Site Suitability Review of the Rolla Landfill

(Joe Murphy)

by
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North Dakota Geological Survey
and
Jeffrey Olson
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Prepared by the
North Dakota Geological Survey
and the
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ND Landfill Site Investigation No. 27

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Bismarck, North Dakota
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INTRODUCTION

Purpose

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

Location of the Rolla Landfill

The Rolla solid waste landfill is located about three miles south of the City of Rolla in Township 162 North, Range 69 West, NE 1/4 Section 33 (Fig. 1). The active area of the landfill encompasses approximately 20 acres. The landfill is owned and operated by Murphy Services, Inc.

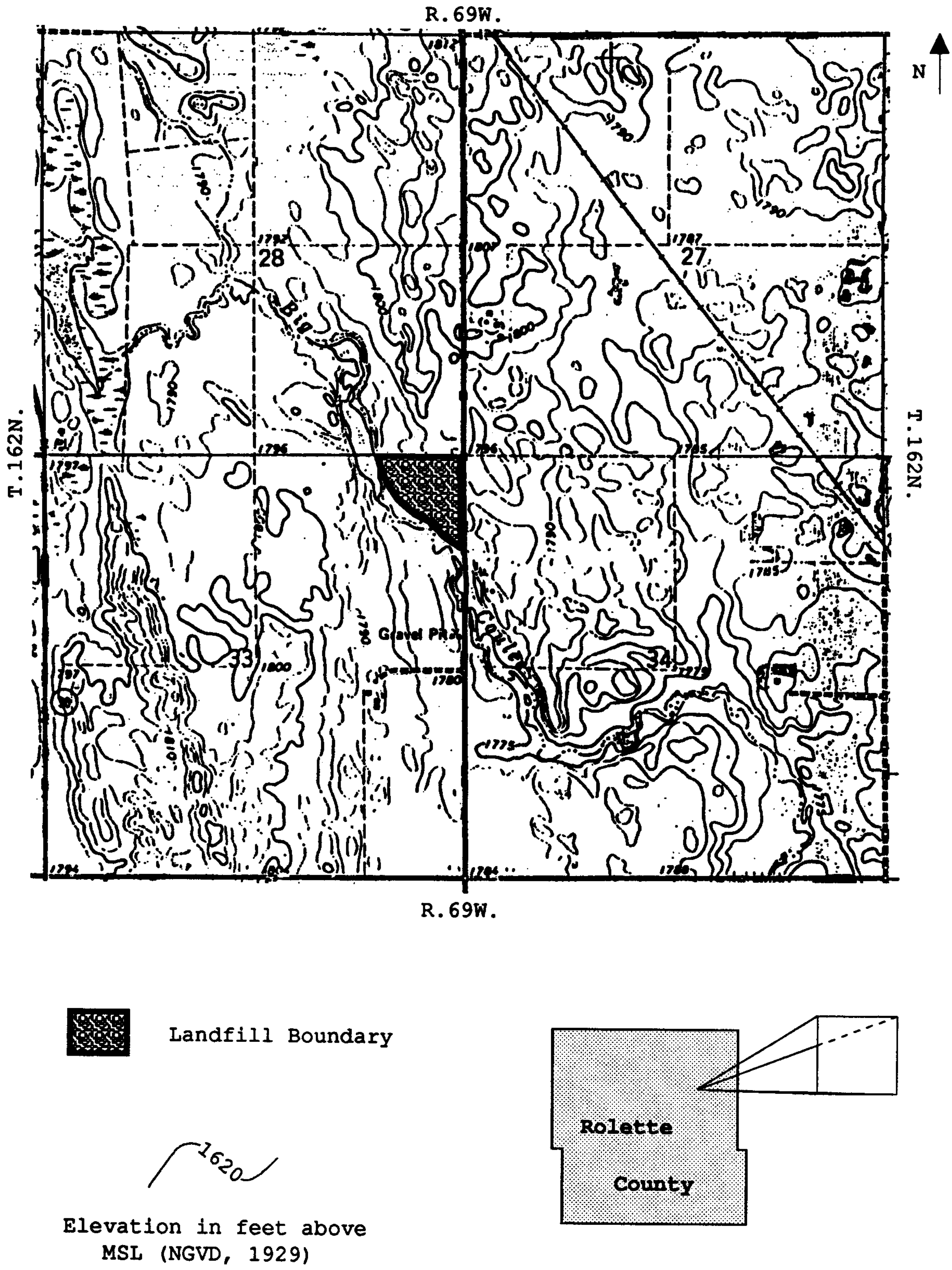

Figure 1. Location of the Rolla landfill in the NE 1/4, NE 1/4 of section 33, T162N, R69W.

Previous Site Investigations

No previous geologic or hydrologic investigations have been performed at the Rolla Landfill.

Methods of Investigation

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

Test-Drilling Procedure

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

Monitoring Well Construction and Development

Five test holes were drilled at the Rolla landfill and monitoring wells were installed in each test hole. The number of wells installed at the landfill was based on the geologic and topographic characteristics of the site. The wells were screened to monitor the top of the uppermost aquifer. The test holes were located around the perimeter of the landfill.

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

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

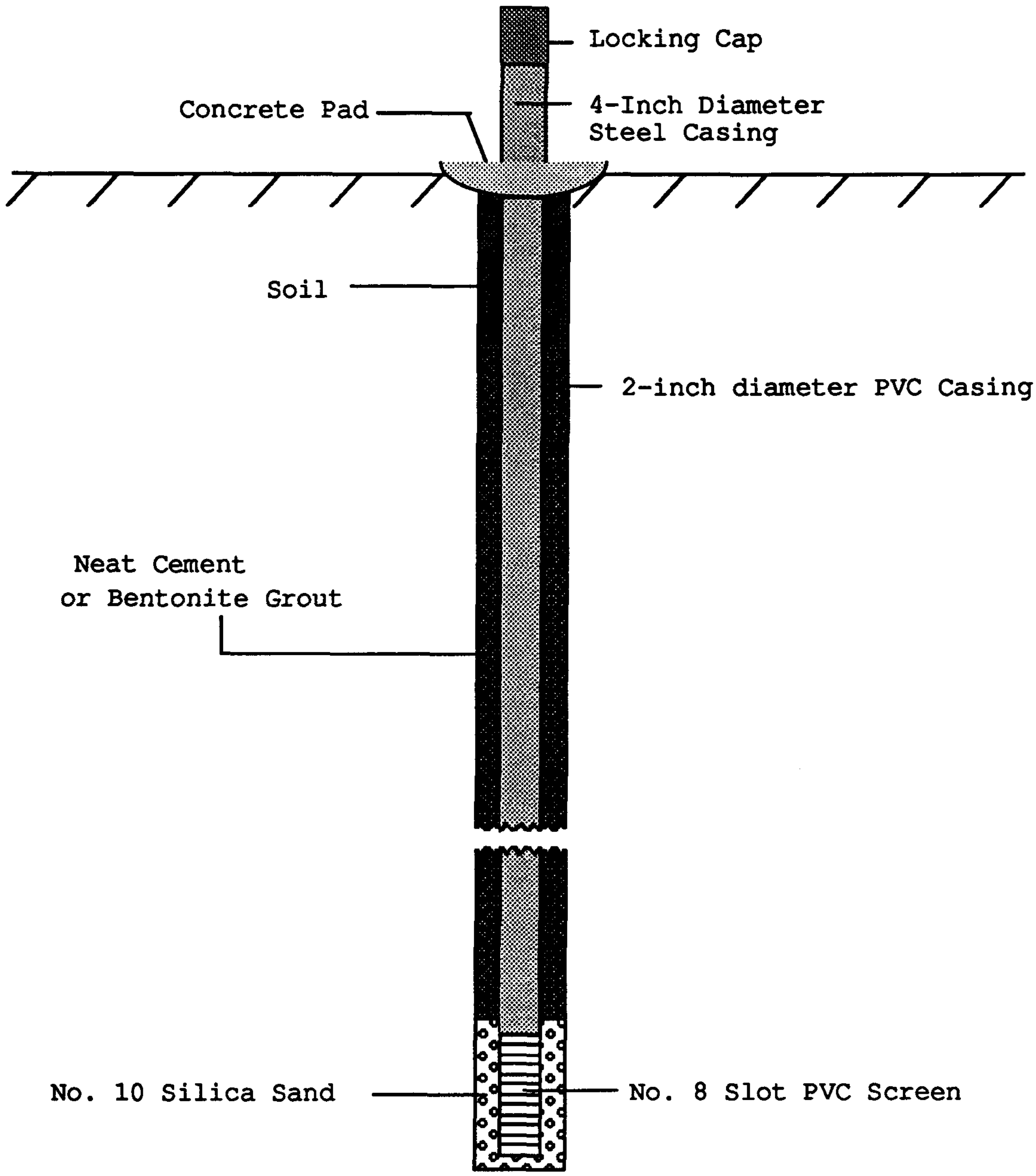

Figure 2. Construction design used for monitoring wells installed at the Rolla landfill.

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

Collecting and Analyzing Water Samples

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

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

1) Raw (500 ml)
2) Filtered (500 ml)

3) Filtered and acidified (500 ml)

4) Filtered and double acidified (500 ml)

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

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

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

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

10078) water-level indicator. These measurements were used to determine the shape and configuration of the water table.

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 162-069-33AAD would be located in the SE1/4, NE1/4, NE1/4, Section 33, Township 162 North, Range 69 West. Consecutive numbers are added following the three letters if more than one well is located in a 10-acre tract, e.g. 162-069-33AAD1 and 162-069-33AAD2.

GEOLOGY

The Rolla landfill is located in an area of rolling topography with partially integrated drainage. An intermittent stream, Big Coulee, borders the landfill on the

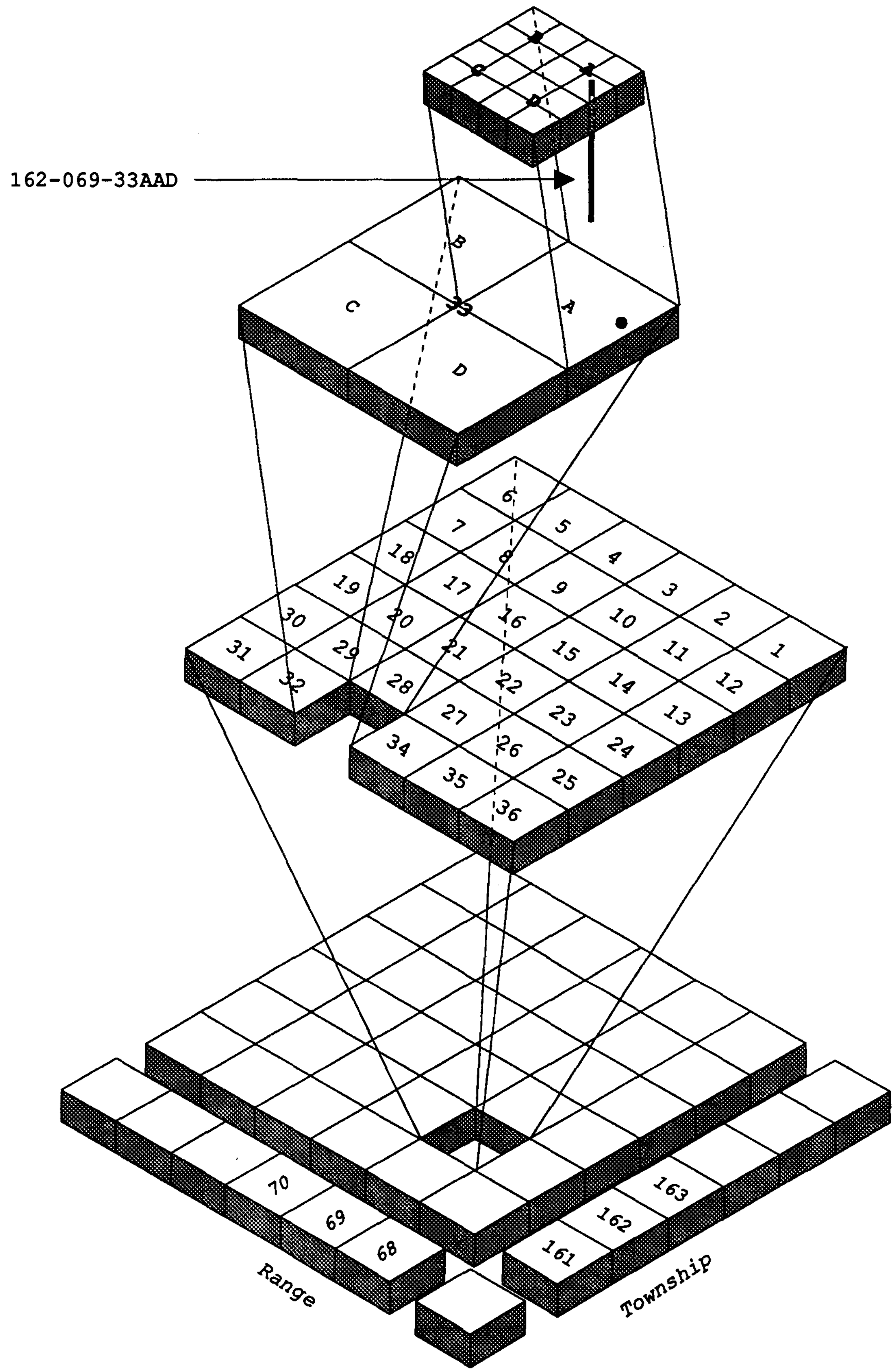

Figure 3. Location-numbering system for the Rolla landfill.

southwest (Fig.4). Surface elevations range from 1,780 feet to 1,795 feet.

The landfill is underlain by more than 100 feet of glacial sediments. At least three glacial advances covered the Rolla area based on the presence of two buried zones of oxidized till (Deal, 1971). In addition to the glacial sediments a surficial layer of alluvium is present near the intermittent stream.

The bedrock surface in the vicinity of the landfill occurs at an elevation of 1,600 to 1,650 feet (Randich and Kuzniar, 1984, Plate 2). The uppermost bedrock unit in test holes nearest the landfill is the Pierre Formation. The lower part of the Fox Hills Formation is present above the Pierre Formation about one mile west of the landfill.

The Pleistocene geologic history is complex and little is known about earlier glacial advances. A north-south trending ridge extending northward from the landfill site is believed to be an esker which was covered with a thin layer of till from the last glacial advance (Deal, 1971). This ridge extends along the east side of section 28 (Fig. 1) and into the southwest corner of section 22.

Test holes drilled around the perimeter of the landfill for this study encountered sandy clay till interbedded with silty, gravelly sand and clayey sand (Fig. 5, lithologic logs in Appendix C). The sand is most prevalent in the northwest corner of the site (test holes 162-069-33AAB1 and 33AAB2).

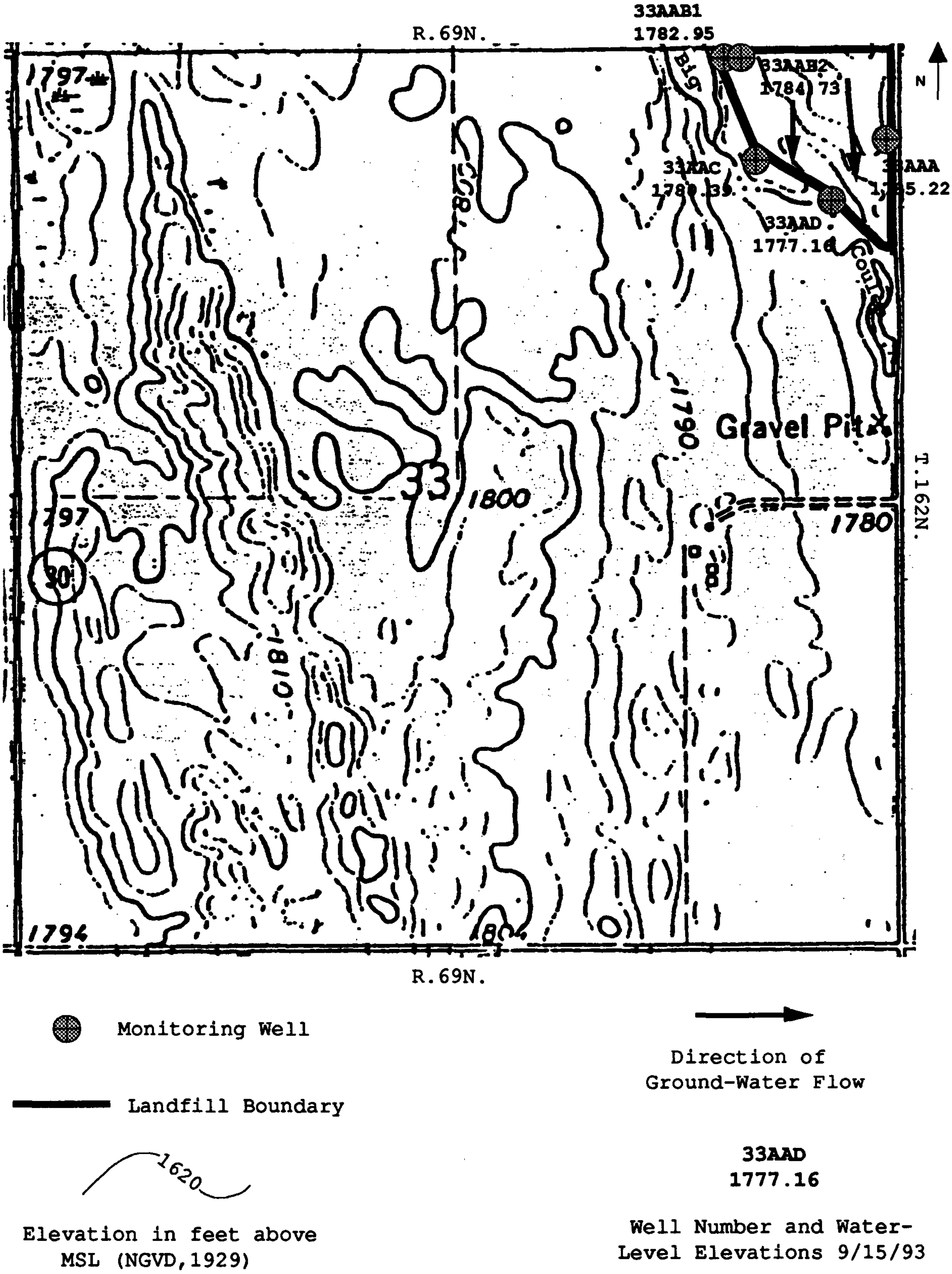

Figure 4. Location of monitoring wells at the Rolla landfill.

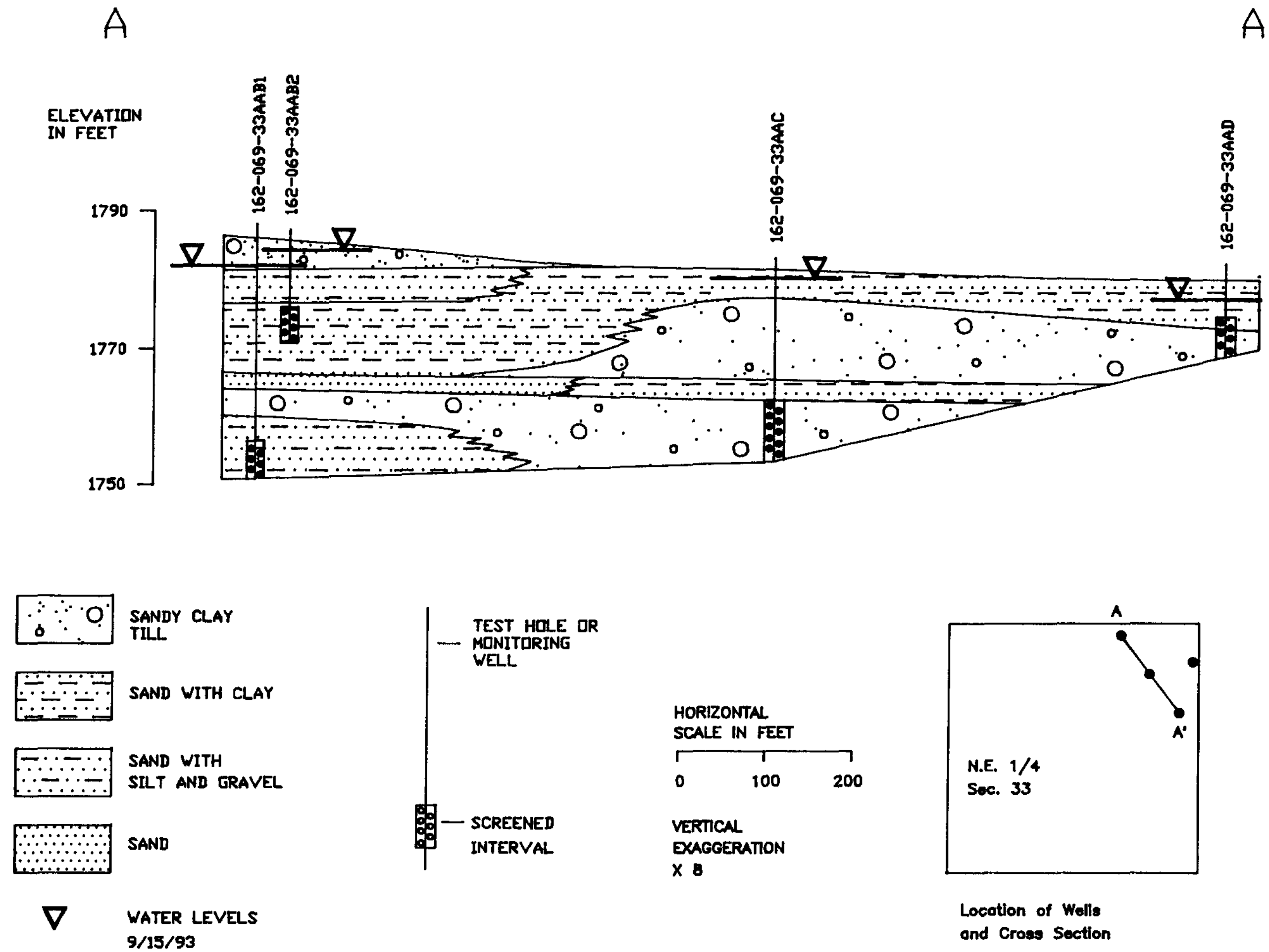

Figure 5. Geohydrologic section A-A' in the Rolla Landfill.

HYDROLOGY

Surface-Water Hydrology

The Big Coulee forms the western and southern boundaries of the Rolla landfill (Fig.1). Numerous wetlands are located along Big Coulee north of the Rolla landfill. The Rolla sewage lagoons are located about two miles north of the landfill along the Big Coulee. Big Coulee flows to the south-southeast and discharges into Mauvais Coulee. The Big Coulee is the municipal water source for the City of Bisbee located about 15 miles southeast of the landfill. The Big Coulee may be susceptible to contamination from refuse runoff and local ground-water discharge from the Rolla landfill.

Regional Ground-Water Hydrology

Regional aquifers consist of both glacial and bedrock lithologies. The Rolla aquifer is located about one mile west of the landfill and occupies an area of about 48 square miles (Randich and Kuzniar, 1984). This aquifer is recharged from precipitation and lateral flow from undifferentiated glacial aquifers and adjacent bedrock aquifers. Discharge is by evapotranspiration and pumpage from domestic and municipal wells (City of Rolla). This aquifer is characterized by a calcium-sulfate-bicarbonate type water.

Undifferentiated sand and gravel aquifers are found throughout the region and are commonly a source for domestic and stock supplies. These aquifers are not extensive and as a result are characterized by limited recharge. The undifferentiated aquifers are generally characterized by a mixed cation-bicarbonate-sulfate type water (Randich and Kuzniar, 1984).

The Pierre Formation underlies the glacial drift beneath the study area. The Pierre aquifer is a source of ground water in areas of extensive fracturing. The Pierre aquifer is characterized by a sodium-sulfate to sodium-chloride type water.

Local Ground-Water Hydrology

Five test holes were drilled at the Rolla landfill and monitoring wells were installed at each site (Fig. 4). The well screens were placed near the top of the uppermost aquifer. Five water-level measurements were taken over a nine week period (Appendix D). All of the wells were placed between the buried refuse and Big Coulee except well 33AAA which is located along the eastern boundary of the landfill (Fig. 4). The undifferentiated aquifer is comprised of a gravelly sand layers that commonly are seperated by clay and till. Wells 33AAB1 and 33AAB2 indicate downward ground-water movement through the sandy clay. The local ground-water flow direction is toward Big Coulee.

Water Quality

Chemical analyses of water samples are shown in Appendix E. An anomalously high chloride concentration of 510 mg/L was detected in well 33AAD. This well is located at the southeast corner of the landfill boundary along Big Coulee (Fig. 6) This concentration is about twice the SMCL of 250 mg/L and about four times higher than the other wells. The high chloride concentration may indicate leachate migration from the landfill.

Well 33AAB1 detected a high iron concentration of 1.1 mg/L which is above the SMCL of 0.3 mg/L. This well is located at the northwest corner of the landfill near the disposal area for construction material. The source of the iron concentration was not determined. The trace element analyses indicate concentrations below MCL and SMCL.

The results of the VOC analyses, from wells 162-069-33AAD and 33AAC, are in Appendicies F and G. No VOC compounds were detected in either well.

CONCLUSIONS

The Rolla landfill is located in an area of rolling topography with partially integrated drainage. An intermittent stream, Big Coulee, borders the landfill on the southwest. Big Coulee is the municipal water source for the

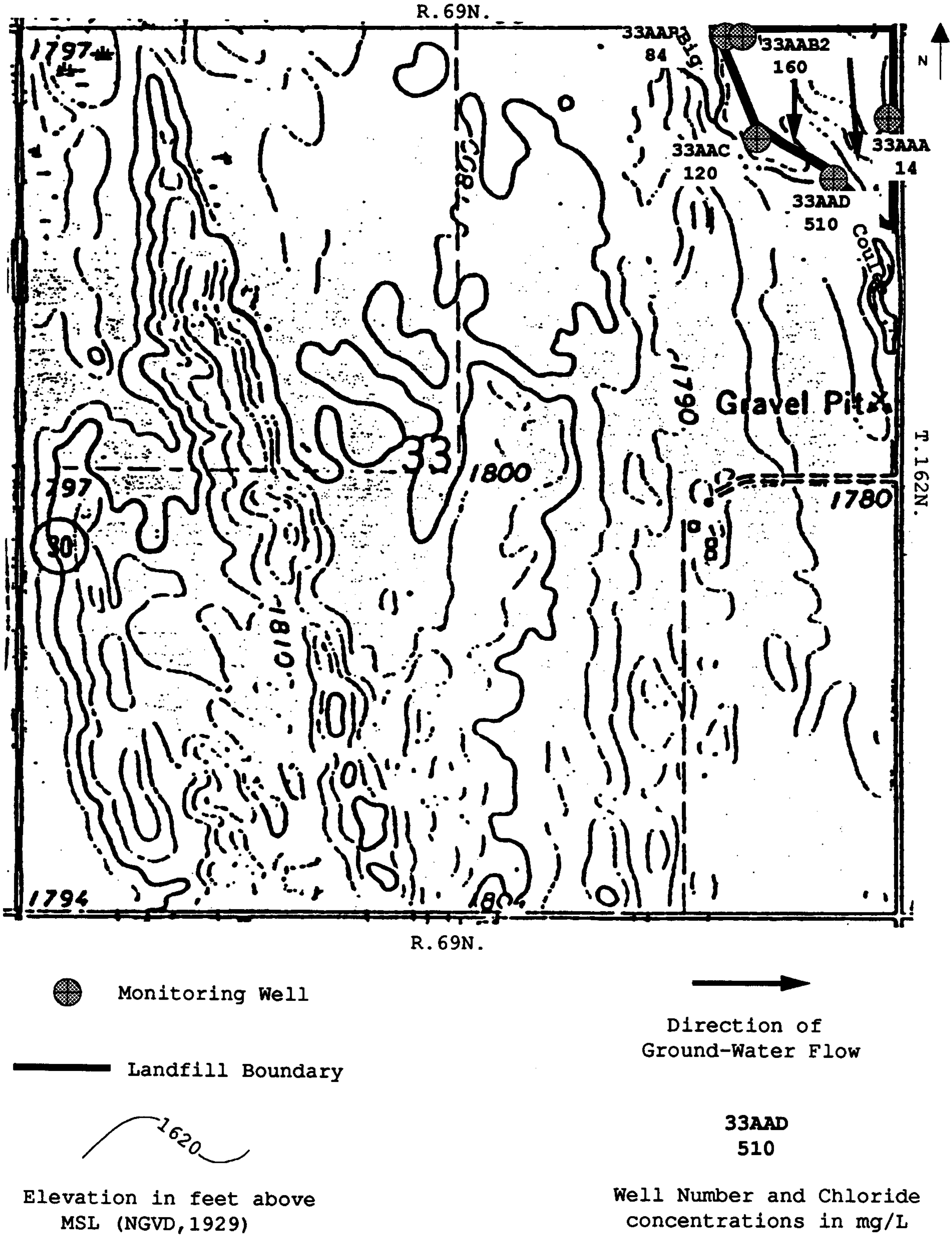

Figure 6. Chloride concentrations at the Rolla landfill.

City of Bisbee located about 15 miles southeast of the landfill.

The landfill is underlain by more than 100 feet of glacial sediments including sandy clay till; silty, gravelly sand; and clayey sand. Ground water occurs at a shallow depth within the sand intervals beneath the landfill. The local ground-water flow direction is southwest toward Big Coulee.

A high chloride concentration (510 mg/L) was detected in monitoring well 162-069-33AAD. This well is located down-gradient from the landfill near Big Coulee. The high chloride concentration may indicate leachate migration from the landfill. The trace element analyses indicate concentrations below MCL and SMCL. No VOC compounds were detected in wells 162-069-33AAD and 33AAC. The Trace element and VOC analyses do not indicate contaminant migration from the landfill.

The main concern regarding the Rolla landfill is the possibility of contaminating the surface water and the underlying ground water that discharges into Big Coulee. The high chloride concentration in well 162-069-33AAD suggests that leachate may have moved beyond the buried refuse and toward Big Coulee. The landfill may require additional monitoring in the future because of the proximity of the landfill to Big Coulee and the presence of a municipal water supply downstream.

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

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Randich, P.G., and Kuzniar, R.L., 1984, Ground-water resources of Bottineau and Rolette Counties, North Dakota: North Dakota Geological Survey, Bulletin 78, North Dakota State Water Commission, County Ground-Water Studies 35, Part III, 41 p.

APPENDIX A

WATER QUALITY STANDARDS
AND
CONTAMINANT LEVELS

Water Quality Standards and Contaminant Levels

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

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

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

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

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

APPENDIX B

SAMPLING PROCEDURE FOR VOLATILE ORGANIC COMPOUNDS

SAMPLING PROCEDURE FOR 40ML AMBER BOTTLES

Sample Collection for Volatile Organic Compounds

by
North Dakota Department of Health
and Consolidated Laboratories

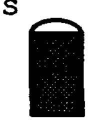
1. Three samples must be collected in the 40ml bottles that are provided by the lab. One is the sample and the others are duplicates.

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

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

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

convex meniscus



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

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

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

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

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

APPENDIX C

LITHOLOGIC LOGS
OF WELLS AND TEST HOLES

162-069-33AAA

NDSWC

Date Completed:	7/13/93	Purpose:	Observation Well
L.S. Elevation (ft):	1787.51	Well Type:	2" PVC
Depth Drilled (ft):	19	Aquifer:	UND
Screened Interval (ft):	14-19	Source:	
		Owner:	Joe Murphy

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Clay, sandy, pale yellowish brown, 10YR6/2.	1-5
SAND	Clayey, moderate yellowish brown, 10YR5/4..	5-8
CLAY	Silty, moderate yellowish brown with dark yellowish orange, mottling.	8-13
CLAY	Sandy, trace gravel, moderate yellowish brown, 10YR5/4 (till).	13-17
CLAY	Sandy, trace gravel, olive gray, 5Y4/1 (till).	17-19

162-069-33AAB1

NDSWC

Date Completed:	7/13/93	Purpose:	Observation Well
L.S. Elevation (ft):	1785.6	Well Type:	2" PVC
Depth Drilled (ft):	35	Aquifer:	UND
Screened Interval (ft):	30-35	Source:	
		Owner:	Joe Murphy

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Silty, trace sand and gravel, pale yellowish brown 10YR6/2 (till).	1-4
SAND	Silty, gravelly, moderately yellowish brown 10YR5/4 (till).	4-9
SAND	Fine to medium grained sand, clayey, trace gravel, moderate yellowish brown 10YR5/4 (till).	9-19
SAND	Fine to medium grained, olive gray 5Y4/1.	19-21
CLAY	Sandy, trace gravel, olive gray 5Y4/1.	21-24
SAND	Fine to medium grained, silty, trace gravel, olive gray 5Y4/1. (till.)	24-35

162-069-33AAB2
NDSWC

Date Completed:	7/13/93	Purpose:	Observation Well
L.S. Elevation (ft):	1786.05	Well Type:	2" PVC
Depth Drilled (ft):	15	Aquifer:	UND
Screened Interval (ft):	10-15	Source:	
		Owner:	Joe Murphy

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
CLAY	Silty, trace sand and gravel, pale yellowish brown 10YR6/2 (till).	1-4
SAND	Silty, gravelly, fine to medium grained, moderate yellowish brown 10YR5/4 (till).	4-8
SAND	Silty, trace gravel, moderate yellowish brown 10YR5/4 (till).	8-12
SAND	Fine to medium grained, clayey, gravelly, moderate yellowish brown 10YR5/4 (till).	12-15

162-069-33AAC

NDSWC

Date Completed:	7/13/93	Purpose:	Observation Well
L.S. Elevation (ft):	1781.16	Well Type:	2" PVC
Depth Drilled (ft):	28	Aquifer:	UND
Screened Interval (ft):	18-28	Source:	
		Owner:	Joe Murphy

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND	Very fine grained, clayey, light gray N7 (alluvium).	1-3
SAND	Fine grained, clayey, gravelly, moderate yellowish brown 10YR5/4 (till).	3-6
CLAY	Sandy, gravelly, moderate yellowsih brown 10YR 5/4 (till).	6-12
CLAY	Sandy, gravelly, olive gray 10YR5/4 (till) 5Y4/1	12-15
SAND	Fine grained, clayey, olive gray 5Y4/1.	15-18
CLAY	Sandy, gravelly, olive gray 5Y4/1 (till).	18-28

162-069-33AAD

NDSWC

Date Completed:	7/13/93	Purpose:	Observation Well
L.S. Elevation (ft):	1778.89	Well Type:	2" PVC
Depth Drilled (ft):	10	Aquifer:	UND
Screened Interval (ft):	5-10	Source:	
		Owner:	Joe Murphy

Lithologic Log

Unit	Description	Depth (ft)
TOPSOIL		0-1
SAND	Medium grained, clayey, dark yellowish brown 10YR4/2 (alluvium).	1-7
CLAY	Sandy, Silty and gravelly, dark yellowish brown (till) 10YR4/2.	7-10

APPENDIX D

WATER-LEVEL TABLES

Rolla Water Levels
8/4/93 to 10/4/93

162-069-33AAA LS Elev (msl,ft)=1787.51
UND Aquifer SI (ft.)=14-19

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/04/93	2.39	1785.12	09/15/93	2.29	1785.22
08/30/93	1.71	1785.80	10/04/93	3.50	1784.01
09/01/93	1.84	1785.67			

162-069-33AAB1 LS Elev (msl,ft)=1785.6
UND Aquifer SI (ft.)=30-35

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/04/93	3.01	1782.59	09/15/93	2.65	1782.95
08/30/93	2.86	1782.74	10/04/93	2.87	1782.73
09/01/93	19.71	1765.89			

162-069-33AAB2 LS Elev (msl,ft)=1786.05
UND Aquifer SI (ft.)=10-15

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/04/93	1.82	1784.23	09/15/93	1.32	1784.73
08/30/93	0.83	1785.22	10/04/93	2.80	1783.25
09/01/93	2.00	1784.05			

162-069-33AAC LS Elev (msl,ft)=1781.16
UND Aquifer SI (ft.)=18-28

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/31/93	0.04	1781.12	09/15/93	0.77	1780.39
09/01/93	0.70	1780.46	10/04/93	2.01	1779.15

162-069-33AAD LS Elev (msl,ft)=1778.89
UND Aquifer SI (ft.)=5-10

Date	Depth to Water (ft)	WL Elev (msl, ft)	Date	Depth to Water (ft)	WL Elev (msl, ft)
08/31/93	1.27	1777.62	09/15/93	1.73	1777.16
09/01/93	1.41	1777.48	10/04/93	2.81	1776.08

APPENDIX E

MAJOR ION AND TRACE-ELEMENT CONCENTRATIONS

Rolla Landfill Water Quality
Major Ions

Location	Screened Interval (ft)	Date Sampled	SiO_2	Fe	Mn	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl	F	NO_3	B	TDS	Hardness $CaCO_3$	as NCH	% Na	SAR	Spec Cond (µmho)	Temp (°C)	pH
			(milligrams per liter)																					
162-069-33AAA	14-19	09/01/93	22	0.03	0.69	150	59	82	5.8	448	0	420	14	0.2	1.2	0.08	976	620	250	22	1.4	1370	9	6.78
162-069-33AAB1	30-35	09/01/93	22	1.1	2.5	430	240	500	19	435	0	2700	84	0.3	0.1	0.62	4210	2100	1700	34	4.7	4290	6	6.62
162-069-33AAB2	10-15	09/01/93	26	0.1	0.28	470	860	700	12	866	0	5200	160	0.6	0.2	0.32	7860	4700	4000	24	4.4	6880	10	6.69
162-069-33AAC	18-28	09/01/93	24	0.05	0.84	140	78	640	15	569	0	1500	120	0.7	0	0.71	2800	670	200	67	11	3640	10	6.75
162-069-33AAD	5-10	09/01/93	34	0.09	0.33	300	300	530	10	759	0	1900	510	0.5	0.2	0.29	3960	2000	1400	37	5.2	4700	12	6.71

Trace Element Analyses

Location	Date Sampled	Selenium	Lead	Cadmium	Mercury	Arsenic	Molybdenum	Strontium
		(micrograms per liter)						
162-069-33AAA	9/1/93	0	0	0	0	1	9	580
162-069-33AAB1	9/1/93	0	0	0	0	0	13	2600
162-069-33AAB2	9/1/93	0	0	0	0	0	11	1300
162-069-33AAC	9/1/93	0	0	0	0	7	12	1100
162-069-33AAD	9/1/93	0	0	1	0	3	18	1300

APPENDIX F

VOLATILE ORGANIC COMPOUNDS
FOR WELL 162-069-33AAD

Volatile Organic Compounds
and
Minimum Concentrations

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

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

* Constituent Detection

VOC Constituents cont.

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

* Constituent Detection

APPENDIX G

VOLATILE ORGANIC COMPOUNDS FOR WELL 162-069-33AAC

Volatile Organic Compounds
and
Minimum Concentrations

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

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

* Constituent Detection

VOC Constituents cont.

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

* Constituent Detection