHBROWN,	84-90
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	90-101
SAND	COARSE GRAINED.	101-102
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	102-153
SHALE	STIFF, GREASY, MEDIUM DARK GRAY (CARLILE FORMATION).	153-163

CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	163-208
SHALE	STIFF, GREASY, MEDIUM DARK GRAY (CARLILE FORMATION).	208-218
SAND	MEDIUM GRAINED.	218-228
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	228-303
SHALE	STIFF, GREASY, MEDIUM DARK GRAY, CARLILE FORMATION.	303-320

132-056-02CCC2

NDSWC

Date Completed: 9/23/93
L.S. Elevation (ft): 1378.35
Depth Drilled (ft): 50
Screened Interval (ft): 40-45

Purpose: Observation Well
Well Type: 20" PVC
Aquifer: UND
Source:
Owner: NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	2-32
CLAY	VERY SANDY, YELLOWISHBROWN.	32-39
SAND	FINE TO MEDIUM GRAINED, YELLOWISHBROWN.	39-50

132-056-02DCC1

NDSWC

Date Completed:	9/22/93	Purpose:	Observation Well
L.S. Elevation (ft):	1278.52	Well Type:	2" PVC
Depth Drilled (ft):	215	Aquifer:	UND
Screened Interval (ft):	163-168	Source:	
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	TRACE OF SAND AND PEBBLES, MODERATE YELLOWISHBROWN.	2-16
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	16-21
SAND	MEDIUM TO COARSE GRAINED	21-23
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	23-33
SAND	MEDIUM TO COARSE GRAINED.	33-34
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	34-38
SAND	MEDIUM TO COARSE GRAINED.	38-66
SAND	MEDIUM TO COARSE GRAINED WITH INTERBEDDED CLAY LENSES.	66-81
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	81-102
ROCKS		102-103
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	103-109
SHALE	STIFF, GREASY, MEDIUM DARK GRAY (CARLILE FORMATION).	109-122
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	122-134
CLAY	STIFF, GREASY, MEDIUM DARK GRAY (CARLILE FORMATION).	134-146
CLAY	SILTY, SANDY, OLIVE GRAY.	146-148
SAND	MEDIUM TO COARSE GRAINED.	148-152

SAND	COARSE GRAINED TO FINE GRAVEL.	152-180
GRAVEL	COARSE GRAINED WITH ROCKS.	180-184
SAND	COARSE GRAINED TO FINE GRAVEL, BOULDER AT 190 FEET.	184-191
CLAY	STIFF, GREASY, MEDIUM DARK GRAY.	191-193
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	193-200
SHALE	STIFF, GREASY, MEDIUM DARK GRAY, CARLILE FORMATION.	200-215

132-056-02DCC2

NDSWC

Date Completed:	9/22/93	Purpose:	Observation Well
L.S. Elevation (ft):	1278.51	Well Type:	2" PVC
Depth Drilled (ft):	60	Aquifer:	UND
Screened Interval (ft):	45-50	Source:	
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	2-16
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	16-35
SAND	MEDIUM GRAINED	35-37
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	37-42
SAND	FINE TO MEDIUM GRAINED.	42-60

132-056-03CBB

NDSWC

Date Completed:	9/27/93	Purpose:	Test Hole
L.S. Elevation (ft):	1312.40	Well Type:	
Depth Drilled (ft):	240	Source:	
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	2-31
CLAY	SANDY, TRACE OF PEBBLES, OLIVE GRAY.	31-64
CLAY	SANDY, TRACE OF PEBBLES, OLIVE GRAY, INTERBEDDED SAND LENSES.	64-71
CLAY	SANDY, TRACE OF PEBBLES, OLIVE GRAY.	71-97
SAND	COARSE GRAINED WITH FINE GRAVEL.	97-100
SAND	FINE TO MEDIUM GRAINED WITH INTERBEDDED CLAY LENSES.	100-103
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY, ROCK AT 117 FEET.	103-144
CLAY	SILTY, OLIVE GRAY.	144-151
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	151-230
SHALE	STIFF, GREASY, MEDIUM DARK GRAY, CARLILE FORMATION.	230-240

132-056-03DCD

NDSWC

Date Completed:	9/28/93	Purpose:	Observation Well
L.S. Elevation (ft):	1394.48	Well Type:	2" PVC
Depth Drilled (ft):	320	Aquifer:	UND
Screened Interval (ft):	103-108	Source:	
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN, ROCK AT 20 FEET.	2-43
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	43-64
SAND	MEDIUM GRAINED, OLIVE GRAY.	64-65
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	65-70
GRAVEL	FINE TO MEDIUM GRAINED.	70-78
SAND	FINE GRAVEL, WITH INTERBEDDED CLAY.	78-85
SILT	CLAYEY, OLIVE GRAY.	85-89
SAND	FINE TO COARSE GRAINED.	89-96
SAND	INTERBEDDED CLAY LENSES.	96-100
SAND	FINE GRAVEL.	100-111
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	111-122
SAND	FINE TO COARSE GRAINED.	122-127
CLAY	SANDY, GRAVELLY, OLIVE GRAY.	127-132
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY, BOULDER AT 163 FEET.	132-185
CLAY	SANDY WITH A TRACE OF PEBBLES, AND INTERBEDDED SAND LENSES.	185-217

SAND	FINE TO MEDIUM GRAINED WITH FINE GRAVEL.	217-220
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	220-244
CLAY	SILTY, OLIVE GRAY.	244-254
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY, ROCK AT 292 FEET.	254-312
SHALE	STIFF, GREASY, MEDIUM DARK GRAY, CARLILE FORMATION.	312-320

132-056-04CCC

NDSWC

Date Completed:	9/22/93	Purpose:	Observation Well
L.S. Elevation (ft):	1353.23	Well Type:	2" PVC
Depth Drilled (ft):	260	Aquifer:	UND
Screened Interval (ft):	163-168	Source:	
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	TRACE OF SAND AND PEBBLES, MODERATE YELLOWISHBROWN.	1-39
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	39-68
SAND	MEDIUM TO COARSE GRAINED.	68-70
SAND	GRAVEL WITH INTERBEDDED CLAY LENSES.	70-77
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	77-82
SAND	MEDIUM TO COARSE GRAINED AND FINE GRAVEL WITH INTERBEDDED CLAY LENSES.	82-90
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	90-119
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	119-132
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	132-137
CLAY	TRACE OF SAND, STIFF, OLIVE GRAY.	137-142
CLAY	SILTY, MEDIUM GRAY.	142-154
CLAY	SANDY, OLIVE GRAY, WITH INTERBEDDED COARSE GRAINED SAND AND LIGNITE.	154-174
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	174-238
ROCKS		238-239
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	239-241
ROCKS		241-242

SHALE	SILTY, LIGHT GREENISH GRAY (NIOBRARA FORMATION).	242-257
SHALE	STIFF, GREASY, MEDIUM DARK GRAY, CARLILE FORMATION.	257-260

132-056-09ABA

NDSWC

Date Completed: 9/27/93
 L.S. Elevation (ft): 1342.76
 Depth Drilled (ft): 260

Purpose: Test Hole
 Well Type:

Source:
 Owner: NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-6
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	6-17
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	17-57
SAND	MEDIUM GRAINED, SILTY, OLIVE GRAY.	57-60
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	60-70
SAND	MEDIUM GRAINED, SILTY, OLIVE GRAY.	70-72
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY, ROCK AT 75 FEET.	72-79
SAND	MEDIUM GRAINED.	79-85
CLAY	INTERBEDDED SAND LAYERS.	85-87
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	87-96
SAND	MEDIUM GRAINED.	96-98
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	98-107
SAND	MEDIUM GRAINED.	107-108
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	108-171
SILT	VERY FINE SAND, CLAYEY, OLIVE GRAY.	171-194
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	194-238
ROCK		238-239

CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	239-258
SHALE	STIFF, GREASY, MEDIUM DARK GRAY, CARLILE FORMATION.	258-260

132-056-09ADD1

NDSWC

Date Completed:	9/29/93	Purpose:	Observation Well
L.S. Elevation (ft):	1397.38	Well Type:	2" PVC
Depth Drilled (ft):	319	Aquifer:	UND
Screened Interval (ft):	305-310	Source:	
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	2-15
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	15-23
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	23-59
ROCK		59-60
SILT	CLAYEY, OLIVE GRAY.	60-68
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	68-122
SHALE	STIFF, GREASY, MEDIUM DARK GRAY, (CARLILE FORMATION).	122-125
CLAY	SANDY, PEBBLEY, OLIVE GRAY.	125-132
SAND	FINE GRAINED.	132-144
SAND	WITH INTERBEDDED CLAY LENSES.	144-147
SAND	FINE TO COARSE GRAINED.	147-169
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	169-182
CLAY	STIFF, GREASY, MEDIUM DARK GRAY, (CARLILE FORMATION).	182-230
ROCK		230-231
CLAY	SILTY, OLIVE GRAY.	231-241
CLAY	SILTY, OLIVE GRAY.	241-247

ROCK		247-248
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	248-300
GRAVEL	COARSE GRAIN WITH PEBBLES.	300-312
SHALE	STIFF, GREASY, MEDIUM DARK GRAY, CARLILE FORMATION.	312-317

132-056-09ADD2

NDSWC

Date Completed:	9/29/93	Purpose:	Observation Well
L.S. Elevation (ft):	1397.60	Well Type:	2" PVC
Depth Drilled (ft):	173	Aquifer:	UND
Screened Interval (ft):	163-168	Source:	
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	2-18
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	18-21
SILT	CLAYEY, OLIVE GRAY.	21-31
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	31-62
SILT	CLAYEY, OLIVE GRAY.	62-69
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	69-79
GRAVEL	FINE GRAINED.	79-83
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	83-105
SILT	OLIVE GRAY.	105-109
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY, ROCK AT 119 FEET.	109-127
SAND	WITH FINE GRAVEL.	127-130
CLAY	SANDY, OLIVE GRAY.	130-131
SAND	COARSE GRAINED WITH FINE GRAVEL.	131-148
CLAY	SANDY, OLIVE GRAY.	148-149
SAND	COARSE GRAINED WITH FINE GRAVEL.	149-171
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	171-173

132-056-09CCC

NDSWC

Date Completed:	10/5/93	Purpose:	Test Hole
L.S. Elevation (ft):	1363.53	Well Type:	
Depth Drilled (ft):	280	Source:	
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	SANDY, YELLOWISHBROWN.	1-8
SAND	MEDIUM GRAINED.	8-9
CLAY	SANDY WITH A TRACE OF PEBBLES, YELLOWISHBROWN.	9-20
CLAY	SANDY, OLIVE GRAY.	20-46
SAND	FINE GRAINED.	46-47
CLAY	SANDY, OLIVE GRAY.	47-73
SAND	FINE TO MEDIUM GRAINED.	73-75
CLAY	SANDY, OLIVE GRAY.	75-80
ROCKS		80-81
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	81-118
CLAY	SANDY, SILTY, OLIVE GRAY.	118-127
CLAY	SANDY, OLIVE GRAY.	127-140
CLAY	SILTY, OLIVE GRAY.	140-147
CLAY	SANDY, OLIVE GRAY.	147-155
CLAY	SANDY, OLIVE GRAY, INTERBEDDED WITH LIGNITE LAYERS.	155-166
CLAY	SANDY, OLIVE GRAY, WITH INTERBEDDED GRAVEL AND LIGNITE.	166-175

CLAY	SANDY, OLIVE GRAY.	175-250
ROCKS		250-251
CLAY	SANDY, OLIVE GRAY.	251-256
CLAY	SANDY, SILTY, OLIVE GRAY.	256-264
SHALE	HARD, LIGHT GRAY, CALCAREOUS NIOBRARA FORMATION.	264-280

132-056-10BBA1

NDSWC

Date Completed: 9/28/93
L.S. Elevation (ft): 1369.57
Depth Drilled (ft): 293

Purpose: Test Hole
Well Type:

Source:
Owner: NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	2-22
CLAY	SANDY WITH A TRACE OF PEBBLES, YELLOWISHBROWN.	22-41
SAND	FINE GRAINED, SILTY, YELLOWISHBROWN.	41-57
ROCKS		57-58
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	58-60
SAND	MEDIUM GRAINED.	60-63
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	63-67
SAND	MEDIUM GRAINED.	67-72
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	72-76
SAND	MEDIUM GRAY.	76-78
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	78-91
SAND	COARSE GRAINED.	91-93
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	93-109
SILT	CLAYEY, OLIVE GRAY.	109-111
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	111-166
SHALE	STIFF, GREASY, MEDIUM DARK GRAY (CARLILE FORMATION).	166-171

CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY, ROCK AT 180 FEET.	171-220
SAND	MEDIUM GRAINED.	220-223
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	223-289
SHALE	STIFF, GREASY, MEDIUM DARK GRAY, CARLILE FORMATION.	289-293

132-056-10BRA2

NDSWC

Date Completed:	9/29/93	Purpose:	Observation Well
L.S. Elevation (ft):	1369.48	Well Type:	2" PVC
Depth Drilled (ft):	72	Aquifer:	UND
Screened Interval (ft):	60-65	Source:	
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	1-24
SAND	FINE GRAINED.	24-26
CLAY	SANDY WITH A TRACE OF PEBBLES, YELLOWISHBROWN, ROCK AT 33 FEET.	26-51
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	51-63
SAND	FINE TO MEDIUM GRAINED.	63-68
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	68-72

132-056-10BDC

NDSWC

Date Completed: 10/9/92
 L.S. Elevation (ft): 1420
 Depth Drilled (ft): 160

Purpose: Test Hole
 Well Type:

Source: SWC
 Owner: Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Sandy with a trace of gravel, moderate yellow-brown 10YR5/4, till.	1-4
SAND	Medium grain, moderate yellow-brown 10YR5/4.	4-5
CLAY	Silty with a trace of sand and gravel, moderate yellow-brown 10YR5/4.	5-11
CLAY	Sandy with a trace of gravel, gray-brown 5YR3/2.	11-14
CLAY	Sandy with a trace of gravel, moderate yellow-brown 10YR5/4 with dark yellow-orange 10YR6/6 mottles	14-32
CLAY	Trace of sand and gravel, medium dark gray N4.	32-36
CLAY	Trace of sand and gravel, moderate yellow-brown 10YR5/4 with dark red-brown 10R3/4 and dark yellow-orange 10YR6/6 mottles.	36-43
CLAY	Trace of sand and gravel, medium dark gray N4.	43-62
SAND	Coarse to very coarse grain, olive gray 5Y4/1.	62-63
CLAY	Sandy with a trace of gravel, medium dark gray N4.	63-83
CLAY	Sandy with a trace of gravel and interbedded sand.	83-86

SAND	Coarse grain, olive gray 5Y4/1.	86-87
CLAY	Sandy with a trace of gravel and interbedded sand, medium dark gray N4.	87-108
SAND	Coarse grain with fine gravel and lignite fragments, olive gray 5Y4/1.	108-112
CLAY	Sandy with interbedded sand, medium dark gray N4.	112-114
CLAY	Sandy with a trace of gravel, medium dark gray N4.	114-122
CLAY	Trace of sand and gravel, medium dark gray N4.	122-138
CLAY	Sandy with a trace of gravel, medium dark gray N4, rock at 138 to 139 feet.	138-145
SAND	Medium to coarse grain, olive gray 5Y4/1.	145-146
CLAY	Sandy with a trace of gravel, medium dark gray N4.	146-160

132-056-10CACD

NDSWC

Date Completed:	10/8/92	Purpose:	Test Hole
L.S. Elevation (ft):	1421.26	Well Type:	
Depth Drilled (ft):	160	Source:	SWC
		Owner:	Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Sandy with a trace of gravel, moderate yellow-brown 10YR5/4, till.	1-48
SAND	Medium to coarse grain, moderate yellow-brown 10YR5/4.	48-50
CLAY	Very sandy with a trace of gravel, moderate yellow-brown 10YR5/4.	50-55
SAND	Medium to coarse grain with fine gravel, (up to 2mm).	55-58
CLAY	Sandy and gravelly, moderate yellow-brown 10YR5/4.	58-66
CLAY	Sandy with interbedded layers of medium to coarse grain sand and fine gravel, moderate yellow-brown 10YR5/4.	66-72
CLAY	Sandy and gravelly, medium dark gray N4.	72-76
CLAY	Sandy with interbedded sand layers, medium dark gray N4.	76-80
CLAY	Sandy with a trace of gravel, medium dark gray N4.	80-86
SAND	Fine to coarse grain, olive gray 5Y4/1.	86-88

CLAY	Sandy, gravelly, medium dark gray N4.	88-107
SAND	Medium to coarse grain, olive gray 5Y4/1.	107-112
CLAY	Very sandy with a trace of gravel, medium gray N4, encountered a rock at 130 to 131 feet.	112-131
CLAY	Sandy with a trace of gravel, medium dark gray N4.	131-160

132-056-10CADD

NDSWC

Date Completed:	10/8/92	Purpose:	Test Hole
L.S. Elevation (ft):	1411.30	Well Type:	
Depth Drilled (ft):	160	Source:	SWC
		Owner:	Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	Very sandy with a trace of gravel, Moderate yellow-brown 10YR5/4 .	2-13
CLAY	Very sandy with a trace of gravel, moderate yellow-brown 10YR5/4 with dark red-brown 10R3/4 and dark yellow-orange 10YR6/6 mottles.	13-46
SAND	Medium to coarse grain with fine gravel (up to 1cm), moderate yellow-brown 10YR5/4.	46-51
CLAY	Sandy, gravelly, moderate yellow-brown 10YR5/4.	51-69
CLAY	Sandy with a trace of gravel and interbedded sand, olive gray 5Y4/1.	69-71
CLAY	Very sandy with a trace of gravel, medium dark gray N4.	71-126
CLAY	Sandy with interbedded sand, medium dark gray N4.	126-129
SAND	Fine to medium grain olive gray 5Y4/1.	129-134
SAND	Medium to coarse grain, olive gray 5Y4/1.	134-143
SAND	Medium to coarse grain with fine gravel, olive gray 5Y4/1.	143-148

CLAY	Sandy with a trace of gravel, medium dark gray N4.	148-149
SAND	Coarse grain with fine gravel.	149-151
CLAY	Very sandy with a trace of gravel, medium dark gray N4.	151-160

132-056-10CBCC

NDSWC

Date Completed: 10/8/92
 L.S. Elevation (ft): 1404.40
 Depth Drilled (ft): 160

Purpose: Test Hole
 Well Type:

Source: SWC
 Owner: Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Sandy, trace of gravel, moderate yellow-brown 10YR5/4, till.	1-3
GRAVEL	Fine (up to 1 mm), clay, moderate yellow-brown 10YR5/4.	3-11
CLAY	Trace of sand and gravel, moderate yellow-brown 10YR5/4.	11-12
GRAVEL	Pale yellow-orange 10YR6/6	12-14
CLAY	Trace of sand and gravel, moderate yellow-brown 10YR5/4	14-17
CLAY	Sandy, trace of gravel, moderate yellow-brown.	17-22
SAND	Fine to coarse grained, moderate yellow-brown 10YR5/4.	22-24
CLAY	Trace of sand and gravel, moderate yellow-brown 10YR5/4.	24-31
Cobbles		31-32
CLAY	Trace of gravel, medium dark gray N4.	32-35

CLAY	Sandy, trace of gravel, medium dark gray N4.	35-66
CLAY	Very sandy, trace of gravel, medium dark gray N4.	66-82
CLAY	Trace of sand and gravel, medium dark gray N4.	82-91
SAND	Fine to very coarse grained, olive gray 5Y4/1.	91-109
SAND	With fine gravel (up to 5mm), olive gray 5Y4/1.	109-110
CLAY	Sandy with a trace of gravel, medium dark gray N4.	110-122
CLAY	Sandy with a trace of gravel, interbedded layer of sand, medium dark gray N4.	122-129
CLAY	Trace of sand and gravel, medium dark gray N4.	129-136
SAND	Fine to coarse grained, olive gray 5Y4/1.	136-140
CLAY	Sandy with a trace of gravel, medium dark gray N4.	140-146
SAND	Medium to coarse grained, olive gray 5Y4/1.	146-152
CLAY	Sandy with a trace of gravel, medium dark gray N4	152-160

132-056-10CBDC

NDSWC

Date Completed:	10/8/92	Purpose:	Test Hole
L.S. Elevation (ft):	1405.26	Well Type:	
Depth Drilled (ft):	160	Source:	SWC
		Owner:	Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Sandy with a trace of gravel, moderate yellow-brown 10YR5/4.	1-22
GRAVEL	Fine (up to 1cm), moderate yellow brown 10YR5/4.	22-23
CLAY	Very sandy and gravelly, moderate yellow-brown 10YR5/4, with dark red-brown 10R3/4 mottles.	23-48
Cobbles		48-49
CLAY	Very sandy with a trace of gravel, moderate yellow-brown.	49-65
SAND	Medium to coarse grain with fine gravel, moderate yellow-brown 10YR5/4.	65-67
CLAY	Sandy, gravelly, moderate yellow-brown 10YR5/4.	67-74
CLAY	Sandy, gravelly, medium dark gray N4.	74-89
SAND	Medium to coarse grain, olive gray 5Y4/1.	89-96
CLAY	Very sandy with a trace of gravel, medium dark gray N4.	96-106
SAND	Medium to coarse grain, olive gray 5Y4/1.	106-108

CLAY	Sandy, with a trace of gravel, medium dark gray N5.	108-115
Cobbles		115-116
CLAY	Sandy with a trace of gravel, medium dark gray N4, boulder at 120-122 feet.	116-152
CLAY	Sandy, gravelly, medium dark gray N4.	152-160

132-056-10CCAB

NDSWC

Date Completed:	12/19/90	Purpose:	Test Hole
L.S. Elevation (ft):	1409.6	Well Type:	
Depth Drilled (ft):	63	Source:	FOTH & VAN DYKE REPORT
		APRIL, 1993	
		Owner:	BIG DIPPER

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	very dark brown to olive brown, 10YR2/1-2.5Y4/4, frozen, dry.	0-3
CLAY	sandy, lean, light olive brown, 2.5Y5/4, stiff, dry, few gravel, common thin gypsum veins, till.	3-8
CLAY	same as above, common jointing and common coarse iron-stained spherical mottles, 10YR5/6.	8-13
CLAY	same as above except till or reworked till, 10YR5/6, to 16.8 feet, 16.8-18 feet laminar bedded fine silty sand and lean clay glacio-fluvial deposits, 2.5Y5/4 to 10YR5/6, common iron stains 7.5YR6/8.	13-18
CLAY	same as till above at 13-16.8 feet to 20.5 feet; at 20.5 feet abrupt textural boundary, Fat clay to 22.5 feet, peds to 21 feet, olive brown, 2.5Y4/4 to 5/6 paleosol, gradual lower boundary.	18-23
SILT	sandy, light olive brown, 2.5Y5/4, laminarsandier beds, interspersed, dry, stiff, common jointing with some iron stains, 10YR5/6.	23-28
ROCK		28-30
CLAY	dark grayish-brown, 2.5Y4/2-4/4, lean, with gravel, many mottles, 7.5YR6/8, many iron and manganese soft concretions, firm, moist.	30-33
CLAY	Shelby tube sample.	33-35

CLAY	same as above except color change to 2.5Y4/2-3/2, few 2.5Y4/0 mottles.	35-38
CLAY	same as above to 42.5 feet except crude platy structure (bedding?), at 42.5 feet fine silty sand, laminar bedding gray mottles, more common downward.	38-43
SAND	silty, yellowish-brown, 10YR5/4, loose, slightly moist, thin silt lenses.	43-48
SAND	same as above except coarser grained and fewer silt lenses, moist, also many 10YR5/6 mottles.	48-53
SAND	yellowish-brown, 10YR5/4-5/6, well graded with gravel, few silt and clay lenses, loose, slightly moist.	53-55.5
SAND	same as above except 10YR5/6-4/6, moist, abrupt lower boundary at 57 feet; f-m w graded, with thin silt lenses and clayey gravel, saturated at 57.9 feet.	55.5-58
SAND	interbedded, well graded, with clay, 10YR-2.5Y4/4-5/4, with silt; saturated, silts very moist, many iron stained linear mottles that may be old roots or heeled joints.	58-63

132-056-10CCAC

NDSWC

Date Completed:	10/16/92	Purpose:	Test Hole
L.S. Elevation (ft):	1405.3	Well Type:	
Depth Drilled (ft):	57	Source:	Foth and Van Dyke
		Report 4/93.	
		Owner:	BIG DIPPER

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1.5
CLAY	2.5Y5/4, sandy, lean, friable, slightly moist, crude medium bedding, common medium 2.5YR-10YR mottles.	1.5-5
CLAY	same as above to 9.5 feet; 9.5-10 feet, 10YR5/4, poorly graded sand, medium loose, slightly moist.	5-10
CLAY	alternating beds of sandy, lean clay, well graded sand and sandy silt, 10YR5/4 - 2.5Y5/4.	10-15
SAND	same as above.	15-18
SAND	same as above to 19.5 feet; gravel lens to 19.7 feet; 19.7-20 feet is sandy lean clay.	18-20
SAND	same as above.	20-24
SAND	same as above to 24.2 feet thin sand lens above 10YR6/3 sandy lean clay, moist, friable.	24-26
SAND	same as above to 27 feet; 27 feet is 10YR5/4 poorly graded sand, loose, moist.	26-30
SAND	same as above except fine medium.	30-33
SAND	same as above fine medium 10YR6/3.	33-35

SAND	same as above.	35-40
SAND	same as above with common laminar sandy silt stringers between 44.5-45.0 feet.	40-45
SAND	same as above increasing silt downward very few 10YR5/6 - 7.5YR5/6 mottles, manganese, oxidized stringers along bedding.	45-50
SAND	2.5Y5/4 - 4/4, silty, loose, wet.	50-55
SAND	same as above.	55-57

132-056-10CCAD

NDSWC

Date Completed:	10/16/92	Purpose:	Test Hole
L.S. Elevation (ft):	1413.1	Well Type:	
Depth Drilled (ft):	65	Source:	Foth and Van Dyke
		Report 4/93.	
		Owner:	BIG DIPPER

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1.5
CLAY	2.5Y5/3, silty, lean, friable, dry to slightly moist, peds to 4.5 feet.	1.5-5
CLAY	2.5Y5/3, sandy, lean, friable, dry, many coarse 2.5Y6/0 - 6/2 mottles increasing downward, few coarse 5YR5/6 mottles, thin bedding.	5-10
CLAY	same as above except iron stained vertical and near horizontal joints to 14.5 feet; 14.5 - 15 feet is massive, sandy lean clay, slightly moist, firm.	10-15
CLAY	same as above to 15.5 feet; 15.5 - 19 feet 2.5Y5/3 sandy, lean, friable, slightly moist, thin cross bedding, common coarse 5YR-2.5Y mottles; 19-20 feet ped development, lean clay with sand (approaching fat clay), weak to moderate paleosol.	15-20
CLAY	20 - 20.4 feet mass diamicton; 20.4 - 24 feet thinly bedded sandy lean clay; 24 - 25 feet 10YR-2.5Y4/4 fat clay, few carbon flecks, old Bt-horizon, peds not apparent.	20-25
CLAY	2.5Y4/3-3/3 sandy, lean (on heavy side), firm, slightly moist, thin bedding, alternating with mass diamicton.	25-30
CLAY	2.5Y4/3-3/3, sandy, lean, grading down to lean clay with sand, many 7.5YR and 5YR mottles, friable, firm bedded near top, with more sand.	30-35
CLAY	same as above, weathered rock.	35-43

CLAY	44.5 - 45 feet, 10YR6/3, lean, with sand alternating with silty sand clays above, silty sands are friable, dry, thin contorted bedding.	43-45
CLAY	lean with sand, moist, firm, diamicton.	45-50
CLAY	N4/0, sandy, lean, moist, friable.	50-55
CLAY	same as above with 1-2 inch moist sand lenses.	55-60
SAND	N4/0-5/0, well grade, wet, cross-bedding, loose.	60-65

132-056-10CCC1

NDSWC

Date Completed: 9/30/93
 L.S. Elevation (ft): 1390.53
 Depth Drilled (ft): 303

Purpose:
 Well Type:

Test Hole

Source:
 REPORT 4/93
 Owner:

FOTH AND VAN DYKE

NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN, ROCK AT 11 FEET.	2-21
SAND	FINE GRAINED.	21-26
CLAY	SANDY WITH A TRACE OF PEBBLES, YELLOWISHBROWN.	26-46
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	46-56
CLAY	SANDY AND PEBBLY, OLIVE GRAY.	56-60
SAND	MEDIUM GRAINED.	60-65
GRAVEL	FINE GRAINED.	65-71
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	71-92
SAND	FINE TO MEDIUM GRAINED.	92-93
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY, ROCK AT 118 FEET.	93-127
SHALE	STIFF, GREASY, MEDIUM DARK GRAY, (CARLILE FORMATION).	127-142
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	142-146
SAND	FINE TO MEDIUM GRAINED.	146-148
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	148-150
SAND	FINE TO MEDIUM GRAINED.	150-160

CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY, ROCKS AT 196 AND 260 FEET.	160-297
SHALE	STIFF, GREASY, MEDIUM DARK GRAY, CARLILE FORMATION.	297-303

132-056-10CCC2

NDSWC

Date Completed: 9/30/93
 L.S. Elevation (ft): 1390.69
 Depth Drilled (ft): 165
 Screened Interval (ft): 155-160

Purpose:
 Well Type:
 Aquifer:
 Source:
 Owner:

Observation Well
 2" PVC
 UND
 SWC
 NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	2-22
SAND	MEDIUM GRAINED.	22-23
CLAY	SANDY WITH A TRACE OF PEBBLES, YELLOWISHBROWN.	23-46
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	46-55
SAND	FINE GRAINED.	55-56
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	56-64
SAND	FINE TO COARSE GRAINED.	64-70
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	70-73
SAND	FINE TO MEDIUM, GRAINED.	73-74
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY, ROCK AT 118 FEET.	74-130
SHALE	STIFF, GREASY, MEDIUM DARK GRAY, (CARLILE FORMATION).	130-144
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	144-145
SAND	FINE TO MEDIUM GRAINED.	145-148
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	148-149
SAND	FINE TO MEDIUM GRAINED.	149-160
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	160-163

132-056-10CCCD

NDSWC

Date Completed: 10/15/92
 L.S. Elevation (ft): 1405.2
 Depth Drilled (ft): 60

Purpose: Test Hole
 Well Type:

Source: Foth and Van Dyke
 Report 4/93.
 Owner: BIG DIPPER LANDFILL

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1.2
CLAY	2.5Y4/4, lean, jointed (vertical); joints are prismatic peds, friable, slightly moist.	1.2-5
CLAY	2.5Y4/4, lean, friable, slightly moist, thinly bedded, few-soft iron-concretions of 2.5Y3/6 mottles.	5-10
CLAY	same as above except thin sand lenses (<0.5 inches thick), and manganese-oxide soft concretions.	10-18.6
SAND	10YR6/3, poorly graded, medium few-silt lenses, dry, loose.	18.6-30
No sample		30-33
SAND	same as above except cross-bedding apparent.	33-35
SAND	same as above except faint horizontal bedding, more fine sands than medium.	35-48
SAND	10YR5/4, well graded, with gravel, loose, dry.	48-50
No sample		50-53
SAND	10YR5/4, poorly graded, loose, dry, with 2.5Y5/3 silt lens (lam) <1.5 inch thick.	53-55

No sample

55-58

SAND

10YR4/3, well graded, with silt, wet, loose, gravel
lens at 59.8 to 59.9 feet.

58-60

132-056-10CDB

NDSWC

Date Completed:	1/8/91	Purpose:	Test Hole
L.S. Elevation (ft):	1422	Well Type:	
Depth Drilled (ft):	68	Source:	Foth and Van Dyke
		Report 4/93.	
		Owner:	BIG DIPPER

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	dark brown, 10YR3/3, dry, frozen to 2 feet.	0-2
CLAY	pale brown, 10YR6/3, sandy, lean, with gravel, dry frozen.	2-3
CLAY	same as above except common jointing, some joints iron stained, 5YR5/6 - 7.5YR5/6, white gypsum veins, slightly moist, more stiff than above.	3-13
CLAY	same as above except 10YR4/2 - 2.5Y4/2, and iron/manganese stains on joints, coal and shale clasts common.	13-18
CLAY	same as above except more gravel, thin bed of sand at 22.9-30 feet.	18-23
CLAY	same as above except few joints, few thin sand lenses (<1 inch thick).	23-28
CLAY	same as above except common to many joints and gypsum veins, gradual change downward to 10YR4/3.	28-33
CLAY	shelby tube sample.	33-35
CLAY	same as above except 10YR4/2, common mottles, 10YR5/6 - 5/8, vertical joints end at 37 feet, platy structure at 35 to 36 feet, cross bedding at 36-37 feet, darkening 10YR4/1.	35-38
No Recovery		38-43

CLAY	Interbedded lean clay, 2.5Y4/2, with gravel and silty sand, 10YR6/4 - 5/6, stiff, slightly moist, common mottles (10YR4/6) in clay.	43-48
CLAY	same as above except clays are 2.5Y3/2, common iron stained vertical joints, platy structure may be bedding.	48-52
SAND	yellowish-brown, 10YR5/4 - 6/4, silty, loose, slightly moist.	52-53
SAND	same as above except thin clays interbedded.	53-58
SAND	same as above except clay beds are thicker and 2.4Y10YR4/4, contorted bedding in sand units of 10YR6/3 - 7/2, common coarse mottles, 10YR5/6, in clays.	58-63
CLAY	dark grayish-brown, 2.5Y4/2, sandy, lean, rppd up clasts of till, no joints, till, few fine manganese-oxidized mottles, possible different till unit, fewer gravel than other tills above.	63-66
CLAY	interbedded lean clays and silty sands, firm, loose, slightly moist, 10YR - 2.5Y4/4.	66-68

132-056-10CDCA

NDSWC

Date Completed: 1/12/91
 L.S. Elevation (ft): 1410.4
 Depth Drilled (ft): 78

Purpose: Test Hole
 Well Type:
 Source: Foth and Van Dyke
 Report 4/93.
 Owner: BIG DIPPER

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	frozen ground.	0-3
TOPSOIL	3-4.5 feet grayed topsoil (wetland).	3-4.5
CLAY	lean, stiff, dry, many iron stained mottles, many thin gypsum veins in root voids to 7.5 feet.	4.5-8
CLAY	same as above to 12 feet; 12-13 feet are stratified lean silts with till clasts, dry, friable, 10YR6/4.	8-13
CLAY	very dark gray, 2.5Y3/0 - 4/0, sandy, lean, common large joints with 7.5YR4/5 - 5/6 iron stains, moist, stiff.	13-18
CLAY	same as above except no joints or mottles.	18-23
CLAY	same as above to 27.8 feet, where laminar bedding starts in silts with clay, lake sediment (?), 2.5Y4/0 - 4/1.	23-28
CLAY	same as above to 30 feet except with thin sand beds; at 30 feet laminar bedded lean clay with sand and silt, fluvial deposits.	28-33
CLAY	same as above to 34.5 feet; same as above except fat clays, laminar bedded lake deposits, 5Y4/1, stiff, very moist.	33-38
CLAY	same as above except lean clay with sand lenses, mollusk shells present.	38-43

CLAY	dark gray to very dark gray, 5Y4/1 - 3/1, lean with gravel, two large clasts of 5Y6/2, stiff, moist, till.	43-48
CLAY	same as above except dominated by 5Y6/2, very moist to 52 feet; 52-53 feet is more stiff and 5Y3/1.	48-53
CLAY	same as above	53-58
CLAY	same as above except lean clay with sand, slightly moist 2 inch thick sand lenses in middle of recovered sample, stiff.	58-61.5
CLAY	same as above except with platy structures or crude bedding.	61.5-63
CLAY	same as above except with silt and sand lenses, lenses were slightly moist.	63-68
CLAY	same as above except with common thin sand lenses (<2 inch thick), most lenses were moist, one saturated at 68.5 feet.	68-73
CLAY	same as above except saturated at 75.5 feet, no platy structure.	73-76
SAND	sitly, interbedded with thin lean clays as above.	76-78

132-056-10CDD2

NDSWC

Date Completed: 9/30/93
 L.S. Elevation (ft): 1305.60
 Depth Drilled (ft): 301

Purpose: Test Hole
 Well Type:

Source: FOTH AND VAN DYKE
 REPORT 4/93
 Owner: NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	1-6
SAND	FINE GRAINED.	6-7
CLAY		7-41
SAND	FINE GRAINED.	41-42
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	42-65
SAND	MEDIUM GRAINED.	65-66
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	66-142
SAND	FINE GRAINED WITH ROCKS.	142-143
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	143-196
SHALE	STIFF, GREASY, MEDIUM DARK GRAY, (CARLILE FORMATION).	196-231
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	231-298
SHALE	STIFF, GREASY, MEDIUM DARK GRAY, CARLILE FORMATION.	298-301

132-056-10CDDC

NDSWC

Date Completed: 10/14/92
 L.S. Elevation (ft): 1404
 Depth Drilled (ft): 66

Purpose: Test Hole
 Well Type:
 Source: Foth and Van Dyke
 Report 4/93.
 Owner: BIG DIPPER LANDFILL

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-4.2
CLAY	A-BE-Bt horizons, 2.5Y3/3, sandy, lean, friable to firm, slightly moist, platy structure or bedding (< 0.125 inch).	4.2-5
CLAY	2.5Y4/3, sandy, lean, with thin beds of sand, friable, moist (more oxidized towards bottom 0.4 foot).	5-10
CLAY	2.5Y5/3, sandy, lean, firm, moist, common-coarse mottles of 2.5Y6/0 and 2.5YR5/8, sand lens (<1 inch) top 0.5 foot, with developed laminated bedding throughout, healed joints becoming increasingly gleyed bottom 0.5 foot.	10-15
CLAY	2.5Y4/0 to 3/0, very dark gray, lean, with sand, moist, firm, few healed joints (slightly oxidized around joint), diamicton, till.	15-20
CLAY	same as above except joints not apparent, one minor (<0.25 inch) sand lens with perched water at 21.2 feet.	20-29
CLAY	finely laminar silts and clays, stratified above, very dark gray medium sands with clay and gravel.	29-30
No sample		30-35
CLAY	same as above except lean, with gravel, N4/0 to 5/0.	35-37

CLAY	very dark gray, lean, with sand-sandy lean clay, firm, moist, diamicton, till, no joints.	37-43.5
SAND	2.5Y5/4, silty, fine to medium, very friable, slightly moist, thin beds, common coarse 7.5YR4/6 mottles.	43.5-44
No sample		44-50
CLAY	alternating sandy, lean, and silty sands (2.5Y5/3 to 5/4), thin beds, friable, slightly moist.	50-51
No sample		51-53
SAND	2.5Y5/4 to 6/3, silty, fine, very friable, slightly moist to dry, silt lens as thick as 3 to 5 inches, silts are darker colored (2.5Y4/3).	53-55
No sample		55-59
CLAY	N4/0, gleyed, sandy, lean, with 2.5Y5/3 to 5Y5/3 silts interbedded glaciofluvial deposits, mostly sandy, lean clay sand units have perched water.	59-61
No sample		61-64
CLAY	N4/0 very dark sandy, lean, moist, firm, diamicton, till.	64-66

132-056-11CBB1

NDSWC

Date Completed: 9/27/93 Purpose: Test Hole
 L.S. Elevation (ft): 1361.49 Well Type:
 Depth Drilled (ft): 282

Source: SWC
 Owner: NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-4
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	4-18
SAND	FINE GRAINED	18-23
CLAY	SANDY, YELLOWISHBROWN.	23-24
SAND	FINE TO MEDIUM GRAINED.	24-27
CLAY	SANDY, YELLOWISHBROWN.	27-28
SAND	FINE TO MEDIUM GRAINED.	28-32
CLAY	SANDY WITH ATRACE OF PEBBLES, OLIVE GRAY.	32-54
SAND	COARSE GRAINED.	54-55
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY, ROCK AT 67 FEET.	55-84
SILT	SANDY, OLIVE GRAY.	84-90
SAND	MEDIUM GRAINED.	90-91
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY, ROCK AT 104 FEET.	91-131
SHALE	STIFF, GREASY, MEDIUM DARK GRAY (CARLILE FORMATION).	131-181
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	181-202
CLAY	SANDY, OLIVE GRAY.	202-209
CLAY	SANDY WITH INTERBEDDED SAND LENSES.	209-213

SILT	CLAYEY, SANDY, OLIVE GRAY.	213-224
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	224-261
SILT	CLAYEY, SANDY, OLIVE GRAY.	261-269
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	269-271
SHALE	STIFF, GREASY, MEDIUM DARK GRAY, CARLILE FORMATION.	271-282

132-056-11CBB2

NDSWC

Date Completed: 9/28/93
L.S. Elevation (ft): 1361.49
Depth Drilled (ft): 33
Screened Interval (ft): 25-30

Purpose: Observation Well
Well Type: 20" PVC
Aquifer: UND
Source: SWC
Owner: NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-4
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN, ROCKS AT 12 FEET.	4-18
SAND	FINE GRAINED.	18-20
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	20-24
SAND	MEDIUM GRAINED.	24-30
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	30-33

132-056-11CCC1

NDSWC

Date Completed:	9/23/93	Purpose:	Test Hole
L.S. Elevation (ft):	1315.66	Well Type:	
Depth Drilled (ft):	240	Source:	SWC
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN, BOULDER AT 8 FEET.	1-11
SAND	MEDIUM GRAINED, PALE BROWN.	11-14
CLAY	SANDY WITH A TRACE OF PEBBLES, YELLOWISHBROWN.	14-18
CLAY	SILTY, MEDIUM GRAY.	18-20
SAND	MEDIUM GRAINED, PALE BROWN.	20-30
CLAY	INTERBEDDED WITH SAND	30-36
CLAY	OLIVE GRAY.	36-38
SAND	MEDIUM GRAINED, LIGHT OLIVE GRAY.	38-51
SAND	FINE TO MEDIUM GRAINED, INTERBEDDED WITH CLAY LENSES.	51-56
CLAY	SILTY, MEDIUM DARK GRAY.	56-64
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	64-81
SAND	FINE GRAINED.	81-82
CLAY	OLIVE GRAY.	82-84
SAND	MEDIUM GRAINED.	84-87
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	87-113

ROCKS		113-114
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	114-122
SAND	FINE GRAINED.	122-123
CLAY	SILTY, TRACE OF PEBBLES, OLIVE GRAY.	123-141
SHALE	STIFF, GREASY, MEDIUM DARK GRAY (CARLILE FORMATION).	141-153
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	153-164
CLAY	SANDY, PEBBLY, OLIVE GRAY, ROCKS AT 193 AND 217 FEET.	164-234
SHALE	STIFF, GREASY, MEDIUM DARK GRAY, CARLILE FORMATION.	234-240

132-056-11CCC2

NDSWC

Date Completed: 9/23/93
 L.S. Elevation (ft): 1315.77
 Depth Drilled (ft): 60
 Screened Interval (ft): 42-47

Purpose: Observation Well
 Well Type: 2" PVC
 Aquifer: UND
 Source: SWC
 Owner: NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	1-11
SAND	MEDIUM GRAINED.	11-12
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	12-18
CLAY	SILTY, OLIVE GRAY.	18-23
SAND	MEDIUM GRAINED.	23-35
CLAY	OLIVE GRAY.	35-38
SAND	MEDIUM GRAINED.	38-50
CLAY	OLIVE GRAY.	50-53
SAND	MEDIUM GRAINED.	53-57
CLAY	OLIVE GRAY.	57-60

132-056-11DBB

NDSWC

Date Completed: 9/21/93
 L.S. Elevation (ft): 1274.44
 Depth Drilled (ft): 200
 Screened Interval (ft): 127-132

Purpose: Observation Well
 Well Type: 2" PVC
 Aquifer: UND
 Source: SWC
 Owner: NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-3
CLAY	SILTY, MODERATE YELLOWISHBROWN.	3-11
CLAY	TRACE OF SAND AND PEBBLES, MODERATE YELLOWISHBROWN.	11-15
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	15-31
GRAVEL	FINE GRAINED UP TO 1 CM IN DIAMETER.	31-33
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY. 6 INCH GRAVEL LENSES AT 37 FEET AND 53 FEET.	33-54
CLAY	SANDY, TRACE OF PEBBLES, OLIVE GRAY.	54-62
SAND	COARSE GRAINED.	62-63
CLAY	SANDY, TRACE OF PEBBLES, OLIVE GRAY.	63-82
CLAY	PEBBLY, TRACE OF SAND, OLIVE GRAY. SANDSTONE ROCK AT 111 FEET.	82-116
SHALE	STIFF, GREASY, MEDIUM DARK GRAY, (CARLILE FORMATION).	116-126
SAND	FINE TO COARSE GRAINED WITH FINE GRAVEL.	126-132
SAND	FINE GRAINED WITH INTERBEDDED CLAY.	132-136
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY WITH A ROCK AT 142 FEET.	136-144
CLAY	SANDY, TRACE OF PEBBLES, OLIVE GRAY.	144-162
SHALE	STIFF, MEDIUM DARK GRAY, GREASY, (CARLILE FORMATION)	162-171

CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY. ROCK AT 181 FEET.	171-182
CLAY	TRACE OF SAND AND PEBBLES, WITH FRAGMENTS OF CARLILE SHALES, OLIVE GRAY.	182-191
SHALE	STIFF, MEDIUM DARK GRAY, GREASY, (CARLILE FORMATION).	191-200

132-056-11DCC

NDSWC

Date Completed: 9/21/93
 L.S. Elevation (ft): 1261.29
 Depth Drilled (ft): 195
 Screened Interval (ft): 135-140

Purpose: Observation Well
 Well Type: 2" PVC
 Aquifer: UND
 Source: SWC
 Owner: NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	SILTY, PALE BROWN.	2-4
CLAY	SILTY, TRACE OF PEBBLES, PALE BROWN.	4-6
GRAVEL	FINE GRAINED.	6-7
CLAY	TRACE OF PEBBLES, PALE BROWN.	7-28
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY. 6 INCH GRAVEL LENSE AT 34 FEET.	28-40
CLAY	SILTY, TRACE OF PEBBLES, OLIVE GRAY.	40-66
CLAY	SILTY, TRACE OF SAND AND PEBBLES, OLIVE GRAY. 6 INCH SAND LENSE AT 76 FEET.	66-80
SAND	COARSE GRAINED WITH FINE GRAINED GRAVEL.	80-82
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	82-103
CLAY	TRACE OF SAND AND GRAVEL WITH INTERBEDDED GRAVEL LENSES.	103-112
CLAY	TRACE OF PEBBLES, OLIVE GRAY.	112-114
SHALE	STIFF, DARK GRAY, GREASY (CARLILE FORMATION).	114-118
CLAY	SILTY, OLIVE GRAY, TILL.	118-123
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	123-132
GRAVEL	FINE GRAINED UP TO 1 CM IN DIAMETER.	132-142

CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	142-171
ROCKS		171-172
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	172-180
SHALE	STIFF, GREASY, MEDIUM DARK GRAY (CARLILE FORMATION).	180-195

132-056-14CCC

NDSWC

Date Completed: 9/20/93
 L.S. Elevation (ft): 1269.30
 Depth Drilled (ft): 200
 Screened Interval (ft): 118-123

Purpose:
 Well Type:
 Aquifer:
 Source:
 Owner:

Observation Well
 2" PVC
 UND
 SWC
 NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	PALE BROWN.	2-4
CLAY	SANDY, PEBBLY, MODERATE YELLOWISHBROWN.	4-21
CLAY	SANDY, PEBBLY, DARK MEDIUM GRAY.	21-48
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY.	48-53
CLAY	SILTY, OLIVE GRAY.	53-62
CLAY	TRACE OF SAND AND PEBBLES, OLIVE GRAY. 6 INCH GRAVEL LENSE AT 72 FEET.	62-79
CLAY	SANDY, PEBBLY, OLIVE GRAY.	79-107
SAND	MEDIUM GRAINED, CLAYEY, OLIVE GRAY.	107-110
CLAY	SANDY, PEBBLY, OLIVE GRAY.	110-119
SAND	MEDIUM TO COARSE GRAINED, OLIVE GRAY.	119-124
CLAY	SANDY, PEBBLY, OLIVE GRAY. 1 FOOT GRAVEL LENSE AT 144 FEET AND A ROCK LAYER AT 151 FEET.	124-186
SHALE	STIFF, GREASY, MEDIUM DARK GRAY (CARLILE FORMATION).	186-200

132-056-15CCD1

NDSWC

Date Completed:	9/30/93	Purpose:	Test Hole
L.S. Elevation (ft):	1346.74	Well Type:	
Depth Drilled (ft):	256	Source:	SWC
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	2-5
GRAVEL	FINE GRAINED.	5-7
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	7-12
CLAY	SILTY, OLIVE GRAY.	12-24
SILT	INTERBEDDED SAND LENSES.	24-29
CLAY	SANDY WITH A TRACE OF PEBBLES, YELLOWISHBROWN.	29-41
SAND	MEDIUM GRAINED.	41-54
SAND	MEDIUM TO COARSE GRAINED.	54-65
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	65-100
SAND	FINE GRAINED.	100-101
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	101-123
CLAY	SANDY WITH INTERBEDDED SAND LENSES, OLIVE GRAY.	123-136
GRAVEL	FINE GRAINED.	136-137
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY	137-174
LIGNITE		174-175
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	175-185

SHALE	STIFF, GREASY, MEDIUM DARK GRAY, (CARLILE FORMATION).	185-193
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	193-252
SHALE	STIFF, GREASY, MEDIUM DARK GRAY, CARLILE FORMATION.	252-257

132-056-15CCD2

NDSWC

Date Completed:	10/1/93	Purpose:	Observation Well
L.S. Elevation (ft):	1346.87	Well Type:	2" PVC
Depth Drilled (ft):	65	Aquifer:	UND
Screened Interval (ft):	55-60	Source:	SWC
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	YELLOWISHBROWN.	2-5
GRAVEL	FINE TO MEDIUM GRAINED.	5-6
CLAY	SILTY, YELLOWISHBROWN.	6-12
CLAY	SILTY, OLIVE GRAY	12-23
CLAY	SILTY WITH INTERBEDDED SAND LENSES, OLIVE GRAY.	23-28
SAND	FINE GRAINED.	28-30
CLAY	SANDY WITH A TRACE OF PEBBLES.	30-41
SAND	MEDIUM GRAINED.	41-56
SAND	MEDIUM TO COARSE GRAINED.	56-62
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	62-65

132-056-16BAA

NDSWC

Date Completed:	10/4/93	Purpose:	Observation Well
L.S. Elevation (ft):	1401.20	Well Type:	2" PVC
Depth Drilled (ft):	318	Aquifer:	UND
Screened Interval (ft):	149-154	Source:	SWC
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	1-3
ROCKS		3-4
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	4-5
ROCKS		5-6
CLAY	TRACE OF SAND AND PEBBLES, YELLOWISHBROWN.	6-36
ROCKS		36-37
CLAY	SANDY WITH A TRACE OF PEBBLES, YELLOWISHBROWN.	37-47
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	47-72
ROCKS		72-73
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	73-99
CLAY	SILTY, OLIVE GRAY.	99-103
CLAY	SANDY WITH LIGNITE FRAGMENTS, OLIVE GRAY.	103-106
CLAY	SANDY WITH INTERBEDDED SAND LENSES, OLIVE GRAY.	106-127
LIGNITE		127-128
SAND	FINE TO COARSE GRAINED WITH FINE GRAVEL.	128-138
SAND	MEDIUM TO COARSE GRAINED WITH FINE GRAVEL.	138-154

CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	154-168
ROCKS		168-169
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	169-196
ROCKS		196-197
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	197-221
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	221-233
SAND	MEDIUM GRAINED.	233-235
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	235-249
ROCKS		249-250
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	250-266
SAND	FINE GRAINED.	266-267
CLAY	SANDY WITH A TRACE OF PEBBLES, OLIVE GRAY.	267-316
SHALE	STIFF, GREASY, MEDIUM DARK GRAY, CARLILE FORMATION.	316-318

132-056-21BBC

NDSWC

Date Completed: 10/5/93
 L.S. Elevation (ft): 1318.92
 Depth Drilled (ft): 220

Purpose: Test Hole
 Well Type:

Source: SWC
 Owner: NDSWC

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	SANDY WITH A TRACE OF PEBBLES, YELLOWISHBROWN.	1-17
CLAY	SANDY, OLIVE GRAY.	17-58
CLAY	SILTY, OLIVE GRAY.	58-76
CLAY	SANDY, OLIVE GRAY.	76-107
SAND	FINE GRAINED.	107-108
CLAY	SANDY, OLIVE GRAY.	108-126
CLAY	SANDY, OLIVE GRAY, INTERBEDDED WITH SHALE GRAVEL.	126-129
CLAY	SANDY, SHALE, OLIVE GRAY.	129-132
CLAY	SANDY, OLIVE GRAY.	132-162
CLAY	SANDY, HARD, OLIVE GRAY.	162-206
SHALE	HARD, BROWN, CALCAREOUS (NIOBRARA FORMATION).	206-216
SHALE	HARD, LIGHT GRAY WITH BROWNISH CLAY, CALCAREOUS, NIOBRARA FORMATION.	216-220

APPENDIX E

PREVIOUS LITHOLOGIC LOGS OF
WELLS AND TEST HOLES

Gwinner Aquifer Study by the NDSWC 1989

132-055-31BCC

NDSWC 12392

Date Completed:	9/27/89	Purpose:	Observation well
L.S. Elevation (ft):	1252	Well Type:	1.25" PVC
Depth Drilled (ft):	180	Aquifer:	GWN
Screened Interval (ft):	158-163	Source:	NDSWC
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
CLAY	iron stained, silty-sandy with pebbles, yellowish-brown oxidized till.	1-19
CLAY	silty sandy with pebbles, rocky, olive-gray till.	19-134
GRAVEL	coarse to very coarse, numerous pea to marble size, well rounded to subrounded, taking on lots of water, rocky, cobbles very coarse from 140-160 ft.	134-173
CLAY	upper sands taking on water like mud, caving, olive-gray.	173-180

132-055-31CCCB

NDSWC 12393

Date Completed:	9/27/89	Purpose:	Observation well
L.S. Elevation (ft):	1250	Well Type:	1.25" PVC
Depth Drilled (ft):	200	Aquifer:	GWN
Screened Interval (ft):	173-178	Source:	NDSWC
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
CLAY	iron stained, silty sandy, with pebbles, yellowish-brown oxidized till.	1-30
CLAY	silty, very sandy with pebbles, olive-gray till.	30-143
SAND	gravelly, well rounded to subrounded, medium sand to coarse gravel.	143-146
TILL	inter bedded with sand & gravel.	146-150
GRAVEL	drilled rough, sandy.	150-154
TILL	layers of sand & gravel, drills choppy then smooth.	154-158
GRAVEL	sandy, very coarse sand to very coarse gravel, pea to marble size gravel, cobbles & rocks, taking a little water, well rounded to subrounded, abundance of shale pebbles.	158-180
CLAY	olive-gray till.	180-181
GRAVEL	coarse as above.	181-189
CLAY	olive-gray till.	189-197
CLAY	black, greasy.	197-200

132-056-14CDA1

NDSWC 4851

Date Completed:	10/14/75	Purpose:	Observation Well
L.S. Elevation (ft):	1251	Well Type:	1.25" PVC
Depth Drilled (ft):	180	Aquifer:	GWN
Screened Interval (ft):	153-156	Source:	NDSWC
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
CLAY	SILTY, SANDY, PEBBLY, DARK YELLOWISH-BROWN, OXIDIZED, TILL	0-25
CLAY	SILTY, SANDY, SLIGHTLY PEBBLY, DARK-GRAY, TILL.	25-74
SAND	MEDIUM TO VERY COARSE GRAIN, GRAVELLY, COARSE GRAVEL AND COBBLE ZONES, GRAVEL COMPOSED OF SHALE PEBBLES.	74-87
CLAY	VERY SANDY, SILTY, GRAVELLY, PEBBLES ARE LARGELY COMPOSED OF SHALE.	87-138
CLAY	VERY SANDY, SILTY, CONTAINS GRAVEL LENSES AND ROCKS.	138-168
SHALE	CARLILE FORMATION, GRAYISH-BLACK, SLIGHTLY CALCAREOUS, WAXY.	168-180

132-056-22DDA

NDSWC 12383

Date Completed:	9/20/89	Purpose:	Observation well
L.S. Elevation (ft):	1265	Well Type:	1.25" PVC
Depth Drilled (ft):	200	Aquifer:	GWN
Screened Interval (ft):	111-116	Source:	NDSWC
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
CLAY	iron stained, silty sandy with pebbles, yellowish-brown oxidized till.	1-27
CLAY	silty sandy with pebbles, olive-gray unweathered till.	27-81
CLAY	very silty, olive-gray.	81-84
CLAY	olive-gray till as above.	84-101
SAND	very fine to fine, drills smooth, well rounded to subrounded.	101-108
GRAVEL	coarse sand to pea gravel, well rounded to subrounded, 40% carbonates, 20% igneous (taking water)	108-118
CLAY	silty sandy, with pebbles, olive-gray till.	118-143
SAND	gravelly, drills fast & choppy.	143-147
CLAY	silty sandy with pebbles, olive-gray till.	147-182
CLAY	very sticky greasy, (bedrock) drills real slow, poor return, dark gray to black.	182-200

132-056-23CAD

NDSWC 12384

Date Completed: 9/20/89
L.S. Elevation (ft): 1259.34
Depth Drilled (ft): 190
Screened Interval (ft): 118-123

Purpose: Observation Well
Well Type: 1.25" PVC
Aquifer: GWN
Source: NDSWC
Owner: NDSWC

Lithologic Log

Unit	Description	Depth (ft)
CLAY	silty, sandy with a trace of pebbles, yellowish-brown, oxidized till.	4-25
CLAY	silty, sandy with a trace of pebbles, poorly sorted, olive gray till.	25-87
CLAY	silty, olive gray.	87-97
SAND & GRAVEL	very fine to coarse grained, gravelly, well rounded to subrounded, turns to gravel from 110 to 117.	97-117
CLAY	olive gray.	117-118
GRAVEL	very coarse grained, sandy.	118-129
CLAY	silty, sandy with a trace of pebbles, olive gray till.	129-178
CLAY	black, greasy, Carlile Formation.	178-190

132-056-24BCC

NDSWC 12386

Date Completed:	9/26/89	Purpose:	Observation well
L.S. Elevation (ft):	1252.74	Well Type:	1.25" PVC
Depth Drilled (ft):	200	Aquifer:	GWN
Screened Interval (ft):	168-173	Source:	NDSWC
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
CLAY	silty sandy with pebbles, poorly sorted yellowish-brown oxidized till.	1-17
CLAY	silty, very sandy with pebbles, poorly sorted, unoxidized olive-gray till, drills fast, half foot layer s. & g. 107-107.5	17-144
SAND	gravelly, 60% shale, well rounded to sub-rounded, taking water.	144-155
GRAVEL	rocky, taking water, well rounded to sub-rounded, drills real choppy & rough.	155-177
CLAY	olive-gray till.	177-183
CLAY	black, greasy.	183-200

132-056-24CCCB

NDSWC 12385

Date Completed:	9/25/89	Purpose:	Observation well
L.S. Elevation (ft):	1255	Well Type:	1.25" PVC
Depth Drilled (ft):	200	Aquifer:	GWN
Screened Interval (ft):	173-178	Source:	NDSWC
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
CLAY	iron stained, silty sandy with pebbles, poorly sorted yellowish-brown oxidized till.	1-15
CLAY	silty sandy with pebbles, poorly sorted, olive-gray till.	15-116
CLAY	black, greasy lake clays.	116-125
CLAY	olive-gray till as above.	125-128
CLAY	black, greasy lake clays.	128-132
SAND	very fine to fine, lignite, drill chatters, carbonates, lignites, silicates, shale.	132-155
GRAVEL	sandy, medium sand to pea gravel, taking water, drills rough.	155-182
CLAY	pebbles, sandy, olive-gray till.	182-187
CLAY	black greasy, bedrock.	187-200

132-056-25DAA

NDSWC 12390

Date Completed:	9/27/89	Purpose:	Observation well
L.S. Elevation (ft):	1245	Well Type:	1.25" PVC
Depth Drilled (ft):	180	Aquifer:	GWN
Screened Interval (ft):	157-162	Source:	NDSWC
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
CLAY	silty sandy with pebbles, yellowish-brown oxidized till.	1-16
CLAY	silty sandy with pebbles, rocky, yellowish-brown unoxidized till.	16-156
GRAVEL	sandy, med. sand to v. coarse gravel, pea to marble size gravel, drills as if v. rocky well rounded to subrounded, taking water, from 160-172 v. coarse.	156-172
CLAY	olive-gray till as above lost circulation stuck, gravels caving.	172-180

132-056-36AAA

NDSWC 12391

Date Completed:	9/27/89	Purpose:	Observation well
L.S. Elevation (ft):	1245	Well Type:	1.25" PVC
Depth Drilled (ft):	180	Aquifer:	GWN
Screened Interval (ft):	163-168	Source:	NDSWC
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
CLAY	silty sandy with pebbles, iron stained, oxidized yellowish-brown till.	1-24
CLAY	silty, very sandy with pebbles, poorly sorted, olive-gray till.	24-86
TILL	interbedded with half foot stringers of sand & gravel.	86-96
CLAY	olive-gray till as above, rocky.	96-131
GRAVEL	coarse to very coarse, rocky, pebbly, drills rough, taking water, pred. shale & carbonates, well rounded to subrounded.	131-172
CLAY	sandy, olive-gray till, poor return, gravels caving above,	172-180

132-056-36BBB

NDSWC 123087

Date Completed:	9/26/89	Purpose:	Observation well
L.S. Elevation (ft):	1268	Well Type:	1.25" PVC
Depth Drilled (ft):	210	Aquifer:	GWN
Screened Interval (ft):	173-178	Source:	NDSWC
		Owner:	NDSWC

Lithologic Log

Unit	Description	Depth (ft)
CLAY	iron stained, silty, very sandy, yellowish-brown oxidized till.	2-25
CLAY	silty sandy with pebbles, poorly sorted, drills fast, olive-gray till.	25-122
SAND	gravelly, pred. shale, well rounded to sub-rounded, drills fast then smooth	122-130
CLAY	seems layered with clay, drills smooth poor return.	130-132
SAND	gravelly, layered with clay & till, drills choppy then smooth.	132-136
CLAY	layered with shale & gravel.	136-150
SAND	very fine to medium, drills fast & choppy taking water, well rounded to subroundedabund. lignites, 20% pred. shale, carbonate & silicates, rocky, 186-188ft.	150-188
CLAY	olive-gray till, rocky.	188-205
CLAY	black, greasy bedrock.	205-210

Previous Landfill Investigation Lithologies

132-056-09DAA

NDSWC

Date Completed:	1/19/86	Purpose:	Observation Well (MW-3)
L.S. Elevation (ft):	1410.71	Well Type:	2" PVC
Depth Drilled (ft):	73	Aquifer:	Undefined
Screened Interval (ft):	63-73	Source:	FOTH & VAN DYKE REPORT
		4/93	
		Owner:	Big Dipper

Lithologic Log

Unit	Description	Depth (ft)
CLAY	LIGHT BROWN TO GRAY, VERY STIFF, CALCITE CEMENT, SMALL AMOUNT OF GRAVEL AND PEBBLES, HEMATITE STRINGERS IN CLAY.	0-10
CLAY	SILTY WITH SOME GRAVEL.	10-20
CLAY	LIGHT BROWN, STIFF, SOME SAND AND PEBBLES.	20-39
SAND	VERY FINE TO COARSE GRAIN.	39-40
CLAY	DARK GRAY, STIFF, WITH HEMATITE STRINGERS.	40-60
SAND	COARSE GRAIN, POORLY SORTED.	60-61
SAND	MIXED WITH COBBLES.	61-62
CLAY	DARK GRAY, STIFF, LITTLE SAND, SOME COBBLES.	62-65
CLAY	SAND LENSES INTERBEDDED.	65-75

132-056-10BBC1

NDSWC

Date Completed:	0	Purpose:	Observation Well (BFI-1)
L.S. Elevation (ft):	1380	Well Type:	1.25" PVC
Depth Drilled (ft):	311	Aquifer:	Undefined
Screened Interval (ft):	119.5-139.5	Source:	FOTH & VAN DYKE REPORT
		4/93	
		Owner:	Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	SANDY CLAY, BLACK, MEDIUM.	0-2
CLAY	SANDY WITH A LITTLE GRAVEL, BROWN, VERY STIFF, TILL.	2-5
CLAY	SANDY, BROWN AND GRAY MOTTLED, STIFF.	5-9
CLAY	SANDY WITH A LITTLE GRAVEL, BROWN, STIFF, TRACE OF SHALE AT 15 feet.	9-28
CLAY	SANDY, GRAY, A LITTLE GRAVEL, RATHER STIFF TO VERY STIFF TO RATHER STIFF.	28-58
SAND	MEDIUM GRAINED, GRAY, WET, VERY DENSE, MEDIUM ALLUVIUM.	58-68
CLAY	SANDY WITH A LITTLE GRAVEL, GRAY, VERY STIFF, LAYER OF SAND AT 90 feet.	68-80
CLAY	SANDY, SAME AS ABOVE.	80-126
SAND	FINE GRAINED, SILTY, FINE ALLUVIUM, GRAY, WET VERY DENSE.	126-135
CLAY	SANDY WITH A LITTLE GRAVEL, GRAY, VERY STIFF, COBBLES FROM 154 ft TO 155 ft AND 159 ft TO 160 ft.	135-160
CLAY	SANDY, SIMILAR TO ABOVE.	160-165

CLAY	SANDY WITH A LITTLE GRAVEL, GRAY, VERY STIFF, WITH LAYERS OF SILT, COBBLES AT 189 ft - 190 ft.	165-185
CLAY	SANDY, GRAY, VERY STIFF, A FEW LAYERS OF SAND.	185-195
CLAY	SANDY.	195-295
SHALE	DARK GRAY, VERY STIFF, TEXTURAL CLASSIFICATION - FAT CLAY, CARLILE FORMATION.	295-311

132-056-10BBC2

NDSWC

Date Completed:	0	Purpose:	Observation Well (BFI-1A)
L.S. Elevation (ft):	1380	Well Type:	1.25" PVC
Depth Drilled (ft):	68	Aquifer:	Undefined
Screened Interval (ft):	44-64	Source:	FOTH & VAN DYKE REPORT
		4/93	
		Owner:	Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	SILTY CLAY, BLACK, MEDIUM.	0-2
CLAY	ANDY WITH A LITTLE GRAVEL, BROWN, VERY STIFF, TILL.	2-5
CLAY	SANDY, BROWN AND GRAY MOTTLED, STIFF.	5-9
CLAY	SANDY WITH A LITTLE GRAVEL, BROWN, STIFF, TRACE OF SHALE AT 15 ft.	9-28
CLAY	SANDY, A LITTLE GRAVEL, GRAY, RATHER STIFF TO VERY STIFF TO RATHER STIFF.	28-58
SAND	MEDIUM GRAINED, ALLUVIUM, GRAY, WET, VERY DENSE.	58-68

132-056-10BCCC

NDSWC

Date Completed:	1/20/86	Purpose:	Observation Well (MW-4)
L.S. Elevation (ft):	1415.6	Well Type:	2" PVC
Depth Drilled (ft):	60.5	Aquifer:	Undefined
Screened Interval (ft):	49-59	Source:	FOTH & VAN DYKE REPORT
		4/93	
		Owner:	Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	LIGHT BROWN STIFF CLAY WITH HEMATITE STRINGERS, CALCITE CEMENT.	2-11
CLAY	SAME AS ABOVE EXCEPT WITH COBBLES.	11-12
CLAY	LIGHT BROWN STIFF WITH HEMATITE STRINGERS AND CALCITE CEMENT.	12-19
SAND	COARSE SAND, VERY FINE, POORLY SORTED.	19-20
CLAY	SILTY, LIGHT BROWN, GRAY, SILTY CLAY - LITTLE SAND.	20-30
CLAY	TRACE OF GRAVEL, GRAY STIFF CLAY WITH SOME COBBL S WHICH ARE ANGULAR TO SUBANGULAR.	30-50
SAND	VERY FINE, COARSE, ROUNDED, POORLY SORT ED. LIGHT GRAY, STIFF CLAY INTERSPERSED.	50-59
SAND	SILTY, DARK GRAY, VERY FINE TO COARSE, INTERMIXED WITH DARK GRAY TIGHT CLAY.	59-60

132-056-10BCCD

NDSWC

Date Completed:	8/23/90	Purpose:	Observation Well
L.S. Elevation (ft):	1416.6	Well Type:	2" PVC
Depth Drilled (ft):	80	Aquifer:	Undefined
Screened Interval (ft):	64.8-74.8	Source:	FOTH & VAN DYKE REPORT
		4/93	
		Owner:	BIG DIPPER

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	Very dark grayish brown, silty, dry, loose, rooted grades to very pale brown B horizon below 0.5 feet, till.	0-5
CLAY	Light yellowish brown, lean, medium density, stiff, mottled with light gray and iron stain with sand and gravel, massive, slightly moist.	5-10
CLAY	Pale brown, lean, medium density, stiff, mottled with light gray and iron stain with sand and gravel, lignite fragments, massive, slightly moist.	10-15
CLAY	Pale brown, lean, dense, stiff, mottled with light gray and iron stain with sand and gravel, dark iron stain along vertical fractures, massive, slightly moist.	15-20
CLAY	Pale brown, lean, dense, very stiff, abundant mottle iron stain, trace of gypsum veining at 21 feet.	20-25
CLAY	Very dark gray, lean, with silt, sand, gravel, medium dense, slightly moist, plastic, cohesive, massive with fine lignite fragments.	25-30
CLAY	Light olive brown, lean, 0.24 inch gypsum vertical veins.	30-35
CLAY	Gray, lean, 0.25 inch gypsum vertical veins.	35-40
CLAY	Gray in upper 1.0 foot, then mottled gray and brown with olive brown clay at 41.3 feet.	40-45

SAND	1.0 foot light yellowish brown, loose, non-cohesive, dry, poorly sorted; 0.2 feet light olive brown silt, very moist to wet, soft; 0.3 feet brown lean clay, moist, soft.	45-50
SILT	0.9 foot olive gray clayey, very moist to wet, soft with trace of sand and gravel; 0.6 feet dark gray, lean.	50-55
CLAY	Dark gray, lean, with sand and gravel, stiff, slightly moist to moist.	55-60
CLAY	Dark gray, lean, dense, sandy clay and clayey sand at 61.3 feet, moist, poorly sorted, with gravel, cohesive.	60-65
CLAY	No returns, probably clay, s.a.a. based on drilling characteristics, SS dry, gray clay, based on cuttings.	65-70
CLAY	Interbedded, gray, lean, with dark gray clayey sand, fine to coarse grained, non-cohesive, dense, wet.	70-75
SAND	Dark gray, well graded, fine to coarse grained, non-cohesive with gravel, medium density, saturated.	75-80
SAND	S.a.a. with 0.3 inch lignite layer at 80.1 feet.	80-81.5

132-056-10BCD

NDSWC

Date Completed:	0	Purpose:	Observation Well (MW19A)
L.S. Elevation (ft):	1410.5	Well Type:	2" PVC
Depth Drilled (ft):	38.5	Aquifer:	Undefined
Screened Interval (ft):	28.3-38.3	Source:	FOTH & VAN DYKE REPORT
		4/93	
		Owner:	Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-2
CLAY	PALE BROWN LEAN CLAY (FILL), DRY AT SURFACE, SLIGHTLY MOIST BELOW 0.8 ft.	2-5
SAND	CLAYEY, PALE BROWN TO YELLOW BROWN LEAN CLAY, W/ CLAYEY SAND, FN-MED, WET, AND CLAYEY SILT, SLIGHTLY MOIST, SOFT, COHESIVE, MASSIVE.	5-10
CLAY	WITH TRACES OF SAND AND GRAVEL, LIGHT OLIVE BROWN LEAN CLAY WITH TRACE SAND & GRAVEL, SOFT, LOOSE, MOIST, DARK IRON STAIN LONG VERY HEALED FRACTURES, MASSIVE, PARTIALLY A CLAYEY SILT.	10-15
SILT	CLAYEY, INTERBEDDED SILTY CLAY & CLAYEY SILT, ABUNDANT IRON STAINS MOTTLING, MOIST.	15-20
CLAY	DARK REDDISH BROWN DENSE LEAN CLAY & VERY DARK GRAY LEAN CLAY WITH SAND & GRAVEL, SLIGHT MOIST, SOFT COHESIVE, MASSIVE.	20-25
CLAY	YELLOW BROWN LEAN CLAY AS ABOVE MOIST, SOFT, WITH SAND & GRAVEL, COHESIVE, MASSIVE.	25-30
CLAY	GRAY CLAY AS ABOVE, SS BARREL WET MAY BE PERCHED ZONE AS IN MW-16.	30-35
CLAY	SAME AS ABOVE EXCEPT WET.	35-40
CLAY	SAME AS ABOVE EXCEPT SLIGHTLY MOIST WITH MOIST SILTY STRINGER AT 41.3 ft (0.1 ft THICK).	40-45

CLAY	SAME AS ABOVE EXCEPT STIFF AND SLIGHTLY MOIST.	45-50
CLAY	SAME AS ABOVE EXCEPT MEDIUM DENSITY.	50-55
CLAY	SAME AS ABOVE EXCEPT VERY STIFF.	55-60
CLAY	SAME AS ABOVE WITH 1/2 inch BROWN SAND ON TOP OF SS. PROBABLY FROM SHALLOW WATER BEARING SAND.	60-65

132-056-10BDD

NDSWC

Date Completed: 0
 L.S. Elevation (ft): 1424.3
 Depth Drilled (ft): 77
 Screened Interval (ft): 71-76

Purpose: Observation Well (WSI-5)
 Well Type: 2" PVC
 Aquifer: Undefined
 Source: FOTH & VAN DYKE REPORT
 4/93
 Owner: Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	SILTY, BLACK CLAY, SILTY, YELLOWISH BROWN.	0-1
CLAY	TILL WITH LOTS OF ROCKS.	1-27
CLAY	SILTY CLAY, OLIVE GRAY, TILL.	27-68
SAND	SAND, FINE TO COARSE, ABOUT 20% GRAVEL.	68-75
CLAY	CLAY, SILT, OLIVE GRAY, TILL.	75-77

132-056-10BDDD

NDSWC

Date Completed:	0	Purpose:	Observation Well (MW-12)
L.S. Elevation (ft):	1419.5	Well Type:	2" PVC
Depth Drilled (ft):	77.5	Aquifer:	Undefined
Screened Interval (ft):	67.3-77.3	Source:	FOTH & VAN DYKE REPORT
		4/93	
		Owner:	Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	VERY DARK BROWN SILT CLAY, ROOTED, DRY, LOOSE, GRADES LIGHTER WITH DEPTH TOPSOIL, LIGHT YELLOW BROWN LEAN CLAY WITH SAND & GRAVEL (TILL), MOTTLED LIGHT GRAY & Fe STAIN, SLIGHTLY MOIST, MEDIUM DENSITY, TILL.	1-5
CLAY	STIFF MASSIVE, COHESIVE; AT 5.0 ft SAME AS ABOVE EXCEPT YELLOW BROWN WITH GYPSUM VEINING AT 6.0+ ft.	5-8.5
CLAY	SAME AS ABOVE WITH 0.3 ft OF GRAVELY CLAY LAYER AT 8.8 ft TO 9.2 ft.	8.5-10
CLAY	SAME AS ABOVE, LIGHT OLIVE BROWN.	10-15
CLAY	SAME AS ABOVE, OCCASIONAL STRINGER OF SAND <0.01 ft THICK, AND TINY <0.005 ft LIGNITE FRAGMENTS.	15-20
CLAY	SAME AS ABOVE.	20-25
CLAY	SAME AS ABOVE WITH THIN <0.05 ft SAND STRINGER, WET, LOOSE.	25-30
CLAY	SAME AS ABOVE, MOIST.	30-35
CLAY	SAME AS ABOVE EXCEPT VERY DARK GRAY-BROWN, SLIGHTLY MOIST, MEDIUM DENSE.	35-40

CLAY	VERY DARK DRY LEAN CLAY WITH TRACE OF SAND AND GRAVEL, COHESIVE, MASSIVE, MEDIUM DENSE, MORE PLASTIC THAN ABOVE SLIGHTLY MOIST, TILL.	40-45
CLAY	SAME AS ABOVE.	45-50
SAND	CLAYEY, SAME AS ABOVE; AT 50.4 ft LIGHT GRAY, FINE-MEDIUM SAND, WELL SORTED, SLIGHTLY MOIST, NON-COHESIVE, TRACE OF GRAVEL, THEN CLAY AS ABOVE, ONLY LESS PLASTIC.	50-55
SAND	SAME AS ABOVE.	55-60
SAND	SAME AS ABOVE WITH SLIGHT MOISTURE INCREASE.	60-65
SAND	SAME AS ABOVE; AT 66.5 ft WET STRINGER VERY FINE SILTY SAND, WET.	65-70
SAND	SAME AS ABOVE.	70-80
SAND	MEDIUM GRAY POORLY GRADED SAND, FINE TO MEDIUM, TRACE COARSE SAND AND GRAVEL, SATURATED NON-COHESIVE, GRAVEL LAYER AT 81.3 ft.	80-84

132-056-10CAAA1

NDSWC

Date Completed:	0	Purpose:	Observation Well (WSI-4)
L.S. Elevation (ft):	1415.6	Well Type:	2" PVC
Depth Drilled (ft):	70	Aquifer:	Undefined
Screened Interval (ft):	63-68	Source:	FOTH & VAN DYKE REPORT
		4/93	
		Owner:	Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	SILTY BLACK.	0-1
GRAVEL	FINE TO COARSE, YELLOWISH-BROWN, ABOUT 30% SAND WITH A FEW ROCKS.	1-6
CLAY	CLAY, SILTY, YELLOWISH BROWN, TILL.	6-29
CLAY	CLAY, SILTY, OLIVE GRAY, TILL.	29-35
SAND	SAND, FINE TO COARSE, YELLOWISH BROWN.	35-36.5
CLAY	CLAY, SILTY, OLIVE GRAY, TILL.	36.5-43
GRAVEL	GRAVEL, FINE TO MEDIUM, YELLOWISH BROWN.	43-44
CLAY	CLAY, SILTY, OLIVE GRAY, TILL.	44-54
SAND	SAND, FINE TO COARSE, YELLOWISH, BROWN.	54-67
CLAY	CLAY, SILTY, OLIVE GRAY, TILL.	67-70

132-056-10CAAD

NDSWC

Date Completed: 0
 L.S. Elevation (ft): 1416.7
 Depth Drilled (ft): 80
 Screened Interval (ft): 70-80

Purpose:
 Well Type:
 Aquifer:
 Source:
 4/93
 Owner:

Observation Well (WSI-6)
 2" PVC
 Undefined
 FOTH & VAN DYKE REPORT
 Big Dipper Inadfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	SILTY, BLACK.	0-1
CLAY	CLAY, SILTY, YELLOWISH BROWN, TILL, GRAVELLY WITH LOTS OF ROCKS.	1-5
CLAY	CLAY, SILTY, YELLOWISH BROWN, TILL WITH A FEW ROCKS.	5-32
CLAY	CLAY, SILTY, YELLOWISH BROWN, TILL WITH ABOUT 20% LIMESTONE GRAVEL AND ROCKS.	32-40
CLAY	CLAY, SILTY, YELLOWISH BROWN, TILL.	40-44
SAND	FINE TO COARSE, YELLOWISH BROWN.	44-50
CLAY	CLAY, SILTY, YELLOWISH BROWN, TILL.	50-53
CLAY	CLAY, SILTY, OLIVE GRAY, TILL.	53-80

132-056-10CAC1

NDSWC

Date Completed:	0	Purpose:	Observation Well (BFI-2A)
L.S. Elevation (ft):	1410	Well Type:	1.25" PVC
Depth Drilled (ft):	65	Aquifer:	Undefined
Screened Interval (ft):	42.5-66.5	Source:	FOTH & VAN DYKE REPORT
		4/93	
		Owner:	Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	SILTY CLAY, BLACK, MEDIUM.	0-2
CLAY	SILTY CLAY, FINE ALLUVIUM, GRAYISH BROWN, STIFF.	2-4
CLAY	SANDY WITH A LITTLE GRAVEL, BROWN AND GRAY MOTTLED, RATHER STIFF TO STIFF, TRACES OF SHALE, TILL.	4-38
CLAY	SANDY WITH A TRACE OF GRAVEL, BROWNISH GRAY, STIFF.	38-45
SAND	SAND, FINE TO MEDIUM GRAINED, A LITTLE GRAVEL, ALLUVIUM, BROWN, DRY, VERY DENSE.	45-65

132-056-10CAC2

NDSWC

Date Completed:	0	Purpose:	Observation Well (BFI-2)
L.S. Elevation (ft):	1410	Well Type:	1.25" PVC
Depth Drilled (ft):	250	Aquifer:	Undefined
Screened Interval (ft):	100-135	Source:	FOTH & VAN DYKE REPORT
		4/93	
		Owner:	Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	SILTY CLAY, BLACK, MEDIUM.	0-2
CLAY	SILTY, GRAYISH BROWN, STIFF, FINE ALLUVIUM.	2-4
CLAY	SANDY WITH A LITTLE GRAVEL, BROWN AND GRAY MOTTLED, RATHER STIFF TO STIFF, TRACES OF SHALE, TILL.	4-38
CLAY	SANDY WITH A TRACE OF GRAVEL, BROWNISH GRAY, STIFF, TILL.	38-45
SAND	FINE TO MEDIUM GRAINED, A LITTLE GRAVEL, ALLUVIUM, BROWN, DRY, VERY DENSE.	45-65
SAND	FINE TO MEDIUM GRAINED, SILTY, ALLUVIUM, BROWN, MOIST, VERY DENSE.	65-75
SAND	FINE GRAINED, ALLUVIUM, GRAY, WET, VERY DENSE.	75-80.5
CLAY	SANDY WITH A TRACE OF GRAVEL, GRAY, VERY STIFF, TILL.	80.5-90
SILT	CLAYEY, FINE ALLUVIUM, GRAY, VERY STIFF WITH LAYERS OF SILT AND SANDY CLAY.	90-95
SAND	FINE GRAINED, ALLUVIUM, GRAY, MOIST, VERY DENSE.	95-100.5
CLAY	SANDY WITH A TRACE OF GRAVEL, TILL, GRAY.	100.5-105

SAND	FINE TO MEDIUM GRAINED, ALLUVIUM, A LITTLE GRAVEL, BROWN AND GRAY, WET, VERY DENSE, GRAVEL AND COBBLES FROM 129 ft - 133 ft.	105-137
CLAY	SANDY WITH A LITTLE GRAVEL, GRAY, STIFF TO RATHER STIFF, A FEW LAYERS OF SAND, TILL.	137-205
CLAY	SILTY WITH A TRACE OF GRAVEL (SHALE), GRAY, VERY STIFF, TILL.	205-215
SAND	FINE GRAINED, SILTY, ALLUVIUM, GRAY, MOIST, VERY DENSE.	215-220.5
CLAY	FAT CLAY / LACUSTRINE DEPOSITS POSSIBLY OF CARLILE FORMATION. DARK GRAY, VERY STIFF, A FEW LAYERS OF SAND CLAY, MAY BE SHALE.	220.5-225
CLAY	FAT CLAY LACUSTRINE DEPOSITS.	225-250

132-056-10CBAC

NDSWC

Date Completed:	0	Purpose:	Observation Well (MW-17)
L.S. Elevation (ft):	1409.64	Well Type:	2" PVC
Depth Drilled (ft):	65	Aquifer:	Undefined
Screened Interval (ft):	48-58	Source:	FOTH & VAN DYKE REPORT
		4/93	
		Owner:	Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	VERY DARK BROWN SILTY CLAY, ROOTED, DRY, LOOSE, ORGANIC, NONCOHESIVE, TILL.	1-5
CLAY	YELLOW BROWN LEAN CLAY, SLIGHT MOIST STIFF, COHESIVE, MEDIUM DENSE, WITH SAND AND GRAVEL, LIGNITE FRAGMENTS, IRON STAIN, MOTTLED WITH LIGHT GRAY, AND VERTICAL GYPSUM VEINING (10%-15% OF SAMPLE).	5-10
CLAY	SAME AS ABOVE WITH MINOR GYPSUM VEINING OLIVE BROWN.	10-15
CLAY	SAME AS ABOVE EXCEPT NO GYPSUM AND ONE THIN (<0.05 FEET) FINE TO MEDIUM SAND STRINGER AT 15.3 FEET, SLIGHTLY MOIST AND VERY SANDY CLAY APPROX. 0.3 FEET THICK.	15-20
CLAY	SAME AS ABOVE WITH VERY MOIST THIN SANDY CLAY LAYER (<0.1 FEET) AT 20.9 FEET, SOFT ABUNDANT IRON STAINING, CLAY BELOW SAND, CLAY IS VERY STIFF AND ONLY SLIGHTLY MOIST.	20-25
CLAY	SAME AS ABOVE; MOIST AND ABUNDANT STAINING.	25-36
CLAY	SAME AS ABOVE, GRADES TO DARK GRAY BROWN.	36-40
CLAY	VERY DARK GRAY LEAN CLAY WITH SAND AND GRAVEL, SLIGHTLY MOIST, SEMI PLASTIC, MASSIVE, COHESIVE, MEDIUM DENSITY, TILL.	40-50

CLAY	GRAY, POORLY GRADED SAND, FINE TO MEDIUM GRAINED GRAVEL, MODERATELY SORTED, MOIST, NONCOHESIVE, MASSIVE, ALLUVIUM OR OUTWASH.	50-55
SAND	SAME AS ABOVE WITH MINOR GRAVEL AND LIGNITE FRAGMENTS, ALLUVIUM OR OUTWASH.	55-60
CLAY	SAME AS ABOVE EXCEPT SATURATED BELOW 59.5 FEET, ALLUVIUM OR OUTWASH.	60-67

132-056-10CBAD

NDSWC

Date Completed:	0	Purpose:	Observation Well (MW-16A)
L.S. Elevation (ft):	1408.2	Well Type:	2" PVC
Depth Drilled (ft):	25	Aquifer:	Undefined
Screened Interval (ft):	12-22	Source:	FOTH & VAN DYKE REPORT
		4/93	
		Owner:	Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	DARK BROWN SILTY CLAY, DRY, ROOTED, LOOSE, TO 0.2 ft, THEN PALE BROWN SILTY LEAN CLAY MIXED WITH TOPSOIL, DRY ROOTED WITH SAND (TILL).	1-5
CLAY	LIGHT BROWNISH-GRAY CLAY, SOFT, MOIST, MOTTLED IRON STAIN WITH LIGNITE FRAGMENTS, COHESIVE.	5-10
CLAY	SAME AS ABOVE EXCEPT LIGHT BROWN, STIFF IRON STAIN AND MINOR GRAY MOTTLING.	10-15.5
SAND	DARK GRAY BROWN WELL GRADED SAND, SATURATED, NONCOHESIVE, POORLY SORTED, (0.5 FEET) .	15.5-16.2
CLAY	VERY DARK LEAN/FAT CLAY WITH SAND AND GRAVEL. SANDY LAYER AT 20.2 FEET (0.1 FEET THICK), WET.	16.2-25
CLAY	SANDY, GRAY TILL AS ABOVE WITH THIN INERBEDDED SANDY LEAN CLAY AND CLAYEY SILT.	25-27

132-056-10CBB

NDSWC

Date Completed:	0	Purpose:	Observation Well (MW-5)
L.S. Elevation (ft):	1424.3	Well Type:	2" PVC
Depth Drilled (ft):	64	Aquifer:	Undefined
Screened Interval (ft):	54-64	Source:	
		Owner:	Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	SILTY, LIGHT BROWN SILTY CLAY; CALCIUM CARBONATE CEMENT, TILL.	1-7.5
CLAY	SAME AS ABOVE EXCEPT WITH COBBLES.	7.5-9
CLAY	SILTY, LIGHT BROWN SILTY CLAY; CALCIUM CARBONATE CEMENT THROUGHOUT.	9-20
CLAY	BROWN TO GRAY STIFF CLAY; COBBLES PRESENT THROUGHOUT.	20-40
SAND	WET CLAYEY SAND; SAND IS COARSE TO VERY FINE; POORLY SORTED (CLAY 30%; SAND 60%; COBBLES AND PEBBLES 10%).	40-64

132-056-10CBC1

NDSWC

Date Completed:	0	Purpose:	Observation Well (MW-20)
L.S. Elevation (ft):	1401.49	Well Type:	2" PVC
Depth Drilled (ft):	28	Aquifer:	Undefined
Screened Interval (ft):	8.5-18.5	Source:	FOTH & VAN DYKE REPORT
		4/93	
		Owner:	Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	FROZEN.	0-3
CLAY	TOPSOIL TO 3.4 FEET, LIGHT OLIVE BROWN (2.5Y5/6-5/4) LEAN CLAY WITH GRAVEL AND COBBLES, MOTTLES ALONG OLD ROOT SYSTEM (2.5Y4/1-4/2), SLIGHTLY MOIST, LEAN.	3-8
CLAY	OLIVE BROWN (2.4Y4/4-4/4) LEAN CLAY WITH GRAVEL, FEW MOTTLES, SLIGHTLY MOIST TO DRY, FIRM.	8-13
CLAY	SAME AS ABOVE EXCEPT 5Y4/6 Fe-STAINS ALONG VERTICAL JOINTS, SHALE CLASTS COMMON, MOIST, VERY MOIST AT 17-18 FEET LEVEL, LEAN.	13-18
CLAY	MINIMAL RECOVERY BECAUSE OF ROCK, APPEARS TO BE SATURATED LEAN CLAY WITH GRAVEL AS ABOVE.	18-23
CLAY	DARK TO VERY DARK GRAY (5Y4/1-3/1) LEAN CLAY, SLIGHTLY MORE PLASTIC AND CLAY-RICH THAN ABOVE SAMPLES, SATURATED, JOINTS NOT APPARENT.	23-28

132-056-10CBC2

NDSWC

Date Completed:	0	Purpose:	Observation Well (MW-23)
L.S. Elevation (ft):	1401.3	Well Type:	2" PVC
Depth Drilled (ft):	60	Aquifer:	Undefined
Screened Interval (ft):	49.75-59.75	Source:	FOTH & VAN DYKE REPORT
		4/93	
		Owner:	Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	BLACK	0-1
CLAY	YELLOWISH BROWN SANDY LEAN CLAY TO LEAN CLAY WITH SAND AND SOME GRAVEL.	1-19
CLAY	DARK GRAY LEAN CLAY WITH SAND AND SOME GRAVEL.	19-20
CLAY	DARK GRAY LEAN CLAY WITH SOME SAND AND GRAVEL.	20-52
GRAVEL		29-31
CLAY	SAME AS ABOVE ZONES OF LEAN CLAY.	31-40
SPLIT SPOON SAMPLE TAKEN		40-42
CLAY	SAME AS ABOVE.	42-52
SAND	COARSE GRAIN, POORLY GRADED WITH GRAVEL.	52-53
CLAY	MIXED WITH SAND AND SILT, DARK GRAY, LOW PLASTICITY.	53-60

132-056-10CCCB

NDSWC

Date Completed:	0	Purpose:	Observation Well (MW-21)
L.S. Elevation (ft):	1398.2	Well Type:	2" PVC
Depth Drilled (ft):	57	Aquifer:	Undefined
Screened Interval (ft):	47-57	Source:	FOTH & VAN DYKE REPORT 4/93
		Owner:	Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	AUGERED THROUGH FROZEN TOPSOIL.	0-3
CLAY	LIGHT OLIVE BROWN (2.5Y5/4) SANDY LEAN CLAY, DRY, FRIABLE, FEW MOTTLES (7.5YR5/6), STRATIFIED A 7-8' DEPTH.	3-8
CLAY	AS ABOVE EXCEPT ALTERNATING CRUDE BEDDING WITH MASSIVE TILL, COMMON Fe STAINED JOINTS (VERTICAL).	8-13
CLAY	AS ABOVE EXCEPT 2.5Y4/4 AND MORE PLASTIC AT 17-18 FEET THAN EITHER ABOVE OR BELOW.	13-18
CLAY	AS ABOVE EXCEPT 2.5Y4/2 TO 21.5 FEET, ABRUPT LOWER BOUNDARY.	18-21.5
SAND	FINE TO MEDIUM, WELL GRADED SAND WITH GRAVEL, 2.5Y6/3, LOOSE.	21.5-23
SAND	AS ABOVE EXCEPT INTERBEDDED WITH LEAN CLAY.	23-24.5
SAND	SAME AS ABOVE EXCEPT WITH GRAVEL UNIT	24.5-25.5
SAND & GRAVEL	SAME AS ABOVE WITH ANOTHER CLAY UNIT.	25.5-28
SAND	YELLOW BROWN 10YR5/4-6/4 POORLY GRADED SAND AND SILTY SAND UNITS INTERBEDED, SOME THIN CLAY BEDS, DIFFERENT SAND LITHOLOGIES AT 30.4 FEET.	28-30.5

NO RECOVERY	AUGERED THROUGH ROCK.	30.5-34
CLAY	VERY DARK GRAYISH BROWN (2.5Y3/2) LEAN CLAY WITH SAND AND GRAVEL, FEW SAND LENSES, CLAYS HAVE CRUDE BEDDING, FIRM, MOIST.	34-38
CLAY	LEAN CLAYS WITH SAND INTERBEDDED WITH GRAYISH BROWN 2.5Y5/2 SILTY SANDS, CLAYS ARE MOIST AND JOINTED, SANDS LOOSE AND SLIGHTLY MOIST, BEDS ,1.5 INCHES.	38-41.5
CLAY	SAME AS ABOVE.	41.5-43
CLAY	VERY DARK GRAYISH BROWN (2.5Y3/2) LEAN CLAY WITH SAND AND GRAVEL, COMMON 5YR4/6-3/4 MOTTLES ON VERTICAL JOINTS, FEW COAL FRAGMENTS, MOIST.	43-48
CLAY	SAME AS ABOVE EXCEPT VERY MOIST, THIN SAND LENSES, SANDS ARE OXIDIZED ABOVE AND REDUCED LOWER IN DEPTH.	48-50.5
CLAY	SAME AS ABOVE EXCEPT SATURATED.	50.5-53
SAND	AS ABOVE TO 53.2 FEET, SILTY, VERY DARK GRAYISH BROWN (2.5Y3/2) SILTY SAND WITH COAL FRAGMENTS, LOOSE, SATURATED.	53-57

132-056-10CDA

NDSWC

Date Completed:	0	Purpose:	Observation Well (MW-26)
L.S. Elevation (ft):	1410.6	Well Type:	2" PVC
Depth Drilled (ft):	76	Aquifer:	Undefined
Screened Interval (ft):	65.8-75.8	Source:	FOTH & VAN DYKE REPORT
		4/93	
		Owner:	Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	PRISMATIC PEDS.	0-2.2
CLAY	2.5Y6/4 SILTY LEAN CLAY WITH SAND; FRIABLE, DRY, PED DEVELOPMENT, CRUDE BEDDING OR PLATY STRUCTURES, GLEYED DEOX AND OXIDE MOTTLES.	2.2-5
CLAY	2.5Y4/2-4/4 SANDY LEAN CLAY, FRIABLE, DRY, VERTICAL JOINTS, SOFT FeConc 10YR AND 2.5YR COLORS, 2.5Y5/0 MOTTLES, DIAMICTON.	5-10
CLAY	2.5Y4/4-5/4 SANDY LEAN CLAY, FRIABLE TO FIRM, DRY TO SLIGHTLY MOIST, VERTICAL JOINTS, MANY COLORS 5Y6/1 AND 5YR3/4 MOTTLES. FeOxide MOTTLES ALONG HORIZONTAL AND VERTICAL JOINTS, WEATHERED CRYSTALLINE CLASTS DIAMICTON.	10-15
CLAY	SAME AS ABOVE EXCEPT FEW THICK (APPROX. 6 INCHES) LENSES OF CRUDE BEDDING.	15-20
CLAY	AS ABOVE EXCEPT MOSTLY CRUDE BEDDING.	20-25
CLAY	AS ABOVE EXCEPT FEW HEALED JOINTS.	25-30
CLAY	AS ABOVE EXCEPT NO APPARENT JOINTS AND FEW SANDIER CRUDE BEDS.	30-35
CLAY	AS ABOVE TO 37.5 FEET, 37.5-39 FEET, 2.5Y4/2-4/3 LEAN CLAY WITH SAND, FIRM DRY TO SLIGHTLY MOIST.	35-39

CLAY	2.5Y4/4 SANDY LEAN CLAY TO 43.6 WITH GRAVEL, MANY FeOxide MOTTLES; 43.6-44 FEET FINE POORLY GRADED SAND LENS, 44-45 FEET, 10YR3/3-3/4 LEAN CLAY WITH SAND VERY FIRM, SLIGHTLY MOIST NO JOINTS.	39-43
CLAY	5Y4/2-2.5Y4/2 SANDY LEAN CLAY, FIRM, SLIGHTLY MOIST, PLATEY STRUCTURE, BEDDING, MANY MnOx, FeOx MOTTLES.	45-50
CLAY	AS ABOVE EXCEPT DOMINATED BY FeOx MOTTLES.	50-52
CLAY	AS ABOVE, EXCEPT HEALED VERTICAL JOINTS.	52-56
CLAY	AS ABOVE EXCEPT 10YR3/2 WITH VERTICAL JOINTS.	56-58
SAND	DARK GRAY TO BLUE GRAY SAND.	58-66
SAND & GRAVEL	SAND AND GRAVEL LENSES.	66-71
CLAY	DARK GRAY TO BLUE GRAY CLAY.	71-76

132-056-10CDC

NDSWC

Date Completed: 0
 L.S. Elevation (ft): 1408.3
 Depth Drilled (ft): 75
 Screened Interval (ft): 63.8-73.8

Purpose:
 Well Type:
 Aquifer:
 Source:
 4/93
 Owner:

Observation Well (MW-33)
 2" PVC
 Undefined
 FOTH & VAN DYKE REPORT
 Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	BLACK TOPSOIL.	0-3
CLAY	WITH A TRACE OF GRAVEL, TILL.	3-7
CLAY	BROWN CLAY	7-25
GRAVEL		25-26
CLAY	GRAY CLAY	26-28
CLAY	BROWN CLAY.	28-47
CLAY	BLUE CLAY.	47-67
CLAY	BLUE CLAY.	59-66
SAND		66-68
CLAY	BLUE CLAY.	68-75

132-056-10CDD1

NDSWC

Date Completed: 0
 L.S. Elevation (ft): 1399.5
 Depth Drilled (ft): 75
 Screened Interval (ft): 64.1-74.1

Purpose:
 Well Type:
 Aquifer:
 Source:
 4/93
 Owner:

Observation Well (MW-35)
 2" PVC
 Undefined
 FOTH & VAN DYKE REPORT
 Big Dipper Landfill

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL	BLACK TOPSOIL.	0-3
CLAY	WITH A TRACE OF GRAVEL, TILL.	3-7
CLAY	BROWN CLAY.	7-25
GRAVEL		25-26
CLAY	GRAY CLAY.	26-28
CLAY	BROWN CLAY	28-47
CLAY	GRAY LEAN CLAY TILL, WET, AT 50 FEET.	47-67
CLAY	AS ABOVE WITH SAND SEAMS, FINE.	67-68

APPENDIX F

WATER-LEVEL TABLES

SWC/NDGS Water-Level Tables

132-056-02CCC1

LS Elev (msl,ft)=1377.73

Undefined Aquifer

SI (ft.)=221-226

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/06/93	153.30	1224.43	10/25/93	153.27	1224.46
10/12/93	153.32	1224.41	11/03/93	153.18	1224.55
10/19/93	153.32	1224.41			

132-056-02CCC2

LS Elev (msl,ft)=1378.35

Undefined Aquifer

DRY

SI (ft.)=40-45

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/06/93	45.00	1333.35	10/25/93	45.00	1333.35
10/12/93	45.00	1333.35	11/03/93	45.00	1333.35
10/19/93	45.00	1333.35			

132-056-02DCC1

LS Elev (msl,ft)=1278.52

Undefined Aquifer

SI (ft.)=163-168

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/06/93	118.71	1159.81	10/25/93	118.60	1159.92
10/12/93	118.89	1159.63	11/03/93	118.37	1160.15
10/19/93	118.79	1159.73			

132-056-02DCC2

LS Elev (msl,ft)=1278.51

Undefined Aquifer

SI (ft.)=45-50

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/06/93	2.19	1276.32	10/25/93	2.26	1276.25
10/12/93	2.32	1276.19	11/03/93	2.11	1276.40
10/19/93	2.31	1276.20			

132-056-03DCD

LS Elev (msl,ft)=1394.48

Undefined Aquifer

SI (ft.)=103-108

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/06/93	46.29	1348.19	10/25/93	46.30	1348.18
10/12/93	46.35	1348.13	11/03/93	46.06	1348.42
10/19/93	46.29	1348.19			

132-056-04CCC

LS Elev (msl,ft)=1353.23

Undefined Aquifer

SI (ft.)=163-168

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/06/93	46.09	1307.14	10/25/93	45.86	1307.37
10/12/93	45.83	1307.40	11/03/93	45.76	1307.47
10/19/93	45.92	1307.31			

132-056-09ADD1

LS Elev (msl,ft)=1397.38

Undefined Aquifer

SI (ft.)=305-310

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/06/93	130.35	1267.03 *	10/25/93	113.35	1284.03*
10/12/93	119.21	1278.17 *	11/03/93	111.93	1285.45*
10/19/93	115.09	1282.29 *			

132-056-09ADD2

LS Elev (msl,ft)=1397.6

Undefined Aquifer

SI (ft.)=163-168

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/06/93	67.23	1330.37	10/25/93	67.04	1330.56
10/12/93	67.22	1330.38	11/03/93	66.88	1330.72
10/19/93	67.12	1330.48			

132-056-10BBA2

LS Elev (msl,ft)=1369.48

Undefined Aquifer

SI (ft.)=60-65

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/06/93	22.04	1347.44	10/25/93	22.32	1347.16
10/12/93	22.34	1347.14	11/03/93	22.10	1347.38
10/19/93	22.36	1347.12			

132-056-10CCCC2

LS Elev (msl,ft)=1390.69

Undefined Aquifer

SI (ft.)=155-160

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/06/93	54.84	1335.85	10/25/93	54.70	1335.99
10/12/93	54.89	1335.80	11/03/93	54.55	1336.14
10/19/93	54.85	1335.84			

132-056-11CBB2

LS Elev (msl,ft)=1361.49

Undefined Aquifer

SI (ft.)=25-30

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/06/93	10.00	1351.49	10/25/93	10.17	1351.32
10/12/93	10.16	1351.33	11/03/93	9.96	1351.53
10/19/93	10.17	1351.32			

132-056-11CCC2

LS Elev (msl,ft)=1315.77

Undefined Aquifer

SI (ft.)=42-47

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/06/93	11.70	1304.07	10/25/93	11.78	1303.99
10/12/93	11.72	1304.05	11/03/93	11.72	1304.05
10/19/93	11.77	1304.00			

* Water levels are erroneous due to a possible leaking annulus.

132-056-11DBB

LS Elev (msl,ft)=1274.44

Undefined Aquifer

SI (ft.)=127-132

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/06/93	99.15	1175.29	10/25/93	111.47	1162.97
10/12/93	106.92	1167.52	11/03/93	111.35	1163.09
10/19/93	111.65	1162.79			

132-056-11DCC

LS Elev (msl,ft)=1261.29

Undefined Aquifer

SI (ft.)=135-140

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/06/93	106.27	1155.02	10/25/93	105.94	1155.35
10/12/93	106.52	1154.77	11/03/93	105.54	1155.75
10/19/93	106.30	1154.99			

132-056-14CCC

LS Elev (msl,ft)=1269.3

Undefined Aquifer

FLOWER

SI (ft.)=118-123

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/06/93	-7.00	1276.30	10/25/93	-7.00	1276.30
10/19/93	-7.00	1276.30			

132-056-15CCD2

LS Elev (msl,ft)=1346.87

Undefined Aquifer

SI (ft.)=55-60

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/06/93	29.11	1317.76	10/25/93	29.15	1317.72
10/12/93	29.16	1317.71	11/03/93	28.92	1317.95
10/19/93	29.11	1317.76			

132-056-16BAA

LS Elev (msl,ft)=1401.2

Undefined Aquifer

SI (ft.)=149-154

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
10/06/93	65.89	1335.31	10/25/93	65.65	1335.55
10/12/93	65.70	1335.50	11/03/93	65.40	1335.80
10/19/93	65.75	1335.45			

SWC/NDGS Water Levels From Landfill Wells

132-056-09DAA

LS Elev (msl,ft)=1410.5

Undefined Aquifer

SI (ft.)=28.3-38.3

Date	Depth to Water (ft)	WL Elev (msl, ft)
03/09/93	43.45	1365.26
06/08/93	41.03	1367.68

Date	Depth to Water (ft)	WL Elev (msl, ft)
09/22/93	38.58	1371.59

132-056-10BBC1

LS Elev (msl,ft)=1380

Undefined Aquifer

SI (ft.)=119.5-139.5

Date	Depth to Water (ft)	WL Elev (msl, ft)
05/25/93	24.40	1355.60
06/08/93	18.62	1361.38

Date	Depth to Water (ft)	WL Elev (msl, ft)
07/19/93	18.08	1361.92

132-056-10BBC2

LS Elev (msl,ft)=1380

Undefined Aquifer

SI (ft.)=44-64

Date	Depth to Water (ft)	WL Elev (msl, ft)
04/20/93	22.21	1357.79
05/25/93	44.11	1335.89

Date	Depth to Water (ft)	WL Elev (msl, ft)
06/08/93	43.12	1336.88
07/19/93	40.72	1339.28

132-056-10BCCC

LS Elev (msl,ft)=1415.6

Undefined Aquifer

SI (ft.)=49-59

Date	Depth to Water (ft)	WL Elev (msl, ft)
04/20/93	42.69	1372.91
05/25/93	42.72	1372.88

Date	Depth to Water (ft)	WL Elev (msl, ft)
06/08/93	42.02	1373.58
07/19/93	41.96	1373.64
09/22/93	40.90	1368.75

132-056-10BCCD

LS Elev (msl,ft)=1416.6

Undefined Aquifer

SI (ft.)=64.8-74.8

Date	Depth to Water (ft)	WL Elev (msl, ft)
03/09/93	68.90	1347.99
04/20/93	69.27	1347.33
05/25/93	69.19	1347.41

Date	Depth to Water (ft)	WL Elev (msl, ft)
06/08/93	68.60	1348.00
06/21/93	68.79	1348.10
09/22/93	70.83	1348.26

132-056-10BCD

LS Elev (msl,ft)=1410.5

Undefined Aquifer

SI (ft.)=28.3-38.3

Date	Depth to Water (ft)	WL Elev (msl, ft)
03/09/93	NT	NT
04/20/93	6.71	1403.79
05/25/93	6.58	1403.92

Date	Depth to Water (ft)	WL Elev (msl, ft)
06/08/93	5.67	1404.83
06/21/93	5.68	1404.80
09/22/93	6.74	1405.74

132-056-10BDD
Undefined Aquifer

LS Elev (msl,ft)=1424.3
 SI (ft.)=71-76

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
04/20/93	68.53	1355.77	06/21/93	68.14	1355.20
05/25/93	69.38	1354.92	07/19/93	68.52	1355.78
06/08/93	68.47	1355.83	09/22/93	70.65	1355.29

132-056-10BDDD
Undefined Aquifer

LS Elev (msl,ft)=1424.3
 SI (ft.)=71-76

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/09/93	56.74	1362.72	09/22/93	58.29	1363.67
06/21/93	56.46	1363.00			

132-056-10CAAA1
Undefined Aquifer

LS Elev (msl,ft)=1415.6
 SI (ft.)=63-68

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/09/93	55.95	1359.01	06/08/93	55.80	1359.80
04/20/93	42.69	1372.91	06/21/93	55.43	1359.53
05/25/93	55.80	1359.80	07/19/93	55.81	1359.79
			09/22/93	57.85	1359.46

132-056-10CAAA2
Undefined Aquifer

LS Elev (msl,ft)=1415.6
 SI (ft.)=63-68

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/09/93	46.85	1357.54	09/22/93	48.32	1358.57
06/21/93	46.20	1358.19			

132-056-10CAAD
Undefined Aquifer

LS Elev (msl,ft)=1416.7
 SI (ft.)=70-80

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/09/93	54.90	1361.92	06/08/93	55.06	1361.64
04/20/93	54.80	1361.90	06/21/93	55.84	1360.98
05/25/93	54.92	1361.78	07/19/93	55.31	1361.39

132-056-10CAC1
Undefined Aquifer

LS Elev (msl,ft)=1410
 SI (ft.)=42.5-66.5

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
04/20/93	66.00	1344.00	06/08/93	66.00	1344.00
05/25/93	66.00	1344.00			

132-056-10CAC2

LS Elev (msl,ft)=1410

Undefined Aquifer

SI (ft.)=100-135

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
04/20/93	64.30	1345.70	06/08/93	63.38	1346.62
05/25/93	64.18	1345.82	07/19/93	63.99	1346.01

132-056-10CBAC

LS Elev (msl,ft)=1409.64

Undefined Aquifer

SI (ft.)=48-58

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/09/93	56.93	1352.91	06/21/93	58.21	1351.63
04/20/93	58.28	1351.36	07/19/93	58.57	1351.07
05/25/93	58.56	1351.08	09/22/93	60.55	1349.09
06/08/93	57.67	1351.97			

132-056-10CBAD

LS Elev (msl,ft)=1408.2

Undefined Aquifer

SI (ft.)=12-22

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/09/93	-0.79	1409.44	06/21/93	NT	NT
04/20/93	0.08	1408.12			

132-056-10CBB

LS Elev (msl,ft)=1424.3

Undefined Aquifer

SI (ft.)=54-64

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/09/93	31.11	1371.22	06/08/93	27.56	1396.74
04/20/93	27.85	1396.45	06/21/93	25.38	1376.95
05/25/93	28.54	1395.76	07/19/93	22.00	1402.30
			09/22/93	26.52	1378.51

132-056-10CBC1

LS Elev (msl,ft)=1401.49

Undefined Aquifer

SI (ft.)=8.5-18.5

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
04/20/93	4.21	1397.28	06/08/93	2.28	1399.21
05/25/93	3.04	1398.45	07/19/93	2.20	1399.29
			09/22/93	6.40	1397.53

132-056-10CBC2

LS Elev (msl,ft)=1401.3

Undefined Aquifer

SI (ft.)=49.75-59.75

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
05/25/93	21.02	1380.28	07/19/93	19.12	1382.18
06/08/93	19.13	1382.17	09/22/93	20.55	1380.75

132-056-10CCCB

LS Elev (msl,ft)=1398.2

Undefined Aquifer

SI (ft.)=47-57

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/09/93	47.40	1350.85	06/08/93	47.00	1351.20
04/20/93	47.27	1350.93	06/21/93	47.13	1351.12
05/25/93	47.20	1351.00	07/19/93	47.19	1351.01
			09/22/93	49.68	1351.27

132-056-10CDA

LS Elev (msl,ft)=1410.6

Undefined Aquifer

SI (ft.)=65.8-75.8

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/09/93	70.52	1339.48	06/08/93	70.15	1340.45
04/20/93	70.36	1340.24	06/21/93	69.72	1340.28
05/25/93	70.13	1340.47	07/19/93	69.68	1340.92
			09/22/93	71.80	1338.80

132-056-10CDC

LS Elev (msl,ft)=1408.3

Undefined Aquifer

SI (ft.)=63.8-73.8

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/09/93	59.27	1348.38	06/08/93	58.39	1349.91
04/20/93	59.09	1349.21	06/21/93	58.69	1348.96
05/25/93	58.89	1349.41	07/19/93	58.74	1349.56
			09/22/93	60.03	1349.97

132-056-10CDD1

LS Elev (msl,ft)=1399.5

Undefined Aquifer

SI (ft.)=64.1-74.1

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/09/93	64.10	1334.40	06/08/93	63.65	1335.85
04/20/93	63.82	1335.68	06/21/93	63.40	1335.10
05/25/93	63.76	1335.74	07/19/93	63.53	1335.97
			09/22/93	63.32	1335.68

NT = NOT TESTED

Gwinner Aquifer Water-Level Tables

132-055-31BCC
GWN Aquifer

LS Elev (msl,ft)=1252
SI (ft.)=158-163

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/30/90	102.83	1149.17	05/11/92	100.18	1151.82
05/08/90	104.17	1147.83	06/09/92	100.22	1151.78
06/14/90	106.43	1145.57	07/07/92	99.96	1152.04
07/05/90	105.56	1146.44	08/10/92	101.69	1150.31
08/02/90	105.92	1146.08	09/08/92	100.78	1151.22
08/29/90	104.71	1147.29	10/14/92	100.47	1151.53
10/22/90	101.83	1150.17	11/09/92	99.34	1152.66
11/19/90	101.18	1150.82	12/11/92	99.11	1152.89
12/17/90	100.09	1151.91			
04/18/91	100.50	1151.50	04/12/93	99.19	1152.81
05/16/91	99.84	1152.16	05/10/93	99.14	1152.86
06/11/91	100.53	1151.47	06/14/93	99.15	1152.85
07/10/91	103.86	1148.14	07/08/93	98.95	1153.05
08/07/91	102.64	1149.36	08/09/93	99.09	1152.91
09/18/91	102.08	1149.92	09/07/93	101.11	1150.89
10/21/91	104.74	1147.26	10/05/93	99.66	1152.34
11/26/91	101.56	1150.44	10/12/93	100.09	1151.91
12/19/91	101.09	1150.91	10/19/93	99.67	1152.33
			10/25/93	99.19	1152.81
04/07/92	99.54	1152.46	11/03/93	100.96	1151.04

132-055-31CCCB
GWN Aquifer

LS Elev (msl,ft)=1250
SI (ft.)=173-178

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/30/90	107.66	1142.34	05/11/92	105.09	1144.91
05/08/90	109.02	1140.98	06/09/92	105.17	1144.83
06/14/90	111.23	1138.77	07/07/92	104.82	1145.18
07/05/90	110.39	1139.61	08/10/92	106.62	1143.38
08/02/90	110.78	1139.22	09/08/92	105.73	1144.27
08/29/90	109.63	1140.37	10/14/92	105.33	1144.67
10/22/90	106.88	1143.12	11/09/92	104.24	1145.76
11/19/90	106.26	1143.74	12/11/92	104.10	1145.90
12/17/90	105.10	1144.90			
04/18/91	105.43	1144.57	04/12/93	104.10	1145.90
05/16/91	104.83	1145.17	05/10/93	104.08	1145.92
06/11/91	105.42	1144.58	06/14/93	104.12	1145.88
07/10/91	108.65	1141.35	07/08/93	103.97	1146.03
08/07/91	107.51	1142.49	08/09/93	104.12	1145.88
09/18/91	107.02	1142.98	09/07/93	105.86	1144.14
10/21/91	109.51	1140.49	10/05/93	104.60	1145.40
11/26/91	106.50	1143.50	10/12/93	105.02	1144.98
12/19/91	106.03	1143.97	10/19/93	104.66	1145.34
			10/25/93	104.22	1145.78
04/07/92	104.40	1145.60	11/03/93	103.86	1146.14

132-056-14CDA1

LS Elev (msl, ft)=1251

GWN Aquifer

SI (ft.)=153-156

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/30/90	105.02	1145.98	05/11/92	102.58	1148.42
05/08/90	106.02	1144.98	06/09/92	103.06	1147.94
06/14/90	108.62	1142.38	07/07/92	102.79	1148.21
07/05/90	107.87	1143.13	08/10/92	104.56	1146.44
08/02/90	107.62	1143.38	09/01/92	103.53	1147.47
08/29/90	106.99	1144.01	10/14/92	103.11	1147.89
10/22/90	104.07	1146.93	11/09/92	101.82	1149.18
11/19/90	103.83	1147.17	12/11/92	101.92	1149.08
12/17/90	102.76	1148.24			
			04/12/93	101.74	1149.26
04/18/91	102.90	1148.10	05/10/93	101.70	1149.30
05/16/91	102.61	1148.39	06/14/93	102.10	1148.90
06/11/91	103.32	1147.68	07/08/93	101.87	1149.13
07/10/91	105.98	1145.02	08/09/93	101.99	1149.01
08/17/91	104.74	1146.26	09/07/93	104.19	1146.81
09/18/91	104.68	1146.32	10/05/93	102.66	1148.34
10/21/91	106.70	1144.30	10/12/93	102.93	1148.07
11/26/91	103.88	1147.12	10/19/93	102.53	1148.47
12/19/91	103.48	1147.52	10/25/93	102.06	1148.94
			11/03/93	101.81	1149.19
04/07/92	102.10	1148.90			

132-056-22DDA

LS Elev (msl, ft)=1265

GWN Aquifer

SI (ft.)=111-116

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/30/90	61.18	1203.82	05/11/92	61.06	1203.94
05/08/90	61.41	1203.59	06/09/92	61.04	1203.96
06/14/90	61.99	1203.01	07/07/92	60.90	1204.10
07/05/90	62.14	1202.86	08/10/92	61.20	1203.80
08/02/90	62.40	1202.60	09/08/92	61.05	1203.95
08/29/90	62.55	1202.45	10/14/92	61.11	1203.89
10/22/90	62.34	1202.66	11/09/92	60.78	1204.22
11/19/90	62.33	1202.67	12/11/92	60.67	1204.33
12/17/90	62.16	1202.84			
			04/12/93	60.26	1204.74
04/18/91	61.82	1203.18	05/10/93	60.26	1204.74
05/16/91	61.48	1203.52	06/14/93	60.19	1204.81
06/11/91	61.50	1203.50	07/08/93	59.99	1205.01
07/10/91	61.77	1203.23	08/09/93	59.94	1205.06
08/07/91	62.06	1202.94	09/07/93	60.08	1204.92
09/18/91	62.08	1202.92	10/05/93	60.06	1204.94
10/21/91	62.04	1202.96	10/12/93	60.05	1204.95
11/26/91	61.77	1203.23	10/19/93	60.04	1204.96
12/19/91	61.72	1203.28	10/25/93	60.02	1204.98
			11/03/93	59.93	1205.07
04/07/92	61.18	1203.82			

132-056-23CAD
GWN Aquifer

LS Elev (msl, ft) = 1259.34
 SI (ft.) = 118-123

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/30/90	56.25	1203.09	05/11/92	56.14	1203.20
05/08/90	56.49	1202.85	06/09/92	56.10	1203.24
06/14/90	57.12	1202.22	07/07/92	55.97	1203.37
07/05/90	57.26	1202.08	08/10/92	56.33	1203.01
08/02/90	57.55	1201.79	09/08/92	56.10	1203.24
08/29/90	57.65	1201.69	10/14/92	56.18	1203.16
10/22/90	57.42	1201.92	11/09/92	55.89	1203.45
11/19/90	57.38	1201.96	12/11/92	55.70	1203.64
12/17/90	57.22	1202.12			
04/18/91	56.87	1202.47	04/12/93	55.33	1204.01
05/16/91	56.53	1202.81	05/10/93	55.37	1203.97
06/11/91	57.04	1202.30	06/14/93	55.23	1204.11
07/10/91	56.89	1202.45	07/08/93	55.07	1204.27
08/07/91	57.15	1202.19	08/09/93	55.06	1204.28
09/18/91	57.16	1202.18	09/07/93	55.14	1204.20
10/21/91	57.14	1202.20	10/05/93	55.23	1204.11
11/26/91	56.81	1202.53	10/12/93	55.12	1204.22
12/19/91	56.79	1202.55	10/19/93	55.09	1204.25
			10/25/93	57.06	1202.28
04/07/92	55.23	1204.11	11/03/93	54.99	1204.35

132-056-24BCC
GWN Aquifer

LS Elev (msl, ft) = 1252.74
 SI (ft.) = 168-173

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/30/90	104.85	1147.89	05/11/92	102.32	1150.42
05/08/90	106.10	1146.64	06/09/92	102.83	1149.91
06/14/90	109.07	1143.67	07/07/92	102.74	1150.00
07/05/90	108.29	1144.45	08/10/92	104.20	1148.54
08/02/90	107.78	1144.96	09/08/92	103.03	1149.71
08/29/90	106.92	1145.82	10/14/92	102.71	1150.03
10/22/90	103.79	1148.95	11/09/92	101.43	1151.31
11/19/90	103.49	1149.25	12/11/92	101.23	1151.51
12/17/90	102.23	1150.51			
04/18/91	102.55	1150.19	04/12/93	101.95	1150.79
05/16/91	102.98	1149.76	05/10/93	101.29	1151.45
06/11/91	99.29	1153.45	06/14/93	101.97	1150.77
07/10/91	106.00	1146.74	07/08/93	101.92	1150.82
08/07/91	104.58	1148.16	08/09/93	101.79	1150.95
09/18/91	104.56	1148.18	09/07/93	104.25	1148.49
10/21/91	106.84	1145.90	10/05/93	102.11	1150.63
11/26/91	103.50	1149.24	10/12/93	102.80	1149.94
12/19/91	103.02	1149.72	10/19/93	101.92	1150.82
			10/25/93	101.39	1151.35
04/07/92	101.67	1151.07	11/03/93	101.76	1150.98

132-056-24CCCB
GWN Aquifer

LS Elev (msl,ft)=1255
 SI (ft.)=173-178

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/30/90	110.07	1144.93	05/11/92	107.79	1147.21
05/08/90	111.60	1143.40	06/09/92	108.46	1146.54
06/14/90	114.95	1140.05	07/07/92	108.48	1146.52
07/05/90	114.20	1140.80	08/10/92	109.25	1145.75
08/02/90	114.30	1140.70	09/08/92	107.98	1147.02
08/29/90	112.60	1142.40	10/14/92	108.14	1146.86
10/22/90	109.26	1145.74	11/09/92	106.92	1148.08
11/19/90	108.70	1146.30	12/11/92	106.41	1148.59
12/17/90	107.25	1147.75			
04/18/91	108.04	1146.96	04/12/93	106.92	1148.08
05/16/91	107.44	1147.56	05/10/93	106.54	1148.46
06/11/91	109.03	1145.97	06/14/93	107.65	1147.35
07/10/91	111.96	1143.04	07/08/93	107.51	1147.49
08/07/91	110.87	1144.13	08/09/93	107.36	1147.64
09/18/91	110.33	1144.67	09/07/93	109.90	1145.10
10/21/91	112.51	1142.49	10/05/93	107.12	1147.88
11/26/91	108.74	1146.26	10/12/93	108.42	1146.58
12/19/91	108.36	1146.64	10/19/93	106.94	1148.06
			10/25/93	106.61	1148.39
04/07/92	106.84	1148.16	11/03/93	107.45	1147.55

132-056-25DAA
GWN Aquifer

LS Elev (msl,ft)=1245
 SI (ft.)=157-162

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/30/90	96.82	1148.18	05/11/92	94.18	1150.82
05/08/90	98.25	1146.75	06/09/92	94.19	1150.81
06/14/90	100.64	1144.36	07/07/92	94.03	1150.97
07/05/90	99.73	1145.27	08/10/92	95.73	1149.27
08/02/90	99.98	1145.02	09/08/92	94.65	1150.35
08/29/90	98.72	1146.28	10/14/92	94.47	1150.53
10/22/90	95.82	1149.18	11/09/92	93.32	1151.68
11/19/90	95.14	1149.86	12/11/92	93.06	1151.94
12/17/90	93.95	1151.05			
04/18/91	94.50	1150.50	04/12/93	93.26	1151.74
05/16/91	93.80	1151.20	05/10/93	93.12	1151.88
06/11/91	94.60	1150.40	06/14/93	93.22	1151.78
07/10/91	98.01	1146.99	07/08/93	93.04	1151.96
08/07/91	96.60	1148.40	08/09/93	93.09	1151.91
09/18/91	96.07	1148.93	09/07/93	95.41	1149.59
10/21/91	98.88	1146.12	10/05/93	93.68	1151.32
11/26/91	95.38	1149.62	10/12/93	94.17	1150.83
12/19/91	95.02	1149.98	10/19/93	93.60	1151.40
			10/25/93	93.09	1151.91
04/07/92	93.53	1151.47	11/03/93	92.97	1152.03

132-056-26DAD

GWN Aquifer

LS Elev (msl, ft)=1265

SI (ft.)=170-173

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/30/90	119.37	1145.63	05/11/92	116.33	1148.67
05/08/90	121.07	1143.93	06/09/92	116.54	1148.46
06/14/90	123.15	1141.85	07/07/92	115.98	1149.02
07/05/90	122.19	1142.81	08/10/92	117.89	1147.11
08/02/90	122.58	1142.42	09/08/92	117.22	1147.78
08/29/90	121.09	1143.91	10/14/92	116.69	1148.31
10/22/90	118.25	1146.75	11/09/92	115.65	1149.35
11/19/90	117.44	1147.56	12/11/92	115.80	1149.20
12/17/90	116.13	1148.87			
04/18/91	116.91	1148.09	04/12/93	115.54	1149.46
05/16/91	116.06	1148.94	05/10/93	115.49	1149.51
06/11/91	116.79	1148.21	06/14/93	115.52	1149.48
07/10/91	120.83	1144.17	07/08/93	115.32	1149.68
08/07/91	119.20	1145.80	08/09/93	115.09	1149.91
09/18/91	118.34	1146.66	09/07/93	117.49	1147.51
10/21/91	122.09	1142.91	10/05/93	115.98	1149.02
11/26/91	118.12	1146.88	10/12/93	116.26	1148.74
12/19/91	117.63	1147.37	10/19/93	115.87	1149.13
			10/25/93	115.26	1149.74
04/07/92	115.93	1149.07	11/03/93	114.84	1150.16

132-056-36AAA

GWN Aquifer

LS Elev (msl, ft)=1245

SI (ft.)=163-168

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/30/90	100.30	1144.70	04/07/92	96.97	1148.03
05/08/90	101.73	1143.27	05/11/92	97.63	1147.37
06/14/90	104.04	1140.96	06/09/92	97.65	1147.35
07/05/90	103.13	1141.87	07/07/92	97.43	1147.57
08/02/90	103.45	1141.55	08/10/92	99.22	1145.78
08/29/90	102.17	1142.83	09/08/92	98.14	1146.86
10/22/90	99.30	1145.70	10/14/92	97.87	1147.13
11/19/90	98.65	1146.35	11/09/92	96.73	1148.27
12/17/90	97.43	1147.57	12/11/92	96.51	1148.49
04/18/91	97.79	1147.21	04/12/93	96.72	1148.28
05/16/91	97.23	1147.77	05/10/93	96.60	1148.40
06/11/91	98.01	1146.99	06/14/93	96.66	1148.34
07/10/91	101.40	1143.60	07/08/93	96.44	1148.56
08/07/91	100.05	1144.95	08/09/93	96.56	1148.44
09/18/91	99.48	1145.52	09/07/93	98.73	1146.27
10/21/91	102.30	1142.70	10/05/93	97.78	1147.22
11/26/91	97.10	1147.90	10/19/93	97.09	1147.91
12/19/91	98.47	1146.53	10/25/93	96.58	1148.42
			11/03/93	96.39	1148.61

132-056-36BBB
GWN Aquifer

LS Elev (msl, ft)=1268
SI (ft.)=173-178

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
03/30/90	122.08	1145.92	05/11/92	119.36	1148.64
05/08/90	123.71	1144.29	06/09/92	119.42	1148.58
06/14/90	125.96	1142.04	07/07/92	119.33	1148.67
07/05/90	125.13	1142.87	08/10/92	120.96	1147.04
08/02/90	125.39	1142.61	09/08/92	119.77	1148.23
08/29/90	123.93	1144.07	10/14/92	119.96	1148.04
10/22/90	121.29	1146.71	11/09/92	118.64	1149.36
11/19/90	120.32	1147.68	12/11/92	118.19	1149.81
12/17/90	119.07	1148.93			
04/18/91	119.91	1148.09	04/12/93	117.68	1150.32
05/16/91	118.93	1149.07	05/10/93	118.39	1149.61
06/11/91	119.89	1148.11	06/14/93	118.54	1149.46
07/10/91	123.57	1144.43	07/08/93	118.37	1149.63
08/07/91	122.85	1145.15	08/09/93	118.38	1149.62
09/18/91	121.30	1146.70	09/07/93	120.74	1147.26
10/21/91	124.46	1143.54	10/05/93	118.85	1149.15
11/26/91	120.68	1147.32	10/12/93	119.43	1148.57
12/19/91	120.34	1147.66	10/19/93	118.73	1149.27
			10/25/93	118.18	1149.82
			11/03/93	118.27	1149.73
04/07/92	118.76	1149.24			

APPENDIX G

NDSWC AND NDGS MAJOR ION AND
TRACE-ELEMENT CONCENTRATIONS

Dakota Landfill Regional Water Quality Major Ions

Location	Screened Interval (ft)	Date Sampled	(milligrams per liter)																	Spec Cond (µmho)	Temp (°C)	pH		
			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
132-056-02CCC1	221-226	10/05/93	28	0.07	0.31	94	30	260	15	581	0	460	15	0.3	6.6	0.87	1200	360	0	60	6	1660	9	7.1
132-056-02DCC1	163-168	10/05/93	23	0.1	0.21	88	26	220	15	485	0	440	22	0.5	6.6	0.87	1080	330	0	58	5.3	1520	9	6.6
132-056-02DCC2	45-50	10/05/93	27	0.09	1.3	210	69	50	9.4	470	0	510	11	0.3	2.9	0.27	1120	810	420	12	0.8	1450	10.8	6.31
132-056-03DCD	103-108	10/05/93	27	0.11	2.6	360	110	66	13	635	0	970	11	0.2	3.5	0.28	1880	1400	830	10	0.8	2160	9.4	6.43
132-056-04CCC	163-168	10/06/93	28	0.02	0.68	160	43	53	11	484	0	320	8.2	0.2	5.3	0.34	868	580	180	16	1	1180	8.5	6.6
132-056-09ADD1	305-310	10/05/93	22	0.07	0.16	57	17	560	17	625	0	160	580	0.8	8.4	2.7	1730	210	0	84	17	1770	7.9	7.37
132-056-09ADD2	163-168	10/05/93	28	0.07	0.28	42	13	390	12	617	5	490	31	0.6	7.1	1.8	1320	160	0	83	13	1820	11.8	7.11
132-056-10BBA2	60-65	10/05/93	27	0.6	3.1	410	120	84	15	625	0	1200	23	0.2	2.3	0.45	2190	1500	1000	11	0.9	2480	9.3	10.47
132-056-10CCC2	155-160	10/06/93	28	0.05	0.79	130	40	150	14	618	0	350	5.8	0.2	7.9	0.62	1030	490	0	39	2.9	1410	8.8	6.55
132-056-11CBB2	25-30	10/05/93	26	0.09	2.3	290	110	160	15	482	0	1100	28	0.2	5.7	0.34	1970	1200	780	23	20	2260	9.8	6.31
132-056-11CCC2	42-47	10/05/93	28	0.14	0.83	150	44	13	4.3	501	0	160	5.5	0.2	0.8	0.13	654	560	150	5	0.2	960	12.3	6.37
132-056-11DBB	127-132	10/05/93	25	0.09	0.11	72	24	260	17	639	0	380	8.5	0.4	7.1	0.85	1110	280	0	659	6.8	1500	10.6	7.09
132-056-11DCC	135-140	10/05/93	25	0.25	0.22	47	13	410	13	686	0	470	64	0.6	5.9	1.8	1388	170		83	14	2200	9.2	6.68
132-056-14CCC	118-123	10/05/93	25	0.34	0.45	81	23	310	14	580	0	400	95	0.4	6.4	1.3	1240	300	0	68	7.8	1800	13.5	6.7
132-056-15CCD2	55-60	10/06/93	28	0.01	0.51	98	30	4	3.4	375	0	64	4	0.1	0.1	0.05	417	370	61	2	0.1	650	9	6.46
132-056-16BAA	149-154	10/06/93	27	0.02	0.67	220	59	29	11	567	0	330	6.3	0.2	3.9	0.22	966	790	330	7	0.5	1330	10.2	6.48

Dakota Landfill Regional Water Quality
Trace Element Analyses

Location	Date Sampled	Selenium	Lead	Cadmium	Mercury (micrograms per liter)	Arsenic	Molybdenum	Strontium
132-056-02CCC1	10/05/93	0	0	0	0	52	6	630
132-056-02DCC1	10/05/93	0	2	0	0	12	11	650
132-056-02DCC2	10/05/93	0	0	0	0	22	2	1100
132-056-03DCD	10/05/93	0	0	0	0	11	0	1700
132-056-04CCC	10/06/93	0	0	0	0	26	2	830
132-056-09ADD1	10/05/93	0	0	0	0	18	17	500
132-056-09ADD2	10/05/93	0	0	0	0	10	15	370
132-056-10BBA2	10/05/93	0	0	0	0	8	3	1900
132-056-10CCCC2	10/06/93	0	0	0	0	20	1	860
132-056-11CBB2	10/05/93	0	0	0	0	12	3	1400
132-056-11CCC2	10/05/93	0	0	0	0	14	1	490
132-056-11DBB	10/05/93	0	0	0	0	44	9	820
132-056-11DCC	10/05/93	0	1	0	0	35	18	400
132-056-14CCC	10/05/93	0	0	0	0	39	15	580
132-056-15CCD2	10/06/93	0	0	0	1	4	0	270
132-056-16BAA	10/06/93	0	0	0	0	34	1	1100

Dakota Landfill Water Quality
Major Ions

Location	Screened Interval (ft)	Date Sampled	(milligrams per liter)															Spec						
			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	Cond (µmho)	Temp (°C)	pH
132-056-10BBC1	119.5-139.5	04/28/93	24	0.01	0.02	120	38	10	5.3	402	0	65	6.2	0.5	97	0.09	564	460	130	5	0.2	842	9	7.71
132-056-10BBC2	44-64	04/28/93	8.3	0.02	0	100	0	120	15	0	36	240	14	0.1	8.1	0.25	613	250	0	49	3.3	1262	9	12.61
132-056-10BCCC	49-59	04/22/93	26	13	1.1	580	300	48	15	622	0	2000	7.1	0.1	0.7	0.22	3300	2700	2200	4	0.4	3000	8.8	6.95
132-056-10BCCD	64.8-74.8	04/21/93	26	12	2	320	92	29	13	755	0	600	6.7	0.2	0.4	0.22	1470	1200	560	5	0.4	1805	8.6	7.14
132-056-10BCD	28.3-38.3	04/22/93	24	0.02	0.05	120	44	16	7.3	331	0	230	4.7	0.2	1.2	0.05	611	480	210	7	0.3	1483	7.5	7.85
132-056-10BDD	71-76	04/21/93	27	2.7	0.65	290	90	20	9.8	670	0	550	3.4	0.2	0.8	0.18	1320	1100	550	4	0.3	1680	8	6.81
132-056-10CAAA1	63-68	04/20/93	25	0.15	2	340	100	31	9.3	796	0	680	8.1	0.2	1.1	0.21	1590	1300	608	5	0.4	1912	9.4	6.83
132-056-10CAAD	70-80	04/21/93	28	2.2	0.35	240	82	140	18	789	0	600	5.1	0.1	7.4	0.69	1510	940	290	24	2	1820	8	7.5
132-056-10CAC2	100-135	04/21/93	33	1.4	1.4	190	52	48	10	617	0	300	4.1	0.2	0.2	0.25	945	690	180	13	0.8	1497	9	7.25
132-056-10CBAC	48-58	04/28/93	28	1.2	0.54	150	34	14	17	557	0	96	3	0.2	0.8	0.08	619	520	58	5	0.3	955	9.7	7.2
132-056-10CBAD	12-22	04/28/93	27	0.01	0.09	160	52	3	4.2	474	0	190	10	0.2	19	0.03	699	610	220	1	0.1	1005	8.3	8.25
132-056-10CBB	54-64	04/22/93	29	0.98	0.14	120	36	6.5	4.7	529	0	49	2.5	0.2	0	0.08	510	450	14	3	0.1	858	8.7	7.2
132-056-10CBC1	8.5-18.5	04/28/93	18	0.11	0.71	120	34	16	7	518	0	57	3.4	0.2	2.6	0.15	514	440	15	7	0.3	11	7.7	7.21
132-056-10CBC2	49.75-59.75	04/27/93	26	0.04	0.01	110	40	2.5	5.8	452	0	75	11	0.2	4.7	0.06	498	440	69	1	0.1	1199	9	7.25
132-056-10CCCB	47-57	04/22/93	25	0.08	4.2	580	210	100	21	635	0	1800	37	0.2	4.1	0.3	3090	2300	1800	9	0.9	2900	8	6.99
132-056-10CDA	65.8-75.8	04/22/93	21	0.05	1.8	440	130	64	16	761	0	990	14	0.1	240	0.31	2290	1600	1000	8	0.7	2670	9	6.67
132-056-10CDC	63.8-73.8	04/22/93	24	0.02	0.5	130	36	8.5	4.5	487	0	130	3	0.2	0	0.09	577	470	74	4	0.2	884	8	7
132-056-10CDD1	64.1-74.1	04/22/93	25	0.24	2.7	460	140	56	14	758	0	1300	6.3	0.1	0.8	0.26	2380	1700	1100	7	0.6	2830	7.7	6.57
132-056-14CDA1	153-156	10/26/89	26	0.22	0.42	93	27	360	15	567	0	630	23	0.3	0.5	1.2	1460	340	0	68	8.5	2100	10	

Dakota Landfill Water Quality
Trace Element Analyses

Location	Date Sampled	Selenium	Lead	Cadmium	Mercury (micrograms per liter)	Arsenic	Molybdenum	Strontium
132-056-10BBC1	10/05/93	5	0	-	0	1	4	420
132-056-10BBC2	10/05/93	0	0	0	0	1	17	370
132-056-10BCCC	10/05/93	1	0	0	0	70	5	2000
132-056-10BCCD	04/22/93	1	0	0	0	45	2	1300
132-056-10BCD	10/05/93	1	0	0	0	32	2	1400
132-056-10BDD	10/06/93	4	3	0	0	2	3	630
132-056-10CAAA1	10/05/93	1	0	0	0	0	0	1300
132-056-10CAAD	10/05/93	0	0	0	0	86	3	1400
132-056-10CAC2	10/05/93	0	0	0	0	10	0	990
132-056-10CBAC	10/06/93	0	0	-	0	28	2	570
132-056-10CBAD	10/05/93	0	0	-	0	1	1	250
132-056-10CBB	10/05/93	0	0	0	0	16	7	670
132-056-10CBC1	10/05/93	0	0	-	0	1	8	580
132-056-10CBC2	10/05/93	1	1	-	0	0	2	190
132-056-10CCCB	10/05/93	1	0	0	0	0	1	2500
132-056-10CDA	10/06/93	7	0	0	0	0	1	1900
132-056-10CDC	04/22/93	0	0	0	0	1	0	530
132-056-10CDD1	10/06/93	1	0	0	0	5	0	2100

Gwinner Aquifer Water Quality
Major Ions

Location	Screened Interval (ft)	Date Sampled	(milligrams per liter)														Spec						
			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	Cond (µmho)	Temp (°C)
132-055-31BCC	158-163	10/25/89	25	0.03	0.47	100	28	410	16	513	0	740	34	0.4	1	1.1	1610	360	0	70	9.4	2300	11
132-055-31CCCB	173-178	10/25/89	27	0.04	0.38	100	27	330	15	536	0	680	28	0.3	1	1.2	1470	360	0	65	7.6	2180	10
132-056-14CDA1	153-156	10/26/89	26	0.22	0.42	93	27	360	15	567	0	630	23	0.3	0.5	1.2	1460	340	0	68	8.5	2100	10
132-056-22DDA	111-116	10/26/89	24	0.18	0.77	230	60	250	15	483	0	1000	36	0.2	1	0.92	1860	820	430	39	3.8	2450	11
132-056-23CAD	118-123	10/26/89	26	0.05	0.57	160	45	230	17	442	0	700	33	0.2	1.9	0.78	1430	580	220	45	4.2	2040	10
132-056-24BCC	168-173	10/26/89	27	0.03	0.52	100	26	320	15	561	0	660	25	0.3	0.4	1.2	1450	360	0	65	7.3	2050	10
132-056-24CCCB	173-178	10/26/89	28	0.04	0.46	100	28	360	15	559	0	630	24	0.3	0.3	1.2	1460	360	0	67	8.2	2080	10
132-056-25DAA	157-162	10/25/89	26	0.08	0.79	190	50	340	16	442	0	990	59	0.3	0.2	1	1890	680	320	51	5.7	2650	10
132-056-26DAD	170-173	09/13/77	26	0.49	0.84	150	43	310	13	506	0	750	43	0.1	1	1	1590	550	140	54	5.7	2200	8 7.9
132-056-26DAD	170-173	08/11/83	28	0	0.74	160	46	280	17	435	0	730	43	0.2	1	0.66	1520	590	230	50	5	2260	10 7.8
132-056-36AAA	163-168	10/25/89	26	0.03	0.54	100	28	380	15	496	0	680	49	0.3	1	1.2	1530	360	0	68	8.7	2240	11
132-056-36BBB	173-178	10/25/89	29	0.12	0.76	210	57	260	18	477	0	920	24	0.2	0.2	1	1760	760	370	42	4.1	2350	11

APPENDIX H

MAJOR ION AND TRACE-ELEMENT
CONCENTRATIONS FROM PREVIOUS STUDIES

FOTH AND VAN DYKE
WATER QUALITY RESULTS
APRIL 14, 1993

TABLE 1

FIELD PARAMETERS	Quant. Limit	Method Reference	Analysis Date	WSI-4	MW-15	MW-26	MW-23	DL-MW-5
				AN-1537 3456 3/10/93	AN-1537 3456 3/10/93	AN-1539 3456 3/11/93	AN-1537 3456 3/9/93	AN-1537 3456 3/10/93
pH	.01	150.1	03/12/93	6.76	7.27	7.07	7.22	7.26
Specific Conductance (umhos)	2	120.1	03/17/93	2000	820	2400	800	780

TABLE 1

FIELD PARAMETERS	Quant. Limit	Method Reference	Analysis Date	DL-MW-3	MW-20	MW-21	MW-33	MW-35
				AN-1537	AN-1539	AN-1539	AN-1539	AN-1539
				3456	3456	3456	3456	3456
				3/9/93	3/9/93	3/11/93	3/11/93	3/11/93
pH	.01	150.1	3/12/93	6.91	7.55	7.38	7.18	7.25
Specific Conductance (umhos)	2	120.1	3/17/93	2200	720	3400	810	1900

TABLE 1

FIELD PARAMETERS	Quant. Limit	Method Reference	Analysis Date	MW-18	DL MW-4	MW-12	WSI-5
				AN-1537	AN-1537	AN-1537	AN-1537
				3456	3456	3456	3456
				3/9/93	3/9/93	3/10/93	3/10/93
pH	.01	150.1	3/12/93	6.98	6.73	7.01	6.91
Specific Conductance (umhos)	2	120.1	3/17/93	1800	3500	3300	1800

TABLE 1

FIELD PARAMETERS =====	Quant. Limit =====	Method Reference =====	Analysis Date =====	MW-17	MW-16A	WSI-6
				AN-1539 3456 3/11/93 =====	AN-1539 3456 3/11/93 =====	AN-1537 3456 3/10/93 =====
pH	.01	150.1	3/12/93	7.24	7.17	7.17
Specific Conductance (umhos)	2	120.1	3/17/93	1200	1100	2000

TABLE 2

GEOCHEMICAL PARAMETERS =====	Quant. Limit =====	Method Reference =====	Analysis Date =====	WSI-4	MW-15	MW-26	MW-23	DL-MW-5
				AN-1537 3456 3/10/93	AN-1537 3456 3/10/93	AN-1539 3456 3/11/93	AN-1537 3456 3/9/93	AN-1537 3456 3/10/93
Ammonia Nitrogen (mg/L as N)	0.020	350.1	4/5/93	ND	2.0	0.14	0.58	0.40
Total Hardness (mg/L CaCO3)	1.0	130.2	3/22-24/93	1400	590	1700	810	500
Iron (mg/L)	0.020	200.7/6010	3/25-30/93	4.06	10.2	38.8	22.7	4.01
Calcium (mg/L)	0.10	200.7/6010	3/30/93	373	158	484	214	138
Magnesium (mg/L)	0.20	200.7/6010	3/25-30/93	117	48.7	146	70.1	39.4
Manganese (mg/L)	0.015	200.7/6010	3/25/93	2.09	0.490	2.58	1.18	0.157
Potassium (mg/L)	0.10	258.1/7610	3/31/93	11.2	9.38	19.5	11.0	6.15
Sodium (mg/L)	0.50	200.7/6010	3/25-30/93	33.5	10.7	69.0	19.0	5.59
Bicarbonate Alkalinity = Total Alkalinity (mg/L CaCO3)	5.0	SM 403	03/16/93	647	525	840	624	446
Carbonate Alkalinity	5.0	SM 403	03/16/93	<5.0	<5.0	<5.0	<5.0	<5.0
Chloride (mg/L)	0.60	300.0	3/17/93	5.6	8.0	8.3	2.0	13
Fluoride (mg/L)	0.10	340.2	3/24/93	0.22	0.24	0.17	0.25	0.29
Nitrate/Nitrite (mg/L as N)	0.050	353.2	3/25/93	0.22	<0.050	38	<0.050	<0.050
Total Phosphorus (mg/L)	0.10	365.4	3/23/93	0.15	0.44	1.5	1.8	<0.10
Sulfate (mg/L)	1.8	300.0	3/17-18/93	610	23	870	62	31
Total Dissolved Solids (mg/L)	10	160.1	3/16/93	1770	520	3170	510	442
Total Suspended Solids (mg/L)	5	160.2	3/16/93	190	725	1510	875	71
Cation Sum (meq/L)	--	SM 104C	--	30.3	13.3	41.9	18.9	10.8
Anion Sum (meq/L)	--	SM 104C	--	25.8	11.2	35.9	13.8	9.9

TABLE 2 revision, 4/8/93, Ammonia and cation sum

(page 1 of 4)

TABLE 2

GEOCHEMICAL PARAMETERS	Quant. Limit	Method Reference	Analysis Date	DL-MW-3	MW-20	MW-21	MW-33	MW-35
				AN-1537	AN-1539	AN-1539	AN-1539	AN-1539
				3456	3456	3456	3456	3456
				3/9/93	3/9/93	3/11/93	3/11/93	3/11/93
Ammonia Nitrogen (mg/L as N)	0.020	350.1	4/5/93	1.5	0.059	0.63	0.056	0.71
Total Hardness (mg/L CaCO3)	1.0	130.2	3/22-24/93	1690	1250	2330	460	2040
Iron (mg/L)	0.020	200.7/6010	3/25-30/93	15.2	93.5	42.9	1.97	35.1
Calcium (mg/L)	0.10	200.7/6010	3/30/93	468	287	522	126	604
Magnesium (mg/L)	0.20	200.7/6010	3/25-30/93	137	96.8	218	34.8	182
Manganese (mg/L)	0.015	200.7/6010	3/25-30/93	0.501	2.62	7.58	0.724	4.34
Potassium (mg/L)	0.10	200.7/6010	3/31/93	12.7	20.0	25.8	6.67	19.3
Sodium (mg/L)	0.50	200.7/6010	3/25-30/93	25.1	2.11	108	7.47	68.0
Bicarbonate Alkalinity =								
Total Alkalinity (mg/L CaCO3)	5.0	SM 403	03/16/93	487	510	635	456	700
Carbonate Alkalinity	5.0	SM 403	03/16/93	<5.0	<5.0	<5.0	<5.0	<5.0
Chloride (mg/L)	0.60	300.0	3/17/93	4.2	8.5	31	1.5	3.3
Fluoride (mg/L)	0.10	340.2	3/24/93	0.19	0.32	0.19	0.23	0.22
Nitrate/Nitrite (mg/L as N)	0.050	353.2	3/25/93	<0.050	0.62	1.6	0.18	0.27
Total Phosphorus (mg/L)	0.10	365.4	3/23/93	0.31	1.3	3.7	0.25	4.6
Sulfate (mg/L)	1.8	300.0	3/17-18/93	1100	47	1800	72	690
Total Dissolved Solids (mg/L)	10	160.1	3/16/93	2220	440	3420	526	2440
Total Suspended Solids (mg/L)	5	160.2	3/16/93	525	1790	445	230	1260
Cation Sum (meq/L)	--	SM 104C	--	37.0	28.1	52.2	9.8	50.8
Anion Sum (meq/L)	--	SM 104C	--	32.8	11.4	51.1	10.7	28.5

TABLE 2

GEOCHEMICAL PARAMETERS	Quant. Limit	Method Reference	Analysis Date	MW-18	DL MW-4	MW-12	WSI-5
				AN-1537 3456 3/9/93	AN-1537 3456 3/9/93	AN-1537 3456 3/10/93	AN-1537 3456 3/10/93
Ammonia Nitrogen (mg/L as N)	0.020	350.1	4/5/93	1.2	1.5	0.97	0.89
Total Hardness (mg/L CaCO ₃)	1.0	130.2	3/22-24/93	1500	2690	2230	1190
Iron (mg/L)	0.020	200.7/6010	3/25-30/93	54.0	17.4	22.4	8.44
Calcium (mg/L)	0.10	200.7/6010	3/30/93	405	486	554	317
Magnesium (mg/L)	0.20	200.7/6010	3/25-30/93	124	300	196	100
Manganese (mg/L)	0.015	200.7/6010	3/25/93	4.75	1.03	1.52	0.838
Potassium (mg/L)	0.10	200.7/6010	3/31/93	19.3	31.3	22.7	11.1
Sodium (mg/L)	0.50	200.7/6010	3/25-30/93	28.8	42.5	121	19.0
Bicarbonate Alkalinity =							
Total Alkalinity (mg/L CaCO ₃)	5.0	SM 403	3/16/93	953	514	564	572
Carbonate Alkalinity	5.0	SM 403	3/16/93	<5.0	<5.0	<5.0	<5.0
Chloride (mg/L)	0.60	300.0	3/17/93	5.4	6.2	36	29
Fluoride (mg/L)	0.10	340.2	3/24/93	0.24	0.13	0.15	0.18
Nitrate/Nitrite (mg/L as N)	0.050	353.2	3/25/93	<0.050	<0.050	<0.050	0.050
Total Phosphorus (mg/L)	0.10	365.4	3/23/93	2.4	0.20	0.55	0.27
Sulfate (mg/L)	1.8	300.0	3/17-18/93	530	2100	1700	570
Total Dissolved Solids (mg/L)	10	160.1	3/16/93	1480	3720	3260	1460
Total Suspended Solids (mg/L)	5	160.2	3/16/93	1440	242	648	316
Cation Sum (meq/L)	--	SM 104C	--	35.5	52.7	51.0	25.7
Anion Sum (meq/L)	--	SM 104C	--	30.2	54.2	47.7	24.1

TABLE 2

GEOCHEMICAL PARAMETERS =====	Quant. Limit =====	Method Reference =====	Analysis Date =====	MW-17	MW-16A	WSI-6
				AN-1539 3456 3/11/93	AN-1539 3456 3/11/93	AN-1537 3456 3/10/93
Ammonia Nitrogen (mg/L as N)	0.020	350.1	4/5/93	ND	ND	1.2
Total Hardness (mg/L CaCO3)	1.0	130.2	3/22-24/93	675	690	930
Iron (mg/L)	0.020	200.7/6010	3/25/93	1.24	2.70	2.03
Calcium (mg/L)	0.10	200.7/6010	3/30/93	184	192	242
Magnesium (mg/L)	0.20	200.7/6010	3/30/93	60.0	62.5	84.3
Manganese (mg/L)	0.015	200.7/6010	3/25/93	0.175	0.156	0.335
Potassium (mg/L)	0.10	258.1/7610	3/31/93	5.34	5.63	17.4
Sodium (mg/L)	0.50	200.7/6010	3/25-30/93	3.01	3.17	147
Bicarbonate Alkalinity =						
Total Alkalinity (mg/L CaCO3)	5.0	SM 403	3/16/93	423	426	632
Carbonate Alkalinity	5.0	SM 403	3/16/93	<5.0	<5.0	<5.0
Chloride (mg/L)	0.60	300.0	3/17/93	14	12	3.5
Fluoride (mg/L)	0.10	340.2	3/24/93	0.18	0.18	0.16
Nitrate/Nitrite (mg/L as N)	0.050	353.2	3/25/93	5.1	5.4	<0.050
Total Phosphorus (mg/L)	0.10	365.4	3/23/93	<0.10	0.12	<0.10
Sulfate (mg/L)	1.8	300.0	3/17-18/93	200	200	580
Total Dissolved Solids (mg/L)	10	160.1	3/16/93	760	704	1500
Total Suspended Solids (mg/L)	5	160.2	3/16/93	260	77	10
Cation Sum (meq/L)	--	SM 104C	--	14.5	15.2	26.0
Anion Sum (meq/L)	--	SM 104C	--	13.1	13.0	24.8

TABLE 3

TOC, COD	Quant. Limit	Method Reference	Analysis Date	WSI-4	MW-15	MW-26	MW-23	DL-MW-5
				AN-1537 3456 3/10/93	AN-1537 3456 3/10/93	AN-1539 3456 3/11/93	AN-1537 3456 3/9/93	AN-1537 3456 3/10/93
Total Organic Carbon (mg/L)	0.50	415.1	3/24/93	7.78	3.83	6.36	2.87	2.84
Chemical Oxygen Demand (mg/L)	20	410.4	3/15-16/93	60	69	232	223	<20

TABLE 3

TOC, COD	Quant. Limit	Method Reference	Analysis Date	DL-MW-3	MW-20	MW-21	MW-33	MW-35
				AN-1537 3456 3/9/93	AN-1539 3456 3/9/93	AN-1539 3456 3/11/93	AN-1539 3456 3/11/93	AN-1539 3456 3/11/93
Total Organic Carbon (mg/L)	0.50	415.1	3/24/93	4.19	1.90	4.9	1.79	7.05
Chemical Oxygen Demand (mg/L)	20	410.4	3/15-16/93	188	114	1160	188	402

TABLE 3

TOC, COD =====	Quant. Limit =====	Method Reference =====	Analysis Date =====	MW-18	DL MW-4	MW-12	WSI-5
				AN-1537	AN-1537	AN-1537	AN-1537
				3456	3456	3456	3456
				3/9/93	3/9/93	3/10/93	3/10/93
Total Organic Carbon (mg/L)	0.50	415.1	3/24/93	4.52	11.2	7.74	3.54
Chemical Oxygen Demand (mg/L)	20	410.4	3/15-16/93	305	123	89	53

TABLE 3

	Quant. Limit	Method Reference	Analysis Date	MW-17 AN-1539 3456 3/11/93	MW-16A AN-1539 3456 3/11/93	WSI-6 AN-1537 3456 3/10/93
TOC, COD						
===== Total Organic Carbon (mg/L)	0.50	415.1	3/24/93	1.58	1.62	3.30
Chemical Oxygen Demand (mg/L)	20	410.4	3/15-16/93	22	31	24

FOTH AND VAN DYKE
WATER QUALITY RESULTS
AUGUST 25, 1993

FIELD PARAMETERS	Quant Limit	Method Reference	Analysis Date	WSI-4 06/22/93	MW-15 06/21/93	MW-26 06/21/93	MW-23 06/23/93	DLMW-5 06/22/93
pH	0.01	150.1	6-24-93	6.74	7.31	6.98	7.14	7.57
Specific Conductance (umhos)	2.0	120.1	6-24-93	1940	891	2050	917	826

FIELD PARAMETERS	Quant Limit	Method Reference	Analysis Date	DLMW-3 06/23/93	MW-20 06/23/93	MW-21 06/21/93	MW-33 06/21/93	MW-35 06/21/93
pH	0.01	150.1	6/24/93	6.83	7.50	6.92	7.02	6.69
Specific Conductance (umhos)	2.0	120.1	6/24/93	2420	809	3420	850	2850



FIELD PARAMETERS	Quant Limit	Method Reference	Analysis Date	MW-18 06/22/93	DL-MW-4 06/22/93	MW-12 06/22/93	WSI-5 06/22/93	MW-19A 06/22/93
pH	0.01	150.1	6/24/93	6.77	6.69	6.93	6.83	7.15
Specific Conductance (umhos)	2.0	120.1	6/24/93	1930	3570	3350	1740	1070

DUY INCORP

FIELD PARAMETERS	Quant Limit	Method Reference	Analysis Date	MW-17 06/22/93	DUP-1 06/22/93	WSI-6 06/22/93	FB-1 06/22/93
pH	0.01	150.1	6/24/93	7.08	7.05	7.03	-
Specific Conductance (umhos)	2.0	120.1	6/24/93	1160	1140	2080	-

GEOCHEMICAL PARAMETERS	Quant Limit	Method Reference	Analysis Date	WSI-4 06/22/93	MW-15 06/21/93	MW-26 06/21/93	MW-23 06/23/93	DL-MW-5 06/22/93
Ammonia Nitrogen (mg/L as N)	0.020	350.1	7/6/93	0.031	0.58	0.13	0.59	0.48
Total Hardness (mg/L as CaCO ₃)	2.0	130.2	6/26/93	1205	720	5400	680	495
Iron (mg/L)	0.020	200.7/6010	7/2/93	0.076	<0.020	0.127	0.160	0.058
Calcium (mg/L)	0.10	200.7/6010	7/14/93	317	124	221	139	114
Magnesium (mg/L)	.20	200.7/6010	7/2 & 14/93	95.5	38.6	64.3	33.7	33.8
Manganese (mg/L)	0.015	200.7/6010	7/2/93	1.79	0.163	0.921	0.476	0.065
Potassium (mg/L)	0.065	258.1/7610	7/15/93	9.28	7.33	7.88	7.43	5.94
Sodium (mg/L)	0.40	200.7/6010	7/2 & 14/93	22.9	11.5	31.2	17.1	6.05
Bicarbonate Alkalinity = Total Alkalinity (mg/L CaCO ₃)	5.0	StdM403	7/6/93	630	510	990	470	420
Carbonate Alkalinity	5.0	StdM403	7/6/93	<5.0	<5.0	<5.0	<5.0	<5.0
Chloride (mg/L)	0.11	300.0	6/29-7/8/93	6.3	0.95	6.4	1.6	0.73
Fluoride (mg/L)	0.10	340.2	7/13/93	0.18	0.24	0.20	0.19	0.22
Nitrate/Nitrite (mg/L as N)	0.050	353.2	6/29/93	0.15	<0.050	22	<0.050	<0.050
Total Phosphorus (mg/L)	0.10	365.4	7/8/93	<0.10	0.54	0.92	0.46	<0.10
Sulfate (mg/L)	0.34	300.0	6/30/93	580	20	740	82	31
Total Dissolved Solids (mg/L)	10	160.1	6/28/93	1460	488	1600	587	431
Total Suspended Solids (mg/L)	5	160.2	6/28/93	63	255	8780	542	64
Cation Sum (meq/L)		StdM104C		25.05	10.10	17.96	10.72	8.92
Anion Sum (meq/L)		StdM104C		24.86	10.64	35.86	11.15	9.07

CITY OF BOSTON

GEOCHEMICAL PARAMETERS	Quant Limit	Method Reference	Analysis Date	DLMW-3 06/23/93	MW-20 06/23/93	MW-21 06/21/93	MW-33 06/21/93	MW-35 06/21/93
Ammonia Nitrogen (mg/L as N)	0.020	350.1	7/6/93	1.3	0.19	0.16	0.24	1.2
Total Hardness (mg/L as CaCO ₃)	2.0	130.2	6/25/93	1610	830	2840	1380	2190
Iron (mg/L)	0.020	200.7/6010	7/2/93	2.98	0.090	0.260	0.056	0.123
Calcium (mg/L)	0.10	200.7/6010	7/14/93	435	85.5	560	67.5	512
Magnesium (mg/L)	0.20	200.7/6010	7/2 & 14/93	131	28.2	204	19.5	142
Manganese (mg/L)	0.015	200.7/6010	7/2/93	0.241	<0.015	2.30	0.250	2.40
Potassium (mg/L)	0.065	258.1/7610	7/15/93	10.4	2.44	18.1	3.06	14.5
Sodium (mg/L)	0.40	200.7/6010	7/2 & 14/93	24.8	1.18	89.0	4.80	54.5
Bicarbonate Alkalinity = Total Alkalinity (mg/L CaCO ₃)	5.0	StdM403	7/6/93	465	555	535	595	610
Carbonate Alkalinity	5.0	StdM403	7/6/93	<5.0	<5.0	<5.0	<5.0	<5.0
Chloride (mg/L)	0.11	300.0	6/30 & 7/8/93	4.8	7.6	320	0.93	4.3
Fluoride (mg/L)	0.10	340.2	7/13/93	0.18	0.24	0.19	0.25	<0.14 ¹
Nitrate/Nitrite (mg/L as N)	0.050	353.2	6/26/93	<0.050	0.29	0.37	<0.050	<0.050
Total Phosphorus (mg/L)	0.10	365.4	7/8/93	0.13	1.2	2.5	3.4	1.1
Sulfate (mg/L)	0.34	300.0	6/30 & 7/8/93	1100	77	1700	79	1400
Total Dissolved Solids (mg/L)	10	160.1	6/28/93	2150	653	3290	518	2580
Total Suspended Solids (mg/L)	5	160.2	6/28/93	189	1760	680	3320	646
Cation Sum (meq/L)		StdM104C		34.08	6.72	49.26	5.29	40.22
Anion Sum (meq/L)		StdM104C		32.34	12.92	46.97	13.57	41.47

¹ Quantitation Limit = 0.14; raised due to limited sample volume

GEOCHEMICAL PARAMETERS	Quant Limit	Method Reference	Analysis Date	MW-18 06/22/93	DLMW-4 06/22/93	MW-12 06/22/93	WSI-5 06/22/93	MW-19A 06/22/93
Ammonia Nitrogen (mg/L as N)	0.020	350.1	7/6/93	0.83	1.3	1.8	0.87	0.036
Total Hardness (mg/L as CaCO ₃)	2.0	130.2	6/25/93	1390	2560	2130	1140	668
Iron (mg/L)	0.020	200.7/6010	7/2/93	1.26	5.22	.531	0.126	0.101
Calcium (mg/L)	0.10	200.7/6010	7/14/93	322	560	556	284	152
Magnesium (mg/L)	0.20	200.7/6010	7/2 & 14/93	99.5	300	170	90.9	49.0
Manganese (mg/L)	0.015	200.7/6010	7/2/93	1.45	0.901	0.979	0.495	0.034
Potassium (mg/L)	0.065	258.1/7610	7/15/93	12.9	15.0	18.7	10.5	5.45
Sodium (mg/L)	0.40	200.7/6010	7/2 & 14/93	26.0	42.3	122	18.0	9.17
Bicarbonate Alkalinity = Total Alkalinity (mg/L CaCO ₃)	5.0	StdM403	7/6/93	925	495	565	555	345
Carbonate Alkalinity	5.0	StdM403	7/6/93	<5.0	<5.0	<5.0	<5.0	<5.0
Chloride (mg/L)	0.11	300.0	6/30/93	4.5	5.2	8.3	1.5	3.8
Fluoride (mg/L)	0.10	340.2	7/13/93	0.22	<0.12 ¹	0.14	0.18	0.29
Nitrate/Nitrite (mg/L as N)	0.050	353.2	6/29/93	<0.050	<0.050	<0.050	<0.050	0.29
Total Phosphorus (mg/L)	0.10	365.4	7/8/93	0.63	0.13	0.18	0.18	<0.10
Sulfate (mg/L)	0.34	300.0	6/30/93	570	2100	1700	560	290
Total Dissolved Solids (mg/L)	10	160.1	6/28/93	1590	3560	3870	1440	776
Total Suspended Solids (mg/L)	5	160.2	6/28/93	2450	150	447	188	212
Cation Sum (meq/L)		StdM104C		25.94	55.27	47.72	22.79	12.16
Anion Sum (meq/L)		StdM104C		30.49	53.77	46.93	22.80	13.05

¹ Quantitation Limit = 0.12; raised due to limited sample volume

GEOCHEMICAL PARAMETERS	Quant Limit	Method Reference	Analysis Date	MW-17 06/22/93	DUP-1 06/22/93	WSI-6 06/22/93	FB-1 06/22/93
Ammonia Nitrogen (mg/L as N)	0.020	350.1	7/6/93	0.44	0.57	1.1	-
Total Hardness (mg/L as CaCO ₃)	2.0	130.2	6/26/93	760	780	1225	-
Iron (mg/L)	0.020	200.7/6010	7/2/93	0.028	<0.020	0.080	-
Calcium (mg/L)	0.10	200.7/6010	7/14/93	144	148	241	-
Magnesium (mg/L)	0.20	200.7/6010	7/2 & 14/93	32.1	31.0	82.1	-
Manganese (mg/L)	0.015	200.7/6010	7/2/93	0.441	0.428	0.343	-
Potassium (mg/L)	0.065	258.1/7610	7/15/93	33.2	34.5	16.1	-
Sodium (mg/L)	0.40	200.7/6010	7/2 & 14/93	32.8	33.2	154	-
Bicarbonate Alkalinity = Total Alkalinity (mg/L CaCO ₃)	5.0	StdM403	7/6/93	530	605	638	-
Carbonate Alkalinity	5.0	StdM403	7/6/93	<5.0	<5.0	<5.0	-
Chloride (mg/L)	0.11	300.0	6/30/93	0.70	0.79	4.2	-
Fluoride (mg/L)	0.10	340.2	7/13/93	0.23	0.25	0.14	-
Nitrate/Nitrite (mg/L as N)	0.050	353.2	6/29/93	0.11	0.10	<0.050	-
Total Phosphorus (mg/L)	0.10	365.4	7/8/93	1.1	1.1	1.0	-
Sulfate (mg/L)	0.34	300.0	6/30 & 7/8/93	120	120	600	-
Total Dissolved Solids (mg/L)	10	160.1	6/28/93	752	768	1550	-
Total Suspended Solids (mg/L)	5	160.2	6/28/93	390	1190	385	-
Cation Sum (meq/L)		StdM104C		12.16	12.33	25.98	-
Anion Sum (meq/L)		StdM104C		13.13	14.62	25.37	-

FOTH AND VAN DYKE
WATER QUALITY RESULTS
SEPTEMBER 21, 1993

FIELD PARAMETERS	Quant Limit	Method Reference	Analysis Date	MW-15 09/21/93	MW-33 09/21/93	MW-35 09/21/93	DL-MW-4 09/22/93	DL-MW-5 09/22/93
pH	0.01	150.1	9/23/93	7.28	7.04	6.71	6.71	7.15
Specific Conductance (umhos)	2.0	120.1	10/04/93	780	760	2900	3600	710

TOTAL ORGANIC CARBON CHEMICAL OXYGEN DEMAND	Quant Limit	Method Reference	Analysis Date	MW-15 09/21/93	MW-33 09/21/93	MW-35 09/21/93	DL-MW-4 09/22/93	DL-MW-5 09/22/93
TOC (mg/L)	0.3	415.1	10/5/93	6.0	3.1	11	7.0	30
COD (mg/L)	20	410.4	9/29/93	30	89	79	30	28

FIELD PARAMETERS	Quant Limit	Method Reference	Analysis Date	MW-17 09/22/93	MW-18 09/22/93	MW-19A 09/22/93	MW-21 09/20/93	MW-20 09/20/93
pH	0.01	150.1	9/23/93	6.98	6.80	7.17	6.95	7.50
Specific Conductance (umhos)	2.0	120.1	10/04/93	1100	1700	1200	3200	790

TOTAL ORGANIC CARBON CHEMICAL OXYGEN DEMAND	Quant Limit	Method Reference	Analysis Date	MW-17 09/22/93	MW-18 09/22/93	MW-19A 09/22/93	MW-21 09/20/93	MW-20 09/20/93
TOC (mg/L)	0.3	415.1	10/5/93	2.7	4.8	2.9	4.7	2.7
COD (mg/L)	20	410.4	9/29/93	86	91	59	127	46

FIELD PARAMETERS	Quant Limit	Method Reference	Analysis Date	MW-23 09/20/93	DL-MW-3 09/21/93	WSI-4 09/21/93	WSI-5 09/21/93	WSI-6 09/21/93
pH	0.01	150.1	9/23/93	7.14	6.88	6.66	6.79	7.10
Specific Conductance (umhos)	2.0	120.1	10/04/93	860	2200	2000	1800	2000

TOTAL ORGANIC CARBON CHEMICAL OXYGEN DEMAND	Quant Limit	Method Reference	Analysis Date	MW-23 09/20/93	DL-MW-3 09/21/93	WSI-4 09/21/93	WSI-5 09/21/93	WSI-6 09/21/93
TOC (mg/L)	0.3	415.1	10/5/93	3.1	5.3	11	4.6	3.5
COD (mg/L)	20	410.4	9/30-10/4/93	635	2280	<20	44	234

FIELD PARAMETERS	Quant Limit	Method Reference	Analysis Date	MW-12 09/21/93	MW-26 09/22/93	DUP-1 09/21/93	DUP-2 09/22/93
pH	0.01	150.1	9/23/93	6.90	6.87	7.25	7.16
Specific Conductance (umhos)	2.0	120.1	10/04/93	3300	3200	840	1200

TOTAL ORGANIC CARBON CHEMICAL OXYGEN DEMAND	Quant Limit	Method Reference	Analysis Date	MW-12 09/21/93	MW-26 09/22/93	DUP-1 09/21/93	DUP-2 09/22/93
TOC (mg/L)	0.3	415.1	10/5/93	8.4	7.9	5.4	3.7
COD (mg/L)	20	120.1	9/30/93	55	42	32	54

GEOCHEMICAL PARAMETERS	Quant Limit	Method Reference	Analysis Date	MW-15 09/21/93	MW-33 09/21/93	MW-35 09/21/93	DL-MW-4 09/22/93	DL-MW-5 09/22/93
Ammonia Nitrogen (mg/L as N)	0.010	350.1	10/2/93	0.47	0.15	0.89	1.1	0.61
Total Hardness (mg/L as CaCO ₃)	2.0	130.2	09/29-10/4/93	540	820	2280	2650	460
Iron (mg/L)	0.020	200.7/6010	10/8/93	1.42	0.029	1.05	14.2	0.029
Calcium (mg/L)	0.10	200.7/6010	10/8-13/93	122	118	494	538	43.3
Magnesium (mg/L)	.20	200.7/6010	10/8-13/93	39.0	33.4	134	290	18.7
Manganese (mg/L)	0.015	200.7/6010	10/8/93	0.132	0.457	2.33	0.958	<0.015
Potassium (mg/L)	0.065	258.1/7610	10/20/93	7.18	5.40	14.7	15.3	5.39
Sodium (mg/L)	0.40	200.7/6010	10/8-13/93	11.6	10.8	53.5	46.0	6.97
Bicarbonate Alkalinity = Total Alkalinity (mg/L CaCO ₃)	5.0	StdM403	9/29-31/93	750	530	872	508	408
Carbonate Alkalinity	5.0	StdM403	9/29-10/1/93	<5.0	<5.0	<5.0	<5.0	<5.0
Chloride (mg/L)	0.11	300.0	9/26/93	1.1	1.4	4.5	5.5	1.3
Fluoride (mg/L)	0.10	340.2	10/1/93	0.20	0.16	<0.10	<0.10	0.17
Nitrate/Nitrite (mg/L as N)	0.050	353.2	10/5/93	<0.050	<0.050	<0.050	<0.050	<0.050
Total Phosphorus (mg/L)	0.10	365.4	10/9/93	<0.10	0.94	1.3	<0.10	<0.10
Sulfate (mg/L)	0.34	300.0	9/26/93	20	75	1400	2000	31
Total Dissolved Solids (mg/L)	10	160.1	9/27-10/4/93	334	352	2250	3580	360
Total Suspended Solids (mg/L)	5	160.2	9/27-9/30/93	404	912	610	83	34
Cation Sum (meq/L)		StdM104C		10.10	9.29	38.66	54.00	4.18
Anion Sum (meq/L)		StdM104C		15.45	12.20	46.71	51.95	8.84

GEOCHEMICAL PARAMETERS	Quant Limit	Method Reference	Analysis Date	MW-17	MW-18	MW-19A	MW-21	MW-20
				09/22/93	09/22/93	09/22/93	09/20/93	09/20/93
Ammonia Nitrogen (mg/L as N)	0.010	350.1	10/2/93	0.34	0.58	0.060	0.12	0.025
Total Hardness (mg/L as CaCO ₃)	2.0	130.2	09/29-10/4/93	740	1310	790	2520	605
Iron (mg/L)	0.020	200.7/6010	10/8/93	1.45	12.1	0.023	0.058	0.029
Calcium (mg/L)	0.10	200.7/6010	10/13/93	156	274	158	514	112
Magnesium (mg/L)	0.20	200.7/6010	10/8-13/93	36.8	78.6	54.5	200	40.8
Manganese (mg/L)	0.015	200.7/6010	10/8/93	0.549	1.34	0.167	3.00	<0.015
Potassium (mg/L)	0.065	258.1/7610	10/20/93	21.6	13.9	5.62	18.4	7.28
Sodium (mg/L)	0.40	200.7/6010	10/8-13/93	20.2	31.5	13.9	91.7	3.15
Bicarbonate Alkalinity = Total Alkalinity (mg/L CaCO ₃)	5.0	StdM403	9/29-31/93	515	715	370	590	495
Carbonate Alkalinity	5.0	StdM403	9/29-10/1/93	<5.0	<5.0	<5.0	<5.0	<5.0
Chloride (mg/L)	0.11	300.0	9/26-10/5/93	0.49	3.5	3.3	32	6.9
Fluoride (mg/L)	0.10	340.2	10/1/93	0.18	0.19	0.31	0.25	0.24
Nitrate/Nitrite (mg/L as N)	0.050	353.2	10/5/93	<0.050	<0.050	0.067	0.45	0.20
Total Phosphorus (mg/L)	0.10	365.4	10/9/93	0.60	0.39	0.23	2.1	0.64
Sulfate (mg/L)	0.34	300.0	9/26/93	160	500	350	1700	100
Total Dissolved Solids (mg/L)	10	160.1	9/27-10/4/93	500	1130	760	2860	380
Total Suspended Solids (mg/L)	5	160.2	9/27/9/30/93	1010	528	456	1150	1540
Cation Sum (meq/L)		StdM104C		12.38	23.13	13.13	46.79	9.27
Anion Sum (meq/L)		StdM104C		13.64	24.81	14.78	48.11	12.18

GEOCHEMICAL PARAMETERS	Quant Limit	Method Reference	Analysis Date	MW-23	DL-MW-3	WSI-4	WSI-5	WSI-6
				09/20/93	09/21/93	09/21/93	09/21/93	09/21/93
Ammonia Nitrogen (mg/L as N)	0.010	350.1	10/2/93	0.42	0.87	<0.010	0.35	1.2
Total Hardness (mg/L as CaCO ₃)	2.0	130.2	9/29-10/4/93	3200	3250	1280	1120	1680
Iron (mg/L)	0.020	200.7/6010	10/8/93	0.111	4.86	0.063	3.46	1.79
Calcium (mg/L)	0.10	200.7/6010	10/13/93	122	424	346	277	227
Magnesium (mg/L)	0.20	200.7/6010	10/8-13/93	33.5	120	108	91.2	77.0
Manganese (mg/L)	0.015	200.7/6010	10/8/93	0.722	0.270	1.99	0.564	0.391
Potassium (mg/L)	0.065	258.1/7610	10/20/93	7.57	11.0	10.2	10.2	16.1
Sodium (mg/L)	0.40	200.7/6010	10/8-13/93	19.6	33.2	35.4	19.8	148
Bicarbonate Alkalinity = Total Alkalinity (mg/L CaCO ₃)	5.0	StdM403	9/29-10/1/93	645	2620	640	904	544
Carbonate Alkalinity	5.0	StdM403	9/29-31/93	<5.0	<5.0	<5.0	<5.0	<5.0
Chloride (mg/L)	0.11	300.0	9/26-10/5/93	1.9	4.3	5.8	1.3	4.4
Fluoride (mg/L)	0.10	340.2	10/1/93	0.24	0.24	0.27	0.19	0.15
Nitrate/Nitrite (mg/L as N)	0.050	353.2	10/5/93	<0.050	<0.050	0.26	0.15	500 *
Total Phosphorus (mg/L)	0.10	365.4	10/9/93	2.6	16	<0.10	<0.10	7.7
Sulfate (mg/L)	0.34	300.0	9/26/93	76	1100	620	560	580
Total Dissolved Solids (mg/L)	10	160.1	9/27-10/4/93	350	1830	1560	1300	1210
Total Suspended Solids (mg/L)	5	160.2	9/27-9/30/93	4470	9600	16	101	7830
Cation Sum (meq/L)		StdM104C		9.97	33.09	28.10	22.70	24.71
Anion Sum (meq/L)		StdM104C		14.54	75.36	25.88	29.78	33.95

* Analysis of unpreserved sample beyond maximum holding time resulted in a detect of <0.050 mg/L. Possible contamination in preserved sample.

GEOCHEMICAL PARAMETERS	Quant Limit	Method Reference	Analysis Date	MW-12	MW-26	DUP-1	DUP-2
				09/21/93	09/22/93	09/21/93	09/22/93
Ammonia Nitrogen (mg/L as N)	0.010	350.1	10/2/93	1.5	0.053	0.46	0.043
Total Hardness (mg/L as CaCO3)	2.0	130.2	9/29-10/4/93	2000	2040	530	790
Iron (mg/L)	0.020	200.7/6010	10/8/93	4.66	<0.020	1.34	0.095
Calcium (mg/L)	0.10	200.7/6010	10/13/93	514	500	119	159
Magnesium (mg/L)	0.20	200.7/6010	10/8-13/93	163	147	38.9	55.0
Manganese (mg/L)	0.015	200.7/6010	10/8/93	1.18	1.57	0.128	0.168
Potassium (mg/L)	0.065	258.1/7610	10/20/93	19.2	15.6	6.64	5.64
Sodium (mg/L)	0.40	200.7/6010	10/8-13/93	132	66.5	10.4	16.2
Bicarbonate Alkalinity = Total Alkalinity (mg/L CaCO3)	5.0	StdM403	9/29-31/93	364	692	636	364
Carbonate Alkalinity	5.0	StdM403	9/29-10/1/93	<5.0	<5.0	<5.0	<5.0
Chloride (mg/L)	0.11	300.0	9/26-10/5/93	6.3	8.4	0.48	3.4
Fluoride (mg/L)	0.10	340.2	10/1/93	0.14	0.17	0.25	0.37
Nitrate/Nitrite (mg/L as N)	0.050	353.2	10/5/93	<0.050	58	<0.050	0.069
Total Phosphorus (mg/L)	0.10	365.4	10/9/93	0.28	3.2	0.28	0.29
Sulfate (mg/L)	0.34	300.0	9/26-10/6/93	1600	1200	20	330
Total Dissolved Solids (mg/L)	10	160.1	9/27-10/4/93	2870	2380	376	758
Total Suspended Solids (mg/L)	5	160.2	9/27-9/30/93	552	1620	660	430
Cation Sum (meq/L)		StdM104C		45.71	40.46	9.87	13.33
Anion Sum (meq/L)		StdM104C		40.77	40.32	13.15	14.25

APPENDIX I

VOLATILE ORGANIC COMPOUNDS
FOR WELL 132-056-10BBC2

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-Dichloroethane	<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
trans-1,2-Dichloroethylene	<2
Chlorobenzene	<2
m-Dichlorobenzene	<5
Dichloromethane	<5
cis-1,2-Dichloroethylene	<2
o-Dichlorobenzene	<2
Dibromomethane	<5
1,1-Dichloropropene	<5
Tetrachloroethylene	<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
Fluorotrchloromethane	<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

APPENDIX J

VOLATILE ORGANIC COMPOUNDS
FOR WELL 132-056-10CBAC

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-Dichloroethane	<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
trans-1,2-Dichloroethylene	<2
Chlorobenzene	<2
m-Dichlorobenzene	<5
Dichloromethane	<5
cis-1,2-Dichloroethylene	<2
o-Dichlorobenzene	<2
Dibromomethane	<5
1,1-Dichloropropene	<5
Tetrachloroethylene	<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	61*
Pentachloroethane	<5
Trichlorotrifluoroethane	<5
Carbondisulfide	<5
Ether	<5

* Constituent Detection

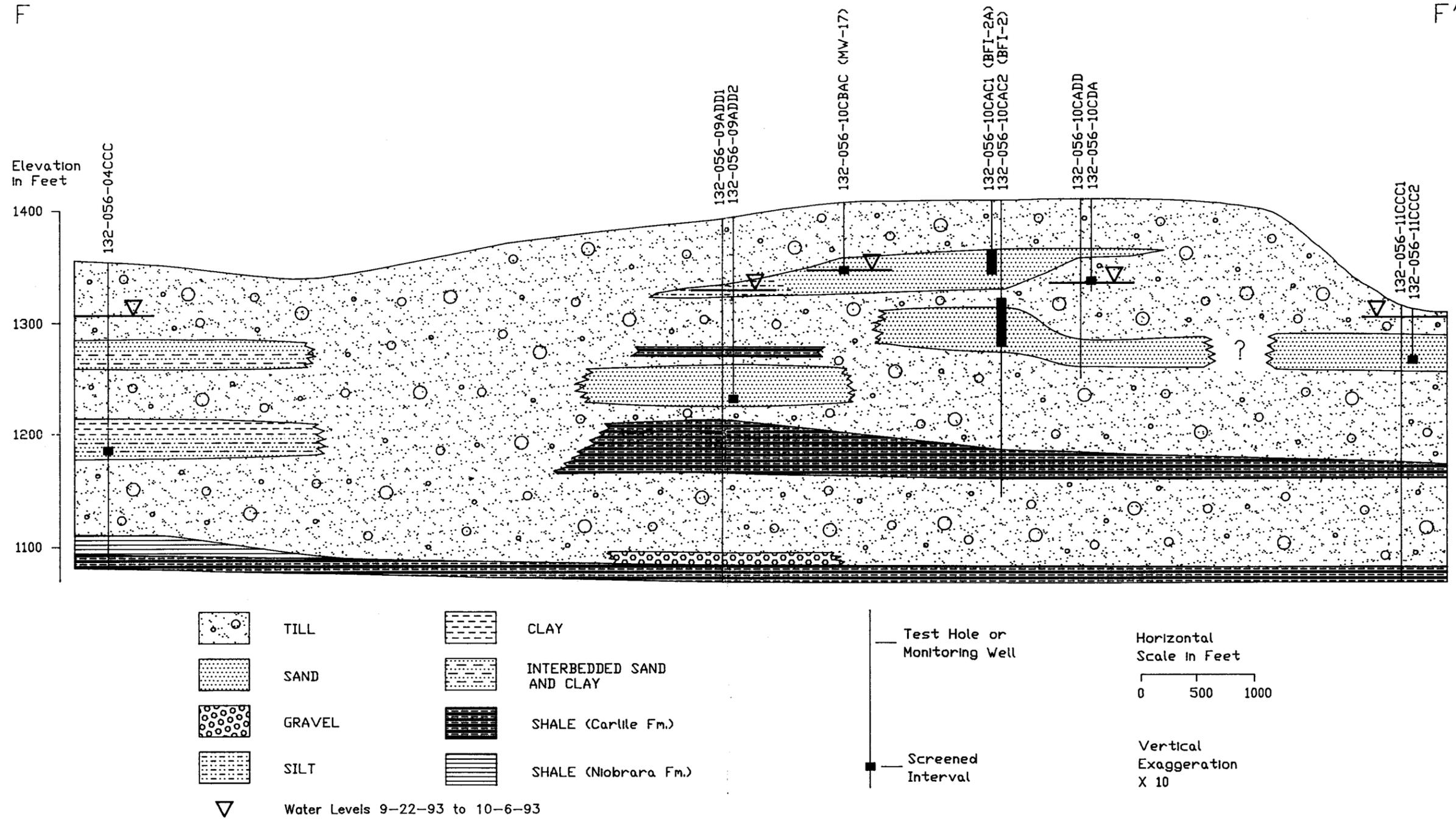


Plate 8. Geohydrologic section F-F' for the Dakota landfill.

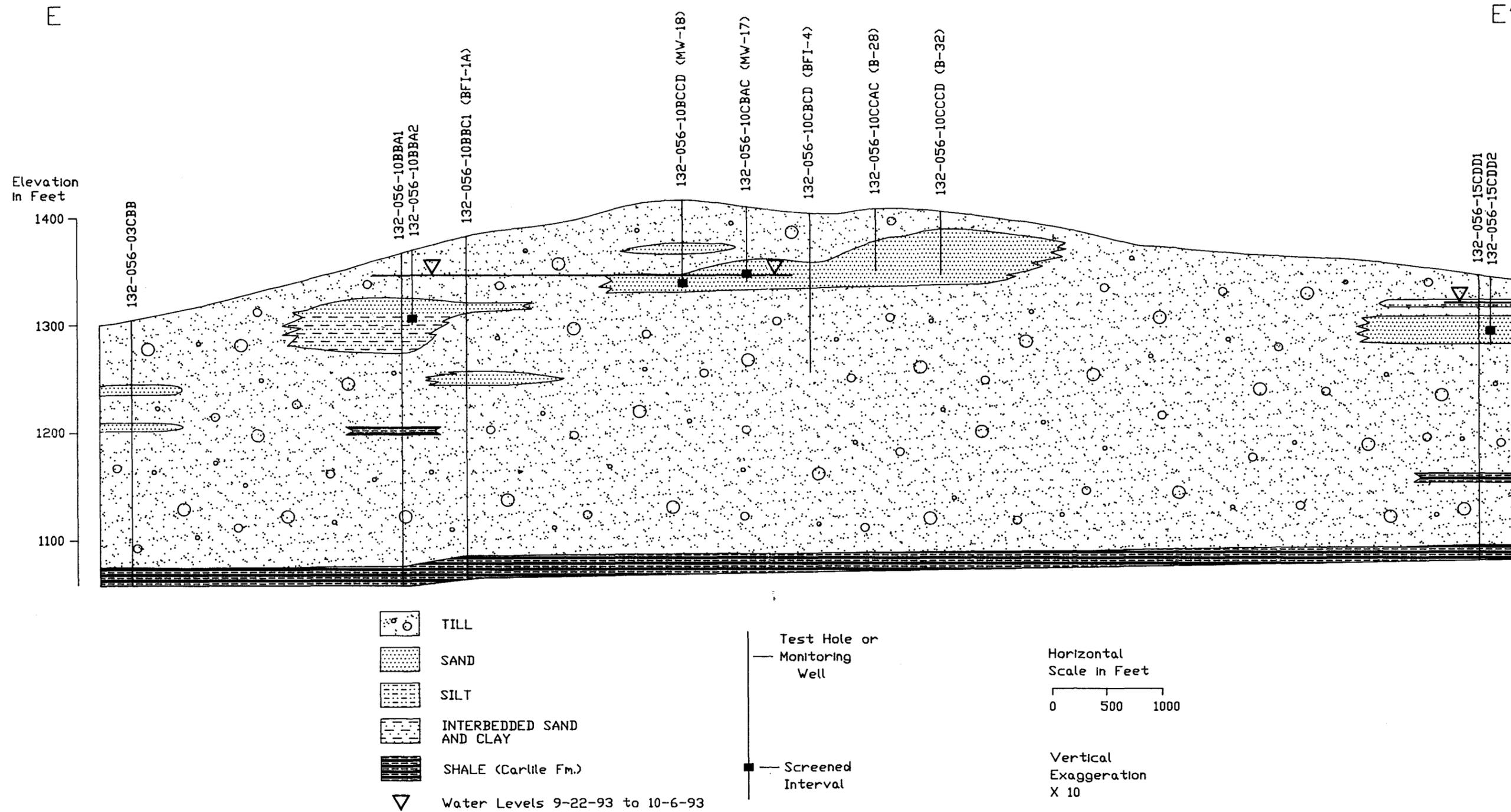
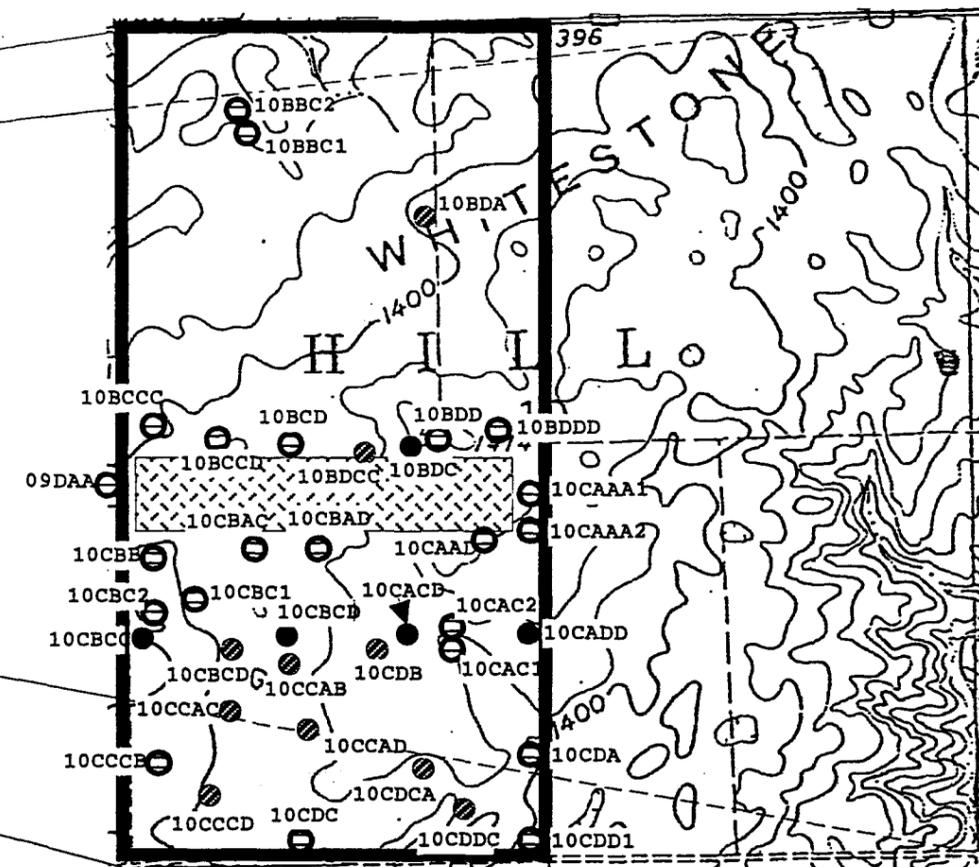
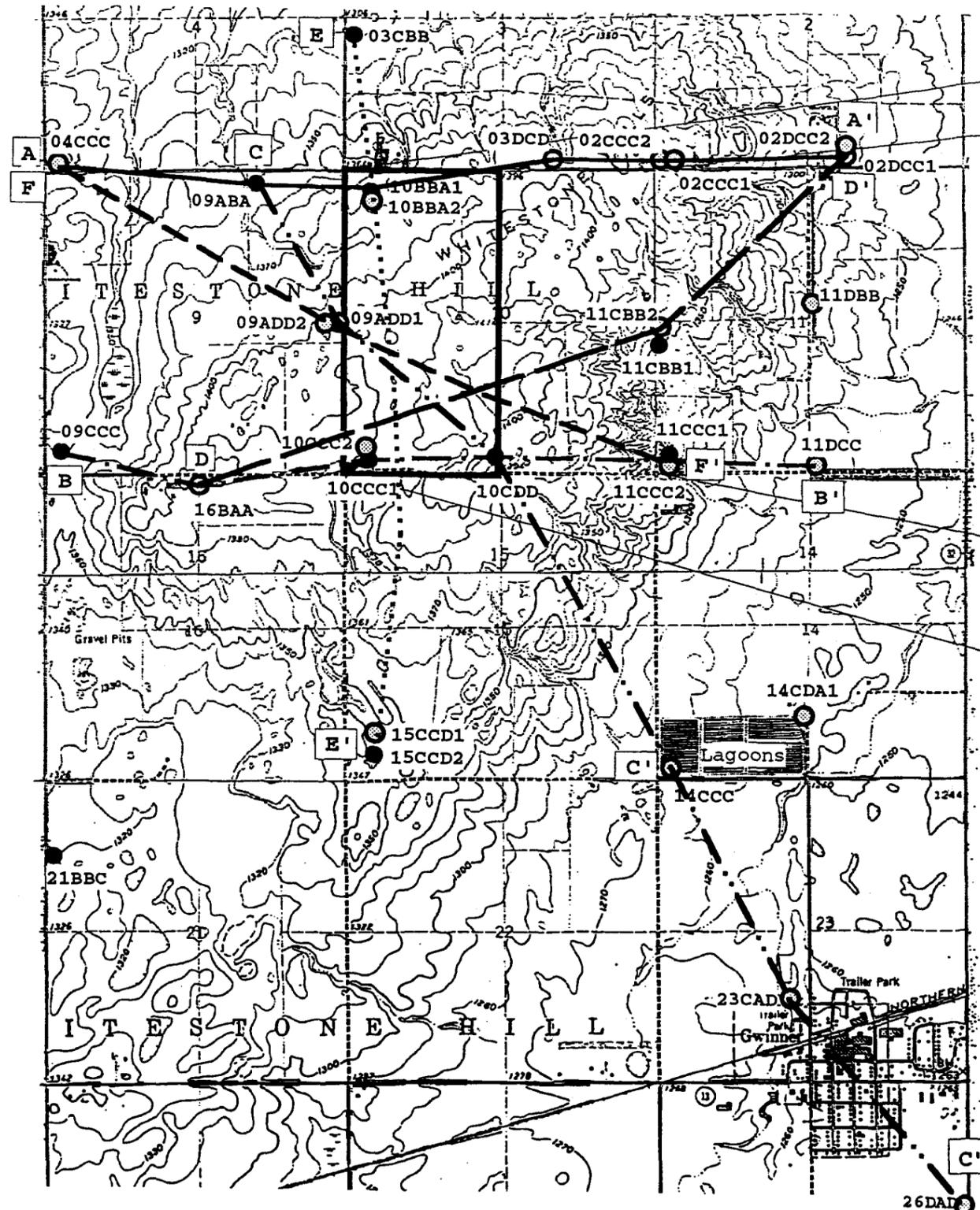


Plate 7. Geohydrologic section E-E' for the Dakota landfill.



- ⊙ SWC Observation Wells
- SWC Test Holes
- ⊖ Other Observation Wells
- ⊗ Other Test Holes
- Landfill Property
- ▨ Active Area

1400
 Elevation in feet
 above MSL (NGVD, 1929)
 Contour Interval 10 feet

10CCC
 Well Number (section, quarter,
 quarter, quarter)

Plate 1. Well and test hole locations in the Dakota landfill study area in the west half of section 10 T.132N., R.52W.

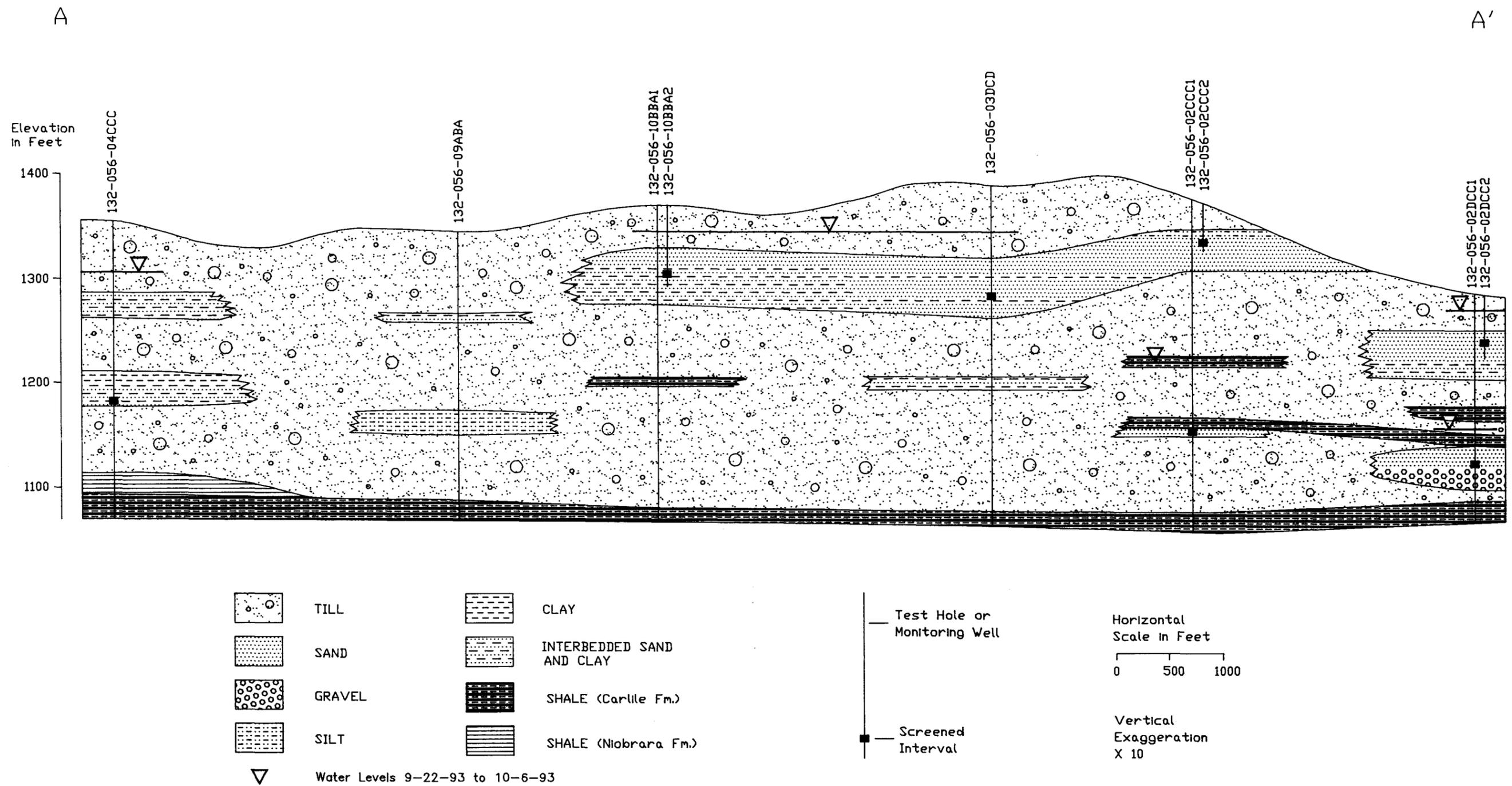


Plate 2. Geohydrologic section A-A' for the Dakota landfill.

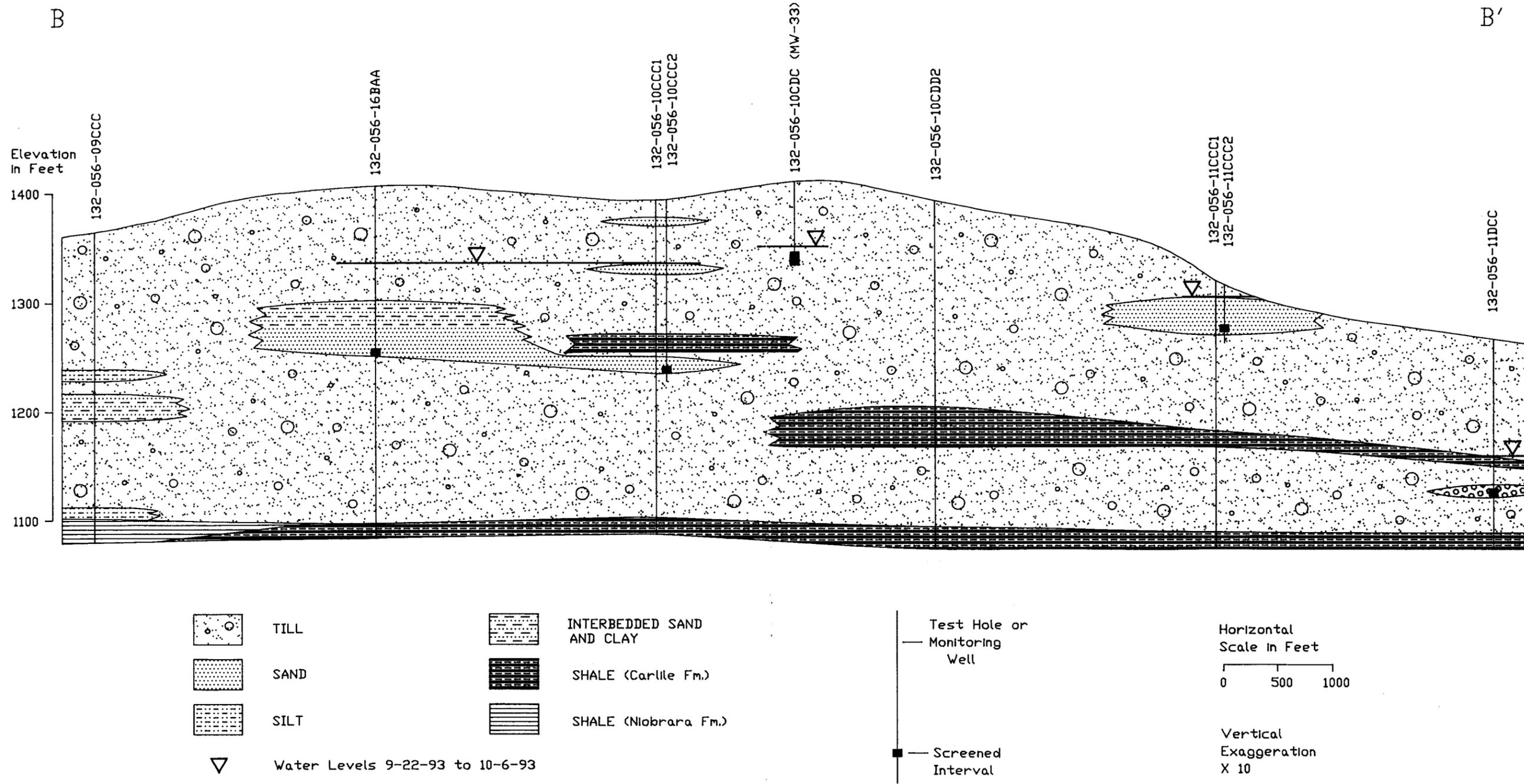


Plate 3. Geohydrologic section B-B' for the Dakota landfill.

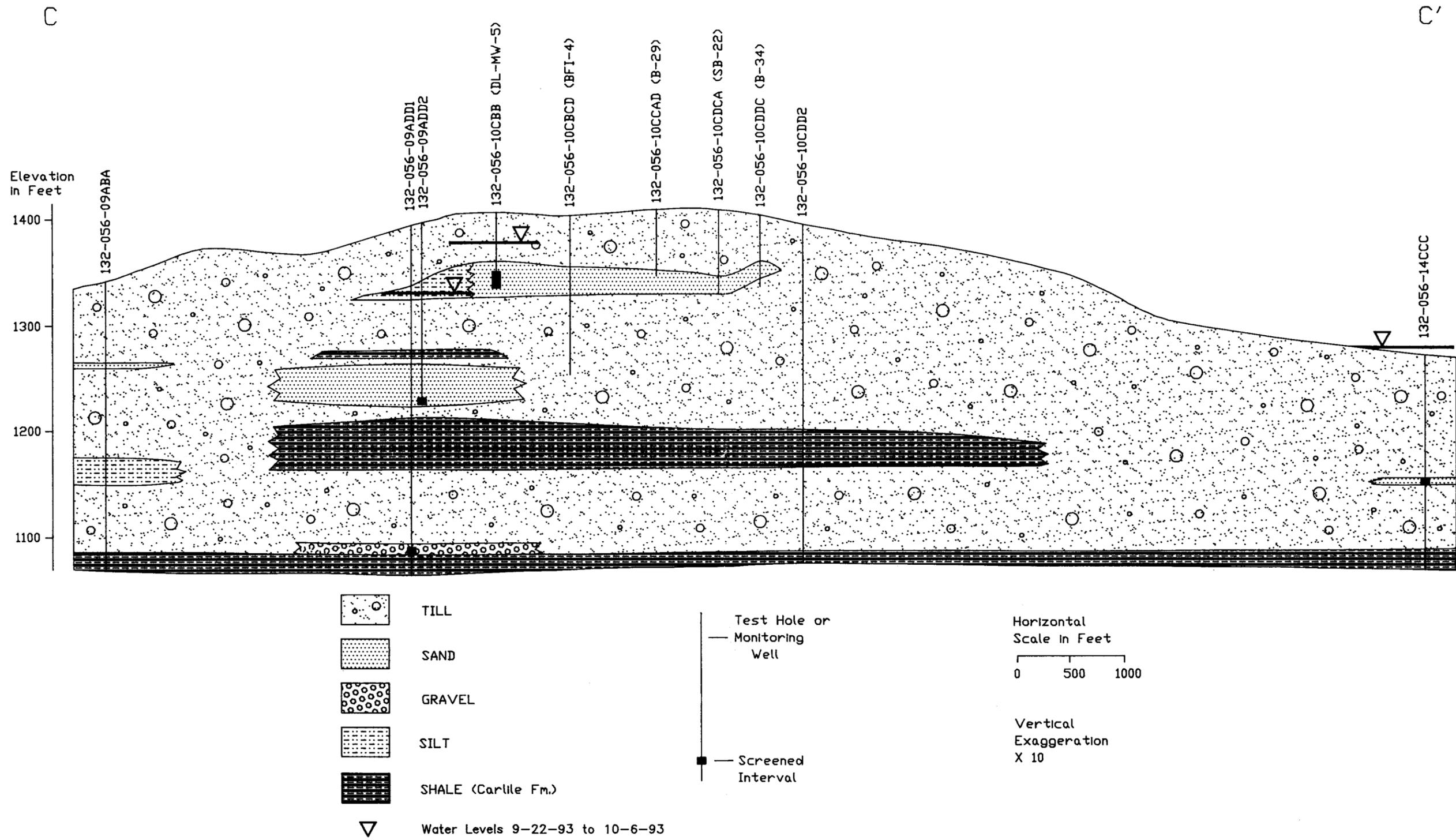


Plate 4. Geohydrologic section C-C' for the Dakota landfill.

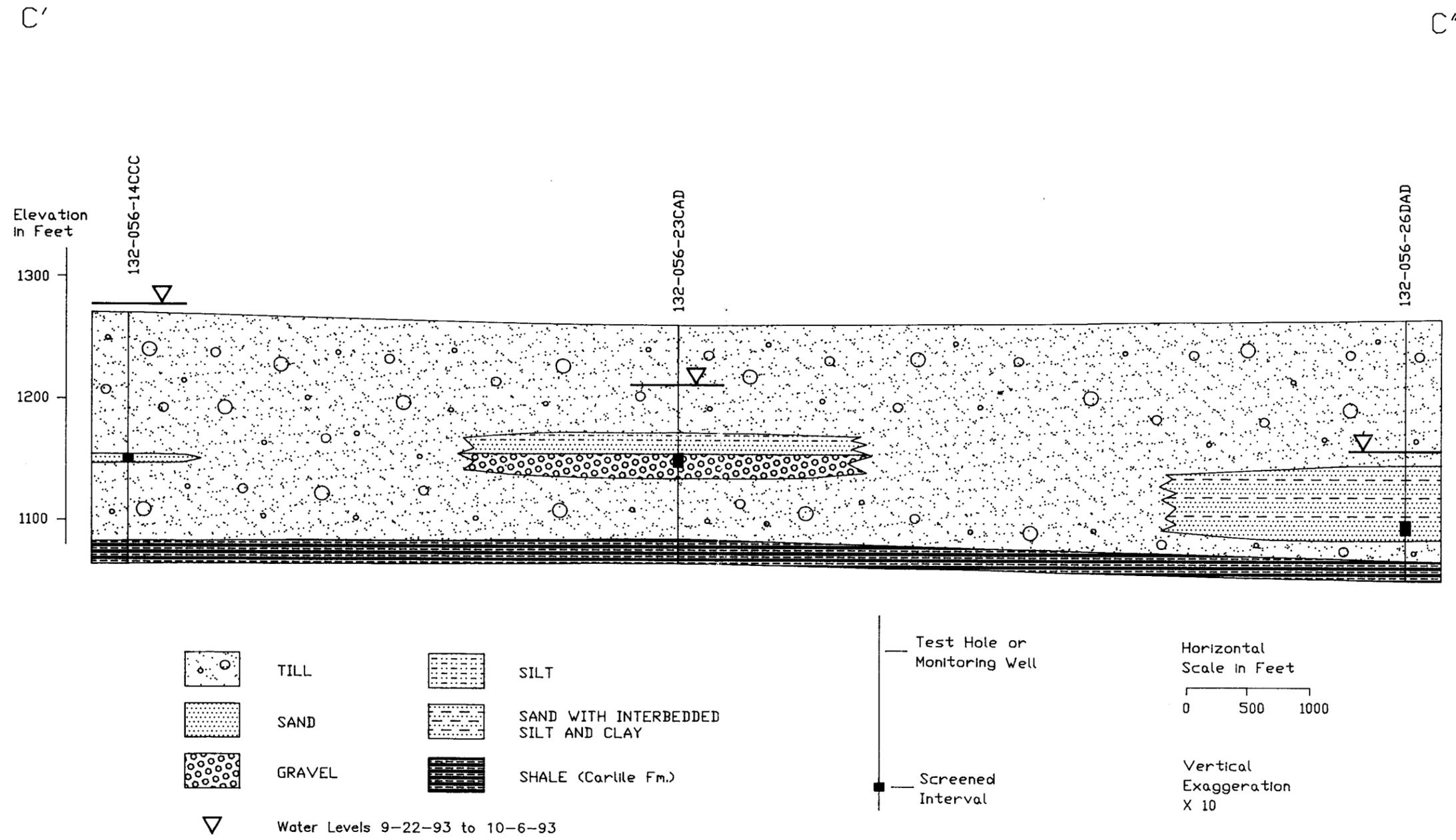


Plate 5. Geohydrologic section C'-C'' for the Dakota landfill.

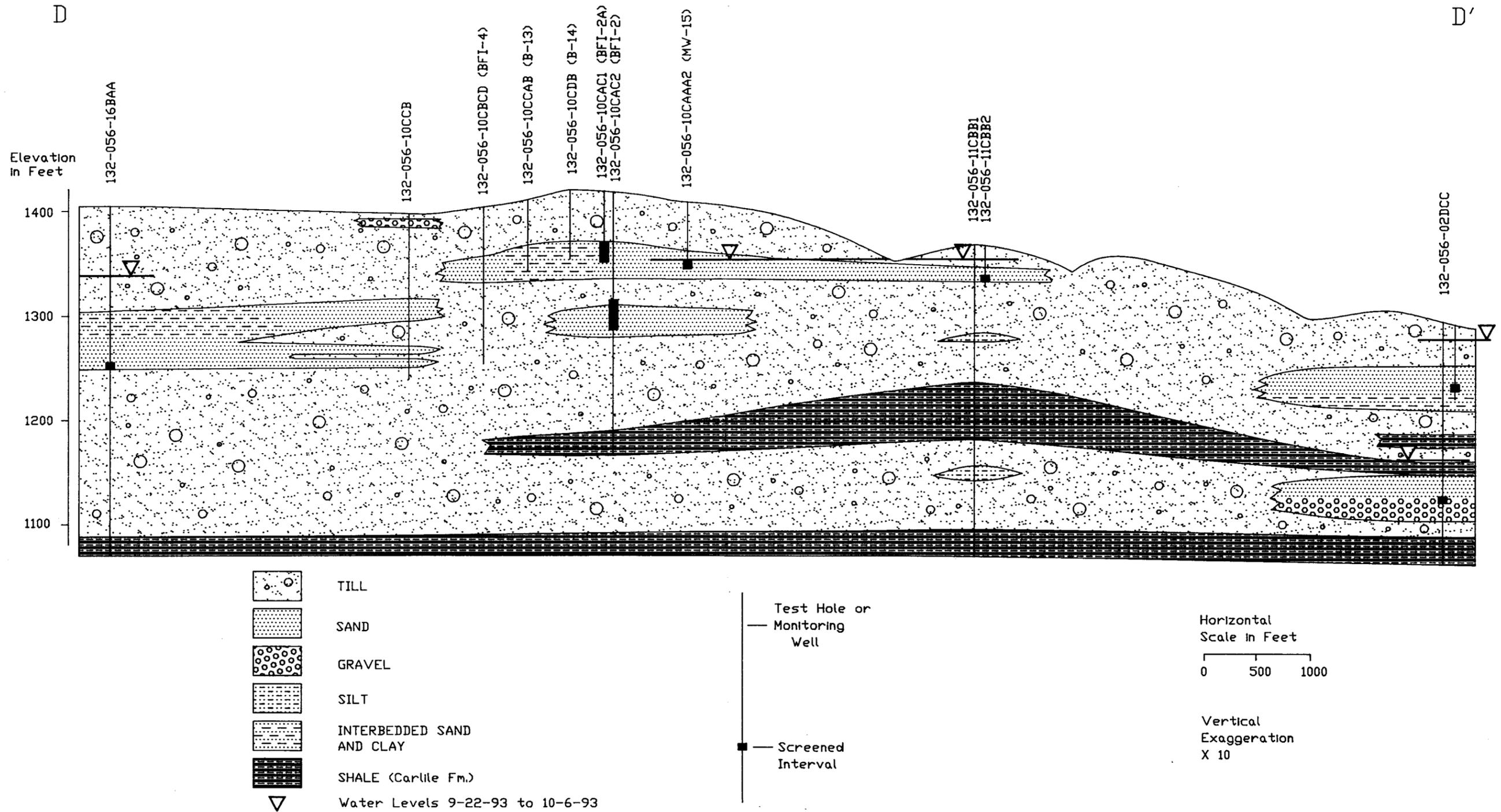


Plate 6. Geohydrologic section D-D' for the Dakota landfill.