IBM

Corporate Environmental Affairs

Interim Remedial Measures Work Plan for the Broadway Complex Owego, New York Index No.: A7-0407-0001

Prepared for:

IBM Corporation
Manassas, Virginia

January 13, 2003

Prepared by:

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I certify that I have reviewed this Interim Remedial Measures Work Plan for the IBM Broadway Complex, Owego, New York in the context of 6NYCRR Part 375-1.11, Interim Remedial Measures, and have prepared, signed, and sealed this Work Plan in accordance with Section II.B.2 of Voluntary Cleanup Agreement Index # A7-0407-0001.

Signature: ______________________ Date: ______________________

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1 INTRODUCTION

This interim remedial measures work plan (IRM Work Plan) has been prepared by Groundwater Sciences, P.C. (GSPC) at the request of IBM Corporation (IBM) for the former IBM leased property known as the Broadway Complex (the "Site") located in the Town of Owego, Tioga County, New York.

1.1 Purpose

The Site is subject to a Voluntary Cleanup Agreement (VCA), Index No. A7-0407-0001, between IBM and the New York State Department of Environmental Conservation (NYSDEC). The VCA requires the development and submittal of a proposed work plan to NYSDEC. As detailed in Sections 2 and 3, the Site has been extensively investigated and, therefore, the IRM Work Plan option has been selected as the most appropriate type of work plan for the Site at this time. The purpose of the IRM Work Plan is to present a discrete set of activities to be undertaken, without extensive further investigation and evaluation, to mitigate site contamination. As required by the VCA, this IRM Work Plan includes a chronological description of the anticipated activities, a schedule for performing those activities, and sufficient detail to allow NYSDEC to evaluate the work plan.

1.2 Organization

This work plan is organized as follows. Section 1 describes the purpose and organization of this work plan. Section 2 presents historical background information regarding the removal of the former septic tank which is the source of the contamination. Section 3 summarizes the results of the previous hydrogeologic investigations conducted in 1997, 1998, and 1999. Section 4 presents the proposed work plan activities and Section 5 presents a schedule for performing those activities.

2 BACKGROUND INFORMATION

The Broadway complex is located in the Town of Owego at 1200 Taylor Road (County Route 606), and is owned by Sanmina-SCI Corporation (formerly Hadco). The Broadway complex is bounded on the west and north by other property of Sanmina-SCI Corporation, on the east by Barnes Creek and the Lockheed Martin facility (formerly IBM), and on the south by the Warneke property. Figure 2-1 shows the location of the Broadway complex site on a portion of the USGS 7-½ minute Apalachin topographic quadrangle map.

The Broadway complex was known as Building 911 when IBM leased it for various engineering and manufacturing purposes from 1956 until 1994. Building 911 is a single-storey, roughly square building of approximately 60,000 square feet with a 2-acre parking lot located adjacent to the building on the south side as shown on Figure 2-2.

In May 1989, IBM removed a 10,000-gallon inactive septic tank that was located near the southeast corner of the Building 911 (Figure 2-2). This septic tank, suspected associated leach field, and storm sewers were shared with Mutual Design, which owned and operated the original 3.6-acre parcel purchased by Hadco in 1979.

The tank removal report[1] noted "pinhole" leaks in the bottom of the tank. At the time of closure, samples were taken from the sludge remaining in the tank and from the soils at four locations around the tank. A discharge pipe from the tank was identified, but no information was available regarding the suspected location of the associated leach field. Analysis of the septic tank sludge indicated the

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[1]IBM Corporation, *Letter to New York State Department of Environmental Conservation Regarding Excavation of Septic Tank,* July 6, 1989.

presence of several volatile organic compounds (VOCs), including trichloroethene (TCE) and 1,1,1-trichloroethane (TCA). Based on these analyses, the predominant chemical was determined to be TCE and its transformation products, 1,2-dichloroethene and vinyl chloride. Results from sampling of soils in the vicinity of the 10,000-gallon septic tank indicated that constituents found inside the tank, specifically VOCs, were present in the soil outside the tank, suggesting that releases from the tank may have occurred. These VOC results are summarized on Table 2-1.

Table 2-1. Analytical Results for Soil Samples from around the Former Septic Tank (µg/kg) May 19, 1989

Parameter	Location			
	NE Side	NW Side	SE Side	SW Side
Trichloroethene	13/260	278/4200	1170/5600	174/79
1,2-Dichloroethene	ND/ND	80/1900	112/4200	5/ND
Vinyl Chloride	ND/ND	33/ND	2/ND	<1/ND
1,1,1-Trichloroethane	ND/520	ND/ND	ND/ND	2/ND
1,2-Dichloroethane	ND/340	ND/ND	ND/ND	ND/ND
Methylene Chloride	ND/3200	ND/ND	ND/ND	2/ND
Chloroform	ND/ND	ND/ND	ND/ND	6/ND
Tetrachloroethene	ND/980	ND/ND	ND/ND	ND/ND

Samples were analyzed by two laboratories: first result is Friend Laboratory, Inc.; second result is Upstate Laboratories, Inc.
ND - Not detected

The soil samples were also analyzed for metals using both total digestion and EP toxicity procedures. The EP toxicity results indicated that no metals were detectable in the leachate, although the samples of the drummed wastes from the tank closure indicated some concentrations of total metals above the detection limits. None of the material was classified as hazardous waste based on the EP toxicity procedure.

3 PREVIOUS INVESTIGATIONS

An investigation work plan[2] was prepared by IBM and approved by NYSDEC in October 1997. Based on analytical results from soil samples collected in October 1997, the investigation work plan was modified in November 1997 and the investigation continued in January and February 1998. The initial investigation results were presented in a status report[3] dated April 30, 1998. Based on recommendations presented in the status report, a followup investigation was conducted in July 1998 and the results were presented in a final report[4] dated October 1, 1998. A comprehensive round of groundwater elevation measurements and groundwater sampling was performed in October 1999.

3.1 Initial Investigation

The initial investigation in late 1997 and early 1998 focused on the shallow soil and groundwater in the vicinity of the former septic system and was organized as a series of tasks: (1) a soil reconnaissance survey, (2) soil borings, (3) soil sampling and monitoring well installation, (4) groundwater sampling and elevations, and (5) *in situ* hyraulic conductivity tests. With the permission of NYSDEC[5], Task 2 (soil borings) was not performed following a review of the preliminary results of the soil

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[2]Groundwater Sciences Corporation, *Work Plan - Broadway Facility Investigation, Owego, New York,* prepared for IBM Corporation, September 25, 1997.

[3]Groundwater Sciences Corporation, *Status Report - Broadway Facility Investigation, Owego, New York,* prepared for IBM Corporation, April 30, 1998.

[4]Groundwater Sciences Corporation, *Final Report - Broadway Facility Investigation, Owego, New York,* prepared for IBM Corporation, October 1, 1998.

[5]New York State Department of Environmental Conservation, *Letter from Thomas S. Suozzo to Mitchell E. Meyers of IBM Corporation Regarding Broadway Complex Site,* November 20, 1997.

reconnaissance survey[6]. Instead, Task 2 was replaced by collection of soil samples during monitoring well installation (Task 3).

During Task 1, a direct-push sampling technique (i.e., Geoprobe®) was used to collect 63 soil reconnaissance samples for jar headspace analysis from 36 grid points in the parking lot south of Building 911. Ten soil samples with the highest jar headspace results were submitted for laboratory analysis. In plan view, these samples were distributed as a band extending from the area south of the loading dock in the center of the south wall of the Broadway building toward the southwestern edge of the parking lot. The laboratory analytical results (Table 3-1) confirmed this distribution of elevated VOC concentrations in shallow soils. The predominant chemical was TCE.

Table 3-1. Summary of Laboratory Analytical Results from Select Direct-Push Soil Samples

Parameter	Number of detections/ samples	Highest Concentration (µg/kg)	Recommended Soil Cleanup Objective (µg/kg)*
Trichloroethene	9/10	120	700
Toluene	9/10	27	1500
1,2-Dichloroethene (total)	1/10	4	300 (trans)
1,1,1-Trichloroethane	1/10	3	800
Xylenes (total)	1/10	3	1200
Methyl Isobutyl Ketone	5/10	3	1000

* Based on TAGM HWR-94-4046, Appendix A, "Recommended Soil Cleanup Objectives", January 24, 1994.

[6] IBM Corporation, *Letter from Mitchell E. Meyers to Thomas Suozzo of NYSDEC Region 7 Presenting Task 1 Preliminary Results,* October 31, 1997.

Three monitoring wells (Task 3) were installed based on the direct-push soil analytical results, and the locations (911-1, 911-2, and 911-3, Figure 2-2) were approved in advance by NYSDEC[7]. Well 911-1 was installed approximately 250 feet southwest of the former septic tank at the location with the highest TCE soil concentrations and monitoring well 911-2 was installed approximately 90 feet southwest of the former septic tank between well 911-1 and the former septic tank. Well 911-3 was installed at a location initially presumed to be downgradient from the former septic tank and leach field, based on historical groundwater elevation data for the Sanmina-SCI facility. The initial investigation concluded that wells 911-1 and 911-2 are downgradient from the former septic tank location and that concentrations of VOCs in groundwater at wells 911-1 and 911-2 are related to releases from the former septic tank. It was determined that well 911-3 is not downgradient from the former septic tank location and has not been impacted.

The initial investigation also concluded that shallow soils have been impacted by VOCs (Table 3-2). However, no VOCs were detected at concentrations greater than NYSDEC's Technical and Administrative Guidance Memorandum No. 4046 Recommended Soil Cleanup Objectives (TAGM 4046 RSCOs). Chromium, copper, and nickel were detected at concentrations believed to be representative of site background at the Sanmina-SCI facility. The highest soil and groundwater VOC concentrations occurred in a narrow band downgradient from (southwest of) the former septic tank. The observed VOC concentrations in soil (Table 3-2) were explained by partitioning from shallow groundwater impacted by historical releases from the former septic tank. The former chemical storage

[7]New York State Department of Environmental Conservation, *Letter from Thomas S. Suozzo to Mitchell E. Meyers of IBM Corporation Regarding Broadway Complex Site, with Map,* November 20, 1997.

area belonging to Sanmina-SCI and monitored by well MW-19 (shown on Figure 2-2) was noted as a possible additional source area for VOCs in groundwater at that time.

Table 3-2. Soil Analytical Results from Initial Investigation Monitoring Wells (µg/kg)

Location (Depth)	911-1 (5'-7' and 9'-11')*	911-2 (5'-9')	911-3 (5'-9')	Recommended Soil Cleanup Objective (µg/kg)**
Volatile Organic Compounds (Method 8240)				
Trichloroethene	1.5J	2J	ND@11	700
Xylenes (total)	0.7J	ND@11	ND@11	1,200
Base/neutral Compounds (Method 8270)				
Bis (2-ethylhexyl)phthalate	48J	150J	89J	50,000
2-Methylnaphthalene	ND@370	39J	ND@370	36,400
Metals				
Barium	99,500J	96,800J	55,700J	300,000 or SB
Chromium	22,700	19,200	14,400	10,000 or SB
Copper	20,300J	41,600J	39,600J	25,000 or SB
Lead	33,000J	12,100J	9,900J	4,000-61,000*** or SB
Mercury	ND@90	ND@100	ND@80	100
Nickel	31,300	27,500	23,500	13,000 or SB

* There was no recovery from 7' to 9'.
** Based on TAGM HWR-94-4046, Appendix A, "Recommended Soil Cleanup Objectives", January 24, 1994.
*** Average level for undeveloped rural areas
J = Estimated value
SB = Site background

The shallow water-bearing unit was described at a silty sand and gravel and is unconfined. *In situ* tests of hydraulic conductivity (K) yielded approximately 30 feet per day for wells 911-1 and 911-2 and 60 ft/day for well 911-3. These values of hydraulic conductivity are reasonable for a silty sand or silty sandy gravel and are consistent with the values calculated for other wells completed in shallow soils of alluvial origin at the adjacent Lockheed Martin facility.

3.2 Followup Investigation

Based on the results of the initial investigation, a followup investigation was performed in July 1998 and is described below.

Two soil borings (911-B1 and 911-B2, Figure 2-2) were drilled in the sewer line bedding material outside the eastern wall of Building 911 and soil samples were collected to determine whether the sewer line could serve as a conduit for VOC transport from the former chemical storage area. The borings were 10 feet deep and three soil samples were collected from each boring. No Method 8240 VOCs were detected in any of these soil samples.

A monitoring well (911-5) that fully penetrates the shallow water-bearing unit was installed as close as practical to the location of the former septic tank to determine whether a source exists that might explain the groundwater concentrations in downgradient wells 911-1 and 911-2. A second fully penetrating shallow monitoring well (911-4) was installed at a location approximately 50 feet northeast of, and presumably upgradient from, well 911-5. The bottom of the shallow water-bearing unit at these two well locations is a layer of silt. Soil samples were collected from both wells and the results are summarized in Table 3-3.

Table 3-3. Summary of Soil Analytical Results from Followup Investigation Monitoring Wells (µg/kg)			
Location (Depth)	**911-4 (6'-8')**	**911-5 (6'-8')**	**Soil Cleanup Objective (µg/kg)***
Volatile Organic Compounds (Method 8240)			
Acetone	ND@11	29	110
1,1-Dichloroethene	ND@11	0.7J	400
1,2-Dichloroethene (total)	ND@11	59	300**
Trichloroethene	ND@11	240	700

* Based on TAGM HWR-94-4046, Appendix A, "Recommended Soil Cleanup Objectives", January 24, 1994.
** Cleanup objective is for the *trans*- isomer.
ND = Not detected
J = Estimated value

As shown on Table 3-3, no VOCs were detected in the shallow unsaturated soils at well 911-4 and four VOCs were detected in the shallow unsaturated soils at 911-5. None of the VOC detections was greater than TAGM 4046 RSCOs.

All five monitoring wells installed during the initial and followup investigations were then sampled and the results are shown on Table 3-4.

Table 3-4. Groundwater Analytical Results (µg/l) July 28, 1998					
Well	**911-1**	**911-2**	**911-3**	**911-4**	**911-5**
Volatile Organic Compounds (Method 8240)					
Trichloroethene (TCE)	2,000	2,200	1J	4J	47,000
1,2-Dichloroethene (total)	190	120	ND@10	ND@10	200
1,1,1-Trichloroethane (TCA)	150	66	ND@10	ND@10	150
Vinyl Chloride	1J	15	ND@10	ND@10	14
1,1-Dichloroethene	73	15	ND@10	ND@10	9J
1,1-Dichloroethane	37	3J	ND@10	ND@10	1J
Tetrachloroethene	4J	ND@10	ND@10	ND@10	21
Toluene	ND@10	ND@10	ND@10	ND@10	5J
Chloroform	1J	ND@10	ND@10	ND@10	ND@10
1,2-Dichloroethane	ND@10	ND@10	ND@10	ND@10	ND@10
Xylenes (total)	ND@10	ND@10	ND@10	ND@10	2J
1,1,2-Trichloroethane	ND@10	ND@10	ND@10	ND@10	1J
All other compounds	ND@10	ND@10	ND@10	ND@10	ND@10

J = Estimated value
ND = Not detected

As shown on Table 3-4, the highest concentrations of TCE and its degradation products were detected in well 911-5 near the former septic tank location. Concentrations of VOCs at wells 911-1 and 911-2 are consistent with the previous sampling results from the initial investigation in January 1998.

Groundwater elevations were measured to determine groundwater elevations, gradients and flow directions. These measurements confirmed that the direction of groundwater flow is from northeast to southwest beneath Building 911 and the parking lot investigation area south of Building 911.

The followup investigation confirmed that the principal chemicals of concern in the groundwater are TCE and its degradation products, with lesser concentrations of TCA and its degradation products.

These are the same chemicals associated with the former septic tank and with the former chemical storage area at Sanmina-SCI well MW-19. Based on groundwater elevation data, the former septic tank is upgradient from wells 911-1 and 911-2, and downgradient from well 911-4. These upgradient-downgradient relationships are supported by the groundwater chemistry results.

The absence of VOCs in samples from the soil borings 911-B1 and 911-B2 suggests that the permeable backfill materials around the buried sewer line are probably not a significant conduit for transport of contaminated groundwater from the former chemical storage facility.

3.3 Comprehensive Hydrogeologic Measurements

In October 1999, groundwater elevations were measured and groundwater was sampled in the five shallow soil zone monitoring wells installed by IBM at the Broadway complex, in wells maintained by Sanmina-SCI to the north, west and southeast, and in wells maintained by IBM on the adjacent Lockheed Martin facility to the east.

3.3.1 Groundwater Elevations and VOC Concentrations

Figure 3-1 is a groundwater elevation contour map (October 25, 1999) for monitoring wells completed in the shallow soil zone. Figure 3-1 shows, in general, that the direction of groundwater flow beneath the Broadway building is from northeast to southwest toward recovery well RW-6.

Figure 3-2 shows the results of groundwater samples collected in October 1999 from the wells completed in the shallow soil zone. The analytical results are consistent with previous sampling events and show that the shallow groundwater plume emanating from the former septic tank location at the Broadway complex is ultimately captured by Sanmina-SCI recovery well RW-6.

3.3.2 Chemical Transport

An average linear velocity for groundwater in the shallow soil zone was estimated as follows. From the slug tests, assume $K = 30$ ft/day. The gradient, i, estimated from Figure 3-1, is 1.0 ft/70 ft = 0.015, and the porosity, n, was estimated at 30%. Together, these values yield

$$v = \frac{Ki}{n} = \frac{30(0.015)}{0.3} = 1.5 \text{ ft / day}$$

The effects of chemical adsorption were then estimated by calculating a partition coefficient for TCE using the following relation and assuming an organic carbon fraction of 0.1%, based on soils of similar alluvial origin in New York State:

$$K_d = K_{oc} f_{oc} = 126(0.001) = 0.126 \text{ ml / g}$$

where K_{oc} is the water/organic carbon partition coefficient for TCE[8] and f_{oc} is the organic carbon fraction.

The effect of sorption reactions on chemical migration is commonly expressed by the retardation equation

$$R = v / v_c = 1 + \frac{\rho_b}{n} K_d$$

where R is the retardation factor, v is the velocity of groundwater, v_c is the velocity of the chemical, and ρ_b is the bulk density. Substituting appropriate values

$$R_{TCE} = 1 + \frac{1.8}{0.3}(0.126) \approx 1.8$$

[8]Pankow and Cherry, *Dense Chlorinated Solvents and Other DNAPLs in Groundwater,* Waterloo Press, 1996.

and

$$v_c = \frac{v}{R} = \frac{1.5\,\text{ft / day}}{1.8} \approx 0.8\,\text{ft / day}$$

Therefore, with an organic carbon fraction of 0.1% and a gradient of 0.015, the velocity of TCE in the study area at the time of the initial and followup investigations was estimated at 0.8 ft/day.

3.3.3 Conclusions

The following conclusions were made regarding the extent of contamination associated with the former septic tank:

1. Although the septic tank was removed in 1989, groundwater concentrations at well 911-5 in 1999 suggest that a small quantity of separate-phase material may exist at the water table, held there by capillary forces as shown schematically on Figure 3-3.

2. The 1999 groundwater elevation contours show that wells 911-1 and 911-2 are downgradient from the former septic tank location and that groundwater concentrations in 911-1 and 911-2 may be related to releases from the former septic tank. Well 911-3 is not downgradient from the former septic tank location and has not been impacted. Well 911-4 is clearly upgradient from the former septic tank.

4 WORK PLAN ACTIVITIES

The focus of the interim remedial measures will be on the shallow soil and groundwater in the immediate vicinity of the former septic tank. The groundwater chemistry data from monitoring well 911-5 (TCE concentration > 10,000 µg/l) suggests that there may be a small residual DNAPL source located at the water table at a depth of 12 to 13 feet in the source area associated with the former septic tank. Cross section A-A' (Figure 4-1) shows upgradient well 911-4, source area well 911-5, and downgradient wells 911-2 and 911-1 in the shallow soil zone. The October 1999 TCE concentrations are posted on this cross section and the water table is also shown relative the screened intervals in the monitoring wells.

4.1 Data Quality Objective

The Data Quality Objective for this IRM Work Plan is to determine the vertical distribution of VOC concentrations in shallow groundwater near the source area. This groundwater data would be used to design a remedial system. The proposed approach is described below.

4.2 Install Monitoring Wells near Source Area

Four 3-inch or 4-inch diameter multi-screen groundwater monitoring wells will be installed using hollow-stem auger methods with continuous split-spoon sampling along transect B-B' approximately 20 feet downgradient from monitoring well 911-5 as shown on Figure 4-1. Transect B-B' is approximately 60 feet long and is oriented perpendicular to the direction of groundwater flow as shown on cross section A-A' (Figure 4-1). The wells will be spaced at intervals of 15 to 20 feet along the transect and will be approximately 20 feet deep. Soil samples will be screened during drilling using a photoionization detector; however, soil samples will not be collected for laboratory analysis. A detailed well installation protocol is presented in Appendix A.

Each well will be constructed with three 1-foot screened intervals spaced across a saturated thickness of approximately 7 to 8 feet. The screened intervals will be surrounded by discrete sand packs placed through the hollow stem auger (Grade 0 or 00N sand as appropriate based on the soil log). The unscreened annular portions of the borehole will be sealed with 2 to 3 feet of dry bentonite gravel that will hydrate when saturated. The deepest screened interval will rest on top of the silt unit at a depth of approximately 18 to 19 feet. The middle screened interval will be in the middle of the saturated zone at a depth of approximately 14 to 15 feet. The upper screened interval will be at the water table at a depth of approximately 11 to 12 feet. These middle and upper screen placement depths will be adjusted for saturated thickness. The saturated thickness will be calculated by interpolating between the measured groundwater elevations in existing wells 911-5 and 911-2.

4.3 Collect Groundwater Samples

Each monitoring well will be sampled using a multilevel groundwater monitoring (MGM) system such as the Waterloo removable packer system designed by Solinst Canada (refer to manufacturer's brochure in Appendix B). The reusable MGM system will consist of a series of three sampling ports separated by inflatable packers that are placed at various depths in a cased multi-screen borehole, effectively isolating and providing access to discrete monitoring levels. The packer length in the Waterloo system is 3 feet, and the system fits in a 3-inch or 4-inch diameter well.

A groundwater sample will be collected from each sample port (3 sample ports per well times 4 wells for a total of 12 samples) and will be analyzed for VOCs by SW-846 Method 8260B. The sample collection procedure will be as specified by the manufacturer of the MGM system. The design of the MGM system allows for groundwater samples to be collected using low-flow methods and produces minimal purge water.

The NELAP-certified IBM Hudson Valley Environmental Laboratory in Hopewell Junction, New York (NYSDOH ELAP #10426 and #11403) will analyze the groundwater samples. One duplicate sample per 20 groundwater samples will be sent to Severn Trent Laboratories of Newburgh, New York (NYSDOH ELAP #10142) for analysis. Laboratory analytical data reports will be of the ISRA type, and will include QC summary (method blanks, surrogates/system monitoring compounds, matrix spike/matrix spike duplicate/blank spike, etc.), standards data, and raw QC data (e.g., chromatograms).

4.4 Evaluate Groundwater Data to Determine Further Course of Action

The laboratory analytical data will be validated and summarized on a detailed cross-section along transect B-B' to evaluate vertical distribution of VOCs in groundwater. Based on the pattern of vertical distribution, one of the following actions will be taken:

1. If the pattern of vertical distribution of VOCs suggests a shallow discrete source near the water table, then additional soil samples will be collected at the source using direct-push methods, and the feasibility of removing additional source material will be evaluated by other means.

2. If the pattern of vertical distribution of VOCs does not suggest a shallow discrete source, then another work plan will be developed and submitted to NYSDEC for review and approval.

5 COMPLETION SCHEDULE

A proposed project completion schedule is shown as a Gantt chart on Figure 5-1. Upon approval of the IRM Work Plan, approximately six weeks will be required to prepare a health and safety plan, make arrangements for hiring subcontractors, design the MGM system and acquire the necessary equipment, arrange for access with the Site owner, and measure the current saturated thickness (Task 1). The MGM system will be custom-designed and its delivery is dependent on the manufacturer. Task 2, well installation, will require approximately four weeks: two weeks to drill and construct four monitoring wells and two weeks to construct surface completions and survey the wells using a licensed surveyor; Task 2 can be performed concurrently with portions of Task 1 (after contractors are hired, site access is granted, saturated thickness is measured, and buried utilities are cleared). Task 3, groundwater sampling, will require one week and will occur no sooner than two weeks following the installation of the last monitoring well. Standard turnaround time for laboratory data with full deliverables is four weeks from the date of sample collection and is shown as Task 4 (Laboratory Analysis). Task 5, final report preparation, including data validation, will require three to four weeks. The total time for IRM Work Plan completion, therefore, is approximately 18 weeks. Monthly progress reports will be submitted by the 10th day of each month beginning with the month subsequent to the approval of this Work Plan.

Figure 3-1
IBM
Corporate Environmental Affairs
Groundwater Elevation Contour Map
Shallow Soil Zone
Broadway Complex, October 25, 1999
DRAWN BY: MKM
DATE: 1/10/03
CHECKED & APPROVED BY: EAR
DRAWING NO.
93004-050-B
GROUNDWATER SCIENCES CORPORATION
805.33 - Groundwater Elevation (feet amsl)
800 - Groundwater Elevation Contour (feet amsl)
- Inferred Direction of Groundwater Flow
- Soil monitoring well
- New monitoring well
- Existing shallow overburden monitoring well
- Withdrawal well
Scale
0
125'
250'
CONRAIL
Price Home
FOSTER
BARNES
810

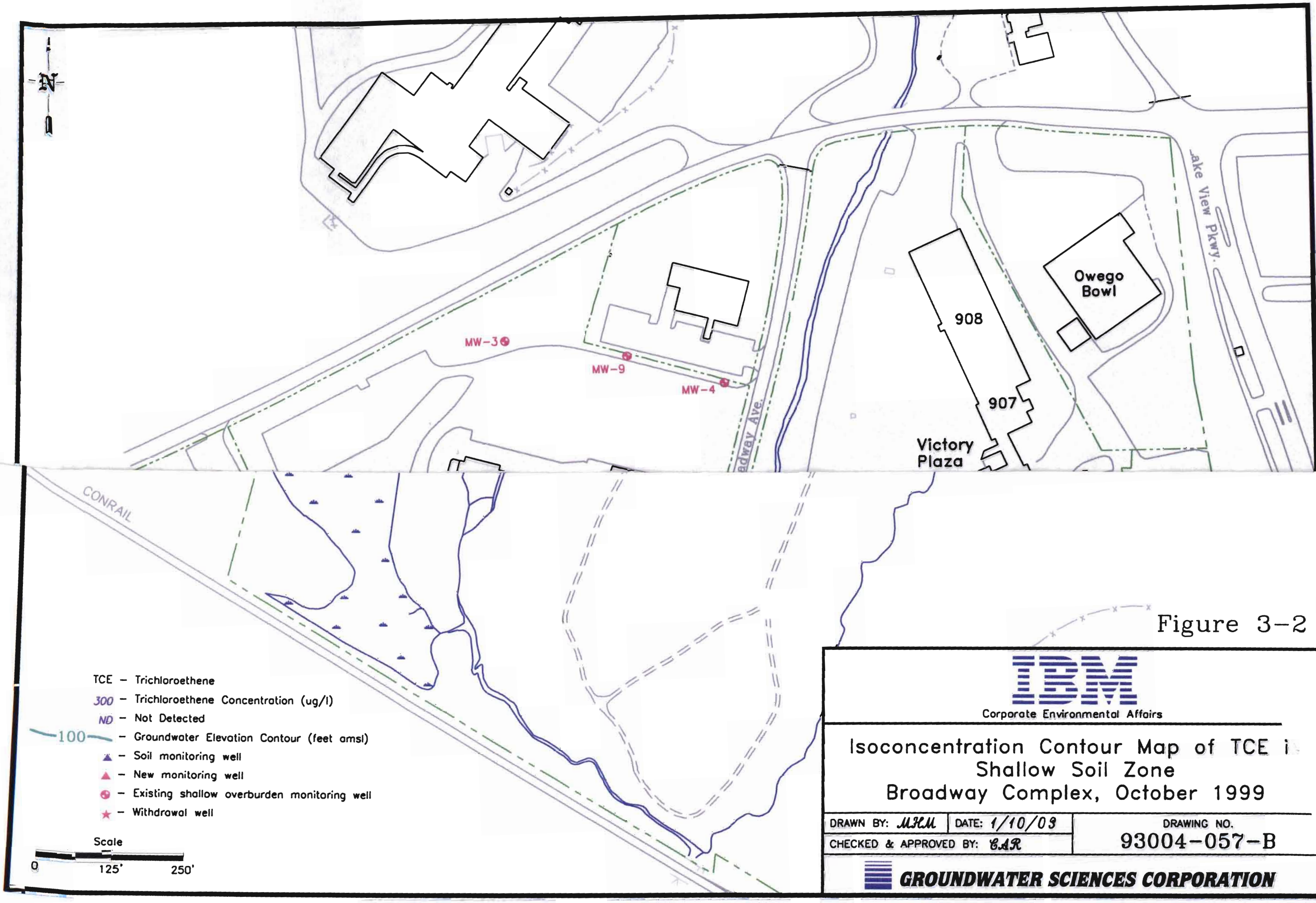

Figure 3-2

IBM Corporate Environmental Affairs

Isoconcentration Contour Map of TCE i[n]
Shallow Soil Zone
Broadway Complex, October 1999

DRAWN BY: MHM	DATE: 1/10/03
CHECKED & APPROVED BY: CAR	DRAWING NO. 93004-057-B

GROUNDWATER SCIENCES CORPORATION

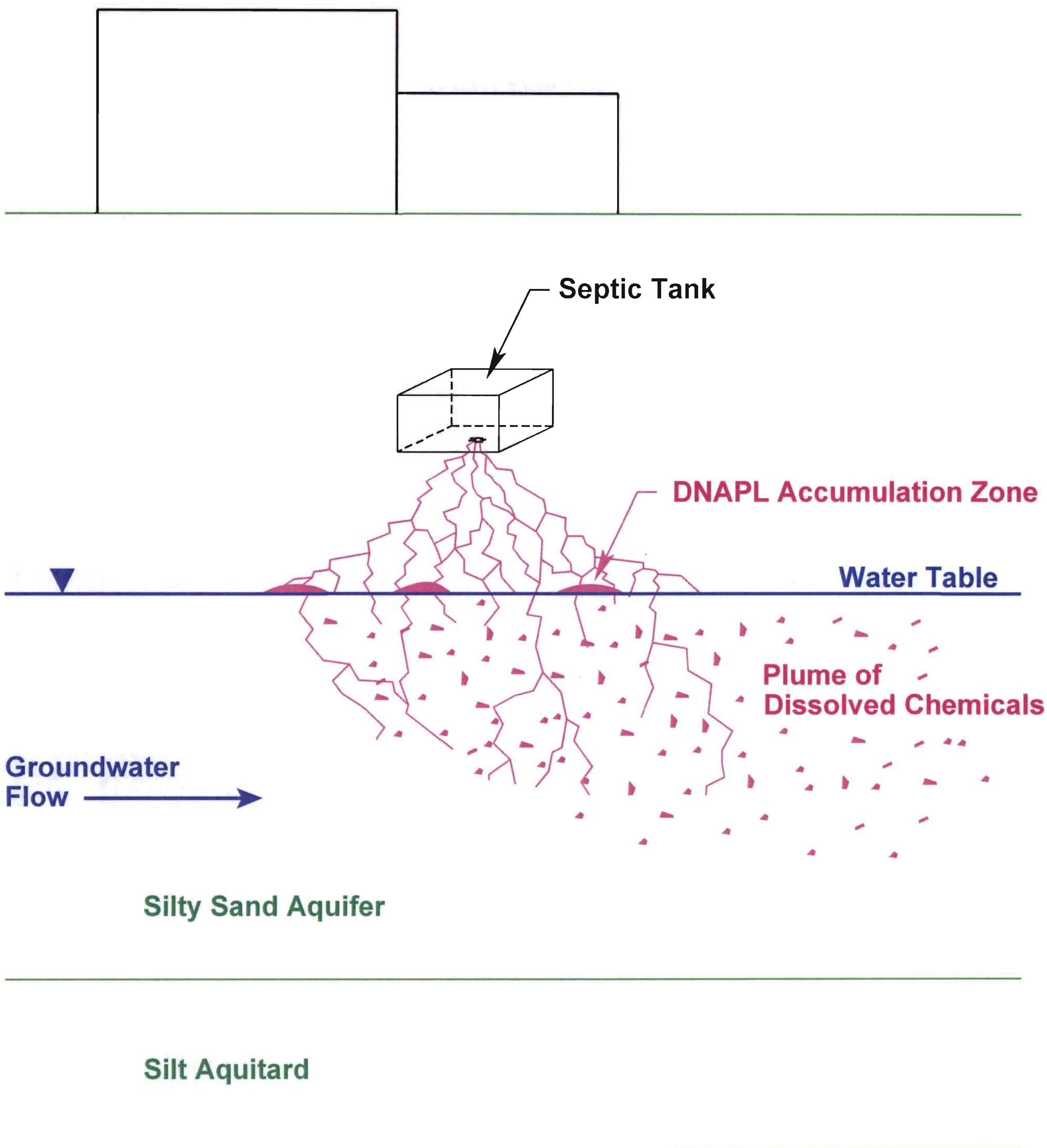

Figure 3-3

Schematic Diagram of a DNAPL Release

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\ADMIN\DNAPL_septic / 01-10-03

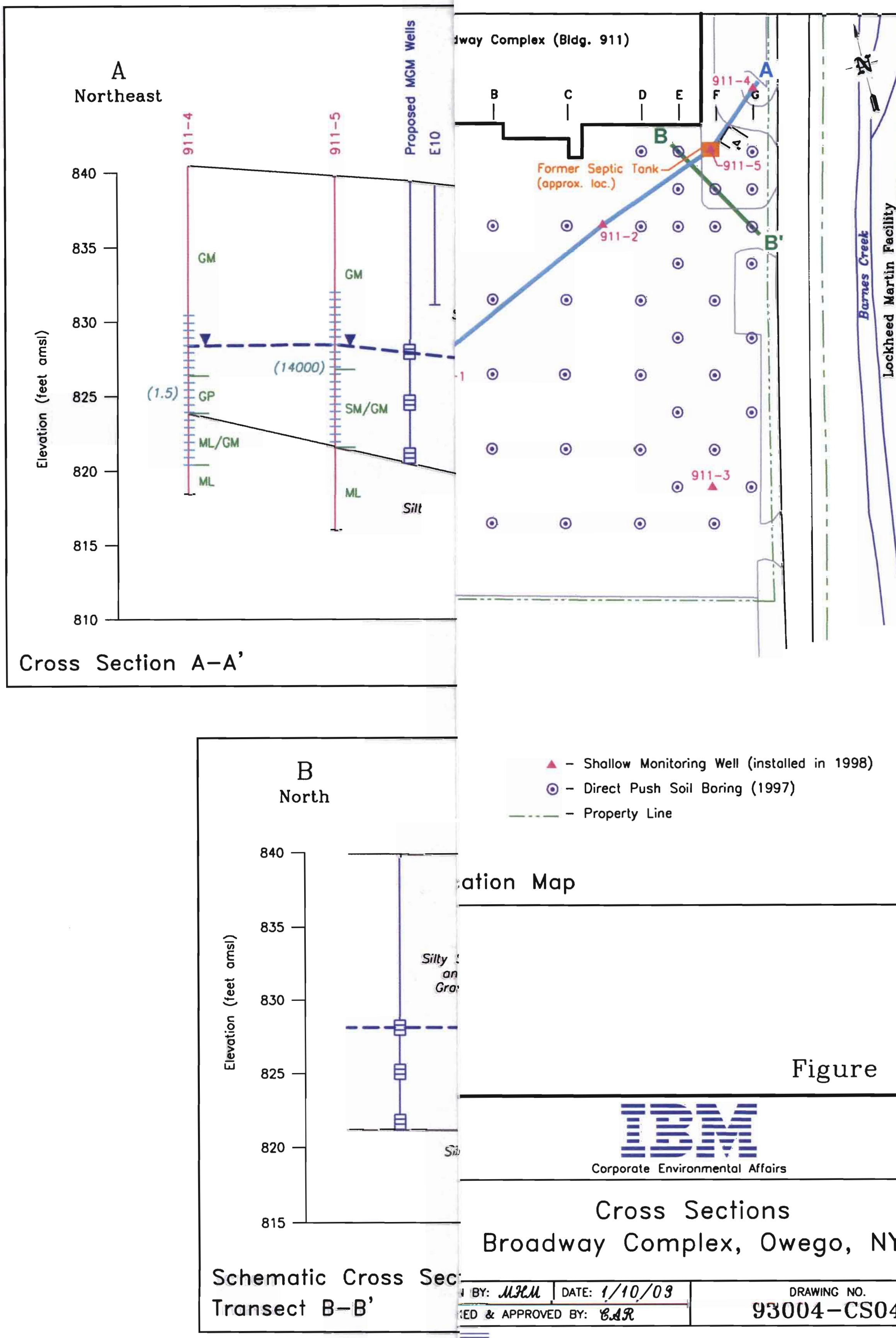

Figure 4-1

IBM
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Cross Sections
Broadway Complex, Owego, NY

BY: MHM | DATE: 1/10/03
ED & APPROVED BY: CAR

DRAWING NO.
93004-CS04

GROUNDWATER SCIENCES CORPORATION

Figure 5-1
IRM Work Plan
Project Completion Schedule
Broadway Complex
Index No. A7-0407-0001

GROUNDWATER SCIENCES, P.C.

January 13, 2003
Project No. 93004.35

APPENDIX A

Monitoring Well Installation and Split Spoon Sampling Protocols

Drilling

A qualified geologist or hydrogeologist will supervise the drilling and installation of each monitoring well and will prepare geologic and well construction logs for each boring. These logs will include the following information: depth, blow counts per six inches, sample number, sample interval, recovery, overburden/lithologic description (soil or rock type, color, grain size, density, moisture, weathering, texture), air monitoring scan, boring size, monitoring pipe description, type of grout, type of surface completion, sand grade, and screen slot size. A sample monitoring well construction and geologic log is attached. Soil descriptions will generally follow the USCS or Burmeister systems.

Prior to drilling, a hole will be hand-augered, where possible, at the precise location of each boring to a depth of up to six feet for the purpose of checking for buried utilities. As an alternative, a backhoe will be used to dig a shallow trench. Depth-specific samples from the hand-augered hole will be logged by the supervising geologist.

Continuous split-spoon sampling of soils will be conducted using a hollow-stem auger rig equipped with two-inch O.D. split-spoon samplers two feet long. Split-spoon sampling will begin at the bottom of the hand-augered hole or trench. After being advanced two feet by blows of a 140-lb. hammer falling 30 inches (standard penetration test), the spoon and sample will be removed and the augers will be advanced through the same two-foot interval. In this way, only undisturbed soil samples will be collected. Blow counts from the standard penetration test will be recorded for each six-inch depth interval. Hollow-stem augers with at least a 4-1/4-inch I.D. will be used during the drilling procedure. The resulting borehole generally will be at least 8 inches in diameter.

During well construction, the screens will be placed such that they correspond to the appropriate monitoring depths described in the Work Plan. The remainder of the well construction will be as described below.

Well Construction

A basic design will be followed to maintain uniformity. This design includes the following elements:

1. Three-inch or four-inch diameter, Schedule 40 or 80, threaded, flush-joint PVC screen and riser pipe. The maximum screened interval will be two feet and maximum sand pack interval will be four feet.

2. Grade 0 or 00N silica sand pack and 10-slot (0.010 inch) screen size. A different sand or screen size may be selected, depending on soil conditions. The sand pack will generally extend at least one foot above the top of the screen and will be emplaced by slowly pouring the sand and periodically measuring the level with a sounding tape to detect bridging of the sand.

3. A minimum of two feet of bentonite gravel to seal the interval above the sand pack. Bentonite slurry (granular bentonite/water mix) or bentonite gravel will be used to seal all specified intervals of the borehole below the static water level. The bentonite slurry will be emplaced by means of a tremie tube and grout pump. Only potable water will be used in mixing the slurry.

4. Bentonite slurry to seal all specified intervals of the borehole above the static water level. The bentonite slurry will be emplaced by means of a tremie tube and grout pump.

5. Surface completion appropriate to the particular location. Wells completed in grassy areas or concrete islands generally will be finished with 4-inch I.D. steel protector pipes extending to a height of approximately 2.5 feet above grade and held in place by a concrete pad extending to a minimum depth of one foot below grade. Wells completed in paved areas generally will be finished with a water-tight steel manhole (Morrison-type) encased in concrete at grade and equipped with a water-tight locking cap.

Following the installation of the new wells, all inner PVC well casings and ground surface elevations will be surveyed to within 0.01 feet by a New York State licensed surveyor. The surveyor will make a small cut on the PVC casing to mark the location of the measurement point. Horizontal grid coordinates will also be surveyed so that the wells can be accurately placed on the site maps.

Air Monitoring

Air monitoring will be performed during drilling activities in accordance with the Health and Safety Plan (HASP). Air monitoring for VOCs will be performed continuously in the breathing zone using an organic vapor analyzer such as a photoionization detector. If persistent concentrations above background are measured in the breathing zone, workers will leave the area until the contamination dissipates or until alternative protective measures are established.

Screening of Water and Cuttings

All soil cuttings generated during drilling activities will be placed on plastic and allowed to aerate. If field screening with an organic vapor analyzer indicates that the soils are contaminated, the soils will be drummed, tested, and disposed of accordingly. The screening level in air for drumming and further testing of the soil will be 5 ppm when the organic vapor analyzer is held above the soil. Otherwise, the cuttings will be spread out near each drilling location.

Decontamination

To reduce the potential for contamination of groundwater samples from drilling equipment and well construction materials, several precautions will be taken:

1. The PVC pipe and screen will be steam-cleaned prior to being used in well construction unless it is delivered in intact sealed plastic wrappings that are certified by the manufacturer to be factory-decontaminated for monitoring well use.

2. The screen and pipe will be lowered into the borehole by hand. All workers handling these materials will wear new, clean, disposable vinyl or other surgical-type gloves.

3. The drilling rig and tools will be thoroughly steam-cleaned upon arrival at the site and before drilling equipment is used in any boring. Split-spoon samplers will also be steam-cleaned on-site before being used or reused.

Health and Safety Plan

Health and safety issues are addressed in a HASP. The HASP is a separate document which addresses field activities, including monitoring well installation. The HASP will be reviewed by all workers prior to beginning field activities.

APPENDIX B

Data Sheets for

Waterloo Multilevel Groundwater Monitoring System, Model 401

Solinst®

Waterloo System

Model 401 Data Sheet

Model 401

Waterloo Multilevel Groundwater Monitoring System*

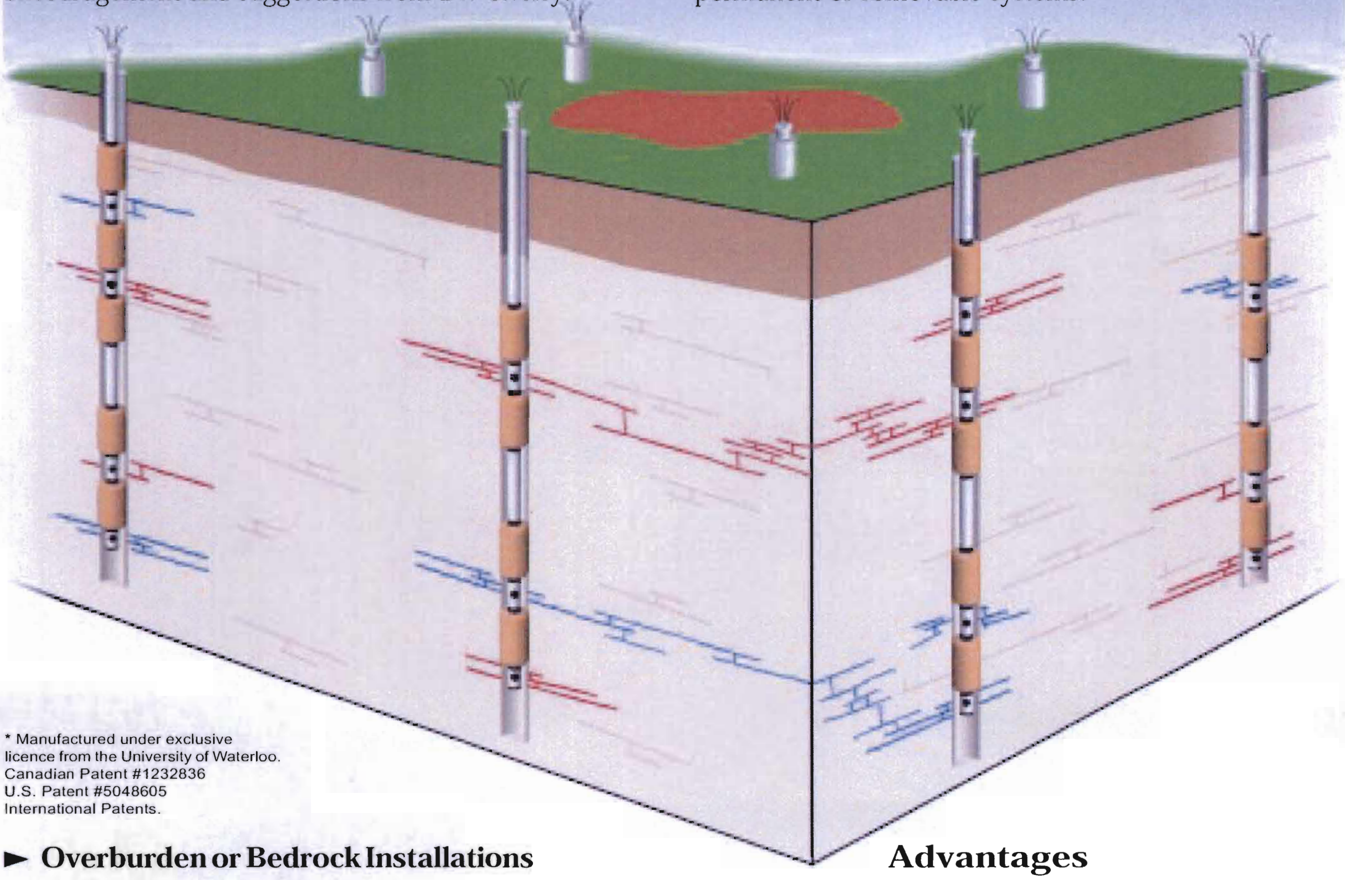
The Waterloo System is used to obtain groundwater samples, hydraulic head measurements and permeability measurements from many discretely isolated zones in a single borehole.

The Waterloo System originated with Dr. John Cherry at the Groundwater Institute of the University of Waterloo in 1984. Ongoing development of the System by Solinst has taken place on a continuous basis since then, with encouragement and suggestions from Dr. Cherry.

Detailed 3-D Data

When a number of Waterloo Systems are used at a site, they allow detailed three-dimensional groundwater information, at a reasonable cost. Fewer drilled holes are an advantage and monitoring times are reduced.

The simple modular system is customized for the needs of each project. This allows monitoring zones to be placed at desired depths using options suitable for either bedrock, overburden or combination applications and with either permanent or removable systems.



* Manufactured under exclusive licence from the University of Waterloo.
Canadian Patent #1232836
U.S. Patent #5048605
International Patents.

- **Overburden or Bedrock Installations**
  - allow monitoring of multiple zones in any geologic setting.
- **Permanent Waterloo Packers**
  - excellent in bedrock or cased holes
  - engineered for permanent seals
- **Removable Hydraulic Packers**
  - reuse at new zones or locations
  - easy decommissioning

Advantages

- Detailed data
- Data integrity
- Reduced project costs
- Purging and sampling times reduced
- Fewer drilled holes
- Reduced site disturbance
- Variety of monitoring options

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Why Multilevels

Groundwater flow is complex, especially in fractured bedrock. Multilevel monitoring allows the actual or potential pathways for contaminant migration to be accurately identified and easily monitored.

► Accurate Assessment

Multilevel monitoring in a number of boreholes at a site gives detailed three-dimensional data.

► Detailed Data

Multilevel monitoring maximizes the information available and reduces disturbance to the sub-surface. The Waterloo System provides for dedicated sampling to avoid cross-contamination.

► Economical

Multilevel systems also provide cost advantages over multiple single monitoring wells. Drilling and installation costs are reduced. Little time is required to obtain each data set. Purge water volumes are minimized, reducing handling and disposal costs.

The Waterloo System

The System uses modular components with specially designed joints held firmly together with nylon shear wires. This forms a sealed casing string so that water can neither get out, nor get in. The casing string is made up of various casing lengths, packers, ports, a base plug and a surface manifold. This allows accurate placement of ports at precise monitoring zones.

A monitoring tube is attached to the stem of each port. It individually connects that packed zone to the surface. The monitoring tubes are like miniature wells (piezometers). They are contained and protected within the sealed casing string.

The standard system is built on 2" (50mm) Sch. 80 PVC to fit 3"- 4" (75 - 100 mm) boreholes and uses 3' (915mm) long packers. Stainless steel components, custom packer materials and sizes are available, if necessary.

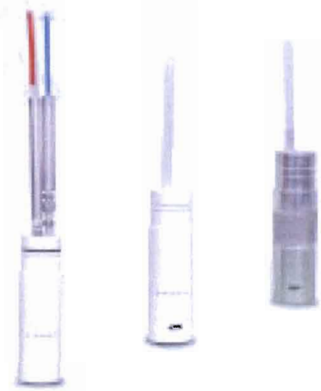
Manifold

O'Ring Joints with Shear Wire

Ports

Monitoring ports are available in PVC or stainless steel. Ports are isolated by packers at each desired monitoring zone and are individually connected to the surface manifold with narrow diameter tubing. Thus formation water enters the port, passes into the stem, up into the monitoring tube attached to the stem, to its static level.

A sampling pump or pressure transducer may be dedicated to each monitoring zone by attachment to the port stem. Dual stem ports are available to allow both sampling and hydraulic head measurements from the same port. Alternatively, the monitoring tubes may be left open to allow sampling and hydraulic head measurements with portable equipment. For installations in silty deposits there are special sampling ports with extra screening to prevent silt entry into the port.



PVC and Stainless Steel Ports

Permanent Waterloo Packer

Joints*

The patented method of joining components of the Waterloo System uses a nylon shear wire and an o-ring. This gives a reliable, leakproof joint that has been tested to 2,000 pounds (900 Kg.) tensile load and leak tested to 200 psi (1375 kPa) internal pressure.

This joint provides a water-tight seal and prevents contact between packer inflation water inside the casing and the formation water outside the casing.

Manifolds

The manifold completes the system at surface. It organizes, identifies, and coordinates the tubes and/or cables from each monitoring zone.

The manifold allows a simple, one-step connection for operation of transducers or of pumps. When dedicated pumps are selected, it allows individual zones to be purged separately, or purging of many zones simultaneously to reduce field times.

* US Patent 5,255,945

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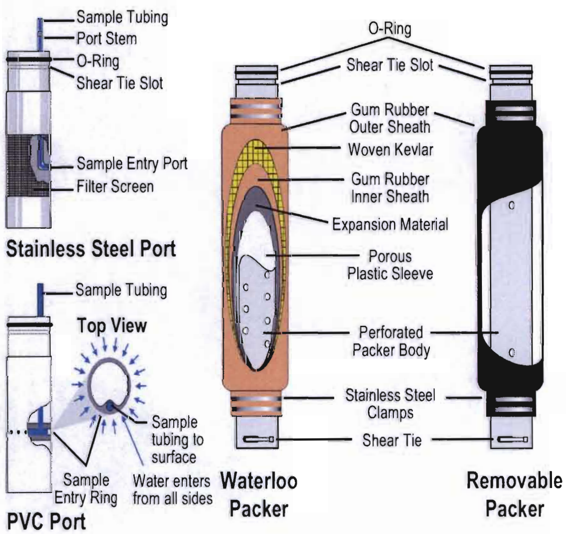
Permanent Waterloo Packers

Permanent packers ensure long term integrity of seals in cored bedrock holes and cased wells. They use a water activated expansion sleeve fitted over the perforated packer body. A layer of porous plastic distributes water evenly to the packer expansion material. A Rubber/Kevlar/Rubber sheath envelops the expansion material. The Kevlar layer provides strength to bridge across large fissures. The pliant gum rubber forms an effective seal against the borehole wall.

Water is added to the inside of the sealed casing string after installation. The water passes through the packer body into the expansion sleeve, causing the material to expand. Thus an engineered seal is permanently formed against the borehole wall.



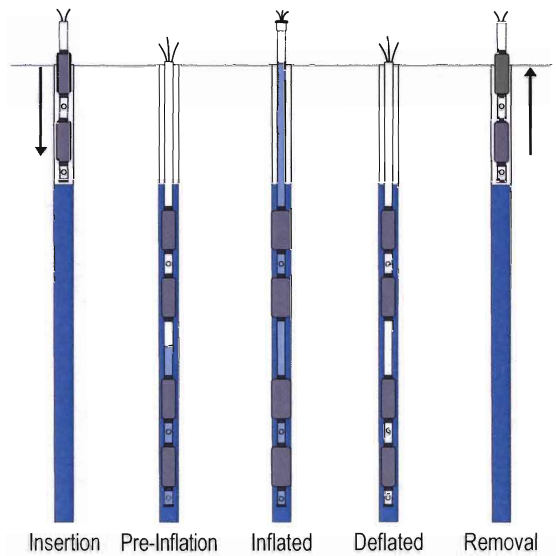
Overburden Applications

Waterloo Multilevel Systems can be used to monitor multiple zones within unconsolidated formations, as well as in bedrock. There are three methods of System installation:

- Within hollow stem augers or temporary casing. Special screened ports are used and flowing sand formations are allowed to collapse around the System.
- Within hollow stem augers or temporary casing using standard tremie methods (or the Solinst Model 561 Sand Bentonite Injector) to place sand around the ports and bentonite seals in the annular space between the monitoring zones, as the augers or temporary casing is lifted.
- Within a cased and screened well.

Removable Hydraulic Packers

These packers allow reuse of the system at other zones or new locations. They facilitate system maintenance and borehole decommissioning, simplify grouting of the hole and allow most of the system to be reused.



Removable packers are made with natural gum rubber and are inflated hydraulically or pneumatically by pressurizing the interior of the Waterloo System casing string. Packers can be constructed to suit various diameters of holes.

Infill Packers

Generally it is desirable to seal off as much of the borehole as possible. These less expensive, bentonite-filled packers are available to fill long void areas between monitoring zones, as a secondary seal.

Installation within Wellscreen/Casing

A permanent 3" or 4" casing and screen string can be installed using typical sand and bentonite placement methods. Then a Waterloo System with either permanent or removable packers can be installed within the screen and casing string, as in a bedrock borehole.

Installs Quickly

Installation of the Waterloo System is quick and easy. A typical System can be installed by one technician and an assistant, in a few hours, without the use of a drilling rig.

Starting with the base plug and lowermost sections, the components are joined together in the order required. As each new port is put into position a new monitoring tube, dedicated pump and/or transducer is connected to it. Successive components are threaded over these tubes, building the casing string, until the System is complete.

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System Flexibility

The Waterloo System is extremely flexible. Each System is customized to suit monitoring needs, site conditions and budget constraints:

- removable or permanent system
- bedrock or overburden application
- groundwater or vadose zone monitoring

Packers and ports can be accurately placed to monitor each zone of interest.

Number of Monitoring Zones/Hole

The maximum number of monitoring zones for a System is determined by the number of tubes and/or cables that will fit inside the casing string. This number is dependent on the monitoring options chosen. Systems can be designed to monitor from 2 to as many as 24 zones.

Standard 2" (50mm) Waterloo System	
Monitoring Option	**# Zones**
Dedicated Pumps and Transducers	7
Open Tubes Only	8
Dedicated Pumps and Open Tubes	5
Dedicated Pumps Only	12
Dedicated Pressure Transducers Only	24

Materials

For particular applications specific materials may be chosen. These may include stainless steel casing and packer bodies, and stainless steel, nylon or Teflon* tubing.

Monitoring Options

Dedicated sampling pumps and/or pressure transducers: Each monitoring port may be fitted with a dedicated sampling pump and/or pressure transducer. This maximizes the speed with which each data set can be obtained, and avoids the need to decontaminate and repreatedly lower portable devices. The sampling pumps are suitable for sampling many types of contaminants, including VOCs.

Purge volumes are very small and with dedicated pumps all zones can be purged simultaneously. Ports with two stems allow a dedicated pump and a transducer to be placed at exactly the same level.

Open Tubes: The most basic version uses open tubes attached to each port. This option allows monitoring with portable sampling and level measurement devices. This provides a very economical and flexible multilevel monitoring device.

Mix of open tubes and dedicated equipment: A third option is to choose a mix of open tubes and dedicated equipment in different zones. This combines the advantages of less expensive portable equipment for shallower zones (i.e. 100 ft., 30 m) and the more time efficient dedicated equipment for deeper zones.

Water level monitoring only: The System can comprise pressure transducers only, for pressure monitoring in up to 24 discrete zones.

Borehole Size

Waterloo or removable packers are designed for use in 3"- 4" boreholes (75 - 100 mm). Systems can also be installed in larger boreholes using:

1. standard tremie methods
2. The Sand/Bentonite Injector
3. screen and casing installed within a larger hole.

Dedicated Sampling Pumps

Dedicated equipment reduces the time and effort required to obtain data, as equipment is not lowered down the borehole and purge volumes are reduced. It gives significant cost savings and avoids cross contamination.

For long term or frequent sampling Waterloo Systems most commonly use the gas drive, Solinst Double Valve Pumps with stainless steel and Teflon* valves. A pump is connected directly to the stem of each port and dual line polyethylene or Teflon tubing connects the pump to the wellhead manifold.

Both automatic and manual pump control units are simple to use. They have quick-connect couplings with only a single connection to the manifold required. Samples from all levels are easily and rapidly obtained. Purging from some or all levels simultaneously is accommodated by the multi-purge feature of the manifold.

An option is to use the inexpensive positive displacement, gas drive Single Valve Pump. A check ball of appropriate size is dropped into an open monitoring tube, and a second smaller tube is pushed co-axially into the monitoring tube. When this is pressurized, the check ball is forced down, to close the inlet, and the water is pushed to the surface.

Single Valve Pumps enable each open monitoring tube to be used to obtain water level measurements manually.

Model #102/P3

Model #402
Triple Tube Sampler

Low Flow Purging and Sampling

Purge volumes are very small due to the small annular space and tubing diameters used in the system.

Consequently sampling is rapid, even though flows are low, especially with dedicated pumps when all zones can be purged simultaneously.

The 5/8" (16mm) diameter Solinst Double Valve Pump is ideal for use when low flow sampling and purging techniques are desired.

Dedicated Transducers

Dedicated pressure transducers allow rapid and accurate measurement of water pressure. Unless static water levels are shallow, transducers are the preferred method of water level measurement, both from an efficiency and an accuracy point of view.

The transducers chosen for use in the Waterloo System are vibrating wire transducers, which are very accurate and rugged. They have superior long term operation with minimal drift over time. They can be read with a manual readout, or with a datalogger which can provide remote, unattended monitoring and telemetry, if desired.

Transducers are available with pressure ranges from 50 psi to 500 psi. (7.25 kPa to 72.5 kPa) and include a thermister for temperature measurement.

Portable Monitoring Equipment

Water level measurements can be made in Waterloo ports fitted with an open tube using the narrow, Solinst Model 102/P3 Water Level Meter. It has a weighted, flexible probe, 1/4" OD by 4" long (6.35mm x 101mm).

Sampling may be performed in open tubes using the Solinst Model 402 Triple Tube Sampler, a 3/8" (10mm) WaTerra footvalve, or a Peristaltic Pump.

* Teflon is a registered trade-mark of the Dupont Corporation.

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Designing Your System

The options chosen for each System will be site and application specific.

Each design is dependent on:

- zones of interest
- geology of the site
- monitoring methods preferred
- cost considerations
- borehole depth, diameter and type

Refer to the drawings below, then select the type of installation that suits your project. Consider the size and depth of each borehole, and whether casing is to be present. Decide if permanent or temporary Systems are preferred, the number of zones and depth of each zone per System, the monitoring options preferred, and any special materials required.

During development of your plans, the Solinst technical staff will be pleased to help evaluate the options and customize a System that best suits your needs.

Projects

Waterloo Systems have been used to monitor:

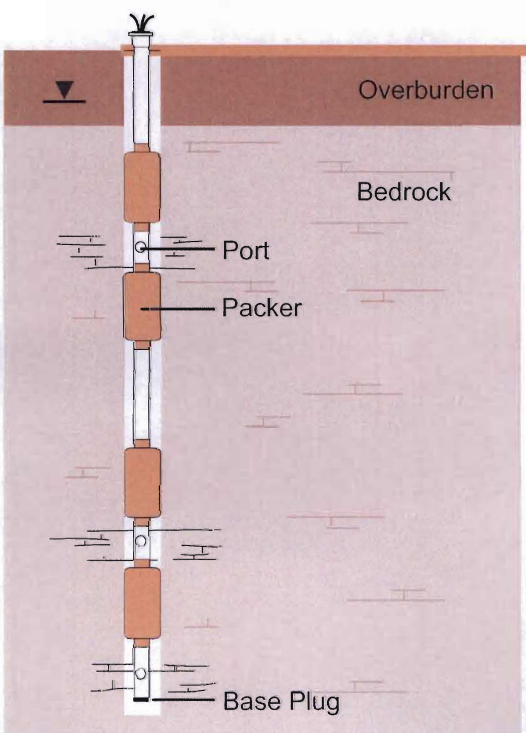
- Salt water intrusion
- DNAPL & LNAPL spill sites
- Industrial cleanups
- Waste disposals/landfills
- Pipeline leaks
- Soil gas surveys
- Dam leakage/rehabilitation
- Contaminant identification/cleanup

Applications

The Waterloo System has been specified by various industries and consultants for numerous sites across the United States, Canada and overseas. Waterloo Systems have been specified and approved at several sites with Superfund or RCRA designations and in each of the U.S. E.P.A. regions. The System has been used for:

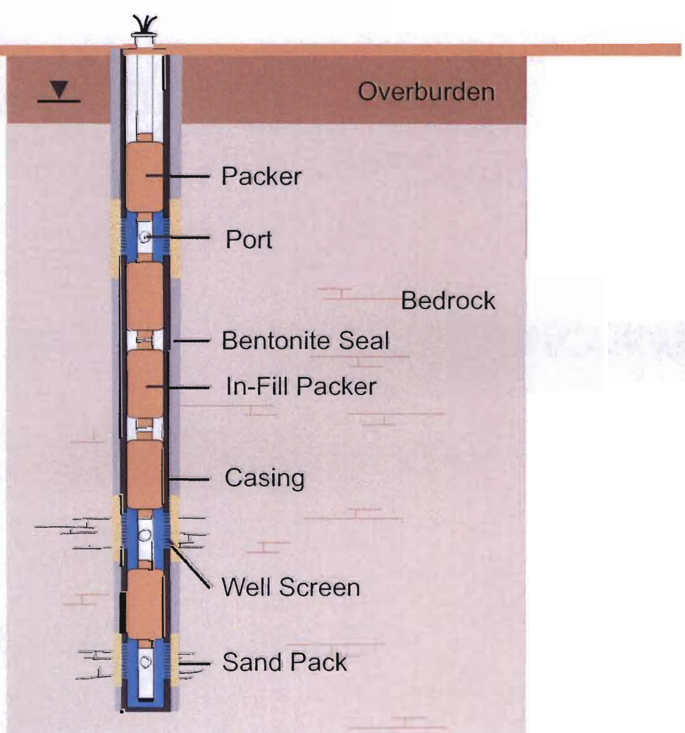
- defining groundwater flow patterns
- performance monitoring of pump and treat systems
- identification and determination of spatial distribution of contaminants
- early warning system/detection of migrating contaminants

Bedrock



Permanent or Removeable Packers in Cored Hole

Bedrock and/or Overburden



Permanent or Removeable Packers in Casing or Well Screen

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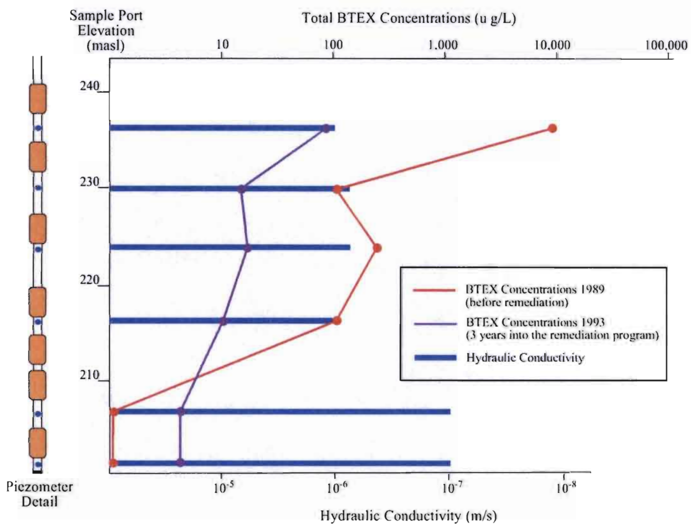
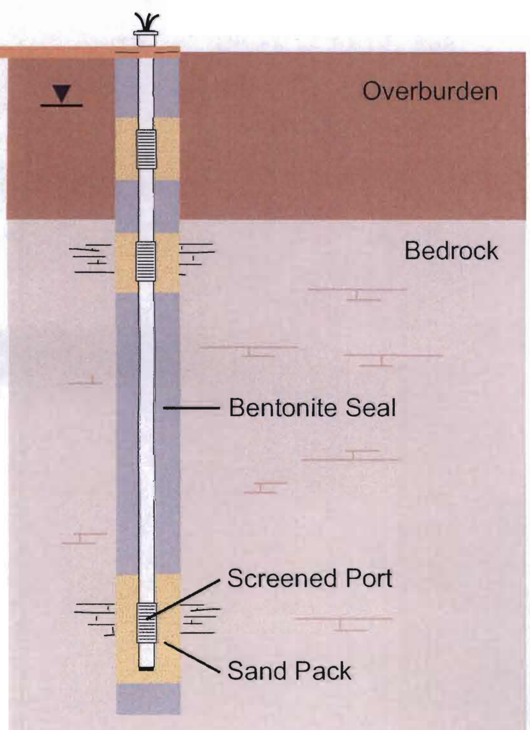
Reliable Data

The effectiveness of the Waterloo System is proven by its ability to accurately and repeatedly obtain pressure and groundwater chemistry data from several distinct zones in a single borehole. The data set below shows a decrease in Total BTEX contamination due to ongoing pump and treat operations at an oil pipeline leak.



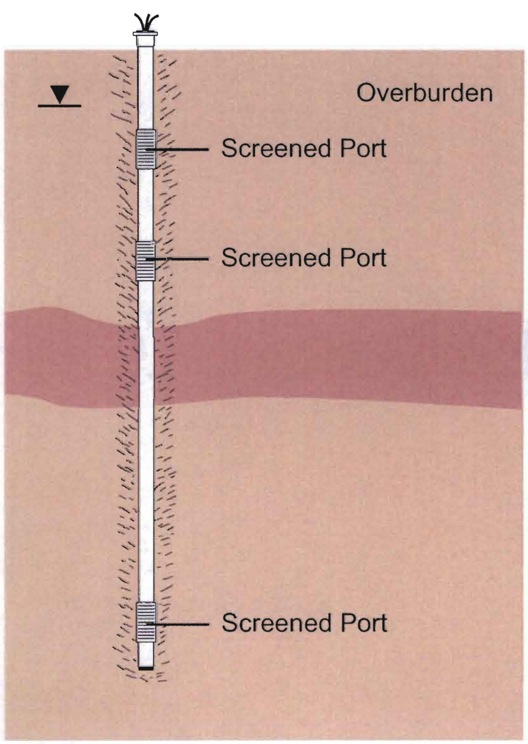
Underground oil pipeline leak assessment. Three 150 ft. (45m) installations, monitored with portableWater Level Meter and Triple Tube Sampler. Two point rising head permeability tests were conducted in each interval of the Multilevel System.

Bedrock and/or Overburden



Direct Burial: Sand and Bentonite with Screened Ports

Overburden



Direct Burial: Formation Collapse with Screened Ports

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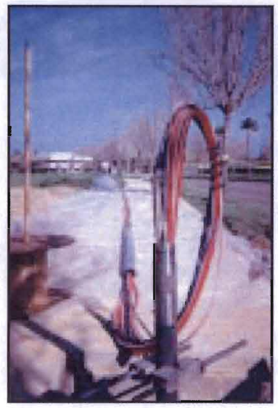
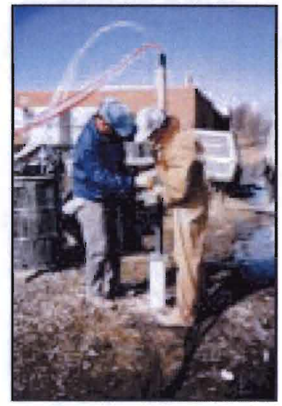
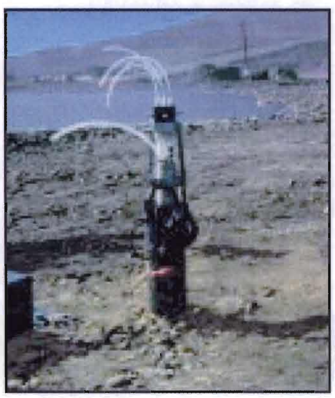
Waterloo Systems comprised entirely of stainless steel casing, packers and ports with Teflon-lined tubing were used to monitor contaminant flow in this bedrock application.



Contaminant investigation at a U.S. Airforce Base. Waterloo Systems installed to 700 ft. in overburden using screened and cased wells. Up to 6 zones per hole with dedicated pumps and tranducers.



Detailed investigation of PCE delineation in carbonate bedrock. A cost analysis of the 14 Waterloo Systems compared with nested piezometers indicated savings both on the capital costs and on the on-going monitoring.



Landfill site over fractured granite, monitored with five Waterloo Systems. Each System comprised of dedicated Double Valve Pumps and Pressure Transducers in 4-6 intervals to depths of 275 feet (84m). The multipurge manifold allowed the monitoring of 21 zones to be completed in less than 2 days.

750ft. (230m) installation for a deep tunnel assessment study. Three zones monitored with dedicated Double-Valve Pumps and pressure transducers. Picture shows technician obtaining pressure measurements and groundwater samples with portable readout and pump control unit.

An investigation of hydraulic properties beneath a large waste site. Multilevel systems were chosen to allow water quality sampling and to help determine the zones of highest permeability within the aquifer.

A large Midwestern USA research project studying agricultural effects on water quality. 22 multilevel installations with 3-4 zones each were installed to depths of 24-60 ft. (7.3-18.3 m) in overburden. Dedicated Double Valve Pumps and Peristaltic Pumps were used.

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