Hart Exhibit 15
Part 4 of 4
Docket No. E-2, Sub 1219

Table F-3

CONCENTRATION DATA: SOIL 20-3 pH MANIPULATION
(mg/L, except as noted)

LC20-3	DETECTION LIMIT	NOMINAL pH				
		2.0	2.5	3.0	3.5	4.0
Eh (mV)		450	454	433	420	280
Al	0.03	113	40	10.2	2.87	0.71
As	0.01					
B	0.02	0.06	0.081	0.092	0.09	0.082
Ba	0.002	0.372	0.173	0.096	0.066	0.047
C	0.05	0.04	0.52	0.48	0.48	0.12
Ca	0.01	31	31	28.2	23.6	17.4
Cd	0.0001					
Cl	0.15	804.31	328.04	166.35	88.7	35.69
Cr	0.0005	0.2663	0.0672	0.0194		
Cu	0.005	1.218	0.7317	0.0487	0.0066	
F	0.1	0.05	0.35	0.33	0.25	0.1
Fe	0.005	102	82	61.6	45.5	30.4
pH units (ACTUAL)		3.15	3.51	3.93	4.33	5.58
K	0.1	21.9	16.3	14.2	12.2	10.9
Li	0.005	0.173	0.098	0.063	0.044	0.028
Mg	0.1	32.6	7.1	3.7	2.7	1.9
Mn	0.005	4.21	3.21	1.97	1.19	0.792
Mo	0.01	0.09	0.07			
Na	0.03	2.53	2.43	2.4	2.37	2.28
Ni	0.02	0.09	0.05	0.03	0.03	
P	0.1	0.3	0.19	0.17	0.12	
SO4	0.15	56.52	60.25	63.63	67.47	74.7
Si	0.02	58	20	11.2	8.68	6.86
Sr	0.002	1.05	0.842	0.571	0.39	0.246
Zn	0.005	0.489	0.205	0.197	0.122	0.131

Table F-3

CONCENTRATION DATA: SOIL 20-3 pH MANIPULATION
(mg/L, except as noted)

LC20-3

	4.5	5.0	5.5	6.0	6.5	7.0	7.5
Eh (mV)	267	137	106	70	61	55	33
Al	0.15	0.05					
As							
B	0.083	0.077	0.063	0.065	0.055	0.059	0.052
Ba	0.053	0.044	0.036	0.032	0.044	0.042	0.035
C	0.16	0.2	0.2	0.44	0.2	0.44	0.72
Ca	10.9	6.73	2.87	2.44	1.88	2.06	1.36
Cd							
Cl	19.5	10.77	4.4	4.06	4.88	4.15	4.17
Cr							
Cu							
F	0.04	0.02	0.03		0.01		0.15
Fe	15.5	7.58	1.77	0.86	0.022	0.054	0.009
pH units (ACTUAL)	4.69	6.37	6.49	6.7	7.28	7.41	7.82
K	40.4	61.1	83.1	98.6	125	119	133
Li	0.016	0.008					
Mg	1.2	0.75	0.32	0.26	0.17	0.2	
Mn	0.562	0.343	0.181	0.157	0.034	0.067	
Mo							
Na	2.51	2.66	2.83	2.95	3.14	3.13	3.11
Ni							
P	0.1	0.11	0.15	0.15	0.14	0.12	0.14
SO4	82.2	92.38	106.97	150.35	122.18	142.74	158.1
Si	5.32	4.15	2.52	1.98	1.08	1.22	0.713
Sr	0.277	0.199	0.095	0.08	0.062	0.069	0.042
Zn	0.116	0.045	0.067	0.074	0.082	0.053	0.044

Table F-3

CONCENTRATION DATA: SOIL 20-3 pH MANIPULATION
(mg/L, except as noted)

LC20-3

	8.0	8.5	9.0	9.5	10.0	10.5	11.0
Eh (mV)	20	-24	-26	-55	-87	-103	-166
Al	0.04	0.091	0.18	0.33	1.63	9.73	25.5
As							
B	0.051	0.048	0.049	0.053	0.073	0.097	0.1
Ba	0.034	0.011	0.004	0.005			
C	1.2	1.64	2	2.84	5.32	12.28	6.64
Ca	0.76	0.43	0.15	0.07	0.02	0.02	0.04
Cd							
Cl	4.63	4.89	4.22	5.47	6.17	6.19	6.1
Cr							
Cu							
F	0.3	0.37	0.5	0.68	1.34	1.61	1.51
Fe	0.018	0.011	0.016	0.102	0.034	0.226	0.026
pH units (ACTUAL)	7.73	7.71	8.2	8.97	9.77	10.18	10.81
K	148	145	153	162	185	258	376
Li							
Mg							
Mn							
Mo						0.01	0.02
Na	3.11	2.97	2.91	2.8	2.03	1.47	1.31
Ni							
P	0.26	0.37	0.53	0.73	4	11.5	17.5
SO4	172.4	166.5	174.19	178.92	180.5	193.48	181.02
Si	0.542	0.498	0.485	0.536	0.678	1.87	4.84
Sr	0.024	0.012	0.004	0.003			
Zn	0.043	0.007	0.046	0.012	0.01	0.012	0.041

Table F-3

CONCENTRATION DATA: SOIL 20-3 pH MANIPULATION
(mg/L, except as noted)

LC20-3

	11.5	12.0	N-1	N-2	N-3
Eh (mV)	-179	-182	-73	-65	-49
Al	45	82	0.24	0.24	0.28
As					
B	0.108	0.11	0.073	0.082	0.078
Ba			0.044	0.039	0.04
C	8.48	10.48	0.24	0.28	0.36
Ca	0.03	0.08	11.2	12.7	12.7
Cd					
Cl	6.24	4.38	3.97	3.87	4.29
Cr					
Cu					
F	1.36	0.83	0.07	0.04	0.06
Fe	0.463	0.093	18	20.8	19.8
pH units (ACTUAL)	11.56	12.08	7.43	7.54	7.47
K	580	1020	13.3	12.4	12.2
Li			0.017	0.019	0.019
Mg			1.25	1.4	1.42
Mn			0.501	0.563	0.561
Mo	0.08	0.14			
Na	1.36	1.96	2.26	2.22	2.3
Ni					
P	22.8	26.3	0.19		
SO4	184.26	183.28	74.87	84.14	84.44
Si	9.13	22.8	5.47	6.04	6.1
Sr			0.161	0.164	0.163
Zn	0.014	0.013	0.063	0.096	0.088

Table F-4

CONCENTRATION DATA: SOIL LC12 pH MANIPULATION
(mg/L, except as noted)

LC12	DETECTION LIMIT	NOMINAL pH				
		2.0	2.5	3.0	3.5	4.0
Eh (mv)		799	764	732	689	663
Al	0.03	78	20.8	6.38	0.27	
As	0.01					
B	0.02				0.035	0.042
Ba	0.002	17.7	10.5	6.26	1.36	0.416
C	0.05	0.08	0.08	0.12	0.24	4.68
Ca	0.01	3.4	2.25	2.16	1.26	0.576
Cd	0.0001	0.0022	0.0018	0.0026	0.0021	0.003
Cl	0.15	1042.75	283.27	148.91	63.27	32.33
Cr	0.0005	0.023	0.0025	0.0005	0.0007	
Cu	0.005	0.0883	0.114	0.0189		0.071
F	0.1	0.13	0.33	0.3	0.15	0.52
Fe	0.005	26	0.871	0.11		
pH units (ACTUAL)		1.94	2.56	3.02	3.91	4.31
K	0.1	17.7	11	8.9	11.3	4.1
Li	0.005	0.122	0.025	0.01		
Mg	0.1	40.3	24.5	21.3	14.5	7.59
Mn	0.005	6.42	3.38	2.89	1.72	0.876
Mo	0.01					
Na	0.03	1.18	1.24	1.07	1.29	1.18
Ni	0.02	0.11				
P	0.1					
SO4	0.15	3.18	1.03	3.29	1.92	2.41
Si	0.02	54.8	17.8	9.86	5.38	3.3
Sr	0.002	0.075	0.054	0.046	0.025	0.009
Zn	0.005	0.812	0.35	0.269	0.19	0.117

Table F-4

CONCENTRATION DATA: SOIL LC12 pH MANIPULATION
(mg/L, except as noted)

LC12

	4.5	5.0	5.5	6.0	6.5	7.0	7.5
Eh (mV)	635	622	593	587	574	569	569
Al	0.03						
As							
B	0.073	0.068	0.065	0.065	0.06	0.063	0.054
Ba	0.149	0.018	0.051	0.065	0.068	0.014	0.021
C	4.4	2.92	0.68	0.4	0.8	7.28	6.6
Ca	0.327	0.093	0.071	0.026	0.071	0.019	
Cd	0.0011	0.0008	0.0005	0.0008			0.008
Cl	17.24	1.32	2.53	2.55	3	3.52	2.3
Cr		0.0006	0.009	0.9	0.009	0.0006	0.0008
Cu			0.0232	0.0249	0.011		0.0085
F	0.12	0.04	0.04	0.17	0.05	0.05	0.09
Fe	0.013	0.018	0.009	0.267	0.006	0.007	0.007
pH units (ACTUAL)	4.65	5.08	5.35	5.45	5.62	5.73	6.05
K	3.8	1.4	5.9	6.2	10.8	7.3	9.7
Li							
Mg	3.88	0.58	0.45	0.23	0.36	0.1	0.11
Mn	0.693	0.084	0.48	0.055	0.038	0.009	0.01
Mo							
Na	1.17	0.88	1.12	1.18	1.24	0.78	0.89
Ni							
P							
SO4	3.65	5.64	13.38	7.82	15.39	6.72	11.78
Si	2.52	1.8	1.54	1.43	1.1	1.05	0.81
Sr	0.005						
Zn	0.102	0.07	0.055	0.052	0.064	0.036	0.033

Table F-4

CONCENTRATION DATA: SOIL LC12 pH MANIPULATION
(mg/L, except as noted)

LC12

	8.0	8.5	9.0	9.5	10.0	10.5	11.0
Eh (mV)	556	546	517	486	476	459	448
Al		0.06	0.17	0.55	0.57	4.47	10.1
As							
B	0.061	0.051	0.046	0.065	0.065	0.074	0.077
Ba	0.061	0.016	0.006	0.007	0.008	0.005	0.005
C	2.64	6.48	8.64	4.16	14.36	32.48	13.04
Ca	0.028	0.36	0.071	0.051	0.033	0.01	
Cd	0.0006	0.0022	0.0007	0.0007			0.002
Cl	3.92	3.55	4.5	2.67	3.59	3.38	2.45
Cr	0.0013	0.0035	0.008	0.0068	0.0101	0.0085	0.0186
Cu		0.024	0.011	0.007	0.008		
F	0.11	0.33	1.25	1.86	2.15	3.14	2.55
Fe	0.01	0.023	0.04	0.237	0.035	0.026	0.015
pH units (ACTUAL)	6.25	6.89	8.16	9.05	9.53	10.38	10.73
K	14	12.2	17.3	18.4	26.5	51.8	104
Li							
Mg	0.18	0.32					
Mn	0.014		0.008	0.024	0.007	0.007	0.006
Mo							
Na	1.09	0.85	0.88	0.71	0.9	0.76	0.87
Ni							
P							
SO4	17.49	12.32	13.48	11.7	18.45	19.74	26.61
Si	0.76	0.52	0.41	0.54	0.41	1.17	2.61
Sr							
Zn	0.055	0.044	0.022	0.092	0.092	0.012	0.018

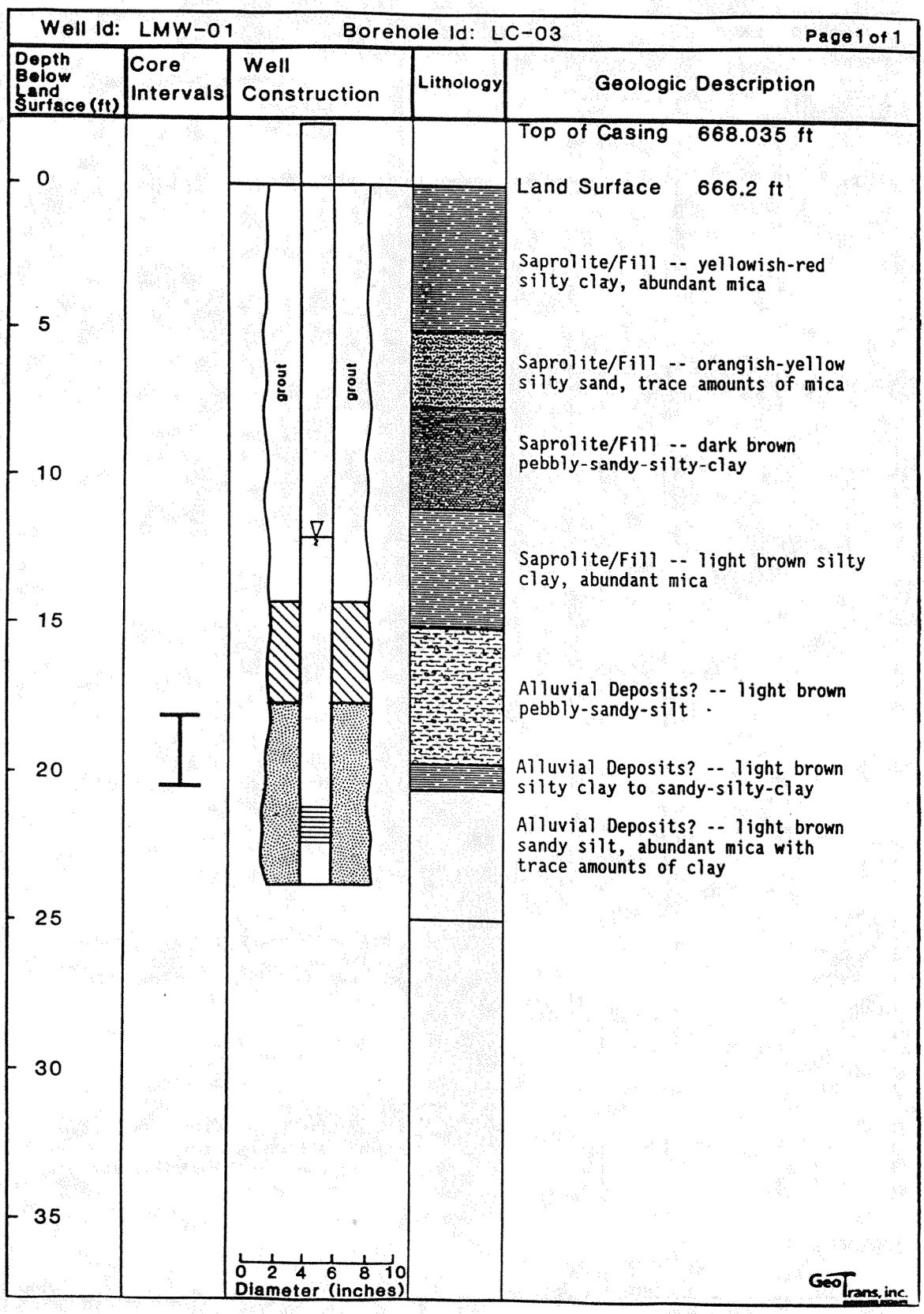
Table F-4

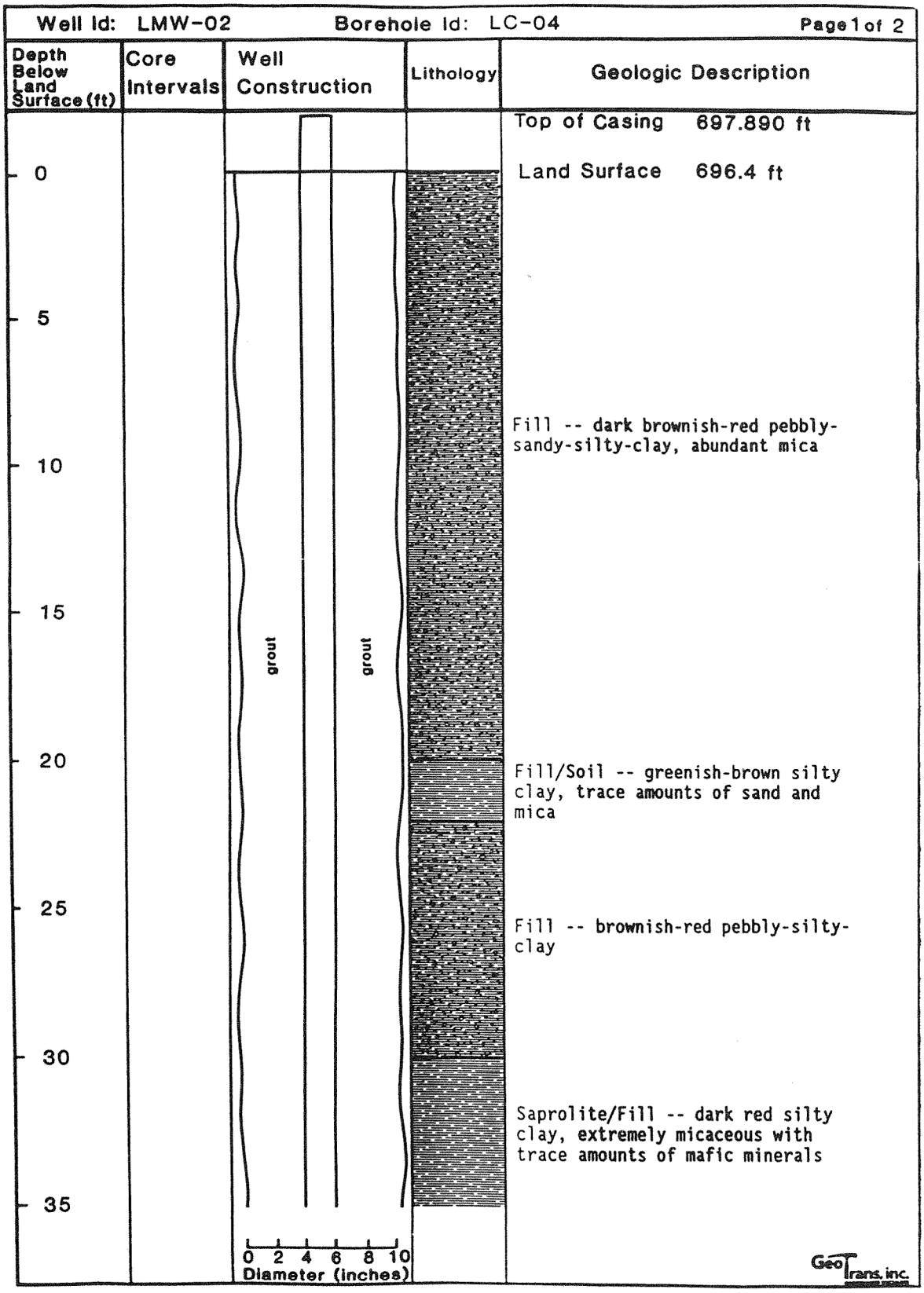
CONCENTRATION DATA: SOIL LC12 pH MANIPULATION
(mg/L, except as noted)

	LC12	
	11.5	12.0
Eh (mV)	429	339
Al	28.8	83
As		
B	0.079	0.09
Ba		0.005
C	39.04	141.6
Ca		0.067
Cd		0.0005
Cl	2.54	4.44
Cr	0.0186	0.0257
Cu	0.017	0.024
F	2.42	1.96
Fe		0.027
pH units (ACTUAL)	11.3	11.94
K	295	1090
Li		
Mg		
Mn		
Mo		
Na	1.22	3.54
Ni		
P		
SO4	29.11	39.63
Si	10.8	36.7
Sr		
Zn	0.022	0.03

Appendix G

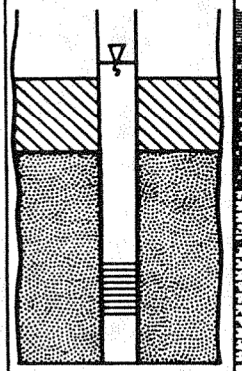
MONITOR WELL LOGS


Well Id: LMW-01
Borehole Id: LC-03
Page 1 of 1
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
Top of Casing 668.035 ft
Land Surface 666.2 ft
0
5
10
15
20
25
30
35
grout
grout
Saprolite/Fill -- yellowish-red silty clay, abundant mica
Saprolite/Fill -- orangish-yellow silty sand, trace amounts of mica
Saprolite/Fill -- dark brown pebbly-sandy-silty-clay
Saprolite/Fill -- light brown silty clay, abundant mica
Alluvial Deposits? -- light brown pebbly-sandy-silt
Alluvial Deposits? -- light brown silty clay to sandy-silty-clay
Alluvial Deposits? -- light brown sandy silt, abundant mica with trace amounts of clay
0 2 4 6 8 10
Diameter (inches)
GeoTrans, inc.

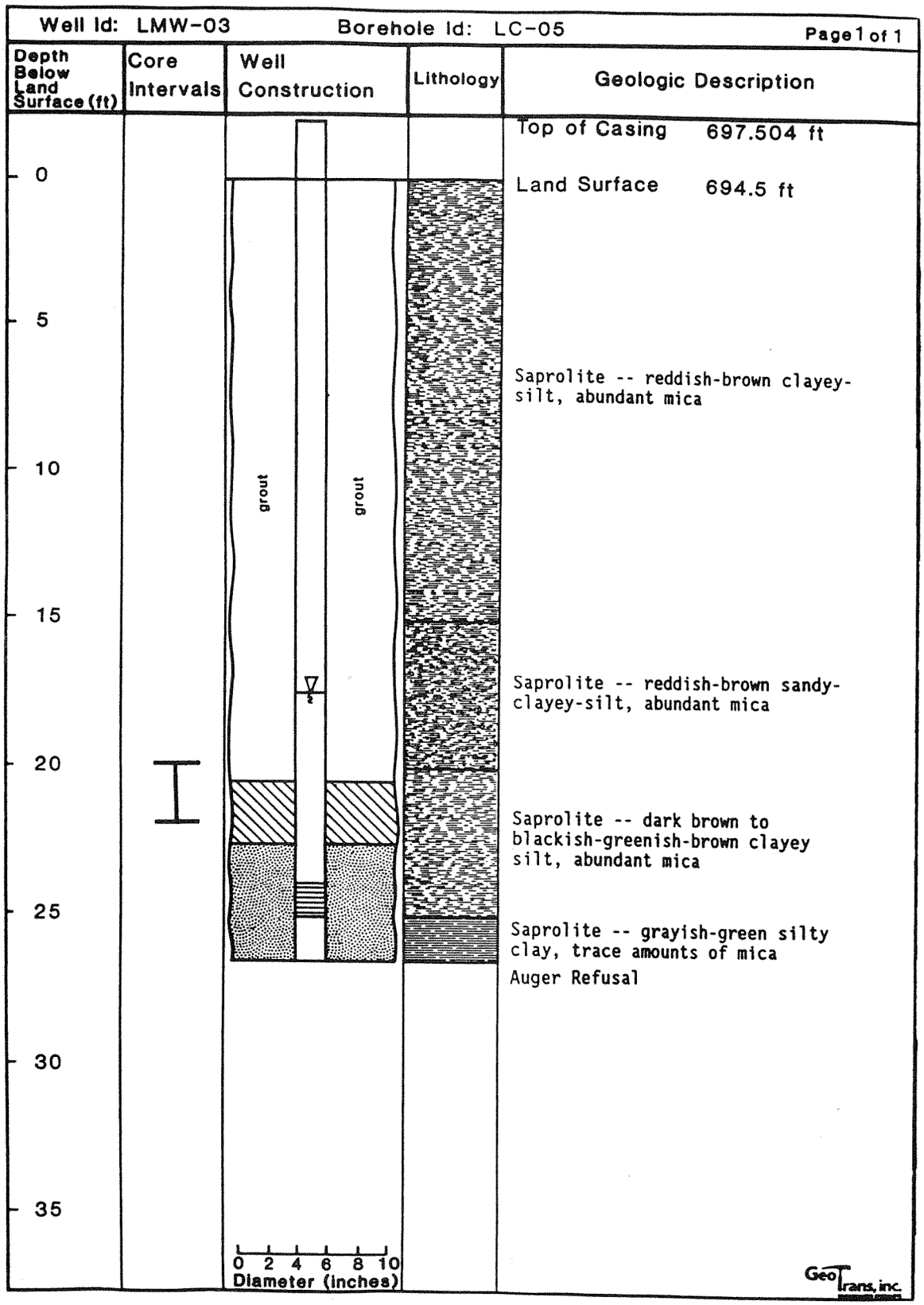

Well Id: LMW-02
Borehole Id: LC-04
Page 1 of 2
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
Top of Casing 697.890 ft
Land Surface 696.4 ft
0
5
10
15
20
25
30
35
grout
grout
Fill -- dark brownish-red pebbly-sandy-silty-clay, abundant mica
Fill/Soil -- greenish-brown silty clay, trace amounts of sand and mica
Fill -- brownish-red pebbly-silty-clay
Saprolite/Fill -- dark red silty clay, extremely micaceous with trace amounts of mafic minerals
0 2 4 6 8 10
Diameter (inches)
GeoTrans, inc.

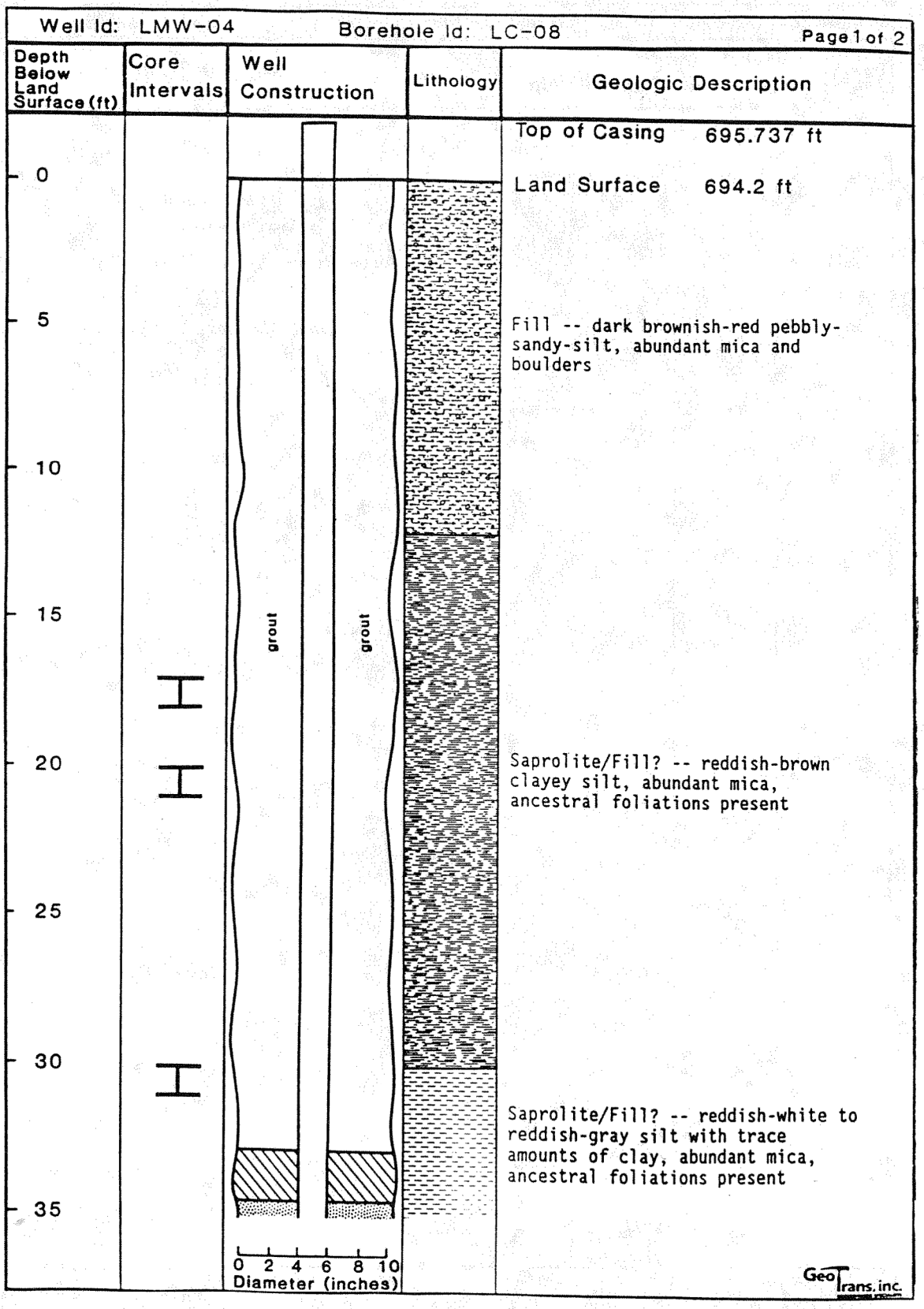
Well Id: LMW-02 Borehole Id: LC-04 Page 2 of 2

Depth Below Land Surface (ft)	Core Intervals	Well Construction	Lithology	Geologic Description
35				
40				Saprolite? -- brownish-greenish-black sandy silt, abundant mica; gravel layer at 43 feet
45				Auger Refusal

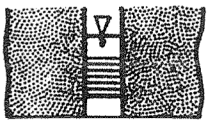


GeoTrans, inc.

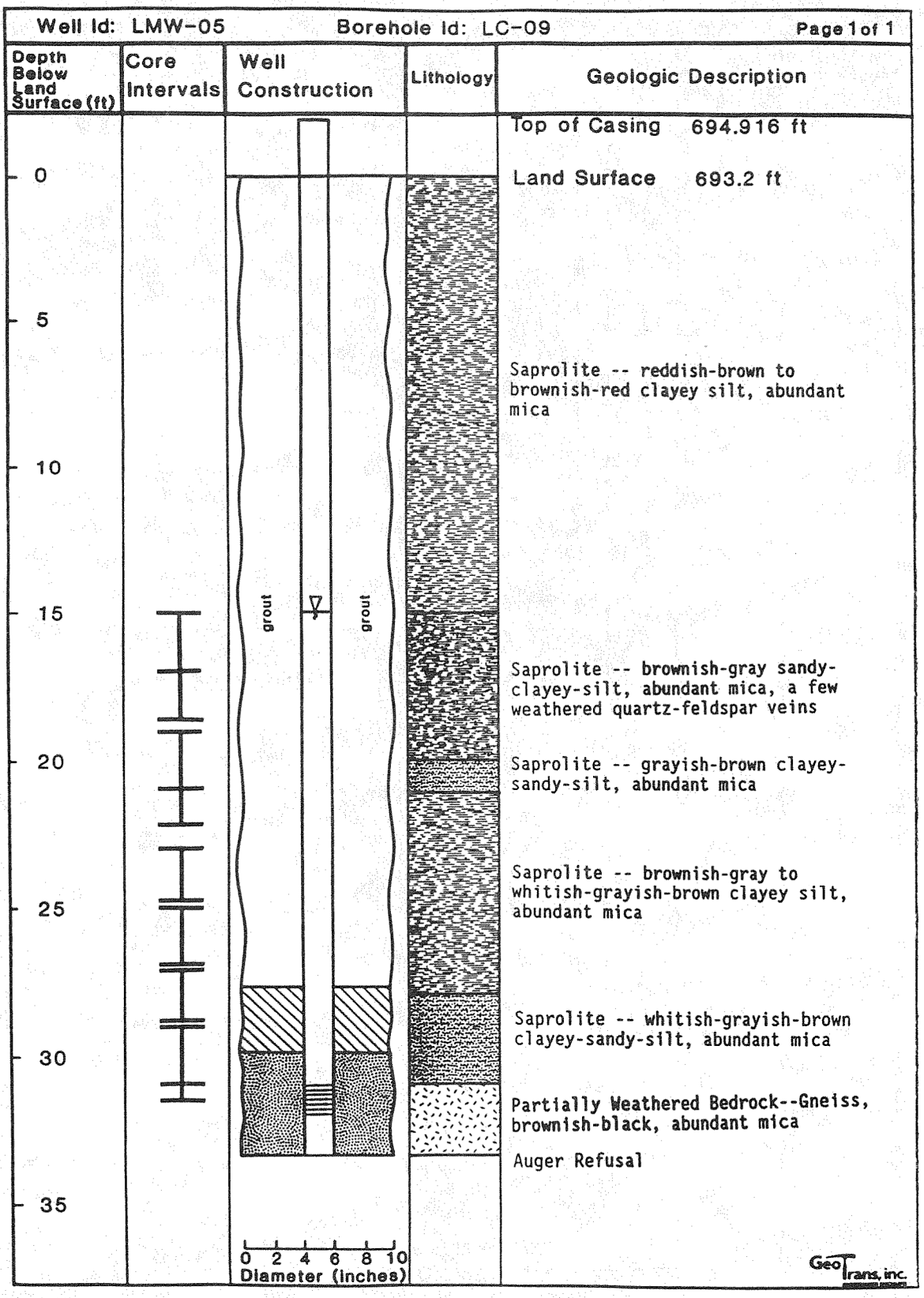

Well Id: LMW-03
Borehole Id: LC-05
Page 1 of 1
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
Top of Casing 697.504 ft
Land Surface 694.5 ft
0
5
10
15
20
25
30
35
grout
grout
Saprolite -- reddish-brown clayey-silt, abundant mica
Saprolite -- reddish-brown sandy-clayey-silt, abundant mica
Saprolite -- dark brown to blackish-greenish-brown clayey silt, abundant mica
Saprolite -- grayish-green silty clay, trace amounts of mica
Auger Refusal
0 2 4 6 8 10
Diameter (inches)
GeoTrans, inc.


Well Id: LMW-04
Borehole Id: LC-08
Page 1 of 2
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
Top of Casing 695.737 ft
Land Surface 694.2 ft
0
5
10
15
20
25
30
35
grout
grout
Fill -- dark brownish-red pebbly-sandy-silt, abundant mica and boulders
Saprolite/Fill? -- reddish-brown clayey silt, abundant mica, ancestral foliations present
Saprolite/Fill? -- reddish-white to reddish-gray silt with trace amounts of clay, abundant mica, ancestral foliations present
0 2 4 6 8 10
Diameter (inches)
GeoTrans, inc.

Well Id: LMW-04 Borehole Id: LC-08 Page 2 of 2

Depth Below Land Surface (ft)	Core Intervals	Well Construction	Lithology	Geologic Description
35				Partially Weathered Bedrock, Schist/Gneiss Auger Refusal
40				

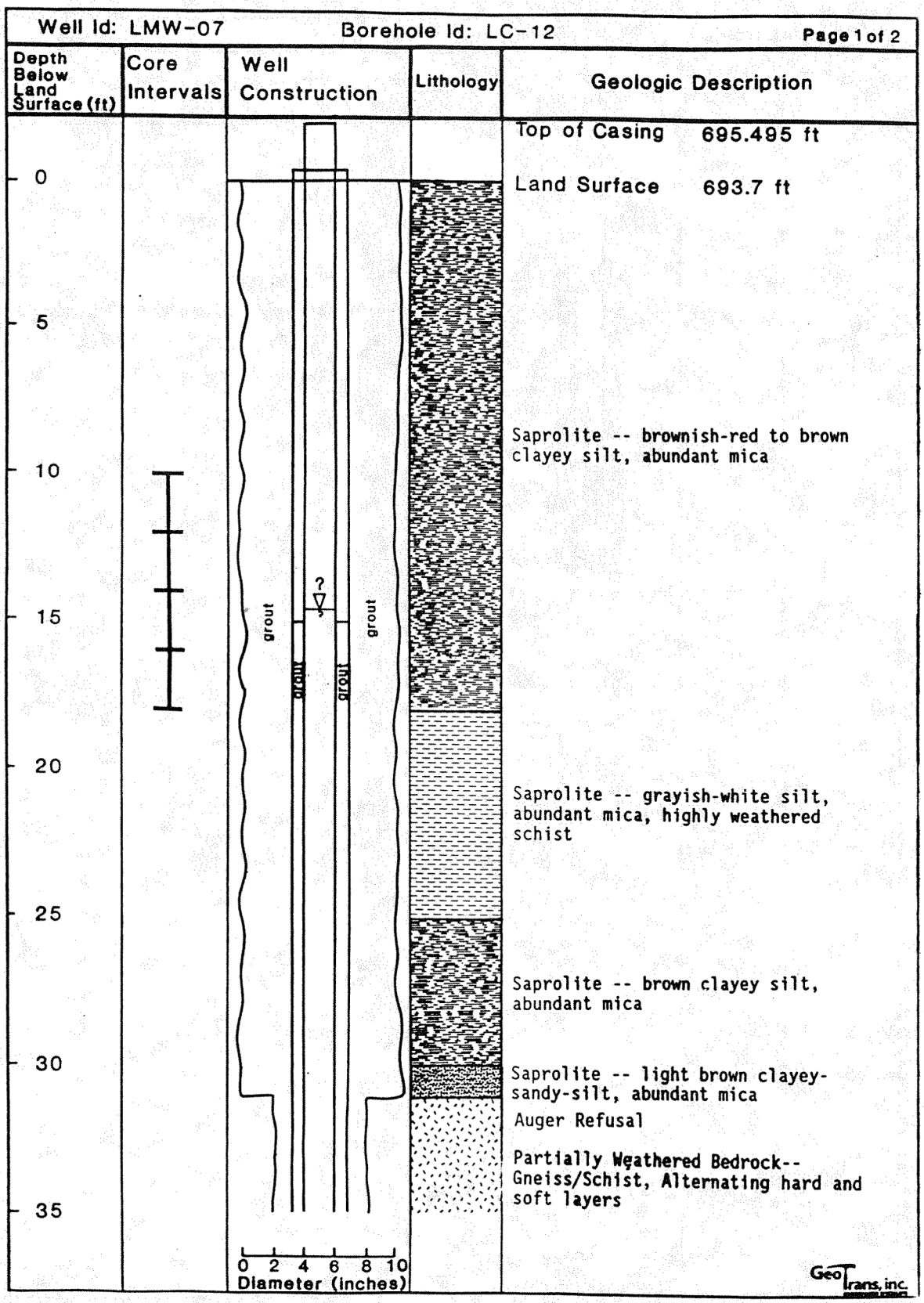
GeoTrans, inc.

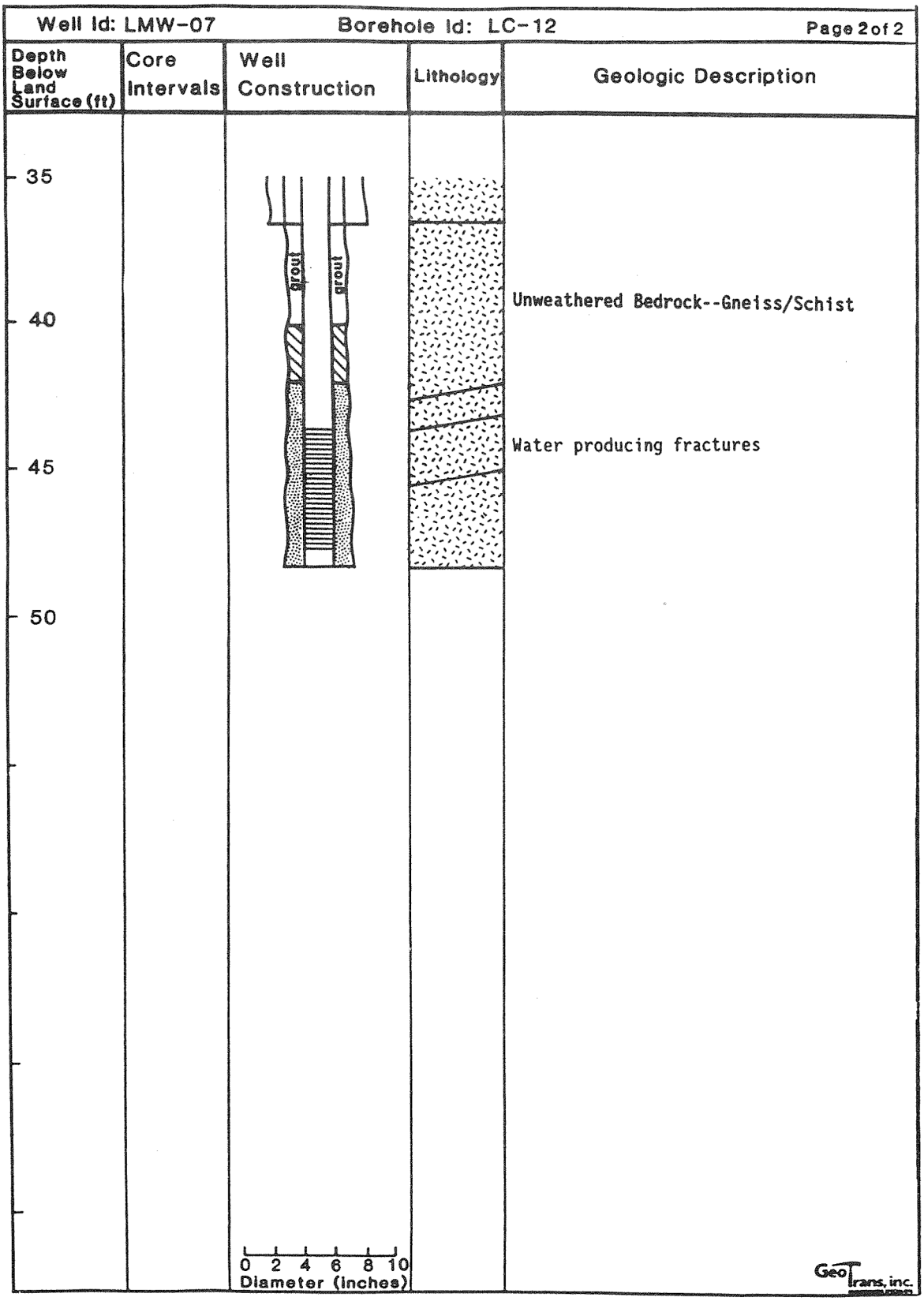

Well Id: LMW-05
Borehole Id: LC-09
Page 1 of 1
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
Top of Casing 694.916 ft
Land Surface 693.2 ft
0
5
10
15
20
25
30
35
grout
grout
Saprolite -- reddish-brown to brownish-red clayey silt, abundant mica
Saprolite -- brownish-gray sandy-clayey-silt, abundant mica, a few weathered quartz-feldspar veins
Saprolite -- grayish-brown clayey-sandy-silt, abundant mica
Saprolite -- brownish-gray to whitish-grayish-brown clayey silt, abundant mica
Saprolite -- whitish-grayish-brown clayey-sandy-silt, abundant mica
Partially Weathered Bedrock--Gneiss, brownish-black, abundant mica
Auger Refusal
0 2 4 6 8 10
Diameter (inches)
GeoTrans, inc.

Well Id: LMW-06 Borehole Id: LC-10 Page 1 of 1

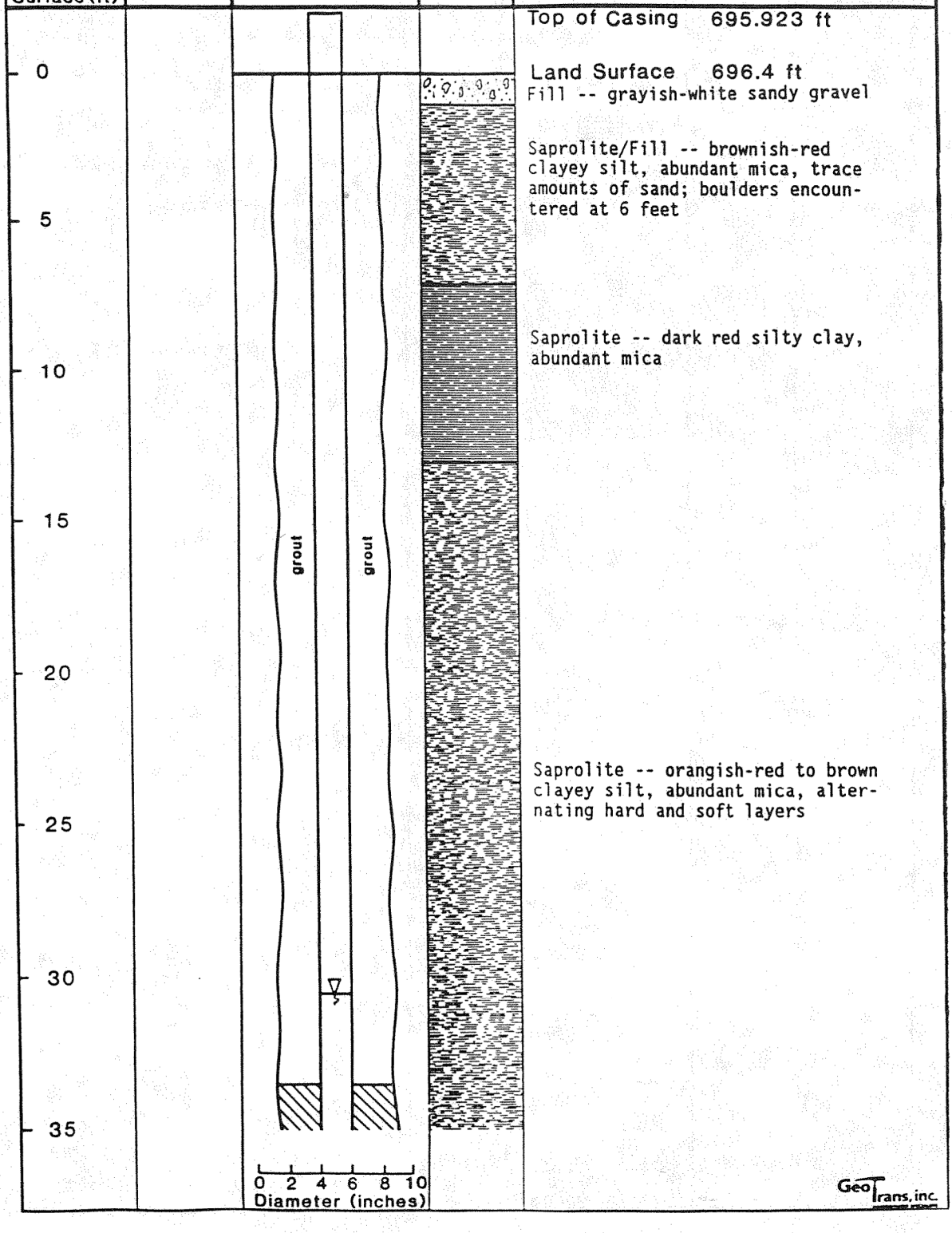
Depth Below Land Surface (ft)	Core Intervals	Well Construction	Lithology	Geologic Description
0				Top of Casing 695.708 ft Land Surface 693.7 ft
5		grout grout		Saprolite -- reddish-brown to brownish-red clayey-silt, abundant mica
10				
15				Saprolite -- brownish-gray sandy-clayey-silt, abundant mica
20				
25				
30				
35		0 2 4 6 8 10 Diameter (inches)		

GeoTrans, inc.

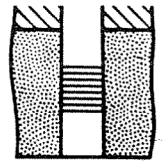
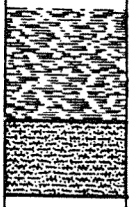

Well Id: LMW-07
Borehole Id: LC-12
Page 1 of 2
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
Top of Casing 695.495 ft
Land Surface 693.7 ft
0
5
10
15
20
25
30
35
grout
grout
grout
grout
?
Saprolite -- brownish-red to brown clayey silt, abundant mica
Saprolite -- grayish-white silt, abundant mica, highly weathered schist
Saprolite -- brown clayey silt, abundant mica
Saprolite -- light brown clayey-sandy-silt, abundant mica
Auger Refusal
Partially Weathered Bedrock-- Gneiss/Schist, Alternating hard and soft layers
0 2 4 6 8 10
Diameter (inches)
GeoTrans, inc.


Well Id: LMW-07
Borehole Id: LC-12
Page 2 of 2
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
35
40
45
50
grout
grout
Unweathered Bedrock--Gneiss/Schist
Water producing fractures
0 2 4 6 8 10
Diameter (inches)
GeoTrans, inc.

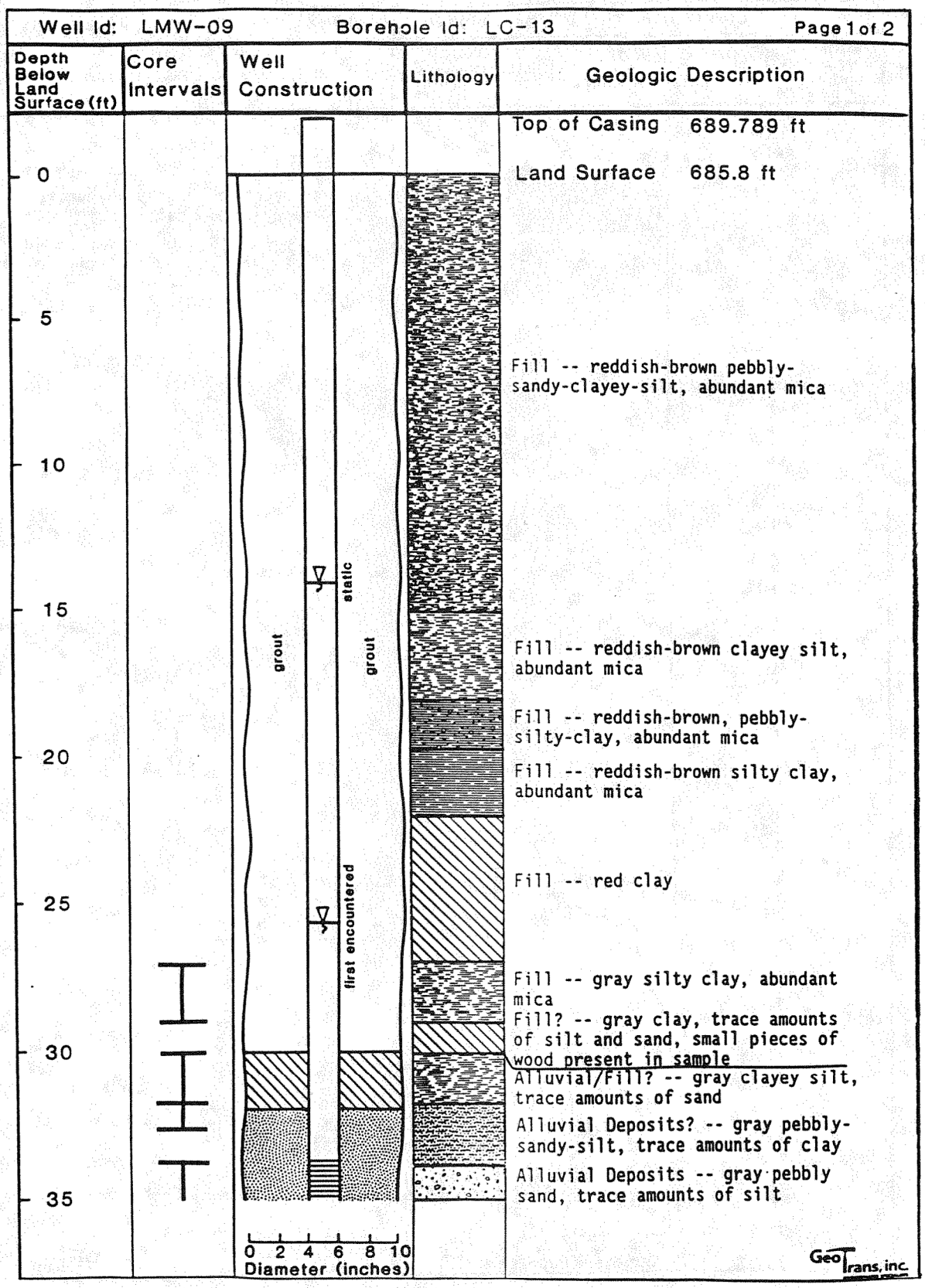
Well Id: LMW-08 Borehole Id: LC-11 Page 1 of 2



Well Id: LMW-08 Borehole Id: LC-11 Page 2 of 2

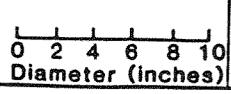
Depth Below Land Surface (ft)	Core Intervals	Well Construction	Lithology	Geologic Description
35				Saprolite -- brown to black sandy silt, partially consolidated, highly weathered schist
40				Auger Refusal

GeoTrans, inc.


Well Id: LMW-09
Borehole Id: LC-13
Page 1 of 2
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
Top of Casing 689.789 ft
Land Surface 685.8 ft
0
5
10
15
20
25
30
35
grout
static
grout
first encountered
0 2 4 6 8 10
Diameter (inches)
Fill -- reddish-brown pebbly-sandy-clayey-silt, abundant mica
Fill -- reddish-brown clayey silt, abundant mica
Fill -- reddish-brown, pebbly-silty-clay, abundant mica
Fill -- reddish-brown silty clay, abundant mica
Fill -- red clay
Fill -- gray silty clay, abundant mica
Fill? -- gray clay, trace amounts of silt and sand, small pieces of wood present in sample
Alluvial/Fill? -- gray clayey silt, trace amounts of sand
Alluvial Deposits? -- gray pebbly-sandy-silt, trace amounts of clay
Alluvial Deposits -- gray pebbly sand, trace amounts of silt
GeoTrans, inc.

Well Id: LMW-09 Borehole Id: LC-13 Page 2 of 2

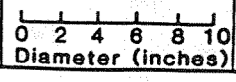
Depth Below Land Surface (ft)	Core Intervals	Well Construction	Lithology	Geologic Description
35				Alluvial Deposits -- grayish- white pebbly-sandy-clayey-silt
40				



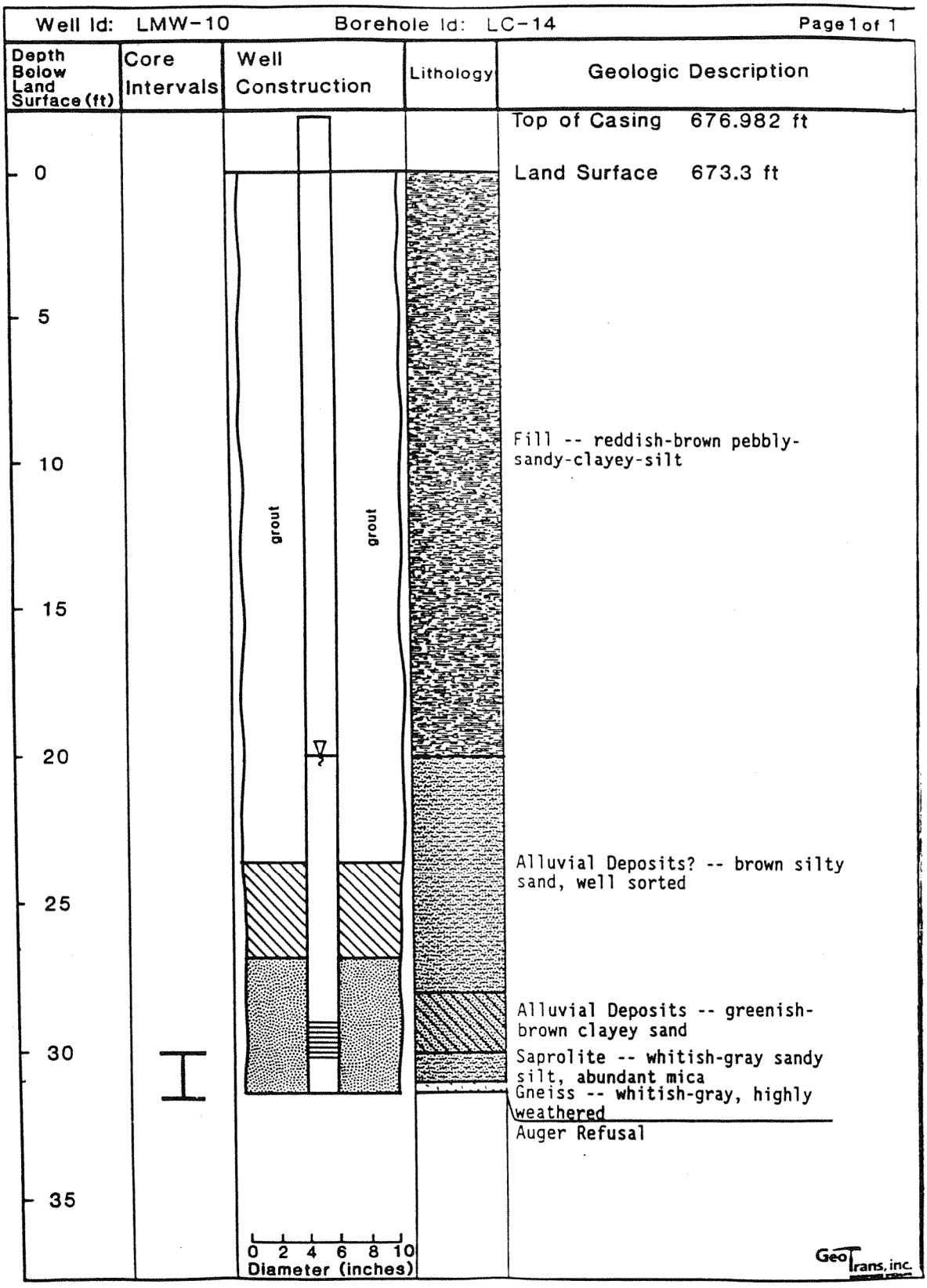
GeoTrans, inc.

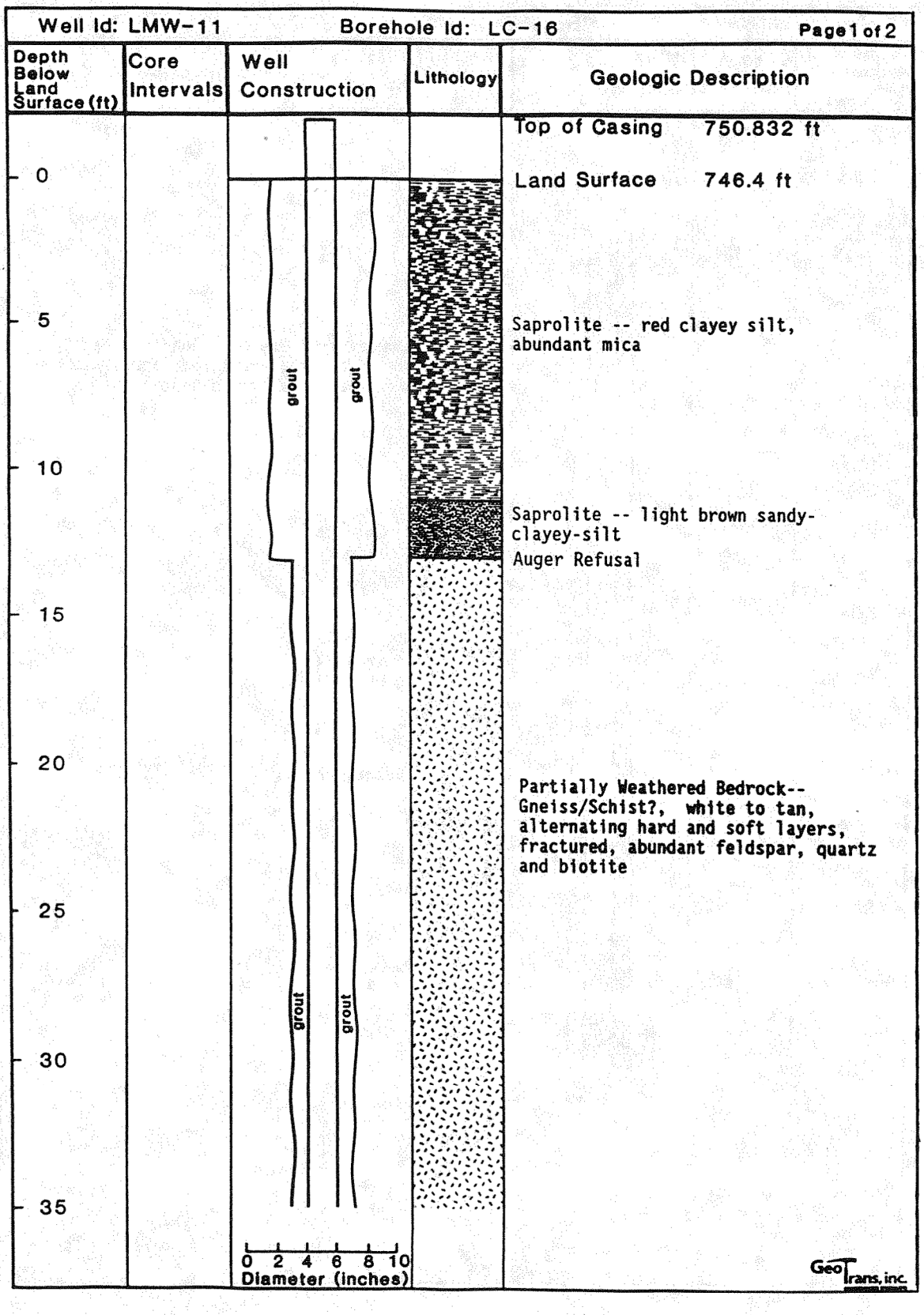
Well Id: LMW-09 Borehole Id: LC-13 Page 2 of 2

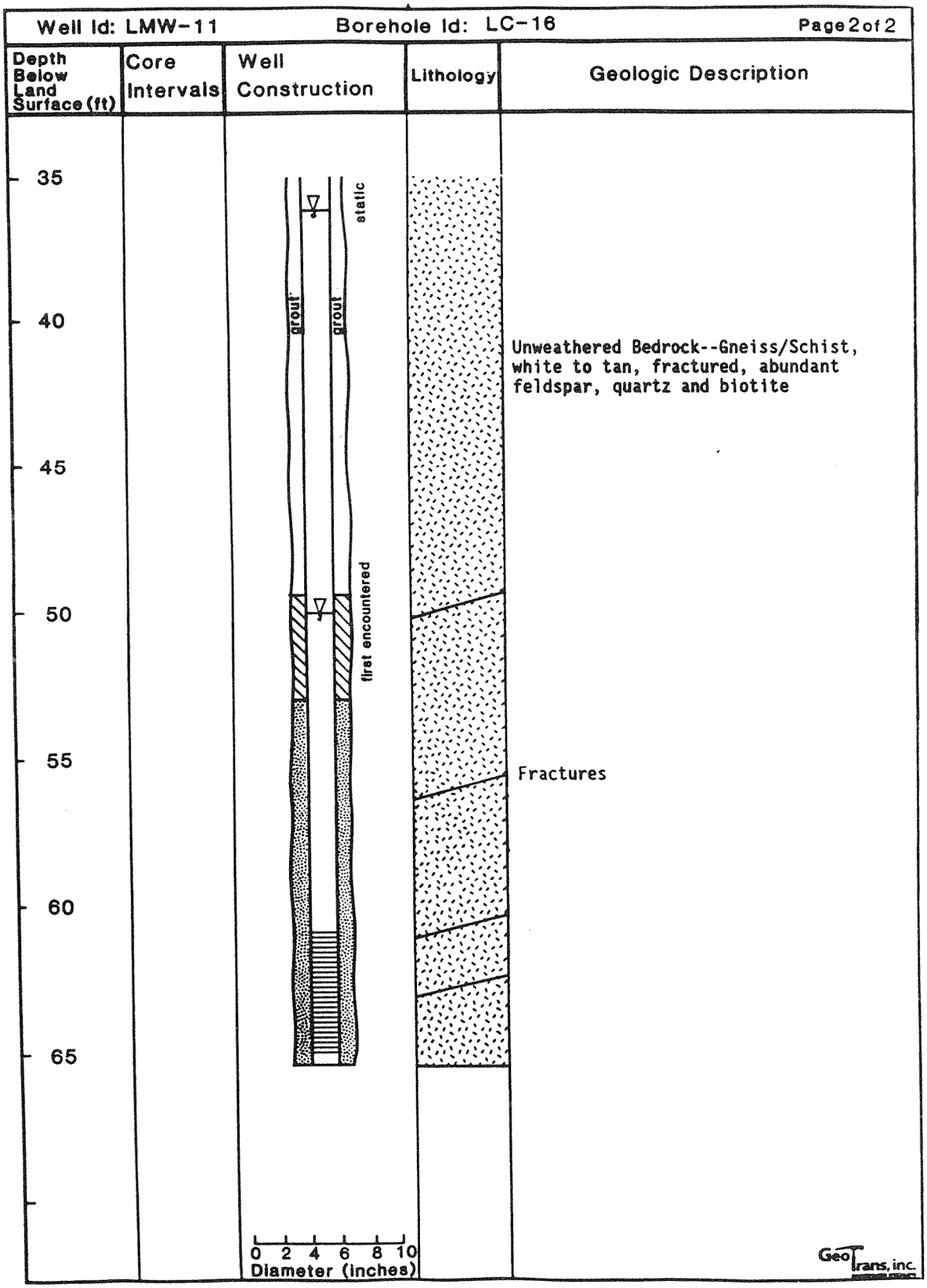
Depth Below Land Surface (ft)	Core Intervals	Well Construction	Lithology	Geologic Description
35				Alluvial Deposits -- grayish- white pebbly-sandy-clayey-silt
40				

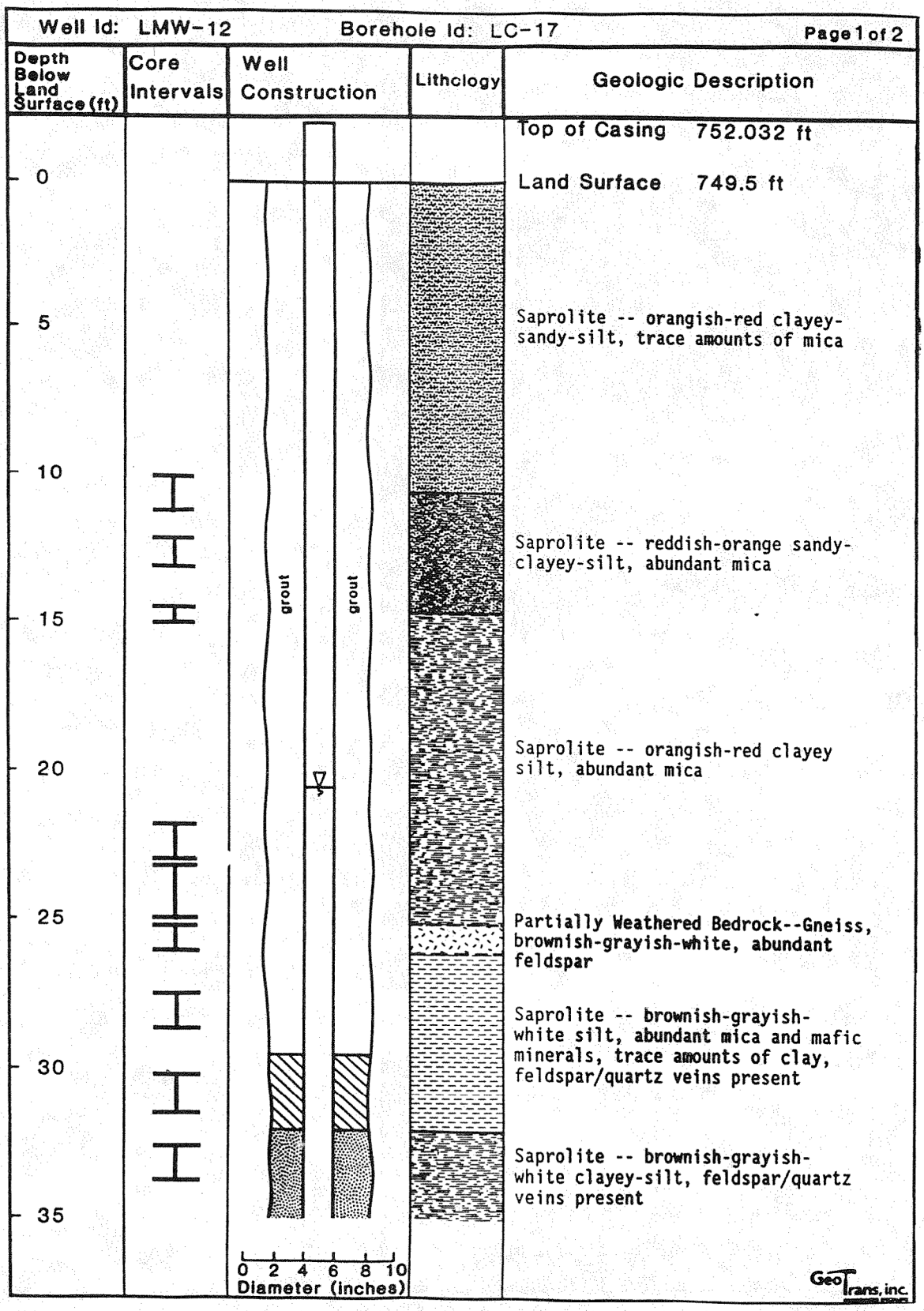


GeoTrans, inc.


Well Id: LMW-10
Borehole Id: LC-14
Page 1 of 1
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
Top of Casing 676.982 ft
Land Surface 673.3 ft
0
5
10
15
20
25
30
35
grout
grout
Fill -- reddish-brown pebbly-sandy-clayey-silt
Alluvial Deposits? -- brown silty sand, well sorted
Alluvial Deposits -- greenish-brown clayey sand
Saprolite -- whitish-gray sandy silt, abundant mica
Gneiss -- whitish-gray, highly weathered
Auger Refusal
0 2 4 6 8 10
Diameter (inches)
GeoTrans, inc.

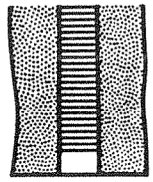

Well Id: LMW-11
Borehole Id: LC-16
Page 1 of 2
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
Top of Casing 750.832 ft
Land Surface 746.4 ft
0
5
10
15
20
25
30
35
grout
grout
grout
grout
Saprolite -- red clayey silt, abundant mica
Saprolite -- light brown sandy-clayey-silt
Auger Refusal
Partially Weathered Bedrock-- Gneiss/Schist?, white to tan, alternating hard and soft layers, fractured, abundant feldspar, quartz and biotite
0 2 4 6 8 10
Diameter (inches)
GeoTrans, inc.

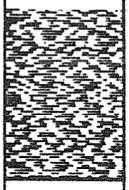

Well Id: LMW-11
Borehole Id: LC-16
Page 2 of 2
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
35
40
45
50
55
60
65
static
grout
grout
first encountered
Unweathered Bedrock--Gneiss/Schist, white to tan, fractured, abundant feldspar, quartz and biotite
Fractures
0 2 4 6 8 10
Diameter (inches)
GeoTrans, inc.

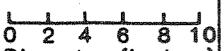

Well Id: LMW-12
Borehole Id: LC-17
Page 1 of 2
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
Top of Casing 752.032 ft
Land Surface 749.5 ft
0
5
10
15
20
25
30
35
grout
grout
Saprolite -- orangish-red clayey-sandy-silt, trace amounts of mica
Saprolite -- reddish-orange sandy-clayey-silt, abundant mica
Saprolite -- orangish-red clayey silt, abundant mica
Partially Weathered Bedrock--Gneiss, brownish-grayish-white, abundant feldspar
Saprolite -- brownish-grayish-white silt, abundant mica and mafic minerals, trace amounts of clay, feldspar/quartz veins present
Saprolite -- brownish-grayish-white clayey-silt, feldspar/quartz veins present
0 2 4 6 8 10
Diameter (inches)
GeoTrans, inc.

Well Id: LMW-12 Borehole Id: LC-17 Page 2 of 2

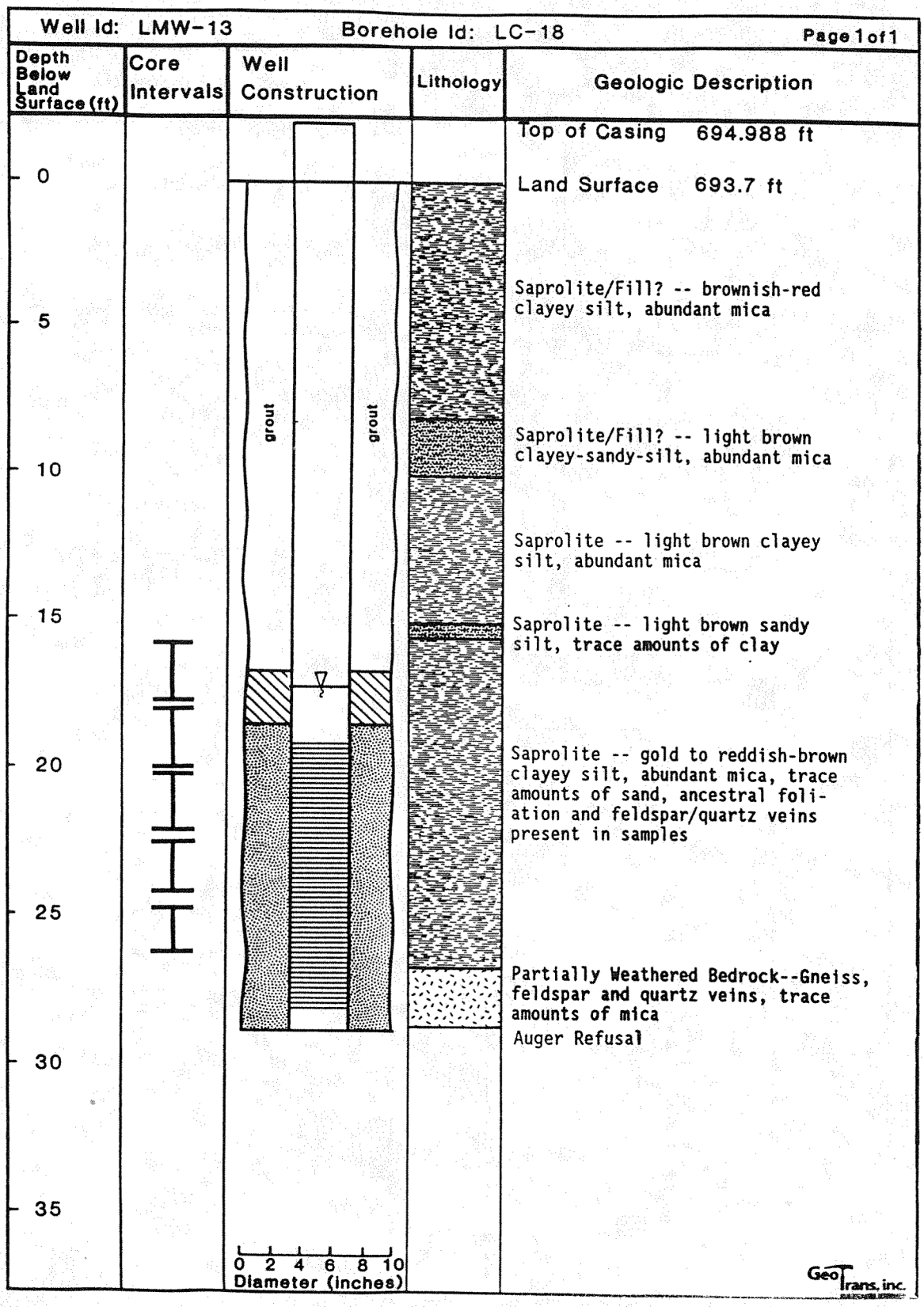
Depth Below Land Surface (ft)	Core Intervals	Well Construction	Lithology	Geologic Description
35				
40				







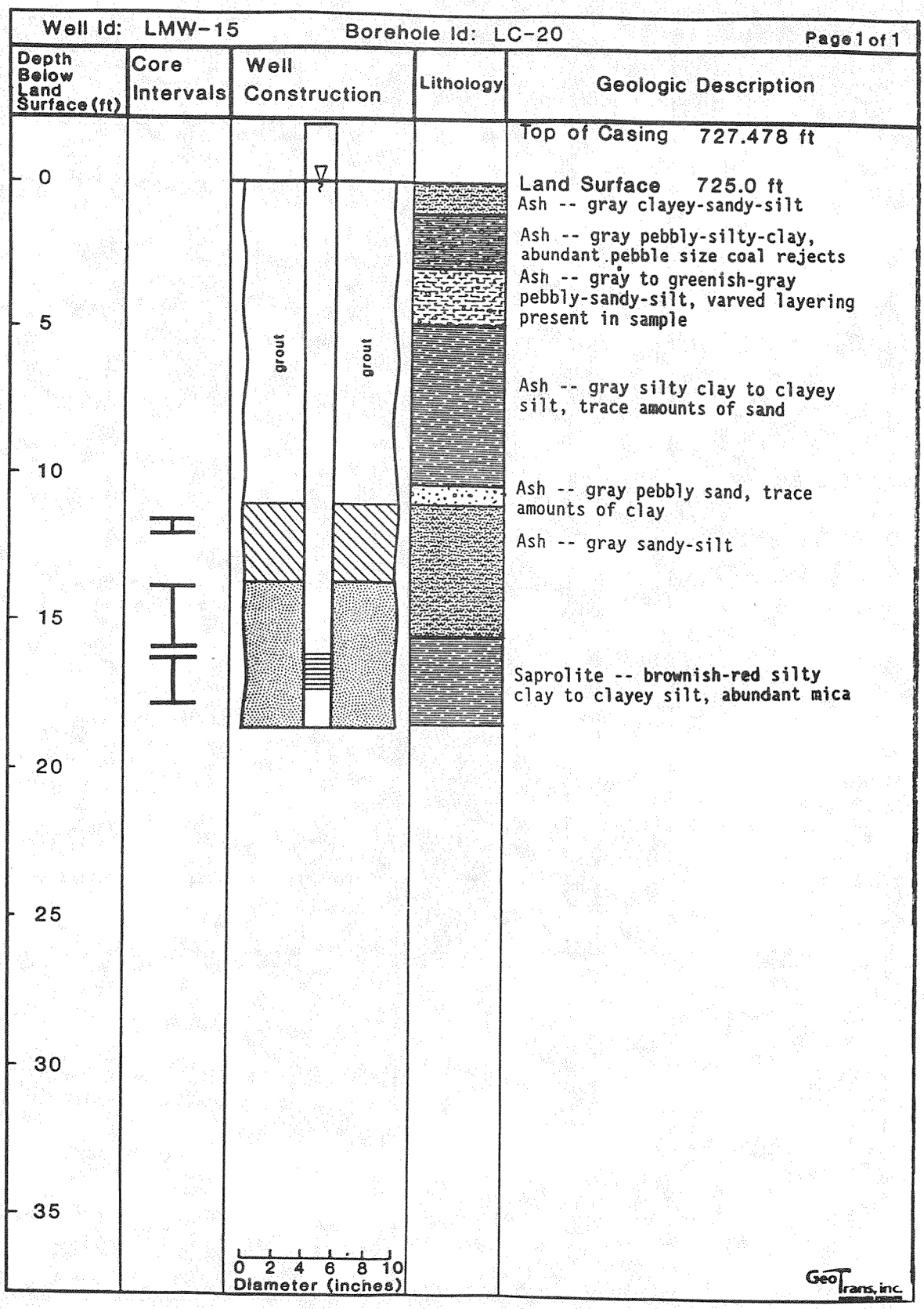
GeoTrans, inc.

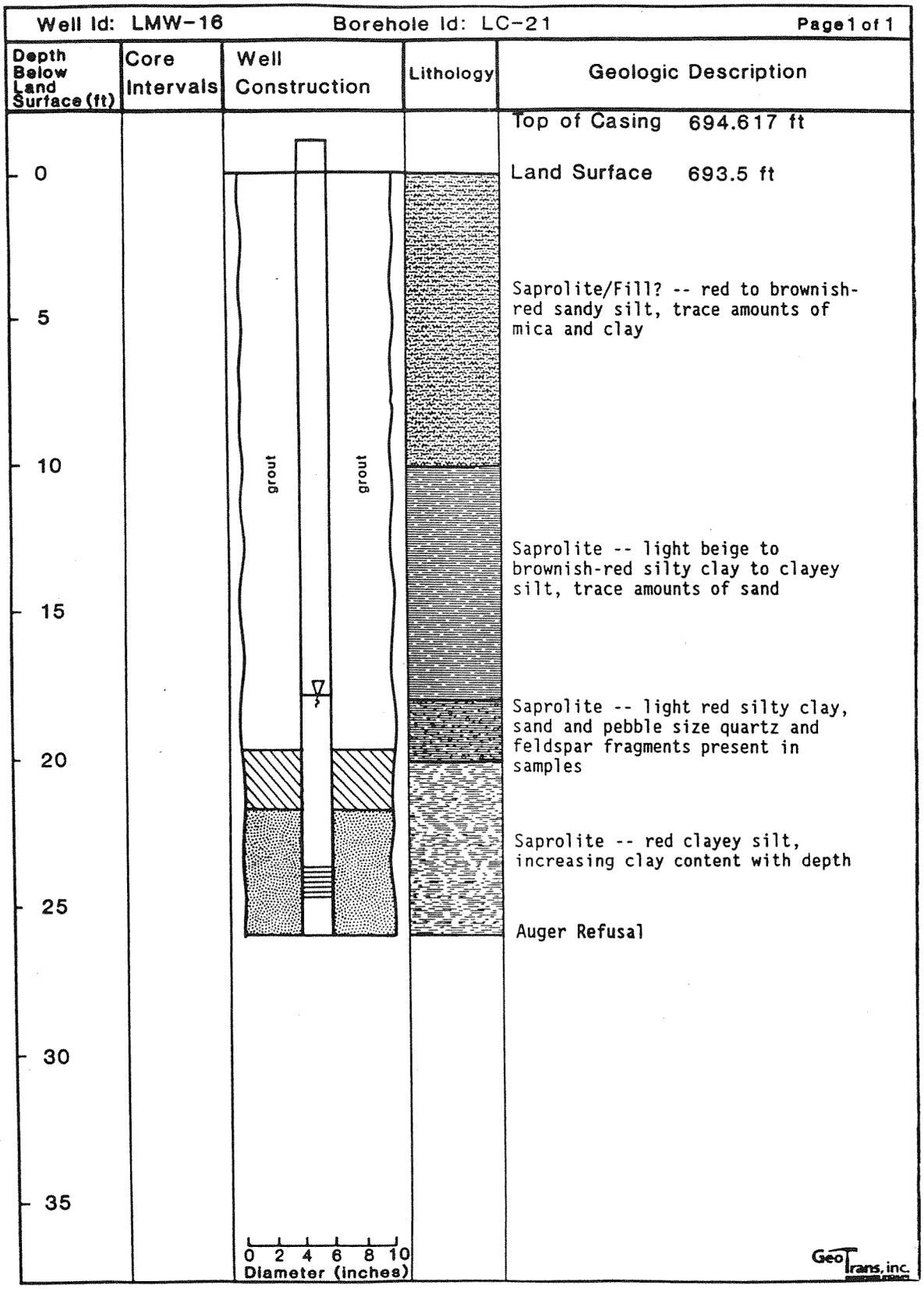

Well Id: LMW-13
Borehole Id: LC-18
Page 1 of 1
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
Top of Casing 694.988 ft
Land Surface 693.7 ft
0
5
10
15
20
25
30
35
grout
grout
Saprolite/Fill? -- brownish-red clayey silt, abundant mica
Saprolite/Fill? -- light brown clayey-sandy-silt, abundant mica
Saprolite -- light brown clayey silt, abundant mica
Saprolite -- light brown sandy silt, trace amounts of clay
Saprolite -- gold to reddish-brown clayey silt, abundant mica, trace amounts of sand, ancestral foliation and feldspar/quartz veins present in samples
Partially Weathered Bedrock--Gneiss, feldspar and quartz veins, trace amounts of mica
Auger Refusal
0 2 4 6 8 10
Diameter (inches)
GeoTrans, inc.

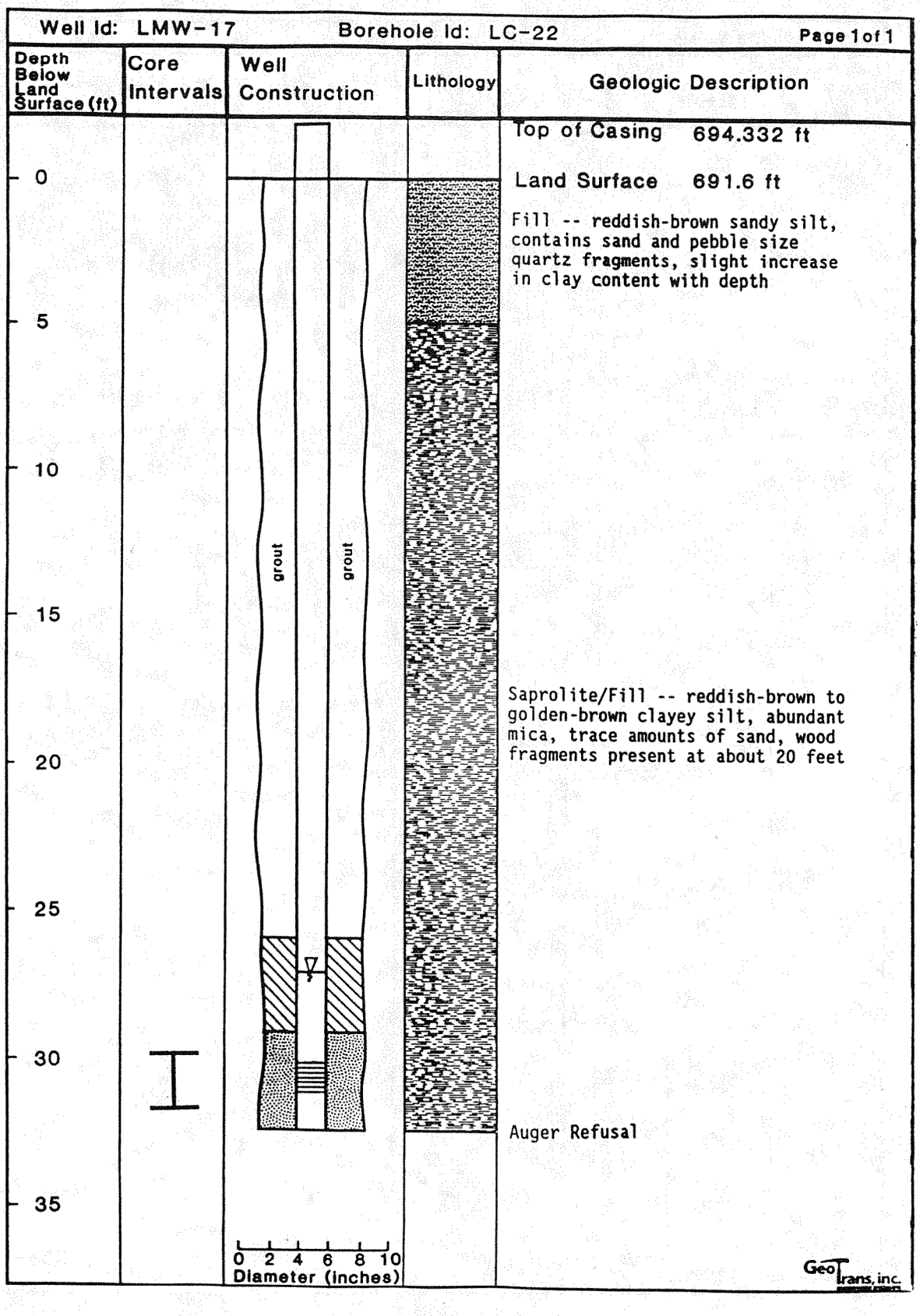
Well Id: LMW-14 Borehole Id: LC-19 Page 1 of 1

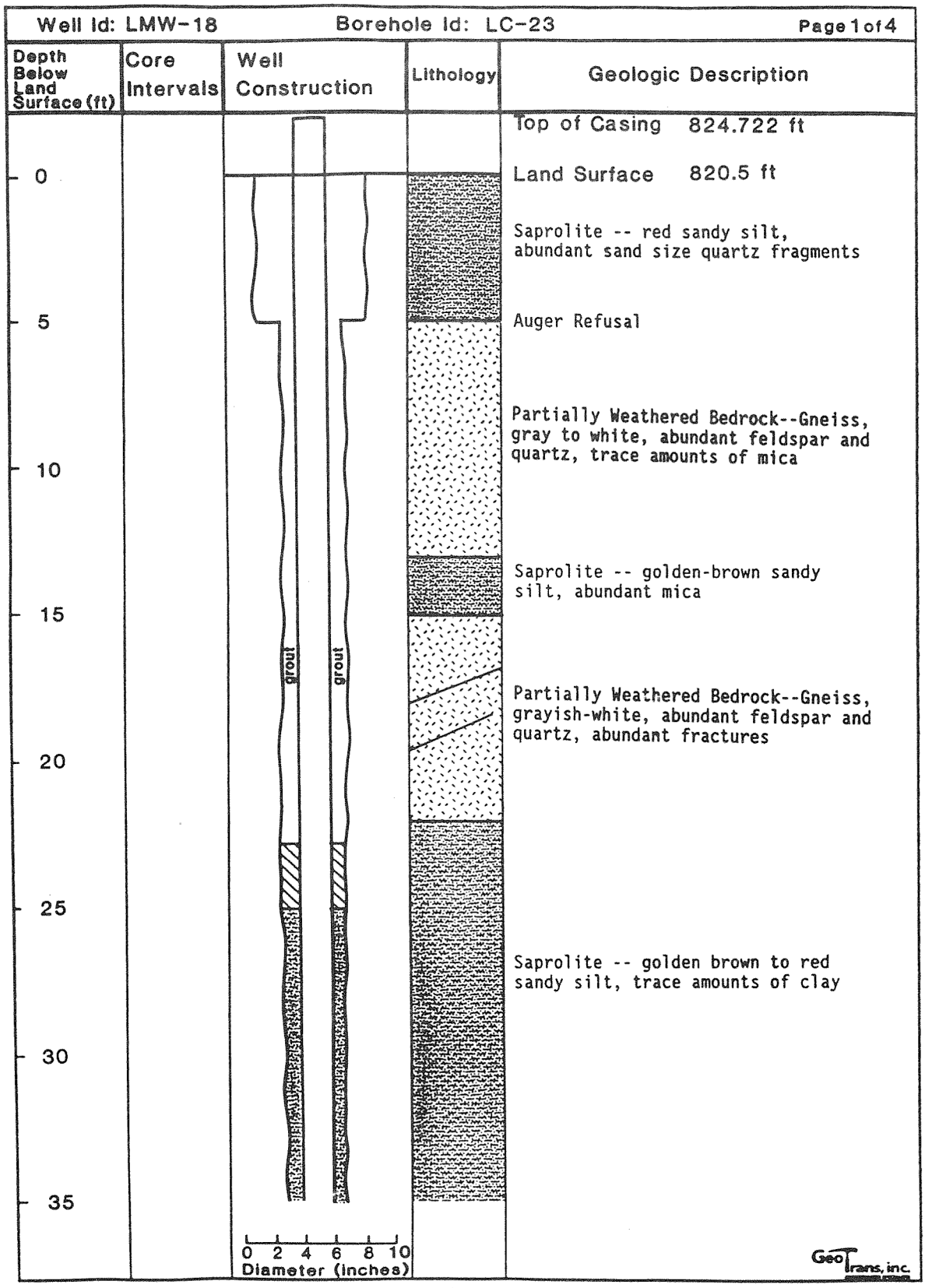
Depth Below Land Surface (ft)	Core Intervals	Well Construction	Lithology	Geologic Description
0				Top of Casing 727.789 ft Land Surface 725.0 ft Ash -- gray clayey-sandy-silt
5		grout / grout		Ash -- gray pebbly-silty-clay, abundant pebble size coal rejects Ash -- gray to greenish-gray pebbly-sandy-silt, varved layering present in sample
10				Ash -- gray silty clay to clayey silt, trace amounts of sand Ash -- gray pebbly sand, trace amounts of clay Ash -- gray sandy silt
15				Saprolite -- brownish-red silty clay to clayey silt, abundant mica
20				Partially Weathered Bedrock--Gneiss, grayish-white feldspar/quartz veins Auger Refusal
25				
30				
35		0 2 4 6 8 10 Diameter (inches)		

GeoTrans, inc.

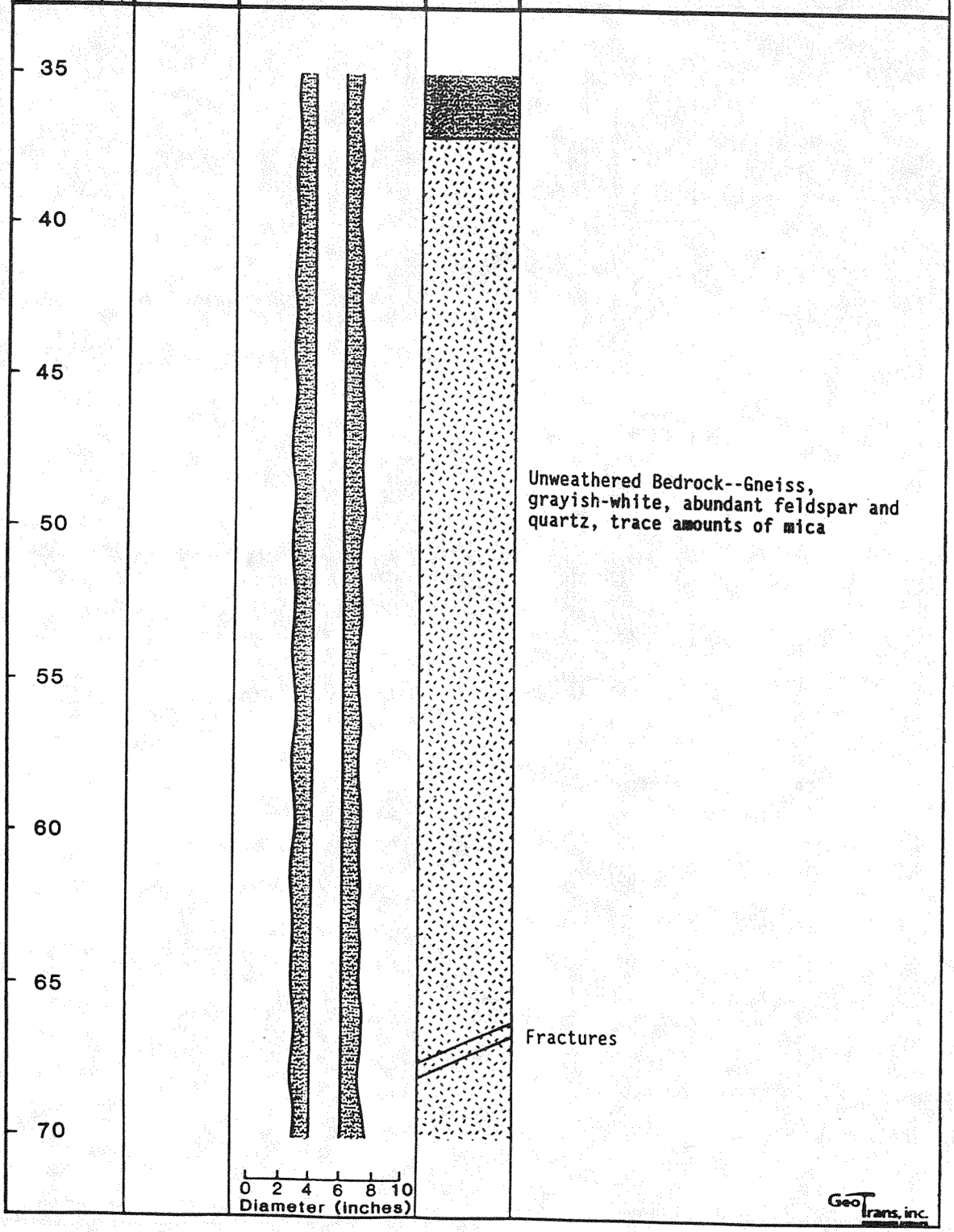

Well Id: LMW-15
Borehole Id: LC-20
Page 1 of 1
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
Top of Casing 727.478 ft
Land Surface 725.0 ft
Ash -- gray clayey-sandy-silt
Ash -- gray pebbly-silty-clay, abundant pebble size coal rejects
Ash -- gray to greenish-gray pebbly-sandy-silt, varved layering present in sample
Ash -- gray silty clay to clayey silt, trace amounts of sand
Ash -- gray pebbly sand, trace amounts of clay
Ash -- gray sandy-silt
Saprolite -- brownish-red silty clay to clayey silt, abundant mica
grout
grout
0
5
10
15
20
25
30
35
0 2 4 6 8 10
Diameter (inches)
GeoTrans, inc.

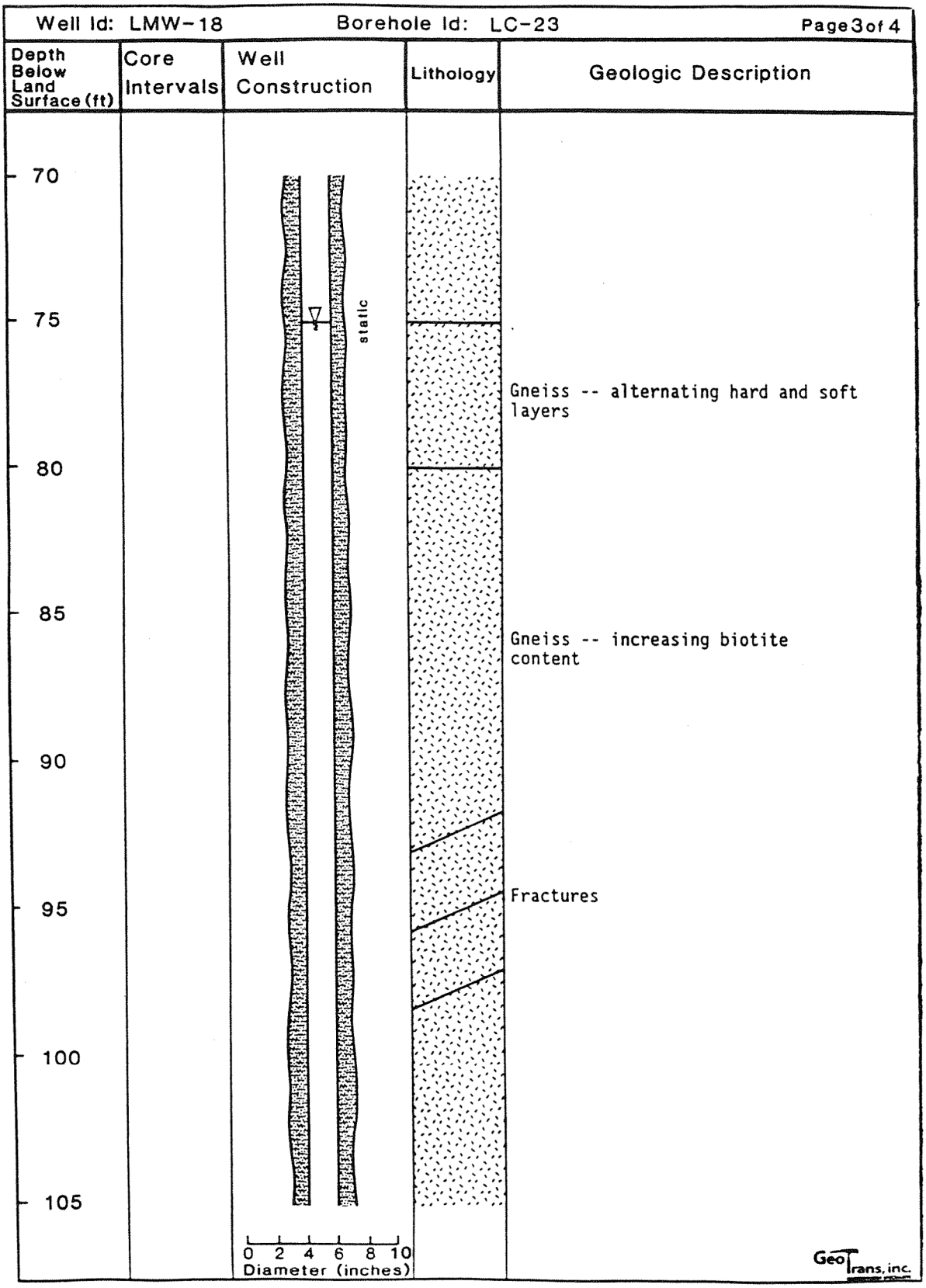

Well Id: LMW-16
Borehole Id: LC-21
Page 1 of 1
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
Top of Casing 694.617 ft
Land Surface 693.5 ft
0
5
10
15
20
25
30
35
grout
grout
Saprolite/Fill? -- red to brownish-red sandy silt, trace amounts of mica and clay
Saprolite -- light beige to brownish-red silty clay to clayey silt, trace amounts of sand
Saprolite -- light red silty clay, sand and pebble size quartz and feldspar fragments present in samples
Saprolite -- red clayey silt, increasing clay content with depth
Auger Refusal
0 2 4 6 8 10
Diameter (inches)
GeoTrans, inc.

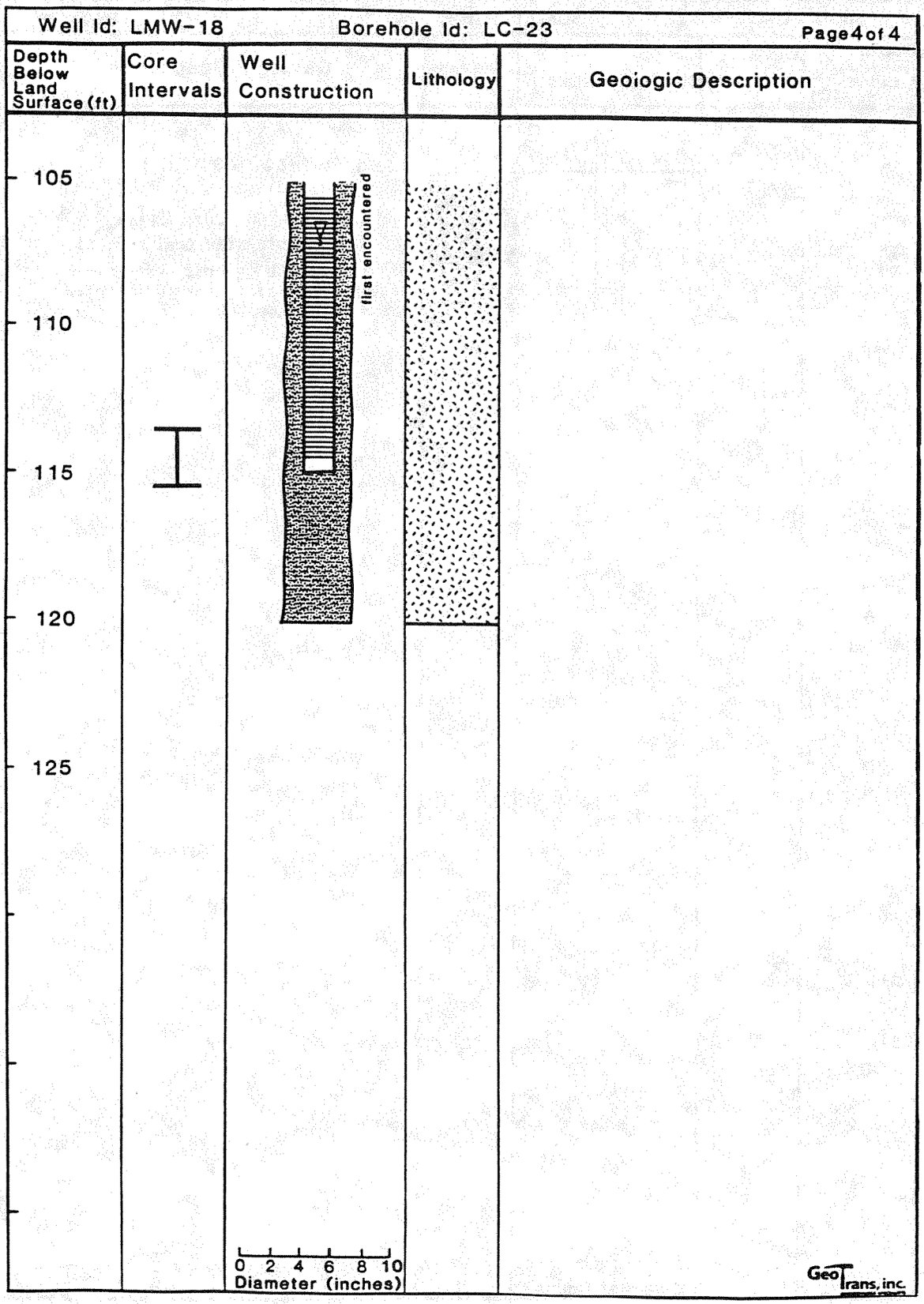

Well Id: LMW-17
Borehole Id: LC-22
Page 1 of 1
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
Top of Casing 694.332 ft
Land Surface 691.6 ft
Fill -- reddish-brown sandy silt, contains sand and pebble size quartz fragments, slight increase in clay content with depth
Saprolite/Fill -- reddish-brown to golden-brown clayey silt, abundant mica, trace amounts of sand, wood fragments present at about 20 feet
Auger Refusal
grout
grout
0
5
10
15
20
25
30
35
0 2 4 6 8 10
Diameter (inches)
GeoTrans, inc.


Well Id: LMW-18
Borehole Id: LC-23
Page 1 of 4
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
Top of Casing 824.722 ft
Land Surface 820.5 ft
0
5
10
15
20
25
30
35
Saprolite -- red sandy silt, abundant sand size quartz fragments
Auger Refusal
Partially Weathered Bedrock--Gneiss, gray to white, abundant feldspar and quartz, trace amounts of mica
Saprolite -- golden-brown sandy silt, abundant mica
Partially Weathered Bedrock--Gneiss, grayish-white, abundant feldspar and quartz, abundant fractures
Saprolite -- golden brown to red sandy silt, trace amounts of clay
grout
grout
0 2 4 6 8 10
Diameter (inches)
GeoTrans, inc.

Well Id: LMW-18 Borehole Id: LC-23 Page 2 of 4

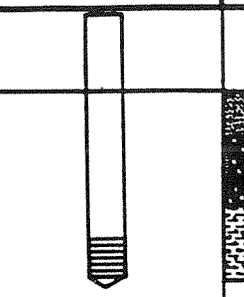


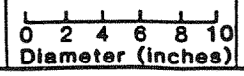

Well Id: LMW-18
Borehole Id: LC-23
Page 3 of 4
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
70
75
80
85
90
95
100
105
static
Gneiss -- alternating hard and soft layers
Gneiss -- increasing biotite content
Fractures
0 2 4 6 8 10
Diameter (inches)
GeoTrans, inc.


Well Id: LMW-18
Borehole Id: LC-23
Page 4 of 4
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geoiogic Description
105
110
115
120
125
first encountered
0 2 4 6 8 10
Diameter (inches)
GeoTrans, inc.

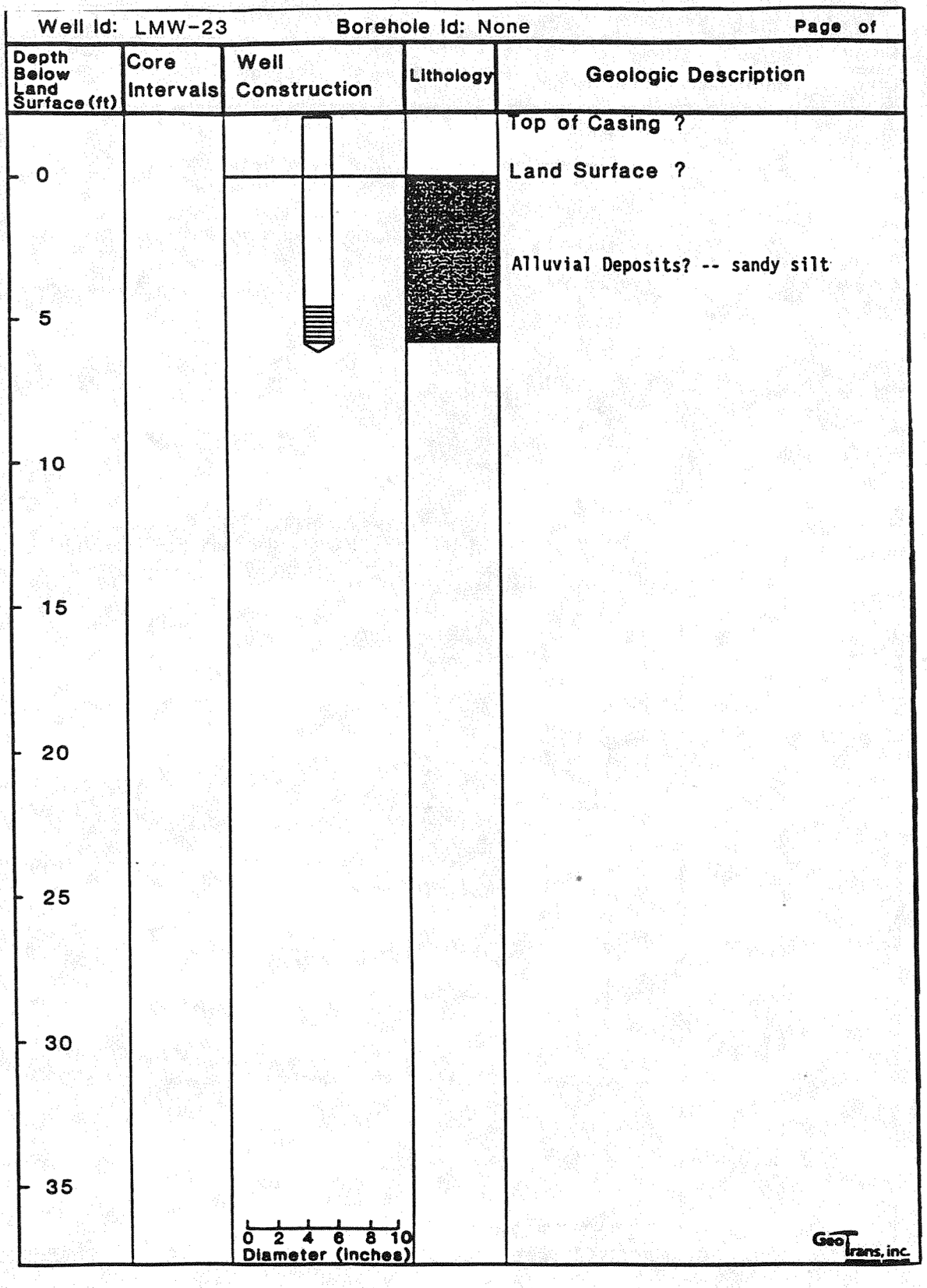
Well Id: LMW-22 Borehole Id: None Page of

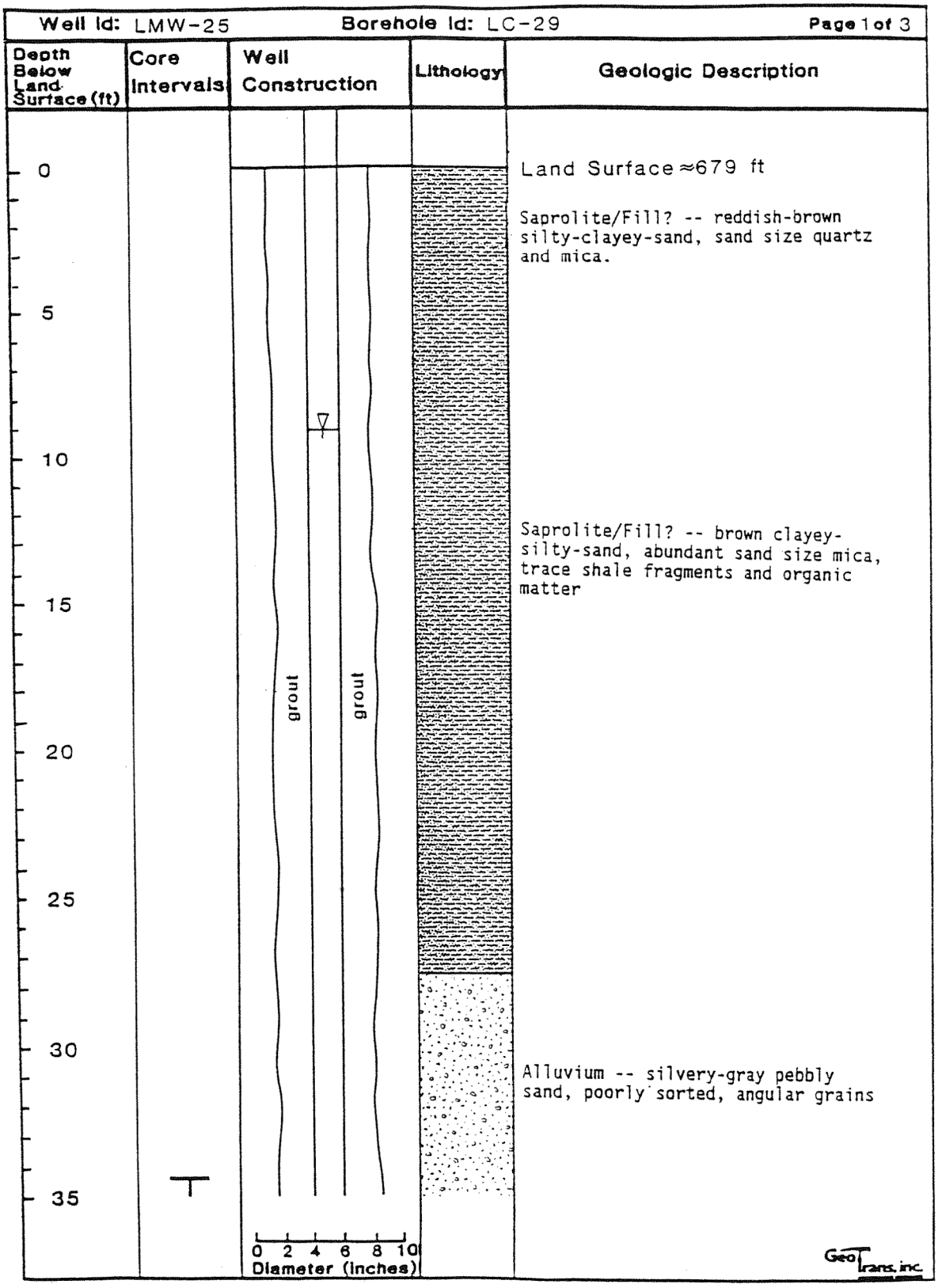
Depth Below Land Surface (ft)	Core Intervals	Well Construction	Lithology	Geologic Description
0				Top of Casing 726.89 ft Land Surface 725.0 ft Ash -- gray clayey-sandy-silt
5				Ash -- gray pebbly-silty-clay, abundant pebble size coal rejects Ash -- gray to greenish-gray pebbly-sandy-silt, varved layering present in sample
10				
15				
20				
25				
30				
35				

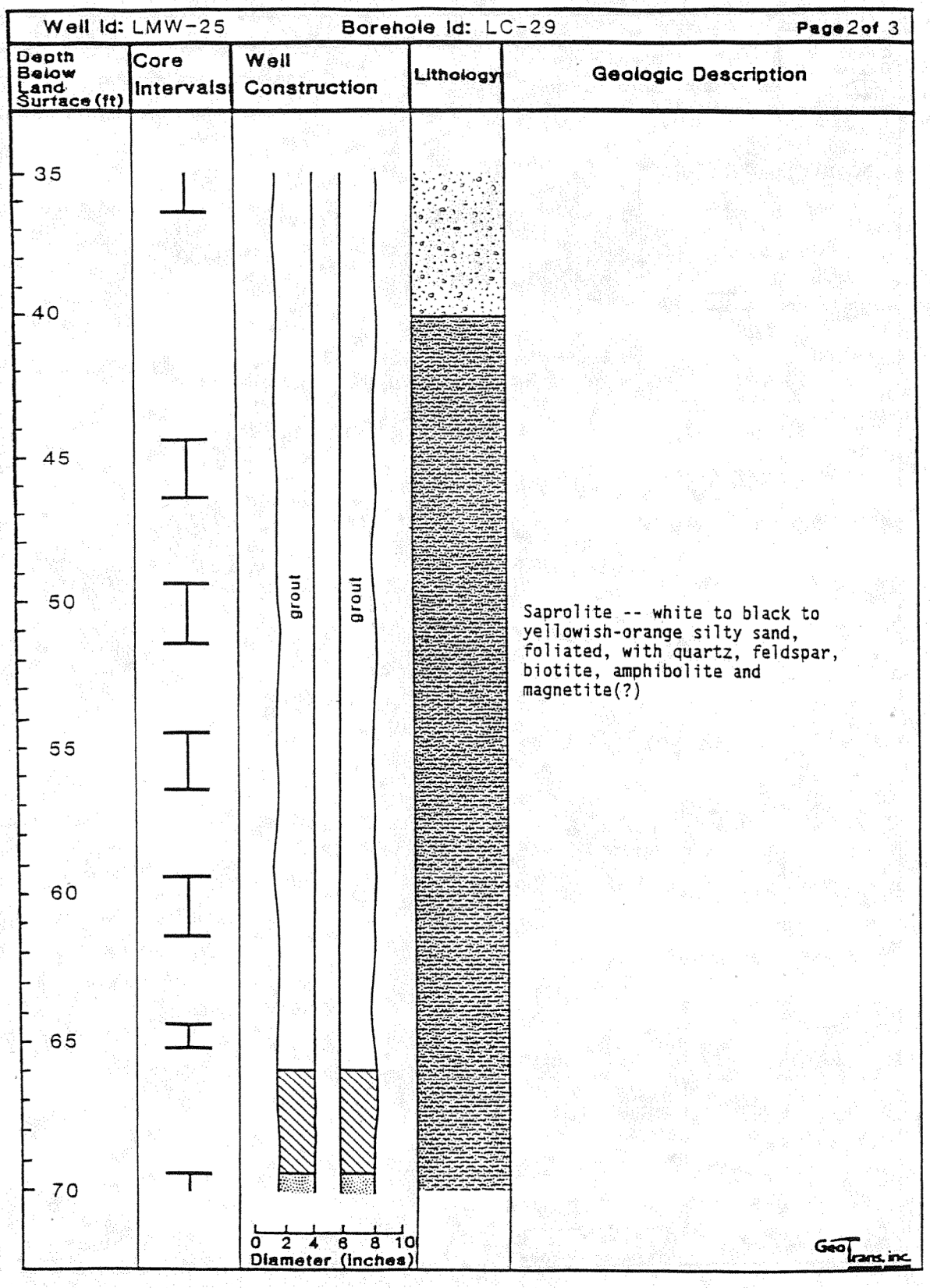


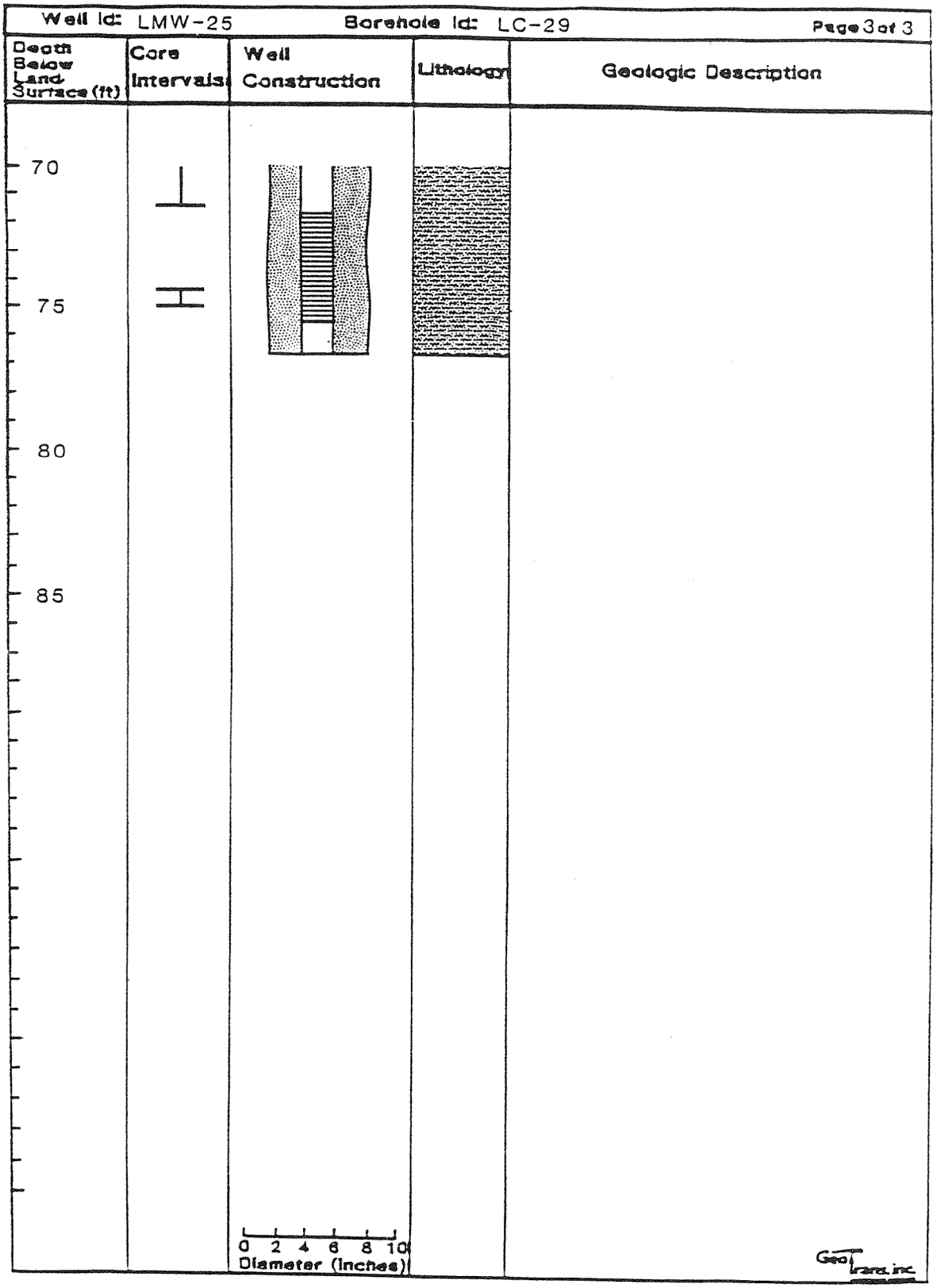


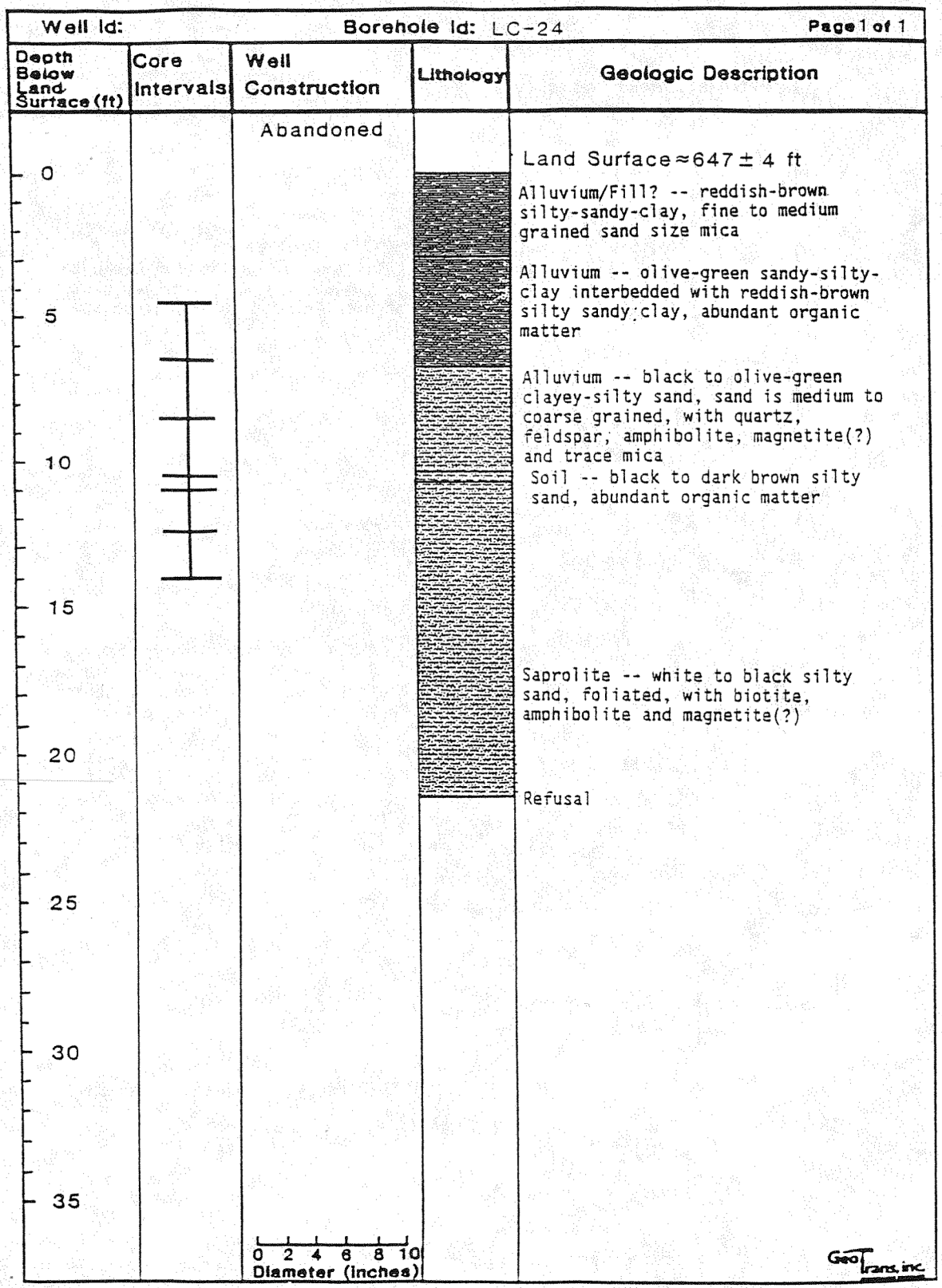
GeoTrans, inc.


Well Id: LMW-23
Borehole Id: None
Page of
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
Top of Casing ?
Land Surface ?
Alluvial Deposits? -- sandy silt
0
5
10
15
20
25
30
35
0 2 4 6 8 10
Diameter (inches)
GeoTrans, inc.

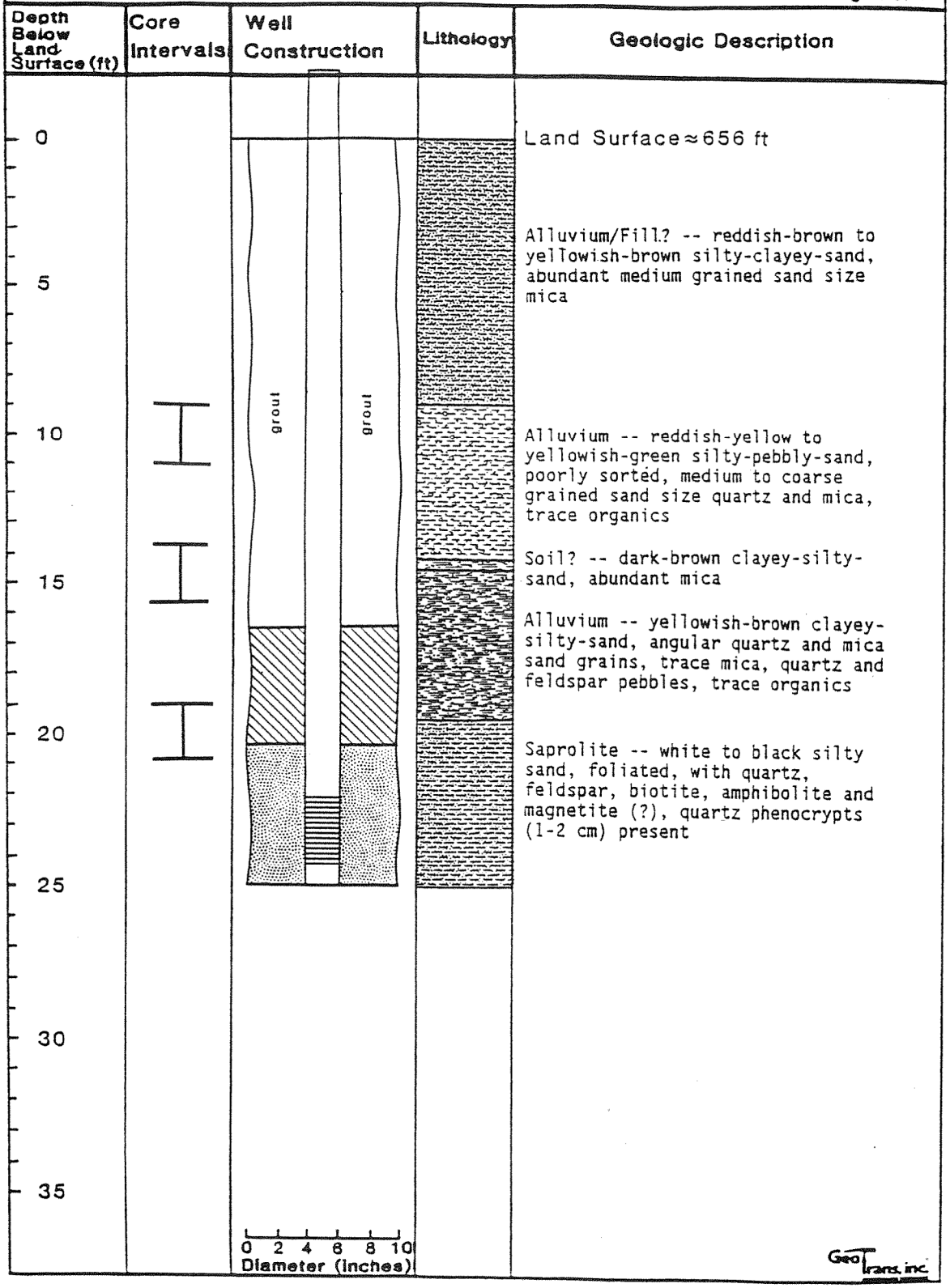

Well Id: LMW-25
Borehole Id: LC-29
Page 1 of 3
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
0
5
10
15
20
25
30
35
grout
grout
0 2 4 6 8 10
Diameter (inches)
Land Surface ≈679 ft
Saprolite/Fill? -- reddish-brown silty-clayey-sand, sand size quartz and mica.
Saprolite/Fill? -- brown clayey-silty-sand, abundant sand size mica, trace shale fragments and organic matter
Alluvium -- silvery-gray pebbly sand, poorly sorted, angular grains
GeoTrans, inc.


Well Id: LMW-25
Borehole Id: LC-29
Page 2 of 3
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
35
40
45
50
55
60
65
70
grout
grout
0 2 4 6 8 10
Diameter (inches)
Saprolite -- white to black to yellowish-orange silty sand, foliated, with quartz, feldspar, biotite, amphibolite and magnetite(?)
GeoTrans, inc.


Well Id: LMW-25
Borehole Id: LC-29
Page 3 of 3
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
70
75
80
85
0 2 4 6 8 10
Diameter (Inches)
GeoTrans, Inc.

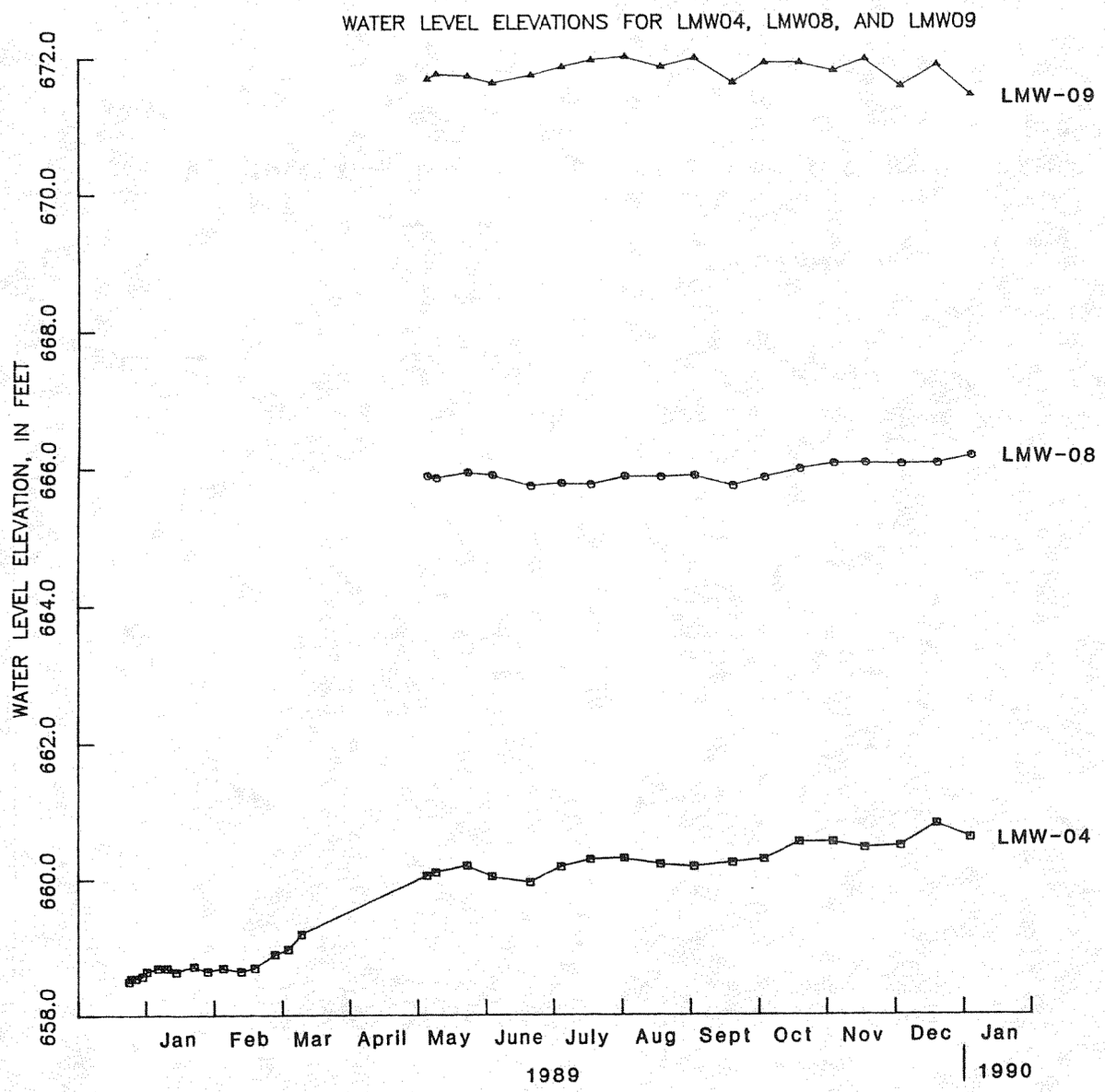

Well Id:
Borehole Id: LC-24
Page 1 of 1
Depth Below Land Surface (ft)
Core Intervals
Well Construction
Lithology
Geologic Description
Abandoned
Land Surface ≈ 647 ± 4 ft
Alluvium/Fill? -- reddish-brown silty-sandy-clay, fine to medium grained sand size mica
Alluvium -- olive-green sandy-silty-clay interbedded with reddish-brown silty sandy clay, abundant organic matter
Alluvium -- black to olive-green clayey-silty sand, sand is medium to coarse grained, with quartz, feldspar, amphibolite, magnetite(?) and trace mica
Soil -- black to dark brown silty sand, abundant organic matter
Saprolite -- white to black silty sand, foliated, with biotite, amphibolite and magnetite(?)
Refusal
0
5
10
15
20
25
30
35
0 2 4 6 8 10
Diameter (Inches)
GeoTrans, Inc.

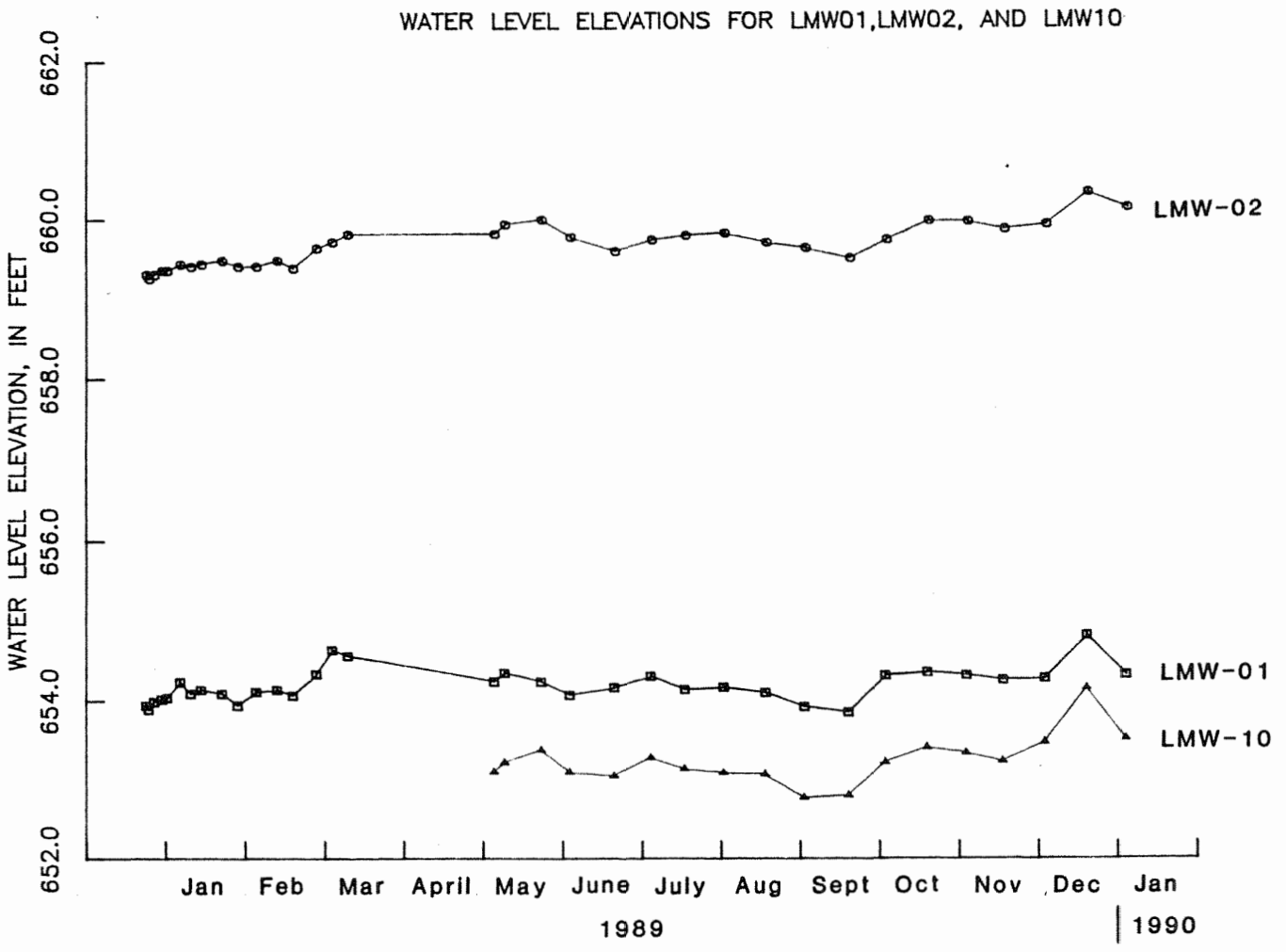
Well Id: LMW-24 Borehole Id: LC-25 Page 1 of 1

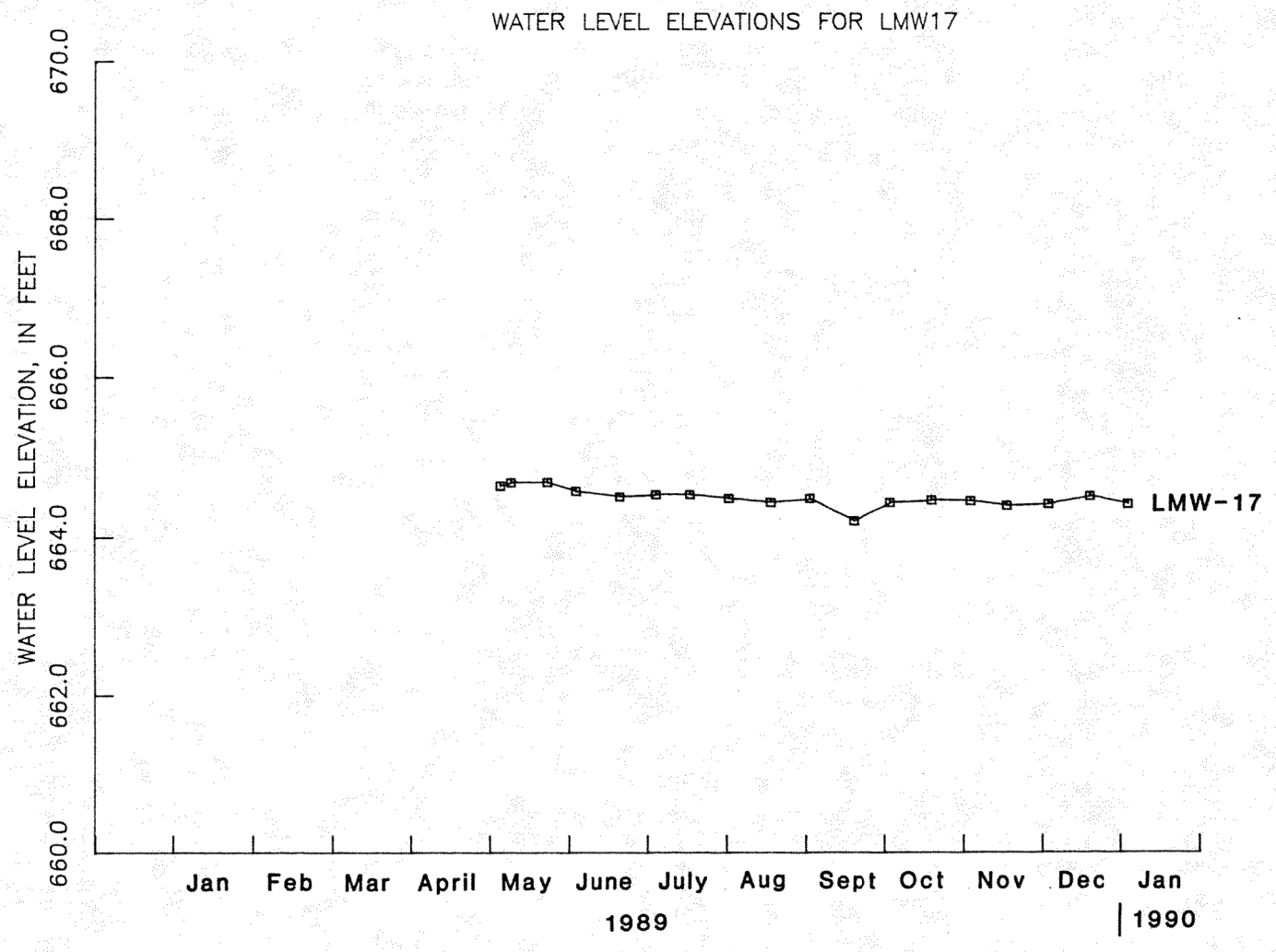


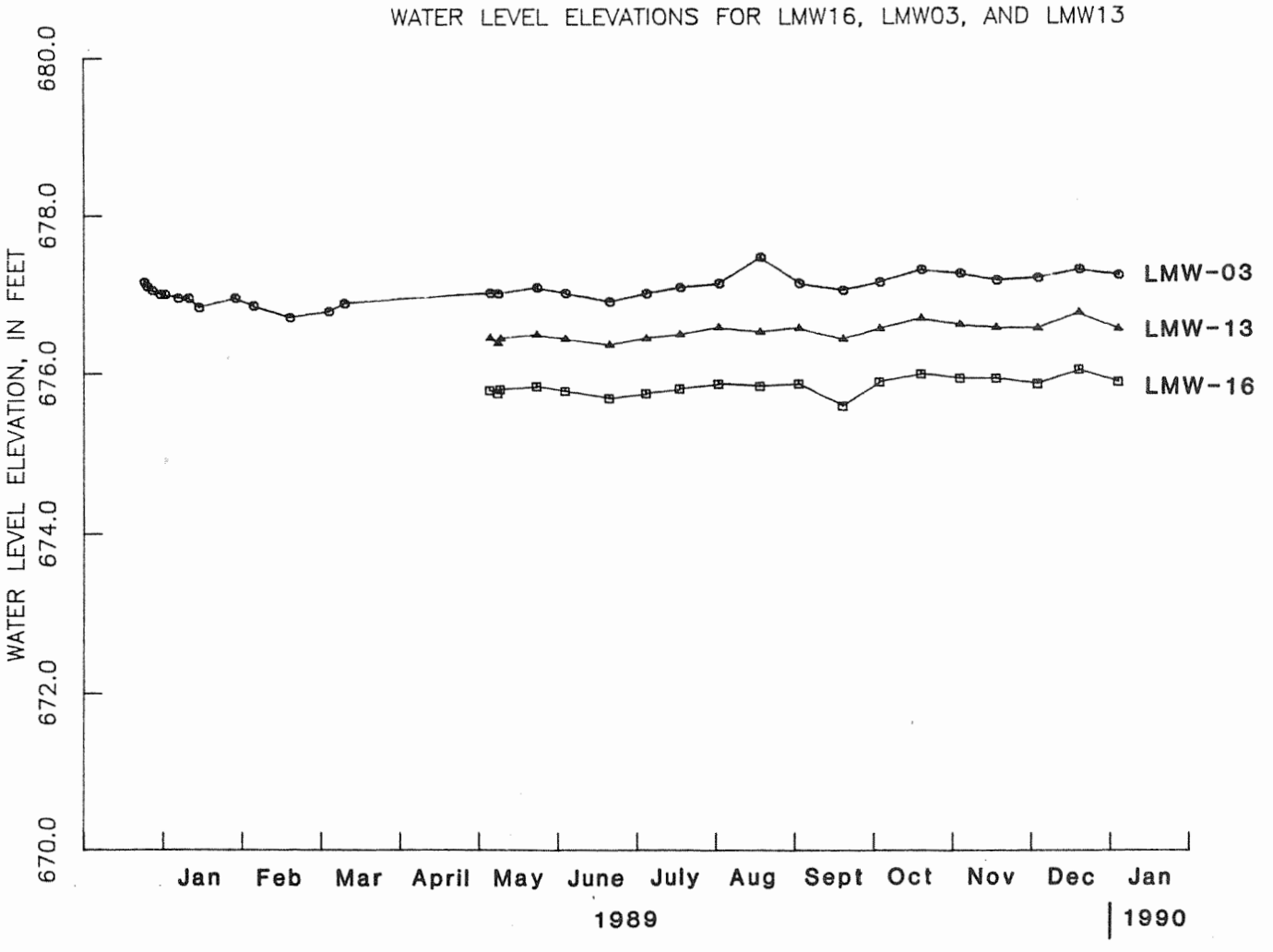
Appendix H

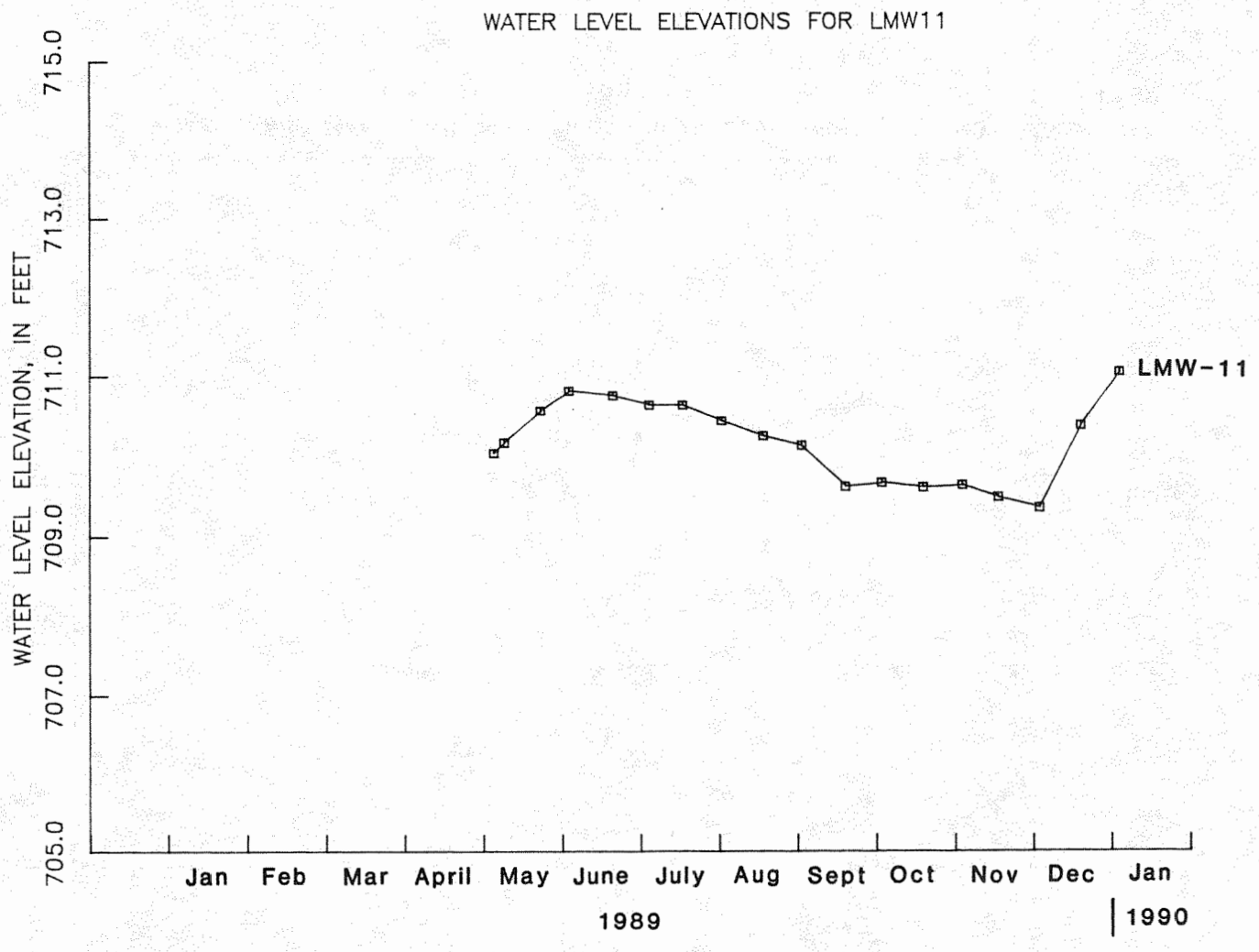
WATER LEVEL ELEVATIONS

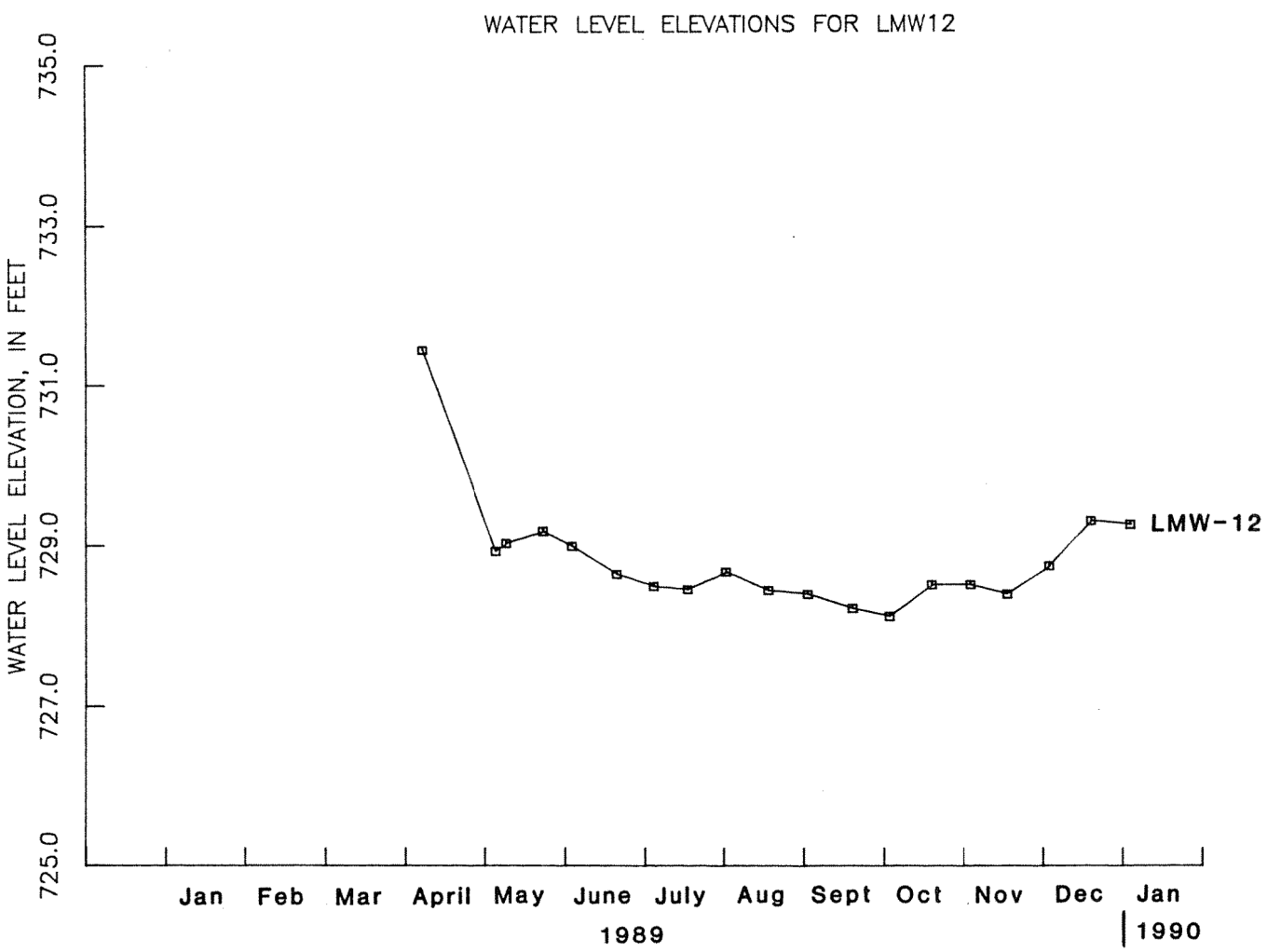

WATER LEVEL ELEVATIONS FOR LMW04, LMW08, AND LMW09
WATER LEVEL ELEVATION, IN FEET
672.0
670.0
668.0
666.0
664.0
662.0
660.0
658.0
LMW-09
LMW-08
LMW-04
Jan
Feb
Mar
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Jan
1989
1990

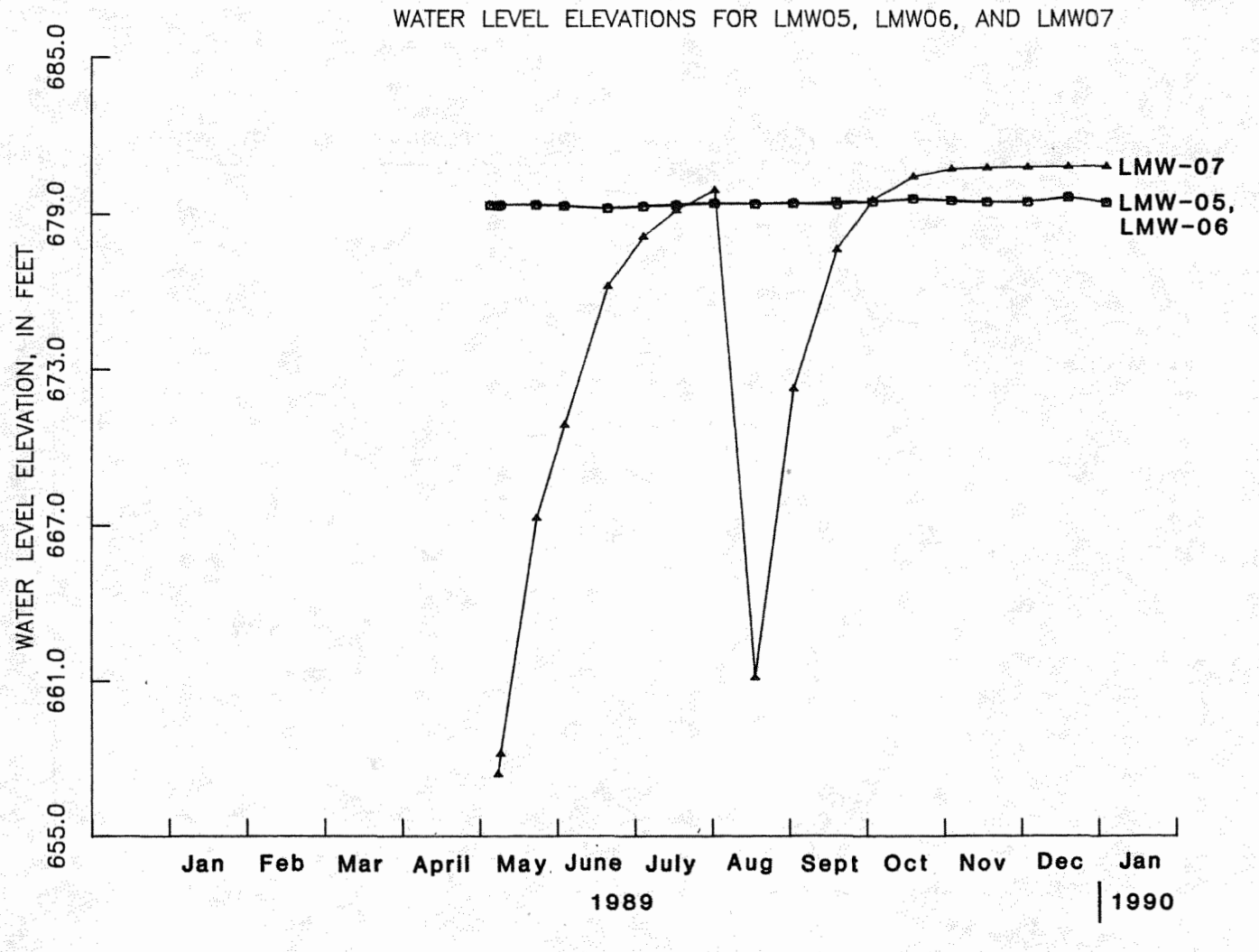

WATER LEVEL ELEVATIONS FOR LMW01,LMW02, AND LMW10
WATER LEVEL ELEVATION, IN FEET
662.0
660.0
658.0
656.0
654.0
652.0
LMW-02
LMW-01
LMW-10
Jan
Feb
Mar
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Jan
1989
1990

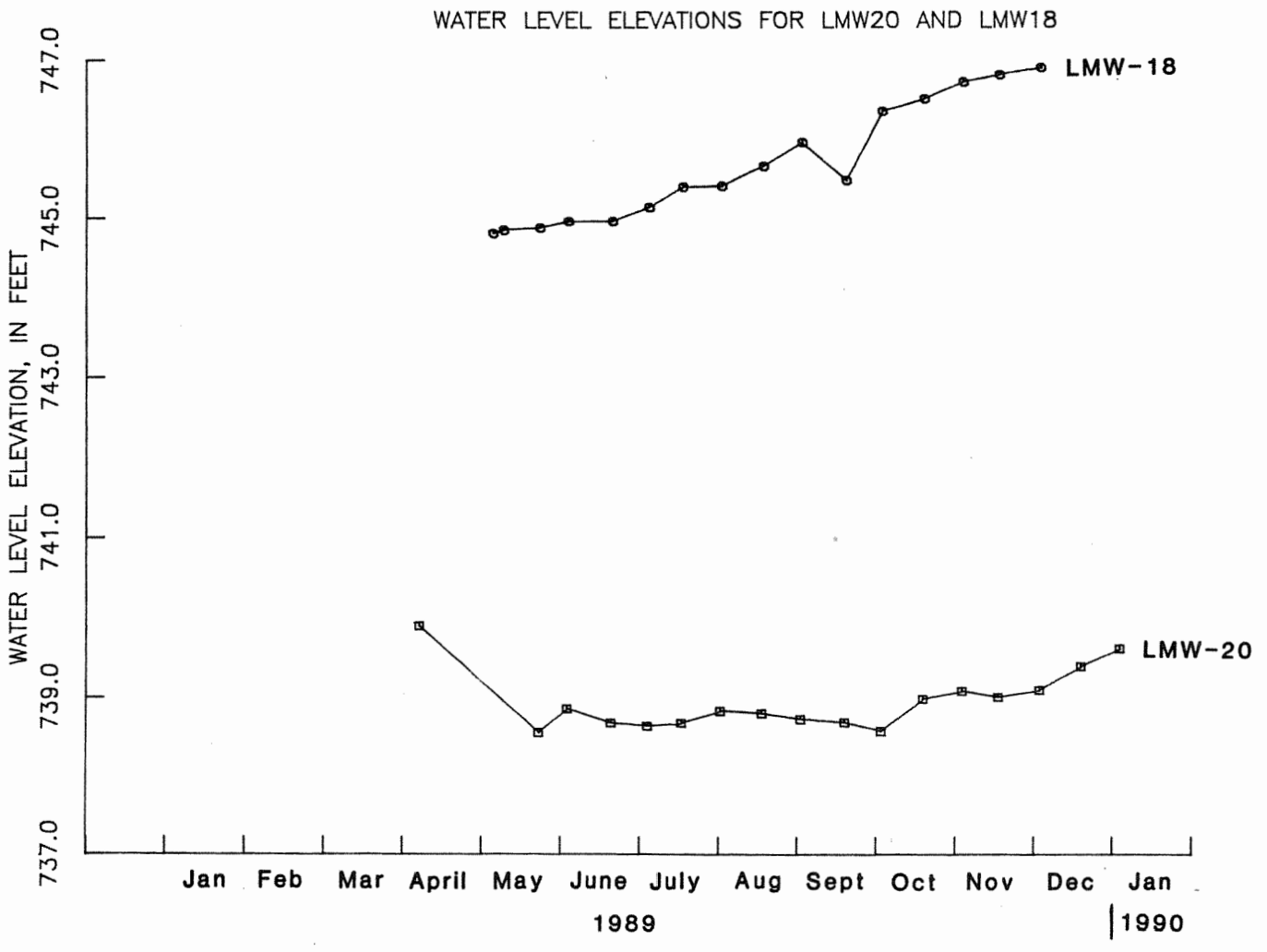

WATER LEVEL ELEVATIONS FOR LMW17
WATER LEVEL ELEVATION, IN FEET
670.0
668.0
666.0
664.0
662.0
660.0
LMW-17
Jan
Feb
Mar
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Jan
1989
1990


WATER LEVEL ELEVATIONS FOR LMW16, LMW03, AND LMW13
WATER LEVEL ELEVATION, IN FEET
680.0
678.0
676.0
674.0
672.0
670.0
LMW-03
LMW-13
LMW-16
Jan
Feb
Mar
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Jan
1989
1990


WATER LEVEL ELEVATIONS FOR LMW11
WATER LEVEL ELEVATION, IN FEET
715.0
713.0
711.0
709.0
707.0
705.0
LMW-11
Jan
Feb
Mar
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Jan
1989
1990

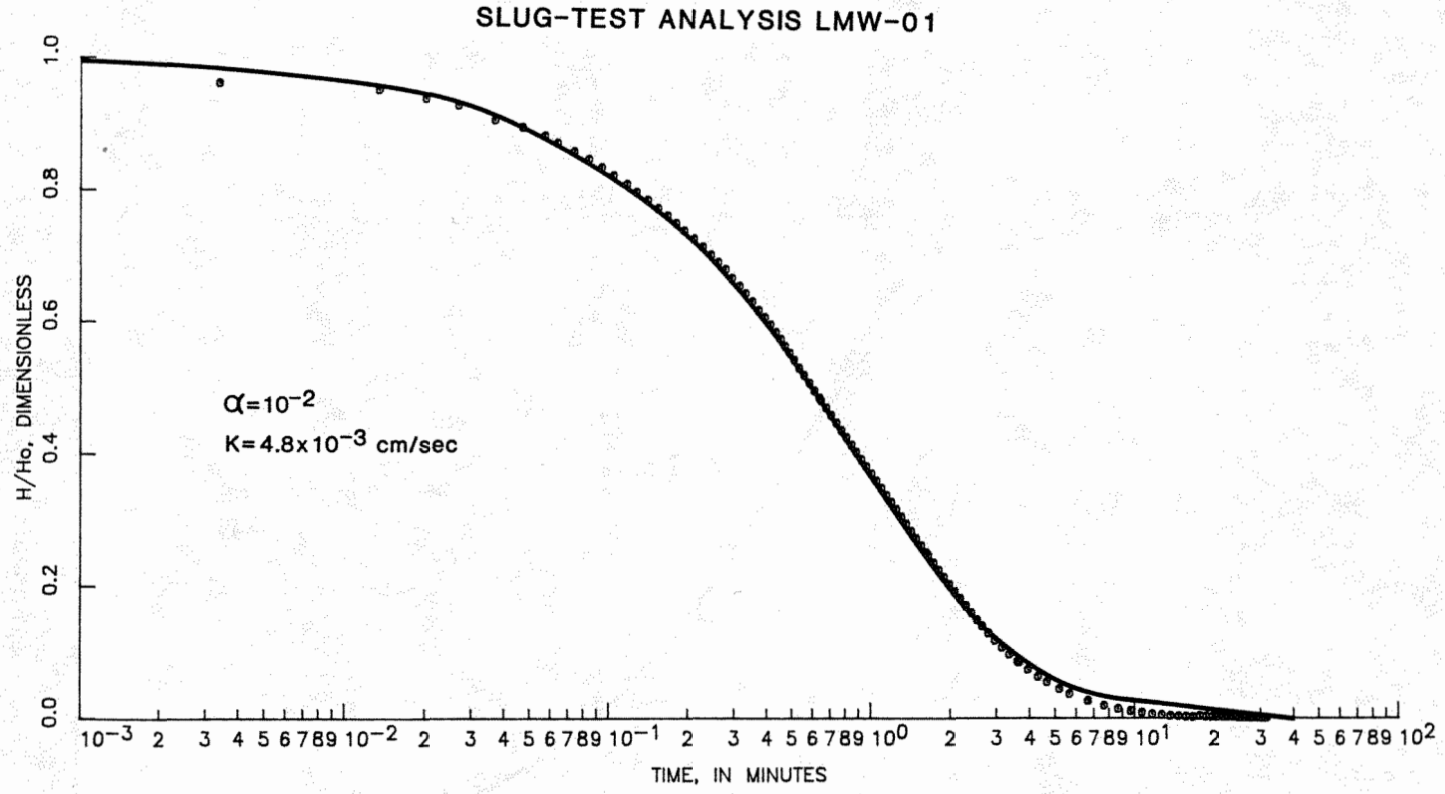

WATER LEVEL ELEVATIONS FOR LMW12
WATER LEVEL ELEVATION, IN FEET
735.0
733.0
731.0
729.0
727.0
725.0
LMW-12
Jan
Feb
Mar
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Jan
1989
1990

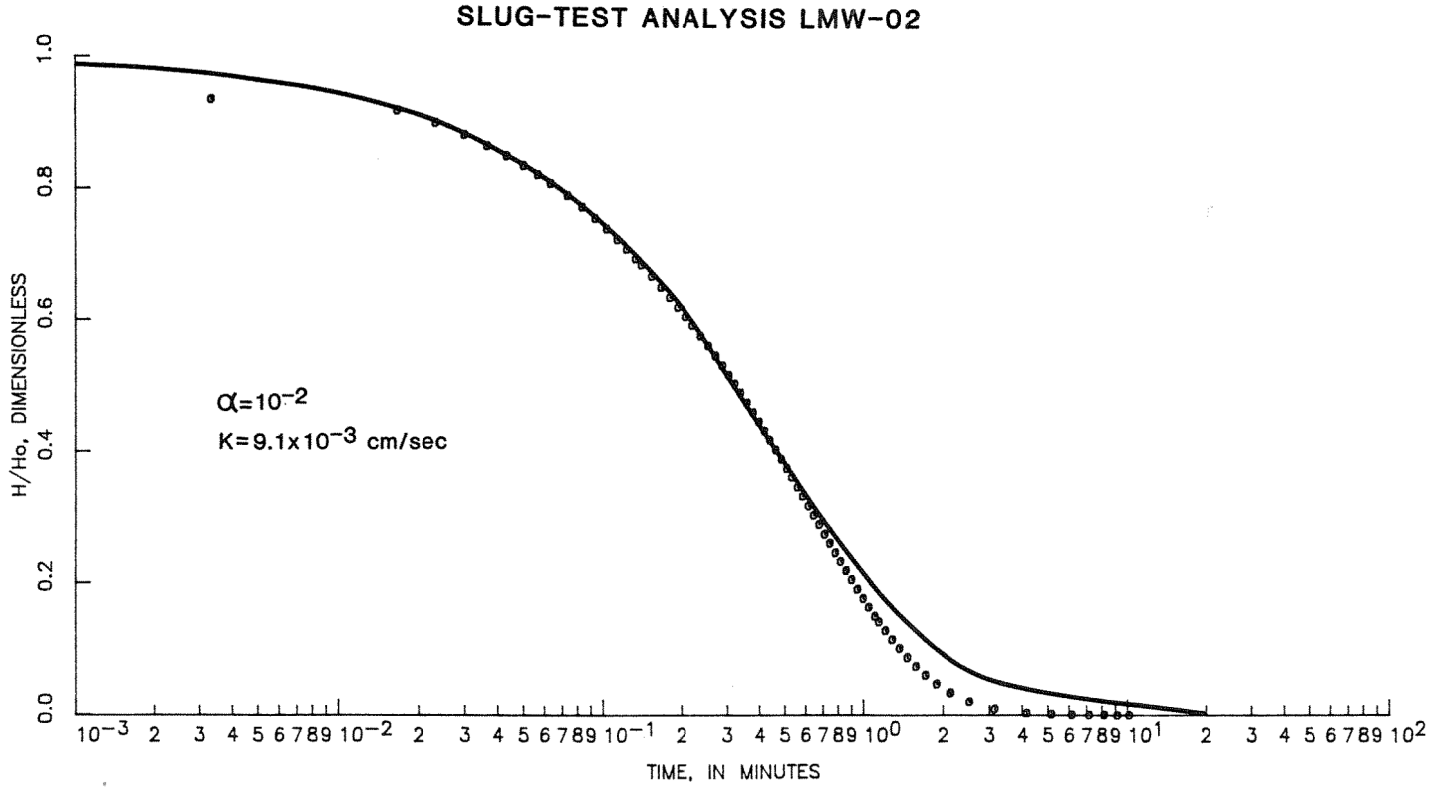

WATER LEVEL ELEVATIONS FOR LMW05, LMW06, AND LMW07
WATER LEVEL ELEVATION, IN FEET
685.0
679.0
673.0
667.0
661.0
655.0
LMW-07
LMW-05,
LMW-06
Jan
Feb
Mar
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Jan
1989
1990

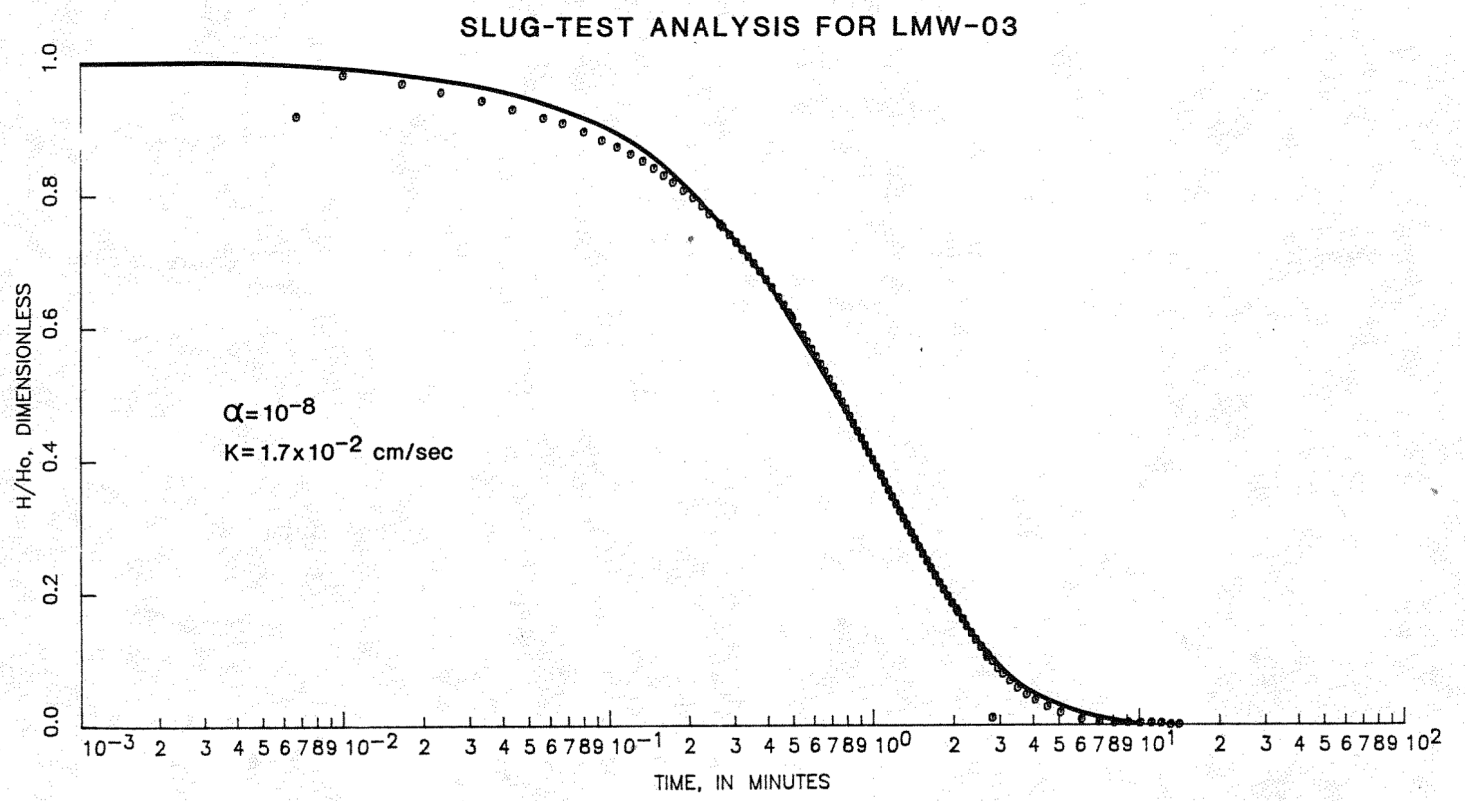

WATER LEVEL ELEVATIONS FOR LMW20 AND LMW18
WATER LEVEL ELEVATION, IN FEET
747.0
745.0
743.0
741.0
739.0
737.0
LMW-18
LMW-20
Jan
Feb
Mar
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Jan
1989
1990

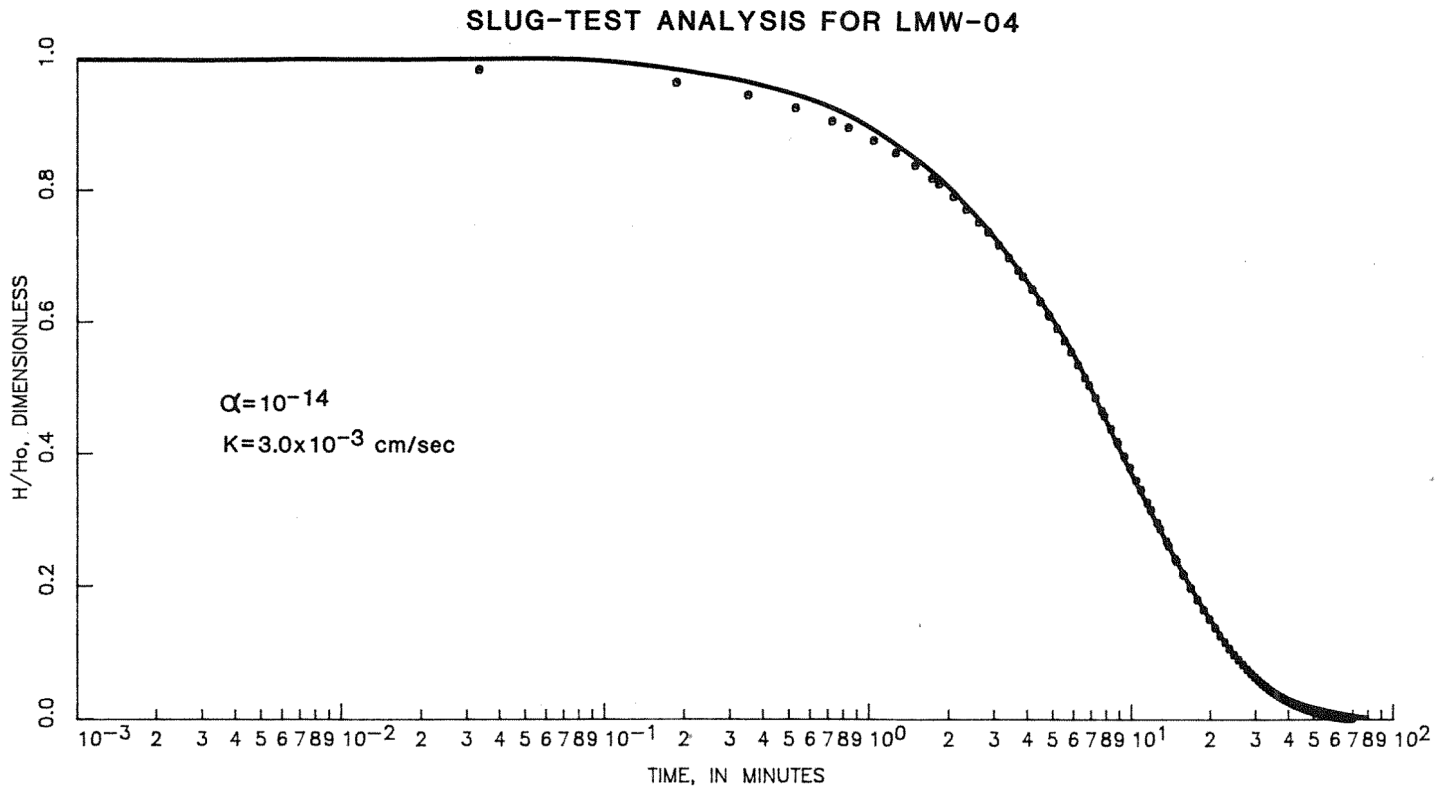
Appendix I

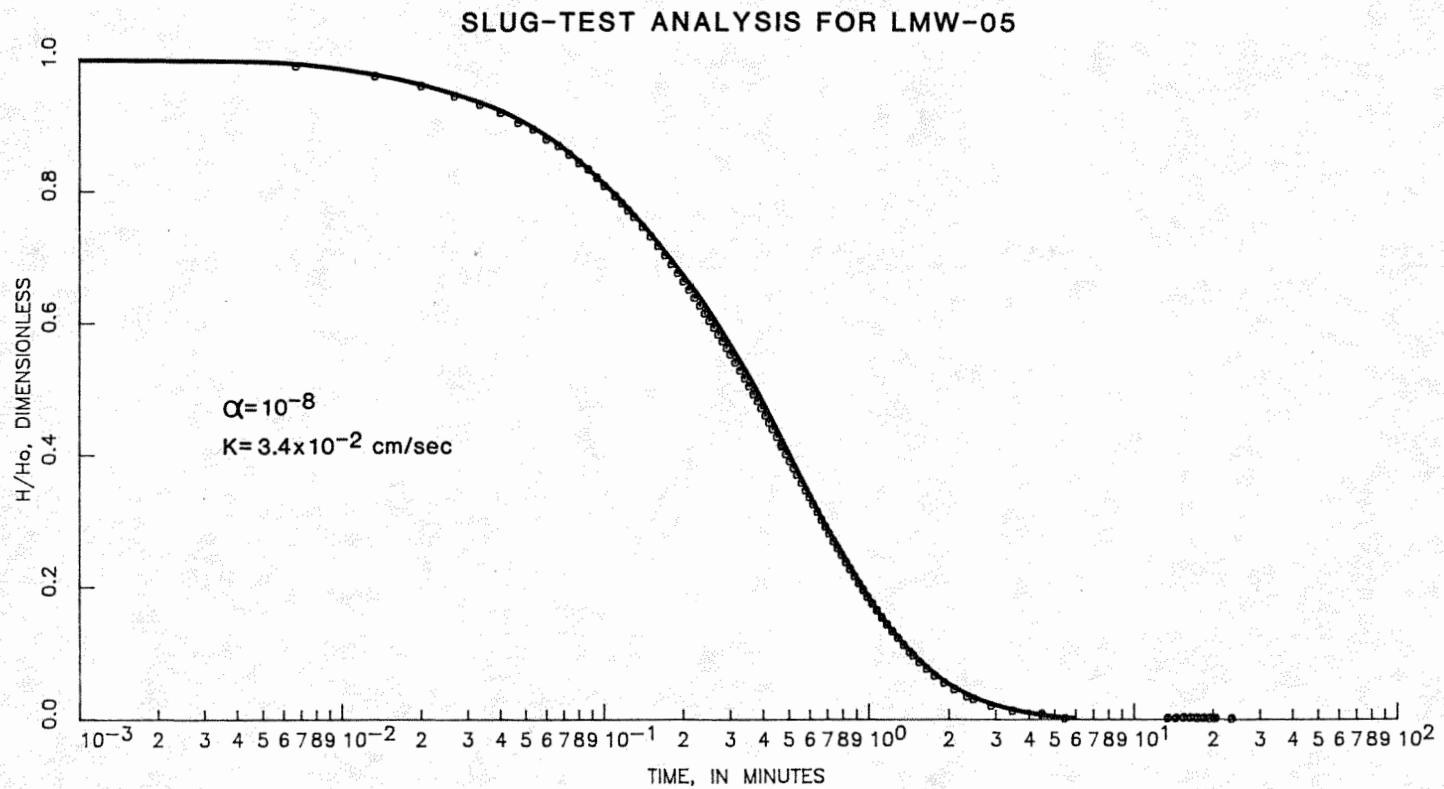
SLUG-TEST ANALYSES

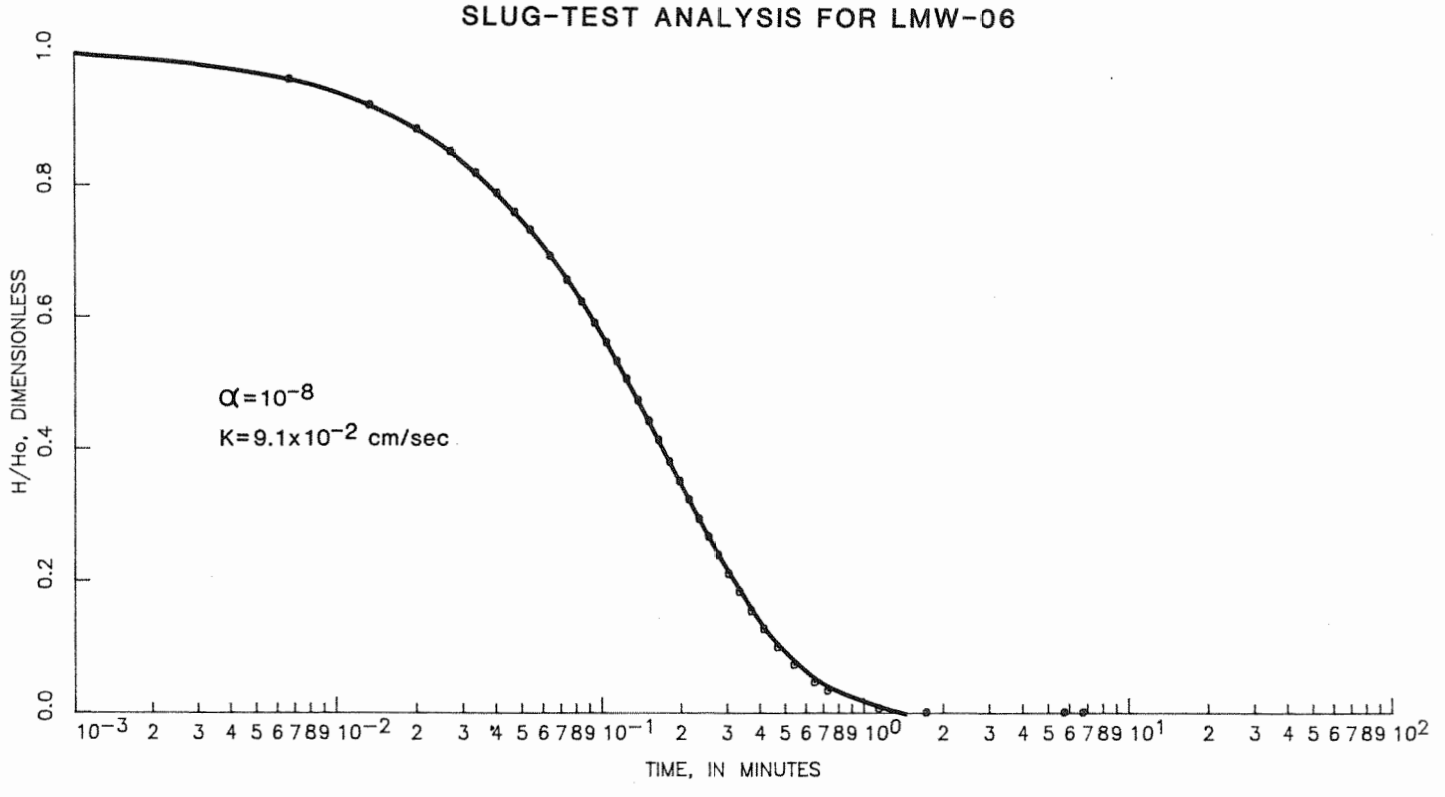

SLUG-TEST ANALYSIS LMW-01
H/Ho, DIMENSIONLESS
1.0
0.8
0.6
0.4
0.2
0.0
α=10⁻²
K=4.8x10⁻³ cm/sec
10⁻³ 2 3 4 5 6 7 8 9 10⁻² 2 3 4 5 6 7 8 9 10⁻¹ 2 3 4 5 6 7 8 9 10⁰ 2 3 4 5 6 7 8 9 10¹ 2 3 4 5 6 7 8 9 10²
TIME, IN MINUTES

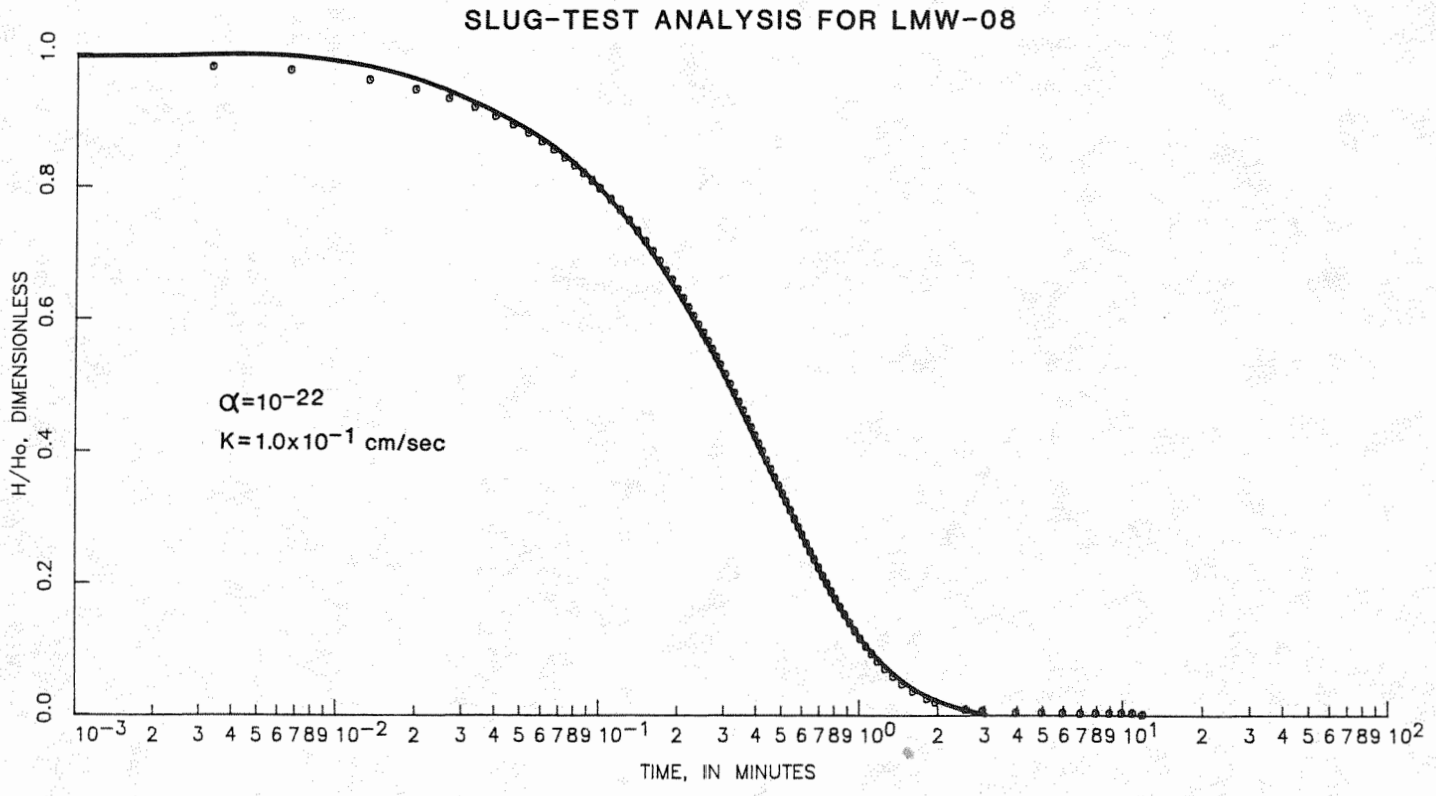

SLUG-TEST ANALYSIS LMW-02
H/Ho, DIMENSIONLESS
0.0
0.2
0.4
0.6
0.8
1.0
α=10⁻²
K=9.1x10⁻³ cm/sec
10⁻³ 2 3 4 5 6 7 8 9 10⁻² 2 3 4 5 6 7 8 9 10⁻¹ 2 3 4 5 6 7 8 9 10⁰ 2 3 4 5 6 7 8 9 10¹ 2 3 4 5 6 7 8 9 10²
TIME, IN MINUTES

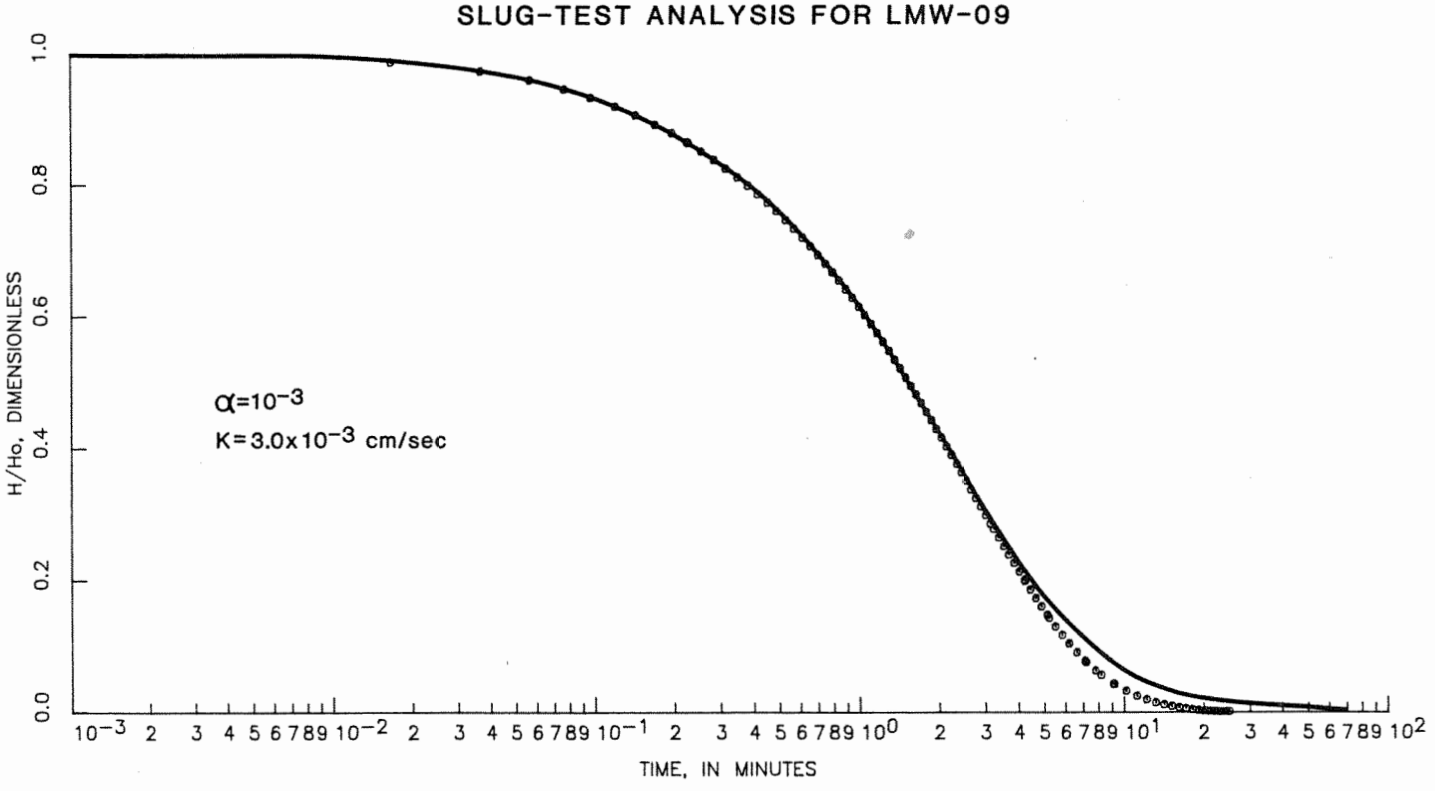

SLUG-TEST ANALYSIS FOR LMW-03
H/Ho, DIMENSIONLESS
1.0
0.8
0.6
0.4
0.2
0.0
α=10⁻⁸
K=1.7x10⁻² cm/sec
10⁻³ 2 3 4 5 6 7 8 9 10⁻² 2 3 4 5 6 7 8 9 10⁻¹ 2 3 4 5 6 7 8 9 10⁰ 2 3 4 5 6 7 8 9 10¹ 2 3 4 5 6 7 8 9 10²
TIME, IN MINUTES


SLUG-TEST ANALYSIS FOR LMW-04
H/Ho, DIMENSIONLESS
0.0
0.2
0.4
0.6
0.8
1.0
α=10⁻¹⁴
K=3.0x10⁻³ cm/sec
10⁻³ 2 3 4 5 6 7 8 9 10⁻² 2 3 4 5 6 7 8 9 10⁻¹ 2 3 4 5 6 7 8 9 10⁰ 2 3 4 5 6 7 8 9 10¹ 2 3 4 5 6 7 8 9 10²
TIME, IN MINUTES

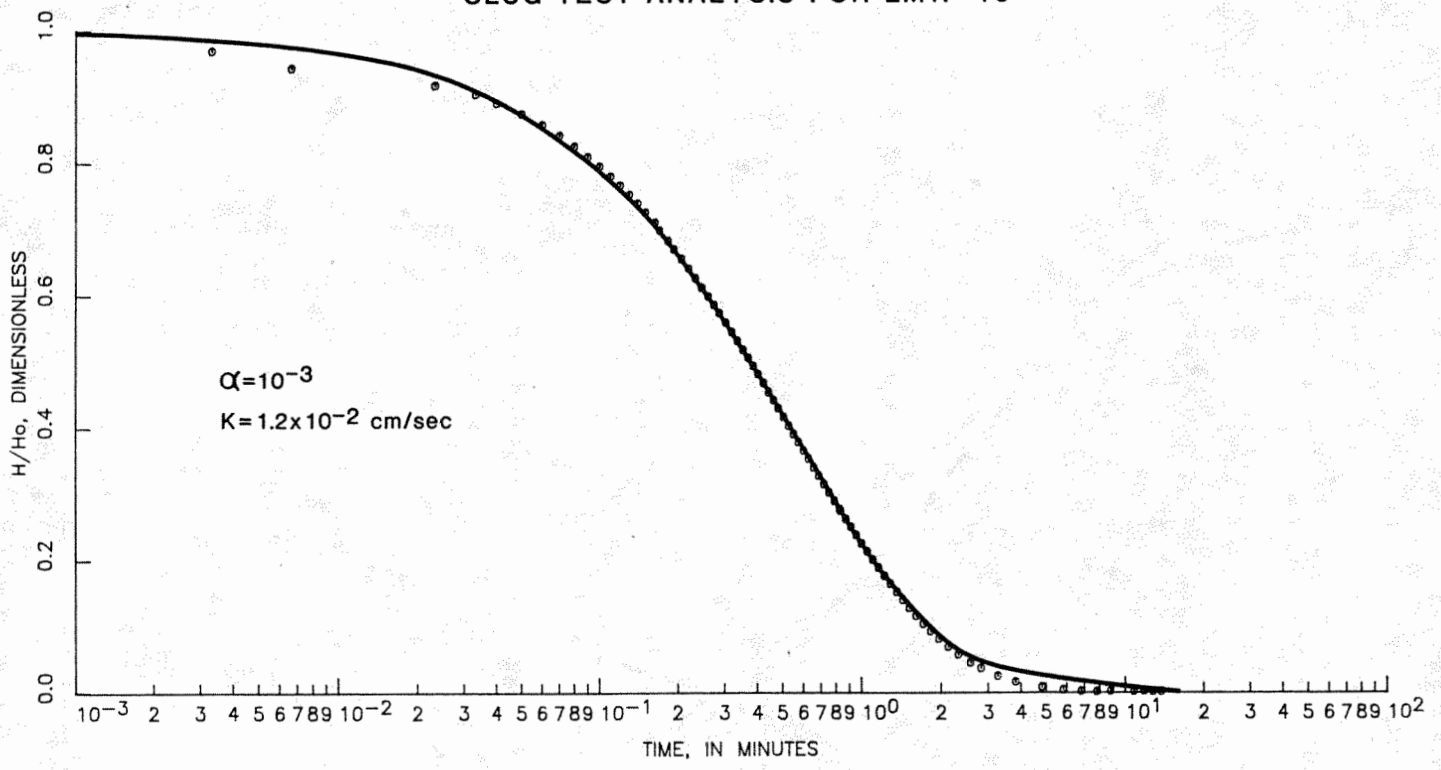

SLUG-TEST ANALYSIS FOR LMW-05
H/Ho, DIMENSIONLESS
0.0
0.2
0.4
0.6
0.8
1.0
α=10⁻⁸
K=3.4x10⁻² cm/sec
10⁻³ 2 3 4 5 6 7 8 9 10⁻² 2 3 4 5 6 7 8 9 10⁻¹ 2 3 4 5 6 7 8 9 10⁰ 2 3 4 5 6 7 8 9 10¹ 2 3 4 5 6 7 8 9 10²
TIME, IN MINUTES

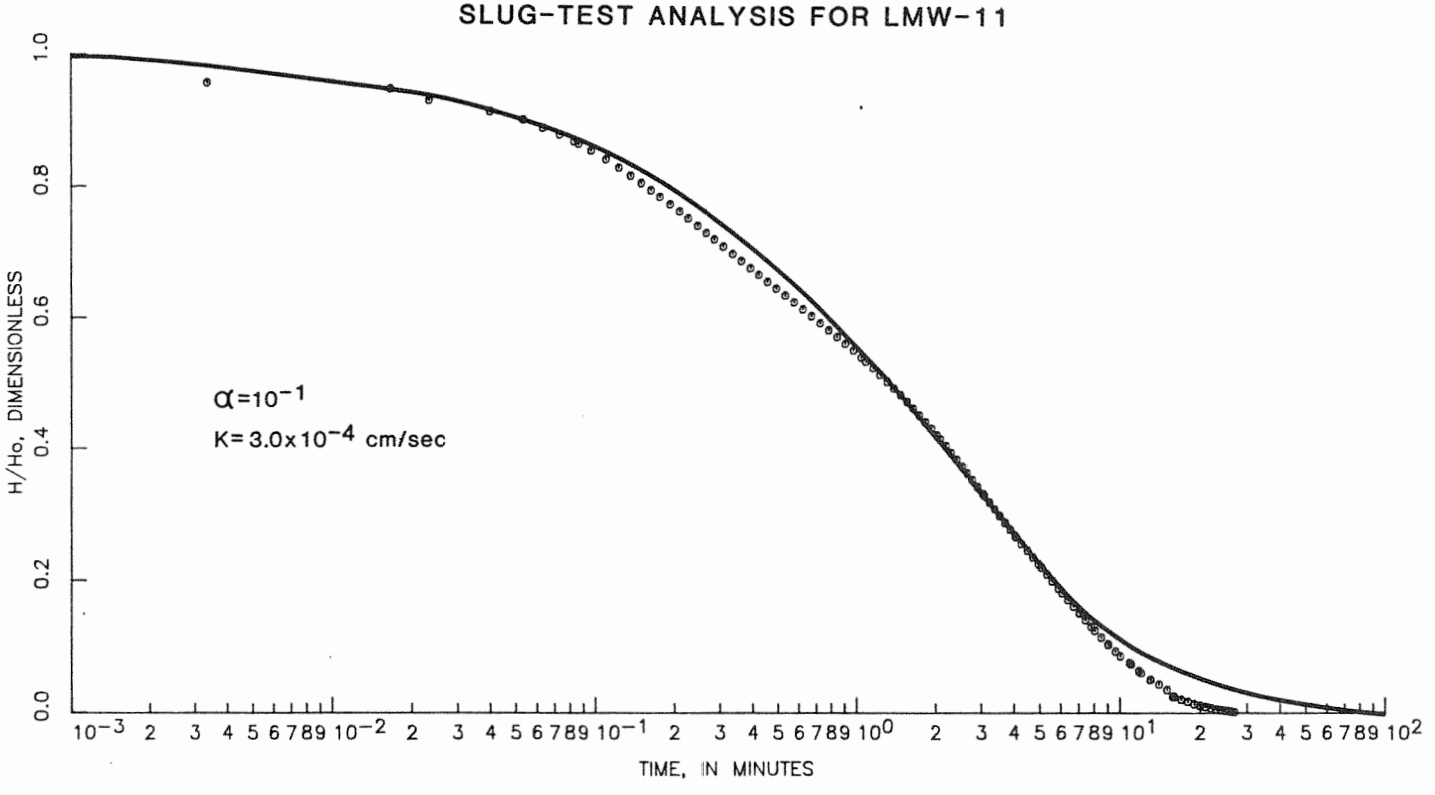

SLUG-TEST ANALYSIS FOR LMW-06
H/Ho, DIMENSIONLESS
0.0
0.2
0.4
0.6
0.8
1.0
α=10⁻⁸
K=9.1x10⁻² cm/sec
10⁻³ 2 3 4 5 6 7 8 9 10⁻² 2 3 4 5 6 7 8 9 10⁻¹ 2 3 4 5 6 7 8 9 10⁰ 2 3 4 5 6 7 8 9 10¹ 2 3 4 5 6 7 8 9 10²
TIME, IN MINUTES

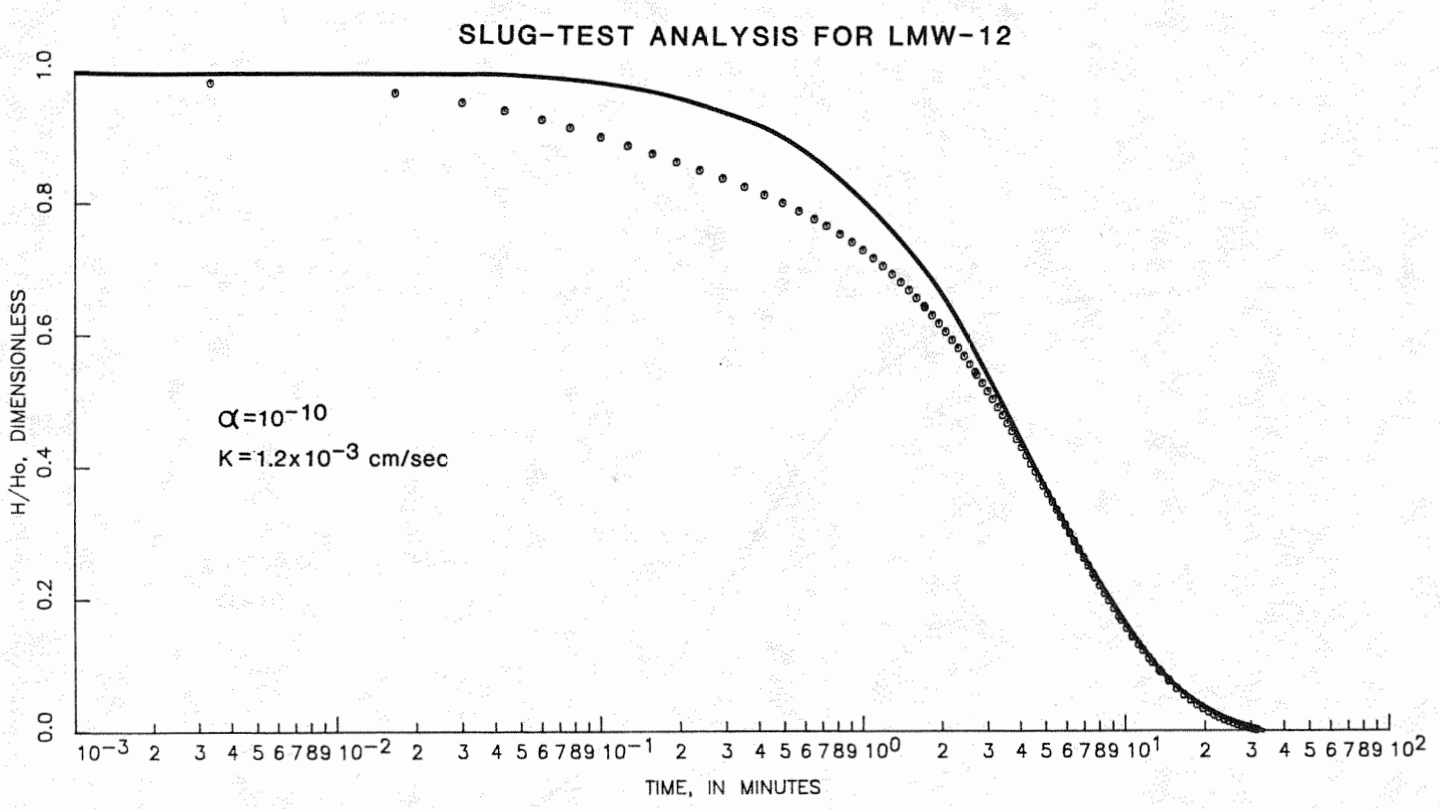

SLUG-TEST ANALYSIS FOR LMW-08
H/Ho, DIMENSIONLESS
0.0
0.2
0.4
0.6
0.8
1.0
α=10⁻²²
K=1.0x10⁻¹ cm/sec
10⁻³ 2 3 4 5 6 7 8 9 10⁻² 2 3 4 5 6 7 8 9 10⁻¹ 2 3 4 5 6 7 8 9 10⁰ 2 3 4 5 6 7 8 9 10¹ 2 3 4 5 6 7 8 9 10²
TIME, IN MINUTES

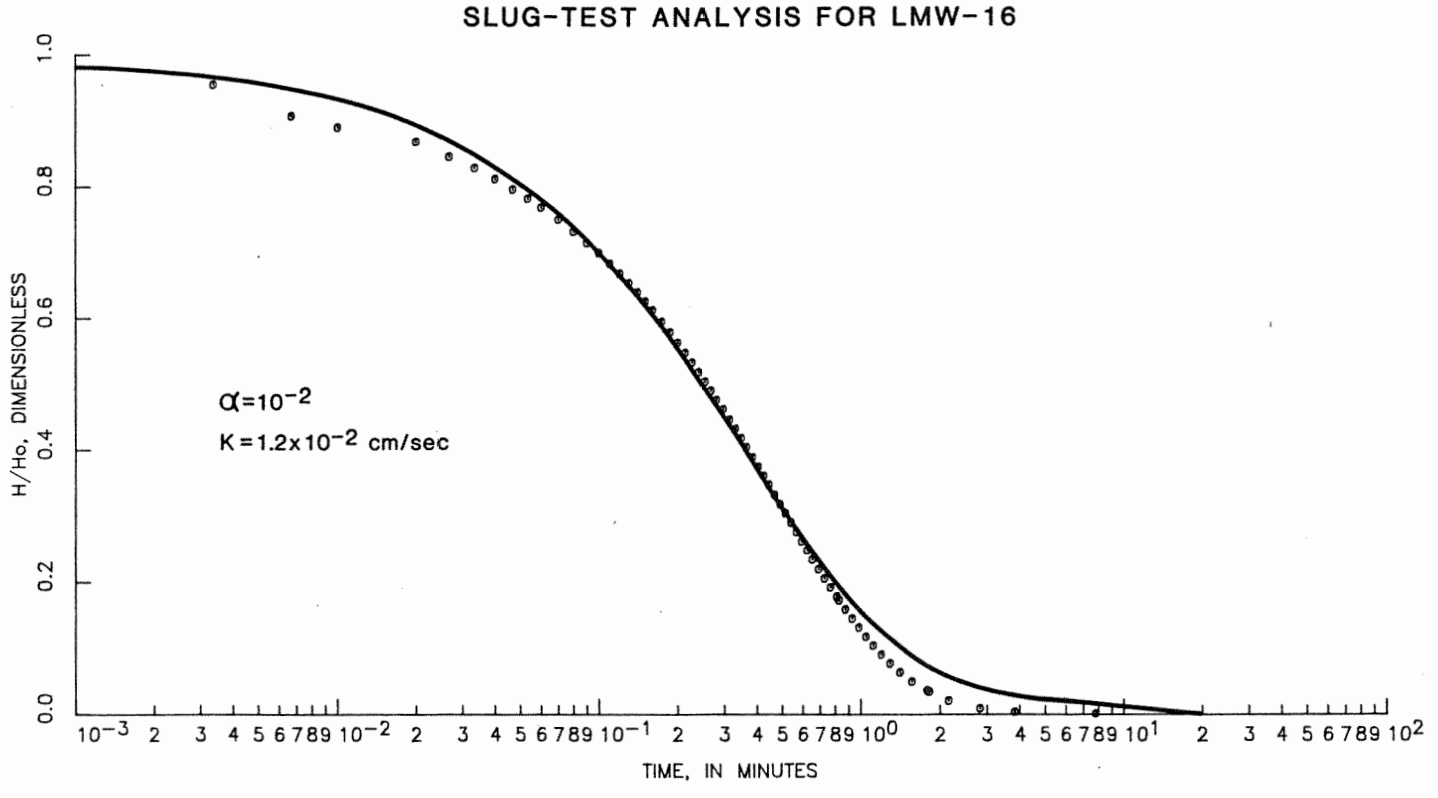

SLUG-TEST ANALYSIS FOR LMW-09
H/Ho, DIMENSIONLESS
0.0
0.2
0.4
0.6
0.8
1.0
α=10⁻³
K=3.0x10⁻³ cm/sec
10⁻³ 2 3 4 5 6 7 8 9 10⁻² 2 3 4 5 6 7 8 9 10⁻¹ 2 3 4 5 6 7 8 9 10⁰ 2 3 4 5 6 7 8 9 10¹ 2 3 4 5 6 7 8 9 10²
TIME, IN MINUTES

SLUG TEST ANALYSIS FOR LMW-10

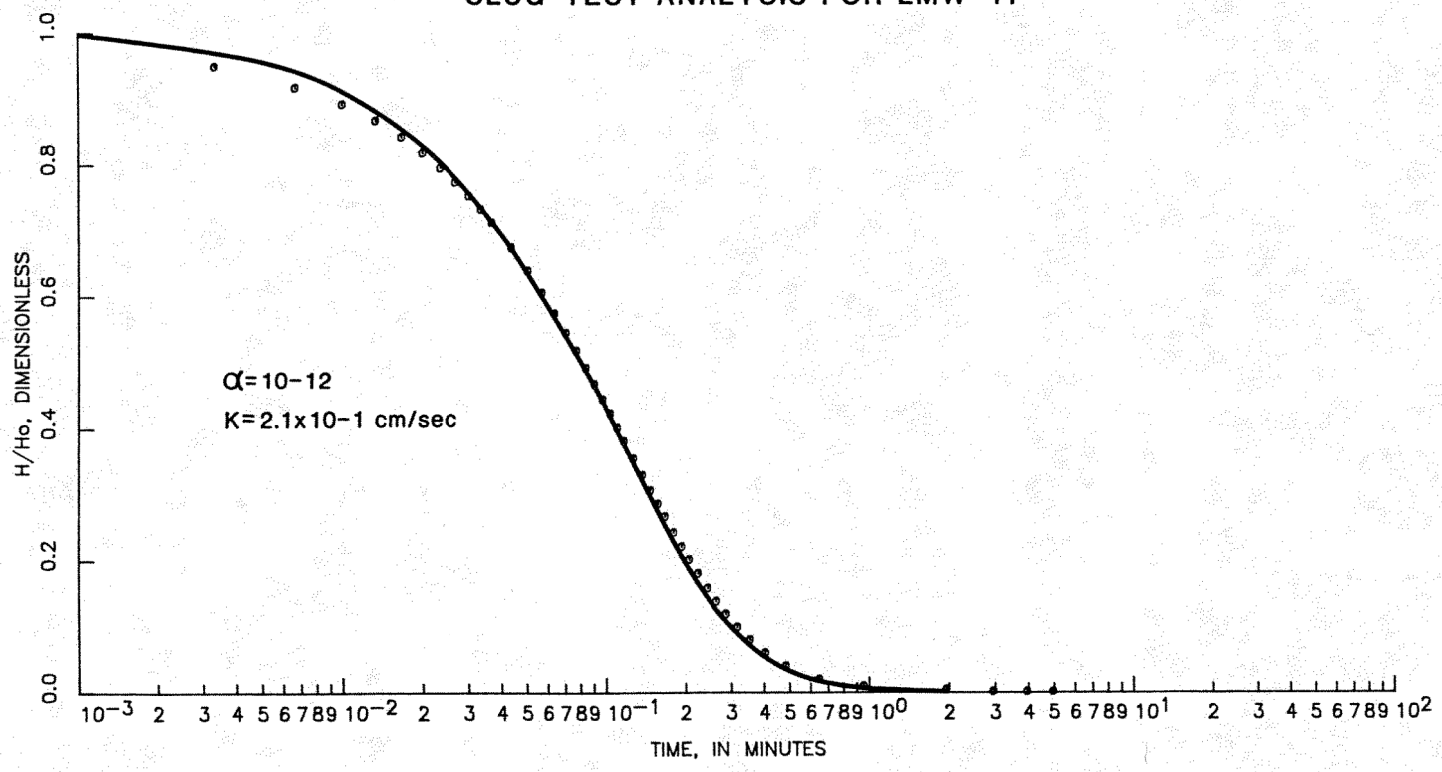



SLUG-TEST ANALYSIS FOR LMW-11
H/Ho, DIMENSIONLESS
0.0
0.2
0.4
0.6
0.8
1.0
α=10⁻¹
K= 3.0x10⁻⁴ cm/sec
10⁻³ 2 3 4 5 6 7 8 9 10⁻² 2 3 4 5 6 7 8 9 10⁻¹ 2 3 4 5 6 7 8 9 10⁰ 2 3 4 5 6 7 8 9 10¹ 2 3 4 5 6 7 8 9 10²
TIME, IN MINUTES


SLUG-TEST ANALYSIS FOR LMW-12
H/Ho, DIMENSIONLESS
0.0
0.2
0.4
0.6
0.8
1.0
α=10⁻¹⁰
K=1.2x10⁻³ cm/sec
10⁻³ 2 3 4 5 6 7 8 9 10⁻² 2 3 4 5 6 7 8 9 10⁻¹ 2 3 4 5 6 7 8 9 10⁰ 2 3 4 5 6 7 8 9 10¹ 2 3 4 5 6 7 8 9 10²
TIME, IN MINUTES


SLUG-TEST ANALYSIS FOR LMW-16
H/Ho, DIMENSIONLESS
0.0
0.2
0.4
0.6
0.8
1.0
α=10⁻²
K=1.2x10⁻² cm/sec
10⁻³ 2 3 4 5 6 7 8 9 10⁻² 2 3 4 5 6 7 8 9 10⁻¹ 2 3 4 5 6 7 8 9 10⁰ 2 3 4 5 6 7 8 9 10¹ 2 3 4 5 6 7 8 9 10²
TIME, IN MINUTES

SLUG-TEST ANALYSIS FOR LMW-17



Appendix J

SOURCE APPORTIONMENT CALCULATIONS

A method to estimate the relative mixing of waters from different sources downgradient of the ash pond is described in this section. Three sources were considered in this treatment: groundwater, ash pond water, and ash delta water. Average compositions of the groundwater and ash pond water analyses were used in the calculations.

A source apportionment approach was used to estimate the relative amounts of each of these three water sources present in the well samples collected between the ash pond and the river. The chemical species which were included in these calculations were selected on the basis that minimal losses or increases would occur due to interactions with the soils between the ash pond and the sampling points. Eight species were initially considered, including chloride, total organic carbon, calcium, strontium, sulfate, sodium, potassium, and silicon. Chloride was dropped from the list since the well samples consistently showed higher chloride levels than the concentrations in any of the source streams. The remaining seven species were then used to regress the relative amounts of the three sources for each of the well samples.

An iterative, trial and error routine was used to obtain a best fit of the compositions. A set of equations was defined for each well sample of the following mathematical form:

$$\Sigma_i \; C_{n_i} \cdot F_i = C_{n_s} \qquad \text{(J-1)}$$

where: C_{n_i} = the concentration of species, n, in the source, i

F_i = the fraction of source, i, in the well sample

C_{n_s} = the concentration of species, n, in the well sample, s.

A set of simultaneous equations was generated from the previous expression for each well sample. The fractions of each source, F_i, were selected to minimize the absolute value of relative errors between the calculated concentrations and the measured values such that:

$$\sum_n \left[\frac{(C_{n_s} - C'_{n_s})}{(C_{n_s} + C'_{n_s})/2} \right]^2 = \text{minimum} \qquad \text{(J-2)}$$

where: C_{n_s} = the calculated concentration of species, n, in a particular sample, s.

C'_{n_s} = the measured concentration of species, n, in the sample, s.

The fractions were also subjected to the conservation constraint that:

$$\sum_i F_i = 1 \qquad \text{(J-3)}$$

The results of these calculations are summarized in Table J-1. These results indicate that most of the water at each of the sampling points comes from the groundwater supply. In general, the closer to the ash pond, the higher the fraction of ash pond water predicted for the samples. In the case of wells L-5, L-6, and L-7, the proportion of ash pond water increases with the depth at which the sample is collected. The calculated contribution of solution associated with the ash delta is generally quite low, but in general represents about 5 to 10% of the volume of most samples.

The comparison of the measured concentrations to the calculated values is also presented graphically. Figure J-1 shows measured data versus the calculated values along with a least square fit line and a line representing a perfect fit of the calculated values. The graphs for the remainder of the samples are presented in Figures J-2 through J-13.

Table J-1

SUMMARY OF SOURCE APPORTIONMENT CALCULATIONS

Well ID		Chemical Species (mg/L)							Mixing Fractions		
		TOC	Ca	Sr	SO_4	Na	K	Si	Ground Water	Ash Pond	Ash Delta
L-1	Meas.	8.3	11	.074	45	4.4	2.7	12	0.84	0.13	0.02
	Calc.	8.8	13	.070	39	5.0	3.4	15			
L-2	Meas.	13	30	0.21	145	9.8	2.0	17	0.54	0.36	0.10
	Calc.	9.0	37	0.18	149	6.2	4.7	13			
L-3	Meas.	11	19	0.14	87	9.2	2.3	10	0.58	0.37	0.05
	Calc.	7.8	22	0.15	82	6.1	4.3	13			
L-4	Meas.	17	24	0.14	114	9.7	2.7	18	0.73	0.20	0.07
	Calc.	9.5	27	0.12	105	5.5	4.0	15			
L-5	Meas.	15	40	0.31	171	15	3.5	15	0.51	0.36	0.13
	Calc.	10	46	0.19	191	6.4	5.0	14			
L-6	Meas.	10	5	0.01	49	6.9	3.1	4.8	0.97	0.00	0.03
	Calc.	10	--	0.04	37	4.6	3.0	17			
L-7	Meas.	6.0	72	0.24	142	12	8.7	13	0.16	0.71	0.13
	Calc.	7.4	48	0.29	207	7.7	6.0	9.5			
L-8	Meas.	17	24	0.14	125	14	2.3	15	0.78	0.14	0.08
	Calc.	10	30	0.11	116	5.3	3.9	16			
L-9	Meas.	14	17	0.14	77	9.6	3.9	6.9	0.57	0.39	0.04
	Calc.	7.5	20	0.15	72	6.1	4.3	12			
L-10	Meas.	30	27	0.15	79	9.2	2.7	10	0.55	0.40	0.05
	Calc	7.7*	23	0.16	85	6.2	4.4	12			
L-13	Meas.	18	30	0.18	136	14	3.5	12	0.66	0.25	0.09
	Calc.	10	35	0.14	140	5.8	4.3	15			
L-16	Meas.	18	37	0.2	122	11	3.9	15	0.65	0.25	0.10
	Calc.	10	37	0.15	151	5.8	4.4	15			
L-17	Meas.	13	14	0.12	58	8.2	E	12	0.69	0.28	0.03
	Calc.	8.1	16	0.15	55	5.6	--	14			

E - Analytical Error Suspected
* - Species was not used in regression calculation

Source Apportionment Results
L-1

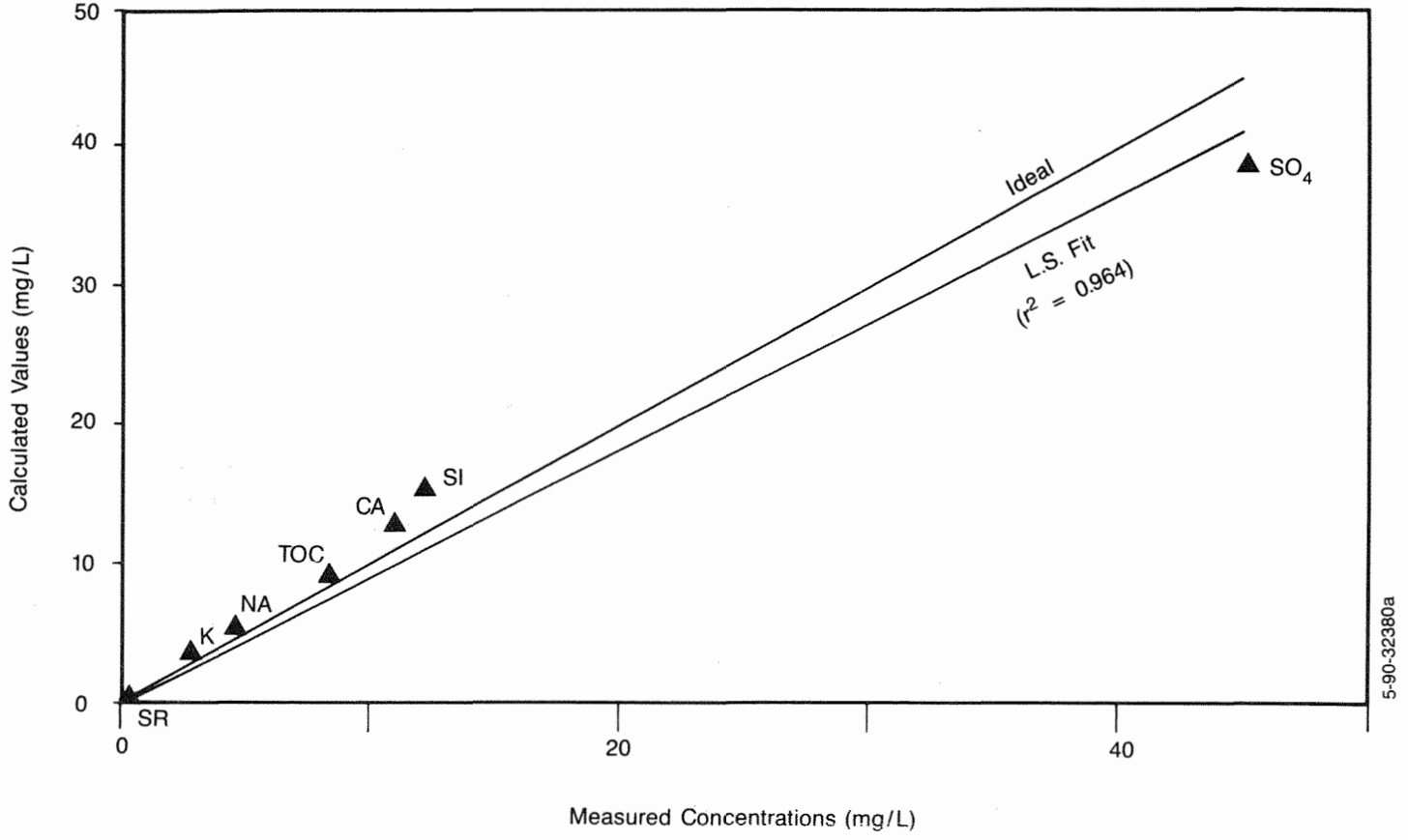


Figure J-1

Source Apportionment Results
L-2

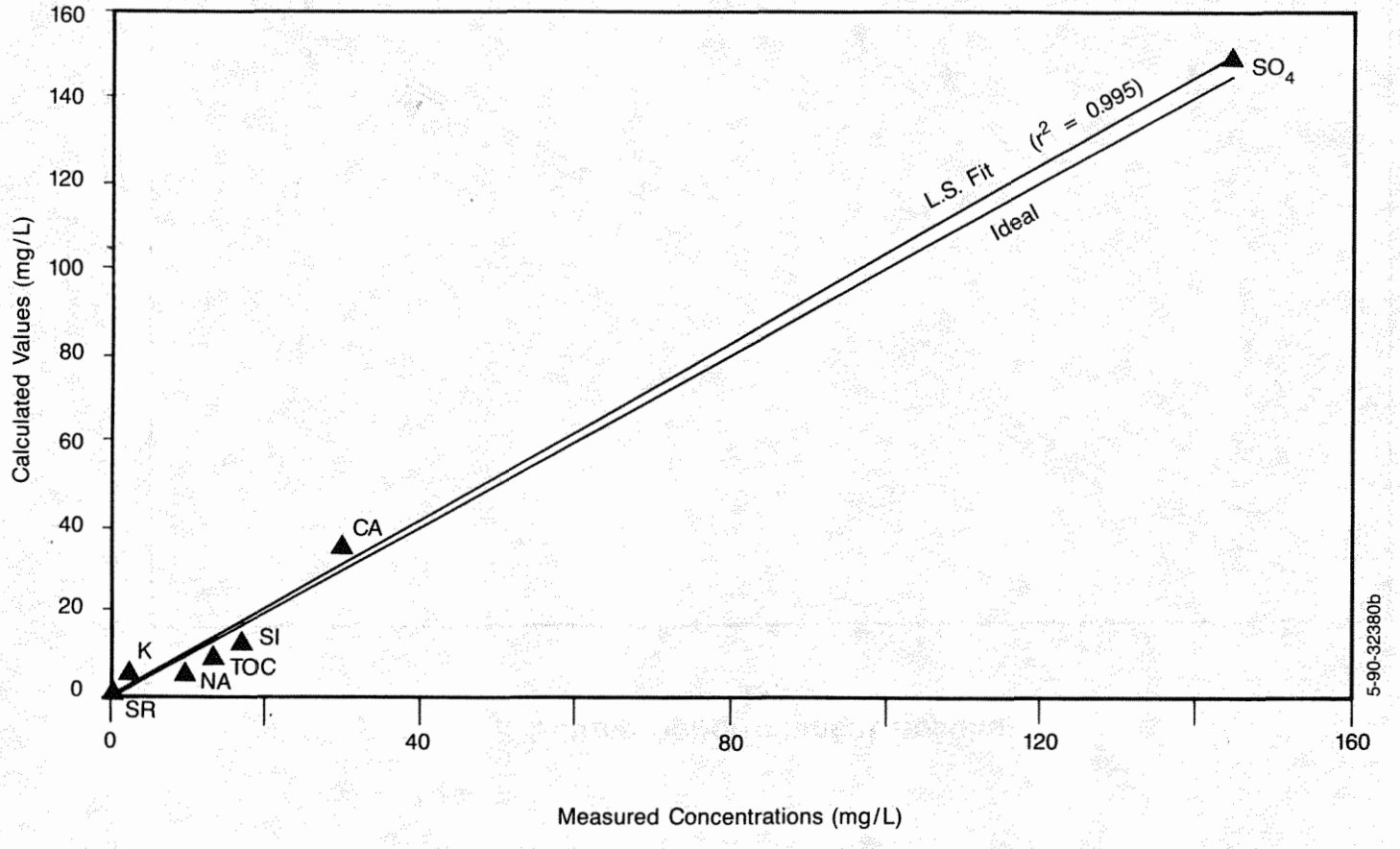


Figure J-2

Source Apportionment Results
L-3

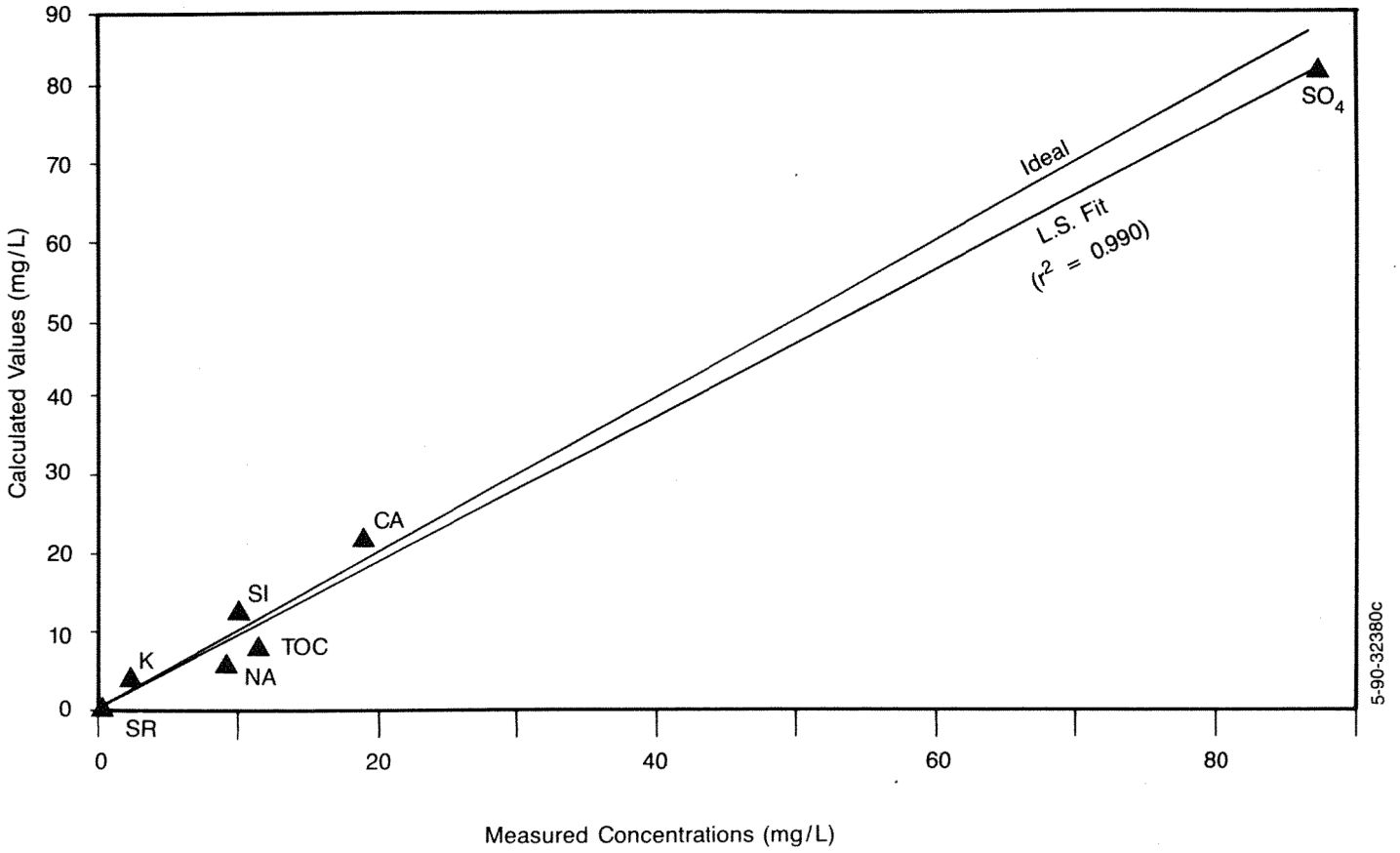


Figure J-3

Source Apportionment Results
L-4

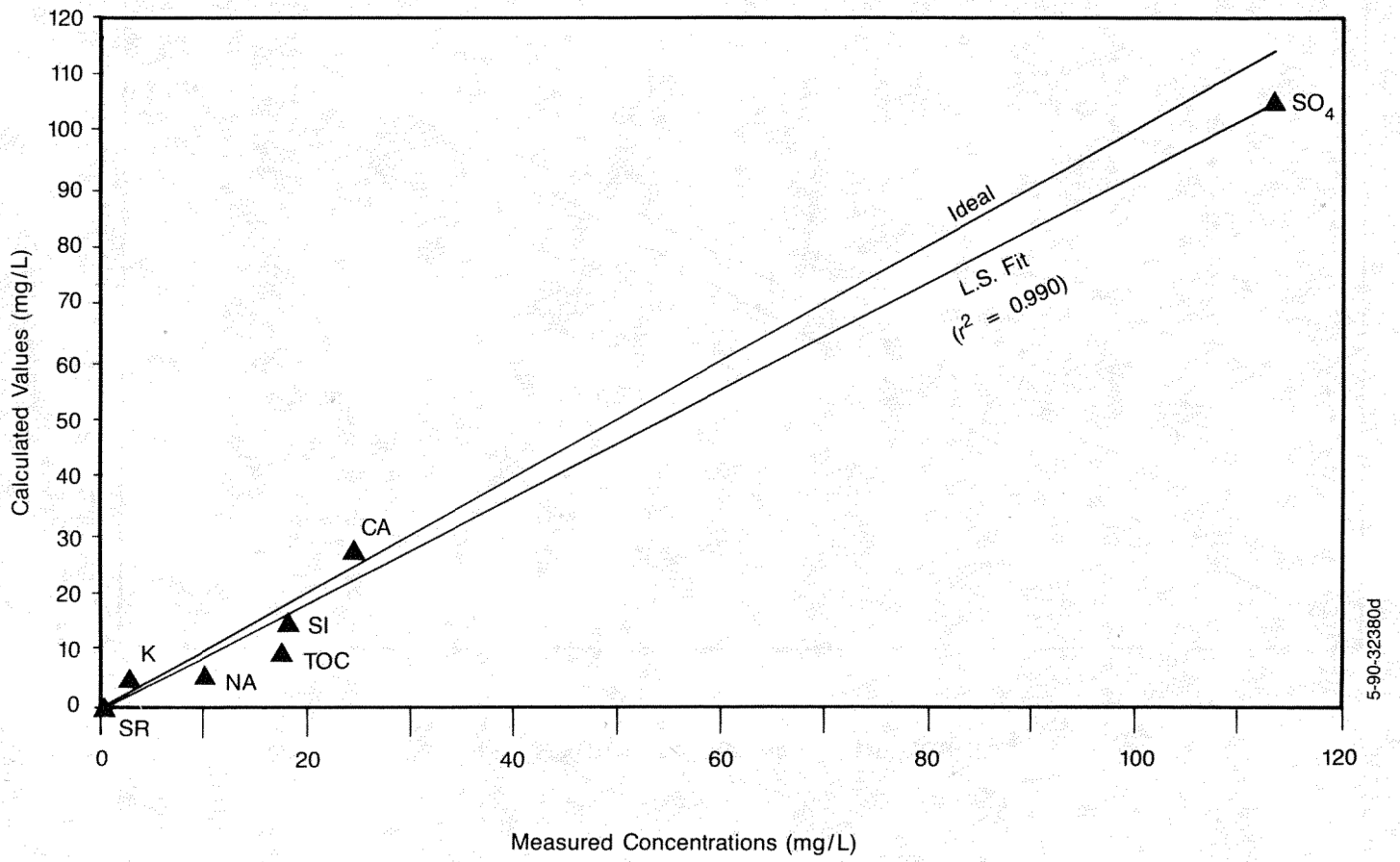


Figure J-4

Source Apportionment Results
L-5

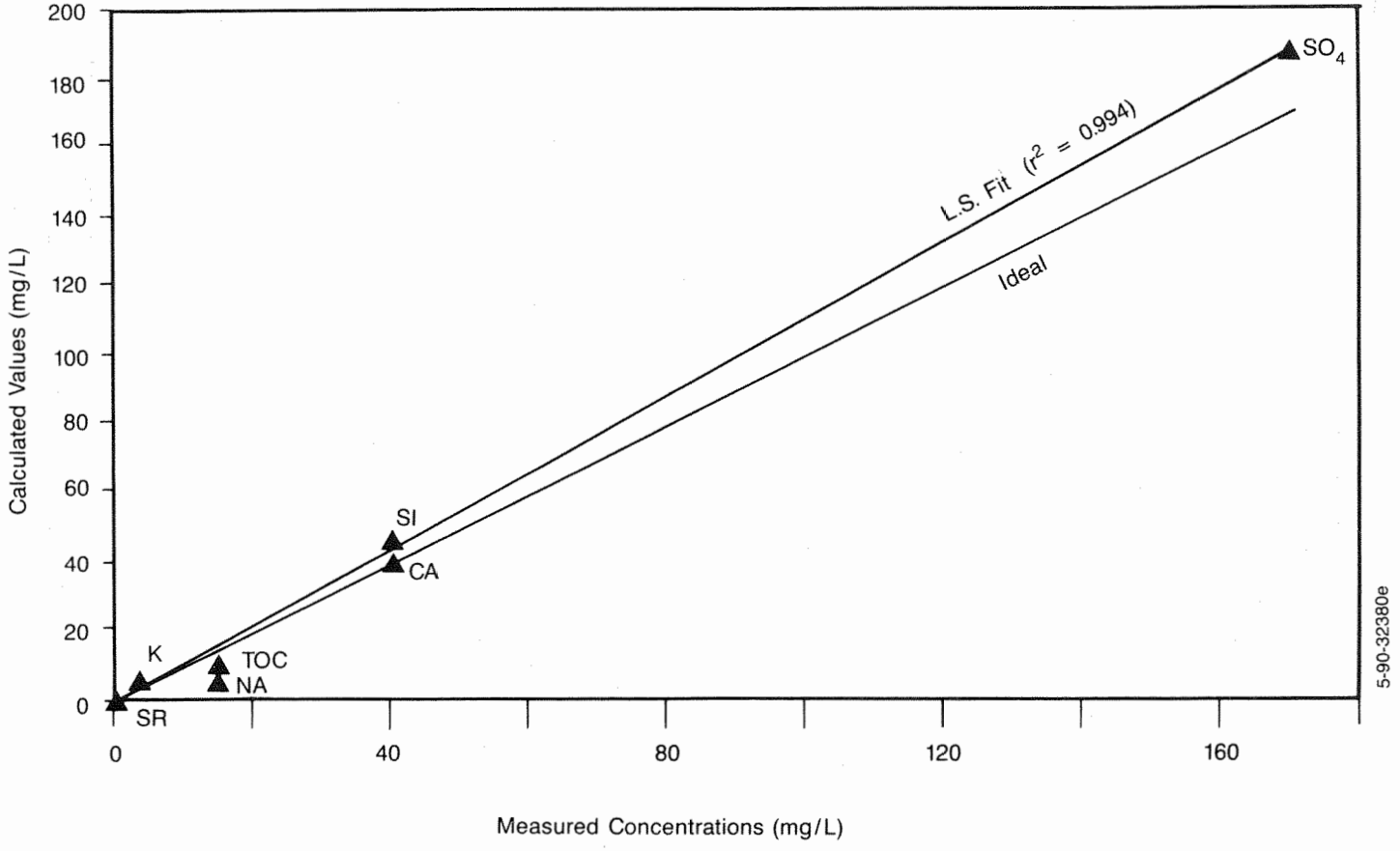


Figure J-5

Source Apportionment Results
L-6

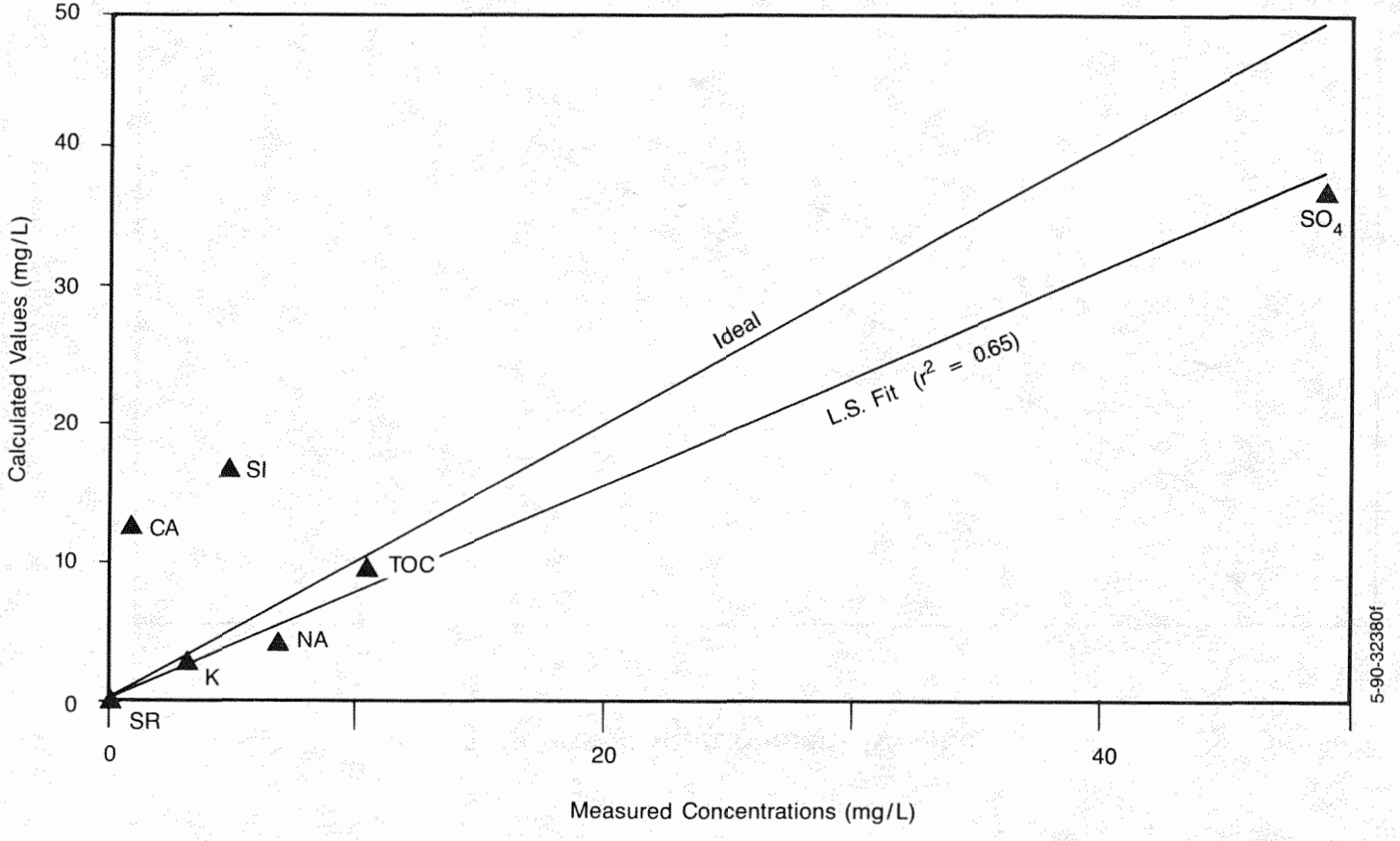


Figure J-6

Source Apportionment Results
L-7

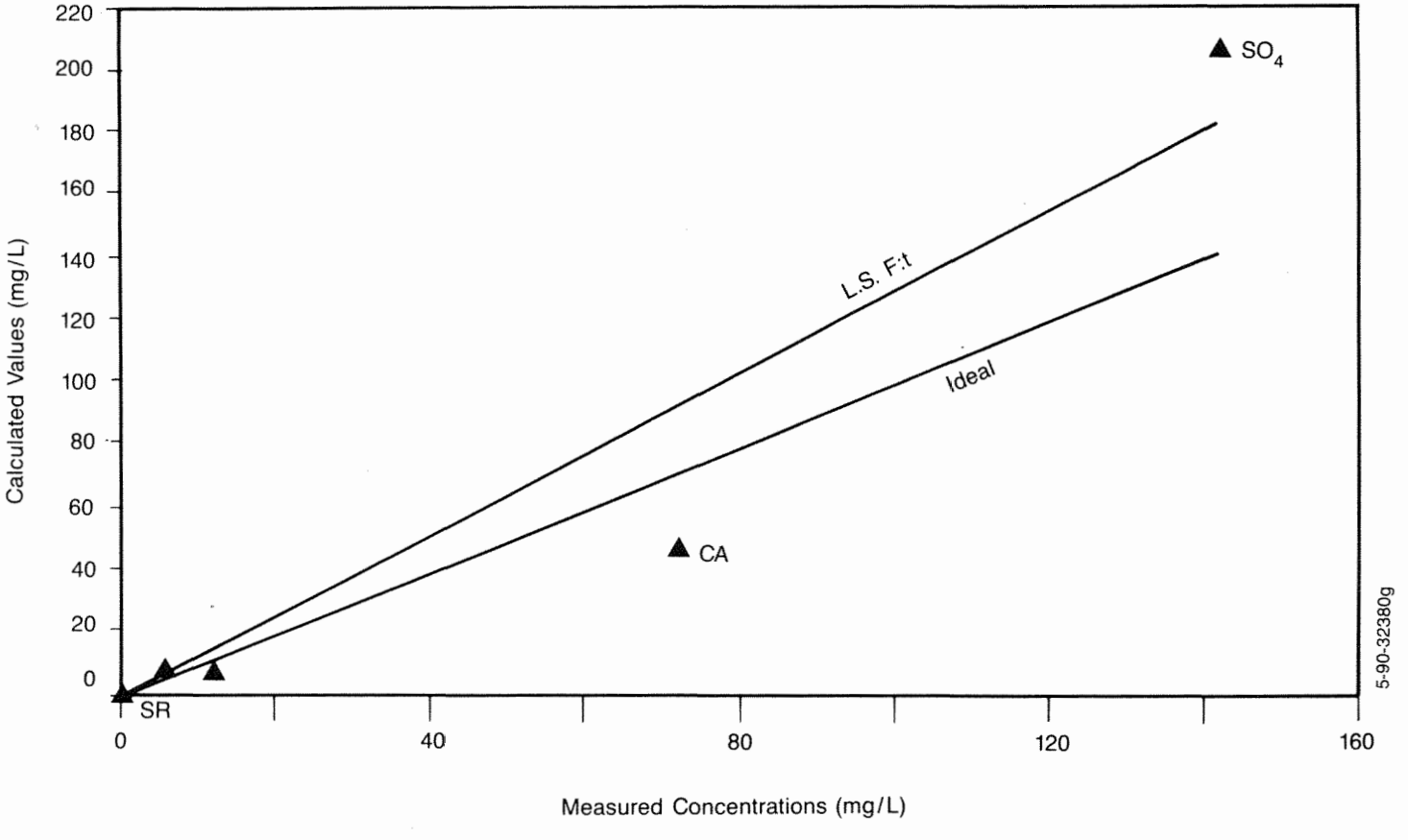


Figure J-7

Source Apportionment Results
L-8

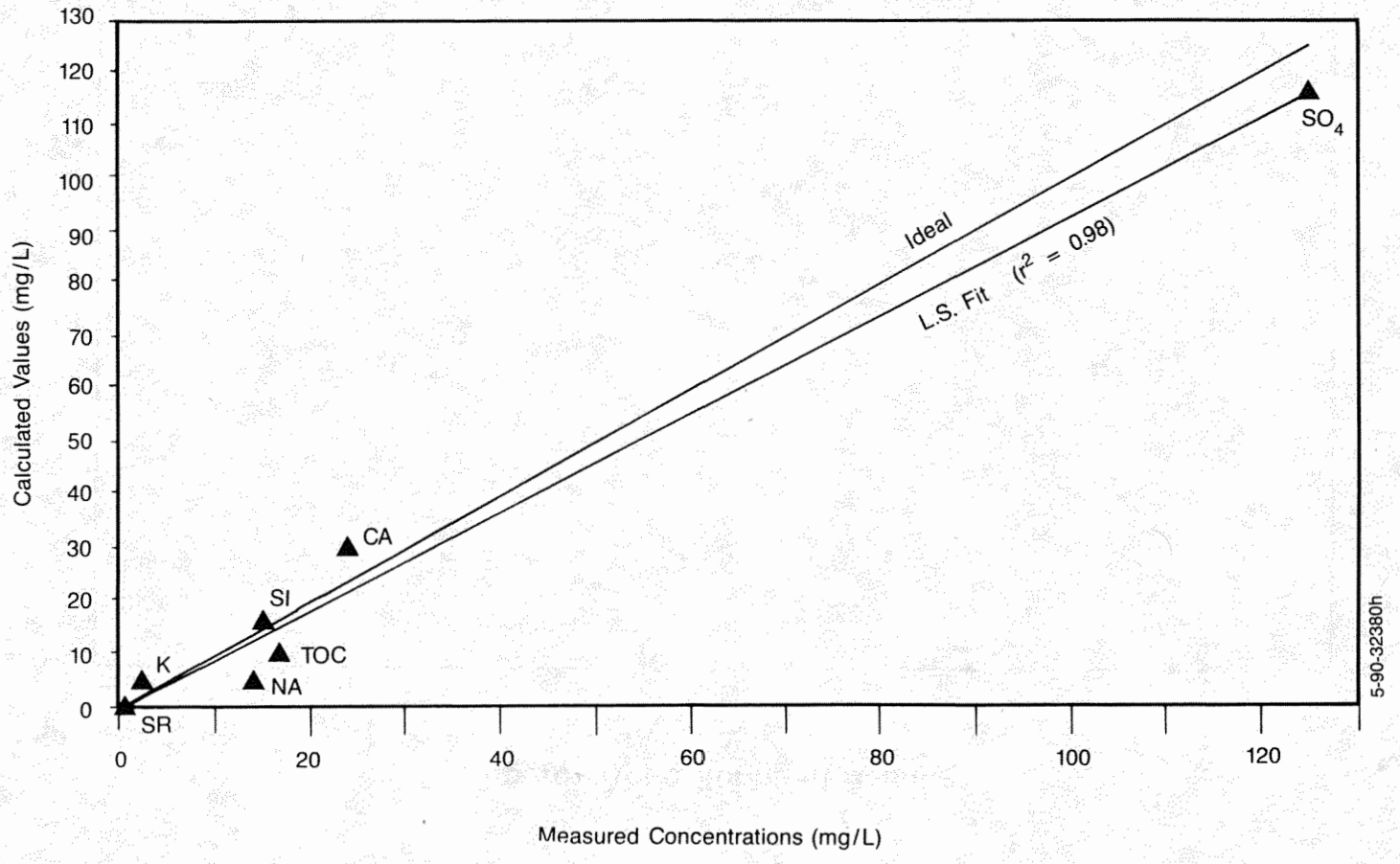


Figure J-8

Source Apportionment Results
L-9

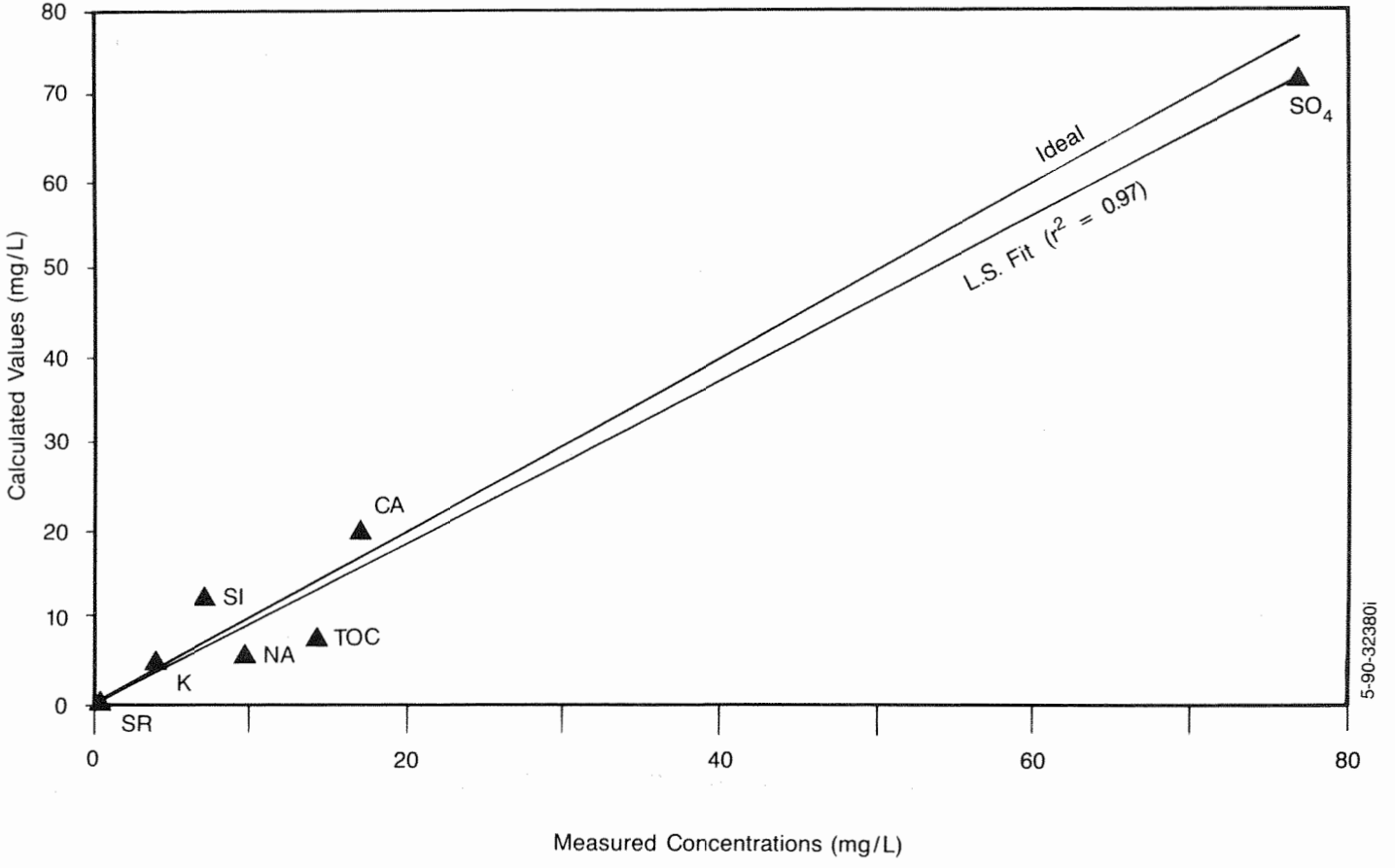


Figure J-9

Source Apportionment Results
L-10

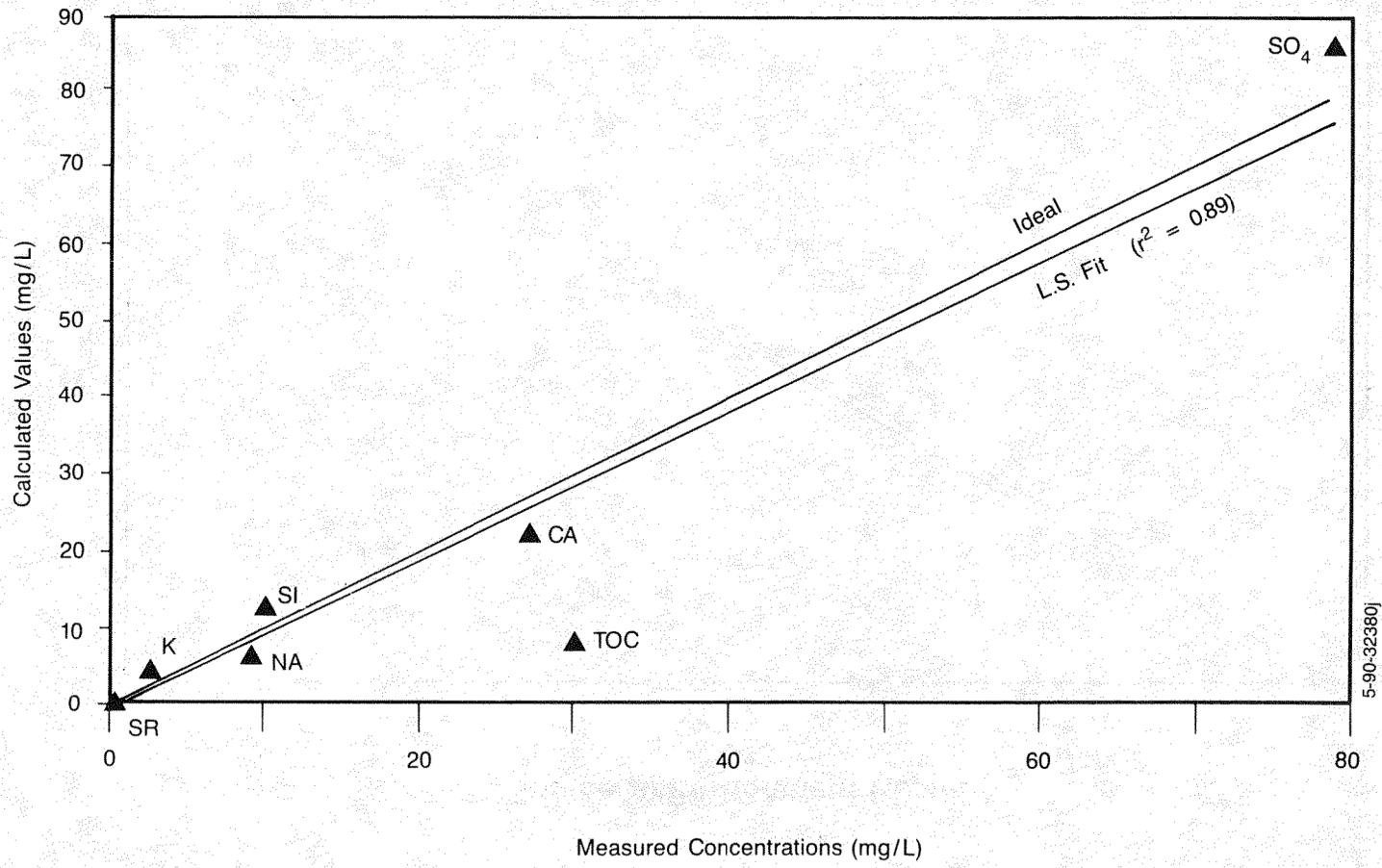


Figure J-10

Source Apportionment Results
L-13

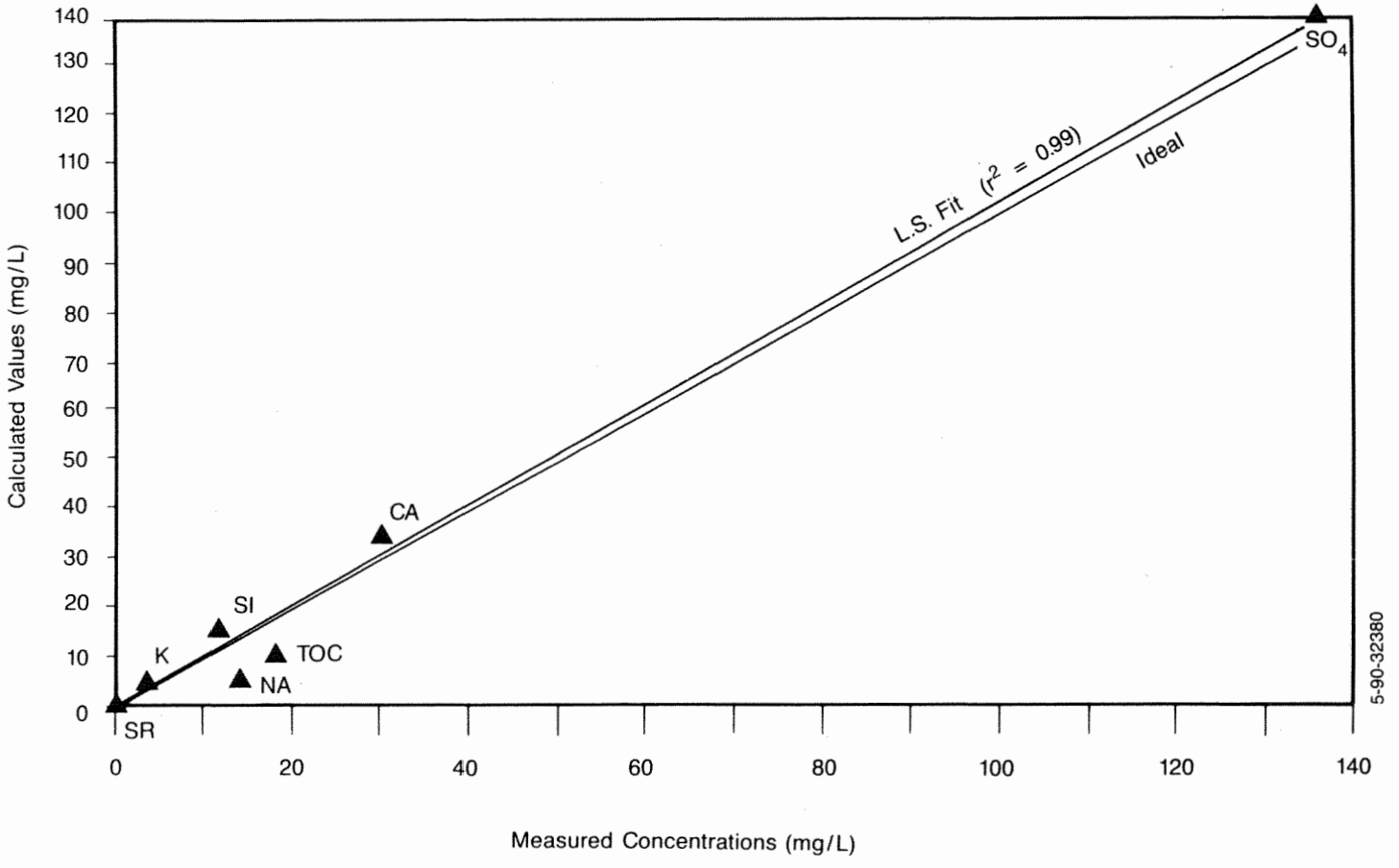


Figure J-11

Source Apportionment Results
L-16

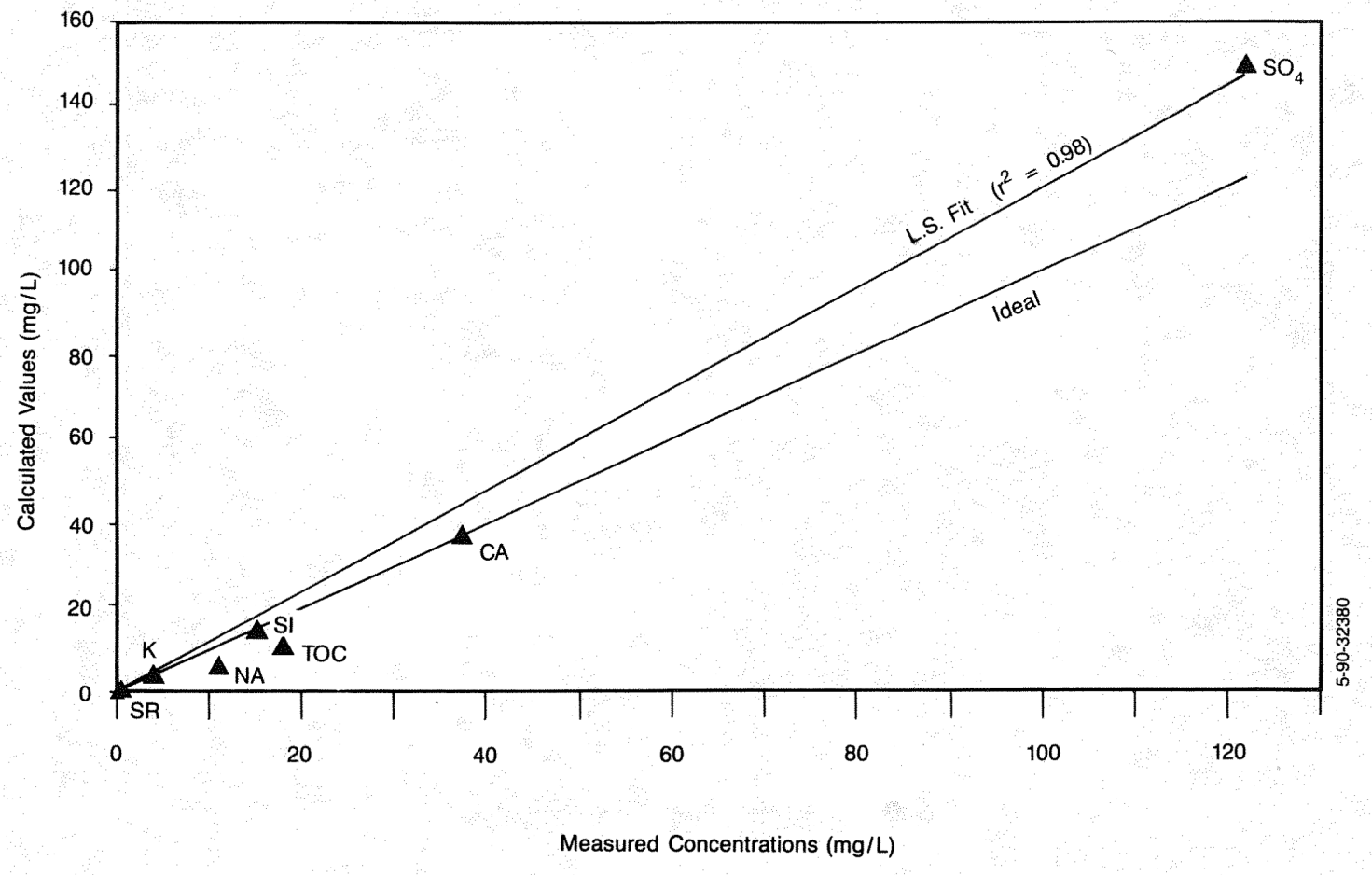


Figure J-12

Source Apportionment Results
L-17

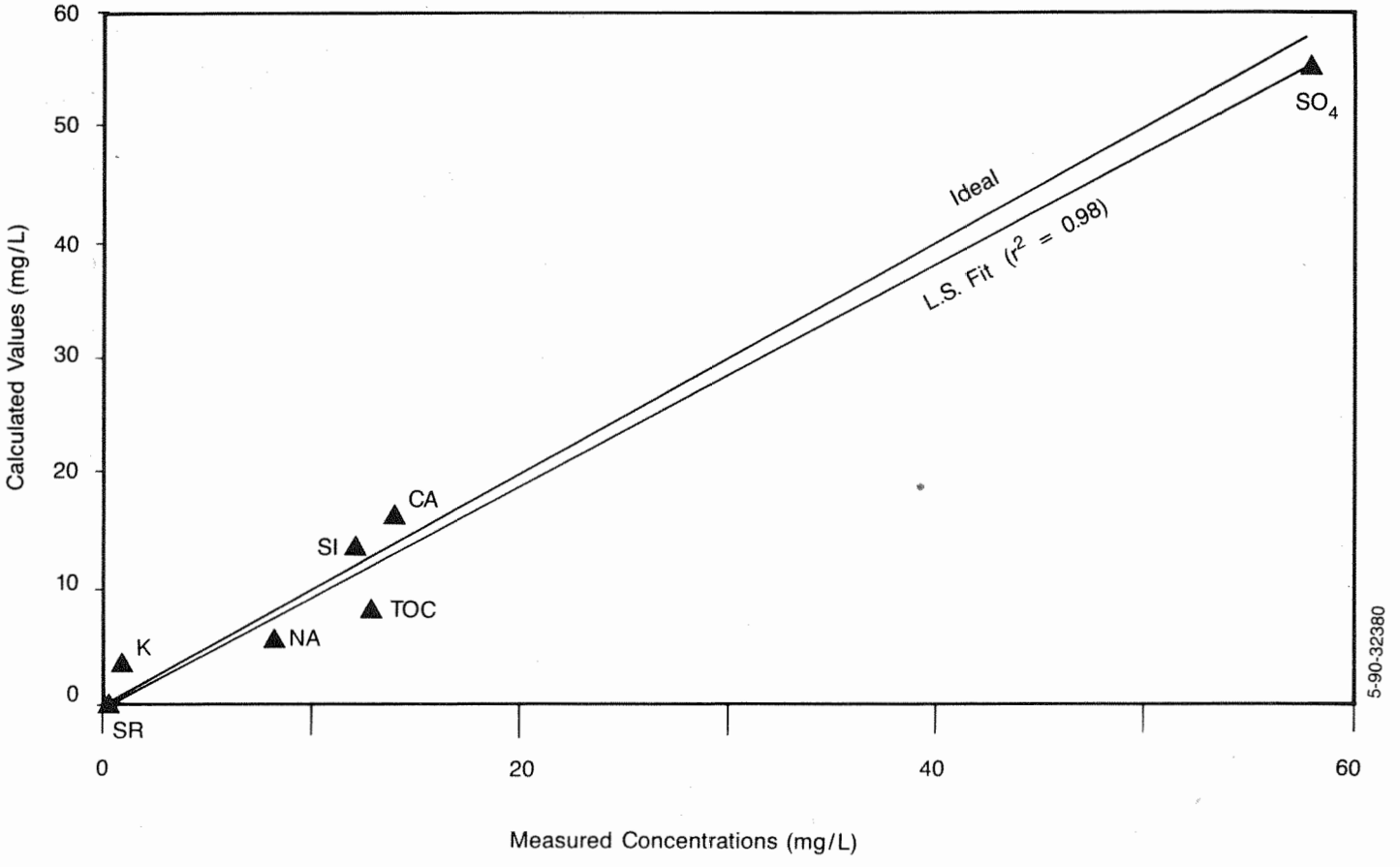


Figure J-13

Appendix K

QUALITY CONTROL RESULTS

Laboratory Quality Control

Almost all of the QC tests carried out in the laboratory fell within control limits, but a few exceptions exist. The exceptions are associated with low concentrations of a few analytes: ammonia, nitrate/nitrite, total phosphate, chloride and organic carbon, usually with analyses carried out on samples collected during Event I.

Correlation coefficients fell slightly below the specified limits for Event I for ammonia, total phosphate and total organic carbon (TOC). Correlation coefficients also were below the control limit for one batch of the Event II samples analyzed for ammonia and for nitrate/nitrite.

Chloride quality control check sample recoveries were below the control limit of 95 percent for three batches. Erratic recovery of control samples was experienced for one batch of Event II nitrate/nitrite analyses.

Poor percentage reproducibility was observed for bromide, chloride, and sulfate present at low concentrations. All bromide concentrations were near the analytical detection limit and all chloride concentrations were low. Relatively high variability often occurs at low analyte concentrations. Poor reproducibility for sulfate was observed only at low concentrations. Sulfate concentrations ranged as high as 2000 mg/L and duplicate agreement was excellent for samples containing 10 mg/L or higher concentrations. The high percentage differences observed at low sulfate concentrations should not present a problem in interpreting sulfate migration data.

A few matrix spikes were outside control limits for Event I analyses. Tests that exhibited high spike recovery were: ammonia, bromide, chloride, and fluoride. Matrix spike duplicate agreement was poor for ammonia for Event I.

With the exception of bromide, the analytes for which there were some laboratory quality control shortfalls were not of major significance to this study. Bromide could come from the boiler chemical cleaning waste, but all bromide concentrations

were very low. The results of laboratory quality control tests associated with analysis of chemical species of major interest to the codisposal study all fell within pre-established control limits.

Field Blanks and Duplicates

Field Blanks. Concentrations of all but three species were negligible in field blanks. High concentrations of ammonia, nitrate/nitrite, and total phosphorous were observed in field blanks either from Event I, from Event II or from both. Ammonia concentrations in field blanks were high relative to measured ammonia concentrations in other samples from both Event I and Event II. For each event, the highest ammonia concentration measured in a sample was less than 3.5 times the field blank. The total phosphate concentration in the field blank for Event I was higher than the total phosphate concentration measured in most of the other samples. Only one Event I sample had a total phosphate concentration greater than twice the concentration in the field blank. The Event II field blank had a concentration of nitrate/nitrite that was comparable to or higher than the nitrate/nitrite concentration in about half of the samples analyzed.

The grass surrounding the ash pond was fertilized during Event I. It is possible that a small amount of wind-blown fertilizer contaminated the field blank. The grass was not fertilized during Event II, but again, some contaminant containing ammonia and nitrate evidently entered the field blank. These high field blanks indicate that the corresponding analyses should be considered to be approximate and that the possibility exists that some of the measured values represent sample contamination.

As indicated above, field blanks contained negligible amounts of the other chemical species examined for this project and there is no reason to suspect contamination for other substances. Field blank results are given in Appendix C; for Event I the field blank had the Sample ID L-050, and for Event II the field blank had the Sample ID L-111.

Field Duplicates. Concentrations of all but four species agreed with each other in field duplicates. The four species for which agreement was poor in at least one set of field duplicates were: ammonia, nitrate/nitrite, total phosphate, and total organic carbon (TOC). Nitrate/nitrite, phosphate, and TOC concentrations in field duplicates agreed well for Event I but not for Event II. Field duplicate agreement for ammonia was poor for Events I and II. For Event II, in the field duplicates from downgradient well LMW-03, significantly higher ammonia, nitrate/nitrite, total

phosphate, and total organic carbon (TOC) concentrations were present in Sample ID L-055 than in the field duplicate L-108. These data again indicate the possibility of contamination with a material containing these species.

Pooled values for field duplicates and analytical duplicates for anions and ammonia are listed in Table K-1 and pooled values for metals are listed in Table K-2. The values in Tables K-1 and K-2 indicate that variability was higher for field replicates than for analytical replicates. This is as expected.

Quality Assurance Results

Audit Sample Recoveries. Analytical results for aqueous audit samples are listed in Tables K-3 and K-4. Recoveries for total dissolved solids (filterable residue) were 99 percent for Event I and 49 percent for Event II. Recoveries for ammonia and anions fell within the range 80 to 110 percent. Recoveries for elements measured by atomic absorption spectrophotometry fell in the range 99 to 120 percent except for magnesium with a very low recovery of 4 percent. Recoveries for elemental analysis by inductively coupled argon plasma spectrometry fell in the range 95 to 110 percent except for a low recovery for selenium of 30 percent.

Figure K-1 illustrates measured and NBS certified concentrations for major elements reported as oxides in NBS Standard Reference Material 1633, fly ash. Recoveries of major elements certified by NBS were excellent except for sodium. The sodium concentration measured by Radian was about a factor of two higher than the NBS certified value.

Analysis by two Analytical Methods. Figure K-2 indicates the results when silicon in aqueous samples was analyzed by a spectrophotometric technique and by ICPES. All but two values agree with each other. The spectrophotometric technique did not give accurate results when the silicon concentration was very high.

Analysis by Two Laboratories. Table K-5 lists results obtained on four samples measured in Radian's laboratories and in Battelle's laboratories. Large differences between measurements made in the two laboratories were observed for carbonate, fluoride for LMW-11 Radian sample ID L-048, nitrate/nitrite, and organic carbon. For carbonate, pH changed between Radian and Battelle for L-040 and L-041. Chloride concentrations were low and other data indicate a high variability for chloride. Fluoride agreed fairly well except for sample L-048. Nitrate/nitrite concentrations were near the detection limit for three of the four samples and the large percent deviation would be expected for these samples. The nitrate/nitrite concentration

Table K-1

POOLED COEFFICIENTS OF VARIATION FOR FIELD AND LABORATORY DUPLICATES

Analyte	Field Duplicates		Analytical Duplicates	
	Coefficient of Variation (%)	Degrees of Freedom	Coefficient of Variation (%)	Degrees of Freedom
Alkalinity	70	3	Not Analyzed	0
Bromide	3	3	4	5
Chloride	7	3	12	4
Fluoride	10	3	3	3
Nitrate/Nitrite as N	32	3	2	4
Phosphate	37	3	2	3
Sulfate	9	3	5	8
Total Inorganic Carbon	1	2	3	27
Total Organic Carbon	16	3	9	47

Table K-2

POOLED COEFFICIENTS OF VARIATION FOR DUPLICATES
FOR ELEMENTAL CONCENTRATIONS

Analyte	Field Duplicates		Laboratory Duplicates	
	Coefficient of Variation %	Degrees of Freedom	Coefficient of Variation[a]	Degrees of Freedom
Arsenic (HGAA)	--	-	6	3
Barium (ICP)	68	3	1	5
Calcium (ICP)	2	3	-	-
Iron (ICP)	47	3	-	2
Iron (FAA)	--	3	-	-
Magnesium (ICP)	-	3	-	-
Magnesium (FAA)	2	3	-	-
Manganese	2.5	3	-	-
Potassium ICP	0	3	-	0
Potassium (FAA)	7	3	1	5
Selenium (HGAA)	-	-	4	3
Silicon (ICP)	5	3	-	-
Sodium (ICP)	4	3	-	-
Sodium (FAA)	3	3	0.6	5
Selenium (HGAA)	-	-	4	3

[a]Includes analytical duplicate analyses on solid samples.

Table K-3

AUDIT SAMPLE RECOVERIES FOR WATER ANALYSIS FOR ANIONS AND FOR ELEMENTS BY ATOMIC ABSORPTION FOR L STATION, EVENTS 1 AND 2

Property	Event 1 Measured/ True (%)	Event 2 Measured/ True (%)
WATER QUALITY VARIABLES		
Filterable Residue	99.3	49
ANIONS AND AMMONIA		
Ammonia		82
Carbonate		82
Chloride		118
Nitrate/Nitrite		111
Organic Carbon	78.4	100
Phosphate, total		100
Sulfate		99
ELEMENTS BY AA		
Arsenic, hydride AA	100	100
Calcium, flame AA	100	80
Chromium, graphite AA	100	99
Copper, graphite AA	100	110
Lead, graphite AA	110	NC
Magnesium, flame AA	100	97
Potassium, flame AA	NC	NC
Selenium, hydride AA	100	120
Sodium, flame AA	NC	FP

NC = Not Calculated
FP = False Positive
AA = Atomic Absorption Spectrophotometry

Table K-4

AUDIT SAMPLE RECOVERIES FOR WATER ANALYSIS FOR ELEMENTS BY INDUCTIVELY COUPLED PLASMA SPECTROMETRY FOR L-STATION, EVENTS 1 AND 2

Element	Event 1 Measured/ True (%)	Event 2 Measured/ True (%)
Aluminum	NC	NC
Antimony	100	98
Arsenic	100	108
Barium	NC	NC
Beryllium	96	102
Boron	NC	NC
Cadmium	100	110
Calcium	100	110
Chromium	95	100
Cobalt	96	100
Copper	94	100
Iron	96	100
Lead	99	95
Magnesium	NC	110
Manganese	97	100
Molybdenum	100	99
Nickel	99	110
Potassium	NC	NC
Selenium	100	NC
Silicon	NC	NC
Silver	NC	NC
Sodium	NC	NC
Strontium, ICPES	NC	NC
Thallium	NC	NC
Vanadium	97	100
Zinc	NC	NC

NC = Not Calculated
FP = False Positive

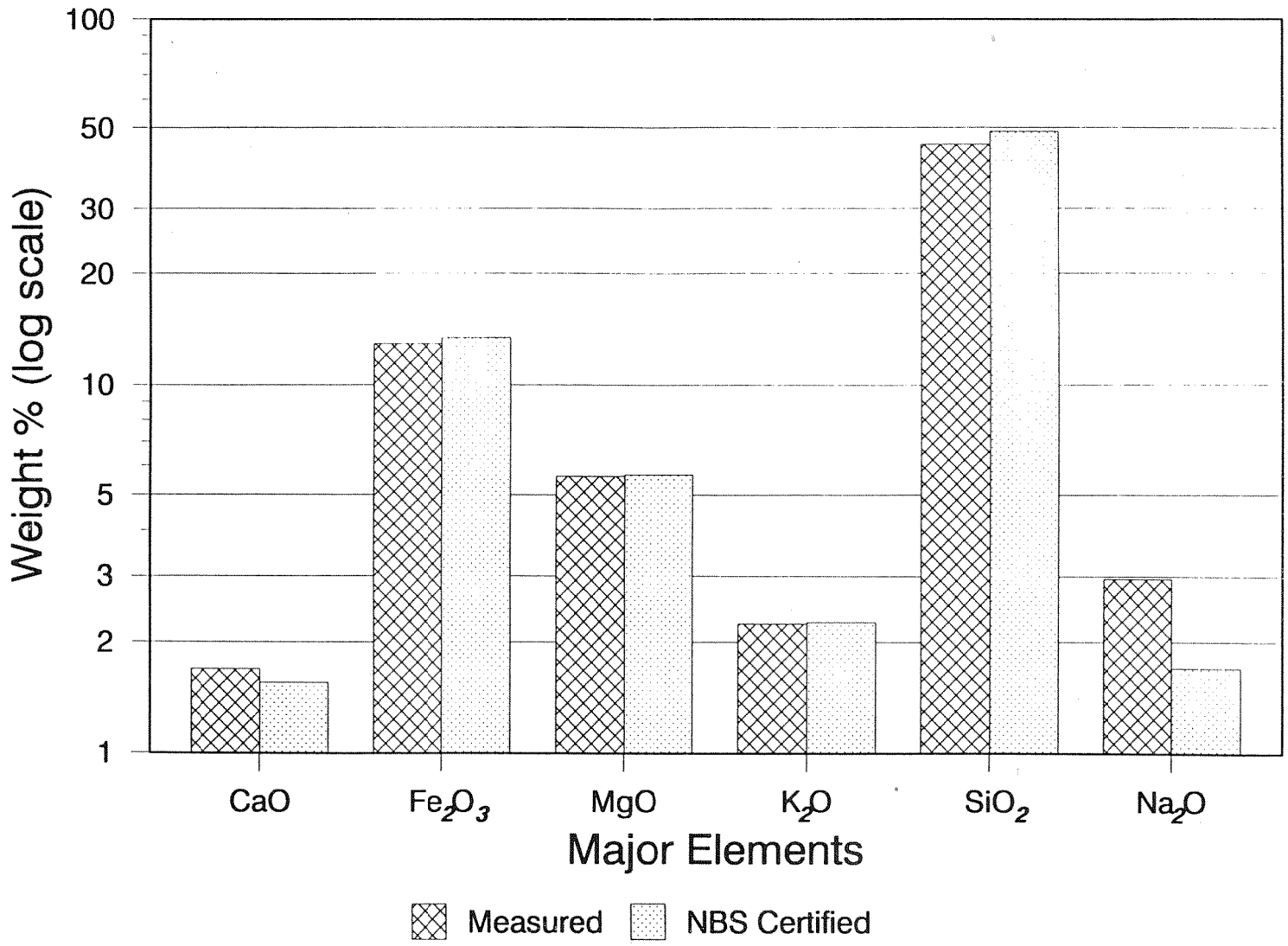


Figure K-1. Measured vs. NBS Certified Concentrations of Major Elements

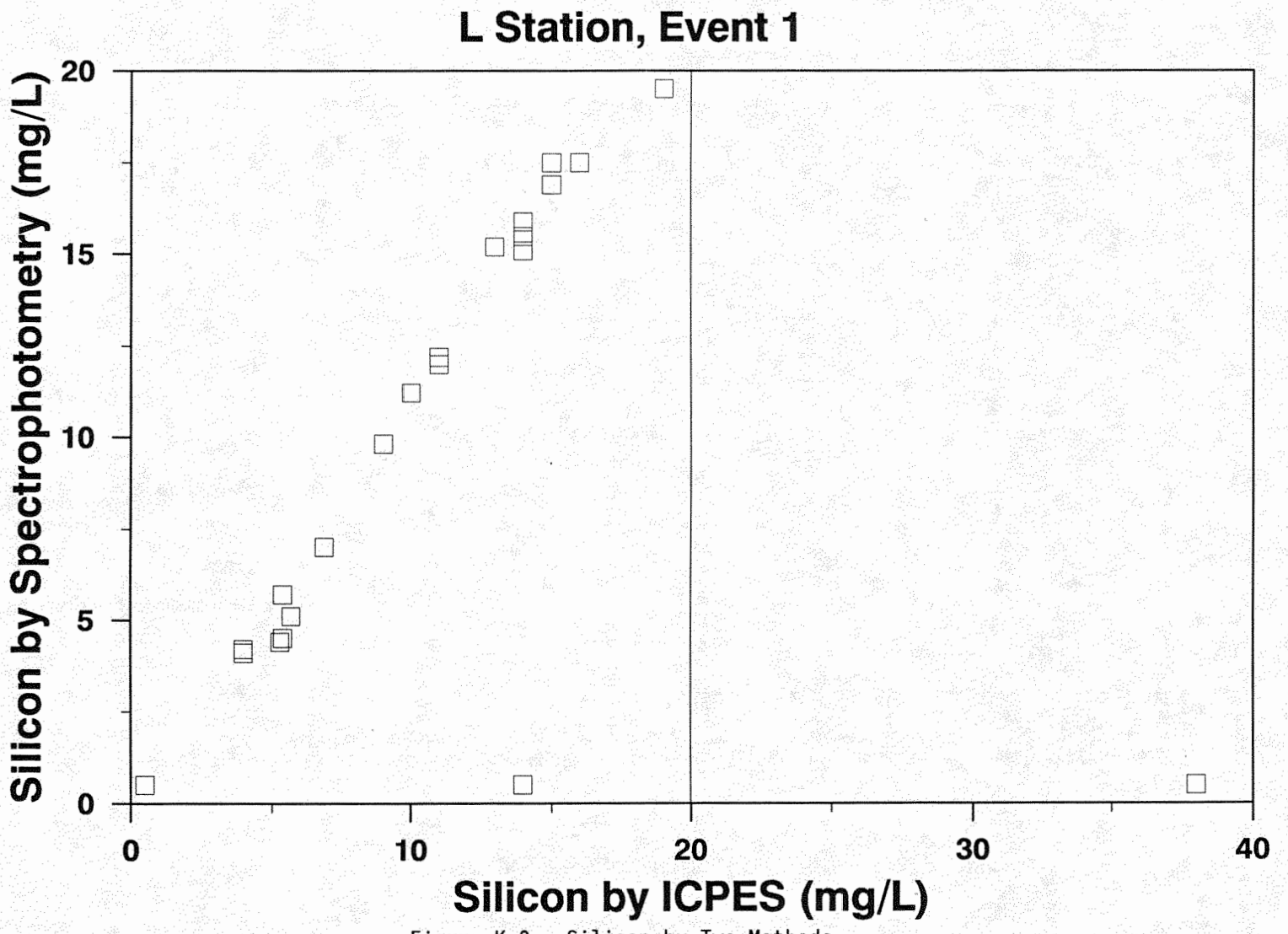


Figure K-2. Silicon by Two Methods

Table K-5

CONCENTRATIONS MEASURED BY RADIAN AND BY BATTELLE ON SPLIT SAMPLES

Property	Units	LMW-14 L-040 Radian Value	LMW-14 L-040 Battelle PNL Value	Relative Standard Deviation (%)	LMW-15 L-041 Radian Value	LMW-15 L-041 Battelle PNL Value	Relative Standard Deviation (%)	LMW-17 L-042 Radian Value	LMW-17 L-042 Battelle PNL Value	Relative Standard Deviation (%)	LMW-11 L-048 Radian Value	LMW-11 L-048 Battelle PNL Value	Relative Standard Deviation (%)
WATER QUALITY VARIABLES													
pH (field)	pH units	4.4	2.88	NC	4.2	2.74	NC	5.8	6.7	NC	6.1	7.05	NC
ANIONS AND AMMONIA IN AQUEOUS MEDIA													
Carbonate (TIC)	mg HCO3/L	310	95.5	53	256	22.4	84	119	35.6	54	264	117	39
Chloride	mg Cl/L	2.3	3.9	26	2.4	3.8	23	5.7	6.3	5	4.3	7	24
Fluoride (Dir)	mg F/L	1.7	1.59	3	0.52	0.72	16	0.082	NM	NC	0.033	0.22	74
Nitrate/Nitrite	mg N/L	0.23	0.11	35	<0.05	0.15	NC	0.07	0.12	25	2.9	3.1	3
Organic Carbon	mg C/L	NM	0.5	NC	<0.5	0.4	NC	1.6	0.4	60	4.6	0.6	77
Sulfate (only)	mg SO4/L	2060	2020	1	1200	1200	0	60	59	1	2.0	1.4	18
ELEMENTS IN AQUEOUS MEDIA BY AA													
Arsenic	mg/L	0.002	0.014	75	<0.002	<0.00002	NC	<0.002	NM	NC	<0.002	NM	NC
ELEMENTS IN AQUEOUS MEDIA BY ICPES													
Aluminum	mg/L	9.1	9.9	4	12	12	0	<0.2	0.12	NC	<0.2	NM	NC
Barium	mg/L	0.02	0.025	11	0.01	0.012	9	0.82	0.872	3	0.14	0.143	1
Boron	mg/L	<0.6	0.12	NC	<0.6	0.33	NC	0.90	0.99	5	<0.6	0.03	NC
Calcium	mg/L	430	470	4	190	200	3	11	11.4	2	9.1	9.5	2
Copper	mg/L	<0.02	0.015	NC	<0.02	0.013	NC	<0.02	NM	NC	<0.02	NM	NC
Iron	mg/L	110	127	7	280	311	5	0.25	0.18	16	<0.04	0.032	NC
Magnesium	mg/L	64	70	4	18	20	5	9.2	9.7	3	3.0	3.3	5
Manganese	mg/L	120	131	4	10	11.4	7	0.05	0.042	9	0.040	0.042	2
Potassium	mg/L	10	12	9	10	15	20	<3	NM	NC	4.0	4.7	8
Silicon	mg/L	38	39	1	14	15	3	11	11	0	14	14	0
Sodium	mg/L	10	11	5	11	11	0	11	11.3	1	9.0	9.2	1
Strontium	mg/L	0.61	0.56	4	0.64	0.61	2	0.094	0.1	3	0.11	0.11	0
Zinc	mg/L	0.79	0.8	1	0.1	0.06	25	0.39	0.4	1	0.09	0.09	0

Note that Radian's pH measurements were made in the field and Battelle's were made in the laboratory

NM = Not Measured
NC = Not Calculated

was higher in the fourth sample (L-048) and results agreed well between the two laboratories. Sulfate concentrations agreed well. Organic carbon concentrations also were near detection limit and exhibited the expected high relative standard deviation.

Arsenic concentration was measured by hydride generation on only two samples. In one case the two measurements indicated concentrations below respective detection limits. In the other case, the Radian value was near the detection limit and the results did not agree very well.

All but four of the 48 pairs of measurements made by ICPES agreed within 10 percent relative standard deviation. There appeared to be no pattern exhibited by the four measurements that differed by more than 10 percent relative standard deviation. In no case did the measurements made by the two laboratories differ by more than 25 percent relative standard deviation.

Data Evaluation

Calculated vs Measured Alkalinity. Calculated and measured alkalinities for Event I and Event II are plotted in Figure K-3. There is generally fair agreement between the two values.

Charge Balances. Charge balances were calculated for aqueous sample analysis. Results are summarized in Table K-6. Alkalinity was calculated as the bicarbonate anion since this was the form most likely to be present at the sample pH's. Most charges balanced within 10 percent although a few higher values were observed. In some cases large charge imbalances are associated with low total ionic concentrations. For one of the duplicates for downstream river water, Event I,(Sample ID, L-030) the poor agreement points to an unacceptable alkalinity measurement.

Agreement Between Sum of Constituents and TDS. Figure K-4 illustrates the agreement between the sum of the constituents and filterable residue (TDS) for Events I and II. In both cases agreement was good.

Major Oxide Summations for Solid Samples. Major oxide sums are listed in Table K-7. Oxide sums ranged from 88 to 100 percent, indicating generally good recovery for the major elements.

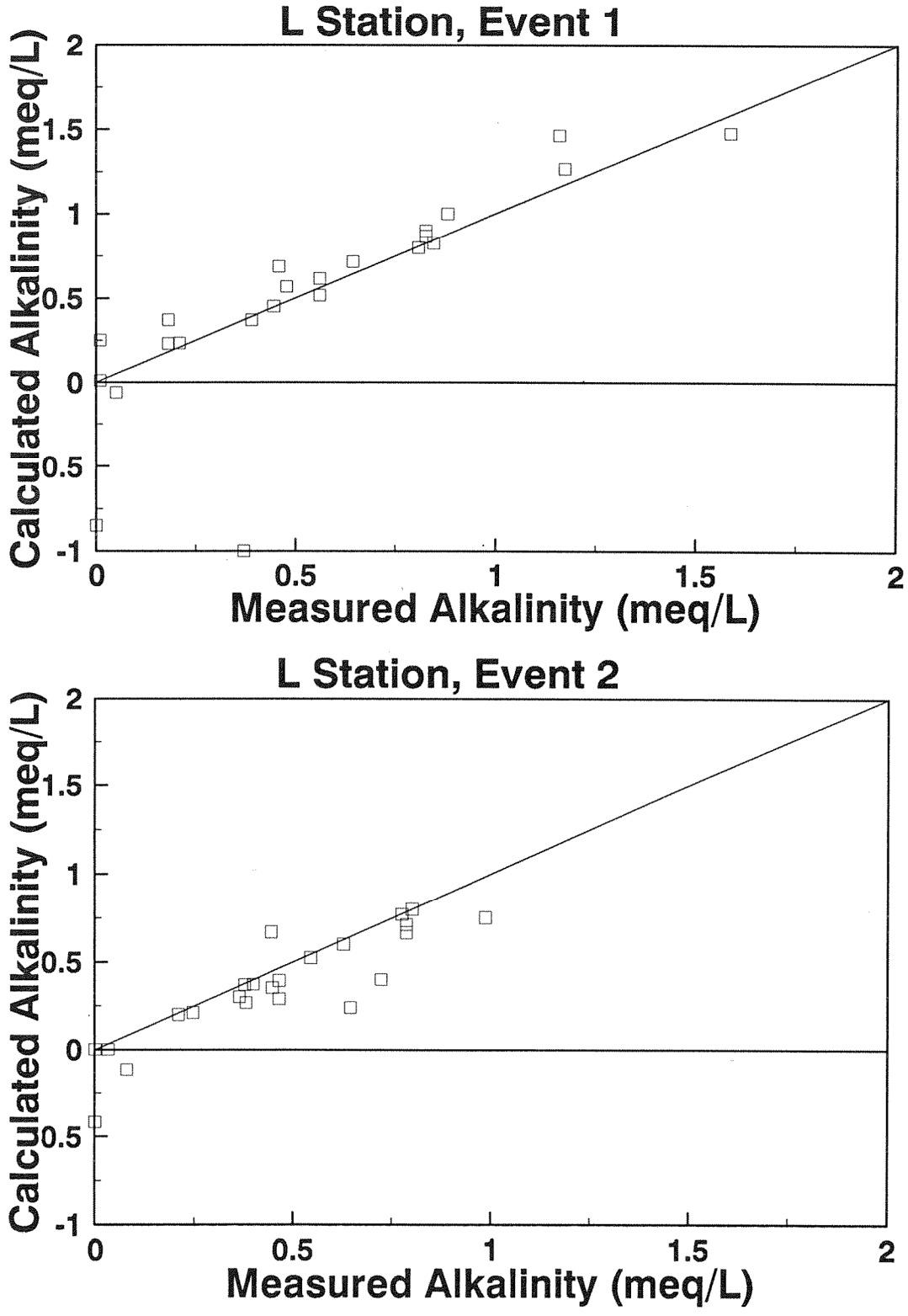


Figure K-3. Calculated vs. Measured Alkalinity, L1

Table K-6

CHARGE BALANCE SUMMARY FOR L STATION, EVENTS 1 AND 2

	Event 1				Event 2			
Location	Sample ID	Sum of Cations (+) (meq/L	Sum of Anions (-) (meq/L)	Charge Balance (%)	Sample ID	Sum of Cations (+) (meq/L)	Sum of Anions (-) (meq/L)	Charge Balance (%)
Ash Delta Wells								
LMW-14	L-040	39.36	43.05	-4.5	L-066	34.08	34.21	-0.2
LMW-15	L-041	24.20	25.08	-1.8	L-067	22.78	23.44	-1.4
LMW-20		No Sample			L-072	1.18	1.59	-14.9
Upgradient Wells								
LMW-11	L-048	1.25	1.01	10.6	L-063	1.18	1.41	-8.7
LMW-11DUP	L-049	1.24	1.02	9.6		No Sample		
LMW-12	L-037	0.97	0.86	6.4	L-064	0.97	1.27	-13.2
LMW-18	L-051	1.18	1.03	7.0	L-070	0.89	1.01	-6.4
LMW-19	L-039	0.72	0.74	-1.2	L-071	0.53	0.59	-5.6
Downgradient Wells								
LMW-01	L-032	1.41	1.43	-1.0	L-053	1.36	1.67	-10.2
LMW-02	L-045	2.20	3.56	-23.7	L-054	3.48	3.79	-4.3
LMW-03	L-027	3.09	2.88	3.6	L-055	2.41	2.64	-4.6
LMW-03DUP		No Sample			L-108	2.49	2.60	-2.2
LMW-04	L-047	4.47	4.15	3.6	L-056	2.89	3.59	-10.8
LMW-05	L-028	4.29	4.25	0.5	L-057	4.24	4.51	-3.2
LMW-06	L-035	1.28	1.38	-3.7	L-058	1.15	1.57	-15.4
LMW-07	L-046	4.68	4.74	-0.6	L-059	5.86	4.84	9.5
LMW-08	L-043	3.13	3.03	1.6	L-060	3.05	3.29	-3.8
LMW-09	L-034	2.72	2.61	2.1	L-061	2.49	2.82	-6.1
LMW-10	L-038	2.15	2.14	0.1	L-062	2.47	2.81	-6.4
LMW-13	L-044		Not Analyzed		L-063	3.36	3.98	-8.5
LMW-16	L-036	3.68	3.70	-0.2	L-068	3.45	3.70	-3.4
LMW-17	L-042	1.86	1.84	0.6	L-069	1.89	1.92	-0.9
River Water								
US (5w)	L-029	0.35	0.29	9.3	L-092	0.33	0.36	-4.9
DS (5w)	L-030	0.39	0.13	49.8	L-093	0.34	0.36	-2.9
DS (5w)DUP	L-031	0.39	0.35	4.8				
Pond Water								
AP1/PPA1	L-033	1.11	0.94	8.6	L-109	1.21	1.32	-4.1
Field Blanks								
Field Blank	L-050	0.04	0.02	42.6	L-111	0.02	0.05	-48.9

Calculated with flame AA data when available
Charge Balance = 100 x (Cations - Anions)/(Cations + Anions)

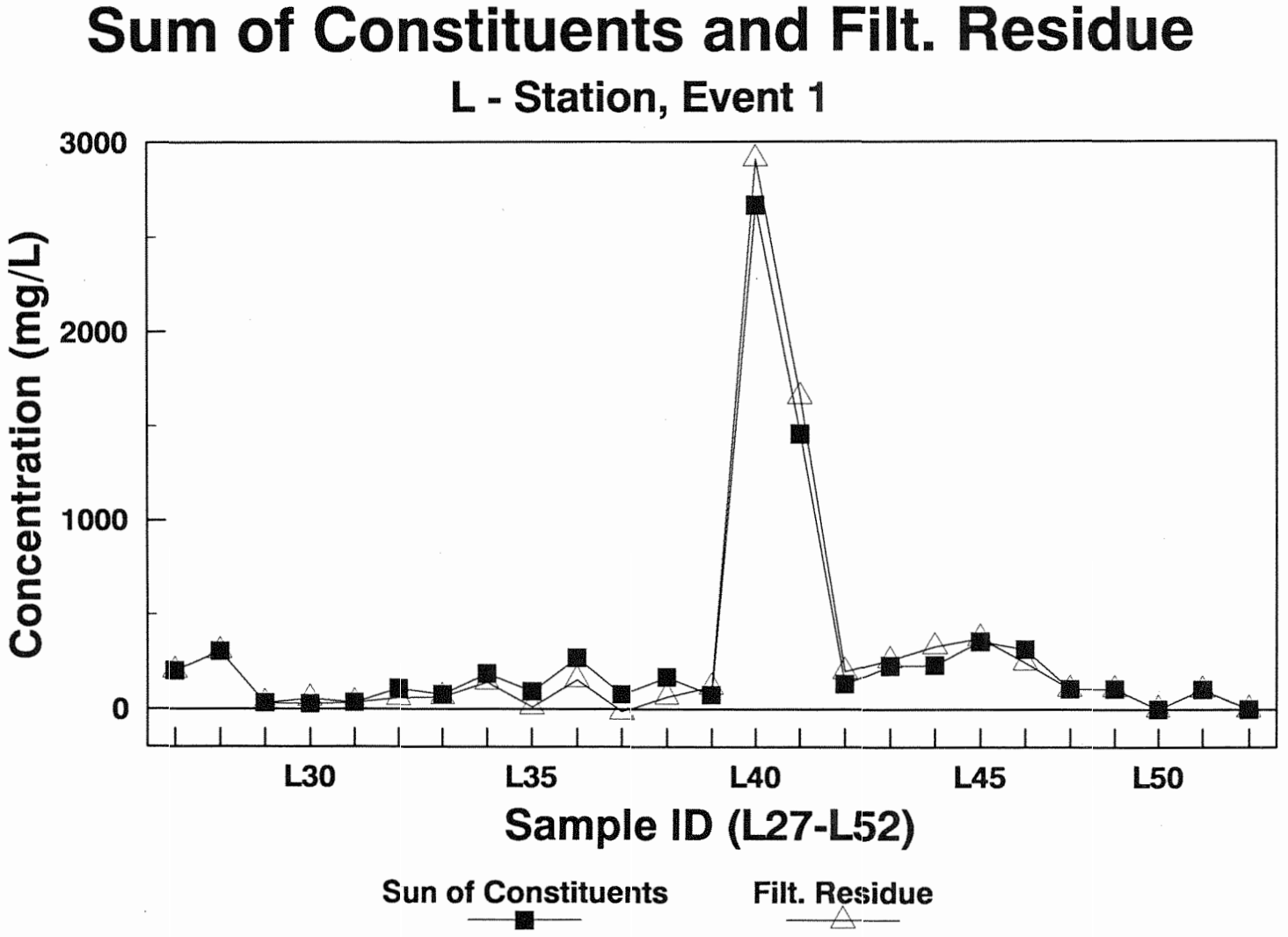


Figure K-4. Agreement Between Sum of Constituents and TDS

Table K-7

MAJOR ELEMENT OXIDE SUMS IN SOLIDS FROM L STATION

Location	Sample ID	Oxide Total (wt%)	Undetermined (wt%)
LMW-12	L-010	97.38	2.62
LMW-12	L-011	101.87	-1.87
LMW-12	L-012	98.10	1.90
LMW-12	L-013	98.62	1.38
LMW-14	L-014	100.39	-0.39
LMW-14	L-015	93.61	6.39
LMW-14	L-016	88.17	11.83
LMW-14	L-017	96.26	3.74
LMW-14	L-018	99.87	0.13
LMW-14	L-019	88.60	11.40
LMW-14	L-019DUP	98.35	1.65
LMW-14	L-020	90.01	9.99
LMW-14	L-020DUP	99.51	0.49
LMW-14	L-021	97.08	2.92
LMW-14	L-022	88.74	11.26
LMW-14	L-023	98.29	1.71
LMW-14	L-024	98.38	1.62
Fusion	Blank	0.72	99.28
NBS	SRM 1633	88.10	11.90