PARADIGM
ENVIRONMENTAL SERVICES, INC.
179 Lake Avenue Rochester, New York 14608 (585) 647 - 2530 FAX (585) 647 - 3311

Volatile Analysis Report for Non-potable Water

Client: **Leader Professional Services**

Client Job Site:	Syracusa Sand & Gravel	**Lab Project Number:**	02-1426
		Lab Sample Number:	5352
Client Job Number:	N/A		
Field Location:	Prod Well	**Date Sampled:**	06/10/2002
Field ID Number:	N/A	**Date Received:**	06/10/2002
Sample Type:	Water	**Date Analyzed:**	06/14/2002

Halocarbons	Results in ug / L
Bromodichloromethane	ND< 2.00
Bromomethane	ND< 2.00
Bromoform	ND< 2.00
Carbon tetrachloride	ND< 2.00
Chloroethane	ND< 2.00
Chloromethane	ND< 2.00
2-Chloroethyl vinyl ether	ND< 2.00
Chloroform	ND< 2.00
Dibromochloromethane	ND< 2.00
1,1-Dichloroethane	ND< 2.00
1,2-Dichloroethane	ND< 2.00
1,1-Dichloroethene	ND< 2.00
cis-1,2-Dichloroethene	ND< 2.00
trans-1,2-Dichloroethene	ND< 2.00
1,2-Dichloropropane	ND< 2.00
cis-1,3-Dichloropropene	ND< 2.00
trans-1,3-Dichloropropene	ND< 2.00
Methylene chloride	ND< 5.00
1,1,2,2-Tetrachloroethane	ND< 2.00
Tetrachloroethene	ND< 2.00
1,1,1-Trichloroethane	ND< 2.00
1,1,2-Trichloroethane	ND< 2.00
Trichloroethene	ND< 2.00
Trichlorofluoromethane	ND< 2.00
Vinyl Chloride	ND< 2.00

Aromatics	Results in ug / L
Benzene	ND< 0.700
Chlorobenzene	ND< 2.00
Ethylbenzene	ND< 2.00
Toluene	ND< 2.00
m,p - Xylene	ND< 2.00
o - Xylene	ND< 2.00
Styrene	ND< 2.00
1,2-Dichlorobenzene	ND< 2.00
1,3-Dichlorobenzene	ND< 2.00
1,4-Dichlorobenzene	ND< 2.00

Ketones	Results in ug / L
Acetone	ND< 10.0
2-Butanone	ND< 5.00
2-Hexanone	ND< 5.00
4-Methyl-2-pentanone	ND< 5.00

Miscellaneous	Results in ug / L
Carbon disulfide	ND< 5.00
Vinyl acetate	ND< 5.00

ELAP Number 10958 Method: EPA 8260B Data File: 60174.D

Comments: ND denotes Non Detect
ug / L = microgram per Liter

Signature:
Bruce Hoogesteger: Technical Director

Chain of Custody provides additional sample information

PARADIGM
ENVIRONMENTAL SERVICES, INC.
179 Lake Avenue
Rochester, NY 14608
(716) 647-2530 * (800) 724-1997
FAX: (716) 647-3311

CHAIN OF CUSTODY

PROJECT NAME/SITE NAME: Syracusa Sand & Grvl

REPORT TO:
COMPANY: Leader Prof. Svcs.
ADDRESS: 640 Kreag Road Suite 300
CITY: Pittsford STATE: NY ZIP: 14534
PHONE: 248-2413 FAX: 248-2834
ATTN: P. von Schondorf
COMMENTS:

INVOICE TO:
COMPANY: Syracusa Sand & Gravel
ADDRESS:
CITY: STATE: ZIP:
PHONE: FAX:
ATTN:

LAB PROJECT #: 02-1426
CLIENT PROJECT #:

TURNAROUND TIME: (WORKING DAYS)
☐ 1 ☐ 2 ☐ 3 ☑ 5 STD ☐ OTHER

REQUESTED ANALYSIS

	DATE	TIME	COMPOSITE	GRAB	SAMPLE LOCATION/FIELD ID	MATRIX	NUMBER CONTAINERS	8260 VOC's	REMARKS	PARADIGM LAB SAMPLE NUMBER
1	6-10-02	12:00		✓	New Pond (Pond)	W	2	✓		5351
2	6-10-02	12:30		✓	Prod. Well	W	2	✓		5352
3										
4										
5										
6										
7										
8										
9										
10										

LAB USE ONLY

SAMPLE CONDITION: Check box if acceptable or note deviation:
CONTAINER TYPE: ☑ PRESERVATIONS: ☑ 22 HOLDING TIME: ☑ TEMPERATURE: ☑ 17°C Iced

Sampled By: Pete von Schondorf Date/Time: 6-10-02 12:30
Relinquished By: Date/Time:
Received By: Date/Time:

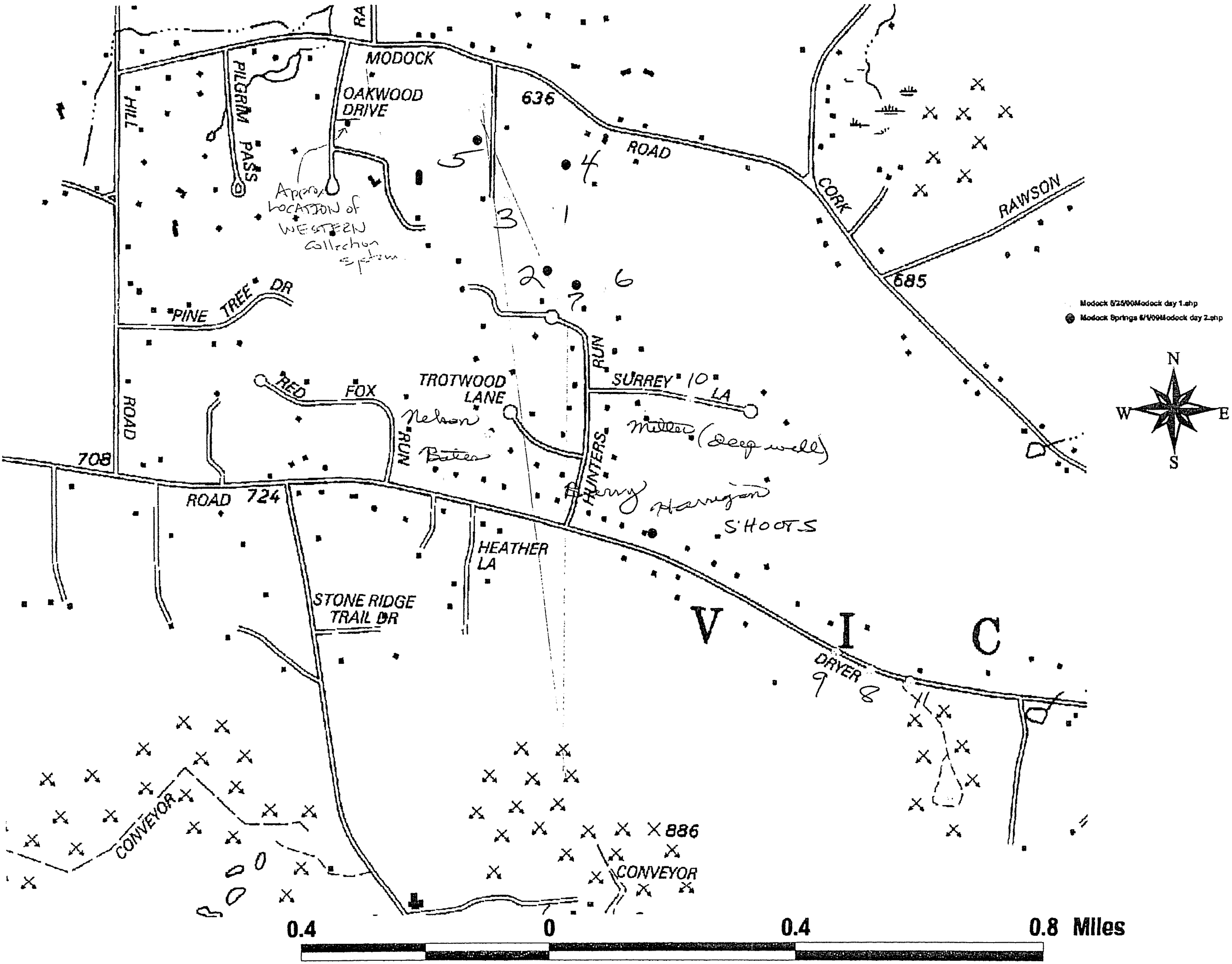
Relinquished By: Date/Time:
Received By: Date/Time:
Received @ Lab By: Date/Time: 6/10/02 4:25PM

Total Cost:
P.I.F.

Attachment 5

References

Modock Study Area - Well & Spring Locations



MODOCK ROAD SPRINGS DATA SUMMARY

Table B-1. Summary of Residential Well Analytical Results

Date	Address	TCE (ppb	TCA (ppb	DCE (ppb	Location
07/29/97	1135 Hunter Run	nd	nd	nd	LeFrois house
04/24/97	1135 Hunter Run	nd	nd	nd	LeFrois house
07/29/97	1145 Hunter Run	nd	nd	nd	Hendler house
08/07/96	7430 Dryer Road	nd	nd	nd	Canioto house
08/19/96	7479 Dryer Road	nd	nd	nd	Dispenza house
08/07/96	7491 Modock Road	nd	nd	nd	Glasner house
04/30/98	7491 Modock Road	nd	nd	nd	Glasner house
08/19/96	7492 Dryer Road	nd	nd	nd	Shaffer house
08/19/96	7500 Dryer Road	nd	nd	nd	Basel house
08/19/96	7511 Dryer Road	nd	nd	nd	Zuhlsdorf house
08/07/96	7514 Dryer Road	5.9	18	1.4	Shoots house
04/30/98	7514 Dryer Road	6.9	6.9	0.5	Shoots house
08/19/96	7514 Dryer Road	6	18	1.5	Shoots house
07/29/97	7514 Dryer Road	9.9	11	nd	Shoots house
07/29/97	7530 Surrey Lane	nd	nd	nd	Perzel house
04/24/97	7530 Surrey Lane	nd	nd	nd	Perzel house
08/07/96	7532 Dryer Road	nd	nd	nd	Harrigan house
07/29/97	7545 Surrey Lane	nd	nd	nd	Miller house
08/07/96	7570 Dryer Road	nd	nd	nd	Forkell house
06/08/94	7571 Modock Road	89	57	13	Turner house
04/10/95	7571 Modock Road	140	120	23	Turner house
08/07/90	7571 Modock Road	88	170	nd	Turner house
11/03/92	7571 Modock Road	250	130	9	Turner house
09/14/93	7571 Modock Road	130	99	12	Turner house
07/29/97	7571 Modock Road	nd	nd	nd	Turner house
04/02/92	7571 Modock Road	70	125	nd	Turner house
05/03/90	7571 Modock Road	59	160	nd	Turner house
08/07/96	7571 Modock Road	nd	nd	nd	Turner house
08/07/96	7585 Modock Road	nd	nd	nd	Larson house

MODOCK ROAD SPRINGS DATA SUMMARY

07/29/97	7585 Modock Road	nd	nd	nd	Larson house
08/25/95	7585 Modock Road	nd	nd	nd	Larson house
11/03/92	7585 Modock Road	nd	nd	nd	Larson house

MODOCK ROAD SPRINGS DATA SUMMARY

Date	Sample Location	Resident	Matrix	Well Type	TCE (ppb)	TCA (ppb)	DCE (ppb)
07/29/97	1135 Hunter Run	LeFrois	GW	Residential Water Supply	nd	nd	nd
04/24/97	1135 Hunter Run	LeFrois	GW	Residential Water Supply	nd	nd	nd
07/29/97	1145 Hunter Run	Hendler	GW	Residential Water Supply	nd	nd	nd
11/09/99	7325 Dryer Road	Bernard	GW	Residential Water Supply	nd	nd	nd
11/09/99	7380 Dryer Road	Ingert	GW	Residential Water Supply	nd	nd	nd
08/07/96	7430 Dryer Road	Canioto	GW	Residential Water Supply	nd	nd	nd
11/09/99	7471 Dryer Road	Barbash	GW	Residential Water Supply	nd	nd	nd
11/09/99	7475 Surrey Lane (Pond)	Steiner	SW	NA	nd	nd	nd
08/19/96	7479 Dryer Road	Dispenza	GW	Residential Water Supply	nd	nd	nd
04/30/98	7491 Modock Road	Glasner	GW	Residential Water Supply	nd	nd	nd
11/09/99	7491 Modock Road	Glasner	GW	Residential Water Supply	nd	nd	nd
08/07/96	7491 Modock Road	Glasner	GW	Residential Water Supply	nd	nd	nd
08/19/96	7492 Dryer Road	Shaffer	GW	Residential Water Supply	nd	nd	nd
08/19/96	7500 Dryer Road	Basel	GW	Residential Water Supply	nd	nd	nd
08/19/96	7511 Dryer Road	Zuhlsdorf	GW	Residential Water Supply	nd	nd	nd
11/09/99	7514 Dryer Road	Shoots	GW	Residential Water Supply	4.6	6.7	nd
08/07/96	7514 Dryer Road	Shoots	GW	Residential Water Supply	5.9	18	1.4
08/19/96	7514 Dryer Road	Shoots	GW	Residential Water Supply	6	18	1.5
04/30/98	7514 Dryer Road	Shoots	GW	Residential Water Supply	6.9	6.9	0.5
07/29/97	7514 Dryer Road	Shoots	GW	Residential Water Supply	9.9	11	nd
04/24/97	7530 Surrey Lane	Perzel	GW	Residential Water Supply	nd	nd	nd
07/29/97	7530 Surrey Lane	Perzel	GW	Residential Water Supply	nd	nd	nd
08/07/96	7532 Dryer Road	Harrigan	GW	Residential Water Supply	nd	nd	nd
07/29/97	7545 Surrey Lane	Miller	GW	Residential Water Supply	nd	nd	nd
11/09/99	7560 Dryer Road	Barry	GW	Residential Water Supply	240	130	16
08/07/96	7570 Dryer Road	Forkell	GW	Residential Water Supply	nd	nd	nd
05/03/90	7571 Modock Road	Turner	GW	Residential Water Supply	59	160	nd
04/02/92	7571 Modock Road	Turner	GW	Residential Water Supply	70	125	nd
08/02/95	7571 Modock Road	Turner	GW	Test Well	80	16	17

MODOCK ROAD SPRINGS DATA SUMMARY

08/07/90	7571 Modock Road	Turner	GW	Residential Water Supply	88	170	nd
06/08/94	7571 Modock Road	Turner	GW	Residential Water Supply	89	57	13
09/14/93	7571 Modock Road	Turner	GW	Residential Water Supply	130	99	12
04/10/95	7571 Modock Road	Turner	GW	Residential Water Supply	140	120	23
08/25/95	7571 Modock Road	Turner	GW	Test Well	200	110	5.5
11/03/92	7571 Modock Road	Turner	GW	Residential Water Supply	250	130	9
08/07/96	7571 Modock Road	Turner	GW	Residential Water Supply	nd	nd	nd
07/29/97	7571 Modock Road	Turner	GW	Residential Water Supply	nd	nd	nd
11/03/92	7585 Modock Road	Larson	GW	Residential Water Supply	nd	nd	nd
07/29/97	7585 Modock Road	Larson	GW	Residential Water Supply	nd	nd	nd
08/25/95	7585 Modock Road	Larson	GW	Residential Water Supply	nd	nd	nd
08/07/96	7585 Modock Road	Larson	GW	Residential Water Supply	nd	nd	nd
11/09/99	7596 Modock Road	Sonenfeld	GW	Residential Water Supply	nd	nd	nd
08/02/95	Eastern Springs - Lower	NA	SW	NA	78	65	17
08/07/96	Eastern Springs - Lower	NA	SW	NA	120	81	8.9
11/09/99	Eastern Springs - Lower	NA	SW	NA	130	79	8.7
07/29/97	Eastern Springs - Lower	NA	SW	NA	150	92	6.8
04/24/97	Eastern Springs - Lower	NA	SW	NA	160	93	3.7
04/30/98	Eastern Springs - Lower	NA	SW	NA	160	80	9.3
08/02/95	Eastern Springs - Middle	NA	SW	NA	68	46	13
08/02/95	Eastern Springs - Upper	NA	SW	NA	60	35	7.8
04/30/98	MW-1	NA	GW	Monitoring	200	110	12
08/25/95	MW-1	NA	GW	Monitoring	210	100	nd
07/29/97	MW-1	NA	GW	Monitoring	220	120	8.1
08/11/95	MW-1	NA	GW	Monitoring	240	120	7.2

MODOCK ROAD SPRINGS DATA SUMMARY

04/24/97	MW-1	NA	GW	Monitoring	250	130	nd
08/07/96	MW-1	NA	GW	Monitoring	320	180	9
11/09/99	MW-10	NA	GW	Monitoring	nd	3.2	nd
11/09/99	MW-11	NA	GW	Monitoring	nd	nd	nd
08/11/95	MW-2	NA	GW	Monitoring	nd	3	nd
08/25/95	MW-2	NA	GW	Monitoring	nd	2.1	nd
08/07/96	MW-2	NA	GW	Monitoring	nd	2	nd
08/11/95	MW-3	NA	GW	Monitoring	nd	nd	nd
08/07/96	MW-3	NA	GW	Monitoring	nd	nd	nd
08/25/95	MW-3	NA	GW	Monitoring	nd	nd	nd
11/09/99	MW-4	NA	GW	Monitoring	140	85	9.7
08/11/95	MW-4	NA	GW	Monitoring	160	110	6.9
08/25/95	MW-4	NA	GW	Monitoring	160	6	5.1
04/30/98	MW-4	NA	GW	Monitoring	180	74	7.4
07/29/97	MW-4	NA	GW	Monitoring	200	110	7.7
08/07/96	MW-4	NA	GW	Monitoring	200	150	7
04/24/97	MW-4	NA	GW	Monitoring	240	140	5.6
08/11/95	MW-5	NA	GW	Monitoring	20	17	nd
08/25/95	MW-5	NA	GW	Monitoring	21	12	0.5
08/07/96	MW-5	NA	GW	Monitoring	38	16	nd
08/07/96	MW-6	NA	GW	Monitoring	24	27	nd
04/24/97	MW-6	NA	GW	Monitoring	24	54	2.2
08/25/95	MW-6	NA	GW	Monitoring	26	26	1.4
08/11/95	MW-6	NA	GW	Monitoring	27	28	1.2
07/29/97	MW-6	NA	GW	Monitoring	42	69	4.9
04/30/98	MW-6	NA	GW	Monitoring	73	40	4.8
04/24/97	MW-7	NA	GW	Monitoring	34	31	1.5
07/29/97	MW-7	NA	GW	Monitoring	38	42	2.8
08/07/96	MW-7	NA	GW	Monitoring	59	20	nd
08/11/95	MW-7	NA	GW	Monitoring	92	32	1.4
08/25/95	MW-7	NA	GW	Monitoring	93	29	1.2
04/30/98	MW-7	NA	GW	Monitoring	96	43	4.1
11/09/99	MW-7	NA	GW	Monitoring	97	46	4.4

MODOCK ROAD SPRINGS DATA SUMMARY

11/09/99	MW-8	NA	GW	Monitoring	nd	nd	nd
11/09/99	MW-9	NA	GW	Monitoring	nd	nd	nd
08/25/95	Trib. 30 @ Lower Spring	NA	SW	NA	110	64	nd
08/02/95	Trib. 30 @ Modock Rd.	NA	SW	NA	32	21	3.8
08/25/95	Trib. 30 @ Modock Rd.	NA	SW	NA	47	25	1.1
08/07/96	Trib. 30 @ Modock Rd.	NA	SW	NA	50	25	nd
08/07/96	Trib. 30 @ Rabbit Run	NA	SW	NA	20	9	nd
08/25/95	Trib. 30 @ Rt. 251	NA	SW	NA	nd	nd	nd
04/24/97	Trib. 30 1st Culvert @ Racoon Run	NA	SW	NA	13	7.3	nd
07/29/97	Trib. 30 1st Culvert @ Racoon Run	NA	SW	NA	14	7	nd
04/24/97	Trib. 30 2nd Culvert @ Racoon Run	NA	SW	NA	4.7	3	nd
04/24/97	Trib. 30 Culvert @ Modock Rd.	NA	SW	NA	32	17	0.58
07/29/97	Trib. 30 Culvert @ Modock Rd.	NA	SW	NA	35	19	nd
11/09/99	Trib. 30 N. of Modock Rd.	NA	SW	NA	34	20	1.2
08/07/96	Trib. 30 N. of Modock Rd.	NA	SW	NA	37	17	nd

	A	B	C	D	E
1	Station	TOC Elevation - local datum		Depth to Water (TOC 11/10/00)	Water Table Elevation
2	Modock Springs - Cast iron manhole cover	100		0	100
3	MW-1	164.26		53.13	111.13
4	MW-2	173.3		53.4	119.9
5	MW-3	157		45.85	111.02
6	MW-4	154.28		43.26	111.02
7	MW-5	122.79		ND	
8	MW-6	180.16		61.42	118.74
9	MW-7	184.83		65.7	119.13
10	MW-8	211.84		50.02	161.82
11	MW-9	212.99		52.5	160.49
12	MW-10	207.27		80.8	126.47
13	MW-11	204.54		42.22	162.32
14	MW-12	232.53		48.81	183.72
15	MW-13	257.16		66.12	191.04
16	MW-14	235.07		56.3	178.77
17	Barry well	203.73		72.95	130.78
18	Bates well	187.54		ND	
19	Nelson well	178.95		ND	

STATE OF NEW YORK
DEPARTMENT OF HEALTH
Rochester Office, Bevier Building, 42 So. Washington Street, Rochester, NY 14608-2099

March 9, 2000

Scott Syracusa
Syracusa Sand and Gravel
P.O. Box 2
Victor, New York 14564

Re: Water Sample Results
Modock Springs
Site ID# 835808N
Victor, Ontario County

Dear Mr. Syracusa:

Enclosed is a copy of the laboratory report for a water sample which was collected from the well at your business on February 15, 2000. The water sample was collected as part of an investigation of groundwater contamination discovered in the former Town of Victor springs on Modock Road. The water sample was analyzed for volatile organic compounds at the NYS Department of Health's Wadsworth Center in Albany. Also enclosed is an explanation sheet to help you interpret the results.

No volatile organic compounds were detected in the sample from your well.

If you have any questions about the sample results please call me at (716) 423-8071.

Sincerely,

David L Napier

David L.Napier
Regional Toxics Coordinator

Cc Dr. Carlson/Mr. VanValkenburg
Mr. Burden – GDO
Mr. Craft – DEC, Region 8
Mr. Richter – Town of Victor

0615 072

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER

PAGE 1 RESULTS OF EXAMINATION FINAL REPORT

SAMPLE ID: 200000593 SAMPLE RECEIVED:02/17/2000 CHARGE: 8.00
PROGRAM: 106:BUREAU OF ENVIRONMENTAL EXPOSURE INVESTIGATION
SOURCE ID: DRAINAGE BASIN: GAZETTEER CODE:3464
POLITICAL SUBDIVISION:VICTOR COUNTY:ONTARIO
LATITUDE: . LONGITUDE: . Z DIRECTION:
LOCATION: 835808N VICTOR SPRINGS
DESCRIPTION:SYRACUSE SAND & GRAVEL
REPORTING LAB: TOX:LAB FOR ORGANIC ANALYTICAL CHEMISTRY
TEST PATTERN: 5022W:VOLATILE ORGANICS IN WATER
SAMPLE TYPE: 120:PRIVATE WATER SUPPLY - DRILLED WELL
TIME OF SAMPLING: 02/15/2000 15:30 DATE PRINTED:02/24/2000

ANALYSIS: 5022W VOLATILE ORGANICS IN WATER-EPA 502.2 (DES 310-33)
DATE PRINTED: 02/24/2000 FINAL REPORT

-----------PARAMETER-------------	-----------RESULT----------------
DICHLORODIFLUOROMETHANE (FREON-12)	< 0.5 MCG/L
CHLOROMETHANE	< 0.5 MCG/L
VINYL CHLORIDE	< 0.5 MCG/L
BROMOMETHANE	< 0.5 MCG/L
CHLOROETHANE	< 0.5 MCG/L
TRICHLOROFLUOROMETHANE (FREON-11)	< 0.5 MCG/L
1,1-DICHLOROETHENE	< 0.5 MCG/L
METHYLENE CHLORIDE (DICHLOROMETHANE)	< 0.5 MCG/L
TRANS-1,2-DICHLOROETHENE	< 0.5 MCG/L
1,1-DICHLOROETHANE	< 0.5 MCG/L
2,2-DICHLOROPROPANE	< 0.5 MCG/L
CIS-1,2-DICHLOROETHENE	< 0.5 MCG/L
CHLOROFORM	< 0.5 MCG/L
BROMOCHLOROMETHANE	< 0.5 MCG/L
1,1,1-TRICHLOROETHANE	< 0.5 MCG/L
1,1-DICHLOROPROPENE	< 0.5 MCG/L
CARBON TETRACHLORIDE	< 0.5 MCG/L
1,2-DICHLOROETHANE	< 0.5 MCG/L
BENZENE	< 0.5 MCG/L
TRICHLOROETHENE	< 0.5 MCG/L
1,2-DICHLOROPROPANE	< 0.5 MCG/L
BROMODICHLOROMETHANE	< 0.5 MCG/L
DIBROMOMETHANE	< 0.5 MCG/L
CIS-1,3-DICHLOROPROPENE	< 0.5 MCG/L
TOLUENE	< 0.5 MCG/L
TRANS-1,3-DICHLOROPROPENE	< 0.5 MCG/L
1,1,2-TRICHLOROETHANE	< 0.5 MCG/L
1,3-DICHLOROPROPANE	< 0.5 MCG/L
TETRACHLOROETHENE	< 0.5 MCG/L

**** CONTINUED ON NEXT PAGE ****

NYS ELAP ID'S: 10762(INORGANIC,NUCLEAR) 10763(ORGANIC) 10765(BACTERIOLOGY)
COPIES SENT TO: CO(1), RO(2), LPHE(1), FED( ), INFO-P( ), INFO-L( )

REGIONAL DIRECTOR OF PH ENGINEERING
NEW YORK STATE DEPARTMENT OF HEALTH
42 SOUTH WASHINGTON ST.
ROCHESTER, N.Y. 14608

SUBMITTED BY:NAPIER

ANALYTICAL REPORT EXPLANATION SHEET FOR **WATER** SAMPLES

SAMPLE ID: laboratory identification number

SAMPLE RECEIVED: the date the laboratory received your sample

POLITICAL SUBDIVISION: your town, city or village **COUNTY:** your county

LOCATION: describes the general sample area

DESCRIPTION: describes the specific sample location (e.g. specific address, kitchen tap, —)

SAMPLE TYPE: describes what was sampled (e.g. water)

TIME OF SAMPLING: date and time that your sample was collected

DATE PRINTED: date report was issued

ANALYSIS: the name of the laboratory test performed

———PARAMETER———	———RESULT———
The chemicals for which the laboratory analyzed the sample	Numbers and symbols that represent the lowest concentration that the laboratory can reliably measure or the concentration of the chemical that the laboratory found in the sample

The following describe the results:

- "<" - means "less than". The number following a less than sign (<) is the lowest level the laboratory test can reliably measure (detection limit). If there is a "<" before any number, then the chemical was NOT detected in your sample.
- MCG/L - Abbreviation for "micrograms per liter". One MCG/L is approximately equivalent to 1 part chemical in a billion parts of water.
- MG/L - Abbreviation for "milligrams per liter". One MG/L is approximately equivalent to 1 part chemical in a million parts of water.
- "B" indicates that the compound was also detected in the laboratory blank, indicating that the compound may have been introduced into the sample at the laboratory. Blanks are control samples known to be free of contaminants and are tested as a quality control measure.
- "J" indicates that the compound was detected at a concentration below the detection limit and the concentration is estimated.
- "PL" indicates that the compound is present in the sample but at a concentration less than the reported level.

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NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER

FINAL REPORT

PAGE 2

RESULTS OF EXAMINATION

SAMPLE ID: 200000593 SAMPLE RECEIVED:02/17/2000 CHARGE: 8.00
POLITICAL SUBDIVISION:VICTOR COUNTY:ONTARIO
LOCATION: 835808N VICTOR SPRINGS
TIME OF SAMPLING: 02/15/2000 15:30 DATE PRINTED:02/24/2000

-----------PARAMETER------------	-----------RESULT---------------
DIBROMOCHLOROMETHANE	< 0.5 MCG/L
1,2-DIBROMOETHANE (EDB)	< 0.5 MCG/L
CHLOROBENZENE	< 0.5 MCG/L
1,1,1,2-TETRACHLOROETHANE	< 0.5 MCG/L
ETHYLBENZENE	< 0.5 MCG/L
m/p-XYLENE	< 0.5 MCG/L
o-XYLENE	< 0.5 MCG/L
STYRENE	< 0.5 MCG/L
ISOPROPYLBENZENE (Cumene)	< 0.5 MCG/L
BROMOFORM	< 0.5 MCG/L
1,1,2,2-TETRACHLOROETHANE	< 0.5 MCG/L
1,2,3-TRICHLOROPROPANE	< 0.5 MCG/L
n-PROPYLBENZENE	< 0.5 MCG/L
BROMOBENZENE	< 0.5 MCG/L
1,3,5-TRIMETHYLBENZENE	< 0.5 MCG/L
o-CHLOROTOLUENE	< 0.5 MCG/L
p-CHLOROTOLUENE	< 0.5 MCG/L
tert-BUTYLBENZENE	< 0.5 MCG/L
1,2,4-TRIMETHYLBENZENE	< 0.5 MCG/L
sec-BUTYLBENZENE	< 0.5 MCG/L
4-ISOPROPYLTOLUENE (p-Cymene)	< 0.5 MCG/L
1,3-DICHLOROBENZENE	< 0.5 MCG/L
1,4-DICHLOROBENZENE	< 0.5 MCG/L
n-BUTYLBENZENE	< 0.5 MCG/L
1,2-DICHLOROBENZENE	< 0.5 MCG/L
1,2-DIBROMO-3-CHLOROPROPANE	< 0.5 MCG/L
1,2,4-TRICHLOROBENZENE	< 0.5 MCG/L
HEXACHLOROBUTADIENE (C-46)	< 0.5 MCG/L
NAPHTHALENE	< 0.5 MCG/L
1,2,3-TRICHLOROBENZENE	< 0.5 MCG/L
PH OF VOLATILE ALIQUOT	2

**** END OF REPORT ****

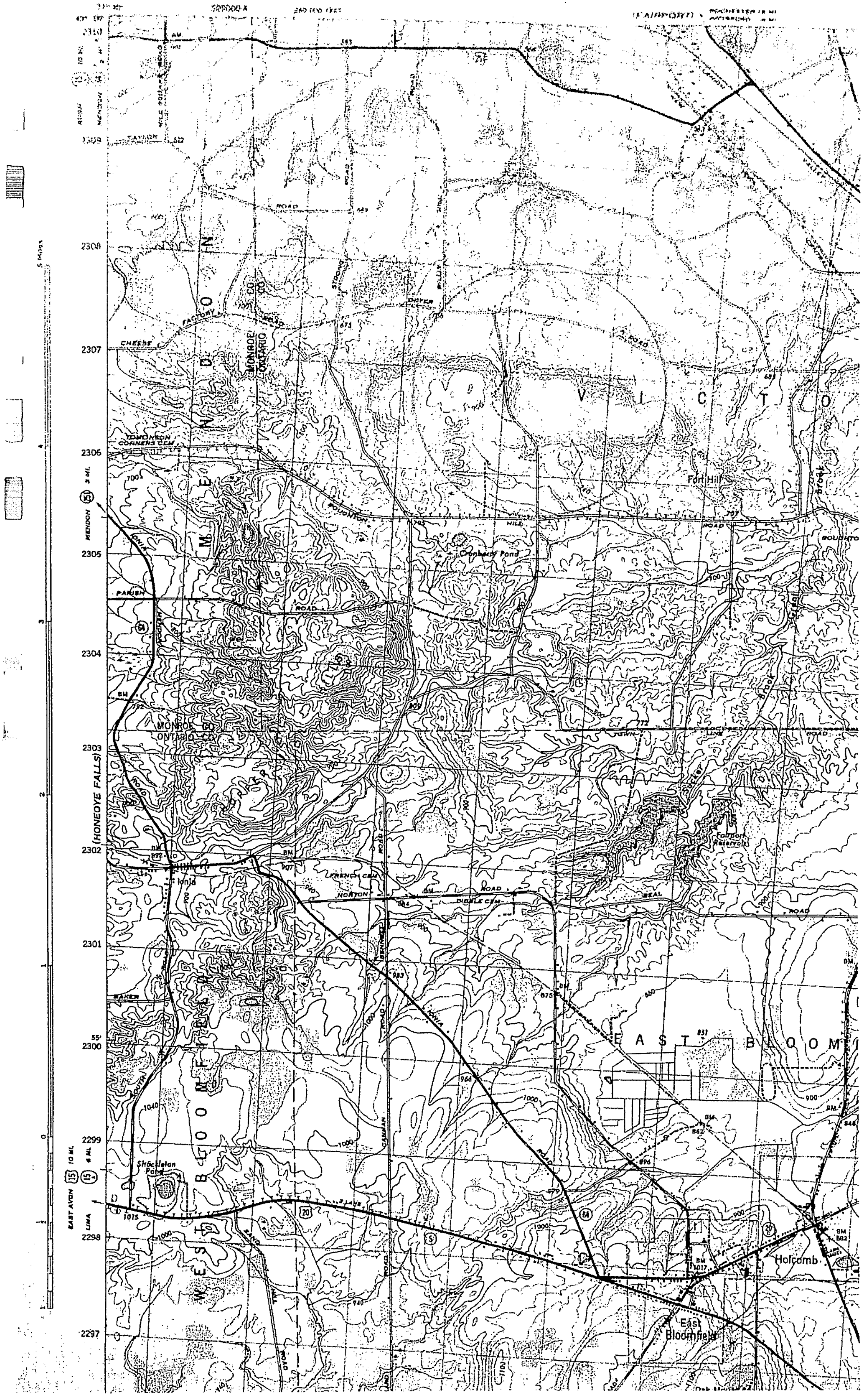
WAR DEPARTMENT
CORPS OF ENGINEERS, U. S. ARMY

NEW YORK
VICTOR QUADRANGLE
GRID ZONE 'B'

Victor Quad

NEW YORK
VICTOR QUADRANGLE
GRID ZONE "B"

WAR DEPARTMENT
CORPS OF ENGINEERS, U. S. ARMY



CONTINENTAL PLACER INC.

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4-10 FG

B.R. DEWITT, INC.
VICTOR PIT
VICTOR, NY

GEOLOGIC SOURCE REPORT
2000 - 2001

Prepared For:
Jeff Holley
Technical Engineer
B.R. DeWitt, Inc.

Prepared by:

Lawrence Delclos
Geologist

December 3, 1999

GEOLOGIC AND ENVIRONMENTAL SERVICES

TABLE OF CONTENTS

1.0 INTRODUCTION 1

1.1 SUBMITTAL 1
1.2 PREPARATION 1
1.3 SURVEY INFORMATION 1

2.0 OPERATIONS 1

2.1 GENERAL 1
2.2 LOCATION AND SITE HISTORY 1

3.0 GEOLOGY 3

3.1 REGIONAL GLACIAL HISTORY 3
3.2 VICTOR PIT GEOLOGY 6

4.0 BEDROCK 8

5.0 WATER TABLE 8

6.0 SOILS 8

7.0 PETROGRAPHY 8

8.0 PLANT FLOW 8

FIGURES

1. Location Map
2. Surficial Geology Map
3. Glacial Deltaic Deposit
4. Soils Map
5. Plant Flow Diagram

APPENDICES

A Glacial Deposits
B Petrographic Analyses
C Source Engineering Data

BACK POCKET

Topographic Base Map
Geologic Cross sections

1.0 INTRODUCTION

1.1 Submittal

This report summarizes the geology and general operational information of the B.R. DeWitt, Inc., Victor sand and gravel operation (Source No. 4-10 FG) located in the Town of Victor, Ontario County, New York. The information is being submitted in compliance with New York State Department of Transportation regulations for continued approval of the deposit as a source of fine and coarse aggregate for use in portland cement and bituminous concretes. The approval period for this operation will be from December 1, 1999 to November 30, 2001.

1.2 Preparation

This report was updated by Lawrence Delclos, Geologist of Continental Placer Inc., in December of 1999. A geologic site inspection and topographic survey were completed on September 11, 1999. The location of the active production faces were surveyed at the time of the site visit utilizing a Pentax PL300 reflectorless survey instrument. The information that follows summarizes the geologic and operational aspects of the pit for the production seasons 2000 and 2001.

1.3 Survey Information

Currently several permanent benchmarks have been established at the site for survey control. The benchmarks at the site include an iron pin set in the hedgerow near the old property line, the corner of the feed hopper and a railroad spike set near the feed hopper and on one of the field conveyor footings. The location and elevation of these points are noted on the topographic base map.

2.0 OPERATIONS

2.1 General

The Victor Pit will produce fine and coarse aggregate for use in portland cement and bituminous concretes. Overburden is stripped approximately 50 to 75 feet in front of the excavation face. Material is excavated by front-end loader and brought to a field hopper to be transported by conveyor to the processing plant. Mining procedures are consistent with those used in the past. The current mine plan for the operation entails expansion of the production faces to the west and north. The area of proposed operations (APO) is shown on the appended Topographic Base Map and Geologic Sections.

Source engineering data excerpted from the materials bureau approved list (April 1999 edition) is presented for reference in Appendix C.

2.2 Location and Site History

The Victor Pit is located in the Town of Victor, Ontario County, New York, approximately 2.5 miles southwest of the Village of Victor on Malone Road as shown on the Location Map (see Figure 1). Mining at the Victor site was started in the 1930's by Hoadley Sand and Gravel and was then operated by Syracuse Sand and Gravel, Inc. The site was purchased by B.R. DeWitt, Inc. in 1952 from Syracuse. The property is owned and operated by B.R. DeWitt, Inc.

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3.0 GEOLOGY

3.1 Regional Glacial History

A synopsis of the glacial history of central New York has been excerpted from the Surficial Geology Map of New York, Finger Lakes Sheet. Surficial geology is shown on the Local Surficial Geology Map (see Figure 2).

> The Finger Lakes Sheet includes part of two physiographic provinces - the Appalachian Uplands and the Erie-Ontario Lowlands. The Tug Hill Upland in the northeast corner of the sheet is an outlier of the Appalachian Uplands, similar in structure and topography, though isolated from them by the eastward projecting Oneida Basin, a part of the Erie-Ontario Lowland.
>
> The region is underlain by several thousand feet of Paleozoic sediments ranging in age from Ordovician to Devonian. Geologic structure is simple, involving only very mild local deformation and regional dip at a fraction of a degree to the south-southwest. Because long erosion has beveled the tilted strata, progressively younger rocks are preserved to the south. Except in areas of steep slope, however, bedrock is generally mantled by a cover of drift which ranges from a few feet thick over the uplands to several hundred feet thick in many valley bottoms.
>
> Landscapes of central New York bear a dominantly glacial imprint. Only vestiges remain of landforms that existed prior to Pleistocene glaciation. Flood plains and valley walls have been reshaped only very incompletely by postglacial processes.
>
> The record of continental glaciation, however, is far from uniform. Glacial erosion and deposition are most extensively expressed in the Erie-Ontario Lowland and in the east-west arcuate belt of the uplands that includes the northern portions of the Finger Lake basins. To the south, in a zone that includes the southern halves of the Finger Lake drainage basins, relief is moderate to high and the plateau is cut by a plexus of glacial troughs or through valleys. In the southern tier of counties along the Pennsylvania border, relief is likewise moderate to high. In this zone, however uplands bear only superficial

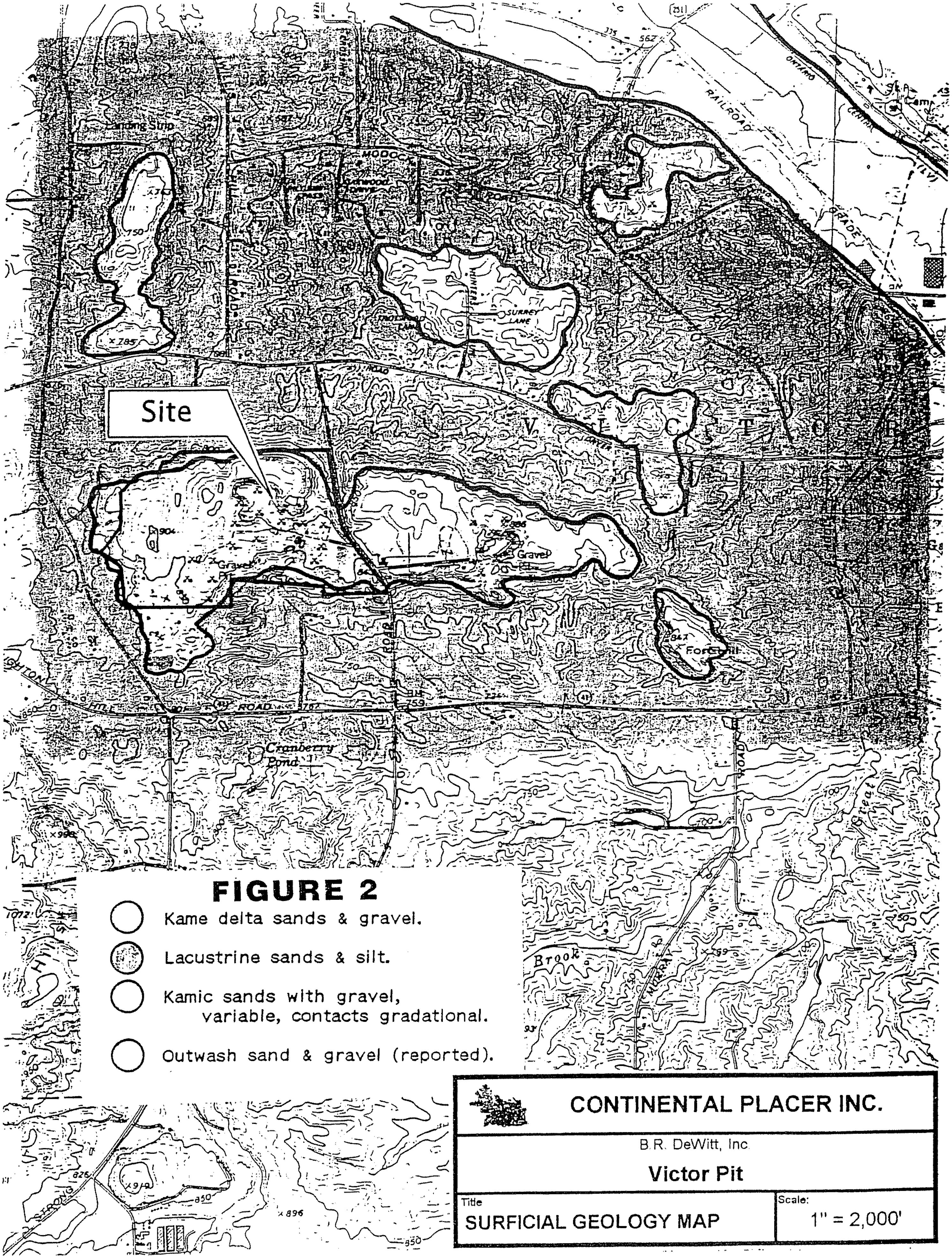

FIGURE 2

○ Kame delta sands & gravel.

▨ Lacustrine sands & silt.

○ Kamic sands with gravel, variable, contacts gradational.

○ Outwash sand & gravel (reported).

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B.R. DeWitt, Inc.

Victor Pit

Title	Scale:
SURFICIAL GEOLOGY MAP	1" = 2,000'

evidence of glacial erosion and valleys follow courses minimally deranged from preglacial patterns. This southward decrease in intensity of glacial modification of topography results not only from the relatively high relief and elevation of the plateau prior to glaciation, but also from diminishing duration and frequency of glacial expansion southward across the state.

Clearly, on the basis of evidence in adjacent areas, New York has experienced several glaciations. Yet, because each glaciation tends to destroy the geologic record of previous events, evidence of multiple glaciation is only preserved in unusual situations. The deflection of the Chemung River from its broad valley into the narrow canyon between Big Flats and Elmira is one such instance, for glacial deposits are inset within the canyon in a manner that was only possible because stream derangement had occurred previously. In protected gullies transverse to the main flow of glacier ice, older drift may escape erosion by later glaciation. Such is the stratigraphic record for instance, in valleys of Sixmile Creek and Great Gully, east-flank tributaries to Cayuga Trough in which organic materials in stratified sediment between till sheets have been radiocarbon-dated at more than 30,000 years. At Fernbank, on the west shore of Cayuga Lake a few miles north of Ithaca, sediments contain plant debris and freshwater shells that indicate glacial impondment of Cayuga Trough more than 50,000 years ago.

In spite of such evidence of prior glaciation, surface deposits in central New York date almost entirely from late Wisconsinan time, an expansion of the ice sheet that began some 27,000 years ago and culminated with maximum extent perhaps 20,000 years ago. In areas with as great topographic relief as southern New York, the wasting of an ice sheet typically leaves isolated areas of debris-covered and stagnating ice. The final melting out of such "dead" ice resulted in kames, eskers and gravel terrace deposits such as those in the Susquehanna Valley near Waverly and Elmira.

As long as the glacier margin lay in the headwaters of the Susquehanna, meltwater escaped freely, distributing outwash gravels in the valleys to the south. As the ice margin retreated north of the bedrock divide, however, meltwater was impounded in many valleys. In subsequent minor fluctuations, the ice margin tended to reach just about the same position without being able to expand across the divide. The result of such ice-margin fluctuation was the building of a massive complex of valley-blocking, ice-marginal deposits. This complex, The Valley Heads Moraine, comprises the present watershed between Susquehanna and St. Lawrence drainage basins across the breadth of the Finger Lakes Sheet.

Recession of the ice margin from the Valley Heads Moraine impounded small trough lakes in each valley between glacier terminus and moraine dam. Most of these "primitive lakes" initially had their outflows southward across the moraine barrier. Continued recession, although interrupted by minor re advances, uncovered alternative outlets at lower elevations or permitted coalescence of the northward expanding marginal lakes. Thus, ancestral Lake Ithaca in the Cayuga

Basin joined Lake Watkins in the Seneca Basin to form Lake Newberry with its outflow south past Horseheads into the Chemung Valley. At maximum extent, Lake Newberry extended into the Keuka Basin as well and received drainage from the other Finger Lake troughs as far east as Marcellus.

When the receding ice margin uncovered the Onondaga bench at the north margin of the plateau, glacial meltwater from as far west as the Erie and Huron Basins found outflow eastward toward the Mohawk Valley, carving deep channelways parallel to the edge of the plateau. Noteworthy among these meltwater scourways are the "Syracuse Channels" (Smoky Hollow, Clark Reservation, Rock Cut, Nottingham, Meadowbrook and Erie Channels) as well as Cedarvale Channel east of Marcellus and Pools Brook and Green Lake Channels east of Fayetteville. Several of these channels show clear evidence of repeated erosion as the ice sheet readvanced during the Port Huron Stadial and then retreated again from the Auburn-Waterloo-Skaneateles Moraine.

Ice recession across the Erie-Ontario Lowlands uncovered a landscape dominated by drumlins and areas of kame and kettle topography. It also brought into existence Lake Iroquois, a more extensive predecessor of Lake Ontario with outlet east to the Mohawk across the col near Rome. East of Rochester the Iroquois shoreline lies along Ridge Road with well-developed barrier-beach deposits. Farther east the Iroquois shoreline was island-studded and with deep embayments into the Seneca and Cayuga Basins.

Ice sheet recession north of the Adirondacks uncovered a lower drainageway in the St. Lawrence Valley initiating a low water stage of Lake Ontario. Unloading of the earth's crust by melting of the continental ice sheet resulted in rebound or rise of the land which was greater at the east than at the west end of the lake. The result of such differential rebound has been a rise of lake level and submergence of river mouths along the south shore of Lake Ontario.

The relatively brief duration of postglacial time, approximately 11,000 years, has been enough only for limited carving of shore bluffs, partial filling of small basins and incomplete stream excavation of valley fill.

3.2 Victor Pit Geology

The Victor operation is located within the Erie-Ontario Lowlands physiographic province of New York State. The surficial geology in the surrounding area is composed of kamic deposits and lacustrine sediments as shown on the Surficial Geology Map (Flint, 1971). The pit is located in a prominent glacial deltaic deposit (see Figure 3). The delta deposit trends in an east-west direction for over 10,000 feet and is approximately 3,000 feet wide. Average relief of the local topography is about 300 feet.

Material is excavated from a typical deltaic sequence of three stratified sand and gravel units comprising bottomset, foreset and topset beds. The bottomset beds are well stratified, occasionally cross-bedded, fine to coarse silty sand with interbedded fine sandy silt and thin

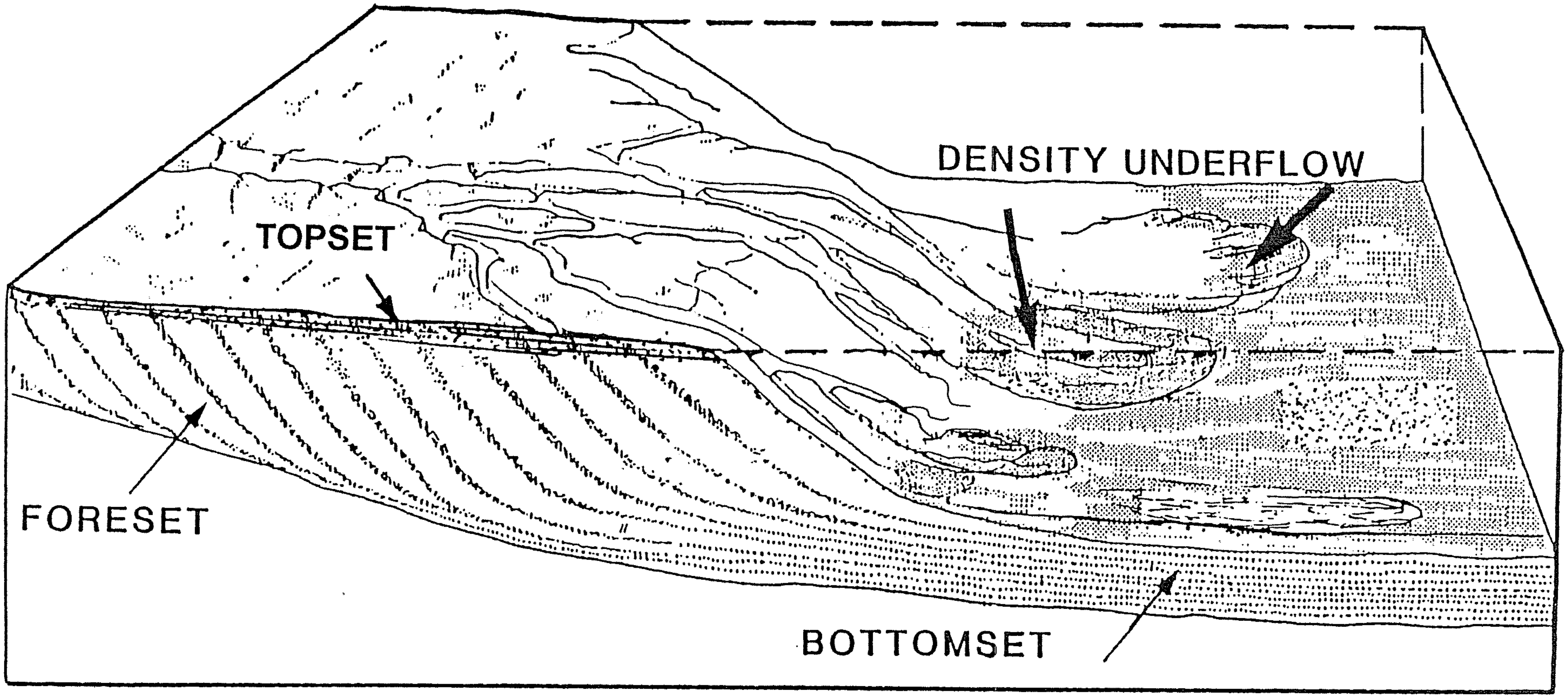


FIGURE 3

Glacial lake delta showing location of topset, foreset and bottomset bedding.

clay laminae. This unit is at least 15 feet thick, showing areas of climbing ripples and draped lamination.

The foreset beds dip 10 to 45 degrees to the south implying north to south flow of the water and are composed of interbedded sandy gravel and gravelly sand. Gravel is generally rounded to subrounded and up to eight inches in diameter and is usually interbedded with sand. The topset beds are similar in composition to the foreset beds but are horizontally bedded and occur in the central part of the deposit. Overburden is one to three feet thick. The pit typically fines downward and to the south. Photographs of the active production areas are shown on the following page. Photograph 1 shows the active northern face (topset beds) with a height of approximately 50 feet. Photograph 2 shows the lower excavation face (forset beds) with an approximate height of about 20 feet.

4.0 BEDROCK

Bedrock has not been encountered at the Victor Pit nor does it outcrop in the immediate vicinity of the site. Based on information from the Geologic Map of New York, it has been inferred that the bedrock underlying the Victor Pit consists of Upper Silurian Akron Dolostone/Bertie Formation (Richard & Fisher, 1970).

5.0 WATER TABLE

The water table is presumed to be at an elevation of approximately 800 feet as expressed by a pond in the southwestern portion of the active pit area.

6.0 SOILS

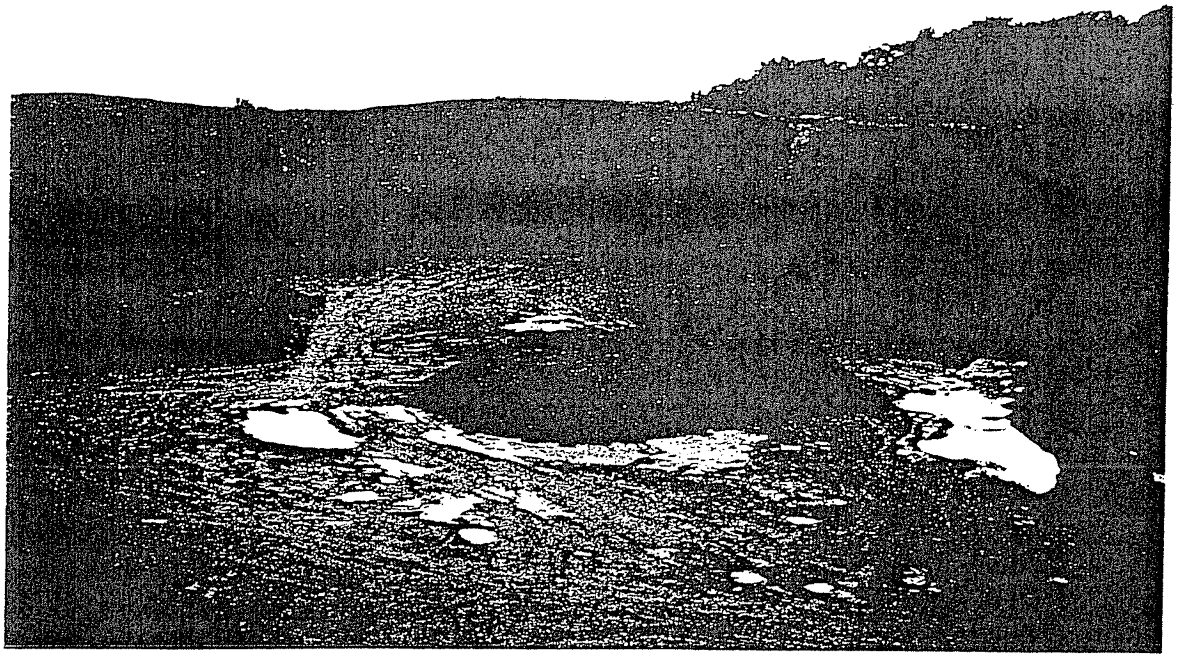
The principal soil types that that can be found at the site are primarily soils of the Palmyra series as shown on the Soils Map (see Figure 4). Also included are the descriptions of the soil types.

7.0 PETROGRAPHY

Petrographic analyses of the pit were taken in 1973 and 1988. As the test sheets detail, the coarse aggregate contains mostly Medina Sandstone and Lockport Dolomite with lesser amounts of other sandstones, quartzites, granite/gneisses, and limestones. The fine fraction consists mainly of sandstones and dolomite with lesser amounts of quartzites, limestones, granites/gneisses, siltstones and quartz; grading to mainly quartz and sandstone. Appendix B contains detailed petrograhpic analyses as well as graphical charts of this data.

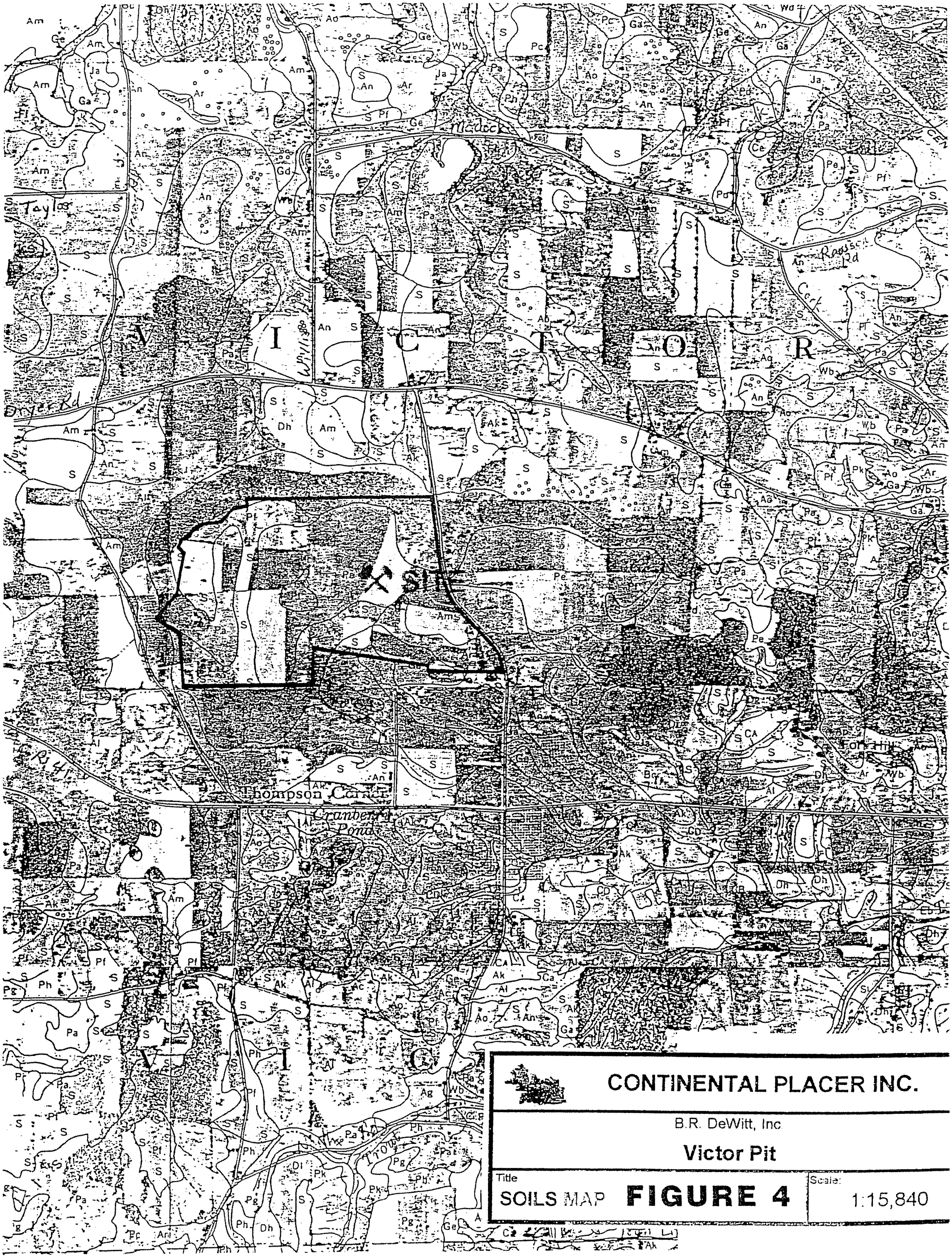
8.0 PLANT FLOW

A Plant Flow Diagram (see Figure 5) follows which illustrates the processing scheme for sand and gravel items. A description of each piece of equipment and a numbering scheme is included on the diagram. The plant capacity is approximately 250 tons per hour.



Photograph 1. View of active excavation face looking north. The height of the face is approximately 50 feet. Material here consists primarily of horizontal layers of sandy gravel and gravelly sand (topset beds). Geology partially obscured by recent talus.

Photograph 2. View of active lower excavation bench looking north (foreground). The height of the face is approximately 20 feet. Material here consists of steeply dipping layers of sandy gravel and gravelly sand (foreset beds).



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Victor Pit

Title

SOILS MAP **FIGURE 4**

Scale:

1:15,840

Palmyra gravelly fine sandy loam, 0 to 3 percent slopes (PaA).—The profile of this level to nearly level soil differs from that described as representative of the series because it has a coarser textured surface layer and a slightly coarser textured subsoil. The soil is on level ridgetops or on broad, flat terraces in areas 10 acres or more in size.

Commonly included with this soil in mapping are the moderately well drained Phelps soils at lower elevations. Some areas, where Halsey soil inclusions are in the deeper depressions, remain wet for longer periods of time. Some small inclusions have a gravelly loam surface texture. Other minor inclusions are areas of Colonie, Arkport, and Schoharie soils.

This soil is well suited to woodland. It is suited to the crops commonly grown in the county and most specialized crops. Gravel in the surface layer interferes with cultivation and growth of some root crops. Cropping can be intensive if the soil is properly managed. Measures that conserve moisture are the main management need. In dry periods, this soil becomes droughty. If specialized crops are grown, supplemental irrigation is generally required. (Capability unit IIs-1; woodland suitability group 2o1)

Palmyra gravelly loam, 5 to 15 percent slopes (Pe).—This soil has complex slopes that are steep enough to interfere moderately with tillage. Runoff is greater than from Palmyra gravelly loam on 0 to 5 percent slopes. The loss of water is fairly serious from this soil, which has only moderately good water-holding capacity. The same crops are grown on this soil as are grown on the nearly level phase, but response to management is generally less, and dry weather does more harm to crops.

Practically all of the crops grown in these two counties are suited to this soil, if they are grown under the rotations and simple management practices suggested in group 3, table 10. When the soil is used for these rotations, it has a low lime requirement, a medium phosphorus requirement, and a high potassium requirement. Its response to heavier rates of fertilization is only fair. Where adequately fertilized, native pastures produce well in spring and early in summer but produce little in midsummer. Birdsfoot trefoil and other deep-rooted legumes produce more on this soil than shallow-rooted plants.

PLANT FLOW DIAGRAM

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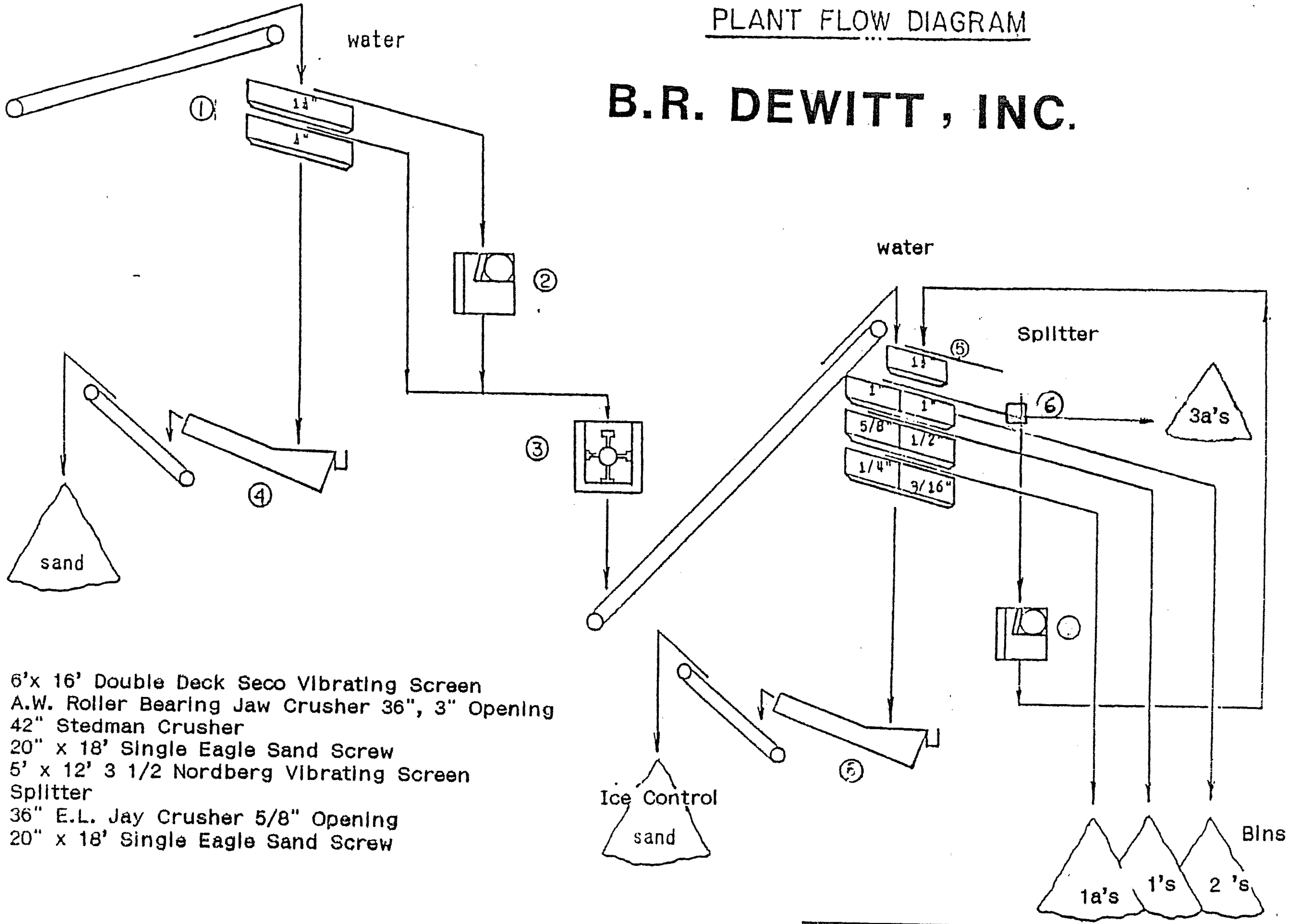

1. 6'x 16' Double Deck Seco Vibrating Screen
2. A.W. Roller Bearing Jaw Crusher 36", 3" Opening
3. 42" Stedman Crusher
4. 20" x 18' Single Eagle Sand Screw
5. 5' x 12' 3 1/2 Nordberg Vibrating Screen
6. Splitter
7. 36" E.L. Jay Crusher 5/8" Opening
8. 20" x 18' Single Eagle Sand Screw

FIGURE 5

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Victor Pit

Title

Scale:

REFERENCES

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Flint, Robert, F. 1971, Glacial and Quaternary Geology, John Wiley and Sons, Inc. New York, pp. 214-220.

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APPENDICES

APPENDIX A

Glacial Deposits

GLACIAL DEPOSITS

Deposits of Valley Glaciers

Deposits produced by glaciers and by the water derived from their melting have long been called collectively *glacial drift*. The drift consists of two main types: those parts deposited directly by the ice are devoid of any layering and are called *unstratified drift* or till; the parts laid down in water adjacent to the ice are layered, and so are called *stratified drift*. The till can be subdivided into a number of types based upon the conditions of deposition, but, for our present purposes, it is sufficient to consider only two: the deposits formed directly by the moving ice and those formed by ablation, or during the retreat of the ice front. The terminology for these has become mixed up with that for topographic features called *moraines*.

ERRATICS Distinct from the above glacial deposits are the *erratic boulders*. These boulders differ from the bedrock on which they lie, and they are obviously in no way related to it. Ordinarily, the boulders are about 1 to 3 meters (3 to 10 feet) in diameter, but boulders as big as a house are not uncommon and some of the large ones are truly enormous: Embleton and King[1] give the examples of one in Northumberland, England, that is 800 meters (2616 feet) long, and the largest of the "Schollen" of Germany, that is 4 km (2.4 miles) by 2 km (1.2 miles), by 120 m (390 feet) thick. The majority of erratic boulders were probably engulfed in the ice by being plucked from the rocks beneath the moving glacier, but they must have undergone considerable attrition during transport, because most of them are somewhat rounded. Some, no doubt, fell upon the glacier from the mountain sides above. How a block 4 km long got into the ice requires some other explanation! Apart from their illustration of the immense ability of ice to transport rocks, these erratic boulders also give much information about ice movement, because certain characteristics rocks can be recognized and their boulders traced. The prospector's technique of tracing "float" boulders is precisely the same thing, and follows the train of boulders moved by the ice.

In addition to showing the direction of ice motion, erratics have also demonstrated that the ice can move uphill. If the erratics are found at an elevation higher than the outcrop whence, they came, they must have been carried uphill by the ice. This probably indicates that the centre of accumulation from which the ice was spreading did not coincide with an earlier watershed; ice spreading outward from central Labrador and over-riding the hills of the Gaspe' peninsula would be an example of this.

Unstratified Drift

Moraines

The term moraine applies to a wide range of depositional features derived from the work of glaciers; they are composed of unstratified material that has been deposited directly by the ice.

Lateral Moraines Lateral moraines are formed at the side of a glacier by fragment that fall off the rock walls of the valley from above the ice. This material is carried along by the moving ice and, near the front of the glacier, where the ice is wasting away, builds up a steepsided ridge on the margins of the glacier. In this part, there may be a narrow valley between the moraine ridge and the main rock wall of the Valley.

Medial Moraine Medial moraines form where two glaciers merge. The marginal moraines on the adjacent sides of the two glaciers necessarily merge when the ice flows combine, and the combined marginal moraines then continue down the glacier, more or less in its middle. If the ice is subject to avalanches above the junction, or if the spur separating the two glaciers is above the firn line, there may be enough snow cover to hide the marginal moraines and the upper part of the medial moraine until the snow finally melts off as the glacier moves farther down the valley. The rock fragments of the medial moraine may extend deep into the ice of the combined glaciers, but do not always do so.

---

[1] Embleton, C. and King, C.A.M.: *Glacial and Periglacial Geomorphology*, Edward Arnold, London, 1968, p. 304.

Ablation Moraine Ablation moraine is the accumulation of surface debris that forms on the wasting part of the glacier. The ice beneath this surface coating is normally very clean in appearance because, in fact, the proportion of rock in the ice is small. As the surface of the ice is lowered by ablation, the fragments that were in the ice have nowhere to go, and accumulate upon the surface as the ice that was surrounding them vanishes away. The layer of ablation moraine increases in thickness toward the snout of the glacier, unless there is heavy rainfall or abundant meltwater on the ice surface; in that case, much of the moraine may well be washed away by the run off.

Terminal Moraines Terminal moraines form at the front of the glacier, but the development of a large moraine requires that the ice front remain stationary for a considerable time. This requires, in turn, that there be a close balance between supply and wasting for the same length of time, so the front of the glacier is neither pushed down the valley over the moraine, nor melted back to some place above it. If the balance is so maintained, then all the rock debris within the ice, and the ablation moraine riding upon it, are dumped in a ridge at the front of the ice, where there is no longer any vehicle to transport it further - the glacier "conveyor belt" has reached the end of its run. If the glacier should later retreat rapidly, the mound of the terminal moraine may act as a dam to create a lake between the moraine and the ice. Such lakes are temporary affairs, because the meltwater over-flowing the moraine usually erodes a channel through it very quickly and so drains the lake. The same meltwater, of course, deposits *outwash* material in front of the moraine through which it has eroded.

Recessional Moraine Recessional moraines develop because a balance between ice supply and wastage is at most a temporary state. A glacier that is retreating because ablation exceeds the ice supply will leave behind it on the valley floor a blanket of ablation moraine as the glacier front recedes up the valley. Should wastage and ice supply again be in balance for some period, the ice front will again be stationary and a heap of till will accumulate to form a recessional moraine. It is obvious that the materials of a recessional moraine, and the characteristics of the deposits, are in no way different from those of a terminal moraine; the latter simply marks the front of maximum advance of the glacier down the valley. Recessional moraines, of course, can be formed only by a retreating glacier, and are generally destroyed if there is a subsequent re-advance of the glacier front.

Ground Moraine Ground moraine forms beneath the ice of the glacier and so is formed differently from the ablation moraine, which is simply lowered from the ice surface onto the ground as the ice melts away. The ground moraine can apparently develop in three ways. In the first, the burden of rock debris picked up by the ice of the bottom of the glacier becomes excessive. The ice then begins sliding over some of the material in its own bottom. Study of the resulting moraines indicated that there may be an accumulation of till thus built up by a "plastering-on" process. In the second, the glacier rides over moraine previously deposited, perhaps even during its own temporary recession. The till is then subjected to the weight of the overlying ice, in addition to the shear stresses caused by the ice movement. The till may be considerably deformed as a result. This commonly takes the form of a reworking and squeezing that produces systematic orientation of the boulders in the till as well as the development of shear surfaces and minor thrust movements within it. In the third process, the material at the bottom of a stagnant ice sheet is slowly accumulated as the ice melts. Obviously, it will be very difficult to distinguish, within the deposits, between ablation moraine and ground moraine deposited by this third method. The two other types of ground moraine can be recognized by the deformation within them.

Four *additional features of moraines* should be noted.

First, from he very circumstance of their formation, marginal moraines merge at their lower ends with the terminal and recessional moraines formed by the same glacier.

Second, the amount of rock material, in the marginal, medial, and terminal moraines and scattered through the mass of the ice as *englacial* debris, reflects the history of the glacier and the conditions along its valley. One side of the valley, for example, may be composed of rock that breaks easily under frost action and sheds abundant material into the ice, while the other wall may be massive and solid and productive of only very little debris. Variations in weather, during the time the ice is making the long journey down the valley, will also influence the rate at which weathering proceeds and rock fragments are added to particular parts of the glacier. There are a number of other factors that may operate as well, but the point of importance here is that the distribution of rock fragments in the ice is not uniform, because of the influence of these various conditions. By the time the ice arrives at the front of the glacier these irregularities of distribution appear across the front of the ice; in some places debris is scarce, in others, it is abundant. The terminal moraine that results is accordingly most irregular in height and width. The typical moraine surface is steep, and is, on both side toward the ice and the side away from it, roughly at the angle of repose for the moraine material. The top surface is typically very irregular and hummocky.

Third, the height of the moraine, of course, depends upon the supply of debris, rate of ice advance, and the time during which, the ice front was stationary. Ordinarily, moraines are not more than a hundred or so metres high and may be very much less, but the terminal moraine of the Franz Josef glacier in New Zealand is 430 metres (1400 feet) in height. Terminal moraines may also be partly, or in large measure. eroded away by melt water, or buried under outwash material, so they are not always large or conspicuous. Many moraines have a core of ice when they are first formed. This core may consist of large masses of ice that have been protected from melting by the coating of ablation moraine accumulated upon them, or it may be ice derived from snowbanks that were piled up in front of the glacier and buried under material that slumped down the front of the moraine. Although the melting rate of the ice of the core is much reduced by the layer of moraine over it, it does eventually melt, of course, and drains away. As it does so, the space formerly occupied by the ice is filled by collapse of the moraine, and a deep hollow (kettle-hole) appears on the surface. From the combined effects of kettles and the original irregularities, the surface of moraine (including ground moraine) may be very hummocky indeed.

Fourth, some moraines have been overridden by re-advance of the ice. The moraine may be deformed considerably and, if the moraine was thoroughly frozen, as by permafrost, one part may be pushed over another on a fault surface. In addition to these gently inclined thrust slices and faults, waves and folds also occur. Moraines that have been developed or modified by this bulldozing action of the ice have been called *push-moraines.*

Stratified Drift (Ice-contact)

Eskers

The esker is a very characteristic deposit formed by retreating ice. Meltwater flowing beneath the ice, or even within the ice. acts like any other stream in transporting any particles it is capable of moving. The particles, of course, come from the material carried within, and at the bottom of, the glacier. These sub-glacial streams are generally of low velocity; at least, they seldom move even small boulders, and the bluff of the material they do carry is sand and fine gravel. Where the stream emerges from beneath the ice at the snout of the glacier, it is no longer constrained by the ice walls, and deposition of the sedimentary load occurs immediately, consequent upon the loss of velocity. Where eskers have been observed actively forming, they are already at least a metre high as they emerge from the sub-glacial tunnel carved by the meltwater, which would indicate that there is also active deposition beneath the ice.

Physically, the eskers are long, narrow ridges of sand and gravel, in some cases including boulders. The ridge is from 3 to perhaps 15 metres (10 to 30 feet) high, with 5 to 10 metres (15 to 30 feet) an ordinary value; some are known as much as 45 metres (150 feet) high. The crest of the ridge is narrow in some cases, but in most eskers the top is about 4 to 6 metres (15 to 20 feet) wide, and without any abrupt irregularities of elevation along the length of the ridge. The flanks of the ridge are steep, and approximate the angle of repose (about 20°) of sand (the chief constituent of the deposit), and the sands and gravels are well layered. The width of the base of the ridge, of course, depends upon the height; even the very high eskers are less than a kilometre wide at the base. Seen from above, the esker is a narrow, straight to slightly sinuous ridge. In some cases it may have tributary eskers. Where the esker has developed under a retreating ice cap instead of a valley glacier, lengths up to 160 km (100 miles) are not uncommon. Obviously such a deposit could be formed only at the front of a retreating glacier. Its position and direction reflect *only* the position of the sub-glacial stream as it emerged from the front of the melting glacier, but the direction of the esker is found to be more or less parallel to the direction of ice movement as well. This is to be expected, because both the ice and the stream beneath it flow down the same slope.

In addition to the mechanism of sub-glacial deposition from meltwater, as outlined in the first paragraph, it has also been suggested that eskers are deposited by the sub-glacial streams as they discharge from under the glacier into ponded meltwater. This would explain the formation of the unusual "beaded" type of esker, and some eskers may well be formed in this way, but it does not appear that the ponded water is a necessity for esker formation. It is probable that most eskers are formed only under stagnant ice and that they are best developed where large stagnant ice caps have melted away.

Crevasse Fillings

Not all narrow elongate ridges resembling eskers were formed by flowing water. Some ridges, usually continuous and less than a kilometre in length, contain horizontally bedded fine and coarse material and are apparently the result of the filling in of glacial crevasses. They are associated with pitted outwash plains, and, unlike some eskers, they have no coating of till on the crest. When the stagnant glacier melts, the crevasse filling is simply dropped to form a ridge. The features just listed are the most likely to be diagnostic in distinguishing crevasse fillings from true eskers[2].

Kames

A *kame* is a more or less isolated mound composed chiefly of stratified sand and gravel, deposited on or against the glacial ice; its character results from the position where it was formed, but may have been modified by later slumping when the bordering ice melted away. In some cases, the stratified deposits of the kame are covered by a layer of ablation till.

Various hypotheses have been offered to explain the development of kames. One suggests deposition where a meltwater stream (not necessarily sub-glacial) discharges into a lake alongside the ice. This would produce a delta-like deposit against the ice and such a delta would be expected to slump when the ice melted, causing a steep slope to the layering in the part formerly supported by the ice. Another suggests that the debris needed to form a kame was collected in a meltwater pool on the surface of stagnant ice. As the water warmed in this pool, it gradually melted its way through the ice to the ground beneath. The solid debris from the former pool was then left as the kame when the surrounding ice melted away. Supporters of this hypothesis have some difficulty in explaining the absence of fine material in the kame, and seem to assume peculiar behavior of the ablation till surrounding the pond.

Kame Terraces Kame terraces are somewhat different and are formed in meltwater flowing along the side of the glacier between the ice and the valley wall. (The ice is lower at the very margin of the glacier, because of radiation from the rocks of the valley wall, which is a better absorber of solar radiation than is the ice.) The meltwater carries sands and gravels off the surface of the ice and deposits them in the marginal stream or lake. The surface of the deposit may initially slope away from the ice, the source of the sediment, but the side of the deposit that was nearest the ice slumps down as the ice melts away. This leaves a steep ice-contact slope on the outside of the kame terrace, but the original gentle slope toward the valley wall remains. When the whole glacier eventually melts away, this deposit of sediment is left as a terrace upon the side of the valley. In settled areas, the terraces have been chosen, in many cases, as the site for buildings because of the relatively flat surface, good drainage, and elevated position of the terrace.

Delta-moraines

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Delta-moraines have many of the features of kames but are much larger, elongated, and more complex. Formed at the front of the melting ice, the length of the moraine approaches that of the ice front, and it may therefore be as much as several kilometres long. Typically, there is an ice-contact slope on one side, reflecting deposition against the now-vanished ice. The internal features show the foreset beds facing away from the ice, as would be expected of deposition from streams emerging from the ice; eskers also end in the moraines in some cases. Like other moraines, these also may branch, the space between the branches reflecting a period of rapid retreat of a part of the glacier front.

Glacial Outwash

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VALLEY TRAINS The meltwater streams have their own special peculiarities. For many valley glaciers the gradient on the valley bottom is very steep and the velocity of the meltwater stream is correspondingly high. At

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[2] Flint, R.F.: "Eskers and Crevasse Fillings," American Journal of Science, vol. 235, 1928, pp. 410-416

the same time, the material supplied to it is very poorly sorted, or not sorted at all. In consequence, there is a very rapid sorting of material by the stream and a very rapid deposition of all the "non-transportable" sizes immediately in front of the glacier. Much of this material may be incorporated into the frontal moraine, while the next finer size fraction is deposited immediately in front of that. Also because of the large load of sediment they carry, the meltwater streams aggrade their channels very rapidly and, as with other rapidly aggrading streams, they follow extremely braided courses, which change almost from minute to minute, upon the surface of their own deposits. Another characteristic of outwash streams is their variable flow. Close to the snout of the glacier, the volume of meltwater may have a diurnal variation in summer, but it is the annual variation that is probably the most important. The flow increases very markedly for a few months during the summer, and then dies off to very low values during the winter. Finally, the glacial stream carries in suspension large quantities of "rock flour," i.e., ground-up rock scraped from the valley floor by the glacier. This has a size range and character different from the clay minerals formed by normal chemical weathering. In suspension, it impacts a characteristic milky appearance to the melt water of a glacier and the finely-divided part may stay in suspension, even in quiet water, for a very long time.

The characteristic U-shape of a glaciated valley is accentuated by the valley train deposits. The deposits are spread out by the wide wanderings of the braided streams, and, as seen in a cross-section of the valley away from the immediate area of the moraines, the surface of the deposit tends to be rather flat. Furthermore, the deposits include everything carried away from the glacier, and may fill the valley bottom to a thickness of several hundred metres. This flat valley bottom may create a sharp break in slope against the valley wall at the margin of the valley train and thus further accentuate the normal U-shaped section of the valley.

Valley trains may later become dissected with the development of terraces. After the glacier disappears and vegetation establishes itself upon the hillsides, the surface is protected from erosion, and there is a reduction in the load of sediment carried by the stream. As a result, the stream begins to cut into its former deposits and leave terraces where the surface of the train once was.

OUTWASH PLAINS

Many of the features characteristic of valley trains are also to be expected in the outwash plains. The distribution by braided streams, for example, spreads the deposits far and wide in front of the glacier. In the same way. also, there is a gradual decrease in gradient of the stream with increasing distance from the ice, reflecting the early deposition of coarse material and the reduced gradient necessary to transport the lighter fractions in an aggrading stream.

The outwash plain may start directly in front of the ice, or it may begin with a moraine and a pro-glacial lake (i.e., a lake between the moraine and the front of the retreating ice). Some sedimentation will obviously occur in the lake, and the level of the sediments may build on its bottom till it is above the level of the bottom of the ice face, and so also above the level of the discharge of the sub-glacial streams. In front of the moraines, the sediments are graded according to size and distance from their source. Gravel and boulders are common near the source, but elsewhere sands are the most common sediment size, and towards the limit of the plain the material becomes much finer still

The outwash deposits are not much different in character from those produced by other streams. That is, they are very irregular in character both in the vertical and in the horizontal, with rapid variations in grain size and very lenticular and discontinuous layering. In effect, they resemble the deposits produced by braided streams anywhere, except that they may contain tills - which would not be possible in a non-glacial deposit. Except in special circumstances, the outwash deposits can not be expected to contain very fine sediments.

Deposits of Continental Glaciers

The deposits formed by continental glaciers can be anticipated, in large measure, from those produced by valley glaciers. We should expect, therefore, to find moraines, eskers, kames, outwash deposits and similar features. Generally speaking, the major differences between the deposits of valley glaciers and the corresponding features of continental ice sheets are related to the great areas covered by the latter. We find, as we would expect, that an ice sheet has a terminal moraine; instead of extending across a valley, however, it extends across half a continent. In the same way also, immensely long recessional moraines mark pauses in the retreat of the ice. The life of continental ice is a complicated affair, however, with a number of advances and retreats; sometimes a later advance went further than an earlier one, or in a different direction, and the terminal moraine of one stage may cross that of another. In the same way also, we find very extensive outwash deposits, not only beyond the terminal moraine but present also in the hundreds of kilometres across which the ice withdrew. Where the ice was stagnant in the later parts of its retreat, eskers and other characteristic features are abundant.

Some differences are to be expected, however. A great ice sheet generally covers everything, burying whole mountain ranges, as in Antarctica and probably also in Greenland. Once the ice has swept up all the pre-existing soils and old erosion products, the only source of additional material available to the glacier is the rock beneath it. Presumably, then, the supply depends upon the ability of the ice to pluck rock fragments loose, and their size depends upon the size of the chunks available. Collapse of large blocks off the rock wall of a valley and onto the ice is not possible.

All the features related to valley glaciers and discussed above are also found in the deposits of continental ice sheets.

We discuss below three additional items: drumlins, glacial lakes, and the events of the last continental glaciation, especially as it influenced North America. The drumlins seem to be more closely related to continental glaciation than to valley glaciers. Glacial lakes are not a peculiarity of ice sheets, and are also found in association with valley glaciers. They did reach immense size during the retreat of the recent continental glaciers, however, and their deposits are of very great importance in several parts of this country.

Unstratified Drift

Drumlins

The term "drumlin" is derived from a Gaelic word that describes a mound, or rounded hill. Drumlins are small, rounded to oval or elongate hills, composed of glacial deposits and having a characteristic "streamline" form. They vary in size from low gentle swells to hills about 45 to 60 metres (150 to 200 feet) high. Drumlins are much more symmetrical than most topographic forms, and a number of attempts have been made to describe them quantitatively. They can be described as ellipsoids; some, at least, approach closely to that form. They have also been compared to the so-called "streamline form" of aircraft wings, bullets, and other shapes that must move through a fluid without creating turbulence adjacent to the surface of the body - this, too, indicates the approximate shape of the drumlin. We may say that in shape it resembles a teardrop, that the blunt end points in the direction whence the glacier came, and that the drumlin mound tapers out into a rounded tail in the direction of ice movement. The length to width ratio for the drumlins varies from 2.5/1 up to about 4/1 - rather less variation than one might expect for a prominent topographic feature. Drumlins do occur in isolation, but are more commonly found in swarms over an area of a few hundred to a few thousand square kilometres. Within any single drumlin field, there may be some variation in height as well as in the ratio of length to width.

Drumlins are composed of a variety of materials. Some are composed of true boulder clay, i.e., boulders of all sizes in a clay matrix. Others contain mainly sandy or clayey till; some include stratified material, and some have a rock core. Kupsch[3] has described one from near Dollard, Saskatchewan, that has nearly all these things within it. Some English drumlins have a core of sand and gravel. It is evident that there is probably some variety in the conditions or methods of deposition.

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[3] Kupsch, W.O.: "Ice-thrust Ridges in Western Canada," Journal of Geology, vol. 70, 1962, pp. 582-94.

GLACIAL DEPOSITS

Deposits of Valley Glaciers

Deposits produced by glaciers and by the water derived from their melting have long been called collectively *glacial drift*. The drift consists of two main types: those parts deposited directly by the ice are devoid of any layering and are called *unstratified drift* or till; the parts laid down in water adjacent to the ice are layered, and so are called *stratified drift*. The till can be subdivided into a number of types based upon the conditions of deposition, but, for our present purposes, it is sufficient to consider only two: the deposits formed directly by the moving ice and those formed by ablation, or during the retreat of the ice front. The terminology for these has become mixed up with that for topographic features called *moraines*.

ERRATICS Distinct from the above glacial deposits are the *erratic boulders*. These boulders differ from the bedrock on which they lie, and they are obviously in no way related to it. Ordinarily, the boulders are about 1 to 3 meters (3 to 10 feet) in diameter, but boulders as big as a house are not uncommon and some of the large ones are truly enormous: Embleton and King[1] give the examples of one in Northumberland, England, that is 800 meters (2616 feet) long, and the largest of the "Schollen" of Germany, that is 4 km (2.4 miles) by 2 km (1.2 miles), by 120 m (390 feet) thick. The majority of erratic boulders were probably engulfed in the ice by being plucked from the rocks beneath the moving glacier, but they must have undergone considerable attrition during transport, because most of them are somewhat rounded. Some, no doubt, fell upon the glacier from the mountain sides above. How a block 4 km long got into the ice requires some other explanation! Apart from their illustration of the immense ability of ice to transport rocks, these erratic boulders also give much information about ice movement, because certain characteristics rocks can be recognized and their boulders traced. The prospector's technique of tracing "float" boulders is precisely the same thing, and follows the train of boulders moved by the ice.

In addition to showing the direction of ice motion, erratics have also demonstrated that the ice can move uphill. If the erratics are found at an elevation higher than the outcrop whence, they came, they must have been carried uphill by the ice. This probably indicates that the centre of accumulation from which the ice was spreading did not coincide with an earlier watershed; ice spreading outward from central Labrador and over-riding the hills of the Gaspe' peninsula would be an example of this.

Unstratified Drift

Moraines

The term moraine applies to a wide range of depositional features derived from the work of glaciers; they are composed of unstratified material that has been deposited directly by the ice.

Lateral Moraines Lateral moraines are formed at the side of a glacier by fragment that fall off the rock walls of the valley from above the ice. This material is carried along by the moving ice and, near the front of the glacier, where the ice is wasting away, builds up a steepsided ridge on the margins of the glacier. In this part, there may be a narrow valley between the moraine ridge and the main rock wall of the Valley.

Medial Moraine Medial moraines form where two glaciers merge. The marginal moraines on the adjacent sides of the two glaciers necessarily merge when the ice flows combine, and the combined marginal moraines then continue down the glacier, more or less in its middle. If the ice is subject to avalanches above the junction, or if the spur separating the two glaciers is above the firn line, there may be enough snow cover to hide the marginal moraines and the upper part of the medial moraine until the snow finally melts off as the glacier moves farther down the valley. The rock fragments of the medial moraine may extend deep into the ice of the combined glaciers, but do not always do so.

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[1] Embleton, C. and King, C.A.M.: *Glacial and Periglacial Geomorphology*, Edward Arnold, London, 1968, p. 304.

Ablation Moraine Ablation moraine is the accumulation of surface debris that forms on the wasting part of the glacier. The ice beneath this surface coating is normally very clean in appearance because, in fact, the proportion of rock in the ice is small. As the surface of the ice is lowered by ablation, the fragments that were in the ice have nowhere to go, and accumulate upon the surface as the ice that was surrounding them vanishes away. The layer of ablation moraine increases in thickness toward the snout of the glacier, unless there is heavy rainfall or abundant meltwater on the ice surface; in that case, much of the moraine may well be washed away by the run off.

Terminal Moraines Terminal moraines form at the front of the glacier, but the development of a large moraine requires that the ice front remain stationary for a considerable time. This requires, in turn, that there be a close balance between supply and wasting for the same length of time, so the front of the glacier is neither pushed down the valley over the moraine, nor melted back to some place above it. If the balance is so maintained, then all the rock debris within the ice, and the ablation moraine riding upon it, are dumped in a ridge at the front of the ice, where there is no longer any vehicle to transport it further - the glacier "conveyor belt" has reached the end of its run. If the glacier should later retreat rapidly, the mound of the terminal moraine may act as a dam to create a lake between the moraine and the ice. Such lakes are temporary affairs, because the meltwater over-flowing the moraine usually erodes a channel through it very quickly and so drains the lake. The same meltwater, of course, deposits *outwash* material in front of the moraine through which it has eroded.

Recessional Moraine Recessional moraines develop because a balance between ice supply and wastage is at most a temporary state. A glacier that is retreating because ablation exceeds the ice supply will leave behind it on the valley floor a blanket of ablation moraine as the glacier front recedes up the valley. Should wastage and ice supply again be in balance for some period, the ice front will again be stationary and a heap of till will accumulate to form a recessional moraine. It is obvious that the materials of a recessional moraine, and the characteristics of the deposits, are in no way different from those of a terminal moraine; the latter simply marks the front of maximum advance of the glacier down the valley. Recessional moraines, of course. can be formed only by a retreating glacier, and are generally destroyed if there is a subsequent re-advance of the glacier front.

Ground Moraine Ground moraine forms beneath the ice of the glacier and so is formed differently from the ablation moraine, which is simply lowered from the ice surface onto the ground as the ice melts away. The ground moraine can apparently develop in three ways. In the first, the burden of rock debris picked up by the ice of the bottom of the glacier becomes excessive. The ice then begins sliding over some of the material in its own bottom. Study of the resulting moraines indicated that there may be an accumulation of till thus built up by a "plastering-on" process. In the second, the glacier rides over moraine previously deposited, perhaps even during its own temporary recession. The till is then subjected to the weight of the overlying ice, in addition to the shear stresses caused by the ice movement. The till may be considerably deformed as a result. This commonly takes the form of a reworking and squeezing that produces systematic orientation of the boulders in the till as well as the development of shear surfaces and minor thrust movements within it. In the third process, the material at the bottom of a stagnant ice sheet is slowly accumulated as the ice melts. Obviously, it will be very difficult to distinguish, within the deposits, between ablation moraine and ground moraine deposited by this third method. The two other types of ground moraine can be recognized by the deformation within them.

Four *additional features of moraines* should be noted.

First, from he very circumstance of their formation, marginal moraines merge at their lower ends with the terminal and recessional moraines formed by the same glacier.

Second, the amount of rock material, in the marginal, medial, and terminal moraines and scattered through the mass of the ice as *englacial* debris, reflects the history of the glacier and the conditions along its valley. One side of the valley, for example, may be composed of rock that breaks easily under frost action and sheds abundant material into the ice, while the other wall may be massive and solid and productive of only very little debris. Variations in weather, during the time the ice is making the long journey down the valley, will also influence the rate at which weathering proceeds and rock fragments are added to particular parts of the glacier. There are a number of other factors that may operate as well, but the point of importance here is that the distribution of rock fragments in the ice is not uniform, because of the influence of these various conditions. By the time the ice arrives at the front of the glacier these irregularities of distribution appear across the front of the ice; in some places debris is scarce, in others, it is abundant. The terminal moraine that results is accordingly most irregular in height and width. The typical moraine surface is steep, and is, on both side toward the ice and the side away from it, roughly at the angle of repose for the moraine material. The top surface is typically very irregular and hummocky.

Third, the height of the moraine, of course, depends upon the supply of debris, rate of ice advance, and the time during which, the ice front was stationary. Ordinarily, moraines are not more than a hundred or so metres high and may be very much less, but the terminal moraine of the Franz Josef glacier in New Zealand is 430 metres (1400 feet) in height. Terminal moraines may also be partly, or in large measure. eroded away by melt water, or buried under outwash material, so they are not always large or conspicuous. Many moraines have a core of ice when they are first formed. This core may consist of large masses of ice that have been protected from melting by the coating of ablation moraine accumulated upon them, or it may be ice derived from snowbanks that were piled up in front of the glacier and buried under material that slumped down the front of the moraine. Although the melting rate of the ice of the core is much reduced by the layer of moraine over it, it does eventually melt, of course, and drains away. As it does so, the space formerly occupied by the ice is filled by collapse of the moraine, and a deep hollow (kettle-hole) appears on the surface. From the combined effects of kettles and the original irregularities, the surface of moraine (including ground moraine) may be very hummocky indeed.

Fourth, some moraines have been overridden by re-advance of the ice. The moraine may be deformed considerably and, if the moraine was thoroughly frozen, as by permafrost, one part may be pushed over another on a fault surface. In addition to these gently inclined thrust slices and faults, waves and folds also occur. Moraines that have been developed or modified by this bulldozing action of the ice have been called *push-moraines.*

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[2] Flint, R.F.: "Eskers and Crevasse Fillings," American Journal of Science, vol. 235, 1928, pp. 410-416

the same time, the material supplied to it is very poorly sorted, or not sorted at all. In consequence, there is a very rapid sorting of material by the stream and a very rapid deposition of all the "non-transportable" sizes immediately in front of the glacier. Much of this material may be incorporated into the frontal moraine, while the next finer size fraction is deposited immediately in front of that. Also because of the large load of sediment they carry, the meltwater streams aggrade their channels very rapidly and, as with other rapidly aggrading streams, they follow extremely braided courses, which change almost from minute to minute, upon the surface of their own deposits. Another characteristic of outwash streams is their variable flow. Close to the snout of the glacier, the volume of meltwater may have a diurnal variation in summer, but it is the annual variation that is probably the most important. The flow increases very markedly for a few months during the summer, and then dies off to very low values during the winter. Finally, the glacial stream carries in suspension large quantities of "rock flour," i.e., ground-up rock scraped from the valley floor by the glacier. This has a size range and character different from the clay minerals formed by normal chemical weathering. In suspension, it impacts a characteristic milky appearance to the melt water of a glacier and the finely-divided part may stay in suspension, even in quiet water, for a very long time.

The characteristic U-shape of a glaciated valley is accentuated by the valley train deposits. The deposits are spread out by the wide wanderings of the braided streams, and, as seen in a cross-section of the valley away from the immediate area of the moraines, the surface of the deposit tends to be rather flat. Furthermore, the deposits include everything carried away from the glacier, and may fill the valley bottom to a thickness of several hundred metres. This flat valley bottom may create a sharp break in slope against the valley wall at the margin of the valley train and thus further accentuate the normal U-shaped section of the valley.

Valley trains may later become dissected with the development of terraces. After the glacier disappears and vegetation establishes itself upon the hillsides, the surface is protected from erosion, and there is a reduction in the load of sediment carried by the stream. As a result, the stream begins to cut into its former deposits and leave terraces where the surface of the train once was.

OUTWASH PLAINS

Many of the features characteristic of valley trains are also to be expected in the outwash plains. The distribution by braided streams, for example, spreads the deposits far and wide in front of the glacier. In the same way. also, there is a gradual decrease in gradient of the stream with increasing distance from the ice, reflecting the early deposition of coarse material and the reduced gradient necessary to transport the lighter fractions in an aggrading stream.

The outwash plain may start directly in front of the ice, or it may begin with a moraine and a pro-glacial lake (i.e., a lake between the moraine and the front of the retreating ice). Some sedimentation will obviously occur in the lake, and the level of the sediments may build on its bottom till it is above the level of the bottom of the ice face, and so also above the level of the discharge of the sub-glacial streams. In front of the moraines, the sediments are graded according to size and distance from their source. Gravel and boulders are common near the source, but elsewhere sands are the most common sediment size, and towards the limit of the plain the material becomes much finer still

The outwash deposits are not much different in character from those produced by other streams. That is, they are very irregular in character both in the vertical and in the horizontal, with rapid variations in grain size and very lenticular and discontinuous layering. In effect, they resemble the deposits produced by braided streams anywhere, except that they may contain tills - which would not be possible in a non-glacial deposit. Except in special circumstances, the outwash deposits can not be expected to contain very fine sediments.

Deposits of Continental Glaciers

The deposits formed by continental glaciers can be anticipated, in large measure, from those produced by valley glaciers. We should expect, therefore, to find moraines, eskers, kames, outwash deposits and similar features. Generally speaking, the major differences between the deposits of valley glaciers and the corresponding features of continental ice sheets are related to the great areas covered by the latter. We find, as we would expect, that an ice sheet has a terminal moraine; instead of extending across a valley, however, it extends across half a continent. In the same way also, immensely long recessional moraines mark pauses in the retreat of the ice. The life of continental ice is a complicated affair, however, with a number of advances and retreats; sometimes a later advance went further than an earlier one, or in a different direction, and the terminal moraine of one stage may cross that of another. In the same way also, we find very extensive outwash deposits, not only beyond the terminal moraine but present also in the hundreds of kilometres across which the ice withdrew. Where the ice was stagnant in the later parts of its retreat, eskers and other characteristic features are abundant.

Some differences are to be expected, however. A great ice sheet generally covers everything, burying whole mountain ranges, as in Antarctica and probably also in Greenland. Once the ice has swept up all the pre-existing soils and old erosion products, the only source of additional material available to the glacier is the rock beneath it. Presumably, then, the supply depends upon the ability of the ice to pluck rock fragments loose, and their size depends upon the size of the chunks available. Collapse of large blocks off the rock wall of a valley and onto the ice is not possible.

All the features related to valley glaciers and discussed above are also found in the deposits of continental ice sheets.

We discuss below three additional items: drumlins, glacial lakes, and the events of the last continental glaciation, especially as it influenced North America. The drumlins seem to be more closely related to continental glaciation than to valley glaciers. Glacial lakes are not a peculiarity of ice sheets, and are also found in association with valley glaciers. They did reach immense size during the retreat of the recent continental glaciers, however, and their deposits are of very great importance in several parts of this country.

Unstratified Drift

Drumlins

The term "drumlin" is derived from a Gaelic word that describes a mound, or rounded hill. Drumlins are small, rounded to oval or elongate hills, composed of glacial deposits and having a characteristic "streamline" form. They vary in size from low gentle swells to hills about 45 to 60 metres (150 to 200 feet) high. Drumlins are much more symmetrical than most topographic forms, and a number of attempts have been made to describe them quantitatively. They can be described as ellipsoids; some, at least, approach closely to that form. They have also been compared to the so-called "streamline form" of aircraft wings, bullets, and other shapes that must move through a fluid without creating turbulence adjacent to the surface of the body - this, too, indicates the approximate shape of the drumlin. We may say that in shape it resembles a teardrop, that the blunt end points in the direction whence the glacier came, and that the drumlin mound tapers out into a rounded tail in the direction of ice movement. The length to width ratio for the drumlins varies from 2.5/1 up to about 4/1 - rather less variation than one might expect for a prominent topographic feature. Drumlins do occur in isolation, but are more commonly found in swarms over an area of a few hundred to a few thousand square kilometres. Within any single drumlin field, there may be some variation in height as well as in the ratio of length to width.

Drumlins are composed of a variety of materials. Some are composed of true boulder clay, i.e., boulders of all sizes in a clay matrix. Others contain mainly sandy or clayey till; some include stratified material, and some have a rock core. Kupsch[3] has described one from near Dollard, Saskatchewan, that has nearly all these things within it. Some English drumlins have a core of sand and gravel. It is evident that there is probably some variety in the conditions or methods of deposition.

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[3] Kupsch, W.O.: "Ice-thrust Ridges in Western Canada," Journal of Geology, vol. 70, 1962, pp. 582-94.

APPENDIX B

Petrographic Analyses

DUNN ASSOCIATES LABORATORY
Earth Materials Testing and Research
Div. of DUNN GEOSCIENCE CORPORATION
Box 158
Averill Park, New York 12018
Office (518) 674-3823
Lab (518) 674-5658

Lab Number 6836/1
Client Number DW-1-323
Date Received October 5, 1973
Date Reported October 31, 1973

PETROGRAPHIC ANALYSIS

Client: Potter-DeWitt Corp.
Victor Pit

Examined by: P.N. Agostino
Date Examined: October 28, 1973
Prewashed: Yes

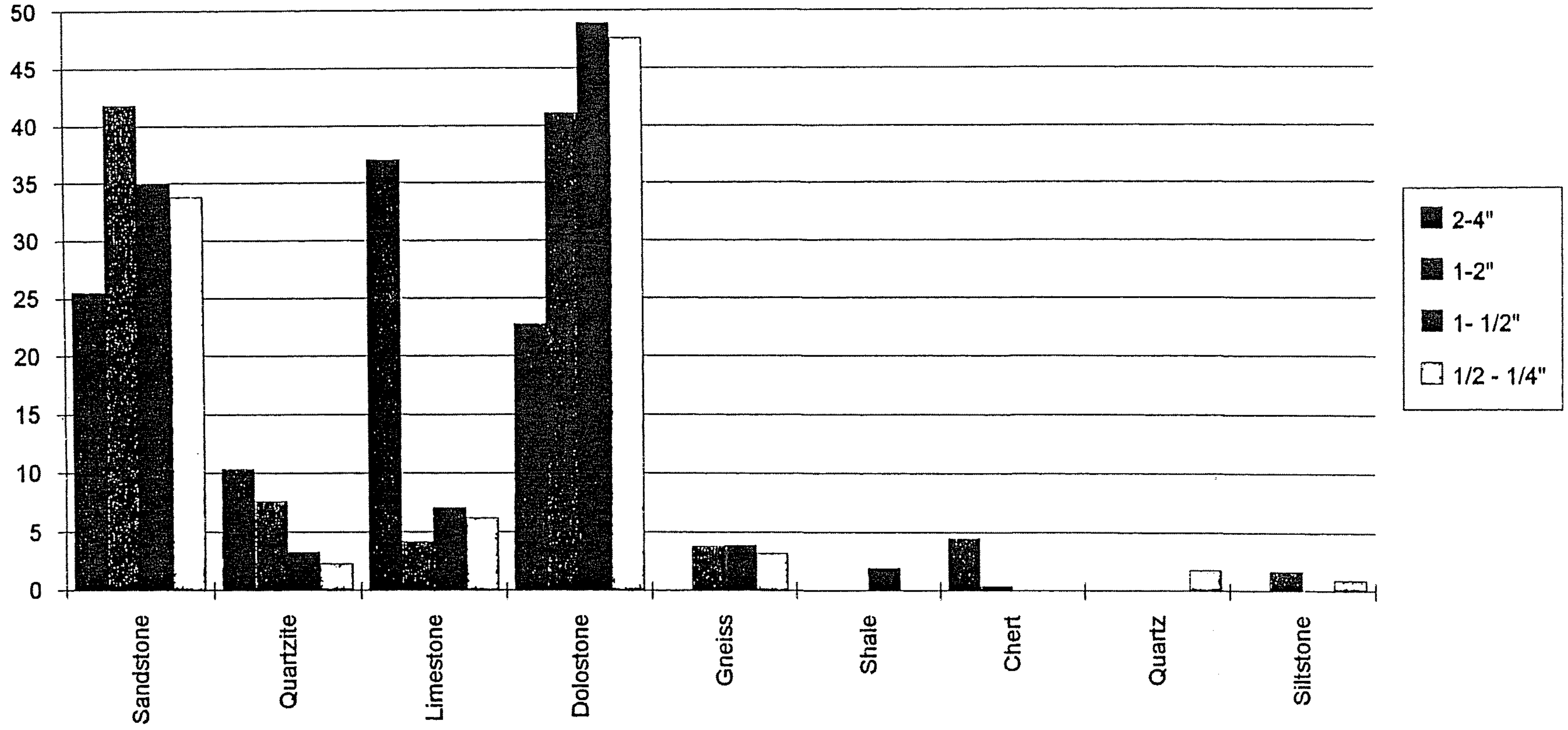
Description of Sample: Coarse Petrographic for NYSDOT Report

Constituents	Composition of Fraction Retained on Sieves %			
	4-2"	2-1"	1-½"	½-¼"
Red Sandstone-fine to med. grained, hard, $CaCO_3$ cement	17.6	19.4	22.0	21.2
Quartzite-gray, red, grn., fine to med. grained, hard	10.3	7.6	3.3	2.3
Sandstone-gray, brown, grn., hard, fine to med. gr.	7.9	22.4	12.9	12.6
Moderately Weathered	0.0	0.4	0.0	2.3
Limestone-gray-blk., fine to medium crystalline	37.0	3.4	5.2	6.2
Moderately Weathered	0.0	0.8	1.9	0.0
Dolostone-gray-grn., fine to coarse grained, siliceous	19.7	34.6	40.5	38.7
Dolostone-gray-grn., porous	3.0	5.5	8.4	9.9
Gneiss-banded	0.0	3.8	3.9	3.2
Shale - gray, fissile	0.0	0.0	1.9	0.0
Natural Conglomerate	0.0	0.0	0.0	0.9
Chert	4.5	0.4	0.0	0.0
Quartz	0.0	0.0	0.0	1.8
Siltstone-gray-green	0.0	1.7	0.0	0.9
Total	100.0	100.0	100.0	100.0

Remarks:

Edward A. McGrady
Dunn Associates Lab /

Coarse Petrographic Analysis - 10/28/1973



CONTINENTAL PLACER INC.
3 WEST CREST DRIVE
CLIFTON PARK, NEW YORK 12065
518-371-0848

FINE PETROGRAPHIC ANALYSIS

CLIENT: B.R. DeWitt, Inc.
Victor Pit 4-10FG

SAMPLE: Bank-Run, Above Water Table
Fine Petrographic

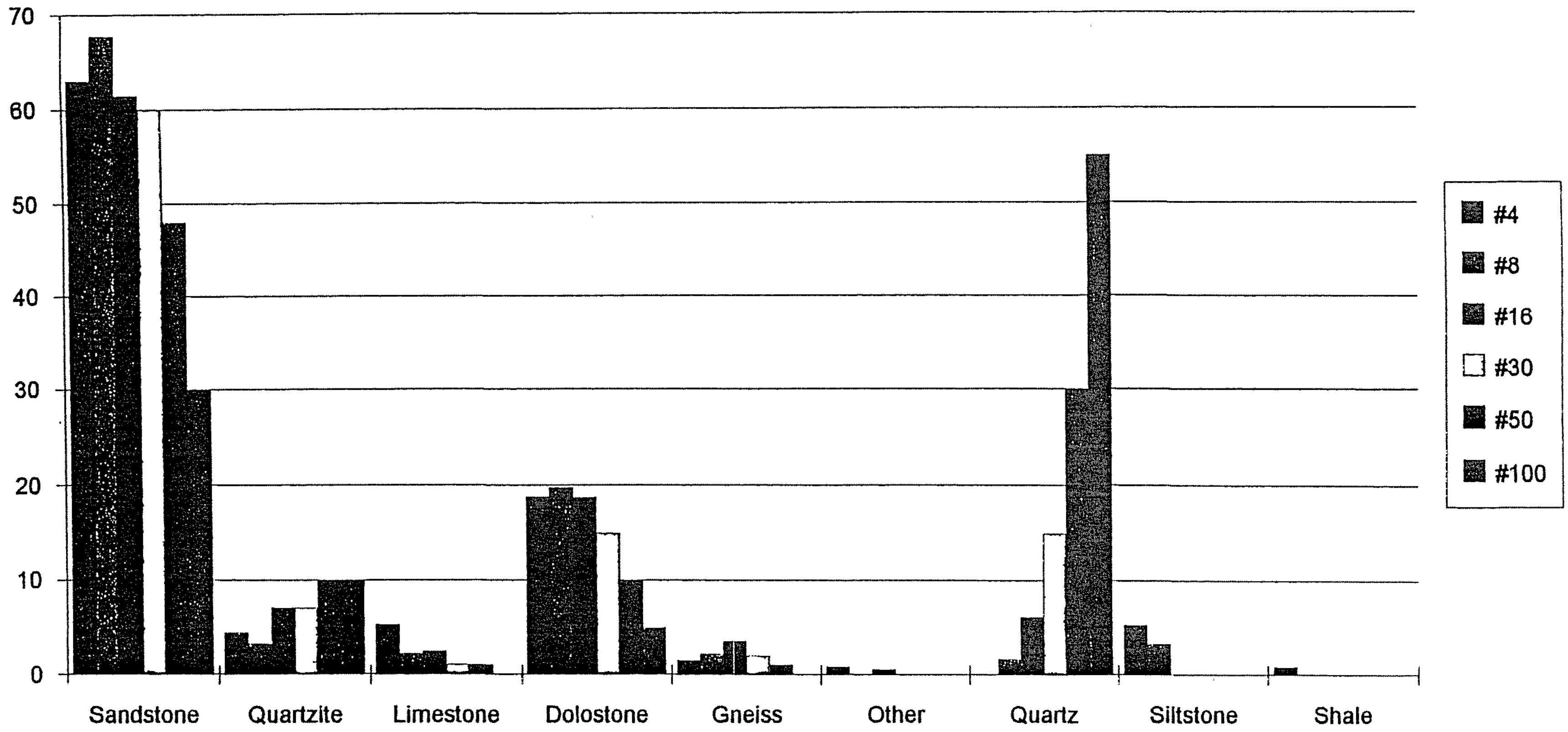
ANALYSIS BY: PHG

DATE: May 1988

	% Retained On Sieve Fraction					
Lithologies	4	8	16	30*	50*	100*
Sandstone (red medina)	22.5	18.2	15.7	10	8	5
Sandstone (gray-brown, fine to medium grain)	40.5	49.5	45.8	50	40	25
Quartzite (gray to brown, hard, dense)	4.5	3.3	7.1	7	10	10
Limestone (micritic, dark gray)	5.3	2.2	2.5	1	1	Trace
Dolomite (gray-brown, fine to coarse xln, siliceous)	18.8	19.7	18.7	15	10	5
Gneiss/Granite	1.5	2.2	3.6	2	1	Trace
Siltstone	5.3	3.3	Trace	--	--	--
Shale	.8	--	--	--	--	--
Natural Conglomerate	.8	Trace	.5	--	--	--
Chert	Trace	Trace	Trace	--	--	--
Quartz	--	1.6	6.1	15	30	55
TOTAL	100%	100%	100%	100%	100%	100%

*Visual Only
Trace: <.3%

Fine Petrographic Analysis - 5/1988



DUNN ASSOCIATES LABORATORY
Earth Materials Testing and Research
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Office (518) 674-3823
Lab (518) 674-5658

Lab Number 6683/1

Client Number DW-1-323

Date Received May 18, 1973

Date Reported June 20, 1973

PETROGRAPHIC ANALYSIS

Client: Potter-DeWitt Corp.

Pit #1 - Victor

Examined by: P. N. Agostino

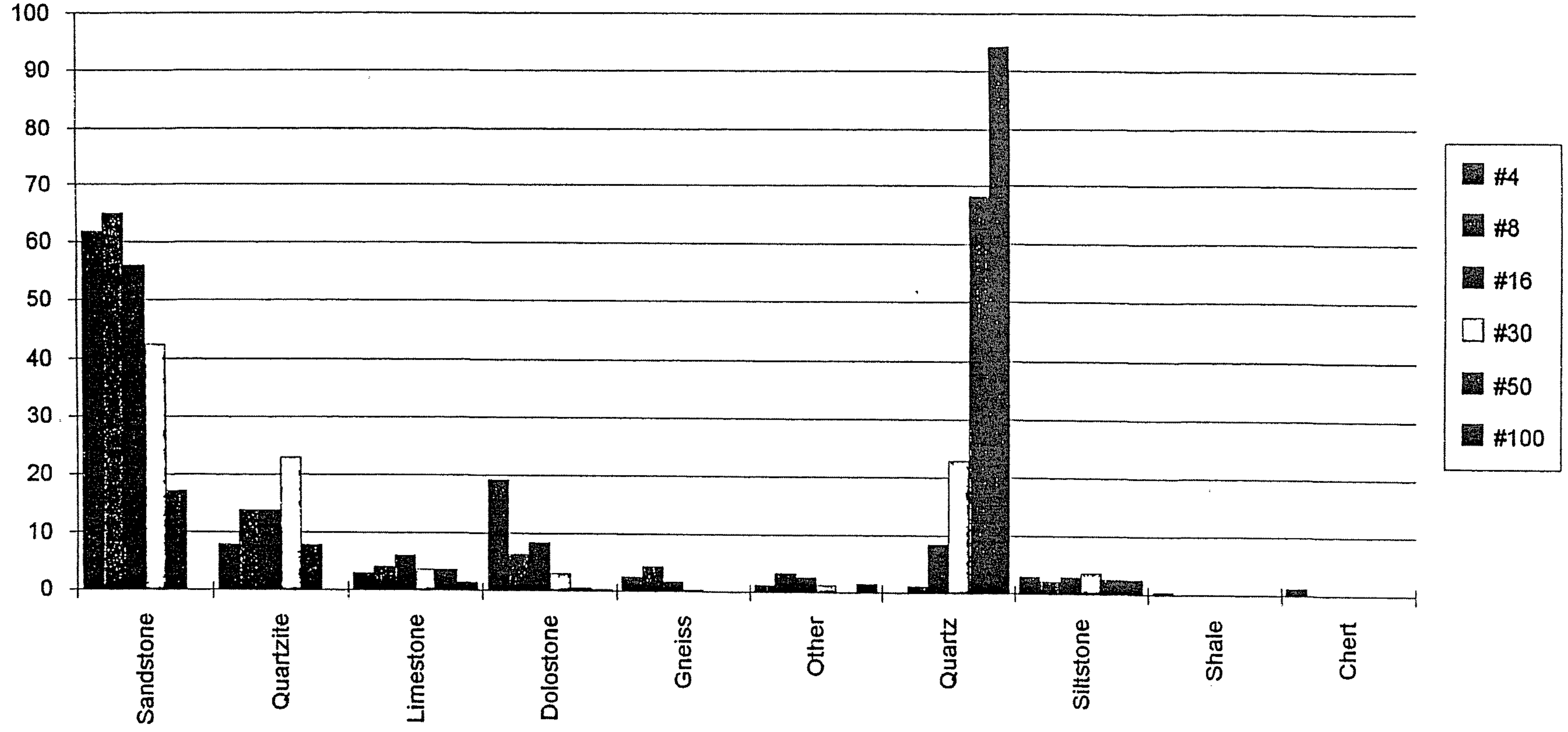
Date Examined: 6/18-20/73

Prewashed: Yes

Description of Sample: Fine Petrographic for NYSDOT Report

Constituents	Composition of Fraction Retained on Sieves %					
	#4	#8	#16	#30	#50	#100
Red Sandstone - fine-med. grained, hard, $CaCO_3$ cement	17.6	21.7	14.2	13.6	8.9	0.0
ranite & Gneiss-massive (contains quartz, tourmaline, amphibole, garnet, feldspar, agnetite) some banding	5.1	.2.5	0.9	1.0	0.3	0.0
imestone-drk.gray to blk., fine-med. crystalline, sub-rounded to rounded	8.3	6.5	9.5	8.0	4.7	2.3
olostone-gray-grn.to blk., ine to coarse crystalline, siliceous, sub-angular to sub-rounded	7.9	7.8	7.6	1.3	1.6	0.6
olostone-gray-grn.-porous, silty-sub-angular to angular	8.3	3.1	4.1	0.7	0.3	0.0
uartzite-gray, red, grn., etc., ine to med. grained, hard, sub-angular	4.6	8.4	12.6	18.9	7.0	0.0
andstone-gray, brn., grn., etc ard, fine-med. gr., angular o sub-angular	42.1	37.0	33.8	31.2	17.2	0.0
Weathered	5.2	6.2	0.9	0.7	0.0	0.0
Natural Conglomerate $CaCO_3$ cement)	0.9	2.8	2.8	2.7	0.6	0.0
hyllite - chlorite rich	0.0	0.0	0.0	0.0	0.3	0.0
Siltstone - green, sub-ounded to rounded	0.0	0.0	3.2	2.0	2.5	1.1
Quartz, white, clear, pink, etc., angular to sub-angular	0.0	4.0	10.4	19.9	56.6	94.3
Hematite - Oolitic	0.0	0.0	0.0	0.0	0.0	1.4
ourmaline	0.0	0.0	0.0	0.0	0.0	0.3
Total Percent	100.0	100.0	100.0	100.0	100.0	100.0

Fine Petrographic Analysis - 6/20/1973



DUNN ASSOCIATES LABORATORY
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Lab Number 6683/2
Client Number DW-1-323
Date Received May 18, 1973
Date Reported June 20, 1973

PETROGRAPHIC ANALYSIS

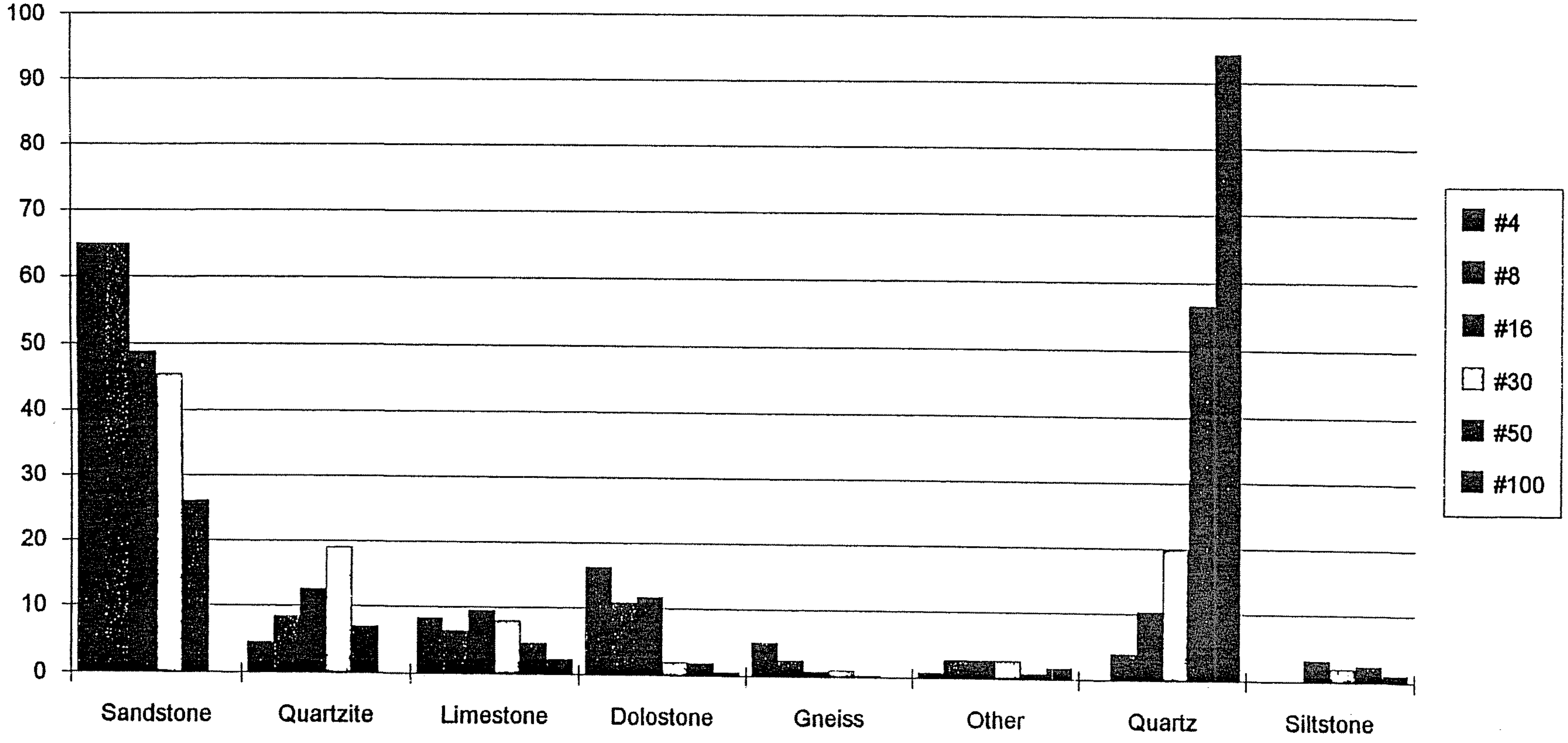
Client: Potter-DeWitt Corp.
Pit #2 - O'Neil

Examined by: P. N. Agostino
Date Examined: June 18-20, 1973
Prewashed: Yes

Description of Sample: Fine Petrographic for NYSDOT Report

Constituents	Composition of Fraction Retained on Sieves %					
	#4	#8	#16	#30	#50	#100
ed Sandstone-fine-med. grained, hard, $CaCO_3$ cement	14.2	20.1	15.0	10.3	4.9	0.0
ranite & Gneiss-massive quartz,tourmaline,amphibole, garnet,feldspar,magnetite) some banding	2.5	4.3	1.7	0.3	0.0	0.0
imestone-drk. gray-blk., fine o med. crystalline, sub-rounded-rounded	2.9	4.0	6.1	3.6	3.6	1.4
olostone-gray-grn. to blk., ine-coarse crystalline, iliceous, sub-angular-sub-rounded	14.1	3.6	6.1	2.7	0.6	0.3
olostone-gray grn.-buff, orous, silty-sub-angular to angular	5.0	2.8	2.3	0.3	0.0	0.0
Quartzite-gray, brn., grn., tc., fine-med. gr., hard, ub-angular-angular	7.9	13.9	13.9	22.9	7.8	0.0
Sandstone-gray, brn., grn., hard, fine-med. gr., angular o sub-angular	42.9	43.3	41.0	31.8	12.3	0.0
eathered	4.6	1.4	0.0	0.3	0.0	0.0
Siltstone-green, sub-rounded to rounded	2.9	2.1	2.9	3.6	2.6	2.5
lack Shale	0.4	0.0	0.0	0.0	0.0	0.0
Natural Conglomerate ($CaCO_3$ cement)	1.3	3.3	2.6	1.3	0.0	0.0
Quartz-white, clear, rose, etc., angular to sub-angular	0.0	1.2	8.4	22.9	68.2	94.3
ematite - Oolite	0.0	0.0	0.0	0.0	0.0	0.6
Garnet - Angular	0.0	0.0	0.0	0.0	0.0	0.3
hert - gray	1.3	0.0	0.0	0.0	0.0	0.0
Magnetite	0.0	0.0	0.0	0.0	0.0	0.6
Total Percent	100.0	100.0	100.0	100.0	100.0	100.0

Fine Petrographic Analysis - 6/18/1973



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Lab (518) 674-5658

Lab Number 6836/2
Client Number DW-1-323
Date Received October 5, 1973
Date Reported October 31, 1973

PETROGRAPHIC ANALYSIS

Client: Potter-Dewitt Corp.
O'Neil Pit

Examined by: P. N. Agostino
Date Examined: October 29, 1973
Prewashed: Yes

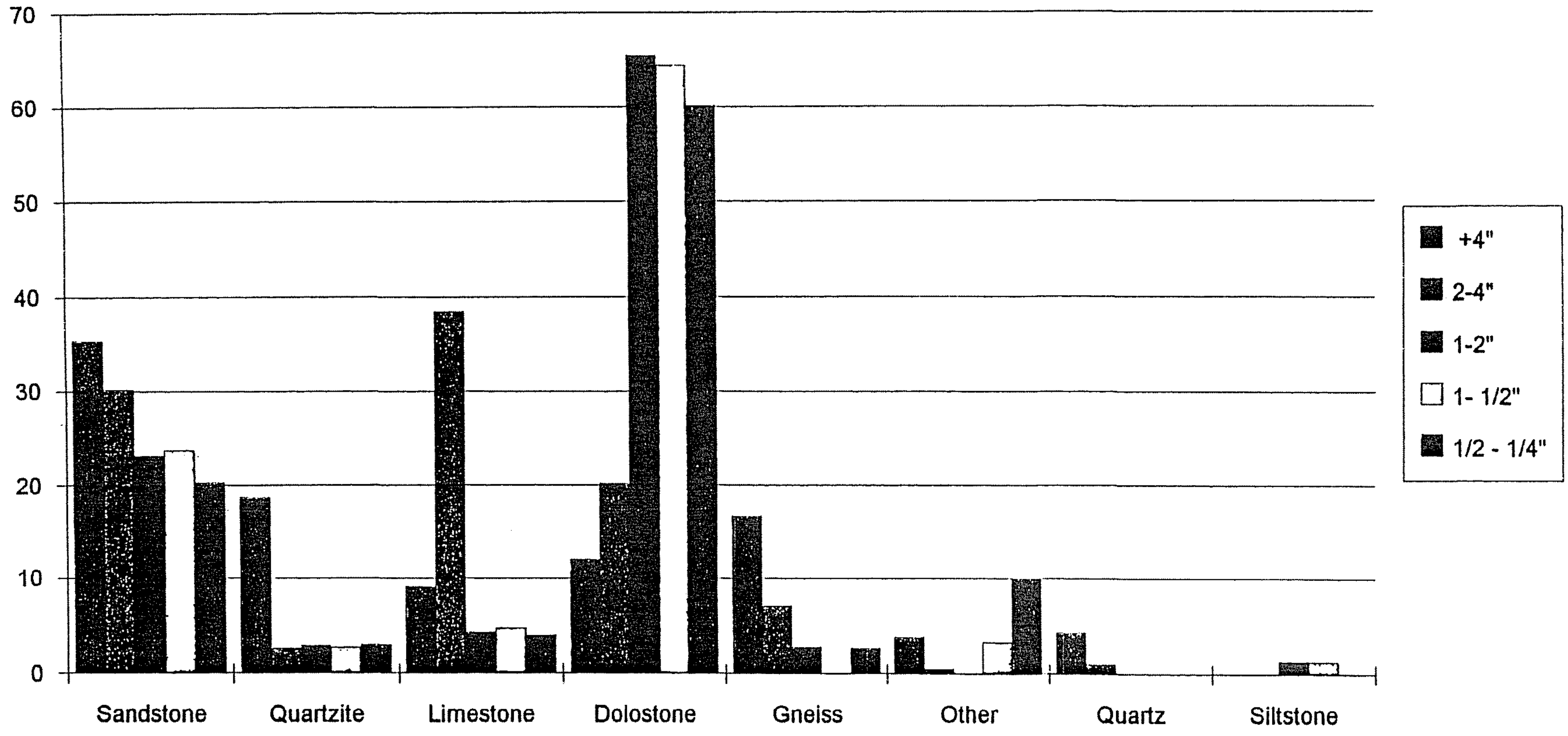
Description of Sample: Coarse Petrographic for NYSDOT Report

Constituents	Composition of Fraction Retained on Sieves					
	+4"	4"-2"	2"-1"	1"-½"	½"-½"	
Red Sandstone-fine to med. grained, dense, $CaCO_3$ cement	24.9	17.0	12.3	15.8	13.3	
Quartzite-gray, red, green, fine to med. grained, dense	18.7	2.6	2.9	2.7	3.0	
Sandstone, gray, brown, green, fine to med. grained	10.5	13.2	10.9	7.9	7.0	
Limestone - gray black, fine to med. crystalline	9.1	38.4	4.3	4.7	4.0	
Dolostone-gray-green, siliceous	12.0	19.4	56.6	55.4	51.8	
Dolostone-gray-green, porous	0.0	0.8	8.8	8.9	8.3	
Gneiss-banded	16.7	7.1	2.8	0.0	2.7	
Shale-gray, fissile	2.9	0.5	0.0	3.3	9.9	
Natural Conglomerate	0.9	0.0	0.0	0.0	0.0	
Quartz-clear to milky	4.3	1.0	0.0	0.0	0.0	
Chert-dense, black	0.0	0.0	0.0	0.0	0.0	
Siltstone-gray to green	0.0	0.0	1.4	1.3	0.0	
Total	100.0	100.0	100.0	100.0	100.0	

Remarks:

Edward A. McGrady
Dunn Associates Lab

Coarse Petrographic Analysis - 10/29/1973



CONTINENTAL PLACER INC.
3 WEST CREST DRIVE
CLIFTON PARK, NEW YORK 12065
518-371-0848

COARSE PETROGRAPHIC ANALYSIS

CLIENT: B.R. DeWitt, Inc.
Victor Pit 4-10FG

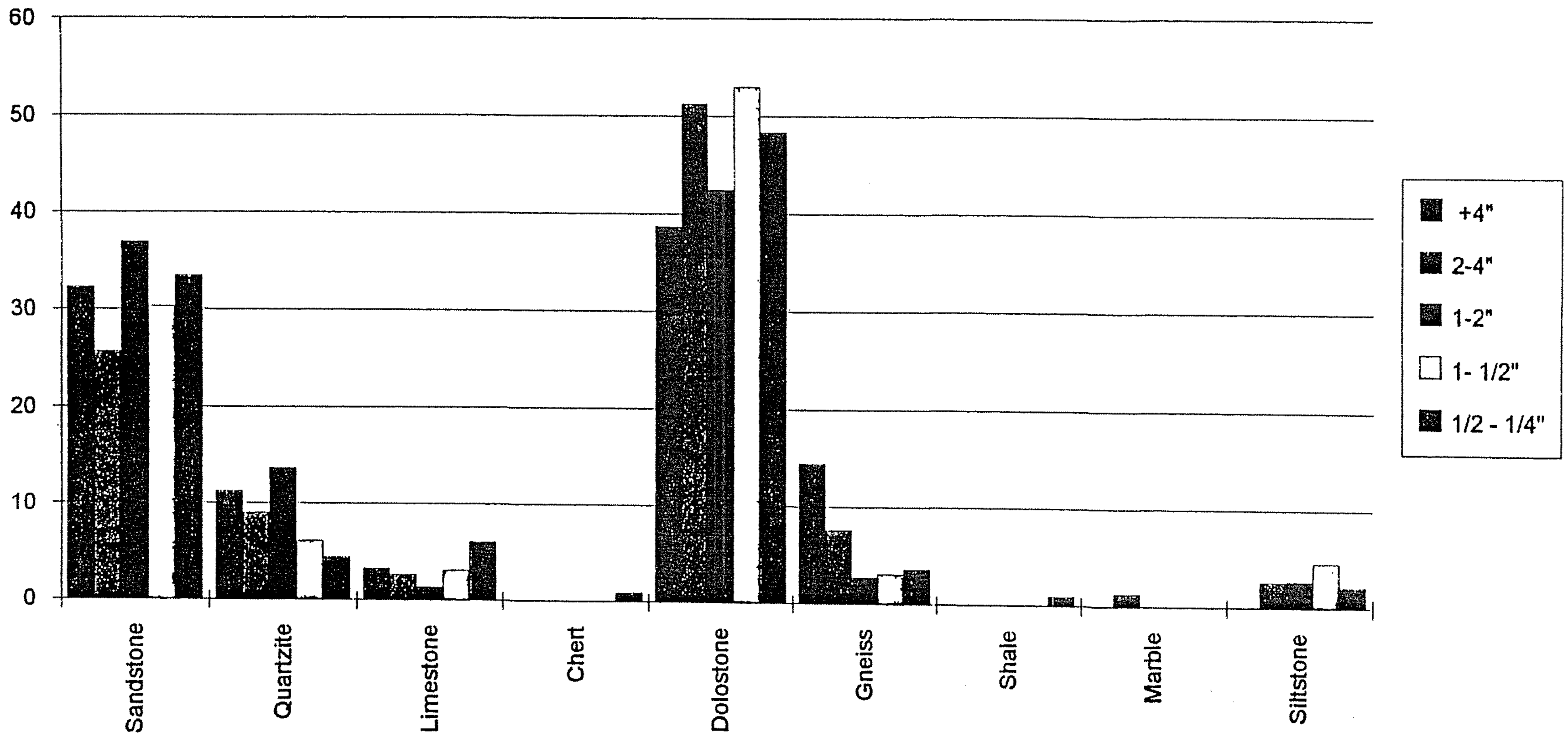
SAMPLE: Bank-Run, Above Water Table
Coarse Petrographic

ANALYSIS BY: JRH

DATE: May 1988

	% Retained On Fraction				
Lithologies	+4"	2"-4"	1"-2"	1/2"-1"	1/4"-1/2"
Sandstone (red medina)	21	16.7	11	21.2	12.2
Sandstone (green, gray, brown dense)	11.3	9.0	26	9.1	21.3
Quartzite (gray-red)	11.3	9.0	13.7	6.1	4.4
Limestone (micritic, gray)	3.2	2.6	1.4	3.0	6.1
Chert	--	--	--	--	.9
Dolomite (gray, brown-gray, siliceous, porous) Lockport Fm	38.7	51.3	42.5	53.0	48.4
Gneiss/Granite	14.5	7.7	2.7	3.0	3.5
Siltstone	--	2.6	2.7	4.5	2.2
Shale	--	--	--	--	.9
Marble	--	1.3	--	--	--
TOTAL	100%	100.2%	100%	99.9%	99.9%

Coarse Petrographic Analysis - 5/1988



APPENDIX C

Source Engineering Data

SOURCE NUMBER	COMPANY NAME SOURCE LOCATION	COUNTY	TEST NUMBER	SPECIFIC GRAVITIES			ABS	REQ'S LOW ALK. CEM	%NC
				BULK (SSD)	BULK	APPARENT			
4- 10G	B R DEWITT INC VICTOR,NY	ONTARIO	98AG 36C	2.68	2.637	2.737	1.4		40
4- 10F	B R DEWITT INC VICTOR,NY	ONTARIO	98AF 89	2.66	2.615	2.730	1.6		

ORIGIN OF SEDIMENTARY ROCKS

BLATT / MIDDLETON / MURRAY

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

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Public Health Statement

Toxicological Profile

Minimal Risk Levels

Division of Toxicology

CONTENTS

Summary

What is it?

What happens to it in the environment?

How might I be exposed to it?

How can it affect my health?

How likely is it to cause cancer?

Is there a medical test for exposure?

Are there federal recommendations?

Glossary

Contact for more information

More external safety and chemistry information

ToxFAQs™ for

1,1-Dichloroethene

CAS# 75-35-4

September 1995

This fact sheet answers the most frequently asked health questions about 1,1-dichloroethene. For more information, you may call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

SUMMARY: Exposure to 1,1-dichloroethene occurs mainly in the workplace. Breathing high levels of 1,1-dichloroethene can affect the liver, kidney, and central nervous system. This chemical has been found in at least 515 of 1,416 National Priorities List sites identified by the Environmental Protection Agency.

What is 1,1-dichloroethene? (Pronounced 1,1-di'klor'o eth'-een)

1,1-Dichloroethene is an industrial chemical that is not found naturally in the environment. It is a colorless liquid with a mild, sweet smell. It is also called vinylidene chloride.

1,1-Dichloroethene is used to make certain plastics, such as flexible films like food wrap, and in packaging materials. It is also used to make flame retardant coatings for fiber and carpet backings, and in piping, coating for steel pipes, and in adhesive applications.

What happens to 1,1-dichloroethene when it enters the environment?

- 1,1-Dichloroethene enters the environment from industries that make or use it.
- 1,1-Dichloroethene evaporates very quickly from water and soil to the air.
- In the air, it takes about 4 days for it to break down.
- 1,1-Dichloroethene breaks down very slowly in water.
- It does not accumulate very much in fish or birds.
- In soil, 1,1-dichloroethene is slowly transformed to other less harmful chemicals.

How might I be exposed to 1,1-dichloroethene?

- Workers may be exposed in industries that make or use 1,1-dichloroethene (these industries are mainly in Texas and Louisiana).
- Food that is wrapped in plastic wrap may contain very low levels of 1,1-dichloroethene. The government controls these levels to prevent harm to your health.
- A small percentage (3%) of the drinking water supplies may contain very low levels of 1,1-dichloroethene.
- Air near factories that make or use 1,1-dichloroethene and air near hazardous waste sites may contain low levels of it.

How can 1,1-dichloroethene affect my health?

The main effect from breathing high levels of 1,1-dichloroethene is on the central nervous system. Some people lost their breath and fainted after breathing high levels of the chemical.

Breathing lower levels of 1,1-dichloroethene in air for a long time may damage your nervous system, liver, and lungs. Workers exposed to 1,1-dichloroethene have reported a loss in liver function, but other chemicals were present.

Animals that breathed high levels of 1,1-dichloroethene had damaged livers, kidneys, and lungs. The offspring of some of the animals had a higher number of birth defects. We do not know if birth defects occur when people are exposed to 1,1-dichloroethene.

Animals that ingested high levels of 1,1-dichloroethene had damaged livers, kidneys, and lungs. There were no birth defects in animals that ingested the chemical.

Spilling 1,1-dichloroethene on your skin or in your eyes can cause irritation.

How likely is 1,1-dichloroethene to cause cancer?

The Environmental Protection Agency (EPA) has determined that 1,1-dichloroethene is a possible human carcinogen.

Studies on workers who breathed 1,1-dichloroethene have not shown an increase in cancer. These studies, however, are not conclusive because of the small numbers of workers and the short time studied.

Animal studies have shown mixed results. Several studies reported an increase in tumors in rats and mice, and other studies reported no such effects.

Is there a medical test to show whether I've been exposed to 1,1-dichloroethene?

Tests are available to measure levels of 1,1-dichloroethene in breath, urine, and body tissues. These tests are not usually available in your doctor's office. However, a sample taken in your doctor's office can be sent to a special laboratory if necessary.

Because 1,1-dichloroethene leaves the body fairly quickly, these methods are useful only for finding exposures that have occurred within the last few days. These tests can't tell you if adverse health effects will occur from exposure to 1,1-dichloroethene.

Has the federal government made recommendations to protect human health?

The EPA has set a limit in drinking water of 0.007 parts of 1,1-dichloroethene per million parts of drinking water (0.007 ppm). EPA requires that discharges or spills into the environment of 5,000 pounds or more of 1,1-dichloroethene be reported.

The Occupational Safety and Health Administration (OSHA) has set an occupational exposure limit of 1 ppm of 1,1-dichloroethene in workplace air for an 8-hour workday, 40-hour workweek.

The National Institute for Occupational Safety and Health (NIOSH) currently recommends that workers breathe as little 1,1-dichloroethene as possible.

Glossary

Carcinogen: A substance that can cause cancer.

CAS: Chemical Abstracts Service.

Ingesting: Taking food or drink into your body.

ppm: Parts per million.

Tumor: An abnormal mass of tissue.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1994. Toxicological profile for 1,1-dichloroethene. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information?

ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

For more information, contact:

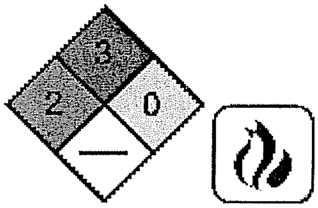
Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop E-29
Atlanta, GA 30333
Phone: 1-888-422-8737
FAX: (404)498-0057

External safety and chemistry information (please see our disclaimer):

1,1-Dichloroethene
$C_2H_2Cl_2$

Stereo Image
MDL Molfile

Search ChemFinder



NFPA Label Key

Vermont SIRI MSDS Archive

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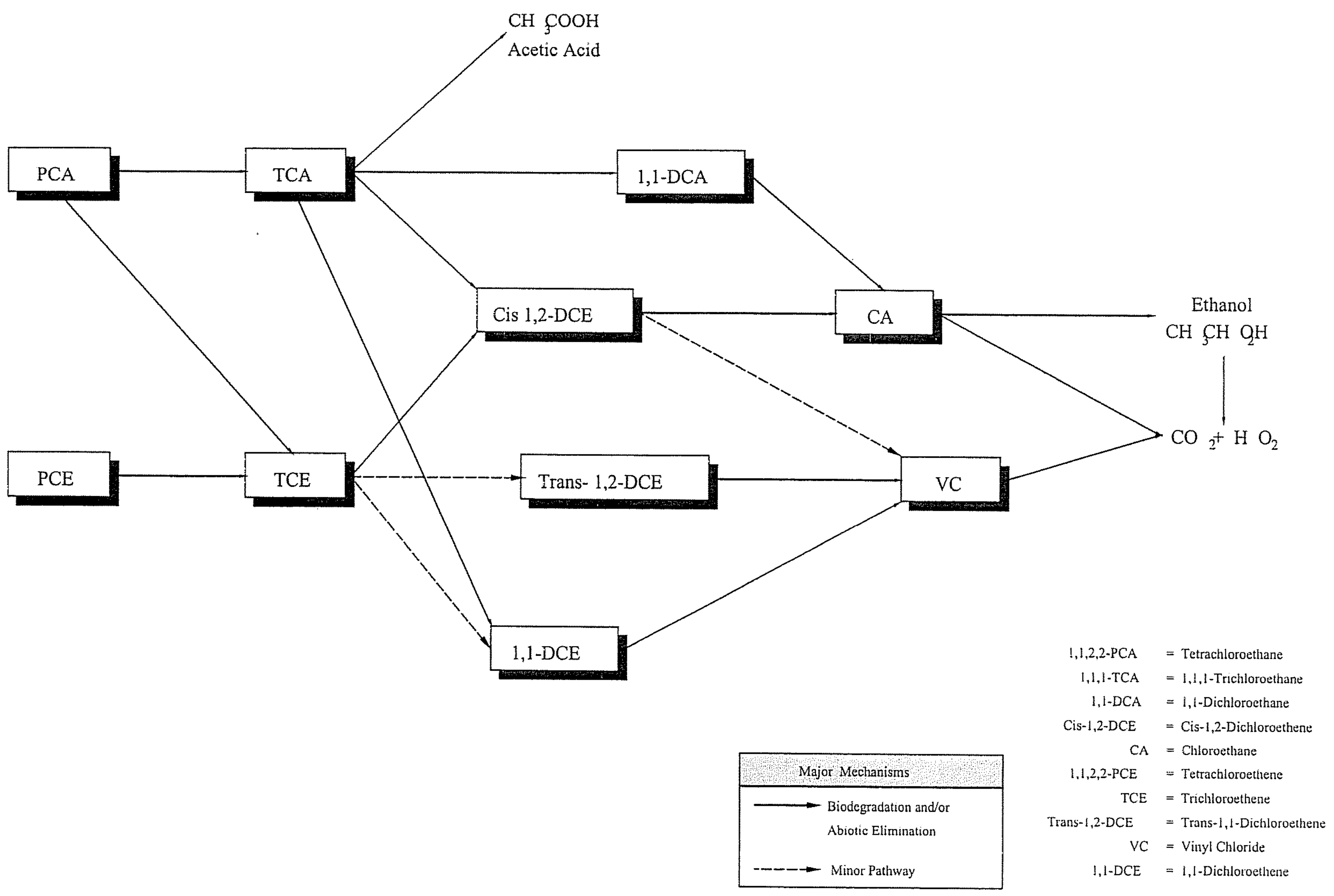


1,1,2,2-PCA = Tetrachloroethane
1,1,1-TCA = 1,1,1-Trichloroethane
1,1-DCA = 1,1-Dichloroethane
Cis-1,2-DCE = Cis-1,2-Dichloroethene
CA = Chloroethane
1,1,2,2-PCE = Tetrachloroethene
TCE = Trichloroethene
Trans-1,2-DCE = Trans-1,1-Dichloroethene
VC = Vinyl Chloride
1,1-DCE = 1,1-Dichloroethene

ecology and environment, inc.

Source: Davis and Olsen, 1990, Predicting the Fate of Organic Compounds, Part 2, Hazardous Materials Control, July/August 1990

2 3

Drawn By:	Date	TDD/Job No.	Dwg. No.
MRE	8-11-98	CB0901SIT0	CB0901F5

Table 5-1. Physical Properties of Organic Contaminants at the North Belmont PCE Site

Chemical	Specific Gravity (g/cc)	Aqueous Solubility (mg/L)	Vapor Pressure (mm Hg)	Henry's Law (atm-m^3 mol)	Log K_{oc} (mL/g)	Log K_{ow}	Vapor Density (g/L)	Water Diffusion Coefficient (sq.cm/sec)	Est. Half-Life (days)	
									Soil	GW
Acetone	[a] 0.79	—	[a] 266	[a] 3.9E-05	[a] 0.43	[a] 0.24	[a] 2.37	—	[b] 1-7	[b] 2-14
Chloroform	[a] 1.48	[a] 8200	[a] 160	[a] 3.2E-03	[a] 1.64	[a] 1.95	[a] 4.88	[a] 9.1E-06	[b] 28-180	[b] 56-1800
1,1-DCA	[a] 1.18	[a] 5060	[a] 182.1	[a] 4.3E-03	[a] 1.48	[a] 1.78	[a] 4.04	—	[b] 32-154	[b] 64-154
1,1-DCE	[a] 1.22	[a] 400	[a] 495	[a] 2.1E-02	[a] 1.81	[a] 2.13	[a] 3.96	[h] 9.5E-06	28-180	56-132
cis-1,2-DCE	[a] 1.28	[a] 3500	[oc] 200@25°C	—	—	—	[oc] 3.34	—	—	—
trans-1,2-DCE	[a] 1.21	[a] 6300	[a] 265	0.384	[a] 1.77	[a] 2.09	[a] 3.96	[c] 9.5E-06	—	—
Methylene chloride	[a] 1.33	[a] 2000	[a] 349	[a] 2.0E-03	[a] 0.94	[a] 1.30	1.89	[c] 1.1E-06	[b] 7-28	[b] 14-56
PCE	[a] 1.62	[a] 150	[a] 14	121	[a] 2.42	[a] 2.60	[a] 6.78	[c] 7.5E-06	180-360	360-720
Toluene	[a] 0.87	[a] 490	[a] 22	[a] 6.7E-03	[a] 2.06	[a] 2.65	[a] 3.77	—	[b] 4-22	[b] 7-28
1,1,1-TCA	[a] 1.34	[a] 300	[a] 100	[a] 1.8E-02	[a] 2.18	[a] 2.48	[a] 5.45	[i] 8E-06	[h] 140-273	[h] 140-546
1,1,2-TCA	[a] 1.44	[a] 4500	[a] 19	[a] 9.9E-04	[a] 1.75	[a] 2.18	[a] 5.45	[h] 8E-06	[h] 136-360	[h] 136-720
TCE	[a] 1.46	[a] 1100	[a] 57.8	87	[a] 2.10	[a] 2.53	[a] 5.37	[c] 8.3E-06	[c] 180-360	[c] 321-1653
TCFM	[a] 1.49	[a] 110	[a] 687	[a] 0.11	[a] 2.20	[a] 2.53	[a] 5.85	4.415	180-360	360-720

Notes: — = Value not provided

a = Montgomery, J.H., and Welkom, L.M., 1990, Groundwater Chemicals Desk Reference, Lewis Publ., Chelsea, MI, 650p.

b = Howard, P.H., et. al., 1991, Handbook of Environmental Degradation Rates, Lewis Publ., Chelsea, MI, 725p.

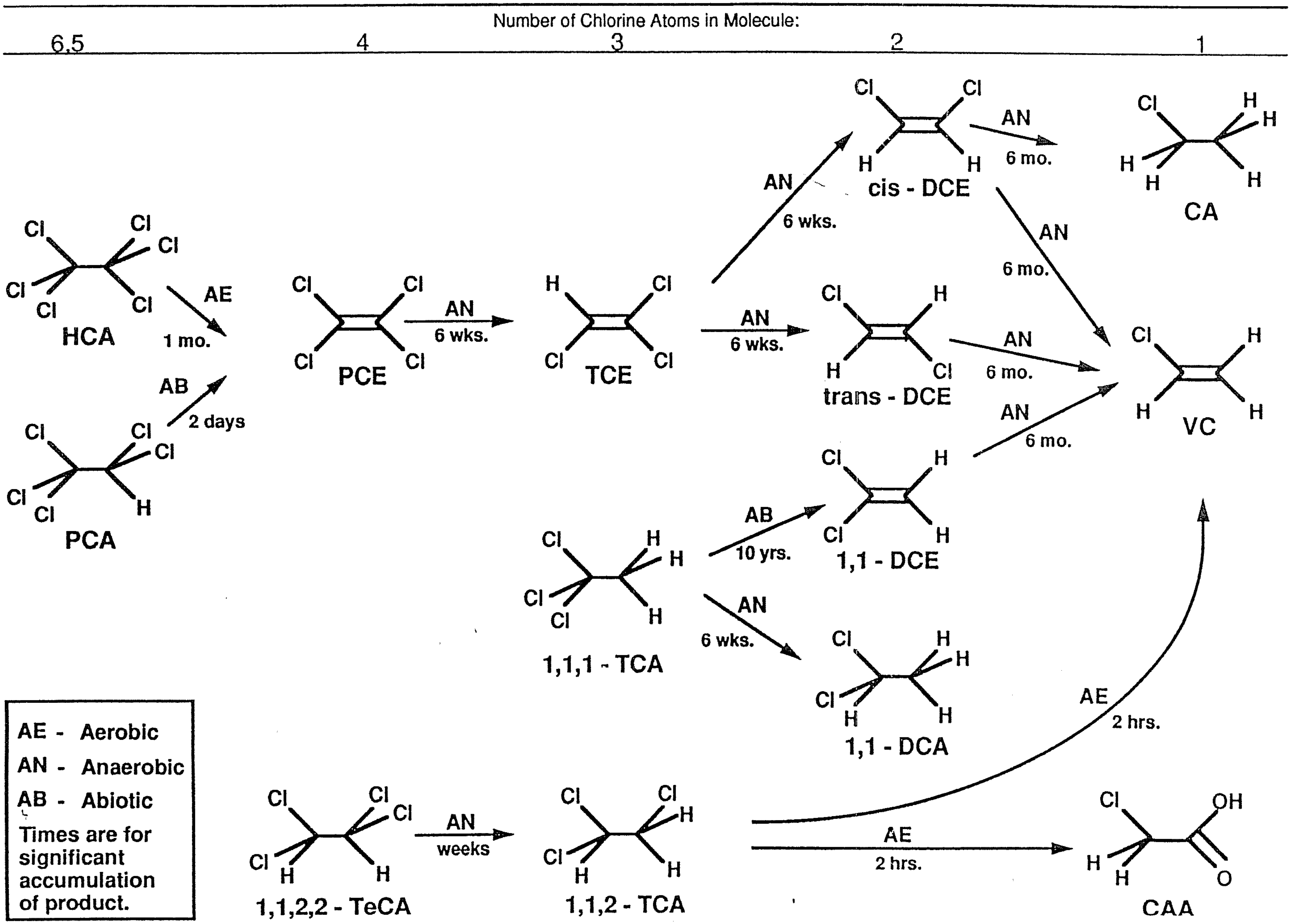
c = Lucius, J.E., et. al., 1990, Properties and Hazards of 108 Selected Substances, USGS Open File Report, 90-408, 559p.

h = Tetra Tech, Inc., 1988, Chemical Data for Predicting the Fate of Organic Chemicals in Water, Vol.2, Database EPRI EA-5818, Vol.2, Elec. Power Res. Inst., Palo Alto, CA, 411p.

i = Mendoza, C.A., and Frind, E.O., 1990b, Advective-Dispersive Transport of Dense Organic Vapors in the Unsaturated Zone, 2. Sensitivity Analysis, Water Res., Vol.26, p.388-398.

oc = Verschuren, K., 1983, Handbook of Environmental Data on Organic Chemicals, 2nd Ed., Var Nastrand, Reihold, NY, 131p.

DEGRADATION PATHWAYS OF CHLORINATED C_2 HYDROCARBONS



AE - Aerobic
AN - Anaerobic
AB - Abiotic
Times are for significant accumulation of product.