



GAI Consultants - NC, Inc.

3812-H Tarheel Drive
Raleigh, NC 27609
919/878-4478
FAX 919/878-4032

January 22, 1996

Mr. Wayne Sullivan
Municipal Engineering Services Company, P.A.
Post Office Box 97
Garner, North Carolina 27529

Re: Groundwater Monitoring Well 4
Alleghany County Landfill
Sparta, North Carolina
Project No. 95183.07

Dear Mr. Sullivan:

The Solid Waste Section of the Division of Solid Waste Management of the Department of Environment, Health, and Natural Resources, State of North Carolina instructed Alleghany County to install an additional groundwater monitoring well (Groundwater Monitoring Well 4) at the Alleghany County Landfill near Sparta, North Carolina. The installation of Groundwater Monitoring Well 4 was required by the March 28, 1995 letter from Mr. Larry Rose, Hydrogeological Technician, Solid Waste Section.

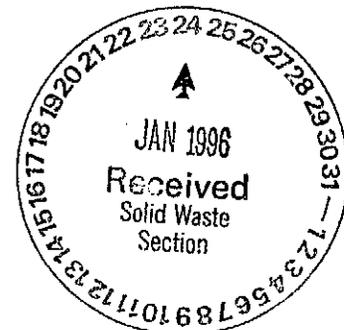
Groundwater Monitoring Well 4 was placed approximately in the location set forth in Mr. Rose's letter. The monitoring well was constructed in general accordance with State Well Construction Standards 15A NCAC 2C and thoroughly developed after construction.

The approximate location of Groundwater Monitoring Well 4 is on Plate 1. A boring log and a well construction record are in Appendix A. Groundwater Monitoring Well 4 and the other existing monitoring wells should be surveyed for vertical and horizontal location to help define groundwater flow and flow directions at the landfill. Total porosity, effective porosity, and slug test results for Groundwater Monitoring Well 4 is 33%, 17%, and 3.6×10^{-4} cm/sec, respectively. Documentation and calculations supporting the porosity values and slug test results are in Appendix B.

We appreciate the opportunity to serve Municipal Engineering and Alleghany County. Please let us know when we can be of additional assistance.

Sincerely,
GAI Consultants - NC, Inc.


Cheryl L. Marks
Geologist

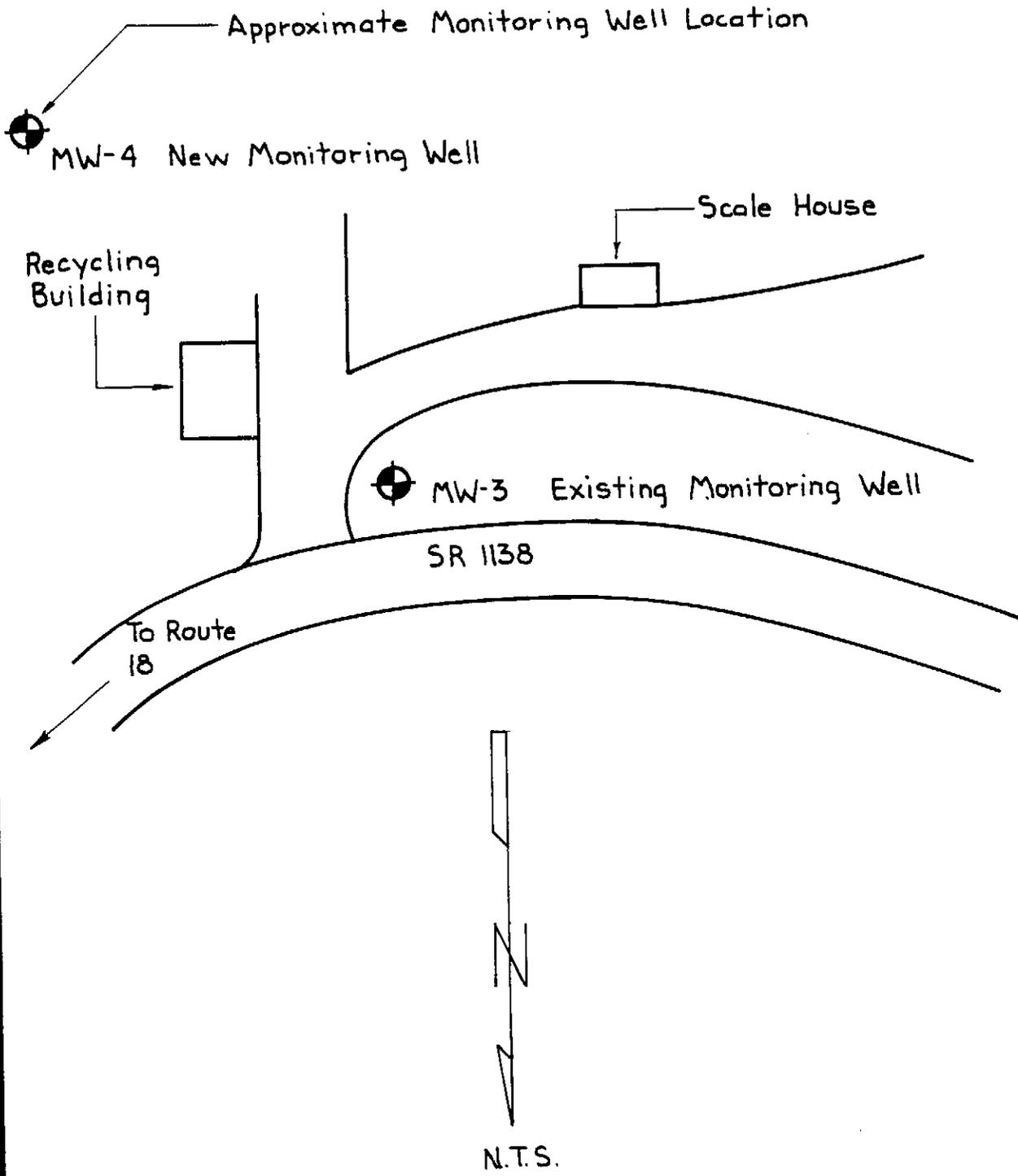


Enclosures

Copies to: Mr. Daniel F. McMillan, Alleghany County (with enclosures)
Mr. Larry Rose, Solid Waste Section (with enclosures)

PLATE

95183.07



SITE PLAN
PLATE I

APPENDIX A
LEGEND SHEETS AND
LOG OF BORING
AND
WELL INSTALLATION RECORD

TERMS AND SYMBOLS USED ON BORING LOGS

DRILLING AND SAMPLING TYPE

AS - Auger Sample	HSA - Hollow Stem Auger	ST - Shelby Tube Sample
BS - Bag Sample	NW - Wireline Core	WB - Wash Bore
CS - Continuous Sample	NX - NX Core	WS - Wash Sample
FA - Flight Auger	RB - Rotary Bit	
HA - Hand Auger	SS - Split Spoon Sample	

SOIL TYPES SYMBOLS

	Sand		Silt		Clay		Gravel
	Silty Sand		Sandy Silt		Sandy Clay		Peat or Highly Organic
	Clayey Sand		Clayey Silt		Silty Clay		Debris Fill

SAMPLER TYPES SYMBOLS

	Shelby Tube		Auger		Denison
	Split-spoon		Rock Core		No Recovery

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on ASTM Designations D-2487 and D-2488 (Unified Classification System). Information on each boring log is a compilation of subsurface conditions, i.e. the soil or rock classifications are obtained from the field as well as from laboratory testing of selected samples. The indicated boundaries between strata on the boring logs are approximate only and may be transitional. Solid lines indicate observed stratum boundaries, and dashed lines indicate interpreted stratum boundaries.

SOIL GRAIN SIZE

U.S. STANDARD SIEVE

	12"	3"	3/4"	4	10	40	200		
BOULDERS	COBBLES		GRAVEL		SAND			SILT	CLAY
			COARSE	FINE	COARSE	MEDIUM	FINE		
	305	76.2	19.1	4.76	2.00	0.420	0.074		0.002
SOIL GRAIN SIZE IN MILLIMETERS									

CONSISTENCY OF COHESIVE SOILS

Descriptive Term	Cohesion (psf)
Very Soft	less than 250
Soft	250 to 500
Firm	500 to 1000
Stiff	1000 to 2000
Very Stiff	2000 to 4000
Hard	greater than 4000

RELATIVE DENSITY OF GRANULAR SOILS

Descriptive Term	Blows Per Ft ("N")
Very Loose	less than 4
Loose	4 to 10
Medium Dense	10 to 30
Dense	30 to 50
Very Dense	greater than 50

MOISTURE CONDITION

Damp	Slight indication of moisture
Moist	Color change with short period of air exposure (granular soil) Below optimum moisture content (cohesive soil)
Wet	High degree of saturation by visual and touch (granular soil) Above optimum moisture content (cohesive soil)
Saturated	Free surface water

RELATIVE PROPORTIONS

trace	minor amount
with	significant amount
modifier/and	sufficient amount to influence material behavior

TERMS AND SYMBOLS USED ON BORING LOGS

SOIL STRUCTURE

Slickensided	Having planes of weakness that appear slick and glossy.
Fissured	Containing shrinkage or relief cracks, often filled with fine sand or silt; usually more or less vertical.
Pocket	Inclusion of material of different texture that is smaller than the diameter of the sample.
Parting	Inclusion less than 1/8 inch thick.
Seam	Inclusion 1/8 inch to 3 inches thick.
Layer	Inclusion greater than 3 inches thick.
Laminated	Alternating partings or seams of different soil type.
Interlayered	Alternating layers of different soil type.
Intermixed	Pockets of different soil type and layered or interlayered structure is not evident.
Calcareous	Having appreciable quantities of carbonate.

STANDARD PENETRATION TEST (SPT)

A 2 in. OD, 1-3/8 in. ID split spoon sampler is driven 1.0 ft. into undisturbed soil with a 140 pound hammer free falling 30 in. The sampler is seated 6 in. into undisturbed soil and the test is performed. The number of blows required to drive the sampler the last 12 in. is the Standard Penetration Resistance or "N" value and is recorded as blows per foot except as noted below.

50/7 — The sampler penetrated 7 in. with 50 blows, after 6 in. of seating.

Ref/3 — The sampler penetrated 3 in. with 50 blows, during 6 in. of seating.

WATER LEVEL MEASUREMENT TERMS

AD — After Drilling
DCI — Dry Cave In

WCI — Wet Cave In
WD — While Drilling

Water levels indicated on the boring logs are the levels measured at the times indicated. Groundwater levels indicated may not have stabilized, particularly in cohesive soils, and may vary over time due to the effects of precipitation, infiltration, construction activity, or other factors.

ABBREVIATIONS

app - apparent	freq - frequent	occ - occasional	SR - Sample Refusal
AR - Auger Refusal	Gn(gn) - Green(ish)	Or(or) - Orange(ish)	st - stiff
bed - bedded	Gr(gr) - Gray(ish)	org - organic(s)	stn - stain(s)
Bk - Black	Gvl(gvl) - Gravel(ly)	ox - oxid(ized) (ation)	stk - streak(s)
Bl(bl) - Blue(ish)	hd - hard	Pt - Peat	T - Tan
BOB - Bottom of Boring	inb - interbedded	pkt - pocket(s)	tn - thin
Br(br) - Brown(ish)	inm - intermixed	prt - parting(s)	tk - thick
c - coarse	jt - joint(s)	Rd(rd) - Red(ish)	tr - trace(s)
calc - calcareous	lam - laminated, laminae	Rec - Recovery	tx - texture
cem - cemented	len - lense(s)	RQD - Rock Quality Designation	v - very
Ch(ch) - Chert(y)	lig - lignite	rt - root(s)	w/ - with
Cl(cl) - Clay(ey)	lo - loose	Sa(sa) - Sand(y)	w/o - without
Cls - Claystone	Ls - Limestone	sat - saturated	Wd - Wood
Cbl - Cobble(s)	lt - light	Sh(sh) - Shale(y)	Wh - White
dk - dark	lyr - layer(s)	Si(si) - Silt(y)	wth - weathered
dn - dense	m - medium	Sis - Siltstone	Y - Yellow
f - fine	mat - matter	slk - slickenside(s)	
fm - firm	mod - moderately	sm - seam(s)	
fiss - fissured	mot - mottled	so - soft	
frac - fractured		sp - spot(s), speck(s)	
frag - fragment(s)		Ss - Sandstone	

PROJECT : Alleghany Landfill
Sparta, North Carolina

JOB NO.: 95183.07

TYPE : HSA, SS

LOCATION : see Plate 1

DEPTH (FT)	SYMBOL	SAMPLES	DESCRIPTION OF MATERIAL	BLOWS PER FT	UNIT DRY WT LB/CU FT	WATER CONTENT %	LIQUID LIMIT	PLASTIC LIMIT	COHESION LB / SQ FT		REMARKS
									PENETRO- METER	UNCONFINED COMPRESSION	
			SILT (ML); Red brown, moist, medium dense, with mica, fine sand, trace clay	20							
5			-grades light brown	16							
10			-grades increasing sand	27							
15			SANDY SILT (ML); Brown green, moist, very dense, with mica, fine	56							
20				62							
25			-grades with light and dark layers	60							
30			-grades saturated, dense	34							
35			-grades increasing sand	37							
40			SILTY SAND (SM); Brown, saturated, medium dense, fine, trace mica	29							

End of Boring at 42 ft

COMPLETION DEPTH: 42.0 ft

DEPTH TO WATER IN BORING: 30.21 ft WD (24 hr 19.14)

DATE: 12-22-95

Monitoring Well 4

North Carolina - Department of Environment, Health, and Natural Resources
 Division of Environmental Management - Groundwater Section
 P.O. Box 29535 - Raleigh, N.C. 27626-0535
 Phone (919) 733-3221

FOR OFFICE USE ONLY	
QUAD. NO. _____	SERIAL NO. _____
Lat. _____	Long. _____ RO _____
Minor Basin _____	
Basin Code _____	
Header Ent. _____	GW-1 Ent. _____

WELL CONSTRUCTION RECORD

DRILLING CONTRACTOR: GAI Consultants

DRILLER REGISTRATION NUMBER: 446

STATE WELL CONSTRUCTION PERMIT NUMBER: N/A

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Sparta County: Alleghany

SR 1138

(Road, Community, or Subdivision and Lot No.)

2. OWNER Alleghany

ADDRESS PO Box 366

(Street or Route No.)

Sparta NC 28675

City or Town State Zip Code

3. DATE DRILLED 12-21-95 USE OF WELL Monitoring

4. TOTAL DEPTH 42.0'

5. CUTTINGS COLLECTED YES NO

6. DOES WELL REPLACE EXISTING WELL? YES NO

7. STATIC WATER LEVEL Below Top of Casing: 19.14 FT.

(Use "+" if Above Top of Casing)

8. TOP OF CASING IS 2.05 FT. Above Land Surface*

* Casing Terminated at or below land surface is illegal unless a variance is issued in accordance with 15A NCAC 2C .0118

9. YIELD (gpm): N/A METHOD OF TEST _____

10. WATER ZONES (depth): 30 - 42'

11. CHLORINATION: Type N/A Amount _____

12. CASING:

From	Depth	To	Ft.	Diameter	Wall Thickness or Weight/Ft.	Material
From <u>+2.05</u>	To <u>27</u>	Ft. <u>2"</u>		<u>Sch 40</u>	<u>PVC</u>	
From _____	To _____	Ft. _____		_____	_____	
From _____	To _____	Ft. _____		_____	_____	

13. GROUT:

From	Depth	To	Ft.	Material	Method
From <u>0</u>	To <u>25</u>	Ft. <u>neat cement</u>		<u>pump</u>	
From <u>25</u>	To <u>26</u>	Ft. <u>bentonite</u>		<u>pellets</u>	

14. SCREEN:

From	Depth	To	Ft.	Diameter	Slot Size	Material
From <u>27</u>	To <u>42</u>	Ft. <u>2</u>	in.	<u>.010</u>	in.	<u>PVC</u>
From _____	To _____	Ft. _____	in.	_____	in.	_____
From _____	To _____	Ft. _____	in.	_____	in.	_____

15. SAND/GRAVEL PACK:

From	Depth	To	Ft.	Size	Material
From <u>26</u>	To <u>42</u>	Ft. <u>NC #2</u>		<u>sand</u>	
From _____	To _____	Ft. _____		_____	

16. REMARKS: Cut bank to provide level ground.

DEPTH		DRILLING LOG
From	To	Formation Description
0	13.3'	Brown silt w/sand
13.3	38.0'	Sandy silt
38.0	42.0'	Silty sand

If additional space is needed use back of form

LOCATION SKETCH

(Show direction and distance from at least two State Roads, or other map reference points)



I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15A NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

Cheryl Marks

1-8-96

SIGNATURE OF CONTRACTOR OR AGENT

DATE

Submit original to Division of Environmental Management and copy to well owner.

A-4

APPENDIX B
DOCUMENTATION AND CALCULATIONS

Client MESCO

GAI CONSULTANTS-NC, INC.

Final Page No. 1 of 9

Job No. 95183.07

Raleigh, NC

Prel. Page No. _____

Subject Alleghany

Calc. CLM Date 1-19-96

CHKd. _____ Date _____

Total Porosity Sandy Silt/Silty Sand 33%

Total porosity is estimated from Table 1.4 and Table 2.4 based on soil obtained and the typical values for similar soil types.

Effective Porosity Sandy Silt/Silty Sand 17%

Textural Classification Triangle for Sandy Silt ranges from 5 to 20% and Silty Sand ranges from 12 to 30%. Average of 17%

EPA default values from Table 3-1 by unified soil classification ML is 15% and SM 20%

Slug Test Data

	Depth (ft.)	k (cm/sec)
MW-4	27-42	3.6×10^{-4}

Table 1.4 Porosity, Void Ratio, and Unit Weight of Typical Soils in Natural State

Description	Porosity (n)	Void Ratio (e)	Water Content (w) ^a	Unit Weight			
				g/cu cm		lb/cu ft	
				γ_d^b	γ_{sat}^c	γ_d	γ_{sat}
1. Uniform sand, loose	0.46	0.85	32	1.43	1.89	90	118
2. Uniform sand, dense	0.34	0.51	19	1.75	2.09	109	130
3. Mixed-grained sand, loose	0.40	0.67	25	1.59	1.99	99	124
most similar → 4. Mixed-grained sand, dense	0.30	0.43	16	1.86	2.16	116	135
5. Windblown silt (loess)	0.50	0.99	21	1.36	1.86	85	116
6. Glacial till, very mixed-grained	0.20	0.25	9	2.12	2.32	132	145
7. Soft glacial clay	0.55	1.2	45	1.22	1.77	76	110
8. Stiff glacial clay	0.37	0.6	22	1.70	2.07	106	129
9. Soft slightly organic clay	0.66	1.9	70	0.93	1.58	58	98
10. Soft very organic clay	0.75	3.0	110	0.68	1.43	43	89
11. Soft montmorillonitic clay (calcium bentonite)	0.84	5.2	194	0.43	1.27	27	80

^a w = water content when saturated, in percent of dry weight.
^b γ_d = dry unit weight.
^c γ_{sat} = saturated unit weight.

TABLE 4.4 Specific yields in percent

Material	Specific Yield		
	Maximum	Minimum	Average
Clay	5	0	2
Sandy clay	12	3	7
Silt	19	3	18
Fine sand	28	10	21
Medium sand	32	15	26
Coarse sand	35	20	27
Gravelly sand	35	20	25
Fine gravel	35	21	25
Medium gravel	26	13	23
Coarse gravel	26	12	22

Source: Johnson (1967).

Table 2.4 Range of Values of Porosity

	n(%)
Unconsolidated deposits	
Gravel	25-40
most similar → Sand	25-50
Silt	35-50
Clay	40-70
Rocks	
Fractured basalt	5-50
Karst limestone	5-50
Sandstone	5-30
Limestone, dolomite	0-20
Shale	0-10
Fractured crystalline rock	0-10
Dense crystalline rock	0-5

$$30 + \left(\frac{50 + 25}{2} \right) = 33$$

TABLE 2-1 Some Typical Values for Different Densities of Some Common Soil Materials*

Soil Type	Density (Mg/m ³)		
	ρ_{sat}	ρ_d	ρ'
Sands and gravels	1.9-2.4	1.5-2.3	1.0-1.3
Silts and clays	1.4-2.1	0.6-1.8	0.4-1.1
Glacial tills	2.1-2.4	1.7-2.3	1.1-1.4
Crushed rock	1.9-2.2	1.5-2.0	0.9-1.2
Peats	1.0-1.1	0.1-0.3	0.0-0.1
Organic silts and clays	1.3-1.8	0.5-1.5	0.3-0.8

*Modified after Hansbo (1975).

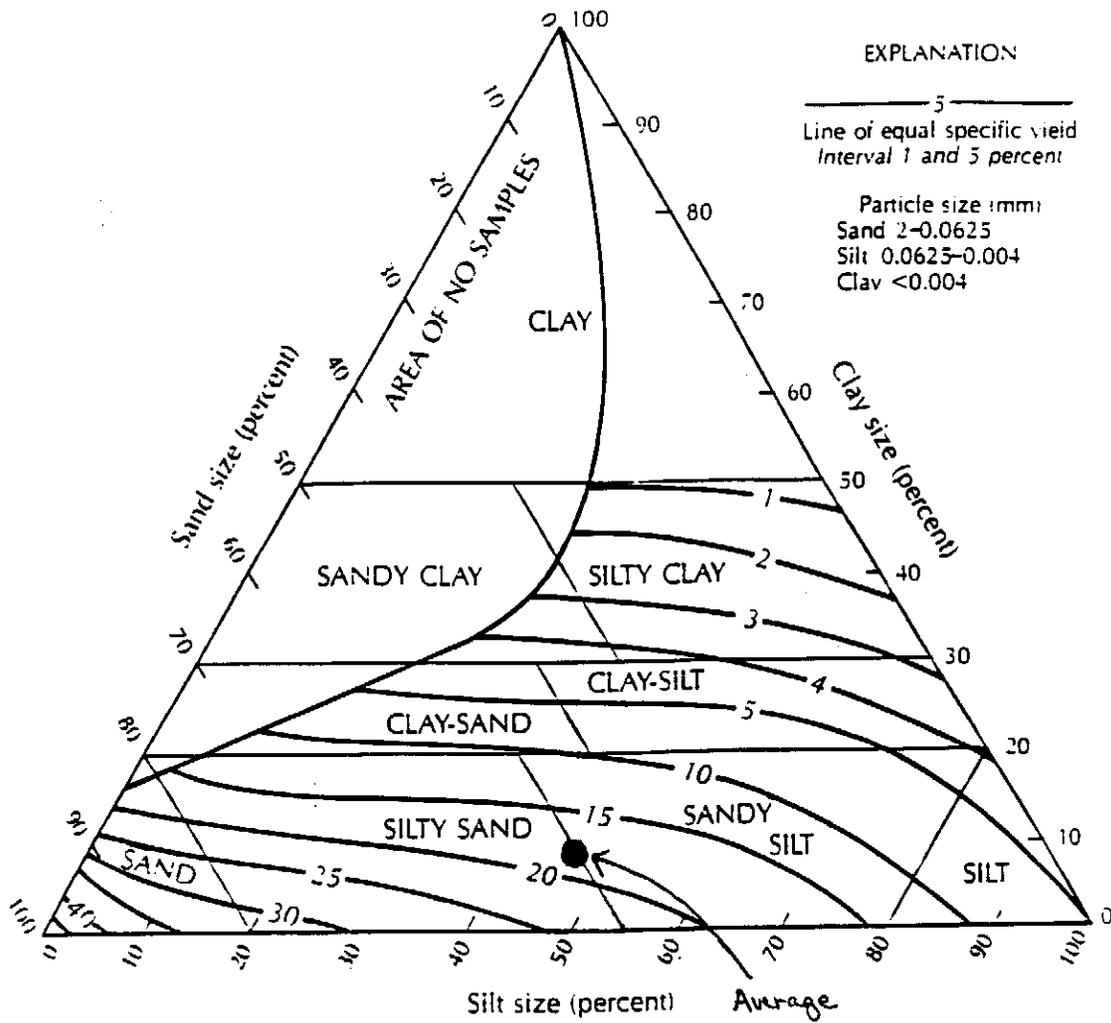


FIGURE 4.11 Textural classification triangle for unconsolidated materials showing the relation between particle size and specific yield. Source: A. I. Johnson, U.S. Geological Survey Water-Supply Paper 1662-D, 1967.

TABLE 3-1. DEFAULT VALUES FOR EFFECTIVE POROSITY (Ne) FOR USE
IN TIME OF TRAVEL (TOT) ANALYSES

Soil textural classes	Effective porosity of saturation ^a
<u>Unified soil classification system</u>	
GS, GP, GM, GC, SW, SP, SM, SC	0.20 (20%)
ML, MH	0.15 (15%)
CL, OL, CH, OH, PT	0.01 _b (1%) ^b
<u>USDA soil textural classes</u>	
Clays, silty clays, sandy clays	0.01 _b (1%) ^b
Silts, silt loams, silty clay loams	0.10 (10%)
All others	0.20 (20%)
<u>Rock units (all)</u>	
Porous media (nonfractured rocks such as sandstone and some carbonates)	0.15 (15%)
Fractured rocks (most carbonates, shales, granites, etc.)	0.0001 (0.01%)

Source: Barari, A., and L. S. Hedges. 1985. Movement of Water in Glacial Till. *Proceedings of the 17th International Congress of the International Association of Hydrogeologists*, pp. 129-134.

^a These values are estimates and there may be differences between similar units. For example, recent studies indicate that weathered and unweathered glacial till may have markedly different effective porosities (Barari and Hedges, 1985; Bradbury et al., 1985).

^b Assumes de minimus secondary porosity. If fractures or soil structure are present, effective porosity should be 0.001 (0.1%).

Coefficient of Permeability of Various Soils

k (cm/sec)	Drainage	Soil Type	Determination of k				
10^2 10^1	Good Good	Clean gravels Clean gravels	Pumping tests. Reliable if properly conducted	Constant head permeameter-reliable	Falling-head permeameter	Computation from grain size	
1.0 10^{-1} 10^{-2} 10^{-3} 10^{-4}	Good Good Good Good Good	Clean sands Clean sand and gravel mixtures					
10^{-5} 10^{-6}	Poor Poor	Very fine sands Organic and inorganic silts, mixtures of sand silt and clay, glacial till, stratified clay deposits.		Unstable. Much experience required			
10^{-7} 10^{-8} 10^{-9}	Practically impervious	Impervious soils, for example, homogeneous clays below zone of weathering.		Fairly reliable			Computation from consolidation data (reliable)

After Casagrande and Fadum (1940).

SLUG TEST DATA: MW

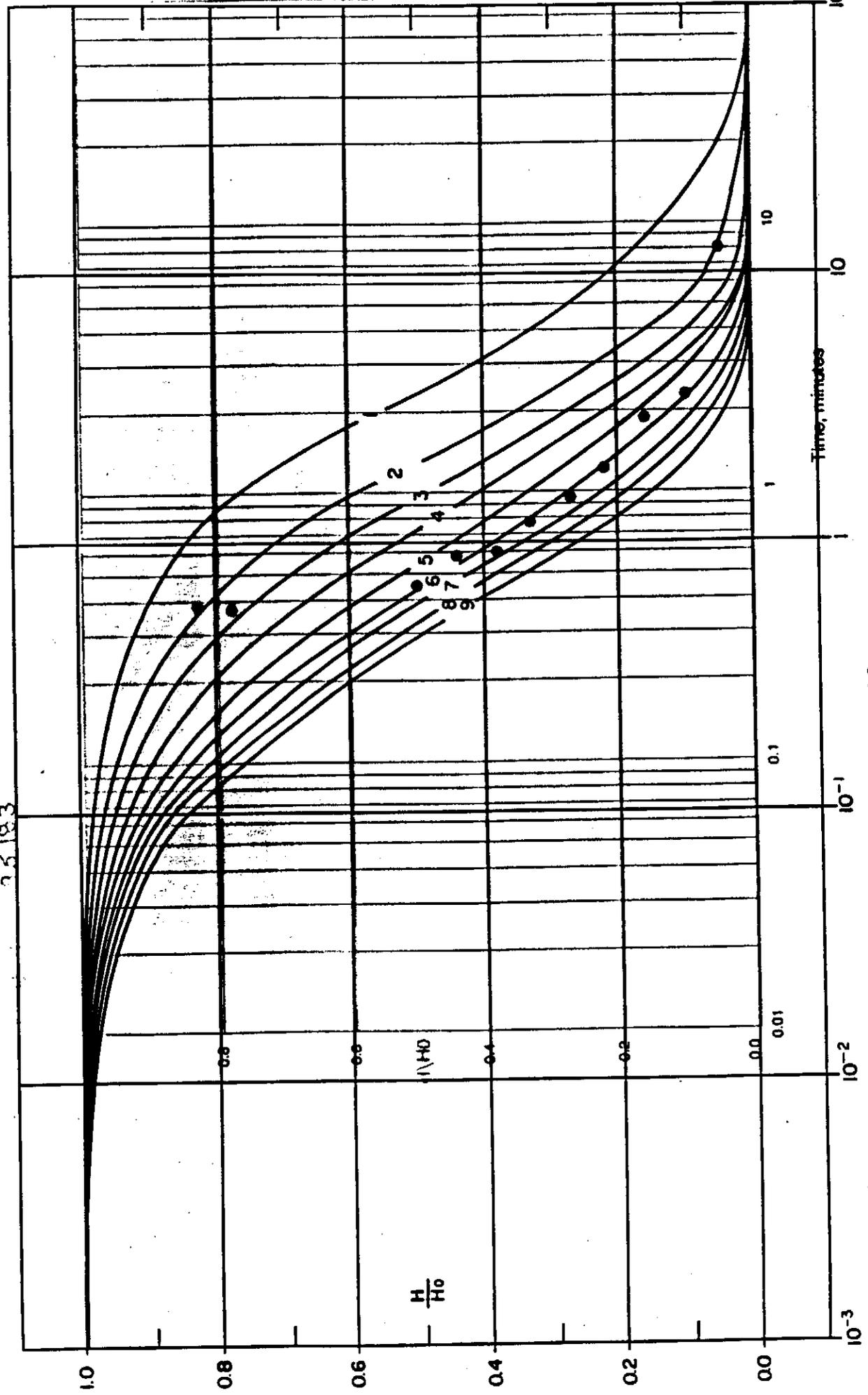
4

DEPTH TO GW	17.09	RADIUS, in.	1
HT OF STICKUP	2.05	WET SCREEN, ft	15
INITIAL GW READING	37	t, min	0.66
INITIAL TIME	0	k, cm/sec	3.6E-04
INITIAL GW BELOW TOC	19.14		
HO	-17.86		

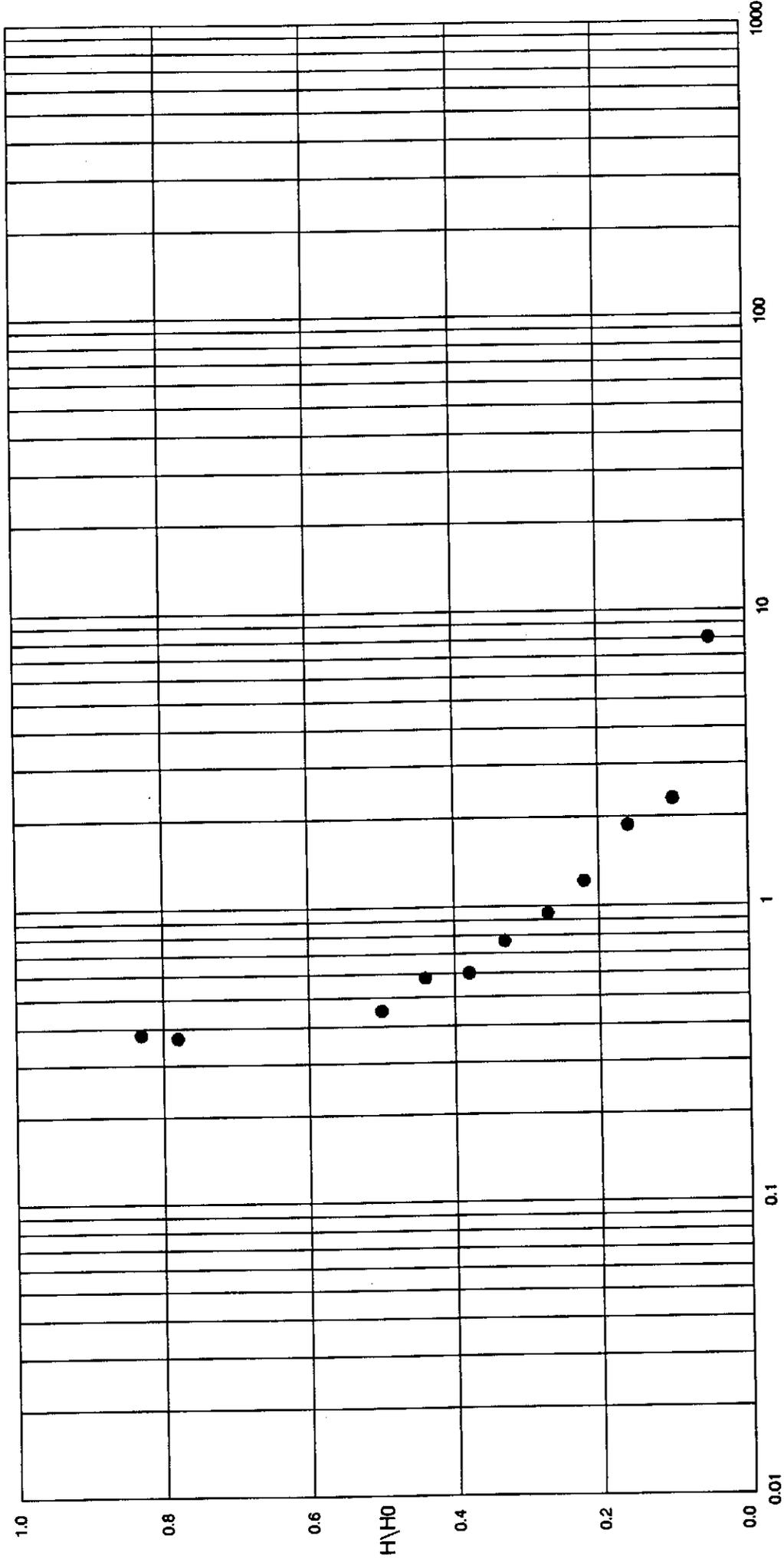
GW READING	DH	H	H/HO	HOUR	MIN	SEC	TIME
34	-3	-14.86	0.83	0	0	23	0.38
33	-4	-13.86	0.78	0	0	22	0.37
28	-9	-8.86	0.50	0	0	27	0.45
27	-10	-7.86	0.44	0	0	35	0.58
26	-11	-6.86	0.38	0	0	36	0.60
25	-12	-5.86	0.33	0	0	46	0.77
24	-13	-4.86	0.27	0	0	57	0.95
23	-14	-3.86	0.22	0	1	13	1.22
22	-15	-2.86	0.16	0	1	53	1.88
21	-16	-1.86	0.10	0	2	18	2.30
20	-17	-0.86	0.05	0	8	2	8.03

101820-1
 MW-4
 W=1
 T=0.66

25183



MW-4 95183



Time, minutes

