21. REPORTING ANALYTICAL RESULTS

The results of each test carried out by the laboratory are reported accurately, clearly, unambiguously, and objectively. Final reports to clients will have each page numbered sequentially indicating total number of pages in report on each page. Client will always be notified in writing, in advance of any lab work subcontracted. Subcontractors will be NY State ELAP approved if analytes are subject to approval. As a minimum, the NYS ELAP ID number of the subcontractor will be listed on the report.

The following information will be included on all reports:

1.) Title – "Analytical Parameters".
2.) Name and address of laboratory, and location where the test was carried out if different from the address of the laboratory and phone number with name of contact person for questions.
3.) Unique identification of report and each page, including the total number of pages.
4.) Name and address of client, where appropriate and project name, if applicable.
5.) Description and unambiguous identification of the tested sample including the client identification code.
6.) Identification of results derived from any sample that did not meet sample acceptance requirements, such as, improper container, holding time, or temperature.
7.) Date of receipt of sample, date and time of sample collection, date(s) of performance test, and time of sample preparation and/or analysis if the required holding time for either activity is less than or equal to 72 hours.
8.) Identification of test method used, or unambiguous description of any non-standard method used.
9.) If the laboratory collected the sample, reference to the sampling procedure.
10.) Any deviations from (such as failed QC), additions to or exclusions from the test method (such as environmental conditions), and any non-

standard conditions that may have affected the quality of the results, including the use and definitions of data qualifiers.
11.) Measurements, examinations and derived results, supported by tables, graphs, sketches and photographs as appropriate, and any failures identified; reporting units on a wet or dry basis.
12.) When required a statement of the estimated uncertainty of the result (NOTE: this NELAP requirement is for radiochemistry only and therefore does not apply to EcoTest reports of analysis).
13.) A signature and title, or an equivalent electronic identification of the person(s) accepting responsibility for the content of the of the report, and date of issue.
14.) Clear indication of data provided by outside sources, such as subcontracted laboratories, clients etc.
15.) Clear identification of numerical results with values outside of quantitation limits.

Subcontracted laboratories are identified by name and/or accreditation number on the report.

If errors are detected or changes made in the report, a subsequent revised report will be issued. The updated report will be titled "Revised Report".

If the laboratory discovers equipment used to derive results in any report casts doubt on the validity of the result it shall notify the client(s) in writing.

The laboratory shall, where clients require transmission of test results by telephone, facsimile or other electronic or electromagnetic means, follow documented procedures that ensure that the above requirements are met and that confidentiality is preserved.

22. CONFIDENTIALITY AND PROPRIETARY RIGHTS

Reports of laboratory analysis will only be released to the named contact person on the sample submittal form or job contract. Proprietary information, if provided by the client, will be protected as Confidential Business Information in accordance with

Title 40, Code of Federal Regulations, Part 2, Subpart B.

23. LABORATORY DATA SYSTEMS AND STORAGE & RETRIEVAL OF DATA AND RECORDS

A. Laboratory Information Management System (LIMS) consists of a Unix based multiuser system utilizing Filepro data base software. The system was designed by our staff to fulfill our particular needs. This system handles sample log-in and generation of final reports. Analysts enter final results for all testing into this system. The system tracks samples and worksheets are generated daily to inform analysts of all uncompleted analysis. This network is not linked to any other computer system in the lab and is therefore isolated from outside intrusion, viruses or other corruption. Each analyst must have a password to log onto system. Access by analysts is limited to current and previous year. Results are currently available on the system back to and including 1986 to selected personnel. Backups of different levels are made daily, weekly and monthly. Copies of complete backups are stored in the lab office and offsite by selected personnel. A second network of computers links all GC/MS instruments and certain GCs. This system is used to transfer data for reporting, archiving, and QC reporting. Only analysts using the instruments have passwords for the system

B. Electronic record archiving system for lab reports consists of storage of complete backup tapes both in office and offsite. This system currently contains all reports from inception of the system in 1986 to present. Electronic data from instruments such as GC/MS and GC is copied to CD ROM disks and archived in lab. ICP raw data from all runs is stored on the instrument's hard drive and on a second hard drive in another computer.

C. Hardcopy data and record storage systems are maintained for all paper records going back at least five years for all records except public drinking water which must be kept for at least ten years. These records are stored in designated storage areas in marked boxes in the lab and in a 40 foot storage container between buildings one and two in a fenced area. A detailed description for location of records is kept in office by Quality Assurance Officer. Large report formats such as those including extensive QC deliverables are scanned and saved on the office computer network as pdf files. Paper copies of such reports are not retained but are either sent to the client or destroyed.

D. Lab analyst notebook storage system consists of a filing system all analyst notebooks filed by name of test method and chronologically. These are stored in the lab. Analysts are instructed not to remove these notebooks from the lab at any time. Quality Assurance Officer has list of individuals who perform tests historically.

24. REFERENCES

1. Standard Methods for the Examination of Water and Wastewater, l8th, 19th, & 20th eds., APHA.

2. National Environmental Laboratory Accreditation Conference, Constitution Bylaws, and Standards, Approved July 2003, Chapter 5, Quality Systems.

3. New York State Environmental Laboratory Approval Program, Certification Manual, Rev. 05/23/07.

ATTACHMENT 2

EcoTest Laboratories Control Limits

ATTACHMENT 3

Example Chain of Custody Form (EcoTest)

ECO TEST LABORATORIES, INC. • ENVIRONMENTAL TESTING
377 Sheffield Avenue, North Babylon, New York 11703
(631) 422-5777 • FAX (631) 422-5770

CHAIN OF CUSTODY RECORD

Client:	
Address:	
Phone:	FAX:
Person receiving report:	
Sampled by:	
Source:	
Job No.:	

MATRIX (Soil, Water, etc.)	COLLECTED		SAMPLE IDENTIFICATION	TOTAL NUMBER OF CONTAINERS	TYPE & NUMBER OF CONTAINERS														REMARKS–TESTS REQUIRED, SPECIAL TURNAROUND, SPECIAL Q.C. etc
	DATE	TIME																	

Relinquished by: *(Signature)* Representing:	DATE/TIME	SEAL INTACT ? YES NO NA	Received by: *(Signature)* Representing:	Relinquished by: *(Signature)* Representing:	DATE/TIME	SEAL INTACT ? YES NO NA	Received by: *(Signature)* Representing:
Relinquished by: *(Signature)* Representing:	DATE/TIME	SEAL INTACT ? YES NO NA	Received by: *(Signature)* Representing:	Relinquished by: *(Signature)* Representing:	DATE/TIME	SEAL INTACT ? YES NO NA	Received by: *(Signature)* Representing:

ATTACHMENT 4

Decontamination Procedures

DECONTAMINATION PROCEDURES

Field sampling equipment will be decontaminated prior to sampling and in between sample locations (e.g., between wells). The decontamination activities will be completed on-site. Procedures for decontaminating any non-disposable field sampling equipment will be conducted as described below. If a submersible pump is dedicated to a monitoring well, then decontamination of the equipment will not be necessary.

1. Rinse equipment with Micro-90 low-phosphate detergent (or equivalent) and potable water solution and scrub with a brush.

2. Rinse equipment with distilled/deionized rinse water.

Appendix S

Remedial Investigation Report – Well Data Summary and Water Level Measurements Tables

Table 2-1
Well Data Summary
Pelham Bay Landfill
Bronx, New York

	Date Installed	Depth (ft)	Diameter (in)	Length of Screen (ft)	Estimated Yield (gpm)	Well Type	Screened Material	Riser Material	Ground Elevation (ft above BD)	Metal Casing Elevation (ft above BD)	Riser Elevation (ft above BD)	Riser Height (ft above GRD)	Screen Elevation Top (ft)	Screen Elevation Bottom (ft)	Northing	Easting	Bedrock Elevation (ft above BD)
1992 WELLS																	
MW-113	26-May-92	12.08	4	5	<0.5	stickup	overburden	sch 40 PVC	8.22	11.42	11.07	2.85	3.99	-1.01	29070.315	-19814.674	-9.78
MW-113B	11-Jun-92	83.98	4	20	~1.5	stickup	bedrock	sch 80 PVC	7.09	10.59	10.20	3.11	-53.78	-73.78	29081.229	-19818.601	-9.91
MW-114	27-May-92	11.87	4	10	< 0.5	flush mount	overburden	sch 80 PVC	7.96	8.26	8.01	0.05	6.14	-3.86	28402.734	-20517.931	-
MW-114B	7-Jul-92	91.48	4	10	< 0.5	flush mount	bedrock	sch 40 PVC	7.62	7.72	7.32	-0.30	-74.16	-84.16	28390.178	-20537.285	-23.38
MW-115	8-Jun-92	42.50	6	20	> 5.0	stickup	overburden	sch 40 PVC	18.44	21.64	20.34	1.90	-2.16	-22.16	27911.455	-20754.435	-22.56
MW-115B	8-Jun-92	72.41	8 & 6	18.41' open hole	> 5.0	stickup	bedrock	8" to 6" (54')	17.71	20.11	open hole	-	-33.89	-52.30	27904.201	-20755.529	-28.29
MW-116	29-May-92	12.20	4	5	<1.0	stickup	sed./fill	sch 80 PVC	10.97	14.27	13.92	2.95	6.72	1.72	26940.256	-20658.534	0.97
MW-116B	29-Jun-92	73.37	4	10	<0.5	stickup	bedrock	sch 80 PVC	11.71	14.11	13.79	2.08	-49.58	-59.58	26901.876	-20656.069	-0.29
MW-117	1-Jun-92	19.66	4	10	0.5	stickup	overburden	sch 80 PVC	5.18	7.49	7.33	2.15	-2.33	-12.33	26639.141	-20177.984	-12.82
MW-117B	29-Jun-92	79.13	4	10	0.5	stickup	bedrock	sch 80 PVC	4.62	6.52	6.40	1.78	-62.73	-72.73	26615.782	-20186.704	-11.38
MW-118	3-Jun-92	17.19	4	10	<1.0	stickup	fill	sch 80 PVC	10.83	13.73	13.19	2.36	6.00	-4.00	26728.412	-19287.747	-
MW-118B	19-Jun-92	112.20	4	20	<0.5	stickup	bedrock	sch 80 PVC	11.00	13.30	13.09	2.09	-79.11	-99.11	26729.859	-19250.687	-39.00
MW-119	10-Jun-92	31.21	4	10	>0.5	stickup	riprap	sch 80 PVC	11.52	13.92	13.78	2.26	-7.43	-17.43	27200.090	-18950.844	-40.48
MW-119B	24-Jun-92	113.51	4	10	<0.5	stickup	bedrock	sch 80 PVC	11.63	14.63	14.29	2.66	-89.22	-99.22	27171.359	-18948.976	-37.37
MW-120	10-Jun-92	55.58	6	20	>10	stickup	overburden	sch 40 PVC	9.05	12.45	11.61	2.56	-23.97	-43.97	27776.950	-18994.003	-43.95
MW-120B	22-May-92	79.70	4	10	<0.5	stickup	bedrock	sch 40 PVC	9.09	10.99	10.84	1.75	-58.86	-68.86	27791.700	-18995.120	-46.91
MW-121	29-May-92	40.71	4	10	>10	stickup	overburden	sch 80 PVC	10.85	13.45	13.10	2.25	-17.61	-27.61	28578.134	-19121.503	-
MW-121B	27-May-92	69.25	4	10	<0.5	stickup	bedrock	sch 80 PVC	11.06	14.66	13.54	2.48	-45.71	-55.71	28587.134	-19126.776	-31.94
MW-122	2-Jun-92	38.15	4	10	>5	stickup	overburden	sch 80 PVC	9.54	12.04	11.68	2.14	-16.47	-26.47	28967.060	-19311.343	-
MW-122B	29-May-92	80.25	4	20	<1.0	stickup	bedrock	sch 80 PVC	9.57	11.37	11.17	1.60	-49.08	-69.08	28975.330	-19321.196	-30.43
MW-123	2-Jul-92	14.50	4	10	<0.5	flush mount	overburden	sch 80 PVC	12.96	13.41	13.23	0.27	8.73	-1.27	27295.939	-21322.259	-
MW-124	2-Jul-92	13.27	4	10	< 0.5	flush mount	overburden	sch 40 PVC	22.14	22.24	22.12	-0.02	18.85	8.85	26498.996	-20818.821	7.64
MW-124B	7-Jul-92	69.67	4	10	<0.5	flush mount	bedrock	sch 40 PVC	20.90	21.00	20.60	-0.30	-39.07	-49.07	26520.305	-20800.748	7.90
MW-125	13-Jul-92	19.58	4	10	~3.0	flush mount	overburden	sch 80 PVC	5.58	6.03	5.92	0.34	-3.66	-13.66	28452.426	-20675.673	-
MW-125B	6-Jul-92	103.04	4	20	~8.0	flush mount	bedrock	sch 40 PVC	5.95	6.15	5.90	-0.05	-77.14	-97.14	28462.816	-20669.218	-45.05
MW-126 (PZ5)	1-Jul-92	140.00	4	20	>2.0	stickup	fill	sch 40 SS	124.12	125.23	124.68	0.56	4.68	-15.32	27770.025	-19860.461	-23.88
PZ-1F	19-May-92	78.42	2	10	-	stickup	fill	sch 40 PVC	80.40	82.60	82.33	1.93	13.91	3.91	28602.070	-19719.777	-
PZ-1B	19-May-92	106.22	2	10	-	stickup	bedrock	sch 40 PVC	79.95	82.35	82.08	2.13	-14.14	-24.14	28607.553	-19715.618	1.45
PZ-2F	13-May-92	97.73	2	10	-	stickup	fill	sch 40 PVC	92.00	95.60	95.48	3.48	7.75	-2.25	28062.389	-20214.844	-10.00
PZ-3F	5-Jun-92	136.00	2	10	-	stickup	fill	iron	127.36	129.26	129.10	1.74	3.10	-6.90	27353.441	-19573.734	-
PZ-3S	29-May-92	160.00	2	10	-	stickup	overburden	iron	126.89	129.49	129.46	2.57	-20.54	-30.54	27352.641	-19567.616	-33.11
PZ-3B	12-Jun-92	172.00	2	5	-	stickup	bedrock	iron	128.82	131.32	130.93	2.11	-36.07	-41.07	27356.313	-19597.121	-28.68
PZ-4F	21-May-92	77.83	2	10	-	stickup	fill	sch 40 PVC	79.31	81.81	81.27	1.96	13.44	3.44	28055.263	-19373.243	-2.69
PZ-5B	17-Jun-92	165.00	2	5	-	stickup	bedrock	iron	123.40	126.20	126.08	2.68	-33.92	-38.92	27773.634	-19882.983	-24.60
CP-1	21-Jun-92	44.35	2	20	-	stickup	overburden	sch 40 PVC	20.72	23.82	23.62	2.90	-0.73	-20.73	27940.300	-20746.521	-42.78
CP-2	16-Jun-92	41.07	2	20	-	flush mount	overburden	sch 40 PVC	18.32	18.42	18.18	-0.14	-2.89	-22.89	27914.767	-20768.121	-37.18
CB-1	30-Jun-92	77.72	2	10	-	stickup	bedrock	sch 40 PVC	19.79	21.89	21.77	1.98	-45.95	-55.95	27922.866	-20747.965	-41.21
HP-1	23-Jun-92	45.40	2	10	-	stickup	overburden	sch 40 PVC	8.40	11.00	10.89	2.49	-24.51	-34.51	27766.674	-18992.946	-37.60
HP-2	25-Jun-92	48.24	2	10	-	stickup	bedrock	sch 40 PVC	9.15	11.55	11.39	2.24	-26.85	-36.85	27748.104	-18989.605	-36.85
HP-3	9-Jul-92	25.19	2	10	-	flush mount	fill	sch 40 PVC	8.63	8.73	8.53	-0.10	-6.66	-16.66	27780.225	-18975.657	-
TB-1	29-Jun-92	56.00	Abandoned Test boring		-	-	-	-	~11	-	-	-	-	-	-	-	~ -27.00
TB-2	14-Jul-92	20.00	Abandoned Test Boring		-	-	-	-	~11	-	-	-	-	-	-	-	-

Table 2-1
Well Data Summary
Pelham Bay Landfill
Bronx, New York

	Date Installed	Depth (ft)	Diameter (in)	Length of Screen (ft)	Estimated Yield (gpm)	Well Type	Screened Material	Riser Material	Ground Elevation (ft above BD)	Metal Casing Elevation (ft above BD)	Riser Elevation (ft above BD)	Riser Height (ft above GRD)	Screen Elevation Top (ft)	Screen Elevation Bottom (ft)	Northing	Easting	Bedrock Elevation (ft above BD)
1989 WELLS																	
MW-101	1-Dec-89	45.00	4	10	-	flush mount	fill	sch 80 PVC	80.02	-	-	-	-	-	28590.892	-19452.983	-
MW-102	5-Dec-89	56.00	4	10	-	flush mount	fill	sch 80 PVC	78.79	78.89	78.43	-0.36	32.43	22.43	27086.164	-19724.929	-
MW-103	27-Nov-89	13.62	4	10	>5	flush mount	overburden	sch 80 PVC	9.43	9.73	9.43	0.00	5.81	-4.19	28946.055	-19300.926	-
MW-104	21-Nov-89	15.35	4	10	~0.6	flush mount	overburden	sch 80 PVC	9.75	9.85	9.55	-0.20	4.20	-5.80	28179.490	-19030.697	-
MW-105	28-Nov-89	17.40	4	10	>5	flush mount	overburden	sch 80 PVC	9.99	10.30	9.99	0.00	2.59	-7.41	27518.177	-18974.661	-
MW-106	28-Nov-89	17.47	4	10	>5	flush mount	overburden	sch 80 PVC	10.05	10.25	9.86	-0.19	2.39	-7.61	26742.231	-18980.711	-23
MW-107	20-Nov-89	15.83	4	5	<0.1	flush mount	overburden	sch 80 PVC	5.03	5.43	5.19	0.16	-5.64	-10.64	26630.328	-20189.235	-
MW-108	21-Nov-89	Destroyed during IRM 5/92			-	flush mount	-	-	-	-	-	-	-	-	-	-	-
MW-109	10-Nov-89	16.75	4	10	<0.1	flush mount	overburden	sch 80 PVC	17.16	17.26	16.96	-0.20	10.21	0.21	28784.326	-20169.171	-5.84
MW-110	30-Nov-89	16.89	4	10	>5	flush mount	overburden	sch 80 PVC	11.39	11.69	11.34	-0.05	4.45	-5.55	26731.688	-19689.792	-
MW-111	1-Dec-89	34.86	4	10	~0.3	flush mount	overburden	sch 80 PVC	20.36	20.86	20.71	0.35	-4.15	-14.15	27930.200	-20744.629	-
MW-112	7-Dec-89	12.00	4	10	<0.1	flush mount	overburden	sch 80 PVC	10.64	10.84	10.54	-0.10	8.54	-1.46	29031.043	-19812.714	-

Notes:
BD = Bronx Datum = 2.608 ft. above mean sea level
SS = Stainless Steel
GRD = Ground
gpm = gallons per minute
HP-2 was damaged during the weekend of 8/8/92
Well depth measured from top of inner riser

Prepared by: DAD
Checked by: PGN
92C4087

Table 2-4
Water Level Measurements
Pelham Bay Landfill
Bronx, New York

Well Number	AUGUST 4, 1992 LOW TIDE AT 1103				AUGUST 12, 1992 HIGH TIDE AT 1208				NOVEMBER 5, 1992 LOW TIDE AT 1420			
	Time	Depth to Water (ft)	Elevation of PVC (ft)	Water Table Elevation (ft)	Time	Depth to Water (ft)	Elevation of PVC (ft)	Water Table Elevation (ft)	Time	Depth to Water (ft)	Elevation of PVC (ft)	Water Table Elevation (ft)
MW-103	omitted		9.43		1244	8.2	9.43	1.23	1433	14.55	9.43	-5.12
MW-104	1114	8.95	9.55	0.60	1212	8.68	9.55	0.87	1442	9.08	9.55	0.47
MW-105	1109	8.87	9.99	1.12	1230	8.80	9.99	1.19	1425	8.89	9.99	1.10
MW-106	1100	14.25	9.86	-4.39	1229	8.10	9.86	1.76	1435	9.04	9.86	0.82
MW-107	1103	6.59	5.19	-1.40	omitted		5.19		1420	5.54	5.19	-0.35
MW-109	1015	10.50	16.96	6.46	1138	10.80	16.96	6.16	1420	11.58	16.96	5.38
MW-110	1113	12.89	11.34	-1.55	omitted		11.34		1445	13.32	11.34	-1.98
MW-111									1508	16.67	20.71	4.04
MW-112	1109	8.39	10.54	2.15	1221	8.74	10.54	1.80	1424	8.96	10.54	1.58
MW-113	1108	9.66	11.07	1.41	Aquistar power failure		11.07		1423	9.97	11.07	1.10
MW-113B	1105	10.12	10.20	0.08	1220	7.53	10.20	2.67				
MW-114	1031	4.27	8.01	3.74	1327	3.07	8.01	4.94	1420	4.45	8.01	3.56
MW-114B	1030	3.45	7.32	3.87	omitted		7.32					
MW-115	1354	16.08	20.34	4.26	pump test		20.34		1431	15.95	20.34	4.39
MW-115B	1351	15.80	21.77	5.97	pump test		21.77					
MW-116	1408	8.15	13.92	5.77	1516	8.36	13.92	5.56	1435	7.51	13.92	6.41
MW-116B	1410	57.70	13.79	-43.91	1548	62.00	13.79	-48.21				
MW-117	1108	8.73	7.33	-1.40	1220	6.82	7.33	0.51	1421	7.7	7.33	-0.37
MW-117B	1104	8.08	6.40	-1.68	1208	6.70	6.40	-0.30				
MW-118	1116	15.62	13.19	-2.43	Aquistar power failure		13.19		1440	13.94	13.19	-0.75
MW-118B	1117	20.02	13.09	-6.93	development		13.09					
MW-119	1106	18.95	13.78	-5.17	1231	12.70	13.78	1.08	1430	18.52	13.78	-4.74
MW-119B	1104	16.20	14.29	-1.91	1238	15.63	14.29	-1.34				
MW-120	development		11.61		1209	11.33	11.61	0.28	1420	12.13	11.61	-0.52
MW-120B	1111	14.42	10.84	-3.58	1239	10.77	10.84	0.07				
MW-121	development		13.10		1215	12.18	13.10	0.92	1437	17.35	13.10	-4.25
MW-121B	development		13.54		1215	66.92	13.54	-53.38				
MW-122	1117	15.28	11.68	-3.60	1217	10.42	11.68	1.26	1427	15.07	11.68	-3.39
MW-122B	1115	15.00	11.17	-3.83	1217	9.75	11.17	1.42				
MW-123	1358	6.70	13.23	6.53	1515	6.90	13.23	6.33	1440	6.55	13.23	6.68
MW-124	1405	10.55	22.12	11.57	1526	10.92	22.12	11.20	1430	11.98	22.12	10.14
MW-124B	1404	12.80	20.60	7.80	1526	9.18	20.60	11.42				
MW-125	1024	3.90	5.92	2.02	1300	3.05	5.92	2.87	1424	3.98	5.92	1.94
MW-125B	1023	3.90	5.90	2.00	omitted		5.90					
MW-126	1304	118.00	124.68	6.68	1425	120.37	124.68	6.31	1443	115.15	124.68	9.53
PZ-1B	1244	77.90	82.08	4.18	1426	78.02	82.08	4.06				
PZ-1F	1251	77.00	82.33	5.33	1428	76.18	82.33	6.15	1510	76.25	82.33	6.08
PZ-2F	1257	94.78	95.48	0.70	1437	dry	95.48	dry	1500	97.6	95.48	-2.12
PZ-3B	1344	132.20	130.93	-1.27	1457	132.40	130.93	-1.47				
PZ-3F	1336	124.70	129.10	4.40	1457	132.40	129.10	-3.30	1454	121.66	129.10	7.44
PZ-3S	1340	131.36	129.46	-1.90	1458	131.60	129.46	-2.14				
PZ-4F	1157	dry	81.27	dry	1505	dry	81.27	dry	1500	Well Dry	81.27	
PZ-5B	1310	121.58	126.08	4.50	1347	133.28	126.08	-7.20				

Note: Elevations are referenced to the Bronx Datum which is 2.608 feet above mean sea level at Sandy Hook, NJ

Prepared by: KNS
Checked by: TRP
92C4087

Appendix T

Well Construction Logs

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

CONSTRUCTION OF WELL / PIEZOMETER **MW-113**

Project name & location PELHAM BAY LANDFILL, BRONX, NEW YORK	*Well lock No.* 3220	*Elevation datum* Bronx Datum (BD) 2.068 ft. above MSL
Drilling company WARREN-GEORGE INC.	*Surveyor* ETTLINGER & ETTLINGER	*Ground elevation* 8.22 ft
Date and time of completion 5/26/92	*Northing* 29070.315	*Top of protective steel casing elevation* 11.42 ft
Inspector D. Davidson	*Easting* -19814.674	*Top of riser pipe elevation* 11.07 ft

A = Top of Riser
B = Ground Surface
C = Top of Bentonite Seal
D = Top of Sand Pack
E = Top of Screen
F = Bottom of Screen
G = Bottom of PVC/Steel
H = Bottom of Borehole

ELEV. (ft above/ below BD)		DEPTHS (ft below / above ground)
11.07	A	2.85
8.22	B	0
6.72	C	1.5
5.72	D	2.5
3.72	E	4.5
-1.28	F	9.5
-1.28	G	9.5
-19.78	H	28

STICKUP (ft)
3.2

GENERALIZED SOIL DESCRIPTION

0-10 inches: Brown organic soil.
11"- 13ft.: Sand, silt, gravel, and decomposed rock.

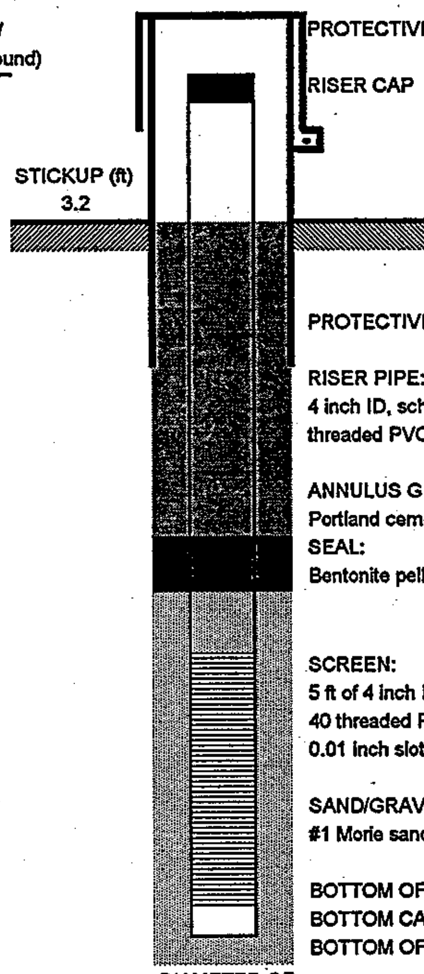
13-14 ft.: Dk-med. grey SILT.

14-18 ft.: Decomposed ROCK.

18-22 ft.: Fine biotite GNEISS with garnet.

22-23 ft.: Coarse grained PEGMATITE DIKE.

23-28 ft.: White and black biotite-feldspar GNEISS with garnet, quartz.



REMARKS (Installation, development) :
MATERIALS: 10 FT. OF 4" SCH 40 PVC RISER, 5 FT. OF SCC 40 PVC SCREEN, 2 BOTTOM/TOP CAPS, 4 BAGS #1 SAND, 1 BUCKET OF BENTONITE PELLETS, 2 BAGS OF PORTLAND CEMENT, 1 4" STICK UP.

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

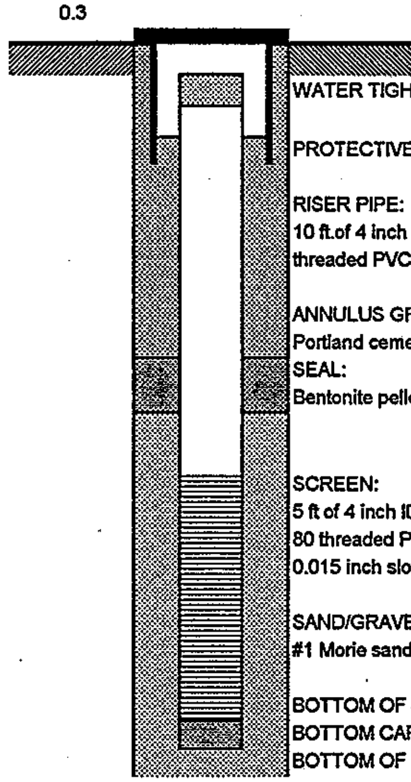
CONSTRUCTION OF WELL / PIEZOMETER **MW-114**

Project name & location	*Well lock No.*	*Elevation datum*
PELHAM BAY LANDFILL, BRONX, NEW YORK	3220	Bronx Datum (BD) 2.608 ft. above MSL
Drilling company	*Surveyor*	*Ground elevation*
WARREN-GEORGE	ETTLINGER & ETTLINGER	7.96 ft
Date and time of completion	*Northing*	*Top of protective steel casing elevation*
5/27/92	28402.734	8.26 ft
Inspector	*Easting*	*Top of riser pipe elevation*
D. Davidson	-20517.931	8.01 ft

A = Ground Surface
B = Top of Riser
C = Top of Bentonite Seal
D = Top of Sand Pack
E = Top of Screen
F = Bottom of Screen
G = Bottom of PVC/Steel
H = Bottom of Borehole

FLUSHMOUNT (ft)
0.3

GENERALIZED SOIL DESCRIPTION	ELEV. (ft above/ below BD)		DEPTHS (ft below/ above ground)
	7.96	A	0
	8.01	B	0.05
0-8 ft.: Dk. brown gravelly sandy organic soil.			
	8.01	C	0.05
	7.14	D	0.82
	6.14	E	1.82
8-12 ft.: Orange-brown and green-brown micaceous varved SILT.			
12-22 ft.: Brown to olive green fine-coarse silty SAND w/ gravel, decomposed micaceous rock. Very green color at 18 ft. (chlorite?) Varved mica. silt stringers at 20 ft.	-3.86	F	11.82
	-3.86	G	11.82
	-5.54	H	13.5



GROUND SURFACE
WATER TIGHT CAP WITH LOCK
PROTECTIVE STEEL CASING CEMENTED IN PLACE
RISER PIPE:
10 ft.of 4 inch ID, schedule 80 threaded PVC
ANNULUS GROUTED WITH:
Portland cement
SEAL:
Bentonite pellets
SCREEN:
5 ft of 4 inch ID, schedule 80 threaded PVC, 0.015 inch slot
SAND/GRAVEL PACK:
#1 Morie sand
BOTTOM OF SCREEN
BOTTOM CAP
BOTTOM OF BOREHOLE

DIAMETER OF BOREHOLE: 11.5"

REMARKS (Installation, development) :
MATERIALS: 5 FT. OF 4" SCH 80 PVC SCREEN,10 FT OF 4" SCH 80 PVC RISER, 1 BOTTOM CAP,
3 BAGS OF #1 SAND, 1 BUCKET OF BENTONITE PELLETS, 1 BAG OF PORTLAND CEMENT,1 FLUSH MOUNT CASING.

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

CONSTRUCTION OF WELL / PIEZOMETER **MW-115**

Project name & location PELHAM BAY LANDFILL, BRONX, NEW YORK	***Well lock No.*** 3220	***Elevation datum*** Bronx Datum (BD) 2.608 ft above MSL
Drilling company WARREN-GEORGE INC.	***Surveyor*** ETTLINGER & ETTLINGER	***Ground elevation*** 18.44 ft
Date and time of completion 6/8/92	***Northing*** 27911.455	***Top of protective steel casing elevation*** 21.64 ft
Inspector B. Atkinson	***Easting*** -20754.435	***Top of riser pipe elevation*** 20.34 ft

A = Top of Riser
B = Ground Surface
C = Top of Bentonite Seal
D = Top of Sand Pack
E = Top of Screen
F = Bottom of Screen
G = Bottom of PVC/Steel
H = Bottom of Borehole

ELEV. (ft above/ below BD)		DEPTHS (ft below/ above ground)
20.34	A	1.9
18.44	B	0
9.44	C	9
1.44	D	17
-2.56	E	21
-22.56	F	41
-22.56	G	41
-22.56	H	41

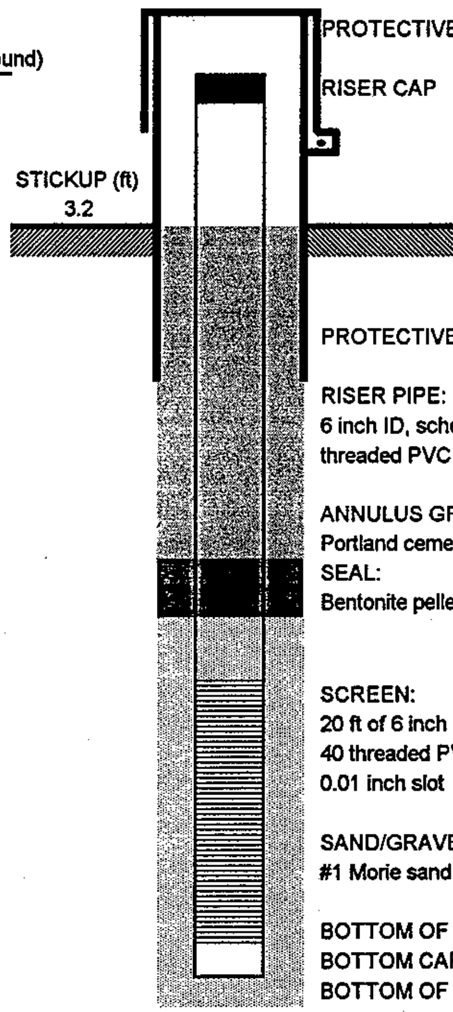
STICKUP (ft)
3.2

GENERALIZED SOIL DESCRIPTION

0-6 ft.: Lt. brown cuttings.

6-16 ft.: Black cuttings.

16-41 ft.: Lt. brown-brown fine SAND w/ mica and gravel.



PROTECTIVE STEEL CAP WITH LOCK

RISER CAP

GROUND SURFACE

PROTECTIVE STEEL CASING CEMENTED

RISER PIPE:
6 inch ID, schedule 40
threaded PVC

ANNULUS GROUTED WITH:
Portland cement

SEAL:
Bentonite pellets

SCREEN:
20 ft of 6 inch ID, schedule
40 threaded PVC,
0.01 inch slot

SAND/GRAVEL PACK:
#1 Morie sand

BOTTOM OF SCREEN
BOTTOM CAP
BOTTOM OF BOREHOLE

DIAMETER OF BOREHOLE:
6"

REMARKS (Installation, development) :
MATERIALS: 22 ft. OF 6" SCH 40 PVC RISER, 20 FT. OF 6" SCH 40 WIRE WRAPPED PVC SCREEN,
8 BAGS OF # 1 SAND, 1 1/2 BUCKETS OF BENTONITE PELLETS, 4 BAGS OF CEMENT.

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

CONSTRUCTION OF WELL / PIEZOMETER **MW-115B**

Project name & location PELHAM BAY LANDFILL, BRONX, NEW YORK	***Well lock No.*** 3220	***Elevation datum*** Bronx Datum (BD) 2.608 ft. above MSL
Drilling company WARREN-GEORGE, INC.	***Surveyor*** ETTLINGER & ETTLINGER	***Ground elevation*** 19.79 ft
Date and time of completion 6/8/92	***Northing*** 27904.201	***Top of protective steel casing elevation*** 21.89 ft
Inspector B. Atkinson	***Easting*** -20755.529	***Top of riser pipe elevation*** 21.77 ft

A = Top of Riser
B = Ground Surface
C = Top of Bedrock
D = Bottom of 8" Casing
E = Bottom of Borehole

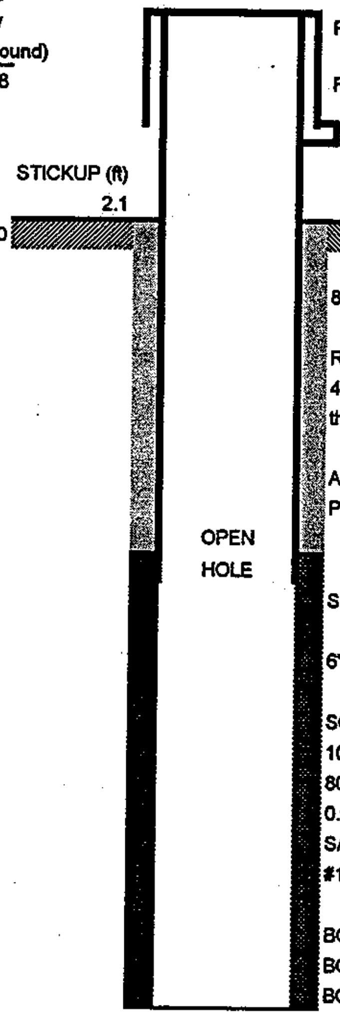
Point	ELEV. (ft above/ below BD)	DEPTHS (ft below/ above ground)
A	21.77	1.98
B	19.79	0
C	-26.21	46
D	-34.21	54
E	-54.21	74

GENERALIZED SOIL DESCRIPTION

0-1.5 ft. Black to brown silty SAND & FILL

1.5-40 ft. Black FILL

40-74 ft.Competent Bedrock: Biotite-Garnet SCHIST.



PROTECTIVE STEEL CAP WITH LOCK

RISER CAP

GROUND SURFACE

8" STEEL CASING CEMENTED IN PLACE

RISER PIPE:
4 inch ID, schedule 80
threaded PVC

ANNULUS GROUTED WITH:
Portland cement

SEAL: Bentonite pellets

6" DIAMETER BORE HOLE

SCREEN:
10 ft of 4 inch ID, schedule
80 threaded PVC,
0.015 inch slot
SAND/GRAVEL PACK:
#1 Morie sand

BOTTOM OF SCREEN
BOTTOM CAP
BOTTOM OF BOREHOLE

DIAMETER OF BOREHOLE:
6"

REMARKS (Installation, development) :
Open bedrock hole 54 - 74 feet. MATERIALS: 10 FT OF 4" SCH 80 PVC SCREEN, 104 FT OF SCH 80 PVC RISER, 21 FT OF 8" STEEL CASING,1 BOTTOM CAP, 6 BAGS OF #1 SAND, 1 BUCKET OF BENTONITE PELLETS, 10 BAGS OF PORTLAND CEMENT, 1 6 " STICK UP CASING.

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

CONSTRUCTION OF WELL / PIEZOMETER **MW-117**

Project name & location PELHAM BAY LANDFILL, BRONX, NEW YORK	***Well lock No.*** 3220	***Elevation datum*** Bronx Datum (BD) 2.608 ft above MSL
Drilling company WARREN-GEORGE, INC.	***Surveyor*** ETTLINGER & ETTLINGER	***Ground elevation*** 5.18 ft
Date and time of completion 6/1/92	***Northing*** 26639.141	***Top of protective steel casing elevation*** 7.49 ft
Inspector D. Davidson	***Easting*** -20177.984	***Top of riser pipe elevation*** 7.33 ft

A = Top of Riser
B = Ground Surface
C = Top of Bentonite Seal
D = Top of Sand Pack
E = Top of Screen
F = Bottom of Screen
G = Bottom of PVC/Steel
H = Bottom of Borehole

ELEV. (ft above/ below BD)		DEPTHS (ft below/ above ground)
7.33	A	2.15
5.18	B	0
1.18	C	4
-0.82	D	6
-2.82	E	8
-12.82	F	18
-12.82	G	18
-12.82	H	18

STICKUP (ft)
2.31

GENERALIZED SOIL DESCRIPTION

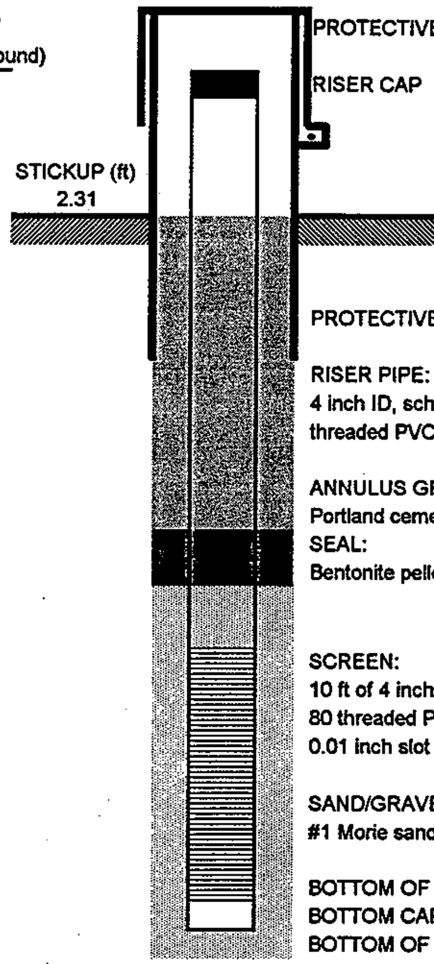
0-2 ft.: Highly organic sandy, silty soil.

2-9 ft.: Crushed SLAG

9-11 ft.: Lt. gray highly organic SILT.

11-18 ft.: Decomposed ROCK w/ silt and sand.

18-28 ft. NX core: Competent bedrock Biotite-feldspar GNEISS w/ quartz and garnet.



PROTECTIVE STEEL CAP WITH LOCK

RISER CAP

GROUND SURFACE

PROTECTIVE STEEL CASING CEMENTED

RISER PIPE:
4 inch ID, schedule 80
threaded PVC

ANNULUS GROUTED WITH:
Portland cement

SEAL:
Bentonite pellets

SCREEN:
10 ft of 4 inch ID, schedule
80 threaded PVC,
0.01 inch slot

SAND/GRAVEL PACK:
#1 Morie sand

BOTTOM OF SCREEN
BOTTOM CAP
BOTTOM OF BOREHOLE

DIAMETER OF BOREHOLE:
11 1/2"

REMARKS (Installation, development) :
MATERIALS: 10 FT OF 4" SCH 80 PVC SCREEN, 10 FT OF 4" SCH 80 PVC RISER, 1 BOTTOM CAP, 2 BAGS OF #1 SAND, 1 BUCKET OF BENTONITE PELLETS, 2 BAGS OF PORTLAND CEMENT, 1 6" STICK UP CASING.

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

CONSTRUCTION OF WELL / PIEZOMETER **MW-117B**

Project name & location PELHAM BAY LANDFILL, BRONX, NEW YORK	***Well lock No.*** 3220	***Elevation datum*** Bronx Datum (BD) 2.608 ft. above MSL
Drilling company WARREN-GEORGE, INC.	***Surveyor*** ETTLINGER & ETTLINGER	***Ground elevation*** 4.62 ft
Date and time of completion 6/29/92	***Northing*** 26615.782	***Top of protective steel casing elevation*** 6.52 ft
Inspector R. Costa	***Easting*** -20186.704	***Top of riser pipe elevation*** 6.40 ft

A = Top of Riser
B = Ground Surface
C = Top of Bedrock
D = Bottom of 8" Casing
E = Top of Bentonite Seal
F = Top of Sand Pack
G = Top of Screen
H = Bottom of Screen
I = Bottom of PVC/Steel
J = Bottom of Borehole

ELEV. (ft above MSL)		DEPTHS (ft below/ above ground)
6.40	A	1.78
4.62	B	0
-19.88	C	24.5
-21.38	D	26
-25.38	E	30
-27.38	F	32
-63.38	G	68
-73.38	H	78
-73.38	I	78
-73.38	J	78

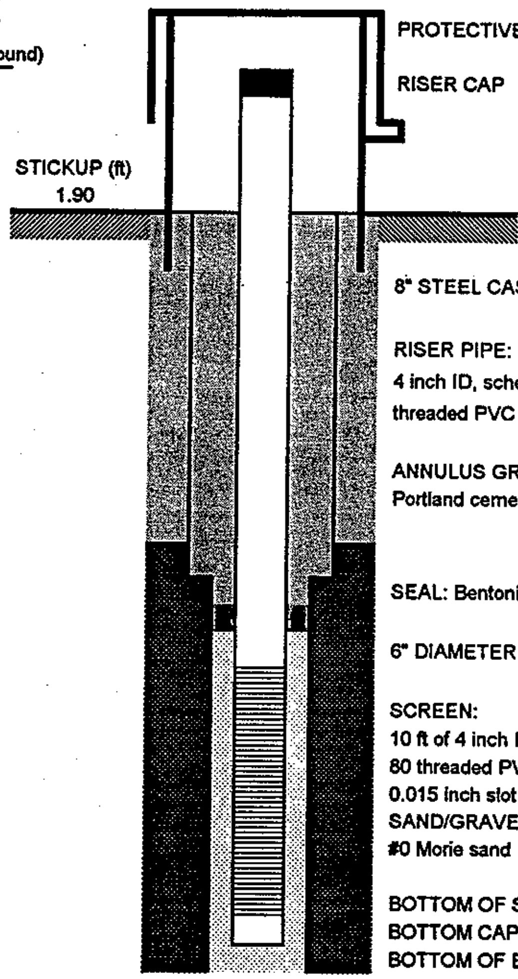
GENERALIZED SOIL DESCRIPTION

0-16 ft.: Brown med. SAND and SILT.

16-24.5 ft.: Decomposed biotite SCHIST.

24.5-78 ft.: Competent Bedrock: Biotite-garnet SCHIST.

STICKUP (ft) 1.90



PROTECTIVE STEEL CAP WITH LOCK

RISER CAP

GROUND SURFACE

8" STEEL CASING CEMENTED IN PLACE

RISER PIPE: 4 inch ID, schedule 80 threaded PVC

ANNULUS GROUTED WITH: Portland cement

SEAL: Bentonite pellets

6" DIAMETER BORE HOLE

SCREEN: 10 ft of 4 inch ID, schedule 80 threaded PVC, 0.015 inch slot

SAND/GRAVEL PACK: #0 Morie sand

BOTTOM OF SCREEN

BOTTOM CAP

BOTTOM OF BOREHOLE

DIAMETER OF BOREHOLE: 7 1/2"

REMARKS (Installation, development) :

MATERIALS: 26 FT OF 8" STEEL CASING; 1 BOTTOM PLUG; 10 FT OF SCH 80 4" PVC SCREEN 0.015 SLOT; 70 FT OF 4" SCH 80 PVC RISER; 6 BAGS #0 MORIE SAND; 1/2 BUCKET BENTONITE PELLETS, 4 BAGS PORTLAND CEMENT; 1 STANDPIPE W/ LOCK.

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

CONSTRUCTION OF WELL / PIEZOMETER **MW-118**

Project name & location PELHAM BAY LANDFILL, BRONX, NEW YORK	*Well lock No.* 3220	*Elevation datum* Bronx Datum (BD) 2.608 ft. above MSL
Drilling company WARREN-GEORGE, INC.	*Surveyor* ETTLINGER & ETTLINGER	*Ground elevation* 10.83 ft
Date and time of completion 6/3/92	*Northing* 26728.412	*Top of protective steel casing elevation* 13.73 ft
Inspector D. Davidson	*Easting* -19287.747	*Top of riser pipe elevation* 13.19 ft

A = Top of Riser
B = Ground Surface
C = Top of Bentonite Seal
D = Top of Sand Pack
E = Top of Screen
F = Bottom of Screen
G = Bottom of PVC/Steel
H = Bottom of Borehole

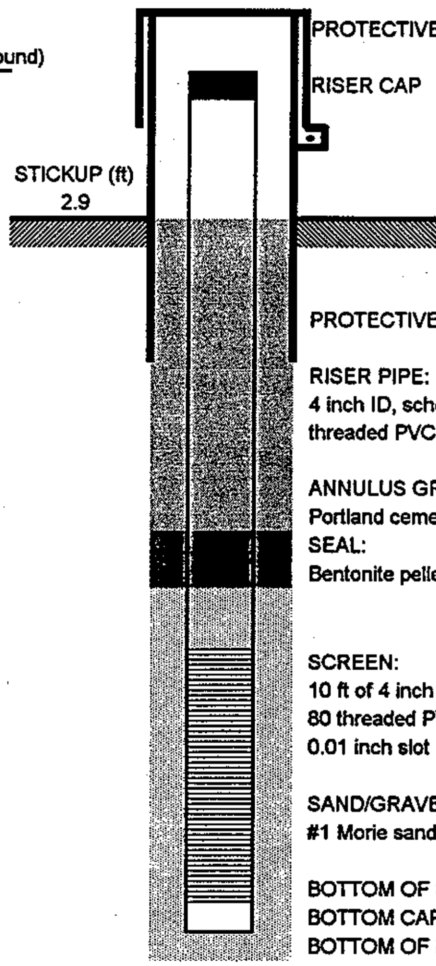
ELEV. (ft above/ below BD)		DEPTHS (ft below/ above ground)
13.19	A	2.36
10.83	B	0
8.83	C	2
7.33	D	3.5
5.83	E	5
-4.17	F	15
-4.17	G	15
-4.71	H	15

GENERALIZED SOIL DESCRIPTION

0-6 ft.: Sand, silt, gravel, and decomposed rock.

6-15 ft.: FILL

STICKUP (ft) 2.9



PROTECTIVE STEEL CAP WITH LOCK

RISER CAP

GROUND SURFACE

PROTECTIVE STEEL CASING CEMENTED

RISER PIPE:
4 inch ID, schedule 80
threaded PVC

ANNULUS GROUTED WITH:
Portland cement

SEAL:
Bentonite pellets

SCREEN:
10 ft of 4 inch ID, schedule
80 threaded PVC,
0.01 inch slot

SAND/GRAVEL PACK:
#1 Morie sand

BOTTOM OF SCREEN
BOTTOM CAP
BOTTOM OF BOREHOLE

DIAMETER OF BOREHOLE:
11 1/2"

REMARKS (Installation, development) :
MATERIALS: 10 FT OF 4" SCH 80 PVC SCREEN, 10 FT OF 4" SCH 80 PVC RISER,1 BOTTOM CAP, 6 BAGS OF #1 SAND, 1 BUCKET OF BENTONITE PELLETS, 3 BAGS OF PORTLAND CEMENT,1 6" STICK UP CASING.

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

CONSTRUCTION OF WELL / PIEZOMETER **MW-119**

Project name & location PELHAM BAY LANDFILL, BRONX, NEW YORK	***Well lock No.*** 3220	***Elevation datum*** Bronx Datum (BD) 2.608 ft. above MSL.
Drilling company WARREN-GEORGE INC.	***Surveyor*** ETTLINGER & ETTLINGER	***Ground elevation*** 11.52 ft
Date and time of completion 6/10/92	***Northing*** 27200.09	***Top of protective steel casing elevation*** 13.92 ft
Inspector D. Davidson	***Easting*** -18950.844	***Top of riser pipe elevation*** 13.78 ft

A = Top of Riser
B = Ground Surface
C = Top of Bentonite Seal
D = Top of Sand Pack
E = Top of Screen
F = Bottom of Screen
G = Bottom of PVC/Steel
H = Bottom of Borehole

ELEV. (ft above/ below BD)		DEPTHS (ft below/ above ground)
13.78	A	2.26
11.52	B	0
-0.48	C	12
-2.48	D	14
-6.48	E	18
-16.48	F	28
-16.48	G	28
-40.48	H	52

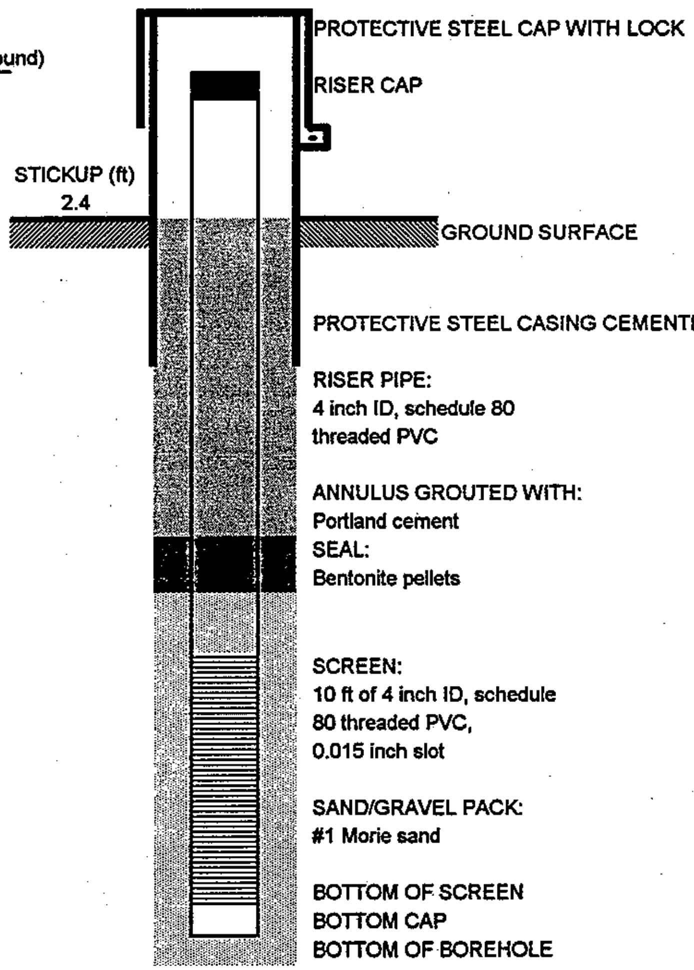
STICKUP (ft) 2.4

GENERALIZED SOIL DESCRIPTION

0-27 ft.: FILL.

27-52 ft.: RIP-RAP

52-58.5 ft.: White and black biotite feldspar GNEISS w/ muscovite, quartz, and garnet.



REMARKS (Installation, development) :
MATERIALS: 10 FT OF 4" SCH 80 PVC SCREEN, 20 FT OF 4" SCH 80 PVC RISER, 1 BOTTOM CAP, 4 BAGS OF #1 SAND, 1 BUCKET OF BENTONITE PELLETS, 3 BAGS OF PORTLAND CEMENT, 1 6" STICK UP CASING.

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

CONSTRUCTION OF WELL / PIEZOMETER **MW-120**

Project name & location PELHAM BAY LANDFILL, BRONX, NEW YORK	*Well lock No.* 3220	*Elevation datum* Bronx Datum (BD) 2.608 ft. above MSL.
Drilling company WARREN-GEORGE, INC.	*Surveyor* ETTLINGER & ETTLINGER	*Ground elevation* 9.05 ft
Date and time of completion 6/10/92	*Northing* 27776.950	*Top of protective steel casing elevation* 12.45 ft
Inspector B. Atkinson	*Easting* -18994.003	*Top of riser pipe elevation* 11.61 ft

A = Top of Riser
B = Ground Surface
C = Top of Bentonite Seal
D = Top of Sand Pack
E = Top of Screen
F = Bottom of Screen
G = Bottom of PVC/Steel
H = Bottom of Borehole

ELEV. (ft above/ below BD)		DEPTHS (ft below/ above ground)
11.16	A	2.56
9.05	B	0
-20.31	C	31
-22.31	D	33
-22.31	E	33
-42.31	F	53
-42.31	G	53
-44.89	H	55.58

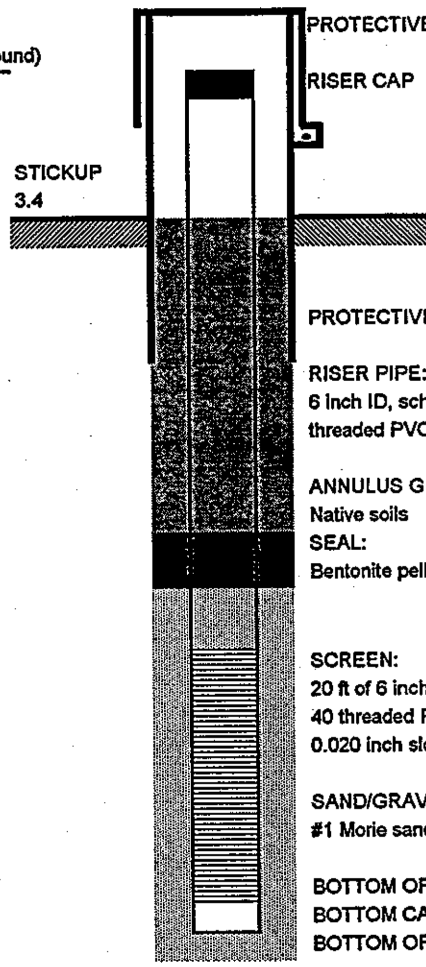
GENERALIZED SOIL DESCRIPTION

0-6 ft.: Brown cuttings.

6-30 ft.: Black cuttings, abundant gravel.

30-46 ft.: Dark grey, silty CLAY.

46-53 ft.: Lt. brown fine SAND.



REMARKS (Installation, development) :

MATERIALS: 20 FT OF 6" SCH 40 PVC SCREEN, 36 FT OF 6" SCH 40 PVC RISER, 1 BOTTOM CAP, 9 BAGS OF #1 SAND, 1 BUCKET OF BENTONITE PELLETS.

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

CONSTRUCTION OF WELL / PIEZOMETER **MW-120B**

Project name & location PELHAM BAY LANDFILL, BRONX, NEW YORK	***Well lock No.*** 3220	***Elevation datum*** Bronx Datum (BD) 2.608 ft. above MSL
Drilling company WARREN-GEORGE, INC.	***Surveyor*** ETTLINGER & ETTLINGER	***Ground elevation*** 9.09 ft
Date and time of completion 5/22/92	***Northing*** 27791.700	***Top of protective steel casing elevation*** 10.99 ft
Inspector J. Prunetti	***Easting*** -18995.120	***Top of riser pipe elevation*** 10.84 ft

A = Top of Riser
B = Ground Surface
C = Top of Bedrock
D = Bottom of 8" Casing
E = Top of Bentonite Seal
F = Top of Sand Pack
G = Top of Screen
H = Bottom of Screen
I = Bottom of PVC/Steel
J = Bottom of Borehole

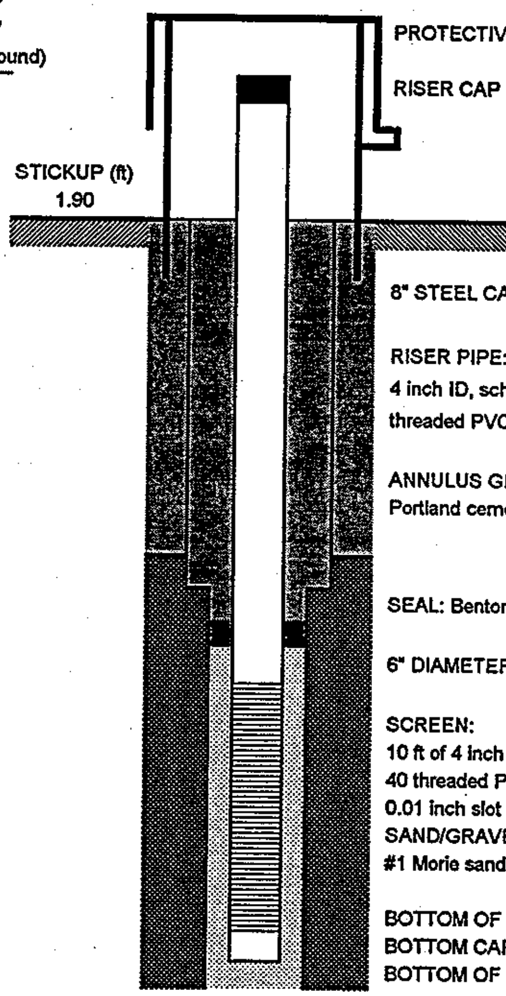
ELEV. (ft above/ below BD)		DEPTHS (ft below/ above ground)
10.84	A	1.75
9.09	B	0
-46.95	C	56
-54.95	D	64
-55.95	E	65
-57.95	F	67
-59.95	G	69
-69.95	H	79
-69.95	I	79
-69.95	J	79

GENERALIZED SOIL DESCRIPTION

0-45 ft.: Dark grey cuttings and fluids; unconsolidated material. (FILL?)

45-56 ft.: Tan cuttings, very soft material. (Glacial Sediment?)

56-79 ft.: Lt. grey cuttings; BEDROCK.



REMARKS (Installation, development) :
8" casing driven to 64 ft.; borehole advanced to 79 ft. to set well.

MATERIALS: 10 FT 4" SCH 40 PVC SCREEN; 70 FT 4" SCH 40 PVC RISER; 65 FT 8" STEEL CASING; 3 BAGS #1 MORIE SAND; 11 BAGS PORTLAND CEMENT; 1 BUCKET BENTONITE PELLETS; I BOTTOM CAP; 1 STANDPIPE W/ LOCK.

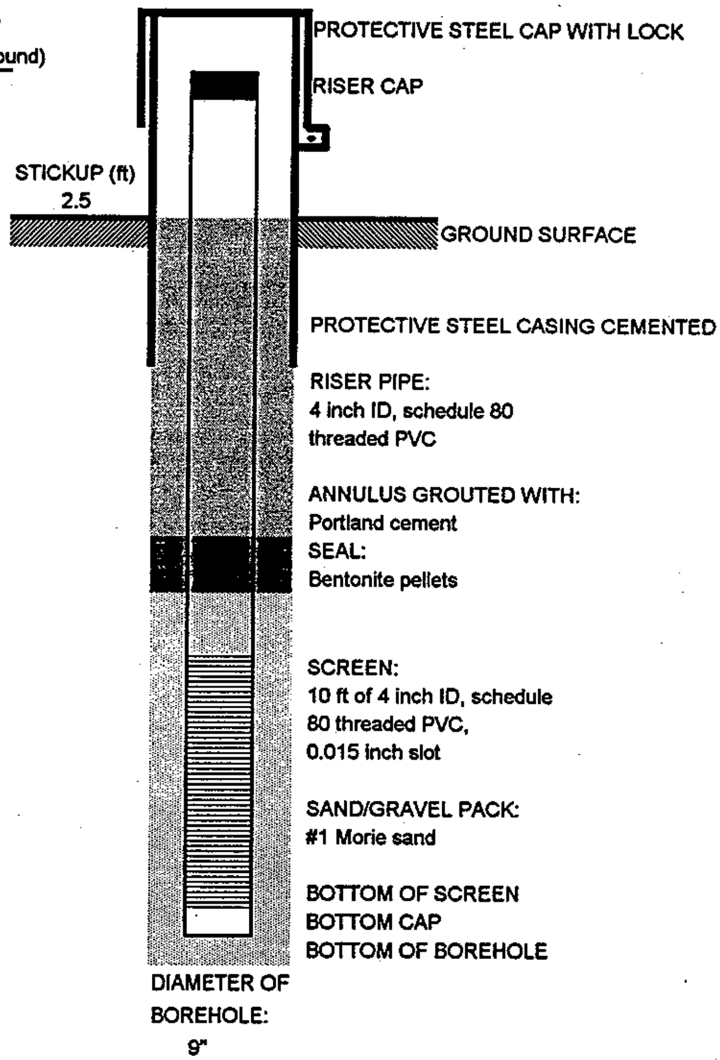
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

CONSTRUCTION OF WELL / PIEZOMETER **MW-122**

Project name & location PELHAM BAY LANDFILL, BRONX, NEW YORK	***Well lock No.*** 3220	***Elevation datum*** Bronx Datum (BD) 2.608 ft, above MSL.
Drilling company WARREN-GEORGE INC.	***Surveyor*** ETTLINGER & ETTLINGER	***Ground elevation*** 9.54 ft
Date and time of completion 6/2/92	***Northing*** 28967.069	***Top of protective steel casing elevation*** 12.04 ft
Inspector B. Atkinson	***Easting*** -19311.343	***Top of riser pipe elevation*** 11.68 ft

A = Top of Riser
B = Ground Surface
C = Top of Bentonite Seal
D = Top of Sand Pack
E = Top of Screen
F = Bottom of Screen
G = Bottom of PVC/Steel
H = Bottom of Borehole

GENERALIZED SOIL DESCRIPTION	ELEV. (ft above/ below BD)		DEPTHS (ft below/ above ground)
	11.68	A	2.14
	9.54	B	0
0-26 ft.: Brownish-dk. grey gravelly cuttings.			
26-28 ft.: Dk. grey-black SILT.	-11.46	C	21
	-14.46	D	24
	-17.46	E	27
28-37 ft.: Lt. brown fine SAND.			
	-27.46	F	37
	-27.46	G	37
	-27.46	H	37



REMARKS (Installation, development) :
30 FT. OF SCH 80 4" PVC RISER, 10 FT. OF SCH 80 4" PVC SCREEN, 1 BUCKET OF BENTONITE PELLETS, 5 BAGS OF #1 SAND, 4 BAGS OF PORTLAND CEMENT, 2 SCH 80 PVC BOTTOM/TOP CAPS.

Appendix U

Groundwater Well Sampling Log

GROUNDWATER ELEVATION CALCULATION SHEET
PELHAM BAY LANDFILL, BRONX, NEW YORK

Date ______________ **Time** ________________________

Measurer ______________

Well Number	Top of Well Elevation**	Depth to Groundwater (ft)	Water Table Elev.
MW – 104	19.132		
MW – 106	18.388		
MW – 109	23.952		
MW – 110	20.013		
MW – 113	14.442		
MW – 114	14.66		
MW – 115	24.807		
MW – 115B	24.876		
MW – 117 *	8.077		
MW – 117B *	Can't locate		
MW – 118	19.113		
MW – 119	20.421		
MW – 120	18.838		
MW – 120B	19.296		
MW – 121	15.621		
MW – 122	17.575		
MW – 124 *	Can't locate		
MW – 124B *	Can't locate		
MW – 126 (PZ-5)	Can't locate		
PZ-A	11.951		
PZ-B *	14.254		
PZ-C	11.374		
PZ-D *	12.411		
PZ-E	9.545		
PZ-F	9.645		

* MW -117, MW-117B, MW-124, MW-124B, PZ-B & PZ-D
are located outside landfill on Pelham park side

** Wells re-surveyed in July 2006

GROUNDWATER ELEVATION LOG
PELHAM BAY LANDFILL, BRONX, NEW YORK

Date ____________________ **Measurer** ______________________________

GROUNDWATER ELEVATION			
Well Number	**Time**	**Elevation (ft) ***	**Comments**
MW – 104		19.132	
MW – 106		18.388	
MW – 109		23.952	
MW – 110		20.013	
MW – 113		14.442	
MW – 114		14.66	
MW – 115		24.807	
MW – 115B		24.876	
MW – 117		8.077	
MW – 117B		--	
MW – 118		19.113	
MW – 119		20.421	
MW – 120		18.838	
MW – 120B		19.296	
MW – 121		15.621	
MW – 122		17.575	
MW – 124		--	
MW – 124B		--	
MW – 126 (PZ-5)		--	
PZ-A		11.951	
PZ-B		14.254	
PZ-C		11.374	
PZ-D		12.411	
PZ-E		9.545	
PZ-F		9.645	

PZ-A, PZ-C, and PZ-E are piezometer wells upstream of slurry wall
PZ-B, PZ-D, and PZ-F are piezometer wells downstream of slurry wall

*** ALL ELEVATIONS REFER TO BRONX HIGHWAY DATUM, WHICH IS 2.608 FEET ABOVE MEAN SEA LEVEL AT SANDY HOOK, NEW JERSEY AS ESTABLISHED BY U.S. COAST AND GEODETIC SURVEY.**

Appendix V

Groundwater Sample Collection
Protocol Modifications

APPENDIX V

GROUNDWATER SAMPLE COLLECTION PROTOCOL MODIFICATIONS

This document describes the modifications to the groundwater sample collection protocols provided in Volume III of the Operation, Maintenance and Monitoring (OM&M) Manual (see Appendix K of this SMP) to address the tidally-influenced nature of groundwater at the Site and deletion of the requirement to gauge for the presence of non-aqueous phase liquid (NAPL). Two groundwater sample collection protocols are provided as Appendix D (Groundwater Sample Collection Using Bailers) and Appendix E (Groundwater Sample Collection Using Low-Flow Rate Purging and Sampling Technique) in Volume III of the OM&M Manual. Additionally, Appendix C of Volume III of the OM&M Manual provides the Long-Term Monitoring Program Sampling and Analysis Plan, which provides general guidance for groundwater sample collection. The general modifications provided herein apply to both groundwater sample collection protocols and the protocol-specific modifications for each technique are described below.

<u>General Groundwater Sample Collection Protocol Modifications</u>

One of the primary objectives of the groundwater monitoring program is to obtain representative groundwater samples (i.e., to characterize groundwater quality during periods when the groundwater is not significantly mixed with surface water from Eastchester Bay). Since the groundwater at the Site is tidally-influenced (i.e., groundwater mixes with surface water from Eastchester Bay during flood [incoming] tide), groundwater samples collected during the incoming and high tides may result in lower concentrations of aqueous species in the groundwater due to dilution. Therefore, groundwater samples will be collected from the monitoring well network during ebb (i.e., outgoing) tide, but prior to low tide conditions (i.e., between approximately 3 to 5 hours following high tide). Collecting groundwater samples during this period should yield samples that are representative of groundwater quality and allow for a sufficient amount of water column to be present in the monitoring wells for well purging and sampling activities. Monitoring wells that generally have a smaller water column height, and therefore less groundwater available for purging and sampling, will be sampled during the earlier part of the ebb tide (i.e., between 3 to 4 hours following high tide). Monitoring wells that generally have a greater water column height will be sampled during the later part of the ebb tide (i.e., between 4 to 5 hours following high tide).

Based on historical NAPL gauging and groundwater quality data (i.e., NAPL has not been detected at the Site and concentrations of aqueous species in the groundwater are not indicative of the presence of NAPL), the monitoring well network will no longer be gauged for the presence of NAPL during the groundwater sampling events. Water-level measurements will be collected from the monitoring well network using an electronic water-level indicator. However, if NAPL is visually observed during purging activities, or if concentrations of aqueous species in the groundwater significantly increase, NAPL gauging will be conducted.

__Low-Flow Rate Purging and Sampling Technique Modifications__

1. The low-flow rate purging and sampling protocol indicates that dedicated gas-operated stainless steel and Teflon bladder pumps (equipped with Teflon or Teflon lined polyethylene tubing) will be used for well purging and sample collection. Bladder pumps will no longer be used during low-flow rate purging and sampling. Alternative well sampling pumps will be used including, but not limited to, submersible pumps (e.g., Grundfos Redi-Flo2, ProActive Monsoon) or peristaltic pumps. Polyethylene tubing will be used and will be dedicated to each monitoring well. The tubing will be replaced in each well as necessary. The submersible pump may be dedicated to the monitoring well or may be portable and used in different monitoring wells. A peristaltic pump will generally be used to purge and sample monitoring wells with a low yield. If a peristaltic pump is used, all sample parameters will be collected directly from the pump discharge with the exception of the volatile organic compound (VOC) sample. The VOC sample will be collected using a disposable polyethylene bailer after all other sample parameters have been collected.

2. The groundwater purging and sampling will be conducted in accordance with United States Environmental Protection Agency (EPA) low-flow (minimal drawdown) groundwater sampling procedures (see attached EPA April 1996 document).

3. Water-level measurements will be collected from the monitoring well and the total depth of the well will be measured (i.e., sounded) using a measuring tape before well purging and sampling activities begin.

4. Well purging flow rates will not exceed 500 milliliters per minute (mL/min) in order to minimize drawdown in the well. The flow rate will be adjusted (i.e., lowered) as necessary with the goal of not exceeding 0.3 feet of drawdown during purging. This goal may be difficult to achieve in some monitoring wells due to geologic heterogeneities within the screened interval (i.e., less transmissive formation). As discussed previously, peristaltic pumps may be used to sample monitoring wells with a low yield.

5. With respect to the monitoring of turbidity during well purging, the well is considered stabilized and ready for sample collection when the turbidity is 50 nephelometric turbidity units (NTUs) or less. The stabilization of turbidity is required along with the other field parameters that are to be monitored during well purging: pH, temperature, specific conductance, oxidation-reduction potential (ORP), and dissolved oxygen (DO).

6. The monitoring wells will be purged until the water quality indicator parameters have stabilized, as discussed in the low-flow rate purging and sampling protocol. However, if the stabilization criteria cannot be achieved after 1 hour of purging, then the groundwater sample will be collected following 1 hour of purging.

7. The polyethylene tubing will be disconnected from the flow-through cell prior to sample collection and the groundwater sample will be collected directly from the submersible pump discharge (i.e., prior to the flow-through cell). This will preclude the need to decontaminate

the flow-through cell between well locations. Groundwater samples will not be collected from the flow-through cell discharge.

8. If a submersible pump is dedicated to a monitoring well, then decontamination of the equipment will not be necessary. Non-dedicated equipment will be decontaminated as follows: Rinse equipment with Micro-90 low-phosphate detergent (or equivalent) and potable water solution and scrub with a brush. Rinse equipment with distilled/deionized rinse water.

Bailer Purging and Sampling Technique Modifications

1. The existing OM&M Manual procedures for bailer purging and sampling protocol indicates that a stainless steel or Teflon bailer will be used for well purging and sample collection. Additionally, a disposable polyethylene bailer will also be permitted for well purging and sample collection. A new or dedicated disposable polyethylene bailer will be used at each well where bailer purging and sampling techniques are being employed during each sampling event. Therefore, there will be no decontamination activities associated with bailer purging and sampling.

2. As discussed previously, NAPL has not been detected at the Site. Therefore, there is no need to initially lower the bailer partially into the water column and decant groundwater from the bailer into a glass container for observation of oil sheens.

3. The bailer purging and sampling protocol indicates that 5 well volumes will be purged prior to sample collection, assuming that the well has not been bailed dry. Alternatively, 3 well volumes will now be purged prior to sample collection.

4. The total depth of the well will be measured (i.e., sounded) using a measuring tape after well purging and sampling activities have been completed.

United States Environmental Protection Agency | Office of Research and Development | Office of Solid Waste and Emergency Response | EPA/540/S-95/504 April 1996

EPA Ground Water Issue

LOW-FLOW (MINIMAL DRAWDOWN) GROUND-WATER SAMPLING PROCEDURES

by Robert W. Puls[1] and Michael J. Barcelona[2]

Background

The Regional Superfund Ground Water Forum is a group of ground-water scientists, representing EPA's Regional Superfund Offices, organized to exchange information related to ground-water remediation at Superfund sites. One of the major concerns of the Forum is the sampling of ground water to support site assessment and remedial performance monitoring objectives. This paper is intended to provide background information on the development of low-flow sampling procedures and its application under a variety of hydrogeologic settings. It is hoped that the paper will support the production of standard operating procedures for use by EPA Regional personnel and other environmental professionals engaged in ground-water sampling.

For further information contact: Robert Puls, 405-436-8543, Subsurface Remediation and Protection Division, NRMRL, Ada, Oklahoma.

I. Introduction

The methods and objectives of ground-water sampling to assess water quality have evolved over time. Initially the emphasis was on the assessment of water quality of aquifers as sources of drinking water. Large water-bearing units were identified and sampled in keeping with that objective. These were highly productive aquifers that supplied drinking water via private wells or through public water supply systems. Gradually, with the increasing awareness of subsurface pollution of these water resources, the understanding of complex hydrogeochemical processes which govern the fate and transport of contaminants in the subsurface increased. This increase in understanding was also due to advances in a number of scientific disciplines and improvements in tools used for site characterization and ground-water sampling. Ground-water quality investigations where pollution was detected initially borrowed ideas, methods, and materials for site characterization from the water supply field and water analysis from public health practices. This included the materials and manner in which monitoring wells were installed and the way in which water was brought to the surface, treated, preserved and analyzed. The prevailing conceptual ideas included convenient generalizations of ground-water resources in terms of large and relatively homogeneous hydrologic *units*. With time it became apparent that conventional water supply generalizations of *homogeneity* did not adequately represent field data regarding pollution of these subsurface resources. The important role of *heterogeneity* became increasingly clear not only in geologic terms, but also in terms of complex physical,

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Communication Training Technology Support — Technology Support Project

Superfund Technology Support Center for Ground Water

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Walter W. Kovalick, Jr., Ph.D.
Director

chemical and biological subsurface processes. With greater appreciation of the role of heterogeneity, it became evident that subsurface pollution was ubiquitous and encompassed the unsaturated zone to the deep subsurface and included unconsolidated sediments, fractured rock, and *aquitards* or low-yielding or impermeable formations. Small-scale processes and heterogeneities were shown to be important in identifying contaminant distributions and in controlling water and contaminant flow paths.

It is beyond the scope of this paper to summarize all the advances in the field of ground-water quality investigations and remediation, but two particular issues have bearing on ground-water sampling today: aquifer heterogeneity and colloidal transport. Aquifer heterogeneities affect contaminant flow paths and include variations in geology, geochemistry, hydrology and microbiology. As methods and the tools available for subsurface investigations have become increasingly sophisticated and understanding of the subsurface environment has advanced, there is an awareness that in most cases a primary concern for site investigations is characterization of contaminant flow paths rather than entire aquifers. In fact, in many cases, plume thickness can be less than well screen lengths (e.g., 3-6 m) typically installed at hazardous waste sites to detect and monitor plume movement over time. Small-scale differences have increasingly been shown to be important and there is a general trend toward smaller diameter wells and shorter screens.

The hydrogeochemical significance of colloidal-size particles in subsurface systems has been realized during the past several years (Gschwend and Reynolds, 1987; McCarthy and Zachara, 1989; Puls, 1990; Ryan and Gschwend, 1990). This realization resulted from both field and laboratory studies that showed faster contaminant migration over greater distances and at higher concentrations than flow and transport model predictions would suggest (Buddemeier and Hunt, 1988; Enfield and Bengtsson, 1988; Penrose et al., 1990). Such models typically account for interaction between the mobile aqueous and immobile solid phases, but do not allow for a mobile, reactive solid phase. It is recognition of this third *phase* as a possible means of contaminant transport that has brought increasing attention to the manner in which samples are collected and processed for analysis (Puls et al., 1990; McCarthy and Degueldre, 1993; Backhus et al., 1993; U. S. EPA, 1995). If such a phase is present in sufficient mass, possesses high sorption reactivity, large surface area, and remains stable in suspension, it can serve as an important mechanism to facilitate contaminant transport in many types of subsurface systems.

Colloids are particles that are sufficiently small so that the surface free energy of the particle dominates the bulk free energy. Typically, in ground water, this includes particles with diameters between 1 and 1000 nm. The most commonly observed mobile particles include: secondary clay minerals; hydrous iron, aluminum, and manganese oxides; dissolved and particulate organic materials, and viruses and bacteria. These reactive particles have been shown to be mobile under a variety of conditions in both field studies and laboratory column experiments, and as such need to be included in monitoring programs where identification of the *total* mobile contaminant loading (dissolved + naturally suspended particles) at a site is an objective. To that end, sampling methodologies must be used which do not artificially bias *naturally* suspended particle concentrations.

Currently the most common ground-water purging and sampling methodology is to purge a well using bailers or high speed pumps to remove 3 to 5 casing volumes followed by sample collection. This method can cause adverse impacts on sample quality through collection of samples with high levels of turbidity. This results in the inclusion of otherwise immobile artifactual particles which produce an overestimation of certain analytes of interest (e.g., metals or hydrophobic organic compounds). Numerous documented problems associated with filtration (Danielsson, 1982; Laxen and Chandler, 1982; Horowitz et al., 1992) make this an undesirable method of rectifying the turbidity problem, and include the removal of potentially mobile (contaminant-associated) particles during filtration, thus artificially biasing contaminant concentrations low. Sampling-induced turbidity problems can often be mitigated by using low-flow purging and sampling techniques.

Current subsurface conceptual models have undergone considerable refinement due to the recent development and increased use of field screening tools. So-called hydraulic *push* technologies (e.g., cone penetrometer, Geoprobe®, QED HydroPunch®) enable relatively fast screening site characterization which can then be used to design and install a monitoring well network. Indeed, alternatives to conventional monitoring wells are now being considered for some hydrogeologic settings. The ultimate design of any monitoring system should however be based upon adequate site characterization and be consistent with established monitoring objectives.

If the sampling program objectives include accurate assessment of the magnitude and extent of subsurface contamination over time and/or accurate assessment of subsequent remedial performance, then some information regarding plume delineation in three-dimensional space is necessary prior to monitoring well network design and installation. This can be accomplished with a variety of different tools and equipment ranging from hand-operated augers to screening tools mentioned above and large drilling rigs. Detailed information on ground-water flow velocity, direction, and horizontal and vertical variability are essential baseline data requirements. Detailed soil and geologic data are required prior to and during the installation of sampling points. This includes historical as well as detailed soil and geologic logs which accumulate during the site investigation. The use of borehole geophysical techniques is also recommended. With this information (together with other site characterization data) and a clear understanding of sampling objectives, then appropriate location, screen length, well diameter, slot size, etc. for the monitoring well network can be decided. This is especially critical for new in situ remedial approaches or natural attenuation assessments at hazardous waste sites.

In general, the overall goal of any ground-water sampling program is to collect water samples with no alteration in water chemistry; analytical data thus obtained may be used for a variety of specific monitoring programs depending on the regulatory requirements. The sampling methodology described in this paper assumes that the monitoring goal is to sample monitoring wells for the presence of contaminants and it is applicable whether mobile colloids are a concern or not and whether the analytes of concern are metals (and metalloids) or organic compounds.

II. Monitoring Objectives and Design Considerations

The following issues are important to consider prior to the design and implementation of any ground-water monitoring program, including those which anticipate using low-flow purging and sampling procedures.

A. Data Quality Objectives (DQOs)

Monitoring objectives include four main types: detection, assessment, corrective-action evaluation and resource evaluation, along with *hybrid* variations such as site-assessments for property transfers and water availability investigations. Monitoring objectives may change as contamination or water quality problems are discovered. However, there are a number of common components of monitoring programs which should be recognized as important regardless of initial objectives. These components include:

1) Development of a conceptual model that incorporates elements of the regional geology to the local geologic framework. The conceptual model development also includes initial site characterization efforts to identify hydrostratigraphic units and likely flow-paths using a minimum number of borings and well completions;

2) Cost-effective and well documented collection of high quality data utilizing simple, accurate, and reproducible techniques; and

3) Refinement of the conceptual model based on supplementary data collection and analysis.

These fundamental components serve many types of monitoring programs and provide a basis for future efforts that evolve in complexity and level of spatial detail as purposes and objectives expand. High quality, reproducible data collection is a common goal regardless of program objectives.

High quality data collection implies data of sufficient accuracy, precision, and completeness (i.e., ratio of valid analytical results to the minimum sample number called for by the program design) to meet the program objectives. Accuracy depends on the correct choice of monitoring tools and procedures to minimize sample and subsurface disturbance from collection to analysis. Precision depends on the repeatability of sampling and analytical protocols. It can be assured or improved by replication of sample analyses including blanks, field/lab standards and reference standards.

B. Sample Representativeness

An important goal of any monitoring program is collection of data that is truly representative of conditions at the site. The term *representativeness* applies to chemical and hydrogeologic data collected via wells, borings, piezometers, geophysical and soil gas measurements, lysimeters, and temporary sampling points. It involves a recognition of the statistical variability of individual subsurface physical properties, and contaminant or major ion concentration levels, while explaining extreme values. Subsurface temporal and spatial variability are facts. Good professional practice seeks to maximize representativeness by using proven accurate and reproducible techniques to define limits on the distribution of measurements collected at a site. However, measures of representativeness are dynamic and are controlled by evolving site characterization and monitoring objectives. An evolutionary site characterization model, as shown in Figure 1, provides a systematic approach to the goal of consistent data collection.

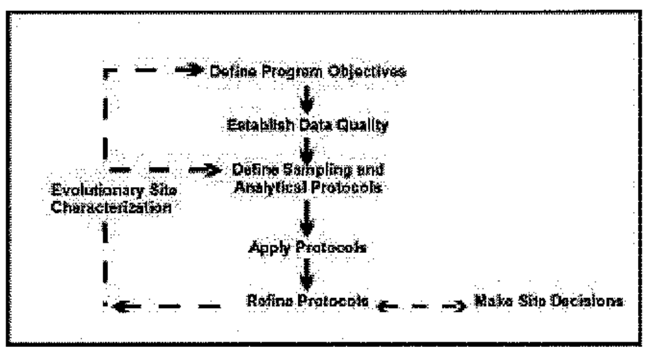

Figure 1. Evolutionary Site Characterization Model

The model emphasizes a recognition of the causes of the variability (e.g., use of inappropriate technology such as using bailers to purge wells; imprecise or operator-dependent methods) and the need to control avoidable errors.

1) Questions of Scale

A sampling plan designed to collect representative samples must take into account the potential scale of changes in site conditions through space and time as well as the chemical associations and behavior of the parameters that are targeted for investigation. In subsurface systems, physical (i.e., aquifer) and chemical properties over time or space are not statistically independent. In fact, samples taken in close proximity (i.e., within distances of a few meters) or within short time periods (i.e., more frequently than monthly) are highly auto-correlated. This means that designs employing high-sampling frequency (e.g., monthly) or dense spatial monitoring designs run the risk of redundant data collection and misleading inferences regarding trends in values that aren't statistically valid. In practice, contaminant detection and assessment monitoring programs rarely suffer these *over-sampling* concerns. In corrective-action evaluation programs, it is also possible that too little data may be collected over space or time. In these cases, false interpretation of the spatial extent of contamination or underestimation of temporal concentration variability may result.

2) Target Parameters

Parameter selection in monitoring program design is most often dictated by the regulatory status of the site. However, background water quality constituents, purging indicator parameters, and contaminants, all represent targets for data collection programs. The tools and procedures used in these programs should be equally rigorous and applicable to all categories of data, since all may be needed to determine or support regulatory action.

C. Sampling Point Design and Construction

Detailed site characterization is central to all decision-making purposes and the basis for this characterization resides in identification of the geologic framework and major hydro-stratigraphic units. Fundamental data for sample point location include: subsurface lithology, head-differences and background geochemical conditions. Each sampling point has a proper use or uses which should be documented at a level which is appropriate for the program's data quality objectives. Individual sampling points may not always be able to fulfill multiple monitoring objectives (e.g., detection, assessment, corrective action).

1) Compatibility with Monitoring Program and Data Quality Objectives

Specifics of sampling point location and design will be dictated by the complexity of subsurface lithology and variability in contaminant and/or geochemical conditions. It should be noted that, regardless of the ground-water sampling approach, few sampling points (e.g., wells, drive-points, screened augers) have zones of influence in excess of a few feet. Therefore, the spatial frequency of sampling points should be carefully selected and designed.

2) Flexibility of Sampling Point Design

In most cases *well-point* diameters in excess of 1 7/8 inches will permit the use of most types of submersible pumping devices for low-flow (minimal drawdown) sampling. It is suggested that *short* (e.g., less than 1.6 m) screens be incorporated into the monitoring design where possible so that comparable results from one device to another might be expected. *Short*, of course, is relative to the degree of vertical water quality variability expected at a site.

3) Equilibration of Sampling Point

Time should be allowed for equilibration of the well or sampling point with the formation after installation. Placement of well or sampling points in the subsurface produces some disturbance of ambient conditions. Drilling techniques (e.g., auger, rotary, etc.) are generally considered to cause more disturbance than *direct-push* technologies. In either case, there may be a period (i.e., days to months) during which water quality near the point may be distinctly different from that in the formation. Proper development of the sampling point and adjacent formation to remove fines created during emplacement will shorten this water quality *recovery* period.

III. Definition of Low-Flow Purging and Sampling

It is generally accepted that water in the well casing is non-representative of the formation water and needs to be purged prior to collection of ground-water samples. However, the water in the screened interval may indeed be representative of the formation, depending upon well construction and site hydrogeology. Wells are purged to some extent for the following reasons: the presence of the air interface at the top of the water column resulting in an oxygen concentration gradient with depth, loss of volatiles up the water column, leaching from or sorption to the casing or filter pack, chemical changes due to clay seals or backfill, and surface infiltration.

Low-flow purging, whether using portable or dedicated systems, should be done using pump-intake located in the middle or slightly above the middle of the screened interval. Placement of the pump too close to the bottom of the well will cause increased entrainment of solids which have collected in the well over time. These particles are present as a result of well development, prior purging and sampling events, and natural colloidal transport and deposition. Therefore, placement of the pump in the middle or toward the top of the screened interval is suggested. Placement of the pump at the top of the water column for sampling is only recommended in unconfined aquifers, screened across the water table, where this is the desired sampling point. Low-flow purging has the advantage of minimizing mixing between the overlying stagnant casing water and water within the screened interval.

A. Low-Flow Purging and Sampling

Low-flow refers to the velocity with which water enters the pump intake and that is imparted to the formation pore water in the immediate vicinity of the well screen. It does not necessarily refer to the flow rate of water discharged at the surface which can be affected by flow regulators or restrictions. Water level drawdown provides the best indication of the stress imparted by a given flow-rate for a given hydrological situation. The objective is to pump in a manner that minimizes stress (drawdown) to the system to the extent practical taking into account established site sampling objectives. Typically, flow rates on the order of 0.1 - 0.5 L/min are used, however this is dependent on site-specific hydrogeology. Some extremely coarse-textured formations have been successfully sampled in this manner at flow rates to 1 L/min. The effectiveness of using low-flow purging is intimately linked with proper screen location, screen length, and well construction and development techniques. The reestablishment of natural flow paths in both the vertical and horizontal directions is important for correct interpretation of the data. For high resolution sampling needs, screens less than 1 m should be used. Most of the need for purging has been found to be due to passing the sampling device through the overlying casing water which causes mixing of these stagnant waters and the dynamic waters within the screened interval. Additionally, there is disturbance to suspended sediment collected in the bottom of the casing and the displacement of water out into the formation immediately adjacent to the well screen. These disturbances and impacts can be avoided using dedicated sampling equipment, which precludes the need to insert the sampling device prior to purging and sampling.

Isolation of the screened interval water from the overlying stagnant casing water may be accomplished using low-flow minimal drawdown techniques. If the pump intake is located within the screened interval, most of the water pumped will be drawn in directly from the formation with little mixing of casing water or disturbance to the sampling zone. However, if the wells are not constructed and developed properly, zones other than those intended may be sampled. At some sites where geologic heterogeneities are sufficiently different within the screened interval, higher conductivity zones may be preferentially sampled. This is another reason to use shorter screened intervals, especially where high spatial resolution is a sampling objective.

B. Water Quality Indicator Parameters

It is recommended that water quality indicator parameters be used to determine purging needs prior to sample collection in each well. Stabilization of parameters such as pH, specific conductance, dissolved oxygen, oxidation-reduction potential, temperature and turbidity should be used to determine when formation water is accessed during purging. In general, the order of stabilization is pH, temperature, and specific conductance, followed by oxidation-reduction potential, dissolved oxygen and turbidity. Temperature and pH, while commonly used as purging indicators, are actually quite insensitive in distinguishing between formation water and stagnant casing water; nevertheless, these are important parameters for data interpretation purposes and should also be measured. Performance criteria for determination of stabilization should be based on water-level drawdown, pumping rate and equipment specifications for measuring indicator parameters. Instruments are available which utilize in-line flow cells to continuously measure the above parameters.

It is important to establish specific well stabilization criteria and then consistently follow the same methods thereafter, particularly with respect to drawdown, flow rate and sampling device. Generally, the time or purge volume required for parameter stabilization is independent of well depth or well volumes. Dependent variables are well diameter, sampling device, hydrogeochemistry, pump flow rate, and whether the devices are used in a portable or dedicated manner. If the sampling device is already in place (i.e., dedicated sampling systems), then the time and purge volume needed for stabilization is much shorter. Other advantages of dedicated equipment include less purge water for waste disposal, much less decontamination of equipment, less time spent in preparation of sampling as well as time in the field, and more consistency in the sampling approach which probably will translate into less variability in sampling results. The use of dedicated equipment is strongly recommended at wells which will undergo routine sampling over time.

If parameter stabilization criteria are too stringent, then minor oscillations in indicator parameters may cause purging operations to become unnecessarily protracted. It should also be noted that turbidity is a very conservative parameter in terms of stabilization. Turbidity is always the last parameter to stabilize. Excessive purge times are invariably related to the establishment of too stringent turbidity stabilization criteria. It should be noted that natural turbidity levels in ground water may exceed 10 nephelometric turbidity units (NTU).

C. Advantages and Disadvantages of Low-Flow (Minimum Drawdown) Purging

In general, the advantages of low-flow purging include:

- samples which are representative of the *mobile* load of contaminants present (dissolved and colloid-associated);
- minimal disturbance of the sampling point thereby minimizing sampling artifacts;
- less operator variability, greater operator control;

- reduced stress on the formation (minimal drawdown);
- less mixing of stagnant casing water with formation water;
- reduced need for filtration and, therefore, less time required for sampling;
- smaller purging volume which decreases waste disposal costs and sampling time;
- better sample consistency; reduced artificial sample variability.

Some disadvantages of low-flow purging are:
- higher initial capital costs,
- greater set-up time in the field,
- need to transport additional equipment to and from the site,
- increased training needs,
- resistance to change on the part of sampling practitioners,
- concern that new data will indicate a *change in conditions* and trigger an *action.*

IV. Low-Flow (Minimal Drawdown) Sampling Protocols

The following ground-water sampling procedure has evolved over many years of experience in ground-water sampling for organic and inorganic compound determinations and as such summarizes the authors' (and others) experiences to date (Barcelona et al., 1984, 1994; Barcelona and Helfrich, 1986; Puls and Barcelona, 1989; Puls et. al. 1990, 1992; Puls and Powell, 1992; Puls and Paul, 1995). High-quality chemical data collection is essential in ground-water monitoring and site characterization. The primary limitations to the collection of *representative* ground-water samples include: mixing of the stagnant casing and *fresh* screen waters during insertion of the sampling device or ground-water level measurement device; disturbance and resuspension of settled solids at the bottom of the well when using high pumping rates or raising and lowering a pump or bailer; introduction of atmospheric gases or degassing from the water during sample handling and transfer, or inappropriate use of vacuum sampling device, etc.

A. Sampling Recommendations

Water samples should not be taken immediately following well development. Sufficient time should be allowed for the ground-water flow regime in the vicinity of the monitoring well to stabilize and to approach chemical equilibrium with the well construction materials. This lag time will depend on site conditions and methods of installation but often exceeds one week.

Well purging is nearly always necessary to obtain samples of water flowing through the geologic formations in the screened interval. Rather than using a general but arbitrary guideline of purging three casing volumes prior to sampling, it is recommended that an in-line water quality measurement device (e.g., flow-through cell) be used to establish the stabilization time for several parameters (e.g. , pH, specific conductance, redox, dissolved oxygen, turbidity) on a well-specific basis. Data on pumping rate, drawdown, and volume required for parameter stabilization can be used as a guide for conducting subsequent sampling activities.

The following are recommendations to be considered before, during and after sampling:
- use low-flow rates (<0.5 L/min), during both purging and sampling to maintain minimal drawdown in the well;
- maximize tubing wall thickness, minimize tubing length;
- place the sampling device intake at the desired sampling point;
- minimize disturbances of the stagnant water column above the screened interval during water level measurement and sampling device insertion;
- make proper adjustments to stabilize the flow rate as soon as possible;
- monitor water quality indicators during purging;
- collect unfiltered samples to estimate contaminant loading and transport potential in the subsurface system.

B. Equipment Calibration

Prior to sampling, all sampling device and monitoring equipment should be calibrated according to manufacturer's recommendations and the site Quality Assurance Project Plan (QAPP) and Field Sampling Plan (FSP). Calibration of pH should be performed with at least two buffers which bracket the expected range. Dissolved oxygen calibration must be corrected for local barometric pressure readings and elevation.

C. Water Level Measurement and Monitoring

It is recommended that a device be used which will least disturb the water surface in the casing. Well depth should be obtained from the well logs. Measuring to the bottom of the well casing will only cause resuspension of settled solids from the formation and require longer purging times for turbidity equilibration. Measure well depth after sampling is completed. The water level measurement should be taken from a permanent reference point which is surveyed relative to ground elevation.

D. Pump Type

The use of low-flow (e.g., 0.1-0.5 L/min) pumps is suggested for purging and sampling all types of analytes. All pumps have some limitation and these should be investigated with respect to application at a particular site. Bailers are inappropriate devices for low-flow sampling.

1) General Considerations

There are no unusual requirements for ground-water sampling devices when using low-flow, minimal drawdown techniques. The major concern is that the device give consistent results and minimal disturbance of the sample across a range of *low* flow rates (i.e., < 0.5 L/min). Clearly, pumping rates that cause minimal to no drawdown in one well could easily cause *significant* drawdown in another well finished in a less transmissive formation. In this sense, the pump should not cause undue pressure or temperature changes or physical disturbance on the water sample over a reasonable sampling range. Consistency in operation is critical to meet accuracy and precision goals.

2) Advantages and Disadvantages of Sampling Devices

A variety of sampling devices are available for low-flow (minimal drawdown) purging and sampling and include peristaltic pumps, bladder pumps, electrical submersible pumps, and gas-driven pumps. Devices which lend themselves to both dedication and consistent operation at definable low-flow rates are preferred. It is desirable that the pump be easily adjustable and operate reliably at these lower flow rates. The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and some volatiles loss. Gas-driven pumps should be of a type that does not allow the gas to be in direct contact with the sampled fluid.

Clearly, bailers and other *grab* type samplers are ill-suited for low-flow sampling since they will cause repeated disturbance and mixing of *stagnant* water in the casing and the *dynamic* water in the screened interval. Similarly, the use of inertial lift foot-valve type samplers may cause too much disturbance at the point of sampling. Use of these devices also tends to introduce uncontrolled and unacceptable operator variability.

Summaries of advantages and disadvantages of various sampling devices are listed in Herzog et al. (1991), U. S. EPA (1992), Parker (1994) and Thurnblad (1994).

E. Pump Installation

Dedicated sampling devices (left in the well) capable of pumping and sampling are preferred over <u>any</u> other type of device. Any portable sampling device should be slowly and carefully lowered to the middle of the screened interval or slightly above the middle (e.g., 1-1.5 m below the top of a 3 m screen). This is to minimize excessive mixing of the stagnant water in the casing above the screen with the screened interval zone water, and to minimize resuspension of solids which will have collected at the bottom of the well. These two disturbance effects have been shown to directly affect the time required for purging. There also appears to be a direct correlation between size of portable sampling devices relative to the well bore and resulting purge volumes and times. The key is to minimize disturbance of water and solids in the well casing.

F. Filtration

Decisions to filter samples should be dictated by sampling objectives rather than as a *fix* for poor sampling practices, and field-filtering of certain constituents should not be the default. Consideration should be given as to what the application of field-filtration is trying to accomplish. For assessment of truly dissolved (as opposed to operationally *dissolved* [i.e., samples filtered with 0.45 µm filters]) concentrations of major ions and trace metals, 0.1 µm filters are recommended although 0.45 µm filters are normally used for most regulatory programs. Alkalinity samples must also be filtered if significant particulate calcium carbonate is suspected, since this material is likely to impact alkalinity titration results (although filtration itself may alter the CO_2 composition of the sample and, therefore, affect the results).

Although filtration may be appropriate, filtration of a sample may cause a number of unintended changes to occur (e.g. oxidation, aeration) possibly leading to filtration-induced artifacts during sample analysis and uncertainty in the results. Some of these unintended changes may be unavoidable but the factors leading to them must be recognized. Deleterious effects can be minimized by consistent application of certain filtration guidelines. Guidelines should address selection of filter type, media, pore size, etc. in order to identify and minimize potential sources of uncertainty when filtering samples.

In-line filtration is recommended because it provides better consistency through less sample handling, and minimizes sample exposure to the atmosphere. In-line filters are available in both disposable (barrel filters) and non-disposable (in-line filter holder, flat membrane filters) formats and various filter pore sizes (0.1-5.0 µm). Disposable filter cartridges have the advantage of greater sediment handling capacity when compared to traditional membrane filters. Filters must be pre-rinsed following manufacturer's recommendations. If there are no recommendations for rinsing, pass through a minimum of 1 L of ground water following purging and prior to sampling. Once filtration has begun, a filter cake may develop as particles larger than the pore size accumulate on the filter membrane. The result is that the effective pore diameter of the membrane is reduced and particles smaller than the stated pore size are excluded from the filtrate. Possible corrective measures include prefiltering (with larger pore size filters), minimizing particle loads to begin with, and reducing sample volume.

G. Monitoring of Water Level and Water Quality Indicator Parameters

Check water level periodically to monitor drawdown in the well as a guide to flow rate adjustment. The goal is minimal drawdown (<0.1 m) during purging. This goal may be difficult to achieve under some circumstances due to geologic heterogeneities within the screened interval, and may require adjustment based on site-specific conditions and personal experience. In-line water quality indicator parameters should be continuously monitored during purging. The water quality indicator parameters monitored can include pH, redox potential, conductivity, dissolved oxygen (DO) and turbidity. The last three parameters are often most sensitive. Pumping rate, drawdown, and the time or volume required to obtain stabilization of parameter readings can be used as a future guide to purge the well. Measurements should be taken every three to five minutes if the above suggested rates are used. Stabilization is achieved after all parameters have stabilized for three successive readings. In lieu of measuring all five parameters, a minimum subset would include pH, conductivity, and turbidity or DO. Three successive readings should be within ± 0.1 for pH, ± 3% for conductivity, ± 10 mv for redox potential, and ± 10% for turbidity and DO. Stabilized purge indicator parameter trends are generally obvious and follow either an exponential or asymptotic change to stable values during purging. Dissolved oxygen and turbidity usually require the longest time for stabilization. The above stabilization guidelines are provided for rough estimates based on experience.

H. Sampling, Sample Containers, Preservation and Decontamination

Upon parameter stabilization, sampling can be initiated. If an in-line device is used to monitor water quality parameters, it should be disconnected or bypassed during sample collection. Sampling flow rate may remain at established purge rate or may be adjusted slightly to minimize aeration, bubble formation, turbulent filling of sample bottles, or loss of volatiles due to extended residence time in tubing. Typically, flow rates less than 0.5 L/min are appropriate. The same device should be used for sampling as was used for purging. Sampling should occur in a progression from least to most contaminated well, if this is known. Generally, volatile (e.g., solvents and fuel constituents) and gas sensitive (e.g., Fe^{2+}, CH_4, H_2S/HS^-, alkalinity) parameters should be sampled first. The sequence in which samples for most inorganic parameters are collected is immaterial unless filtered (dissolved) samples are desired. Filtering should be done last and in-line filters should be used as discussed above. During both well purging and sampling, proper protective clothing and equipment must be used based upon the type and level of contaminants present.

The appropriate sample container will be prepared in advance of actual sample collection for the analytes of interest and include sample preservative where necessary. Water samples should be collected directly into this container from the pump tubing.

Immediately after a sample bottle has been filled, it must be preserved as specified in the site (QAPP). Sample preservation requirements are based on the analyses being performed (use site QAPP, FSP, RCRA guidance document [U. S. EPA, 1992] or EPA SW-846 [U. S. EPA, 1982]). It may be advisable to add preservatives to sample bottles in a controlled setting prior to entering the field in order to reduce the chances of improperly preserving sample bottles or introducing field contaminants into a sample bottle while adding the preservatives.

The preservatives should be transferred from the chemical bottle to the sample container using a disposable polyethylene pipet and the disposable pipet should be used only once and then discarded.

After a sample container has been filled with ground water, a Teflon™ (or tin)-lined cap is screwed on tightly to prevent the container from leaking. A sample label is filled out as specified in the FSP. The samples should be stored inverted at 4°C.

Specific decontamination protocols for sampling devices are dependent to some extent on the type of device used and the type of contaminants encountered. Refer to the site QAPP and FSP for specific requirements.

I. Blanks

The following blanks should be collected:

(1) field blank: one field blank should be collected from each source water (distilled/deionized water) used for sampling equipment decontamination or for assisting well development procedures.

(2) equipment blank: one equipment blank should be taken prior to the commencement of field work, from each set of sampling equipment to be used for that day. Refer to site QAPP or FSP for specific requirements.

(3) trip blank: a trip blank is required to accompany each volatile sample shipment. These blanks are prepared in the laboratory by filling a 40-mL volatile organic analysis (VOA) bottle with distilled/deionized water.

V. Low-Permeability Formations and Fractured Rock

The overall sampling program goals or sampling objectives will drive how the sampling points are located, installed, and choice of sampling device. Likewise, site-specific hydrogeologic factors will affect these decisions. Sites with very low permeability formations or fractures causing discrete flow channels may require a unique monitoring approach. Unlike water supply wells, wells installed for ground-water quality assessment and restoration programs are often installed in low water-yielding settings (e.g., clays, silts). Alternative types of sampling points and sampling methods are often needed in these types of environments, because low-permeability settings may require extremely low-flow purging (<0.1 L/min) and may be technology-limited. Where devices are not readily available to pump at such low flow rates, the primary consideration is to avoid dewatering of the well screen. This may require repeated recovery of the water during purging while leaving the pump in place within the well screen.

Use of low-flow techniques may be impractical in these settings, depending upon the water recharge rates. The sampler and the end-user of data collected from such wells need to understand the limitations of the data collected; i.e., a strong potential for underestimation of actual contaminant concentrations for volatile organics, potential false negatives for filtered metals and potential false positives for unfiltered metals. It is suggested that comparisons be made between samples recovered using low-flow purging techniques and samples recovered using passive sampling techniques (i.e., two sets of samples). Passive sample collection would essentially entail acquisition of the sample with no or very little purging using a dedicated sampling system installed within the screened interval or a passive sample collection device.

A. Low-Permeability Formations (<0.1 L/min recharge)

1. Low-Flow Purging and Sampling with Pumps

a. "portable or non-dedicated mode" - Lower the pump (one capable of pumping at <0.1 L/min) to mid-screen or slightly above and set in place for minimum of 48 hours (to lessen purge volume requirements). After 48 hours, use procedures listed in Part IV above regarding monitoring water quality parameters for stabilization, etc., but do not dewater the screen. If excessive drawdown and slow recovery is a problem, then alternate approaches such as those listed below may be better.

b. "dedicated mode" - Set the pump as above at least a week prior to sampling; that is, operate in a dedicated pump mode. With this approach significant reductions in purge volume should be realized. Water quality parameters should stabilize quite rapidly due to less disturbance of the sampling zone.

2. Passive Sample Collection

Passive sampling collection requires insertion of the device into the screened interval for a sufficient time period to allow flow and sample equilibration before extraction for analysis. Conceptually, the extraction of water from low yielding formations seems more akin to the collection of water from the unsaturated zone and passive sampling techniques may be more appropriate in terms of obtaining "representative" samples. Satisfying usual sample volume requirements is typically a problem with this approach and some latitude will be needed on the part of regulatory entities to achieve sampling objectives.

B. Fractured Rock

In fractured rock formations, a low-flow to zero purging approach using pumps in conjunction with packers to isolate the sampling zone in the borehole is suggested. Passive multi-layer sampling devices may also provide the most "representative" samples. It is imperative in these settings to identify flow paths or water-producing fractures prior to sampling using tools such as borehole flowmeters and/or other geophysical tools.

After identification of water-bearing fractures, install packer(s) and pump assembly for sample collection using low-flow sampling in "dedicated mode" or use a passive sampling device which can isolate the identified water-bearing fractures.

VI. Documentation

The usual practices for documenting the sampling event should be used for low-flow purging and sampling techniques. This should include, at a minimum: information on the conduct of purging operations (flow-rate, drawdown, water-quality parameter values, volumes extracted and times for measurements), field instrument calibration data, water sampling forms and chain of custody forms. See Figures 2 and 3 and "Ground Water Sampling Workshop -- A Workshop Summary" (U. S. EPA, 1995) for example forms and other documentation suggestions and information. This information coupled with laboratory analytical data and validation data are needed to judge the "useability" of the sampling data.

VII. Notice

The U.S. Environmental Protection Agency through its Office of Research and Development funded and managed the research described herein as part of its in-house research program and under Contract No. 68-C4-0031 to Dynamac Corporation. It has been subjected to the Agency's peer and administrative review and has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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Figure 2. **Ground Water Sampling Log**

Project ______________ **Site** ______________ **Well No.** ____________ **Date** ________________________

Well Depth ___________ **Screen Length** _________ **Well Diameter** ________ **Casing Type** ___________

Sampling Device ______________ **Tubing type** ___________________ **Water Level** ________________

Measuring Point _________________ **Other Infor** ____

____

Sampling Personnel ____

Time	pH	Temp	Cond.	Dis.O_2	Turb.	[ ]Conc			Notes

Type of Samples Collected

____

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3\pi\ r^3$

Figure 3. **Ground Water Sampling Log** (with automatic data logging for most water quality parameters)

Project ______________ **Site** ______________ **Well No.** ____________ **Date** ______________________
Well Depth ___________ **Screen Length** _________ **Well Diameter** ________ **Casing Type** __________
Sampling Device ______________ **Tubing type** ____________________ **Water Level** _______________
Measuring Point _________________ **Other Infor** ____
____
Sampling Personnel ____

Time	Pump Rate	Turbidity	Alkalinity	[ ] Conc	Notes

Type of Samples Collected

____

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3\pi r^3$

Appendix W

NYSDEC Groundwater Monitoring
Well Decommissioning Procedures

GROUNDWATER MONITORING WELL DECOMMISSIONING PROCEDURES

April 2003

New York State Department
of Environmental Conservation

Division of Environmental Remediation

DECOMMISSIONING PROCEDURES

NYS SUPERFUND STANDBY CONTRACT
WORK ASSIGNMENT D002852-10

NPL SITE MONITORING WELL DECOMMISSIONING

NEW YORK STATE DEPARTMENT
OF ENVIRONMENTAL CONSERVATION

MAY 1995
Revised October 1996

0266-317-002

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NYS SUPERFUND STANDBY CONTRACT
NPL SITE MONITORING WELL DECOMMISSIONING

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A	Health and Safety Plan
B	Equipment Decontamination SOPs
C	Construction Inspection Forms
D	Hydraulic Pressure Testing SOP

DISCLAIMER

October 21, 1996

RE: New York State Department of Environmental Conservation
Division of Environmental Remediation
Monitoring Well Decommissioning Procedures

Per your request, the enclosed referenced document is being made available to you for informational purposes. These procedures may be used as a guidance when decommissioning a monitoring well. Please note that this document does not address some site specific special situations that may be encountered in the field. These procedures have not been adopted by the Department of Environmental Conservation. Compliance with the procedures set forth in this document does not relieve any party of the obligation to successfully and satisfactorily decommission a well.

If you have any questions, please contact Ben Loredo, of my staff, at (518) 457-0927.

Sincerely,

Gerald J. Rider, Jr., P.E.
Chief, Operation, Maintenance and Support Section
Bureau of Hazardous Site Control
Division of Environmental Remediation
New York State Department of Environmental Conservation

Enclosure

INTRODUCTION

Malcolm Pirnie, Inc. has developed hazardous waste site monitoring well decommissioning procedures for the New York State Department of Environmental Conservation (NYSDEC) under the New York State Superfund Standby Contract, Work Assignment No. D002852-10. These procedures have been established as a guide for successful decommissioning of wells that are no longer used for monitoring at select National Priorities List (NPL) sites in New York State. A well is successfully decommissioned when:

- Migration of existing or future contaminants into an aquifer or between aquifers cannot occur.
- Migration of existing or future contaminants in the vadose zone cannot occur.
- The potential for vertical or horizontal migration of fluids in the well or adjacent to the well is minimized
- Aquifer yield and hydrostatic ahead are conserved.

The decommissioning procedures are based on NYSDEC-approved methods originally developed by Malcolm Pirnie which entailed an extensive literature search and consultations withe industrial and NYSDEC officials. The literature search included sources from the National Ground Water Association, American Society for Testing and Materials (A.S.T.M.), State and EPA guidance documents, Malcolm Pirnie decommissioning procedures, and various other technical sources. A complete listing of sources is included at the end of these procedures. The industry officials consulted include drilling contractors, equipment suppliers and manufacturers, and A.S.T.M. members on Soil and Rock (D-18) and Water (D-19) committees.

These decommissioning procedures describe criteria for a satisfactorily decommissioning a monitoring well. Selection of a preferred decommissioning method will be dependent on site-specific and location-specified conditions such as the type of aquifer, the mature of the contamination, geological conditions and the type of well construction. Prior to initiating field work, the available site and location-specific data will be collected and reviewed, and a pre-construction inspection of the monitoring well will be conducted to assist in determining the best-suited decommissioning method.

For maximum protection of human health and the environment, any material brought to the surface during the decommissioning process will be treated as a hazardous waste unless sample data indicates otherwise. The selection of disposal methods for these materials will depend on information reported in site investigation reports and analytical characterization of the retrieved materials for hazardous characteristics (see Sections 4.1.3 through 4.1.4). An appropriate procedure will be followed for the physical and hydrologic setting of the well that best protects the environment.

The following sections describe the procedures that will be implemented to properly decommission a well, including the procedure for selecting which decommissioning method will be used. There are eleven elements to be addressed in decommissioning a monitoring well at a hazardous waste site:

1) Reviewing Site Data
2) Selecting the Well Decommissioning Method
3) Preparing a Site-Specific Health and Safety Plan
4) Preparing a Materials Handling and Disposal Plan
5) Establishing Decontamination Procedures
6) Locating and Setting-Up on the Well
7) Removing the Protective Casing
8) Decommissioning of Screen and Riser
9) Selecting, Mixing, and Placing Grout
10) Backfilling and Site Restoration
11) Quality Assurance/Quality Control (QA/QC) Procedures

The proper well decommissioning methods and selection process are presented on the flow chart presented as Plate 1. For each decommissioning method, the specific procedures are determined by (1) geology, (2) contaminants, and (3) well design. For example, decommissioning a well that penetrates a confining layer may require a different approach than decommissioning an unconfined water table well.

1.0 REVIEWING SITE DATA

The first step in selecting the well decommissioning process consists of reviewing all pertinent site information; boring and well logs, field inspection sheets, and laboratory analytical results performed on site soil and groundwater samples. This site information will form the basis for decisions throughout the decommissioning process. Field inspection of the wells prior to decommissioning is also recommended to verify the characteristics and conditions of the wells. Special conditions such as access problems, well extensions through capped and covered landfills, and cap conditions due to seasonal weather patterns should be assessed. At well locations that have been extended, the burial of a previous concrete pad may require the excavation of soil to the top of the concrete pad to remove the well. Decommissioning work requiring the use of heavy vehicular equipment on RCRA landfill caps should be scheduled during dry weather if possible so as to minimize damage to the cover. If work must be performed during the Spring, Winter or inclement weather, special measures such as placement of plywood to reduce ruts should be employed to maintain the integrity of the completed landfill cover system. A sample Monitoring Well Field Inspection Log indicating the minimum information to be collected during field verification activities is included as Figure 1.

2.0 SELECTING THE WELL DECOMMISSIONING METHOD

The primary rationale for well decommissioning is to prevent contaminant migration along the disturbed construction zone created by the original well boring. This requires selection of a decommissioning procedure that takes into account factors such as:

- The hydrogeological conditions at the well site.
- The presence or absence of contamination in the groundwater.
- The original well construction details.

This section presents a summary of the well decommissioning methods and the selection process, which is illustrated in the flow chart presented as Plate 1. The primary well decommissioning procedures consist of:

- Casing pulling.
- Overdrilling.
- Grouting the casing in-place.
- Perforating the casing followed by grouting in-place.

A general discussion of each decommissioning procedure is presented in Sections 2.1 through 2.4.

2.1 CASING PULLING

In general, casing pulling is the preferred method for decommissioning wells where: no contamination is present; contamination is present but the well does not penetrate a confining layer; and when both contamination and a confining layer are present but the contamination cannot cross the confining layer. Additionally, the well construction materials and well depth must be such that pulling can be effected without breaking the riser.

Casing pulling involves removing the well casing by lifting. The procedure for removing the casing must allow grout to be added during pulling. The grout will fill the space once occupied by the material being withdrawn. Grout mixing and placement must be performed according to the procedures in Section 9.0.

An acceptable procedure to remove casing involves puncturing the bottom of the casing, flushing with water to remove sand (if necessary to mitigate lock-up of the casing during pulling), filling the casing with grout tremied from the bottom of the well, using jacks to free casing from the hole, and lifting the casing out by using a drill rig, backhoe, crane, or other suitable equipment. Additional grout must be added to the casing as it is withdrawn. In wells or wellpoints in which the bottom cannot be punctured, the casing or screened interval will be perforated prior to being filled with grout. This procedure should be followed for wells installed in collapsible formations or for highly contaminated wells. At site locations in which the borehole does not collapse it may not be necessary to perforate the well casing prior to pulling the well (i.e., grouting the borehole can be completed after the well materials have been removed). However, measurements of the borehole depth must be taken before and after the well is pulled to ensure that no collapse of well construction or formation materials occurred.

In the event that the casing or well screen is severed during casing pulling or if borehole collapse occurs, the remaining materials can be removed by overdrilling using the conventional augering method described in Section 2.2. In situations where well materials such as PVC screens and risers are suspected to sever, and removal of all well materials is required (i.e., at wells that are contaminated or those that penetrate an aquiclude), the contractor should install rods inside the well so that the rods would serve as a steel guide pipe for advancing augers during overdrilling.

At sites in which well casings have been grouted into a rock socket the casing pulling procedure may not be feasible. An alternative procedure involving overdrilling into the bedrock, pulling the casing, and subsequently grouting the openhole interval may be employed. For uncontaminated wells or wells with low levels of contamination, overdrilling, grinding on the rock, and grouting inside and outside of the well should be acceptable if the casing cannot be pulled. When this procedure is not acceptable and the casing must be pulled from a contaminated well, a spin and flush drilling technique may be used to advance flushpoint casing equipped with a diamond cutting shoe to the bottom of the casing socket. Water used during the spin and flush casing advancement will be controlled by the use of oversized casing, a coupling and a drilling tee. Drilling water will be containerized and disposed of in accordance with the site specific Material Handling and Disposal Plan.

2.2 OVERDRILLING

Overdrilling is used where casing pulling is determined to be unfeasible, or where installation of a temporary casing is necessary to prevent cross-contamination, such as when a confining layer is present and contamination in the deeper aquifer could migrate to the upper aquifer as the well was pulled (see Section 2.5). The overdrilling method should:

- Follow the original well bore.
- Create a borehole of the same or greater diameter than the original boring.
- Remove all of the well construction materials.

Acceptable methods for overdrilling include the following:

- Using conventional augering (i.e., a hollow stem auger fitted with a plug). The plug cutter will grind the well construction materials, which will be brought to the well surface by the auger.

- Using a conventional cable tool rig to advance casing having a larger diameter than the original boring. The cable tool kit is advanced within the casing to grind the well construction materials and soils, which are periodically removed with large diameter bailer. This method is not applicable to bedrock wells.

- Using an over-reaming tool with a pilot bit nearly the same size as the inside diameter of the casing and a reaming bit slightly larger than the original borehole diameter. This method can be used for wells with steel casings.

- Using a hollow-stem auger with outward facing carbide cutting teeth having a diameter two to four inches larger than the casing. Outward-facing cutting teeth will prevent severing the casing and drifting off center.

- Using a hollow-stem auger with a steel guide pipe inside. The casing guides the cutter head and remains inside the auger. The guide pipe should be firmly attached to the inside of the casing by use of a packer or other type of expansion or friction device.

Prior to overdrilling, an expandable J-plug or other suitable well cap will be used to prevent the introduction of soil or cuttings into the well, thereby ensuring a continuous grout column for wells that are grouted in place.

In all cases above, overdrilling should advance through the original bore depth by a distance of 0.5 feet to ensure complete removal of the construction materials. When the overdrilling is complete, the casing and screen can be retrieved from the center of the auger (American Society for Testing and Materials, Standard D 5299-92, 1992), if one of the hollow stem auger methods described above is employed. Subsequent to overdrilling at flush mount well locations where it may be impractical to remove well materials from inside the augers, a 1-2 foot deep area should be excavated by hand around the flush-mount well to facilitate a conventional well removal while tremie-grouting inside the well. Alternatively, the soil within the annular space may be removed by raising the augers to allow the soil to fall out and re-advance the augers to the original target depth. Grout should then be tremied within the annular space between the augers and well casings. The grout level in the borehole should be maintained as the drilling equipment and well materials are sequentially removed. After overdrilling is completed, the borehole must be grouted according to the procedures in Section 9.0 and the upper five feet of borehole must be restored according to the procedures in Section 10.0.

2.3 GROUTING IN-PLACE

Grouting in-place is the simplest decommissioning procedure, but offers the least long-term protection of all the methods. As discussed in Section 2.5, however, this method is preferred for the bedrock portion of bedrock wells, and is used for decommissioning cased wells in certain situations. For cased wells, the procedure involves filling the casing with grout to a level of five feet below the land surface, cutting the well casing at the five-foot depth, and removing the top portion of the casing and associated well materials from the ground. The casing must be grouted according to the procedures in Section 9.0. In addition, the upper five feet of the borehole is filled to land surface and restored according to the procedures described in Section 10.0.

For wells installed in bedrock, the procedure involves filling the casing (or open hole) with grout to the top of rock according to the procedures in Section 9.0. The grout mix, however, will vary according to the hydrogeological conditions as discussed in Section 2.5.

It should be noted that for wells located on landfills regulated under 6NYCRR Part 360, the screened interval of the well must be sealed separately and hydrostatically tested to ensure its adequacy before sealing the remaining borehole. The Standard Operating Procedure (SOP) for the hydrostatic test has been included under Appendix D.

2.4 CASING PERFORATION/GROUTING IN-PLACE

At this time, casing perforation is the preferred method for wells with four-inch or larger inside diameter which are designated to be grouted in-place in accordance with the selection flow chart. The procedure involves perforating the well casing and screen then grouting the well. A wide variety of commercial equipment is available for perforating casings and screens in wells with four-inch or larger inside diameters. Due to the diversity of application, experienced contractors must recommend a specific technique based on site-specific conditions. A minimum of four rows of perforations several inches long and a minimum of five perforations per linear foot of casing or screen is recommended (American Society for Testing and Materials, Standard D 5299-92, 1992).

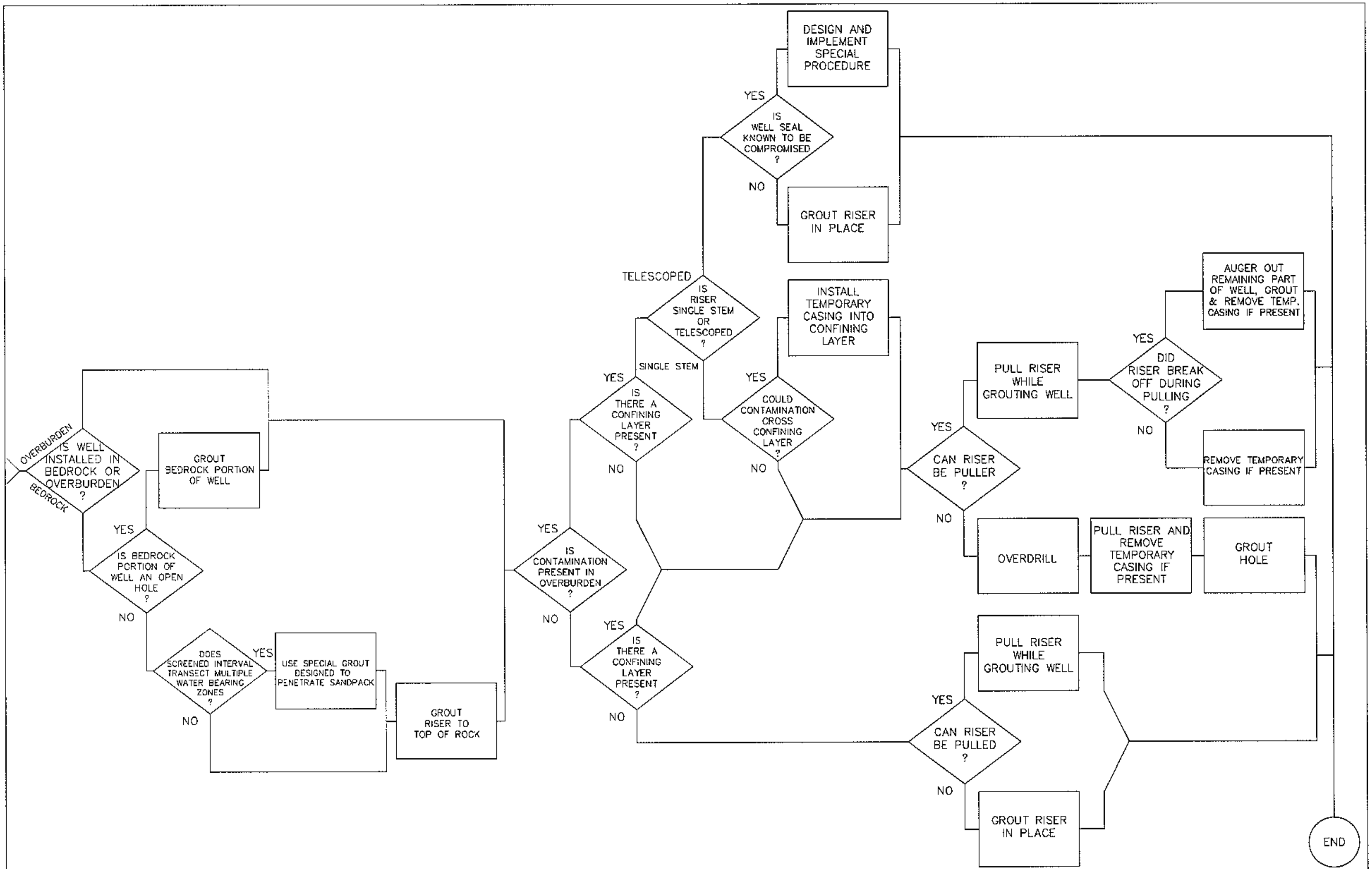
After perforating is complete, the borehole must be grouted according to the procedures in Section 9.0 and the upper five feet of borehole must be restored according to the procedures in Section 10.0.

2.5 SELECTION PROCESS AND IMPLEMENTATION

Selection of the decommissioning method is governed by the flow chart presented as Plate 1. A discussion of the selection criteria and decommissioning methodology is presented below.

2.5.1 Contaminated Monitoring Wells/Piezometers

For wells and piezometers suspected or known to be contaminated with NAPL or DNAPL product, measurement of the product volume will be determined using a weighted cotton string or by using an interface probe. Subsequent to calculation of the product volume, the NAPL/DNAPL product will be removed from inside the well. Removal of the contaminant product will be accomplished by bailing, pumping or installing an absorbent passive recovery system. Subsequent to product recovery, all contaminated materials will



Decommissioning Proceedure Selection

Source: Malcolm Pirnie for NYSDEC, March 1995, Plate 1

decom_flo2.dwg

be disposed of in accordance with the segregation and containment procedures described in Section 4.1.2.

2.5.2 Bedrock Wells

As illustrated on Plate 1,if the well is constructed within a bedrock formation, the screened or the open hole portion of the well is grouted to the top of the bedrock. Prior to initiating any grouting procedure, the depth of the well will be measured to determine if any silt or debris infilling has plugged the well. If plugging has occurred, the well will be flushed with an appropriately sized roller bit or drill rods to remove or suspend the obstruction in the water column. The borehole will then be tremie grouted from the bottom of the well to the top of bedrock to insure a continuous grout column. Note that if the bedrock well is cased, the screen should be perforated to the top of the rock if the inside diameter of the casing is 4-inches or larger. Furthermore, if the screened interval transects multiple water bearing zones the special grout mix discussed in Section 9.1.3 should be used to ensure penetration of the sand pack.

After the rock hole is grouted, the overburden portion of the well is decommissioned in accordance with the following sections. If the borehole extends to the surface, no further decommissioning procedures are required; however, the boring should only be filled to within 5-feet of the ground surface and site restoration should be completed in accordance with Section 10.0.

2.5.3 Uncontaminated Overburden Wells

For overburden wells and the overburden portion of bedrock wells, the first decision point in determining the decommissioning method considers whether the overburden portion of the well exhibits evidence of contamination, as determined through historical groundwater and/or soil sampling results. If the overburden portion of the well is uncontaminated, the next criteria considers whether the well penetrates a confining layer. In the case that the overburden portion of the well does not penetrate a confining layer, the casing should be pulled (and tremie-grouted) if possible. As a general rule, PVC wells greater than 25-feet deep should not be pulled unless site-specific conditions or other factors indicate that the well can be pulled without breaking. If the well cannot be pulled, such as in the case that a bedrock portion of the well has already been grouted in place, or if the well materials and depth prohibit pulling or will likely result in breakage, the well should be grouted in-place as accordance with Section 2.3 (if the casing is less than 4-inch in diameter) or Section 2.4 (if the casing diameter is 4-inches or larger).

If the overburden portion of the well penetrates a confining layer, the casing should be removed by pulling (if possible) in accordance with Section 2.1. If the casing cannot be removed by pulling, the well should be removed by overdrilling. The overdrilling method used will depend on the site-specific conditions and requirements. If pulling is attempted and fails (i.e., a portion of the riser breaks) the remaining portion of the well should be removed by using the conventional augering procedure identified in Section 2.2. In all cases, after the well construction materials have been removed, the borehole will be grouted in accordance with Section 9.0 and the upper five feet will be restored in accordance with Section 10.0.

2.5.4 Contaminated Overburden Wells

If an overburden well or the overburden portion of a bedrock well is contaminated as evidenced by historical sampling results, the first decision point in selecting a decommissioning procedure is whether the well penetrates a confining layer. If the well does not penetrate a confining layer, the selection process follows the same pathway as for uncontaminated wells that penetrate a confining layer (i.e., the casing is pulled, if possible; otherwise the well is overdrilled - see Section 2.5.3). Plastic sheeting should be placed around the well surface to contain contaminated materials displaced during removal of the well.

For overburden wells that are contaminated and which penetrate a confining layer, the next selection criteria is whether the well riser is a single stem or is telescoped inside one or more outer casings. The procedures to be followed in determining the decommissioning method are presented for both situations below.

2.5.4.1 Single Stem Riser

If the riser is a single stem, the potential for cross-contamination between confining layers must be addressed. In particular, if the lower confining unit is contaminated, there is a potential that the contamination may be transferred to the upper unit as the well construction materials are removed to the ground surface. In this event, it will be necessary to install a temporary casing having a diameter larger than the original borehole into the top of the confining layer. This may be accomplished using a hollow stem auger or by employing a spin and flush technique to advance the casing. If the confining layer is less than 5 feet thick, the casing should be installed to the top of the confining layer. Otherwise, it is installed to a depth of 2 feet below the top of the confining layer. After the temporary casing has been set, the well can be removed and grouted through pulling (if possible) or through overdrilling if pulling is not feasible. Plastic sheeting should be placed around the well surface to contain contaminated materials displaced during removal of the well. As an alternative to installation of a temporary casing, the hollow-stem auger could serve the same purpose in that it would prevent the contamination from migrating to the upper unit. The hollow-stem auger would be advanced into the confining layer until the joint between the uppermost sections was nearly flush with the ground surface, and the sections would be disconnected to expose the riser prior to pulling or overdrilling.

After the casing and screen are removed and the well is grouted, the temporary casing (if used) is removed and the casing and/or hollow stem auger can be decontaminated for reuse. The upper 5 feet of the well surface should then be restored in accordance with Section 10.0.

2.5.4.2 Telescoped Riser

If the riser is telescoped in one or more outer casings, the decommissioning approach is dependent on the integrity of the well seal. For the purpose of the monitoring well decommissioning procedures, the well seal is defined as the bentonite seal above the sand pack. Although it is not possible to visually inspect or otherwise test the well seal to assess its condition, an indication of the well seal integrity may be obtained through review of the boring logs and/or a comparison of groundwater elevations if the well is part of a cluster. Any problems noted on the boring logs pertaining to the well seal, such as bridging of bentonite pellets or running sands, or disparities between field notes (if available) and the well log would indicate the potential for a poor well seal. Alternatively, if the well is part of a cluster a comparison of groundwater elevations between the shallow and deep wells should also be performed. By observing trends at other clusters it may be possible to identify inconsistencies in groundwater elevations at the well slated for decommissioning, thereby indicating a poor well seal.

If there is no evidence that the well seal integrity is compromised, the riser should be grouted in-place in accordance with Section 2.3 or 2.4, depending on the diameter of the well casing, and the upper 5 feet of the well surface should be restored in accordance with Section 10.0. If indications are that the well seal is not competent, it will be necessary to design and implement a special procedure to remove the well construction materials, as the presence and configuration of the outer casing(s) will be specific in the individual wells and will be a key factor in the decommissioning approach. The special procedure should be designed to mitigate the potential for cross-contamination during removal of the well construction materials, and should be designed prior to initiating field work.

3.0 PREPARATION OF A SITE-SPECIFIC HEALTH AND SAFETY PLAN

Prior to initiating decommissioning activities at a site, it is necessary to prepare a site-specific health and safety plan (HASP) in accordance with the requirements of 29 CFR 1910.120. Accordingly, the HASP should include:

- The names of key personnel responsible for site health and safety, including an appointed site health and safety officer.
- A safety and health risk analysis for each site task and operation.
- Employee training requirements.
- Personal protective equipment (PPE) to be used by employees for each of the site tasks and operations being conducted.

- Medical surveillance requirements.
- Frequency and types of air monitoring, personnel monitoring and environmental sampling techniques and instrumentation to be used.
- Site control measures.
- Decontamination procedures.
- Site standard operating procedures.
- A contingency plan for responses to emergencies.
- Confined space entry procedures.

An example of a health and safety plan is attached as Appendix A. This document provides a general framework for preparing a HASP. Examples of site-specific information, such as names of responsible personnel, contaminant data, and other information which must be developed to meet the OSHA requirements discussed above are included in Appendix A but will need to be modified in the site-specific HASP.

4.0 PREPARATION OF A MATERIALS HANDLING AND DISPOSAL PLAN

Materials handling and disposal procedures for each of the wells slated for decommissioning should be identified in a site-specific materials handling and disposal plan. This plan will be used as a guideline to ensure safe and efficient control of contaminated materials, and will promote conformance with the applicable regulatory requirements for storage, characterization, labeling, transportation and disposal of materials prior to off-site transport.

4.1 MATERIALS HANDLING PROCEDURES

The materials anticipated to be generated during well decommissioning activities include decontamination fluids, disposable safety equipment (including personal protective equipment), drill cuttings, groundwater, well construction materials (PVC and/or stainless steel casings, well screens, sand, bentonite/grout mixtures, etc.), and any spill-contaminated materials. Proper handling of these materials is effected through a series of steps, including: identification/pre-characterization of the waste materials; segregation/containment of the wastes including storage in proper containers; characterization of the waste materials through analytical testing to determine the absence/presence or nature of the contamination; and proper labeling in accordance with 49 CFR Part 172. Each of these steps is described in the following sections.

4.1.1 Identification/Pre-characterization

Prior to initiating well decommissioning activities at a site, the site history, most importantly historical analytical data from the monitoring wells, must be reviewed as well as the monitoring well construction details: number, type (overburden, bedrock), depth, diameter, and construction materials. This knowledge will aid in estimating the nature and quantities of waste materials which potentially may be generated as a result of decommissioning activities and will also assist in pre-determining the number of roll-off boxes, 55-gallon drums, and any other containers necessary to contain the wastes generated at each respective site.

4.1.2 Segregation and Containment

During well decommissioning activities, generated waste materials must be contained and segregated according to the nature of the suspected contamination. Well materials generated from decommissioning those wells with known contamination will be segregated from materials generated from those wells with little to no contamination (based on historical results). Contaminated materials will be further segregated according to contaminant type (e.g., well materials suspected of containing volatile organic contamination will be segregated from materials suspected of containing Polychlorinated Biphenyl (PCB) contamination).

For wells exhibiting contamination, all materials brought to the surface must either be decontaminated, disposed of at an appropriate Treatment, Storage and Disposal Facility

Fluids generated during the decommissioning program will generally be contained in 55-gallon drums unless extremely large volumes are expected; in this case 5,000-gallon tankers or other suitable temporary storage may be used. All drums will be initially labeled according to the wastewater source(s) and will be assumed to contain the same contaminants as the groundwater measured by the particular monitoring well being decommissioned. All 55-gallon drums containing fluids should be sealed and temporarily stored at the decontamination pad until final off-site disposal at an approved treatment facility.

4.1.3 Characterization

Hazardous waste characterization is necessary to determine the nature of the waste materials, to verify whether the materials are hazardous, and to determine proper disposition. Characterization of waste materials will be conducted at each of the sites to determine the appropriate disposal requirements. The decision as to the number, location and types of samples to be collected will be site specific and will depend on factors such as the quantity of waste generated and type of containers used, the nature of the waste, and the distribution of contaminant types across the site with respect to the origin of the waste materials. In general, the sample collection program will be designed to ensure that analytical data representative of all the materials to be disposed will be generated from the minimal number of samples. This may be accomplished by means such as:

- collection of composite samples for contaminants such as metals and PCBs (compositing is not typically acceptable for volatile organic compound analyses).
- collection of grab samples from select drums/containers suspected of elevated contaminant concentrations based on visual observation (e.g., soil staining, liquid sheen or non-aqueous product) or PID screening

Sample analysis will be based on site history and the requirements of the disposal facility. At a minimum, the samples should be analyzed for the parameters of concern indicated by past monitoring well analytical results, as well as the hazardous waste

(TSDF), or properly containerized in a secure area for disposal by others. For all uncontaminated wells, the materials (except the casings) can be left at the surface near the former well unless the surrounding land use prohibits this disposal (e.g., if the well is located in an area where people could be exposed to the materials left on the surface; or if recovered decommissioning materials would not be consistent with the intended use of the land). In this case, the materials must be disposed of in a 6NYCRR Part 360 landfill. For contaminated wells, PVC and/or steel casing materials may be decontaminated for disposal in a Part 360 landfill, provided that the decontamination effort is thorough and cost effective. Requirements for characterization and disposal of contaminated materials are discussed in Sections 4.1.3 through 4.1.5.

Containment methods will be based on the estimated quantity of materials anticipated to be generated at each respective site. Solid waste materials (i.e., well construction materials, soils, drill cuttings, PPE), will typically be contained in roll-off boxes or 55-gallon drums. Since federal DOT regulations (49 CFR Part 177) generally limit the combined truck and cargo weight to 80,000 lbs, most hazardous waste transporters will limit the roll-off box capacity to 20 tons of hazardous waste per shipment. Thus, if the materials are to be transported off-site to a treatment, storage and disposal facility (TSDF) that accepts bulk waste, and if the anticipated quantity of waste will be large (greater than 5 tons), water-tight roll-off containers may be more practical and cost-effective for temporarily containing and transporting the waste in lieu or in combination with 55-gallon drums (e.g., 55-gallon drums may still be used for personal protective equipment or other articles not directly derived from the abandoned well). The roll-off containers should be lined with disposable HDPE liners to prevent contact with the container, and will be initially labeled according to the source(s) of the contained waste materials. Likewise, if drums are used they will be lined with a protective plastic sleeve, filled and the drum initially labeled according to the source of the contaminated materials. After the contents of the roll-offs and drums have been characterized, they should be labeled in accordance with 49 CFR Part 172. Roll-off containers will be covered with polyethylene covers and tarps with bows during temporary storage and transportation, and all drums will be sealed.

characteristic parameters: toxicity by TCLP; ignitability; reactivity; and corrosivity in accordance with 40 CFR Part 261.

4.1.4 Labeling

Depending on the nature of the materials, proper labeling of the storage containers (roll-offs and/or drums) must be completed according to 49 CFR Part 172.

4.1.5 Disposal

Disposal of waste materials will depend on whether the waste has been characterized as hazardous or non-hazardous. Non-hazardous waste will be disposed of on-site in accordance with NYSDEC TAGM #4032 with the prior consent of the owner and the Department, or may be landfilled at a permitted 6NYCRR Part 360 facility.

For wastes that exhibit contamination, the requirements for disposal or treatment will be dependent on the waste characteristics. To determine these requirements the following procedure should be followed upon receipt of the waste characterization results:

1) Determine if the waste is characteristically hazardous (by failure of any of the criteria for toxicity, corrosivity, reactivity, or ignitability) or if it is a listed hazardous waste per the classifications identified in 40 CFR Part 261.

2) Determine the EPA hazardous waste code(s) for the applicable waste classification(s) listed in 40 CFR Part 261.

3) Determine any treatment standards for the hazardous waste code(s) per 40 CFR Part 268. Depending on the waste classification, treatment standards may be based on final concentration in the waste/waste extract or may require a specific treatment technology (e.g., incineration).

4) If the hazardous waste contains other constituents that are not listed in the treatment standards, and if landfilling is a disposal option, it should be determined if the waste is a California List waste per the criteria in 40 CFR Part 268.32 (e.g., under these regulations, nonliquid wastes must not contain total halogenated organics at or in excess of 1,000 ppm).

5) If the hazardous waste meets all treatment standards including the California List Standards (if applicable), it may be disposed of at a permitted hazardous

waste land disposal facility. For each shipment the generator is required to provide the following manifest information:

- Hazardous Waste Code(s)

- Corresponding concentration-based or technology-based treatment standards.

- Manifest number.

- Waste analysis data.
- Certification Statement per 40 CFR 268.7(a)(2)(D)(ii).

In addition, the generator is required to maintain the records specified in 40 CFR Part 268.7(a)(7) for a minimum of 5 years.

6) If the waste fails to meet any of the treatment standards listed in 40 CFR Part 268, it must be sent to a treatment, storage, or recycling facility. If the waste's treatment standard is technology-based, it must be treated in accordance with the specified method. Land disposal is not allowable unless the waste is eligible for a National Capacity Variance (40 CFR Subpart C) and meets the California List standards. In all cases, the notification and recordkeeping requirements identified above must be fulfilled by the generator.

The hazardous waste will be transported in accordance with DOT regulations (49 CFR Parts 172-173) to either a secure hazardous waste landfill or TSDF, as appropriate. The contractor will be responsible for arranging for proper transportation and the disposal of the wastes. The Engineer will sign a hazardous waste manifest, as an agent of the Owner.

5.0 EQUIPMENT DECONTAMINATION REQUIREMENTS

Since the monitoring well decommissioning will involve multiple wells, there is a possibility of contamination from one well location to another. To avoid cross-contamination, procedures have been established for decontamination after operations at each well location is complete. The procedures for decontamination of personnel at the site will be specified in the site-specific Health and Safety Plan. Decontamination of equipment will follow established equipment cleaning protocols which are written in accordance with the Engineer's corporate policies and OSHA regulations.

The drilling and excavation equipment (i.e., drill rigs, cutting bits, and associated equipment) will be cleaned at a constructed decontamination facility. In general, the decontamination facility (i.e., decon pad or wash pad) will consist of plywood placed over a heavy synthetic liner. The pad will slope down to a sump that will collect all liquids. A detailed description and drawing of the decontamination facility that will be constructed is included in Appendix B as Item 1.

The drilling and excavation equipment will be prepared before it is brought to the decontamination facility and then cleaned at the facility. The preceding preparation includes removing gross soil/rock from the equipment to minimize losses during movement to the decon pad. At the decontamination facility, the equipment will be rinsed with low-volume water or steam, washed with phosphate-free detergent, and rinsed again with pressurized low-volume water or steam. The equipment will be inspected by the Engineer's field representative after cleaning. The detailed cleaning procedures are included in Appendix B as Item 2.

In the event that sampling equipment must be used, the decontamination guidelines included in Appendix B as Item 3 will be followed. In general, these guidelines describe cleaning with non-phosphate detergent, then performing rinsing cycles with water and acid. After the equipment is air-dried, it must be wrapped in aluminum foil to avoid accidental contamination after cleaning.

After all equipment is decontaminated, the solutions produced must be properly containerized and disposed of. All other disposable contaminated supplies/equipment such as disposable safety and sampling equipment will also need to be properly disposed of. Unless characterization of the decon fluids and disposable equipment is performed in accordance with Section 4.0, these materials will be handled in the same manner as the drill cuttings/fluids from the well locations. All materials must be temporarily stored in a secure area such as the fenced decon pad.

If sampling is necessary, the Engineer's personnel will be responsible for the decontamination of the sampling equipment. The decontamination of drilling and excavation equipment is the responsibility of the Contractor(s). The Engineer's field representative will make daily inspections to insure that decontamination procedures are being followed.

6.0 LOCATING AND SETTING-UP ON THE WELL

The following tasks shall be performed to locate the well to be decommissioned:

- Notify property owner and/or other interested parties including the governing regulatory agency prior to site mobilization whenever possible.
- Review information about the well contained in the site file. This information may include one or more of the following: the site map, well boring log, well construction diagram, field inspection log, well photograph, and proposed well decommissioning procedure.
- Verify the well location and identification by locating the identifying marker.
- Verify the depth of the well in the well construction log by sounding with a weighted tape.

After the well has been located, the decommissioning procedure should be selected in accordance with Section 2.0 based on the available boring and sampling data. The rig must be set up prior to initiating drilling to ensure proper alignment with the well (i.e., the drill string must be aligned with the monitoring well).

7.0 REMOVING THE PROTECTIVE CASING

7.1 GENERAL

Removal of the protective casing of a well must not interfere with or compromise the integrity of decommissioning activities performed at the well.

The procedure for removing the protective casing of a well depends upon the decommissioning method used. When a well is decommissioned by the overdrilling or casing pulling method, the protective casing may be removed either before or after the casing is removed. When the decommissioning procedure requires casing perforation or grouting in-place, the protective casing should be removed after grout is added to the well. The protective casing handling and disposal must be consistent with the methods used for the well materials, unless an alternate disposal method can be employed (e.g., steam cleaning followed by disposal as nonhazardous waste).

7.2 PRIOR TO SEALING THE WELL BORE

When overdrilling, the protective casing must be removed first, unless the drilling tools have an inside diameter larger than the protective casing. The variety of protective casings available preclude developing a specific removal procedure. In all cases, however, the specific procedure used must minimize the risk of:

- breaking the well casing off below ground and
- allowing foreign material to enter the well casing.

If the decommissioning method used is casing pulling, the decision of when to remove the protective casing is not critical.

An acceptable protective casing removal method involves breaking up the concrete seal surrounding the casing and jacking or hoisting the casing out of the ground. A check should be made during pulling to insure that the inner well casing is not being hoisted with the protective casing. If this occurs, the well casing should be cut off after the base of the protective casing is lifted above the land surface.

7.3 AFTER SEALING THE WELL

If the decommissioning method used allows well casing to remain in the ground, the protective casing should be removed after the well has been properly filled with grout. This will insure that the well is properly sealed regardless of problems with protective casing removal. During grouting in-place, the well casing must be removed to a depth of five feet below the land surface. The upper five feet of casing and the protective casing can be removed in one operation if a casing cutter is used. If the height of the protective casing makes working conditions at the well awkward, the casing can be cut off at a lower level. However, the inner well casing must remain aboveground and cannot be damaged in any way that prevents the well from being filled with grout.

8.0 DECOMMISSIONING OF SCREEN AND RISER

After setting up on the well and removing the protective casing (if necessary), the well screen and riser are decommissioned in accordance with the appropriate procedure and methodology as discussed in Section 2.0 (i.e., if the wells are overdrilled or pulled, the casing and riser are removed. Otherwise, they are perforated and/or grouted in-place). During the decommissioning activities the requirements of the site-specific health and safety plan, materials handling and disposal plan and equipment decontamination plan will be followed to ensure maximum protection of human health and the environment.

9.0 SELECTING, MIXING, AND PLACING GROUT

9.1 SELECTING GROUT MIXTURE

There are two types of grout mixes that may be used to seal wells: a standard mix and a special mix. Both mixes use Type 1 Portland cement and four percent bentonite by weight. However, the special mix uses a smaller volume of water and is used in situations where excessive loss of the standard grout mix is possible (e.g. highly-fractured bedrock or coarse gravels).

9.1.1 Standard Grout Mixture

For most boreholes, the following standard mixture will be used:

- One 94-pound bag Type I Portland cement
- 3.9 pounds powdered bentonite
- 7.8 gallons potable water

This mixture results in a grout with a bentonite content of four percent by weight, and will be used in all cases except in boreholes where excessive use of grout is anticipated. In these cases a special mixture will be used (see Section 9.1.2).

See Section 9.2 for grout mixing procedures.

9.1.2 Special Mixture

In cases where excessive use of grout is anticipated, such as high permeability formations and highly fractured or cavernous bedrock formations, the following special mixture will be used:

- One 94-pound bag type I Portland cement
- 3.9 pounds powdered bentonite
- 1 pound calcium chloride
- 6.0-7.8 gallons potable water (depending on desired thickness)

The special mixture results in a grout with a bentonite content of four percent by weight. It is thicker than the standard mixture because it contains less water. This grout is expected to set faster than the Standard Grout Mixture. The least amount of water that can be added for the mixture to be readily pumpable is six gallons per 94-pound bag of cement.

See Section 9.2 for grout mixing procedures.

9.1.3 Alternate Special Grout

In cases where the penetration of the sandpack is critical, such as bedrock wells with screens that transect multiple water-bearing zones, the following alternate mixture will be used:

- One 94 pound bag Type III Portland Cement.
- 3.9 pounds powdered bentonite.
- 7.8 gallons potable water.

Refer to Section 9.2 for grout mixing procedures. It should be noted that this grout is expected to set faster than the standard grout mixture.

9.2 GROUT MIXING PROCEDURE

To begin the grout-mixing procedure, calculate the volume of grout required to fill the borehole. If possible, the mixing basin should be large enough to hold all of the grout necessary for the borehole. Tall cylindrical and long shallow basins should not be used as it is difficult to obtain a homogeneous mixture in these types of basins.

Mix grout until a smooth, homogeneous mixture is achieved. No lumps or dry clots should be present. Grout can be mixed manually or with a mechanized mixer. One acceptable type of mixer is a vertical paddle grout mixer. Colloidal mixers should not be used as they tend to excessively decrease the thickness of the grout for the above recipes.

9.3 GROUT PLACEMENT

Grout will be placed in the borehole from the bottom to the top using a tremie pipe of not less than 1-inch diameter. Grout will then be pumped into the borehole until the grout appears at the land surface (when grouting open holes in bedrock, the grout level only needs to reach above the bedrock surface). Any groundwater displaced during grout placement will be pumped via suction lift to a 55-gallon drum for proper disposal.

At this time the rate of settling should be observed. When the grout level stabilizes, casing or augers will be removed from the hole. As each section is removed, grout will be added to keep the level between 0-feet and 5-feet below land surface. If the grout level drops below the land surface to an excessive degree, an alternate grouting method must be used. One possibility is to grout in stages; i.e., the first batch of grout is allowed to partially cure before a second batch of grout is added.

Upon completion of grouting, insure that the final grout level is approximately five feet below land surface. A ferrous metal marker will be embedded in the top of the grout to indicate the location of the former monitoring well.

10.0 BACKFILLING AND SITE RESTORATION

The uppermost five feet of the borehole at the land surface will be filled with a material appropriate to the intended use of the land. The materials will be physically similar to the natural soils. No materials will be used that limit the use of the property in any way. The surface of the borehole will be restored to the condition of the area surrounding the borehole. For example, concrete or asphalt will be patched with concrete or asphalt of the same type and thickness, grassed areas will be seeded, and topsoil will be used in other areas. All solid waste materials generated during the decommissioning process will be disposed of properly.

11.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) PROCEDURES

This section describes the quality control/quality assurance (QA/QC) procedures necessary for monitoring and ensuring the Contractor's adherence to the Monitoring Well Decommissioning Project procedures, plans and specifications, prepared by the Engineer. This section will discuss the minimum inspection and documentation requirements necessary to facilitate proper well decommissioning procedures and also will:

- Review the general requirements specified in the Contract Documents.
- Define roles and responsibilities of all parties.
- Establish the key tasks to be monitored by the on-site construction inspector and the appropriate inspector forms and logs to be used for recording the Contractor's activities.
- Establish procedures for communicating change orders, field modifications and variations from the Contract Documents to the Owner.
- Establish scheduled meetings and briefings during the construction phase.

The overall goal of the project QA/QC program is to ensure that proper well decommissioning techniques and procedures are used in accordance with the requirements of the Contract Documents. The QA/QC procedures herein should be followed by QA personnel including: Construction Contractor personnel, the Contractor's subcontracted laboratory and field personnel, and the Engineer's on-site construction inspector.

11.1 RESPONSIBILITY AND AUTHORITY

The principal organizations involved in developing, designing and conducting well decommissioning activities are the Owner, Engineer, and the Construction Contractor.

11.1.1 Owner

The Owner will be responsible for reviewing the well decommissioning procedures to determine whether the documents meet their requirements, and to obtain approval of the procedures from the appropriate regulatory agencies. The Owner will have the responsibility and authority to review and accept or reject any design or procedural revisions or requests. The Owner also has the responsibility and authority to review and approve the Construction Monitoring Report and all QA documentation collected during well decommissioning activities.

11.1.2 Engineer

The Engineer will be responsible for reviewing and approving any engineering design changes, construction monitoring and quality assurance in accordance with this QA Plan. The Engineer will inform all parties involved with construction of their responsibilities, lines of communication, lines of authority, and QA/QC procedures. The Engineer's construction inspector (QA Engineer) will monitor decommissioning activities and will be assigned specific responsibilities and tasks. Most of the waste sample collection and testing will be conducted by the contractor at a frequency and manner specified in the site specific Materials Handling and Disposal Plan.

The person filling the construction inspector (QA Engineer) position will be trained and certified to operate an HNu organic vapor photoionization detector (PID), will be OSHA 40-hour Hazardous Waste Worker trained and will have a working knowledge of documents pertaining to well decommissioning activities, including this plan. The Engineer's field personnel will be instructed to contact the construction inspector (QA Engineer) in the event well decommissioning requirements are not being met, QA procedures are not being implemented, or construction problems have been encountered.

11.1.3 Construction Contractor

In addition to performing the monitoring well decommissioning in accordance with the design documents, the Contractor will be required to obtain the services of a qualified testing laboratory to perform the analytical testing of the waste materials and will also be responsible for procuring transportation and disposal/treatment services.

11.2 PROJECT MEETINGS

The Engineer's management of the monitoring well decommissioning project will include conducting periodic project meetings as described below:

11.2.1 Pre-construction Meeting

The Engineer will schedule and attend one (1) pre-construction meeting for the purpose of discussing the project approach and answering contractor questions. The Engineer will also prepare and distribute meeting minutes. The meeting will also:

- Provide each party (organization) with relevant QA documents and supporting information.
- Familiarize each organization with the QA Plan and its role relative to the well decommissioning criteria and construction documents.
- Review the responsibilities of each organization and review the lines of authority and communication for each organization.
- Discuss the established procedures for observations and tests including waste sampling.

- Discuss the established procedures for handling construction deficiencies, repairs, and/or retesting.
- Review methods for documenting and reporting inspection data.

11.2.2 Monthly Progress Meetings

Monthly project meetings will be held during the course of the work to discuss the project schedule and work performed to date, and to address and resolve any existing or anticipated problems.

A special meeting will be held when and if a major QA problem or deficiency is present or likely to occur. At a minimum, the meeting shall be attended by the Construction Contractor and the Engineer's on-site inspector (QA Engineer). The purpose of the meeting will be to define and resolve the problem(s) or deficiencies encountered. The meeting minutes will be documented by the Engineer.

11.3 KEY TASKS

The key tasks that the Engineer will conduct during the well decommissioning project are briefly summarized below.

11.3.1 Review of Contractor Submissions

Prior to well decommissioning activities, all written submissions required by the contract documents will be evaluated and forwarded to the Owner, together with written submissions regarding their suitability. The Engineer will also obtain and review all necessary shop drawings, material tests and as-built drawings submitted throughout the construction and will make recommendations for acceptance/rejection to the Owner. The contractor's progress will be continuously monitored during the construction period, and Owner will be informed of the schedule and any corrective measures planned or implemented.

Throughout the project, payment requests by the contractor will be reviewed for accuracy and completeness prior to making recommendations relative to payment. Review will involve comparing actual notes of field personnel to items contained in the payment request. Discrepancies will be discussed with the contractor and will be amended if necessary.

11.3.2 Construction Inspection

The Engineer will provide full-time inspection of the contractor during all critical well decommissioning activities at each of the sites. This will be accomplished by providing an experienced on-site inspector(s) to document the contractor's adherence to the contract specifications and monitoring the contractor's progress. The Engineer will notify the Owner in the event that the contractor fails to perform the decommissioning work as specified in the contract and recommend to the Owner the acceptance, conditional approval/disapproval or rejection of the contractor's work. The Engineer will issue instructions, field orders, interpretations and clarification of contract language to the contractor as required. In the event that a change order is necessary, the Engineer will submit the change order with a detailed cost estimate to the Owner. The Engineer will also document, evaluate and recommend a course of action for all disputes and claims with the contractor.

In addition, the Engineer will inspect, evaluate and document the monitoring well condition after the well has been removed.

11.4 DOCUMENTATION

The Engineer's on-site construction inspector will document all monitoring well decommissioning activities. Such documentation will include, at a minimum, daily reports of construction activities, photographs, and sketches as necessary. Field investigation reports will be completed by the construction inspector when major questions arise at the site. Forms to be used for this purpose are presented in Appendix C.

The Engineer will maintain complete and detailed records associated with all construction and related activities during the duration of the project. These records will be maintained at the Engineer's office(s) and will include but not be limited to the following:

- Daily work completed and important conversations.
- Contractor's daily use of personnel, material and equipment.
- Records documenting the contractor's deviation from work as specified in the contract documents, and any instructions issued regarding deviations.
- Unusual circumstances (weather conditions, labor disputes, environmental problems, health and safety hazards encountered, etc.).
- General files including correspondence and other documentation related to the project.
- Job meeting minutes with documentation on resolution of issues raised.
- Records of contractor's submittals including shop drawings, modifications/change orders, soil tests, material tests and action taken (e.g.,Owner approval/disapproval, further information needed).
- Construction photos.
- Telephone conversation

In addition, the Engineer will submit monthly Project Summary Reports to the Owner. These reports will identify the work which has been accomplished and will document the status of each monitoring well at each site where decommissioning work has occurred.

Upon substantial completion of the decommissioning activities at each site, the Engineer will prepare a detailed list of any work remaining unfinished. The Engineer will then prepare and submit a written notice to the Owner which will include a determination as to whether the completed work meets the requirements of the contract documents. Following satisfactory completion of the work, the Engineer will perform a final inspection of the site and submit a notice to the Owner that decommissioning activities were performed in accordance with the contract documents as revised by any approved change orders or modifications to the scope of work.

Documentation on the condition of the removed wells with respect to the impacts of hazardous waste, minerals and other pertinent environmental factors, or discernable through direct observation, will be presented to Owner along with any recommendations for future well installation techniques and materials.

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EXAMPLE

APPENDIX A

HEALTH AND SAFETY PLAN

EXAMPLE

HEALTH AND SAFETY PLAN FOR MULTIPLE NPL SITES MONITORING WELL DECOMMISSIONING

NEW YORK STATE DEPT. OF ENVIRONMENTAL CONSERVATION DIVISION OF HAZARDOUS WASTE REMEDIATION

AUGUST 1994
REVISED NOVEMBER 1994
REVISED MARCH 1995

____

Site Health and Safety Officer

____

Project Manager

____

Corporate Health & Safety Manager

EXAMPLE

We, the undersigned, being employed by Consultant, have read in full and understand this Health and Safety Plan:

Signature	Print	Date
Signature	Print	Date
Signature	Print	Date
Signature	Print	Date
Signature	Print	Date
Signature	Print	Date
Signature	Print	Date
Signature	Print	Date
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Signature	Print	Date

EXAMPLE

HEALTH AND SAFETY PLAN
FOR
MULTIPLE NPL SITES MONITORING WELL DECOMMISSIONING

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1.0 INTRODUCTION

1.1 GENERAL

In accordance with Consultant corporate policies and OSHA regulations, this Health and Safety Plan (HASP) describes specific health and safety practices and procedures to be used during Monitoring Well Decommissioning activities at the ____________ Site, located in ____________, New York. The HASP covers Consultant employees and activities, and is not intended to cover the activities of other employers on the site. This general Health and Safety Plan will be modified for each monitoring well-decommissioning assignment with site-specific data including site-specific contaminant and emergency response information, identification of hazards associated with the individual contaminants or categories of contaminants known to be present at the site, a hospital route, and identification of task-specific personal protective equipment (PPE). Consultant accepts no responsibility for the Health and Safety of subcontractor personnel. This HASP presents information on known site health and safety hazards and includes the equipment, materials and procedures that will be used to eliminate or control these hazards and is based on an assessment of potential health and safety hazards at the site using available historical information. Environmental monitoring will be performed during the course of field activities to provide real-time data for an on-going assessment of potential physical and chemical hazards. Personal detector tubes will be utilized in conjunction with an HNu photoionization detector to determine the extent of exposure to chemical hazards.

All Consultant personnel involved with site inspection, environmental sampling, and other monitoring well decommissioning activities will be required to comply with this Health and Safety Plan. Tasks on this site will be completed using methods that meet the requirements set forth in the OSHA Health and Safety regulations contained in 29 CFR 1910 and 1926. Construction subcontractor(s) conducting drilling and excavating operations are required to provide their own Health and Safety Plans.

1.2 ORGANIZATION

The Consultant Project Manager, the Health and Safety Officer and the Site Health and Safety Coordinator (or his designee) identified below will determine and enforce compliance.

- PROJECT MANAGER

  Name:
  Telephone: Office:
  Home:

- CORPORATE HEALTH AND SAFETY MANAGER:

  Name:
  Telephone: Office:
  Home:

- SITE HEALTH AND SAFETY OFFICER

  Name:
  Telephone: Office:
  Home:

- SITE HEALTH AND SAFETY COORDINATOR

  Name:
  Telephone: Office:
  Home:

The following roles have been identified for consultant project personnel:

Project Manager - The Project Manager has full responsibility for implementing and executing an effective program of employee protection and accident prevention. He may delegate authority to expedite and facilitate any application of the program.

Health and Safety Manager - The Health and Safety Manager serves as the administrator of the corporation's health and safety program. He is responsible for ensuring that consultant field personnel are properly trained, that they have obtained medical clearance to wear respiratory protection (per 29 CFR Part 1910.134(b)(10)), and that they are properly trained in the selection, use and maintenance of personal protective equipment, including qualitative respirator fit testing.

The Health and Safety Manager will also serve as scientific advisor for the duration of the project, providing guidance on data interpretation and the determination of appropriate levels of worker protection.

Site Health and Safety Officer - The Site Health and Safety Officer is knowledgeable in safety and worker protection techniques as they relate to the project. Responsibilities include the development of the specific provisions of this HASP, including the level of personnel protection to be employed, identification of emergency procedures, and personnel/equipment decontamination procedures. This individual will provide technical assistance to project management on problems relating to industrial hygiene and work site safety.

Any health and safety briefings required during the course of the project will be conducted by the Site Health and Safety Officer. Examples of briefings might include accident prevention, respirator refresher courses or current issues. The frequency of safety briefings will be based upon the potential hazards specific to the designated work tasks and any new information relative to such hazards which are discovered during the project.

Site Health and Safety Coordinator - Consultant's Site Health and Safety Coordinator or his/her designee will be responsible for enforcement of this HASP for consultant employees at the site and for monitoring the personal exposures of employees to hazardous substances contained in air, soil or water. This will consist of spot checking workplace air sampling performed by the Subcontractor such as organic vapor monitoring and the documentation of such data. Consultant's Site Health and Safety Coordinator or his/her designee will communicate directly with consultant's Site Health and Safety Officer on a regular basis to advise him/her of monitoring results and any unexpected conditions found at the site. As data are received and evaluated, the Site Health and Safety Officer will adapt this Health and Safety Plan to fit the current consultant employee protection needs at the site. All affected consultant employees and the Subcontractor's designated Site Health and Safety Officer will be informed of the air sampling results.

When unsafe work conditions are identified, the Site Health and Safety Coordinator or his/her designee is authorized to order consultant personnel to stop work. Resolution of all on-site health and safety problems will be coordinated through the Project Manager with assistance from the Health and Safety Manager and Site Health and Safety Officer as well as the Subcontractor's designated Health and Safety personnel.

2.0 HAZARD EVALUATION

2.1 SUMMARY OF PROJECTED RISKS

Due to the variety of potential contaminants at the site, the possibility exists that workers will be exposed to hazardous substances during field activities (see Table 2-1). The principal points of exposure would be through direct contact with contaminated fill/soils and groundwater, through the inhalation of contaminated particles or vapors. In addition, the use of drill rigs and backhoes on-site will present conditions for potential physical injury to workers. Further, since work will be performed during summer/winter time periods, the potential exists for heat/cold stress to impact workers especially those wearing protective equipment and clothing. The specific tasks involved in well decommissioning have been delineated in the July 1994 Work Plan for Multiple NPL Sites Monitoring Well Decommissioning, and in the February 1995 NPL Site Monitoring Well Decommissioning Procedures prepared by Consultant.

Although no work can be considered completely risk-free, logical and reasonable precautions will be implemented to provide an adequate level of protection for workers. The integration of medical evaluations, worker training relative to chemical hazards, safe work practices, proper personal protection, environmental monitoring, work zones and site control, appropriate decontamination procedures and contingency planning into the project approach will minimize the chance of unnecessary exposures and physical injuries.

2.2 PHYSICAL HAZARDS

Well decommissioning and sampling activities at the _______________ Site may present the following physical hazards:

- The potential for physical injury during heavy construction equipment use, such as drill rigs and backhoes.
- The potential for heat/cold stress to employees during the summer/winter months (see Section 8.0).
- The potential for slip-and-fall injuries due to rough, uneven terrain.