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SmartData Solutions

Plume Delineation Using Membrane Interface Probe (MIP) Savannah River Site Aiken, South Carolina

PREPARED FOR

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Introduction

Westinghouse Savannah River Company, LLC (WSRC) contracted **COLUMBIA Technologies, LLC (COLUMBIA)** to conduct an investigation of subsurface contamination at the Savannah River Site, located in Aiken, South Carolina. This investigation involved delineating the depth and horizontal extent of contamination using Membrane Interface Probe (MIP) technology, and characterizing soil types with Cone Penetrating Testing (CPT) technology. The purpose of this investigation was to characterize subsurface soils in the vadose and saturated zones and to begin the delineation of the nature and extent of soil and groundwater contamination at the site. A second purpose was to evaluate the use of the MIP probe as a screening level tool for delineating volatile organic compound (VOC) contamination.

The investigation was conducted from September 18^{th}, 2002 through October 4^{th}, 2002. COLUMBIA personnel on-site during the investigation included Douglas McInnes.

Objectives

The objectives of the MIP/CPT investigation were twofold:

1. Characterize subsurface soils in the vadose and saturated zones.
2. Evaluate the effectiveness of using the MIP probe as a screening level tool for delineating the boundaries of VOC contamination in the subsurface.

The standard characterization screening method involves performing CPT pushes at selected locations to obtain lithology information followed by performing a second push at the same locations to obtain water samples for laboratory analysis. Identifying more efficient methods of performing screening level characterizations are important to increasing productivity while maintaining quality of data. This work involved testing a combined MIP/CPT tool to allow collection of lithology and contaminant profile data with one push at each location. In order to determine if the MIP tool provided a sufficient level of data quality to eliminate or minimize the amount of water sampling needed during screening level characterization activities, water samples for VOC analysis were collected for comparison with the MIP results.

Equipment Description

The MIP portion of the probe was developed and patented by Geoprobe Systems, Inc. The operating principle is based on heating the soil and/or water around a semi-permeable polymer membrane to 121ºC (250ºF), which allows VOCs to partition across this membrane. The MIP can be used in saturated or unsaturated soils. Using nitrogen as a carrier gas, which sweeps across the back of the membrane, the VOCs are carried to the installed detectors. It takes approximately 75 seconds for the nitrogen gas stream to travel through 200 feet of inert tubing and reach the detectors.

COLUMBIA utilizes three detectors: a Photo Ionization Detector (PID), a Flame Ionization Detector (FID) and an Electron Capture Detector (ECD), mounted on a laboratory grade Shimadzu Model 14A gas chromatograph. The output signal from the detectors is captured by a MIP data logging system installed on a MIP Field Computer or laptop computer. Speed, detector data and temperature are displayed continuously in real time during each push of the probe. Conductivity data is also typically recorded with the MIP system, although at this site, soil units were defined with the CPT unit. In addition, the data logs can be printed for display and analysis following the data logging run or exported to common spreadsheet software for further analysis.

The PID detector consists of a special UV lamp mounted on a thermostat controlled, low volume, flow-through cell. The temperature is adjustable from ambient temperature to 250ºC. The 10.2 electron volt (eV) UV lamp emits energy at a wavelength of 120 nanometers, which is sufficient to ionize most aromatics (benzene, toluene, xylene, etc.) and many other molecules (H_2S, hexane, ethanol) whose ionization potential is below 10.2 eV. The PID also emits a lower response for chlorinated compounds such as TCE and PCE. Methanol and water, which have ionization potentials greater than 10.2 eV, do not respond on the PID. Detection limits for aromatics are in the low picogram range. Since the PID is non-destructive, it is often run first in series with other detectors for multiple analyses from a single injection. Use of the PID is mandated in several EPA methods (8021, TO-14 etc.) because of its sensitivity and selectivity.

The most commonly used GC detector is the FID, which responds linearly from its minimum detectable quantity of about 100 picograms. The FID response is very stable from day to day, and is not susceptible to contamination from dirty samples or column bleed. This detector responds to any molecule with a carbon-hydrogen bond, but poorly to compounds such as H_2S, CCl_4, or NH_3. The carrier gas effluent from the GC column is mixed with hydrogen and burned. Hydrogen supports a flame and ionizes the analyte molecules. A collector electrode attracts the negative ions to the electrometer amplifier, producing an analog signal, which is directed to the data system input.

The ECD detector consists of a sealed stainless steel cylinder containing radioactive Nickel-63. The Nickel-63 emits beta particles (electrons), which collide with the carrier gas molecules, ionizing them in the process. This forms a stable cloud of free electrons in the ECD cell. When electro-negative compounds (especially chlorinated, fluorinated or brominated molecules) such as carbon tetrachloride or TCE enter the cell, they immediately combine with the free electrons, temporarily reducing the number remaining in the electron cloud. The detector electronics, which maintain a constant current of about one nanoampere through the electron cloud, are forced to pulse at a faster rate to compensate for the decreased number of free electrons. The pulse rate is converted to an analog output, which is transmitted to the data system.

Response Tests

Prior to MIP logging, response tests with specific compounds are conducted to evaluate the sensitivity of the particular probe to be used and the detectors. Before each location, a response test is performed. For this site, a mixture of benzene and TCE was used. A standard stock solution of 50mg/mL was created with methanol based on the specific density of the particular compound. Aliquots of these solutions were added to 500 mL of DI water to create a concentration of ten ppm. At several locations, a concentration of one ppm was used for low level detection. The heated probe was inserted into this test solution and the PID and ECD detector responses were recorded. The FID does not respond strongly to the above compounds at concentrations less than ten ppm. To test the FID, butane is released on the membrane for four seconds. The results of these response tests are included in Appendix A.

Investigation Methods

MIP/CPT profiling was conducted at locations, as shown in Figure 1, in an area approximately 2000 feet by 2200 feet, using a 25 Ton CPT rig provided by Gregg InSitu. Initially, 30 locations had been identified for investigation. The real time results obtained with the MIP probe allowed the investigators to reduce the level of needed sampling by 11 locations. The detector suite provided by COLUMBIA was mounted in the Gregg CPT rig, and a sub-assembly was manufactured by Gregg to provide a mounting location for the MIP sensor. This sub-assembly was originally mounted inline above both the CPT Cone and resistivity sub-assembly, providing an offset between the cone tip and MIP membrane of 4.5 feet. It was later decided that the resistivity sub-assembly was not functioning as well as expected, and that the extra joints in the leading end of the tool string were limiting the depth to which the sensor string could be advanced. The resistivity sub-assembly was removed from the tool string, resulting in an offset of 2.5 feet from cone tip to MIP membrane. These offsets have been taken into account in the data files provided for analysis, and the interpretation of results for this project. Twelve locations were performed in front of the P reactor site, two locations behind the P Reactor, and five locations on the far side of a drainage channel north of the P Reactor area. The results from each location are presented in Appendixes B and C. Maps and graphical representations of the results have been prepared for easier visualization of the subsurface.

The MIP/CPT probe string was advanced at two foot intervals during most of the project, in order to maintain production goals. At several locations, the MIP/CPT probe was advanced at one foot intervals for greater resolution of MIP readings in areas of particular interest. These areas of interest were determined based on historical data provided by previous investigations, or from the real-time results of the MIP/CPT sensor string. At several locations, for which historical data was available, the MIP/CPT sensor string was advanced to a depth of 50 to 70 feet before beginning the two foot interval measurements. This minimized duplication of effort with the previous work.

Summary of Results

The Soil Conductivity portion of the MIP probe was not used at this site. Please refer to Gregg InSitu for further analysis and explanation of the subsurface soil. In general, the soils at this site are interbedded sands, silts and clays.

The ECD responded significantly at a number of locations at this site, which indicate the presence of chlorinated compounds at depth (Figures 2, 3 and 4). The ECD is very sensitive to chlorinated compounds. At high concentrations, the detector becomes saturated at the value of 1.2E+07 microvolts (uV). This occurred at several locations. When this occurs, the PID can be used to determine relative contamination concentration, as it also responds to chlorinated compounds. Saturation of the ECD occurred at locations PGCPT-01, PGCPT-02, PGCPT-04, PGCPT-07, and PGCPT-09. The PID response at these locations measured 2.0E+05uV, 3.0E+05uV, 1.25E+06uV, 1.25E+06uV, and 5.0E+05uV, respectively, thus the highest levels of contamination detected by the MIP at the site occurred at locations PGCPT-04 and PGCPT-07.

Locations PGCPT-08 and PGCPT-09 were completed behind the P-Reactor building (Figure 1). For the first 50 feet at both locations, the MIP tool was stopped at five foot intervals to allow the heating block to regain optimal temperature to sufficiently volatilize contamination, then two foot intervals were performed to the termination of the boring. The southernmost location, PGCPT-08 was completed by combining the logs from two separate runs. The first run completed 102 feet before the friction on the rod string became too great. The second run started data collection at 90 feet and continued to 143.8 feet. These files were combined together at 90 feet, hence the change in the ECD baseline at this interval. This location had very little ECD response. Location PGCPT-09, approximately 60 feet to the north of

PGCPT-08, saturated the ECD between 102 feet and 106 feet and again at 112 feet below ground surface (bgs). PID response in this interval measured 5.0E+05uV.

Locations PGCPT-01 through PGCPT-04 were located north of borings PGCPT-08 and PGCPT-09, in front of the P-Reactor Building (Figure 1). Locations PGCPT-01 and PGCPT-02 were completed in two foot intervals for the entire log, while locations PGCPT-03 and PGCPT-04 were performed in five foot intervals for the first 50 feet, then two foot intervals were performed to the termination of the boring. These four locations are in close proximity to each other and all recorded ECD response, three of which saturated the detector. PGCPT-03 had a response of 1.0E+06uV, at the intervals of 56 feet and between 106 feet and 108 feet bgs. The two easternmost locations, PGCPT-01 and PGCPT-02, had the highest responses within approximately the same interval of 123 feet to 134 feet and 121 feet to 137 feet bgs, respectively. Location PGCPT-04 saturated the detector at a much shallower interval, 94 feet to 96 feet bgs.

Location PGCPT-29, approximately 190 feet WNW of location PGCPT-04 (Figure 1), was driven directly to 50 feet bgs, then two foot intervals were performed. One foot intervals were performed between 70 and 86 feet, and 98 and 104 feet, to obtain even greater resolution. The ECD measured 1.50E+06uV at 98 feet and 99 feet bgs.

MIP locations PGCPT-05 through PGCPT-07 were probed to the north of locations PCPT-01 through PGCPT-04 (Figure 1). These locations were driven directly to 50 feet bgs, then two foot intervals were performed. Maximum responses of 2.0E+06uV (PGCPT-06), 8.0E+06uV (PGCPT-05) and 1.2E+07uV (PGCPT-07) were measured within the interval of 121 feet to 140 feet bgs. The ECD at location PGCPT-07 was saturated within this interval, while MIP PGCPT-05 and PGCPT-06 recorded their highest responses 138 feet bgs and 131 feet bgs, respectively.

Locations PGCPT-11, PGCPT-12, PGCPT-15 and PGCPT-18 were completed farther to the north (Figure 1). These locations were driven directly to 50 feet bgs, then two foot intervals were performed to the termination of the boring. Location PGCPT-11, the easternmost location of the four, measured minimal ECD response, while location PGCPT-12, towards the west, measured 6.0E+05uV at 84 feet bgs. Location PGCPT-15 had a shallow response at 10 feet bgs, and small response below 130 feet bgs. MIP PGCPT-18 was profiled with one foot intervals between 117 and 126 feet bgs to obtain greater resolution. This log exhibits anomalous ECD responses between 114 and 120 feet bgs. Field notes indicate fluctuations of pressure in the gas transfer line, which can cause elevated ECD response. These values are not included in the processed data and graphics.

The northernmost transect, located on the far side of a drainage channel consists of locations PGCPT-23 through PGCPT-27, from west to east (Figure 1). These locations were pushed continuously to a depth ranging from 50 to 80 feet, below which the probe was stopped at two foot intervals. PGCPT-23 displays small anomalous ECD responses in the 90 to 106 foot range. Field notes indicate fluctuations of pressure in the gas transfer line, which can cause elevated ECD response. These values are not included in the processed data or graphics. No ECD response was detected at other locations in this transect.

The majority of the contamination occurs on the north side of the P-Reactor Building, and varies in depth from 121 to 140 feet bgs, although contamination is found as shallow as 84 feet bgs. Contamination was detected on the south side of the building (PGCPT-09), but quickly diminishes (PGCPT-08).

Comparison of MIP Results with Laboratory Results

Laboratory analysis of groundwater samples detected chlorinated compounds Trichloroethylene (TCE) and Tetrachloroethylene (PCE). A total of 78 samples were taken, and samples were taken at all MIP locations, with the exception of PGCPT-08. The results of these laboratory analyses, compared with MIP detector results, are located in Appendix D.

In general, correlation between MIP detector results and laboratory data was high, as can be seen on Figures 5, 6, and 7. Figure 5 is an aerial view from the east. It illustrates the strong correlation of non-detect water samples (blue spheres) with areas shown by the MIP profiling to be uncontaminated (areas not filled in by green, yellow and red colors). Figure 6 is a view directly from the east. This figure also shows the areas where the MIP did not detect any chlorinated compounds. This conclusion is confirmed with numerous blue spheres that indicate non-detect water samples taken from these areas. One orange sphere does lie between two zones of higher concentration, as defined by the MIP system, and will be discussed below in the paragraph on false negatives. Figure 7 is a transect connecting the profiles from PGCPT-18, in the northwest corner of the site, to PGCPT-01, in the southeast corner of the site (see Figure 1 for transect location). This illustration also clearly shows the high correlation between water sample laboratory data and MIP detection.

Some of the laboratory results from individual water samples did not correlate exactly with the corresponding MIP measurements of the same intervals. This is to be expected due to the nature of sampling method limitations and the resolution of the MIP profiling.

Apparent false positives may occur when the MIP system detects contamination that resides in less permeable zones, and the water sample, collected over a multiple foot interval, draws water largely from the most permeable zone. Preferential water sampling and homogenization and dilution of water samples is a challenge when trying to obtain a representative water sample with most sampling tools. The MIP system may also be responding to a chlorinated compound that was not analyzed in the lab sample, or a chlorinated compound besides TCE or PCE, that was not included in the graphical analysis.

Apparent false negatives may occur when the water sample is drawn from a thin zone that lies at a point between the interval where the MIP system is optimized by stopping and heating up to optimal detection temperatures. Furthermore, the actual water sample was probably collected at a distance of several feet from the MIP location and may be reflecting slightly different lithologic and chemical conditions.

Recommendations for Future Subsurface Profiling

1) **Combined Sensors.** Merging the MIP and CPT suite of tools appears to have been quite effective, and allows for the possibility of merging the MIP with other CPT tools, such as the gamma and fluorescence probes.
2) **Probing Rate.** As opposed to the constant penetration rate of standard CPT tools, the MIP is normally operated by pushing discrete intervals and allowing the temperature to recover. The interval pushed varies depending on the size target that is important to delineate. Typical MIP operation intervals are one foot pushes. At this site, two foot pushes were performed to increase productivity, with the exception of two locations (PGCPT-18 and PGCPT-29), where one foot pushes were performed across specific intervals for greater delineation of contamination. In general, two foot pushes appear to have been adequate for defining chlorinated occurrences at multiple depths, however one foot pushes may have resulted in better resolution and better correlation with laboratory results.

   At one location, the MIP/CPT package was pushed at a constant rate. This test was performed twice, the first time at a speed of 2cm/sec, and the second time at a speed of 0.5cm/sec. Both constant pushes resulted in the MIP heating block stabilizing at approximately 60ºC. The resulting profiles did not detect the smaller, lower concentration layers of contamination, but did clearly see the larger, higher occurrences (Appendix E). It is suggested that in the future, one should use the constant push rate MIP only when thick NAPL phases or areas of high concentration (greater than 10 ppm) are the target of the investigation. To see lower levels (less than 1 ppm), it is important to stop and allow the temperature of the MIP to recover.
3) **Trapping and Speciation.** In order to speciate the occurrences or see concentrations at lower levels, it is recommended to use an enhanced

analytical feature, such as trapping and concentration of gases to be run with an onboard chromatographic analysis combined with the MIP. This may not be of value if the contaminant of concern is at high levels, but this approach has proved to be very valuable for differentiating plumes and tracing them down gradient.

4) **Replacement Probes.** The sediments underlying this part of the Savannah River Site are moderately abrasive to the heater block portion of the MIP probe (which protects the membrane). Expect to replace probes approximately every 2000 feet.

5) **Data Processing.** The results and correlation with laboratory data can be viewed easily on the 3-D images. The high correlation suggests the MIP system can be used with confidence without a large number of confirmation samples.

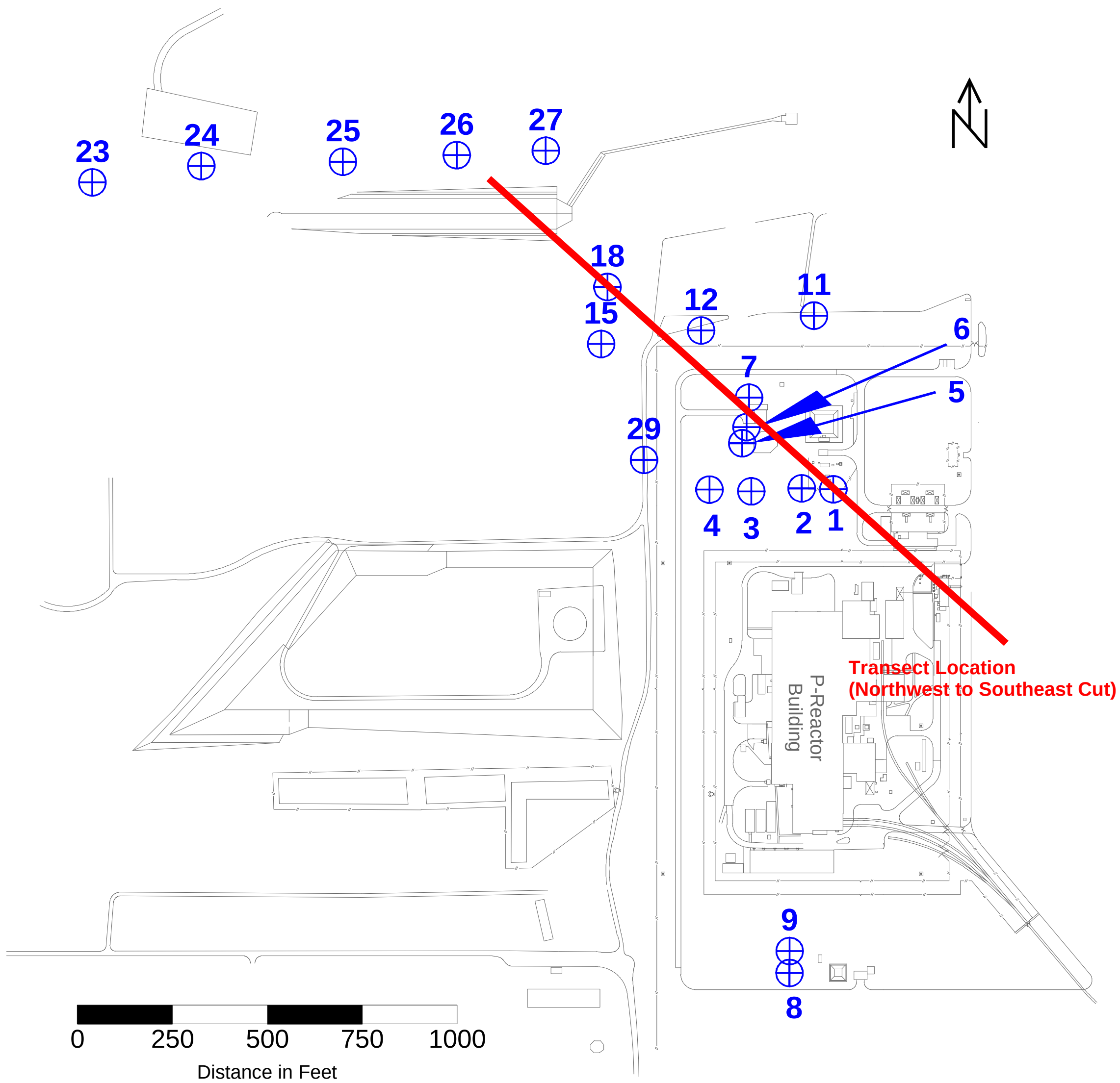

Figure 1
Base Map and MIP/CPT Transect Locations
Westinghouse Savannah River Company, LLC
Savannah River Site
September 18th, 2002 - October 4th, 2002

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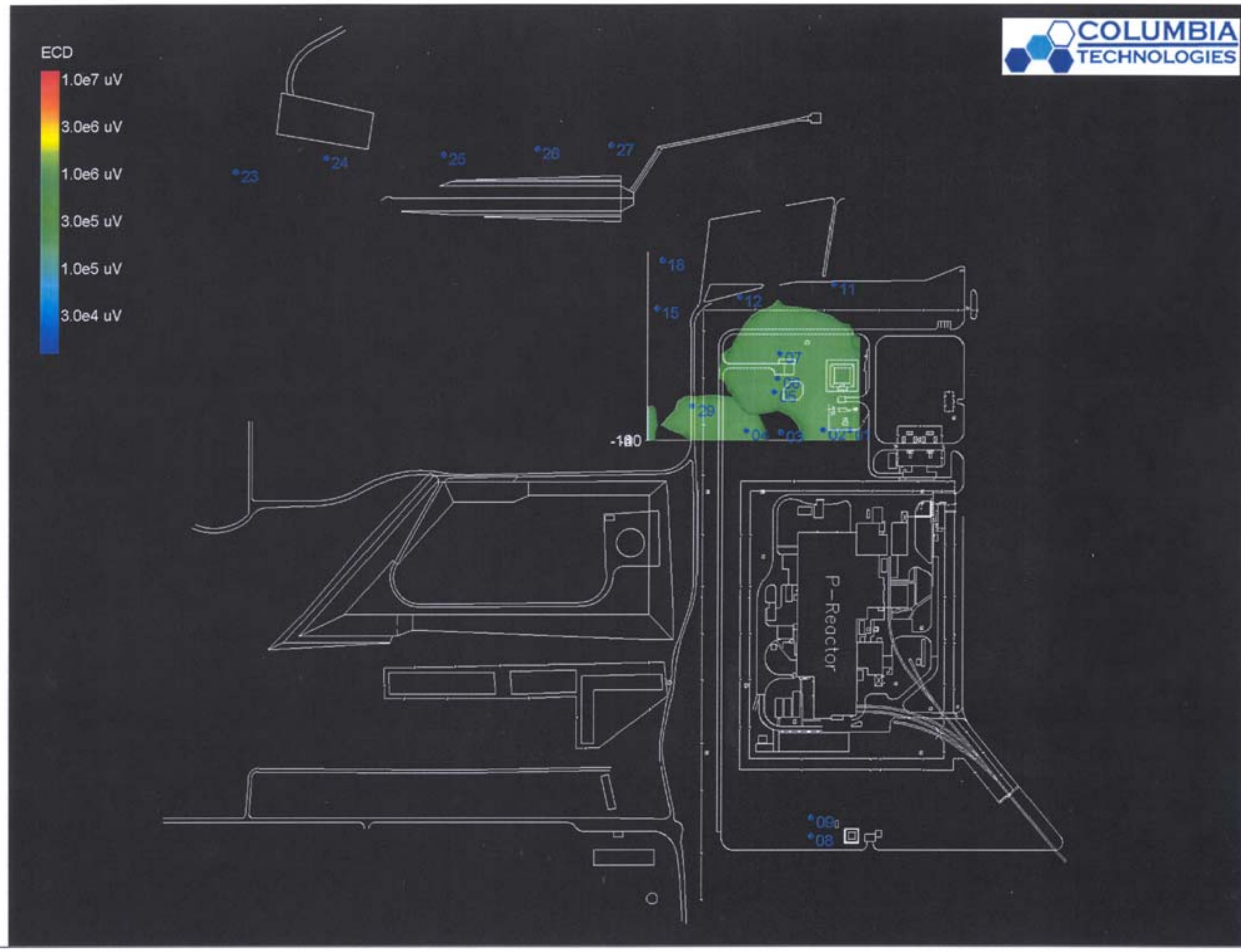

Figure 2
ECD Response, 1.0E+06uV and Above,
Plan View of the Entire Site
Westinghouse Savannah River Company, LLC
Savannah River Site
September 18th, 2002 – October 4th, 2002

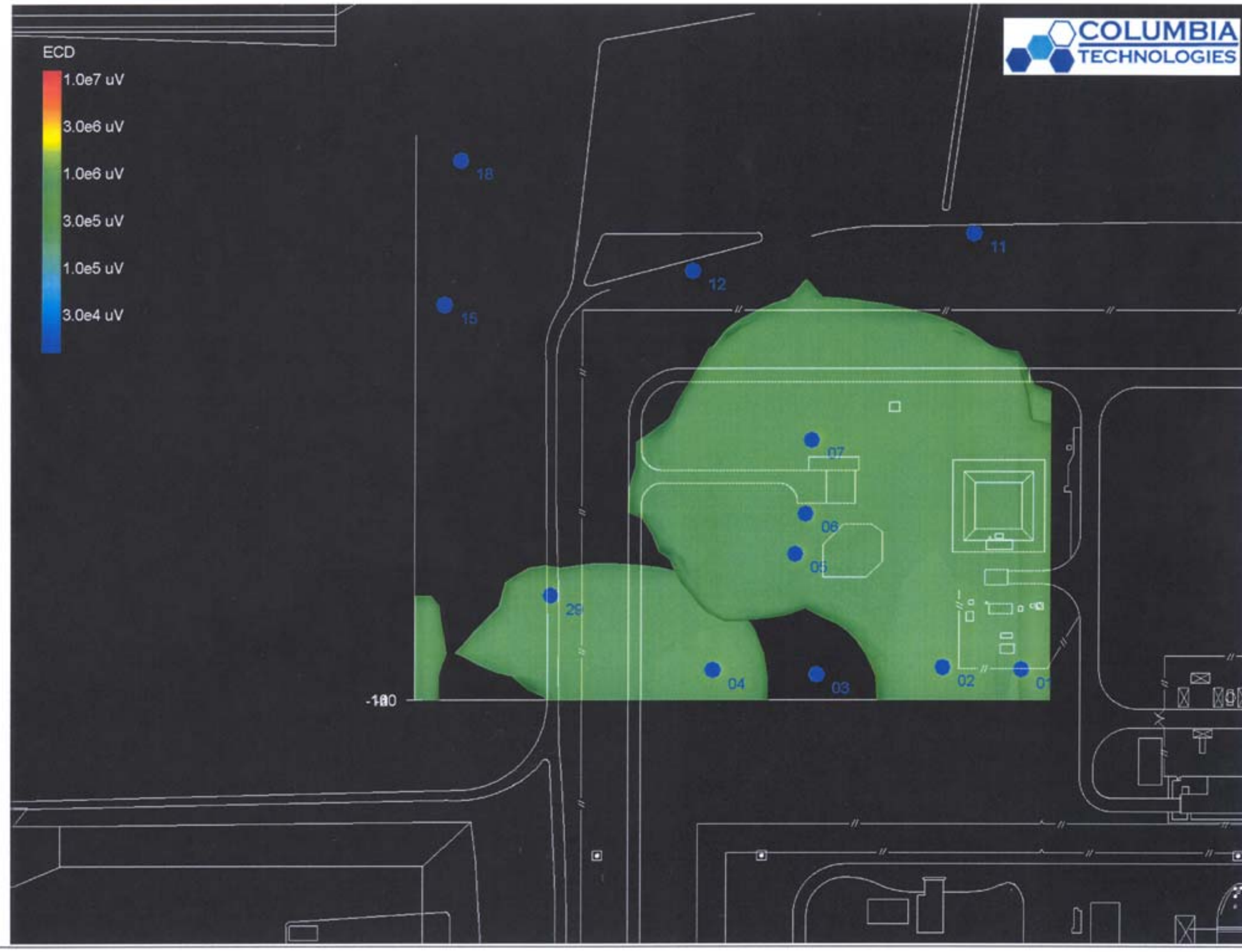

Figure 3
ECD Response, 1.0E+06uV and Above,
Plan View North of P-Reactor Building
Westinghouse Savannah River Company, LLC
Savannah River Site
September 18th, 2002 – October 4th, 2002

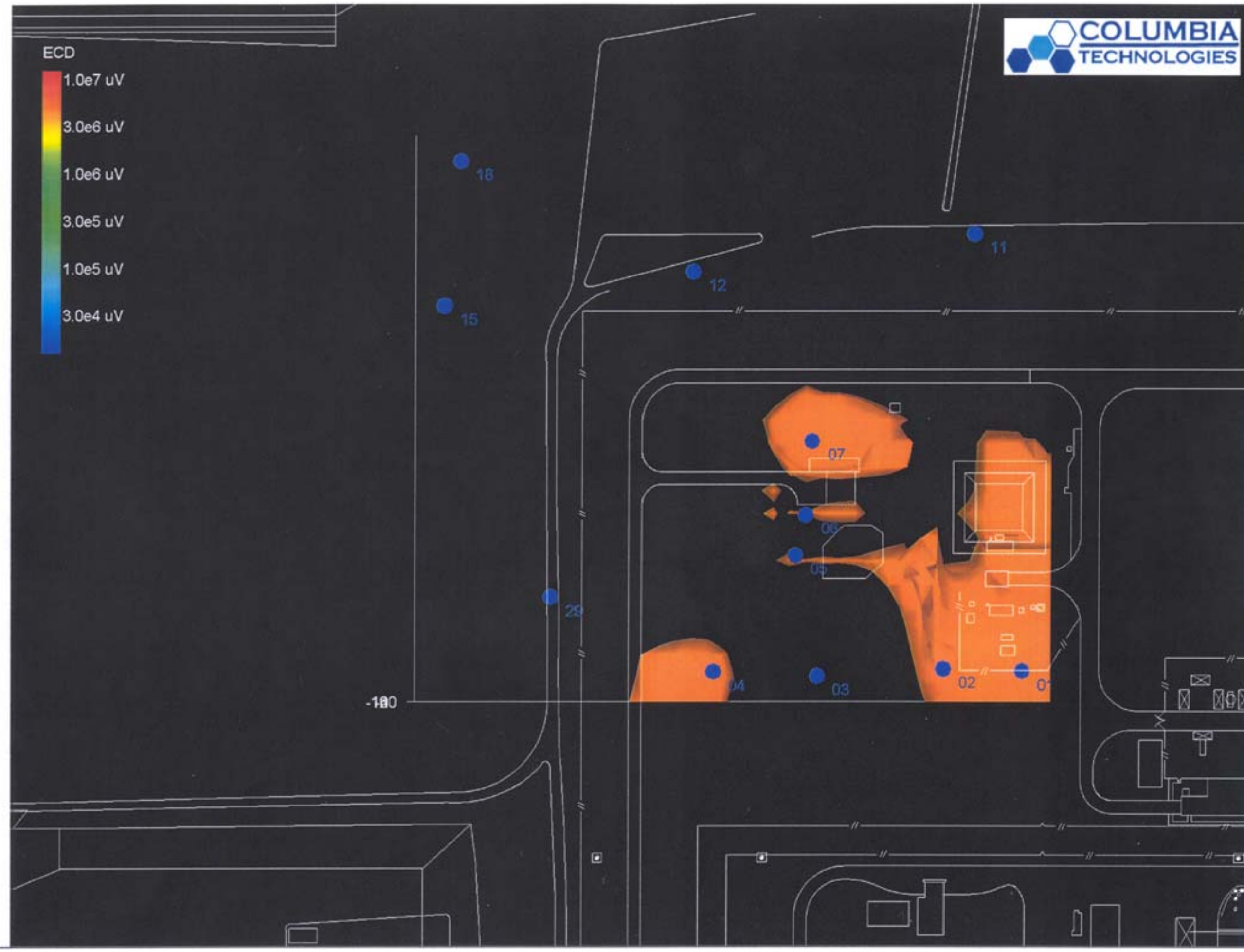

Figure 4
ECD Response, 5.0E+06uV and Above,
Plan View North of P-Reactor Building
Westinghouse Savannah River Company, LLC
Savannah River Site
September 18th, 2002 – October 4th, 2002

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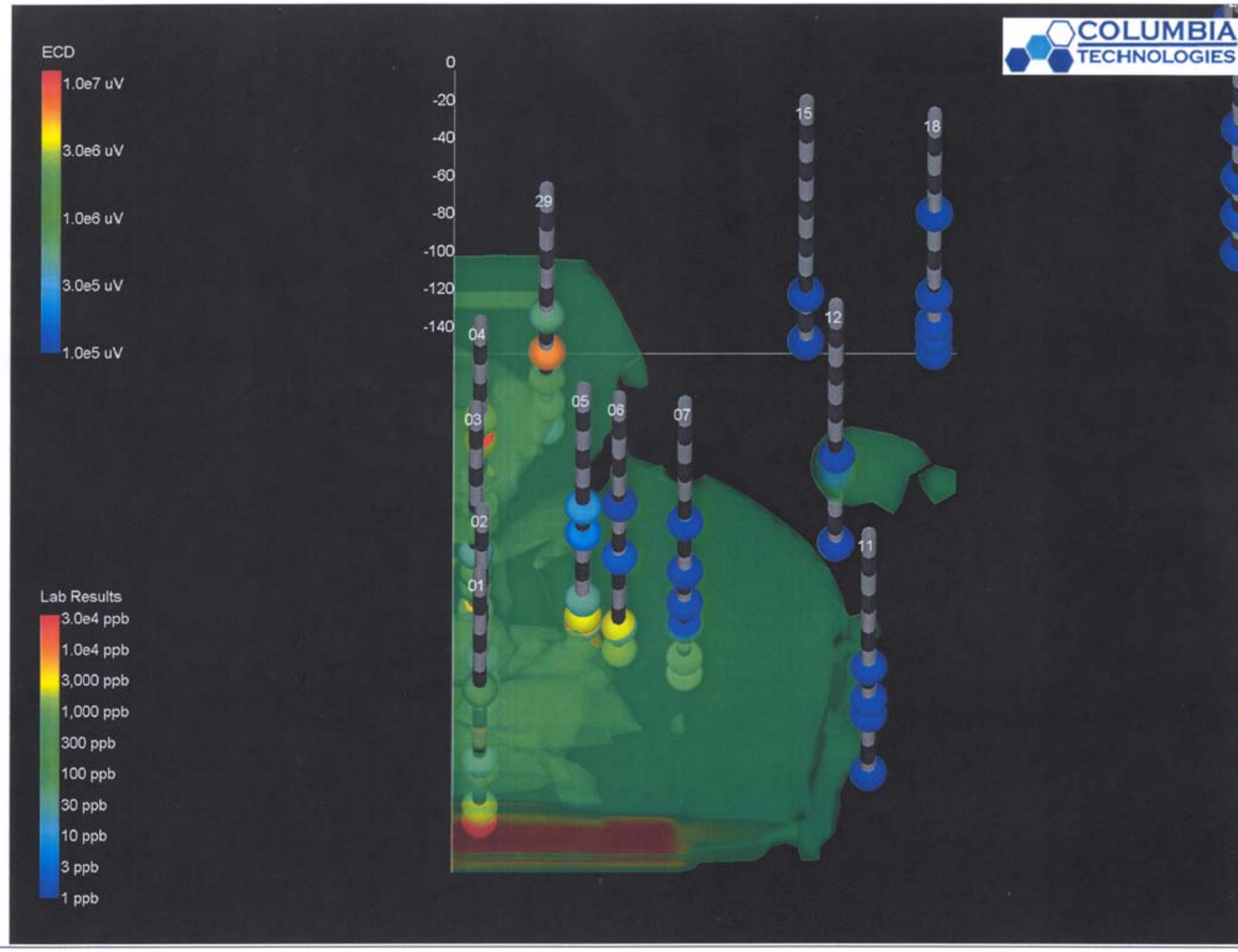

Figure 5
ECD Response, 5.0E+05uV and Above,
Aerial View from the East, With Laboratory Results
Westinghouse Savannah River Company, LLC
Savannah River Site
September 18th, 2002 – October 4th, 2002

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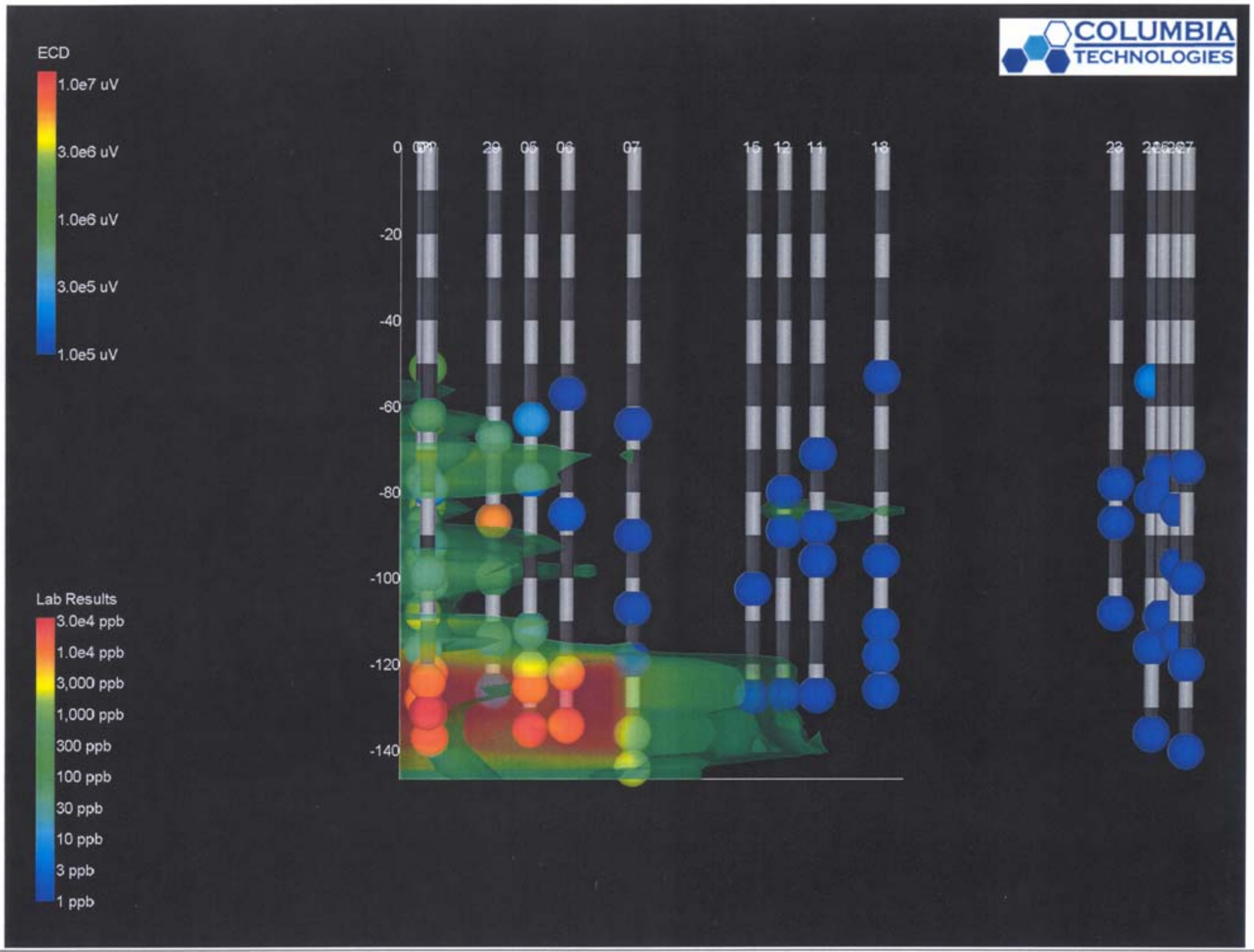

Figure 6
ECD Response, 5.0E+05uV and Above,
Side View from the East, With Laboratory Results
Westinghouse Savannah River Company, LLC
Savannah River Site
September 18th, 2002 – October 4th, 2002

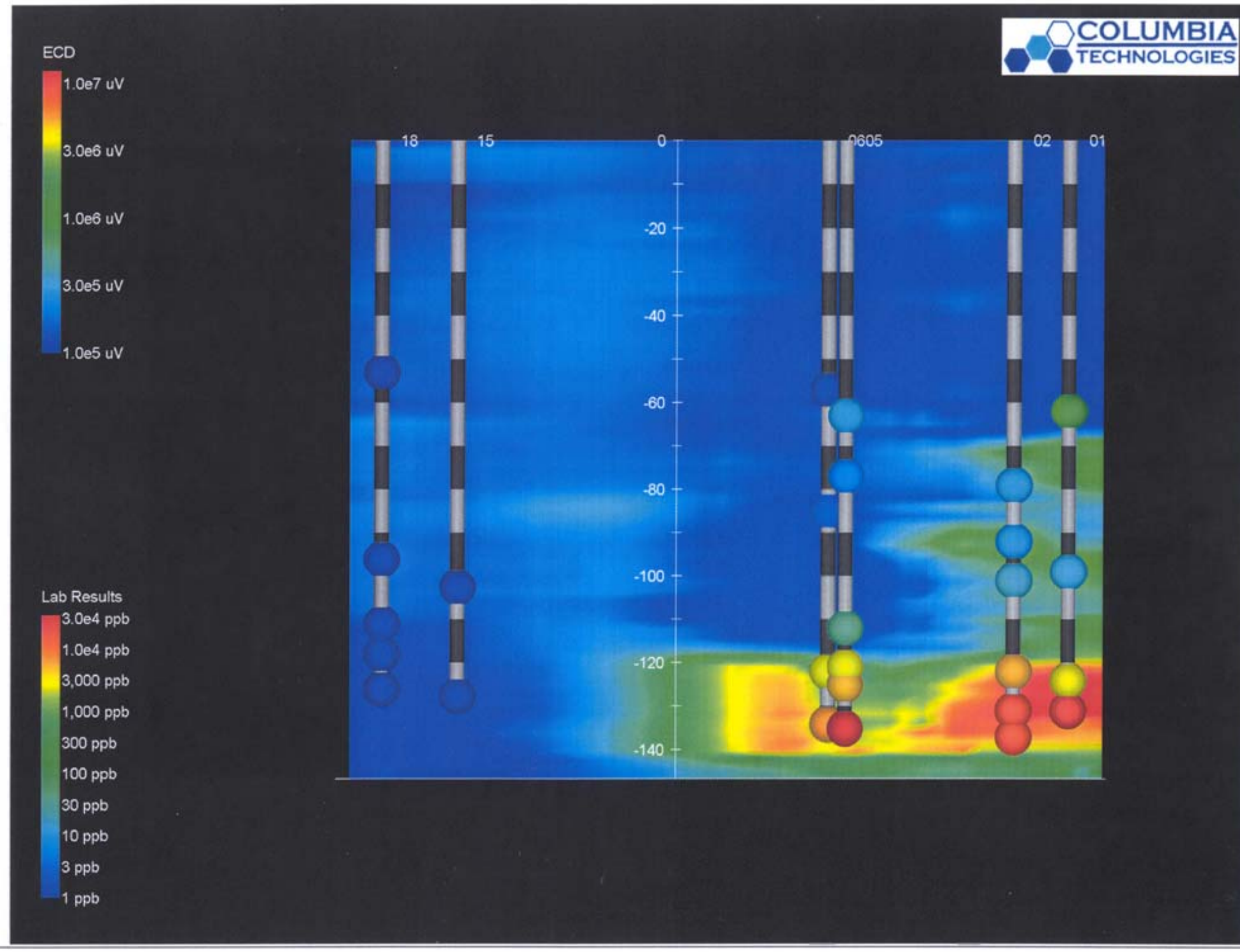

Figure 7
ECD Response, Northwest to Southeast Cut
With Laboratory Results
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Savannah River Site
September 18th, 2002 – October 4th, 2002

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Appendix A: Response Tests

DAILY MIP CALIBRATION SHEET

Site ID: Savannah River Site
Personnel Onsite: Doug McInnes

Client: WSRC
Client Onsite: Karen Vangelas

Date	06-Sep-02			Date	09-Sep-02		
Location ID	PGCPT-01			Location ID	PGCPT-02		
	Baseline	10 uL (1 ppm)	Response		Baseline	10 uL (1 ppm)	Response
PID	3.00E+04	4.40E+04	1.40E+04	PID	3.00E+04	4.40E+04	1.40E+04
ECD	3.51E+05	5.46E+05	1.95E+05	ECD	1.50E+05	2.80E+05	1.30E+05
FID (Butane)	1.20E+06			FID (Butane)	1.20E+06		

Date	11-Sep-02			Date	12-Sep-02		
Location ID	PGCPT-03			Location ID	PGCPT-04		
	Baseline	10 uL (1 ppm)	Response		Baseline	10 uL (1 ppm)	Response
PID	4.70E+04	5.60E+04	9.00E+03	PID	4.60E+04	5.70E+04	1.10E+04
ECD	4.30E+05	5.40E+05	1.10E+05	ECD	2.00E+05	3.29E+05	1.29E+05
FID (Butane)	1.20E+06			FID (Butane)	1.20E+06		

Date	19-Sep-02			Date	19-Sep-02		
Location ID	PGCPT-05			Location ID	PGCPT-06		
	Baseline	10 uL (1 ppm)	Response		Baseline	10 uL (1 ppm)	Response
PID	4.70E+04	5.20E+04	5.00E+03	PID	1.60E+04	2.50E+04	9.00E+03
ECD	3.90E+05	5.50E+05	1.60E+05	ECD	4.30E+05	5.40E+05	1.10E+05
FID (Butane)	1.20E+06			FID (Butane)	1.20E+06		

Date	20-Sep-02			Date	24-Sep-02		
Location ID	PGCPT-07			Location ID	PGCPT-08		
	Baseline	10 uL (1 ppm)	Response		Baseline	100 uL (10 ppm)	Response
PID	5.00E+04	5.70E+04	7.00E+03	PID	4.90E+04	9.20E+04	4.30E+04
ECD	1.36E+05	2.80E+05	1.44E+05	ECD	1.70E+05	7.80E+05	6.10E+05
FID (Butane)	1.20E+06			FID (Butane)	1.20E+06		

Date	25-Sep-02			Date	30-Sep-02		
Location ID	PGCPT-09			Location ID	PGCPT-11		
	Baseline	100 uL (10 ppm)	Response		Baseline	200 uL (20 ppm)	Response
PID	4.70E+04	9.40E+04	4.70E+04	PID	4.50E+04	2.10E+05	1.65E+05
ECD	1.30E+05	1.90E+06	1.77E+06	ECD	2.20E+05	3.50E+06	3.28E+06
FID (Butane)	1.20E+06			FID (Butane)	1.20E+06		

DAILY MIP CALIBRATION SHEET

Site ID: Savannah River Site
Personnel Onsite: Doug McInnes
Client: WSRC
Client Onsite: Karen Vangelas

Date	30-Sep-02		
Location ID	PGCPT-12		
	Baseline	200 uL (20 ppm)	Response
PID	5.60E+04	2.30E+05	1.74E+05
ECD	1.20E+05	3.40E+06	3.28E+06
FID (Butane)	1.20E+06		

Date	01-Oct-02		
Location ID	PGCPT-15		
	Baseline	100 uL (10 ppm)	Response
PID	4.20E+04	8.30E+04	4.10E+04
ECD	3.50E+05	1.80E+06	1.45E+06
FID (Butane)	1.20E+06		

Date	01-Oct-02		
Location ID	PGCPT-18		
	Baseline	100 uL (10 ppm)	Response
PID	4.80E+04	8.20E+04	3.40E+04
ECD	1.00E+04	1.50E+06	1.49E+06
FID (Butane)	1.20E+06		

Date	02-Oct-02		
Location ID	PGCPT-29		
	Baseline	100 uL (10 ppm)	Response
PID	4.80E+04	9.70E+04	4.90E+04
ECD	1.80E+05	1.70E+06	1.52E+06
FID (Butane)	1.20E+06		

Date	02-Oct-02		
Location ID	PGCPT-26		
	Baseline	100 uL (10 ppm)	Response
PID	5.40E+04	1.10E+05	5.60E+04
ECD	1.50E+05	1.20E+06	1.05E+06
FID (Butane)	1.20E+06		

Date	02-Oct-02		
Location ID	PGCPT-27		
	Baseline	100 uL (10 ppm)	Response
PID	4.10E+04	9.50E+04	5.40E+04
ECD	1.70E+05	1.20E+06	1.03E+06
FID (Butane)	1.20E+06		

Date	03-Oct-02		
Location ID	PGCPT-25		
	Baseline	100 uL (10 ppm)	Response
PID	5.00E+04	1.10E+05	6.00E+04
ECD	1.10E+05	1.20E+06	1.09E+06
FID (Butane)	1.20E+06		

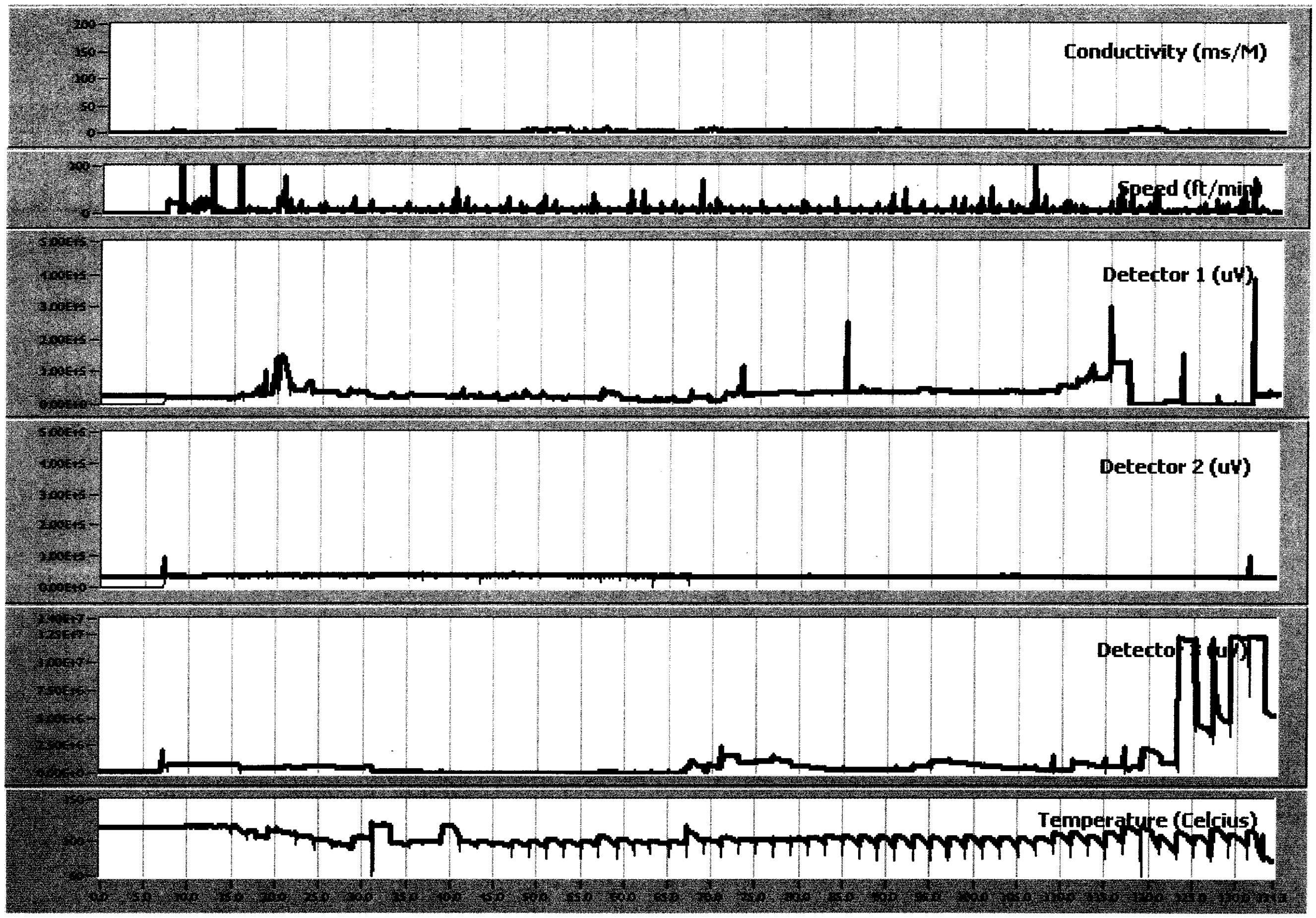
Date	03-Oct-02		
Location ID	PGCPT-24		
	Baseline	10 uL (1 ppm)	Response
PID	4.20E+04	6.30E+04	2.10E+04
ECD	1.10E+05	2.70E+05	1.60E+05
FID (Butane)	1.20E+06		

Date	03-Oct-02		
Location ID	PGCPT-23		
	Baseline	100 uL (10 ppm)	Response
PID	5.20E+04	9.10E+04	3.90E+04
ECD	1.70E+05	2.20E+06	2.03E+06
FID (Butane)	1.20E+06		

Appendix B: MIP Logs

(Best Fit Scale)

PGCPT-01



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Savannah River Site
September 06, 2002

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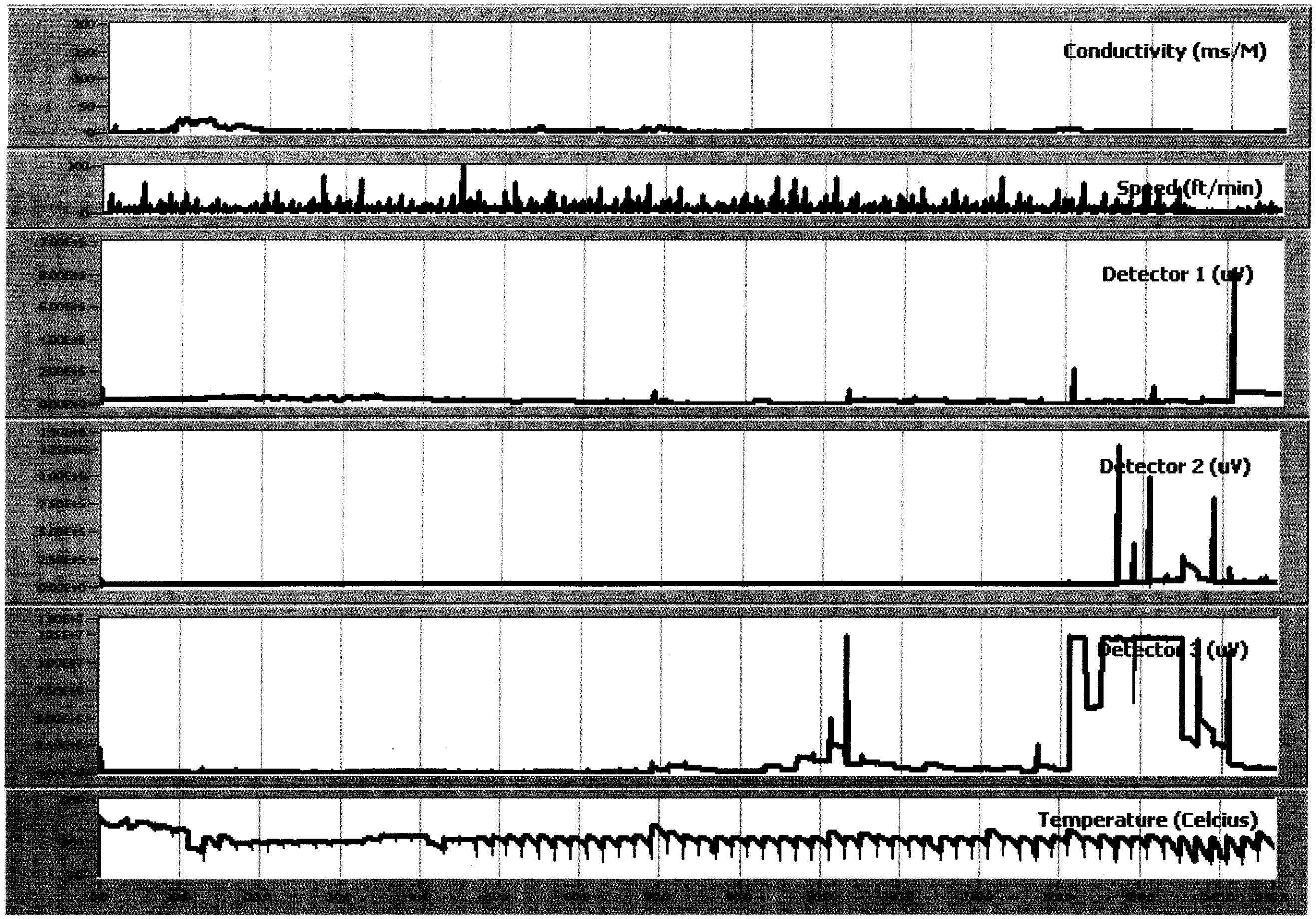
PGCPT-02



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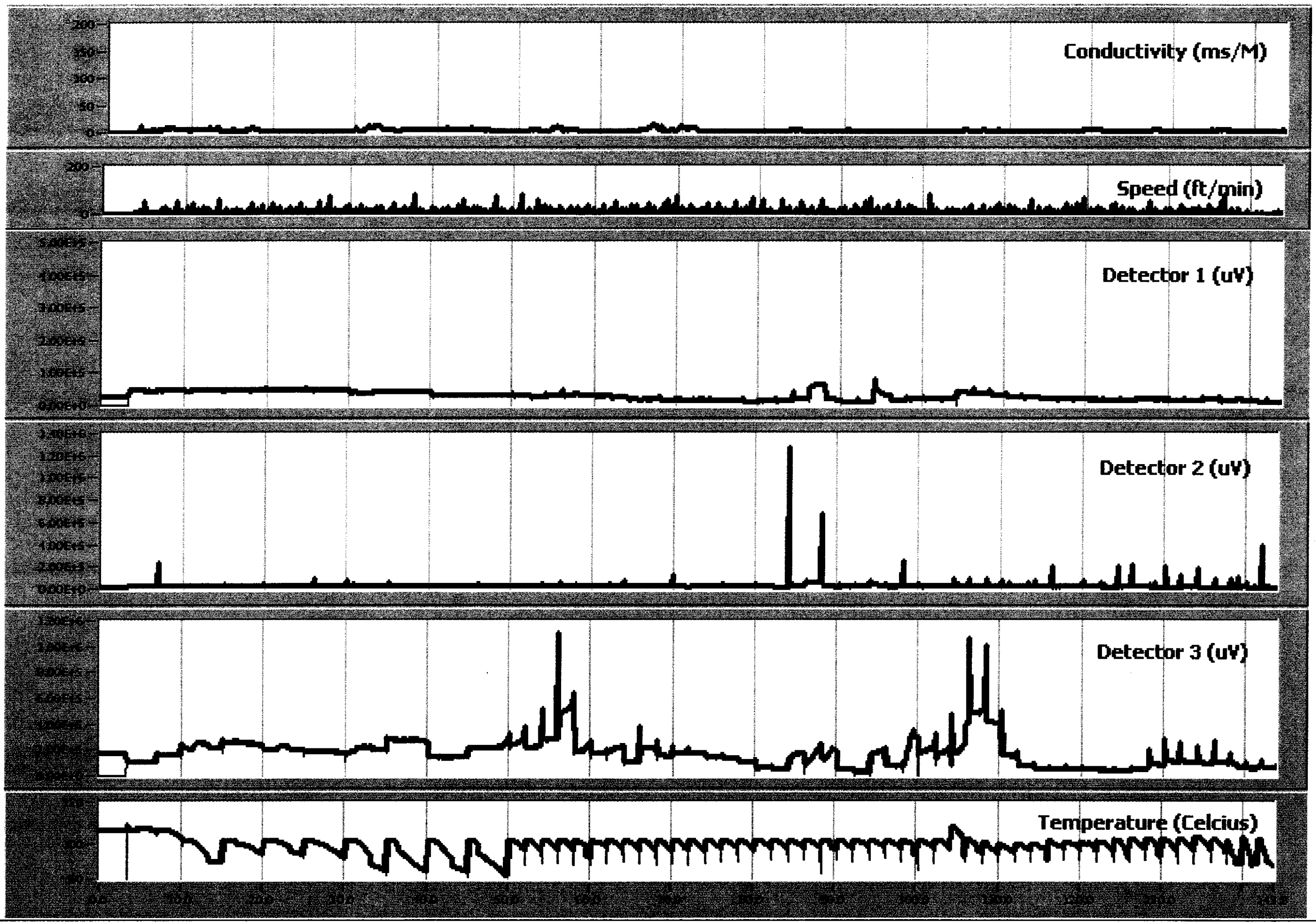
PGCPT-03



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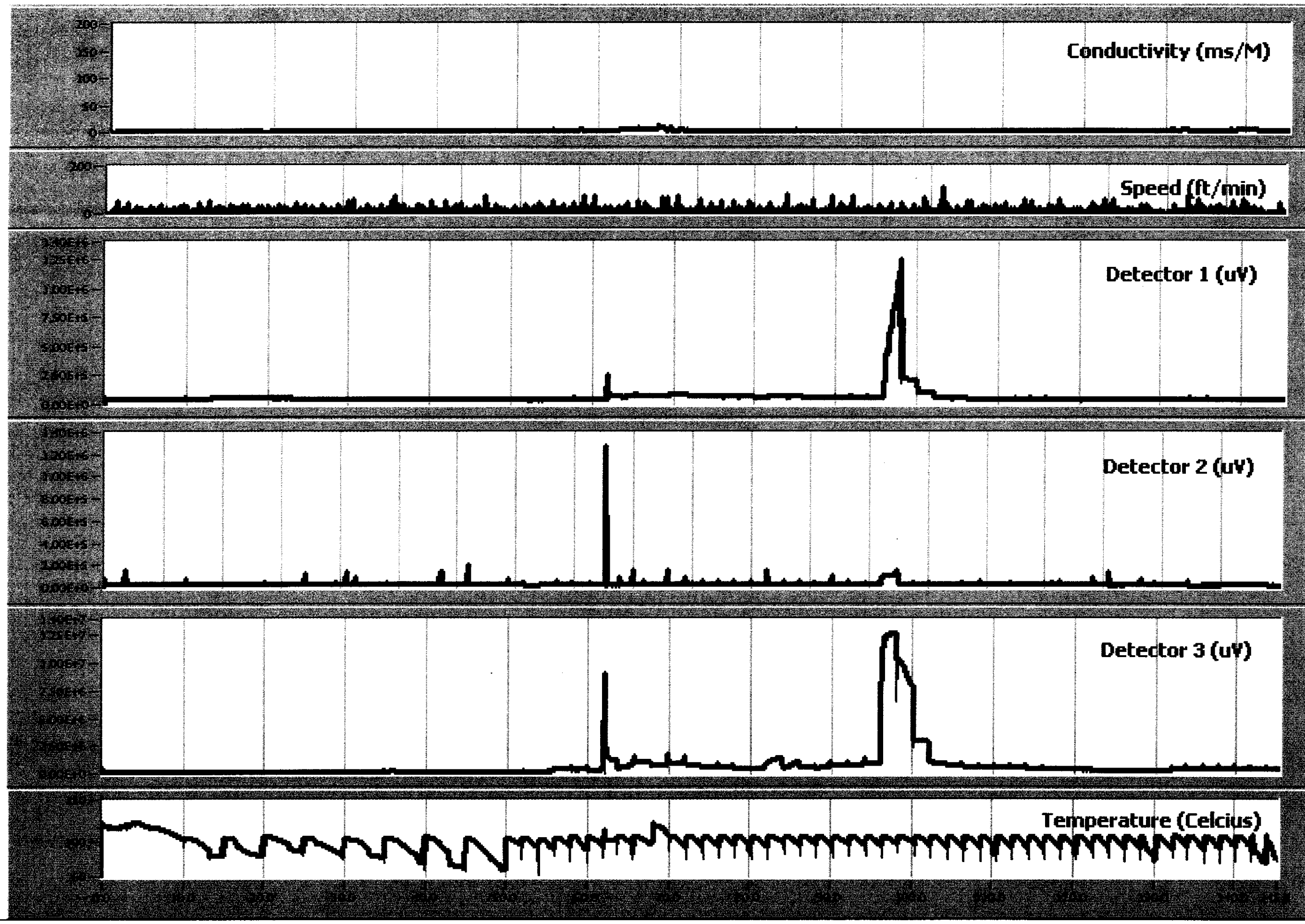
PGCPT-04



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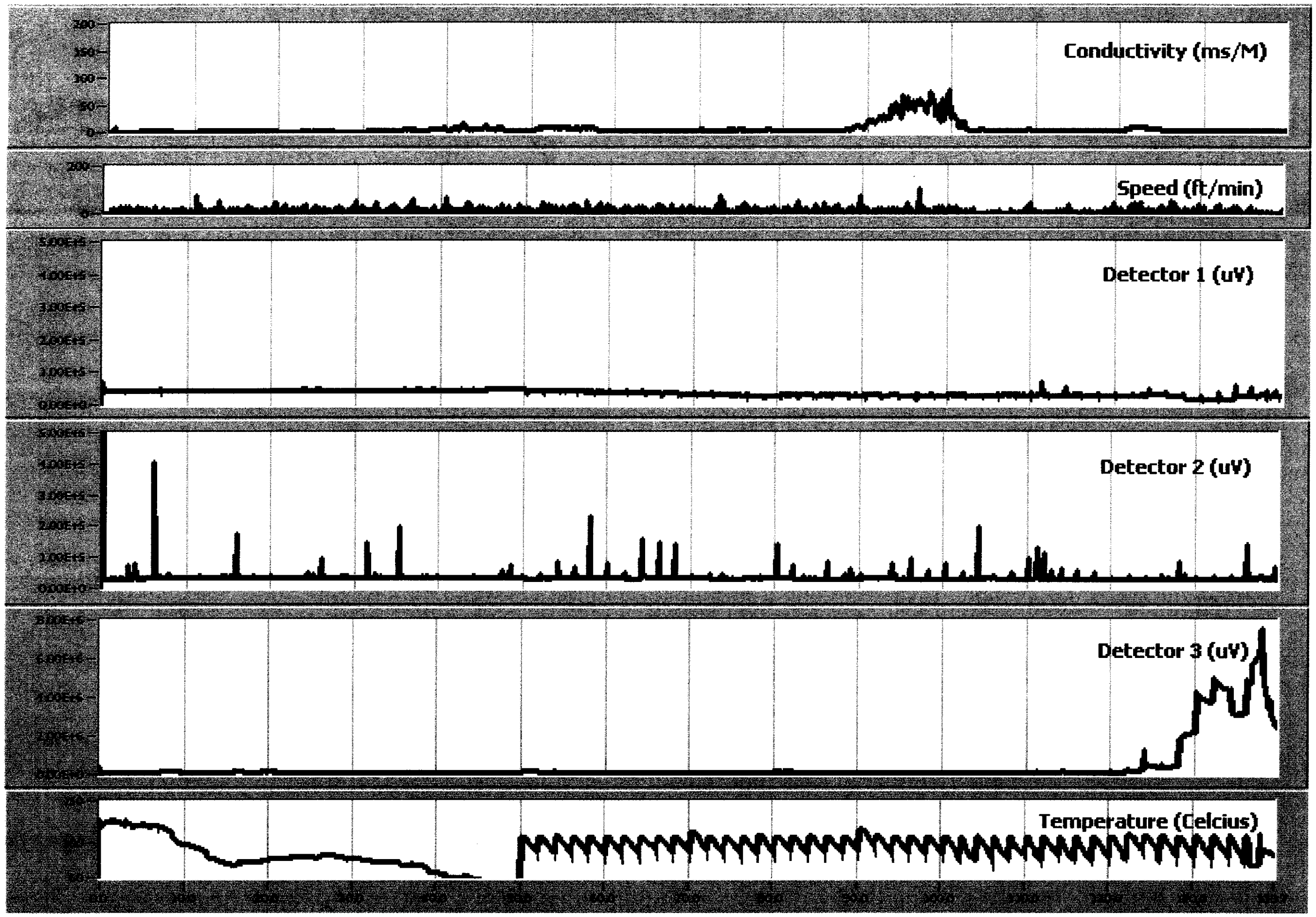
PGCPT-05



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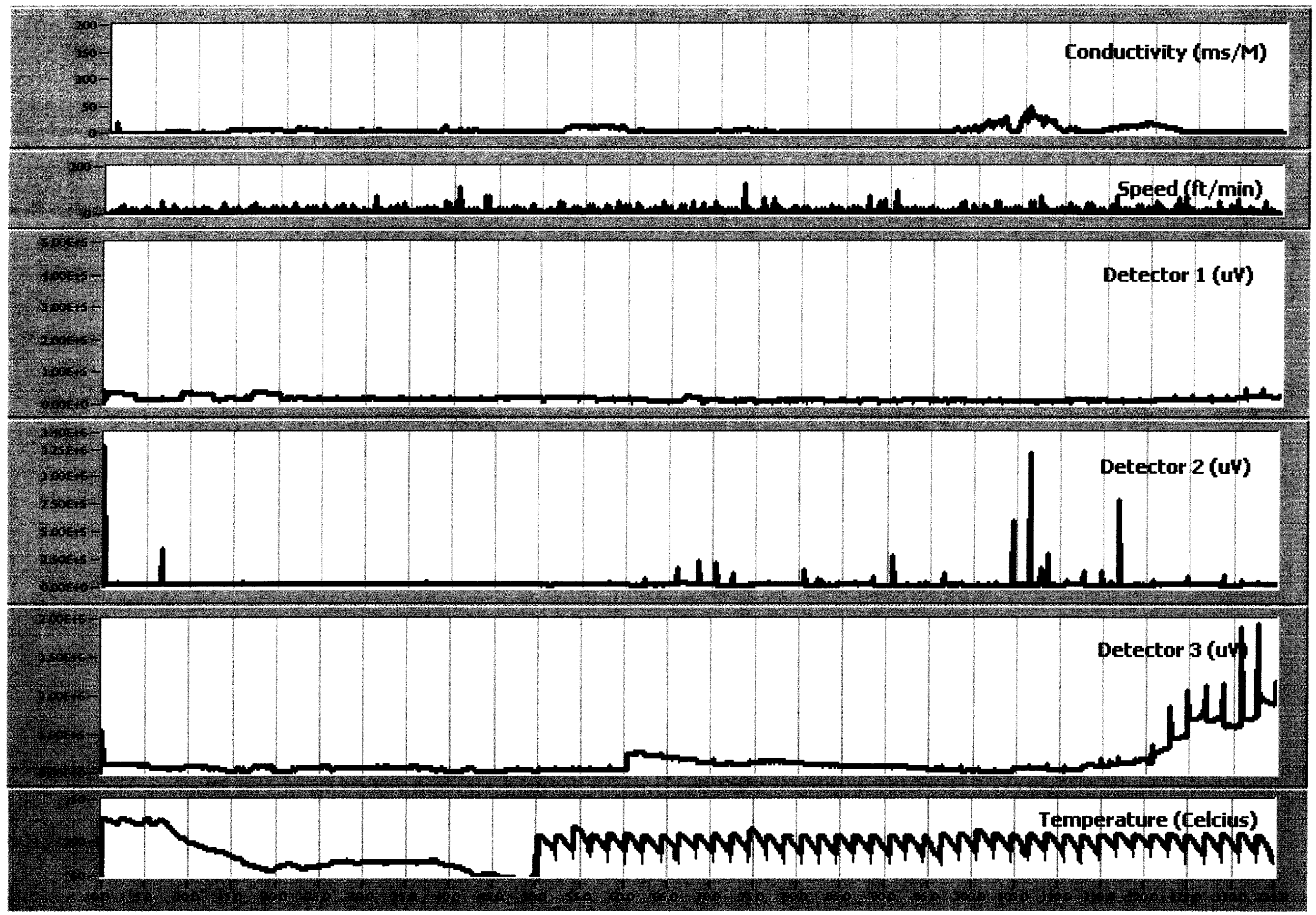
PGCPT-06



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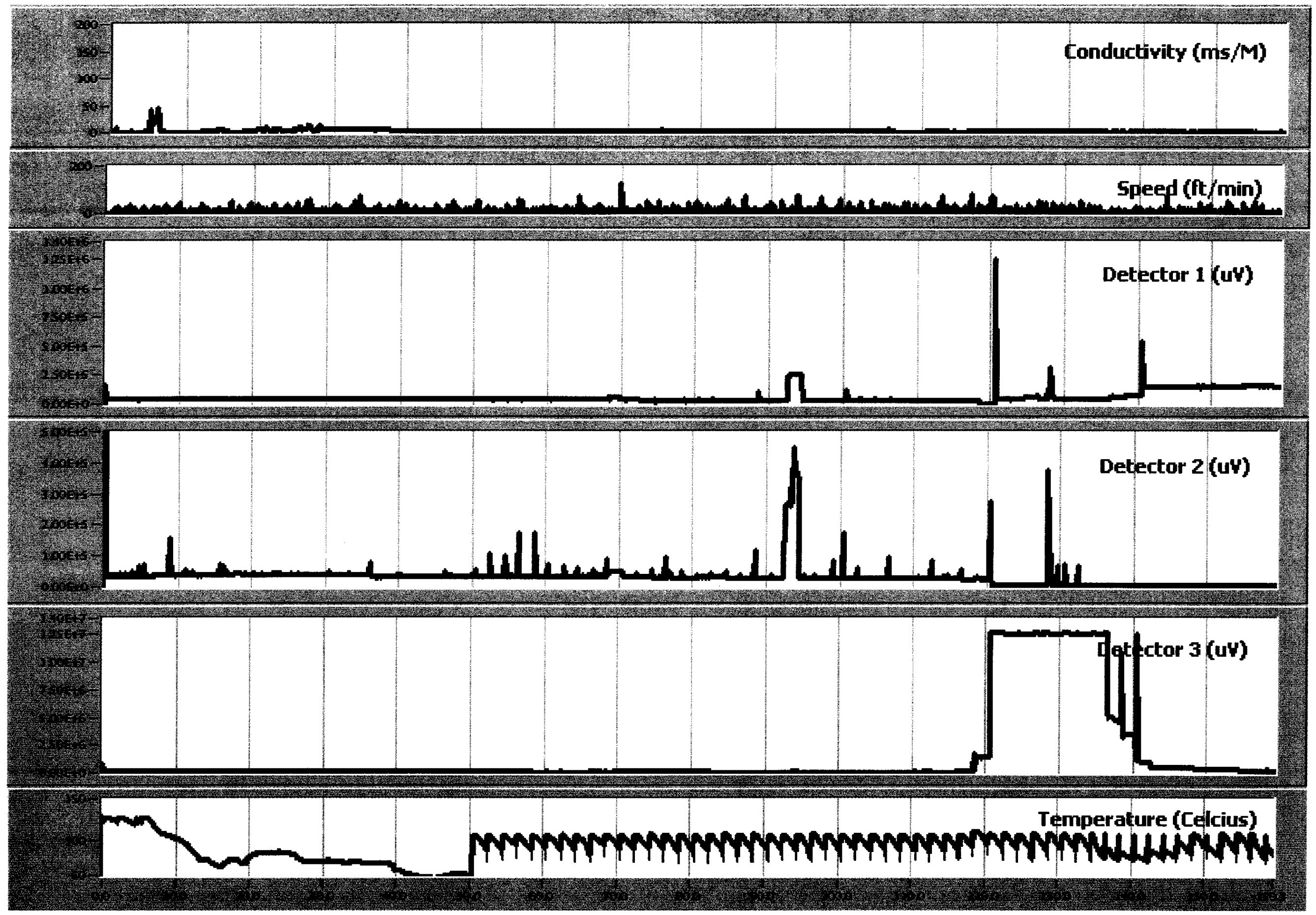
PGCPT-07



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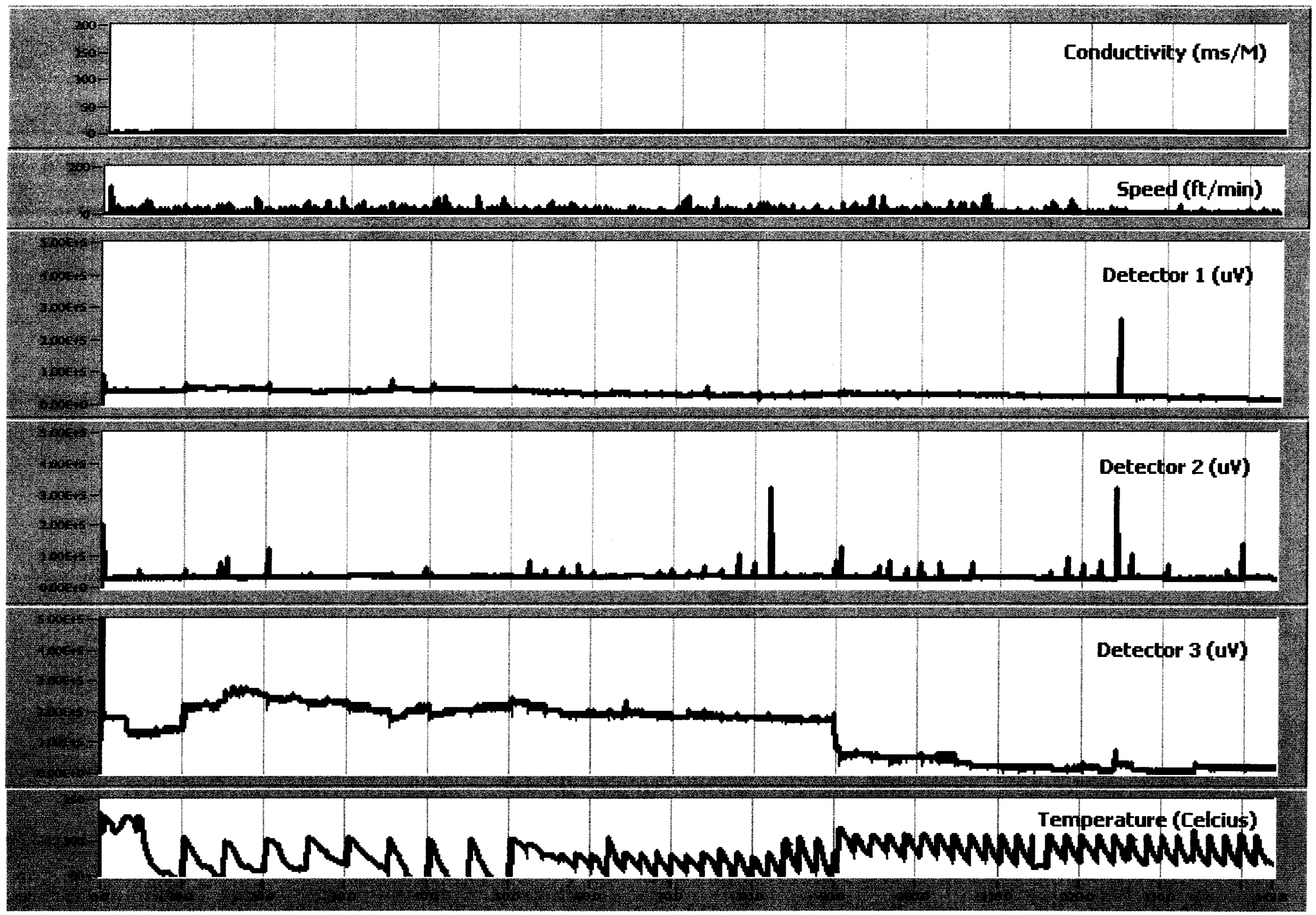
PGCPT-08



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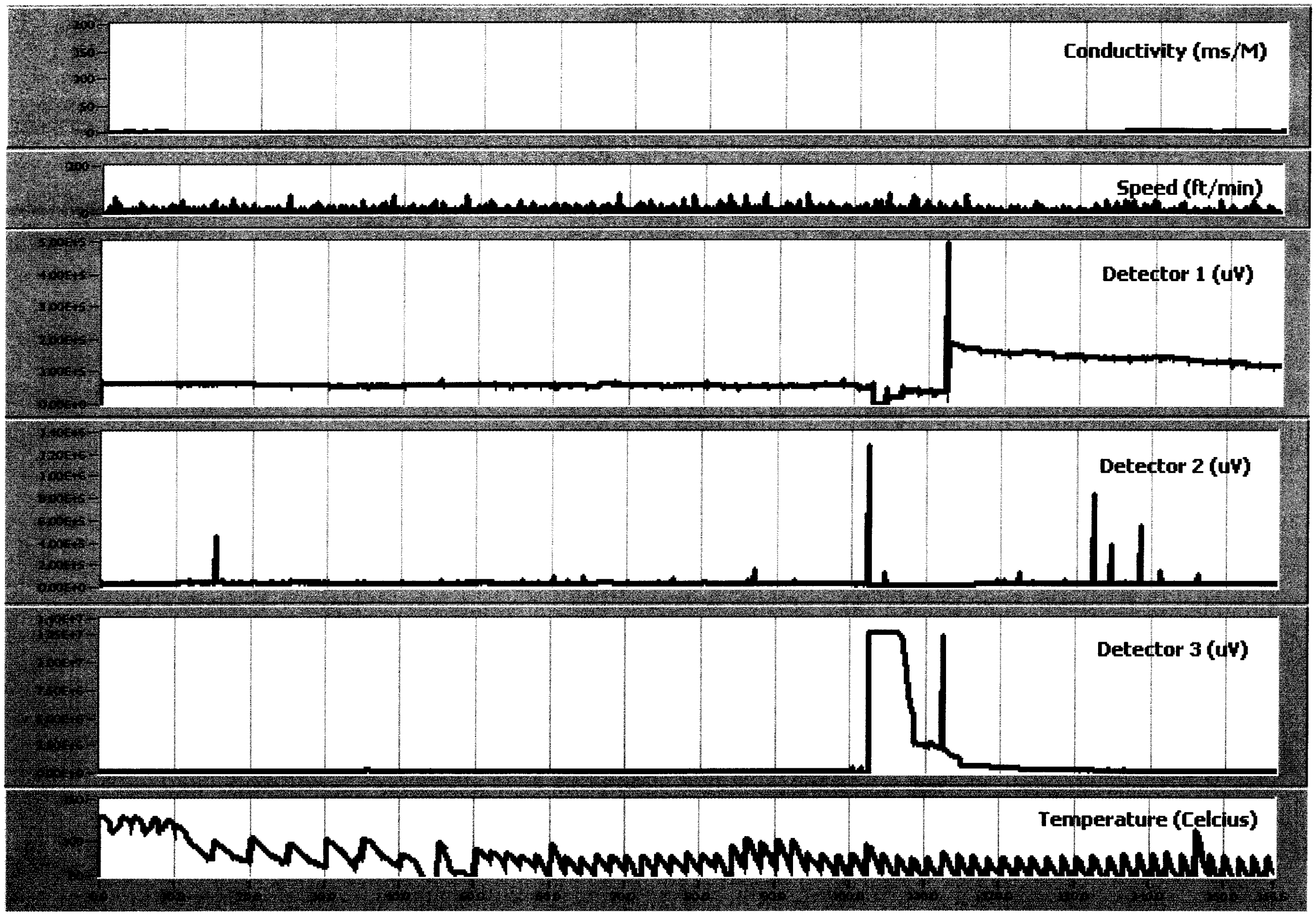
PGCPT-09



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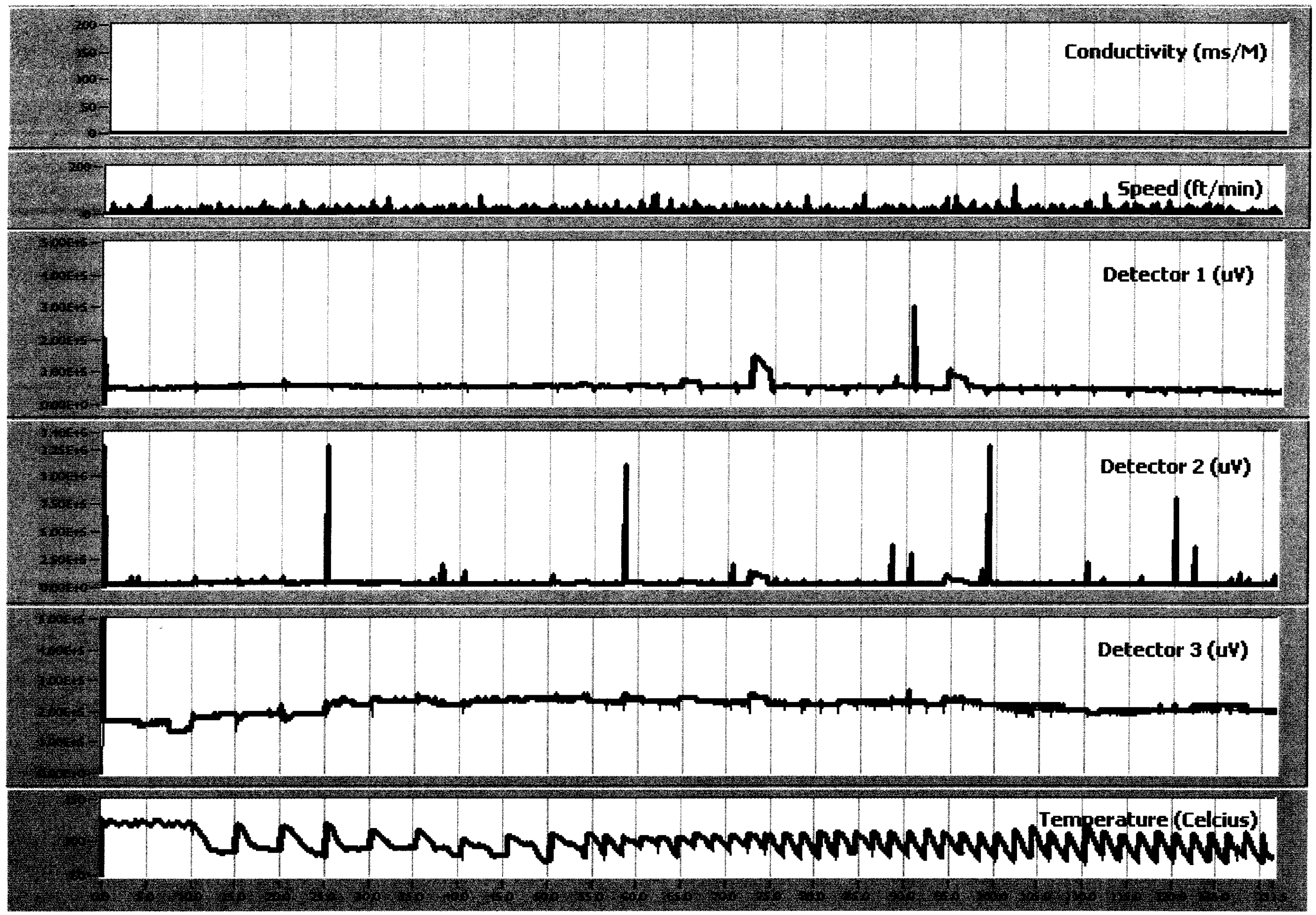
PGCPT-11



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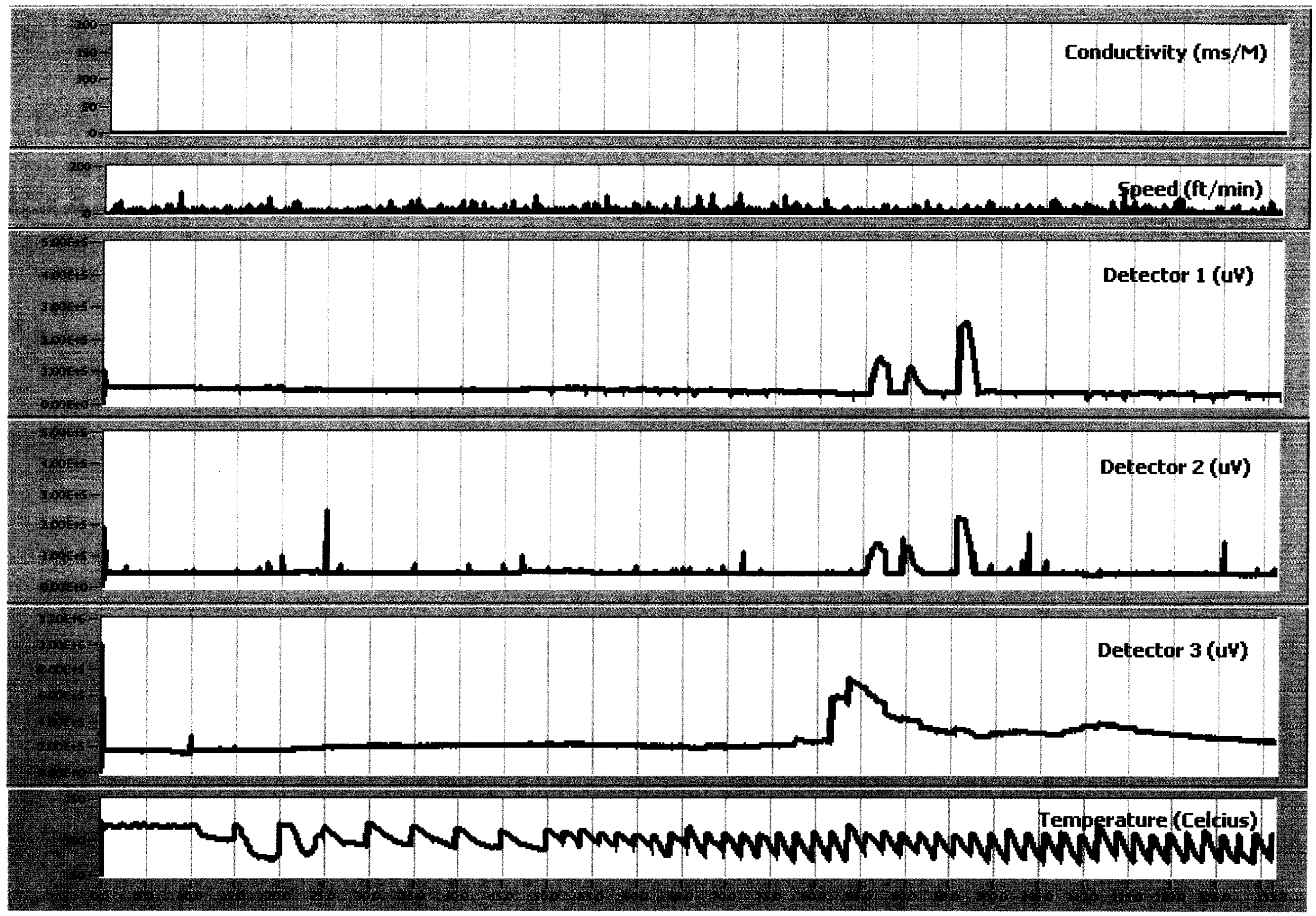
PGCPT-12



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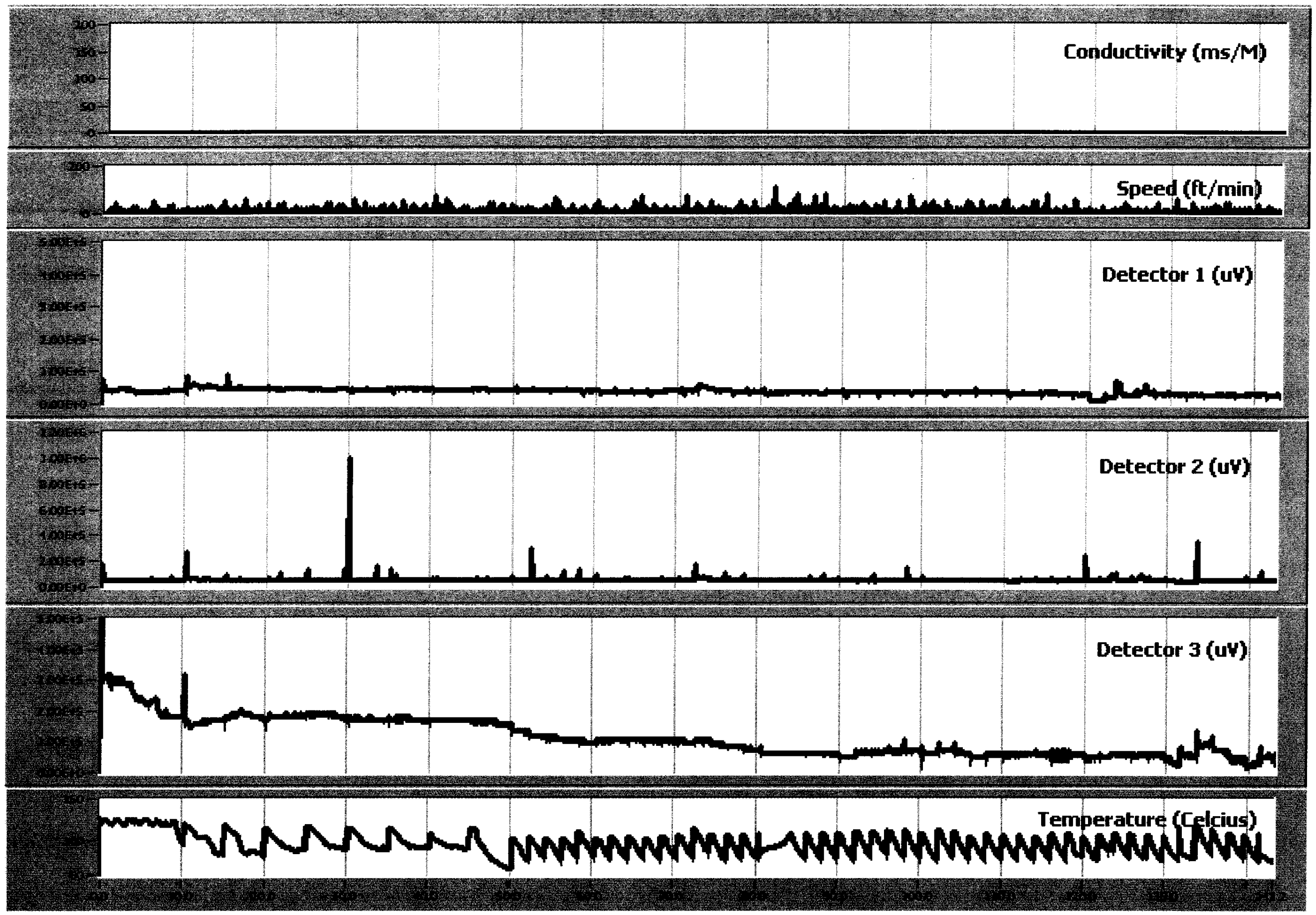
PGCPT-15



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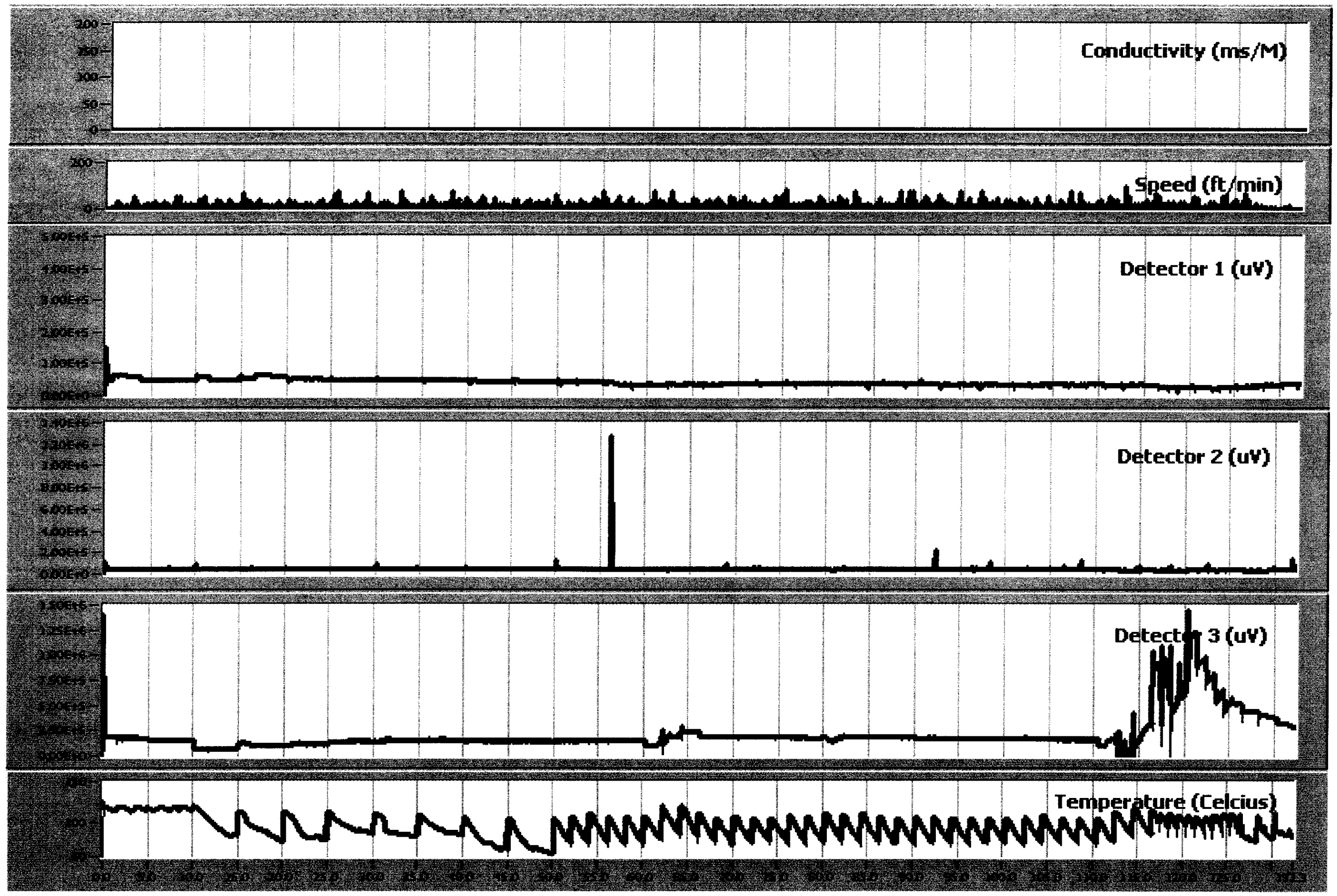
PGCPT-18



ECD responses from 114ft to end of log are most likely magnified due to unstable nitrogen flow

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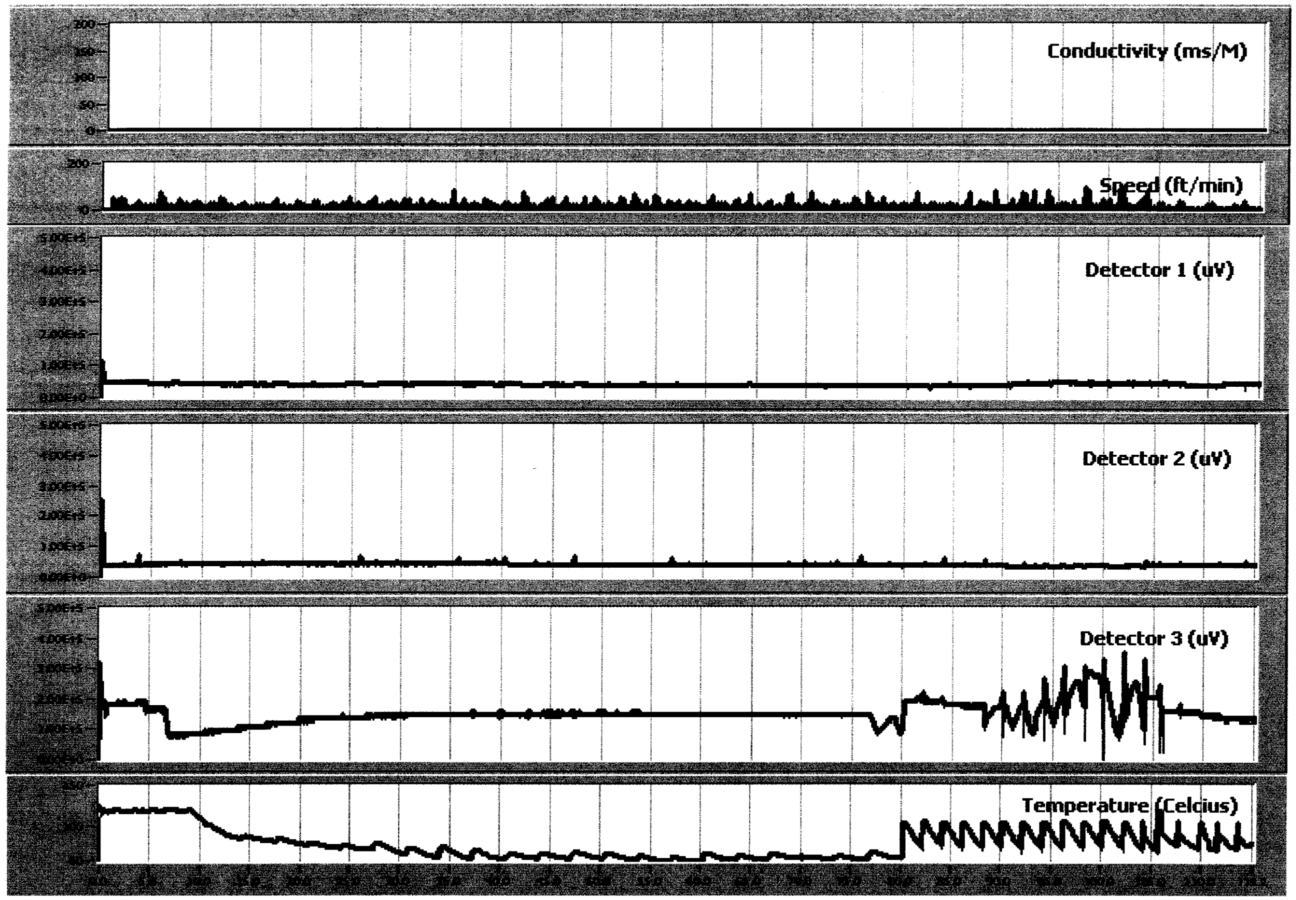
PGCPT-23



ECD responses from 88 ft to 106 ft are most likely magnified due to unstable nitrogen flow

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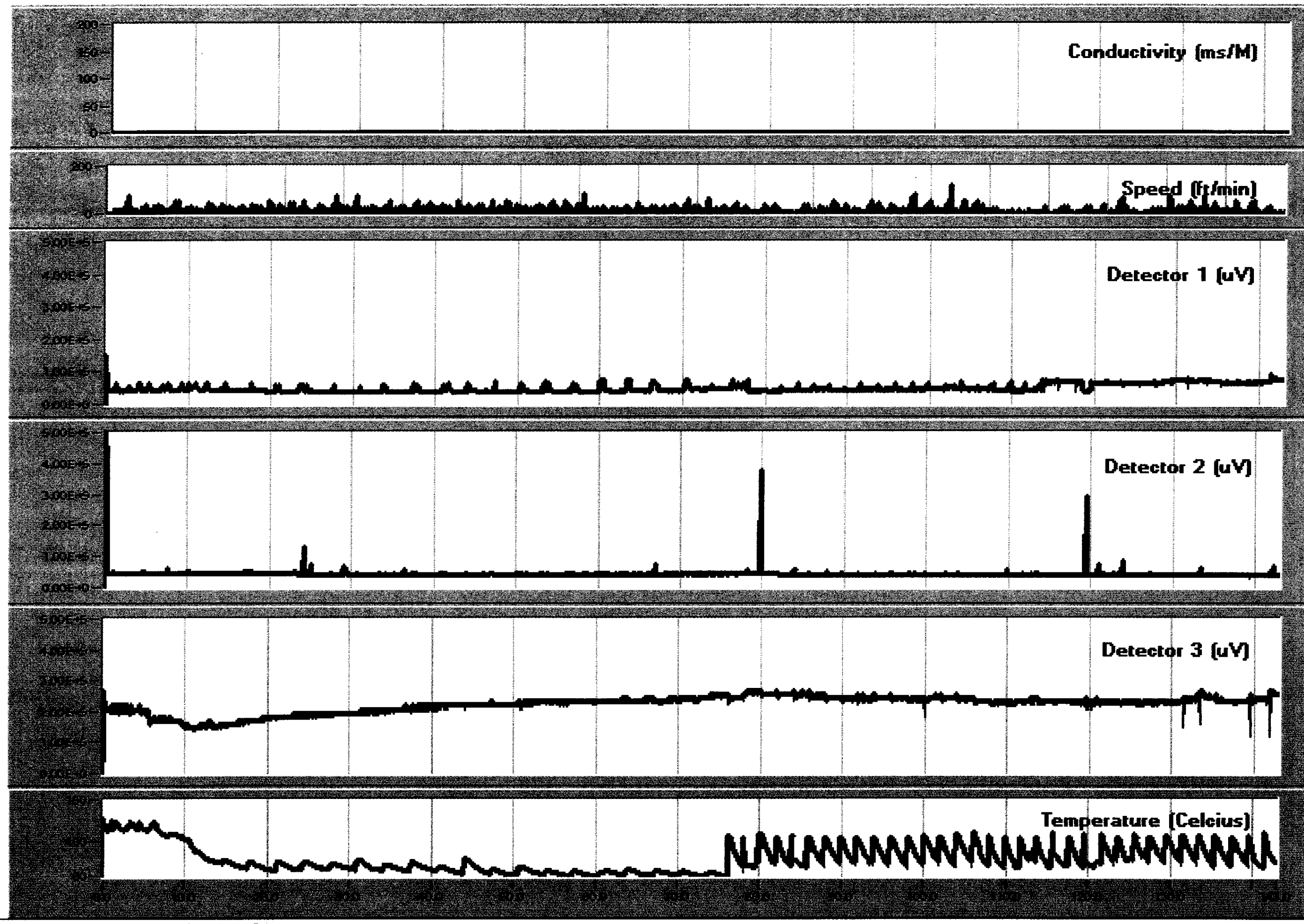
PGCPT-24



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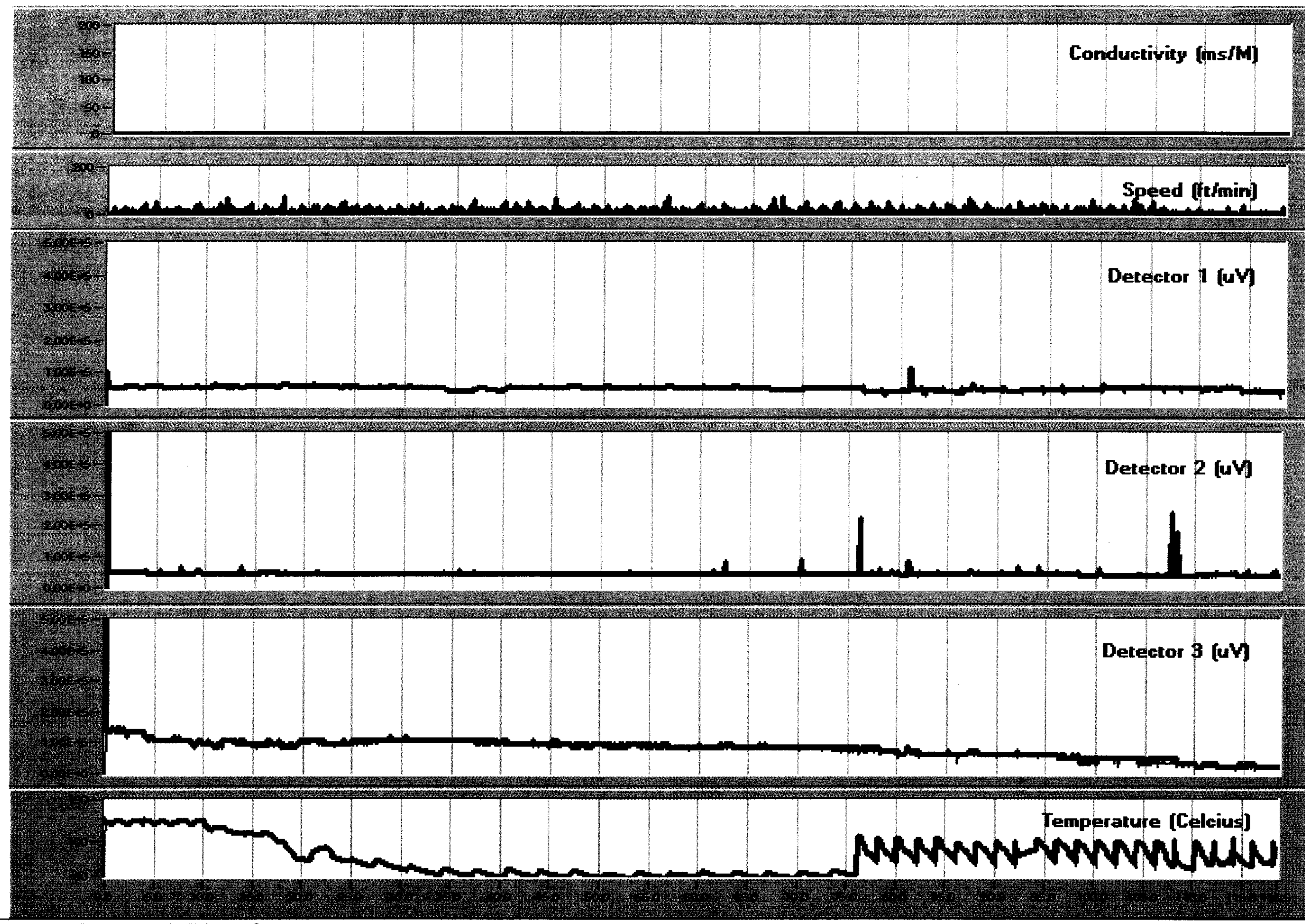
PGCPT-25



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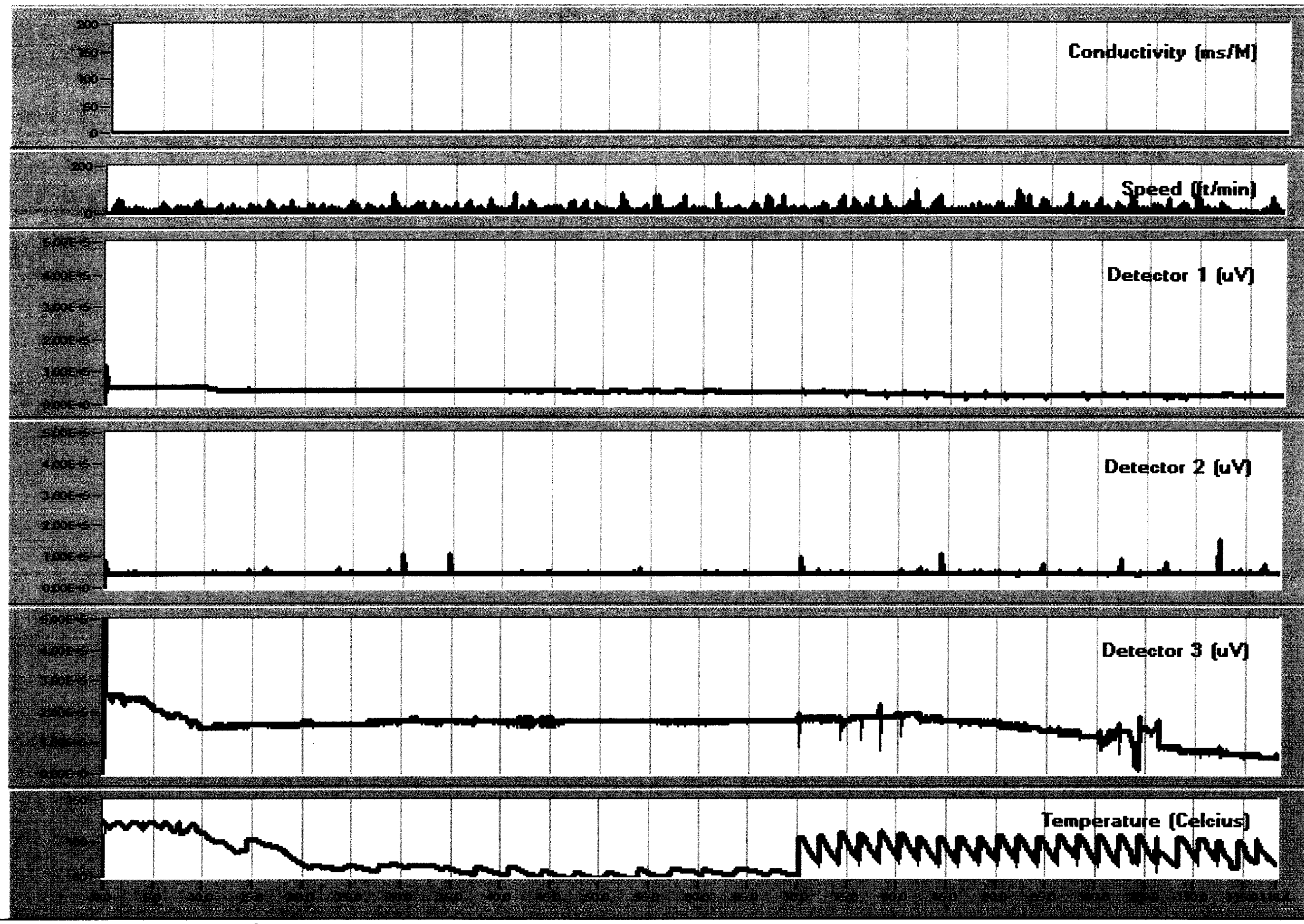
PGCPT-26



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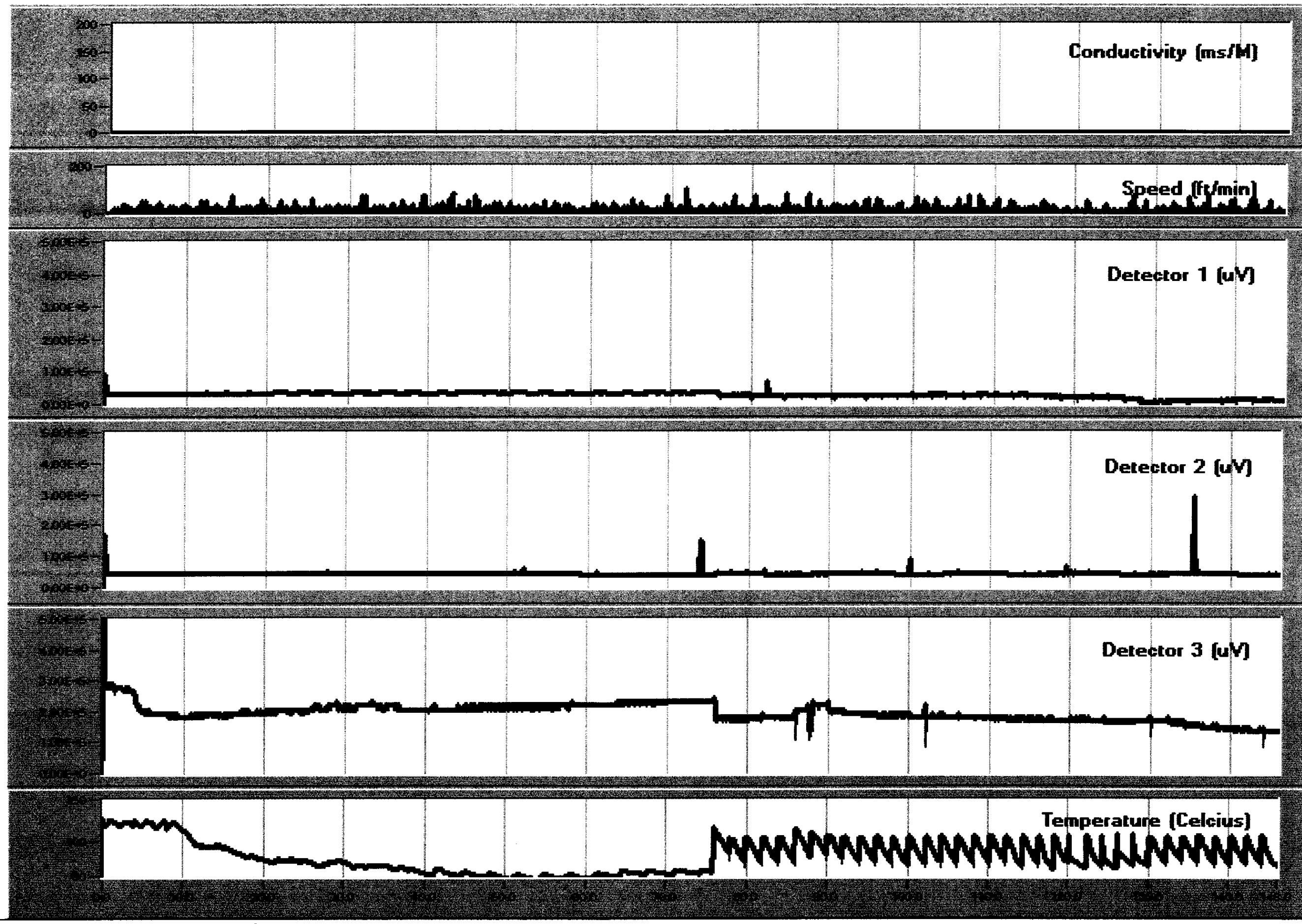
PGCPT-27



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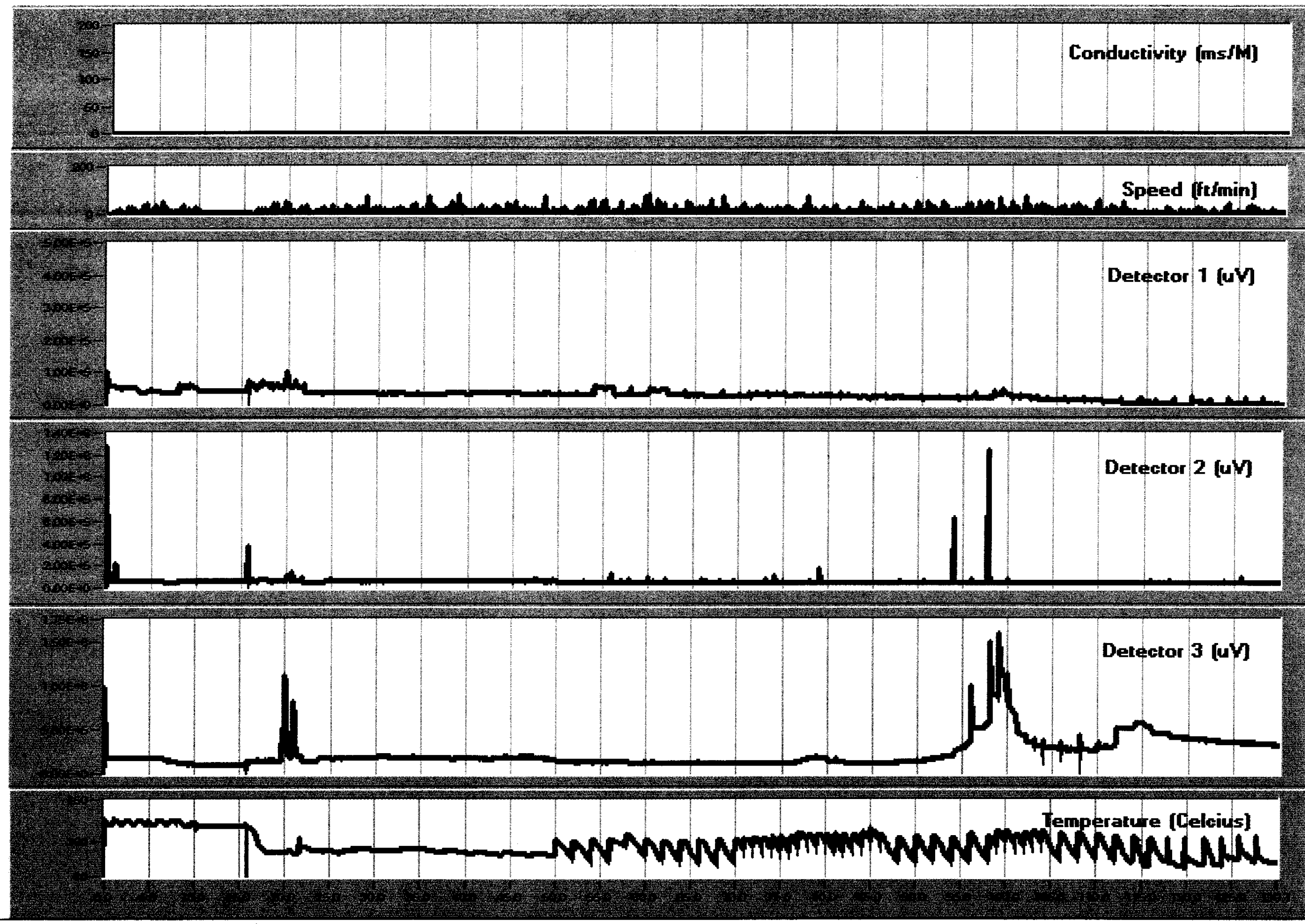
PGCPT-29



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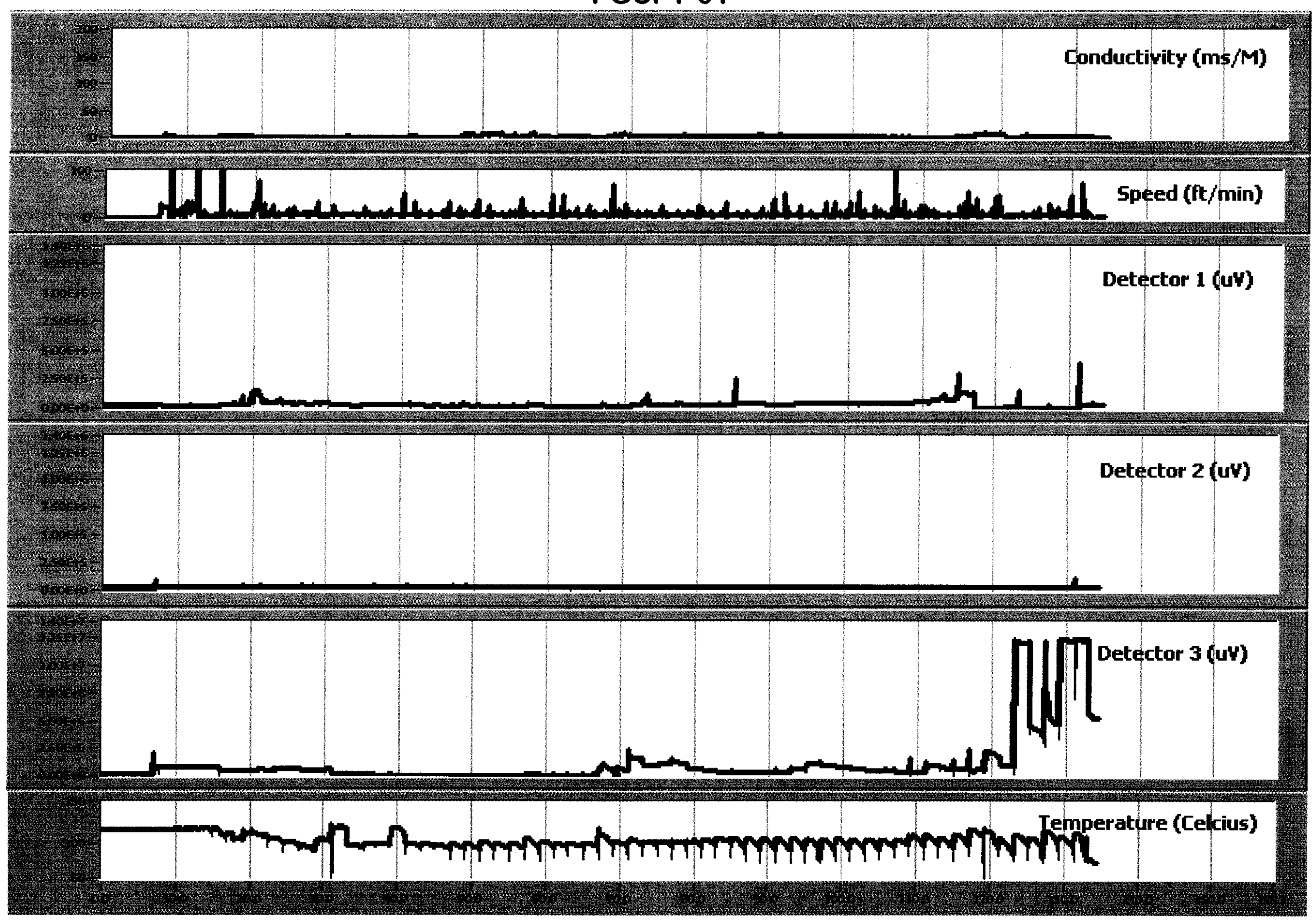
Appendix C: MIP Logs

(Standardized Scale)

PGCPT-01



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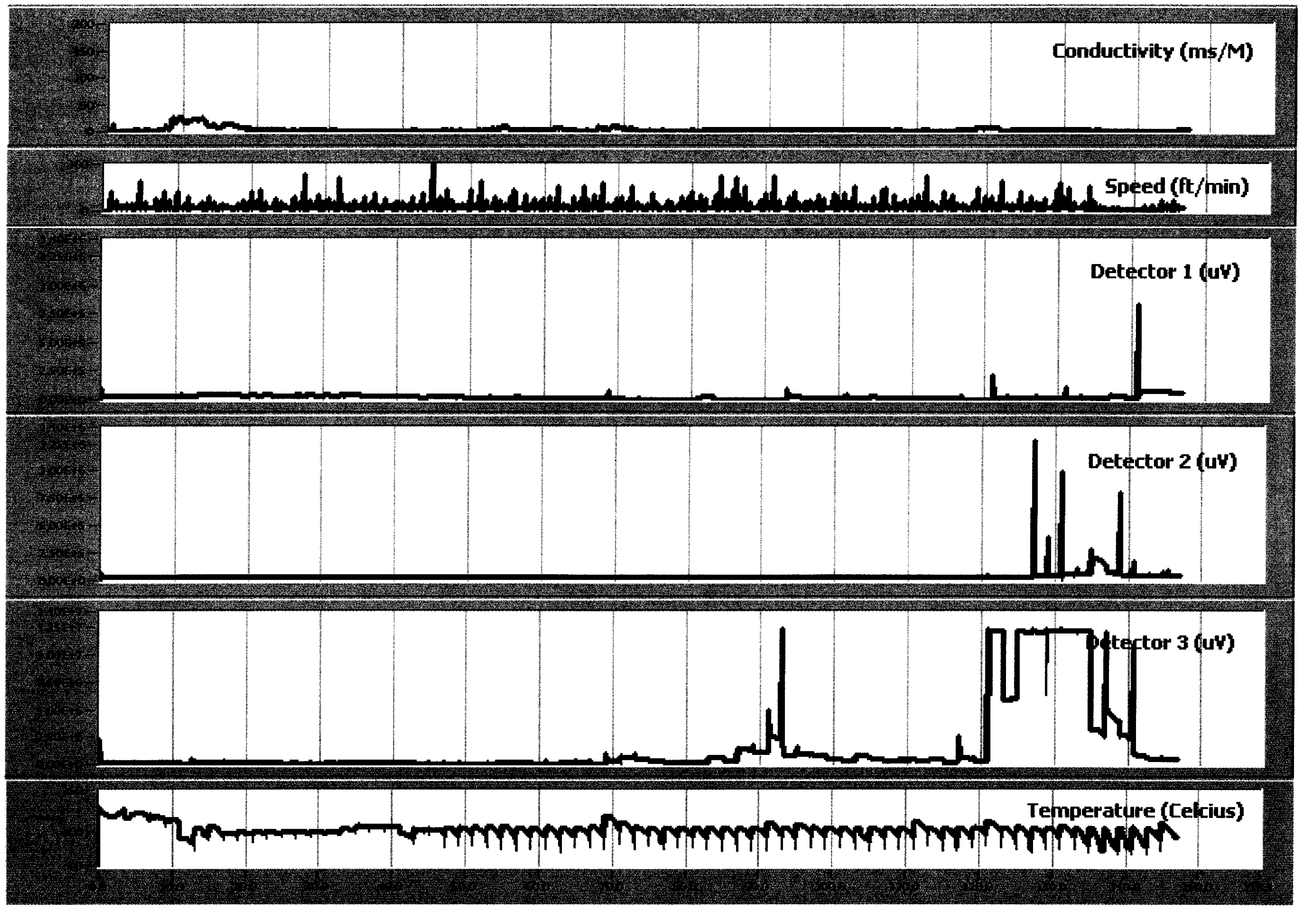
PGCPT-02



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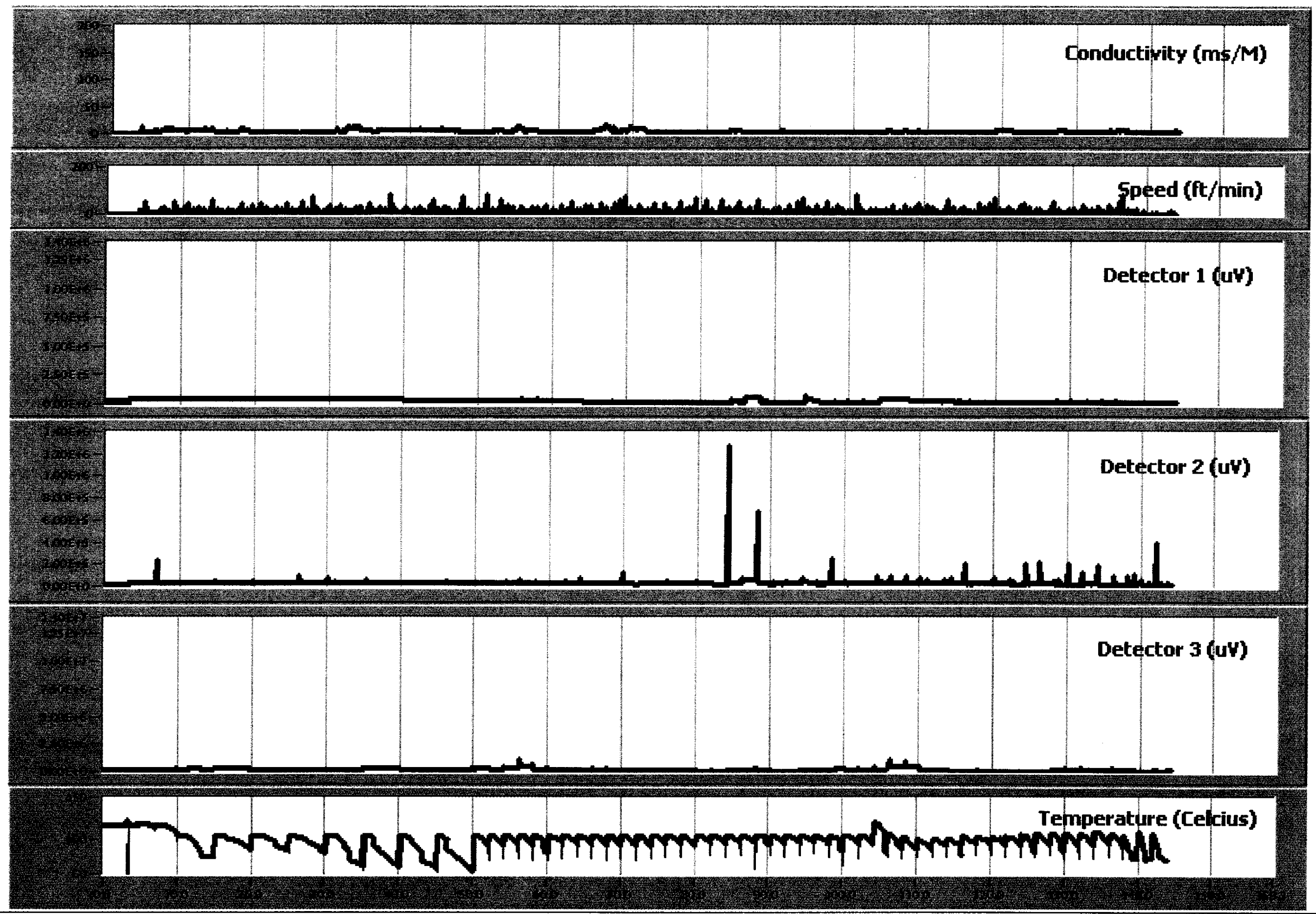
PGCPT-03



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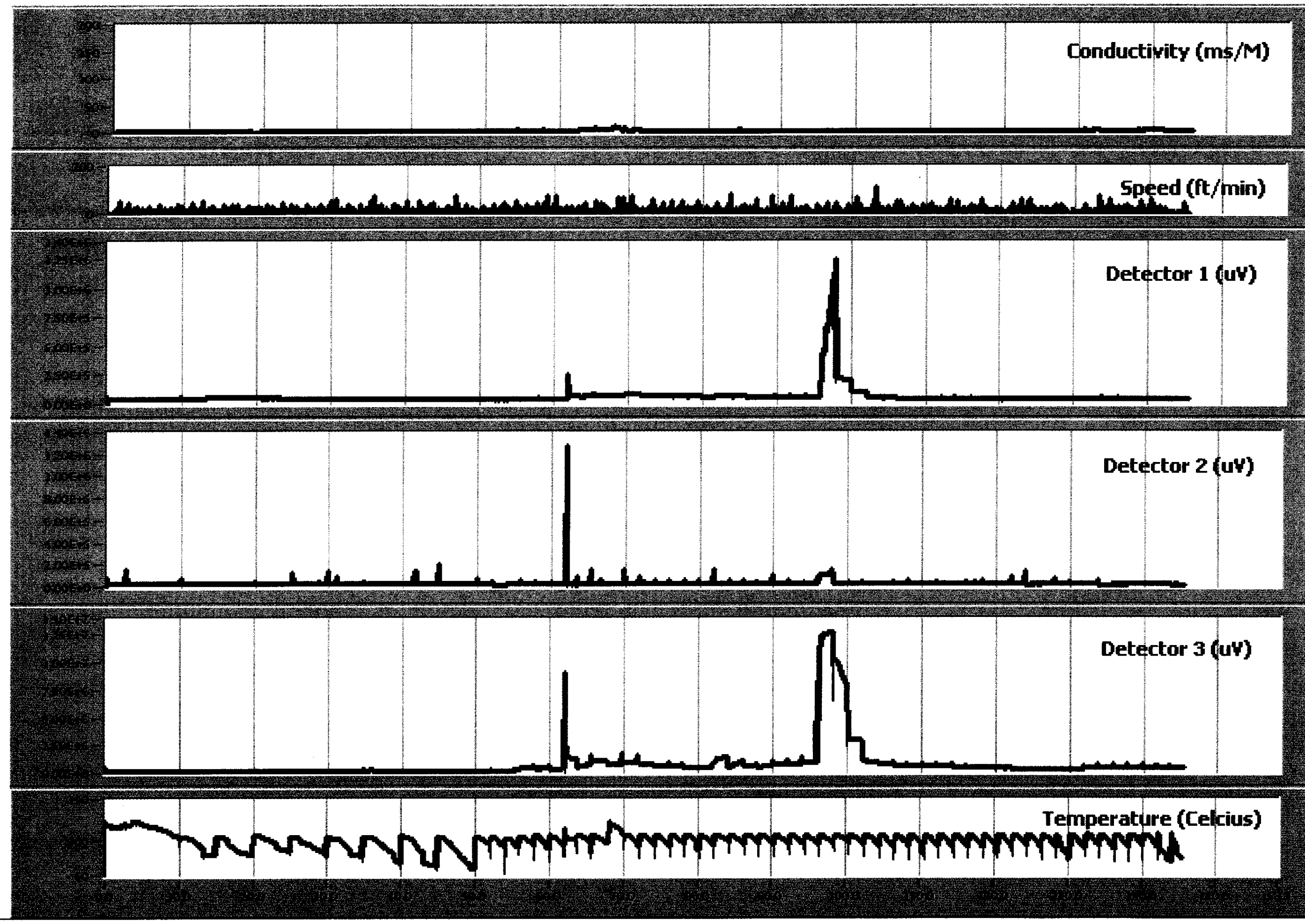
PGCPT-04



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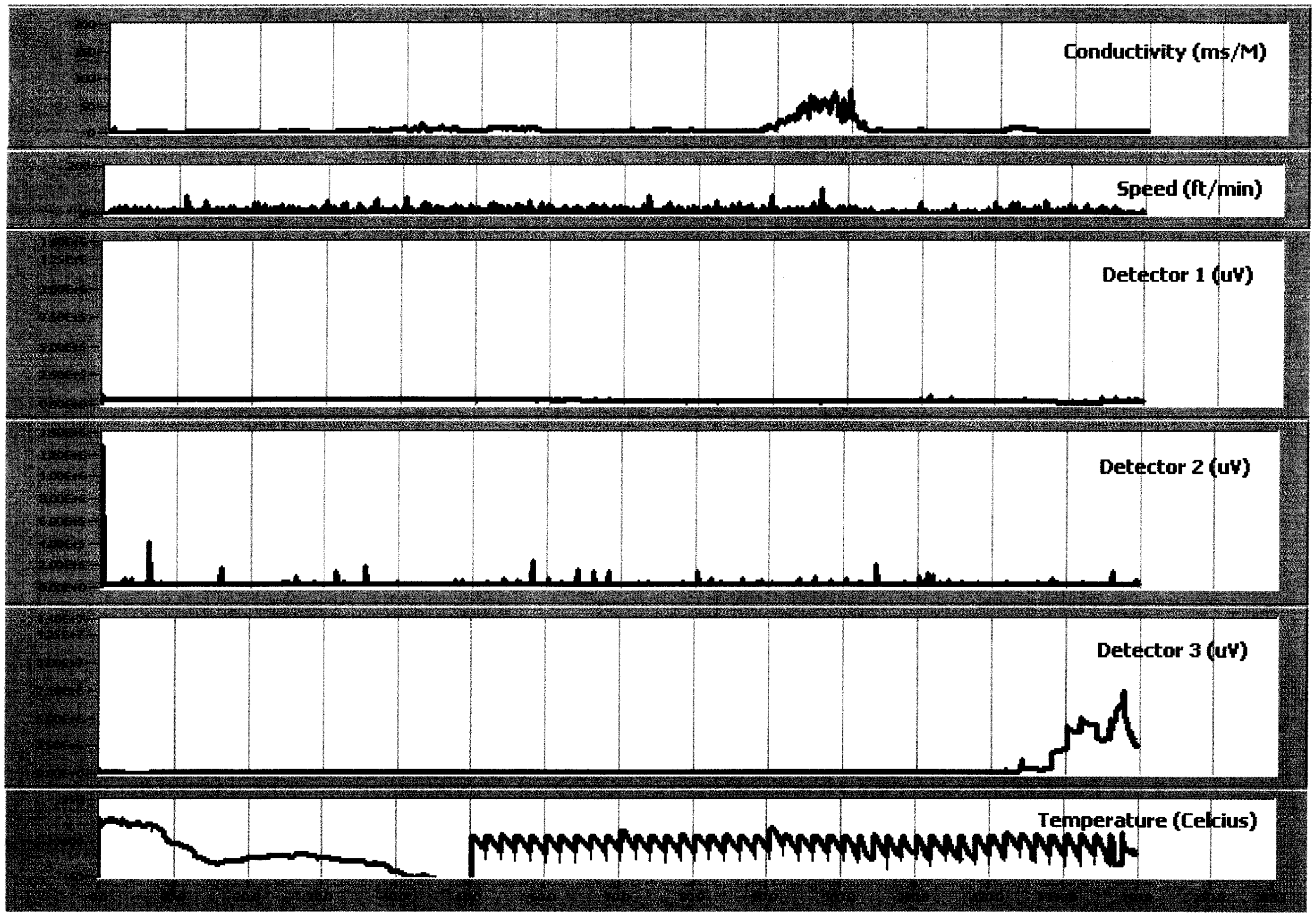
PGCPT-05



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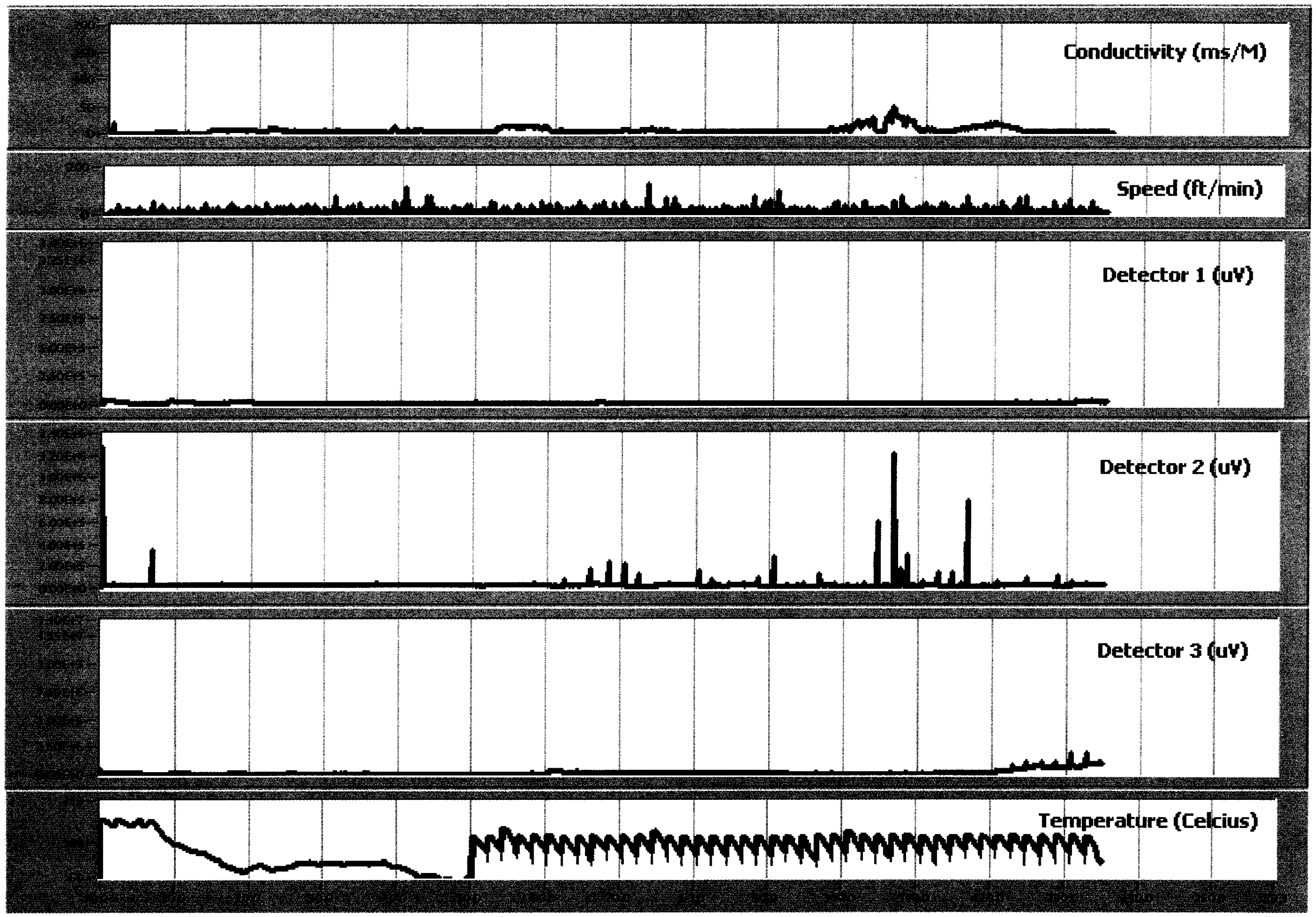
PGCPT-06



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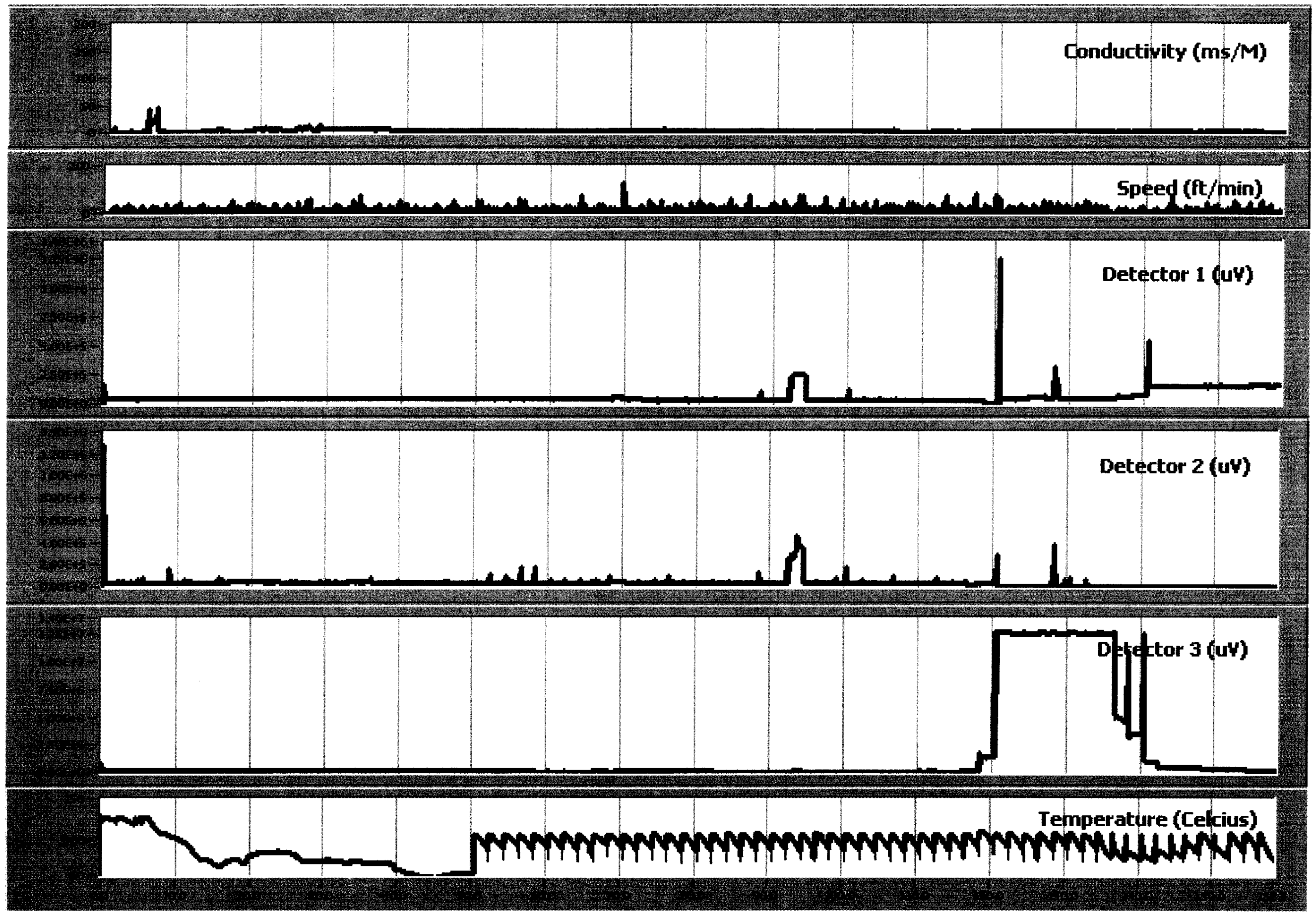
PGCPT-07



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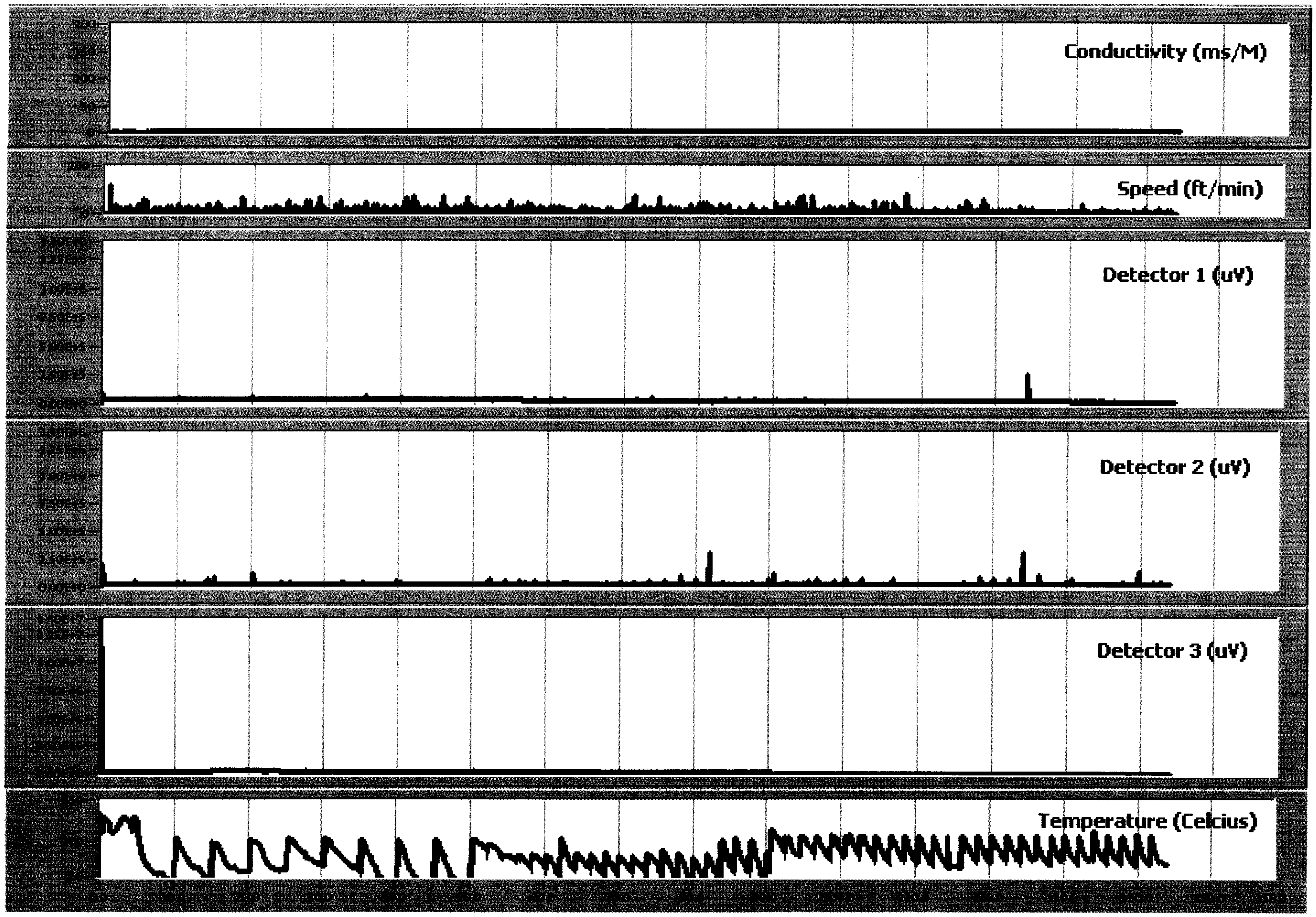
PGCPT-08



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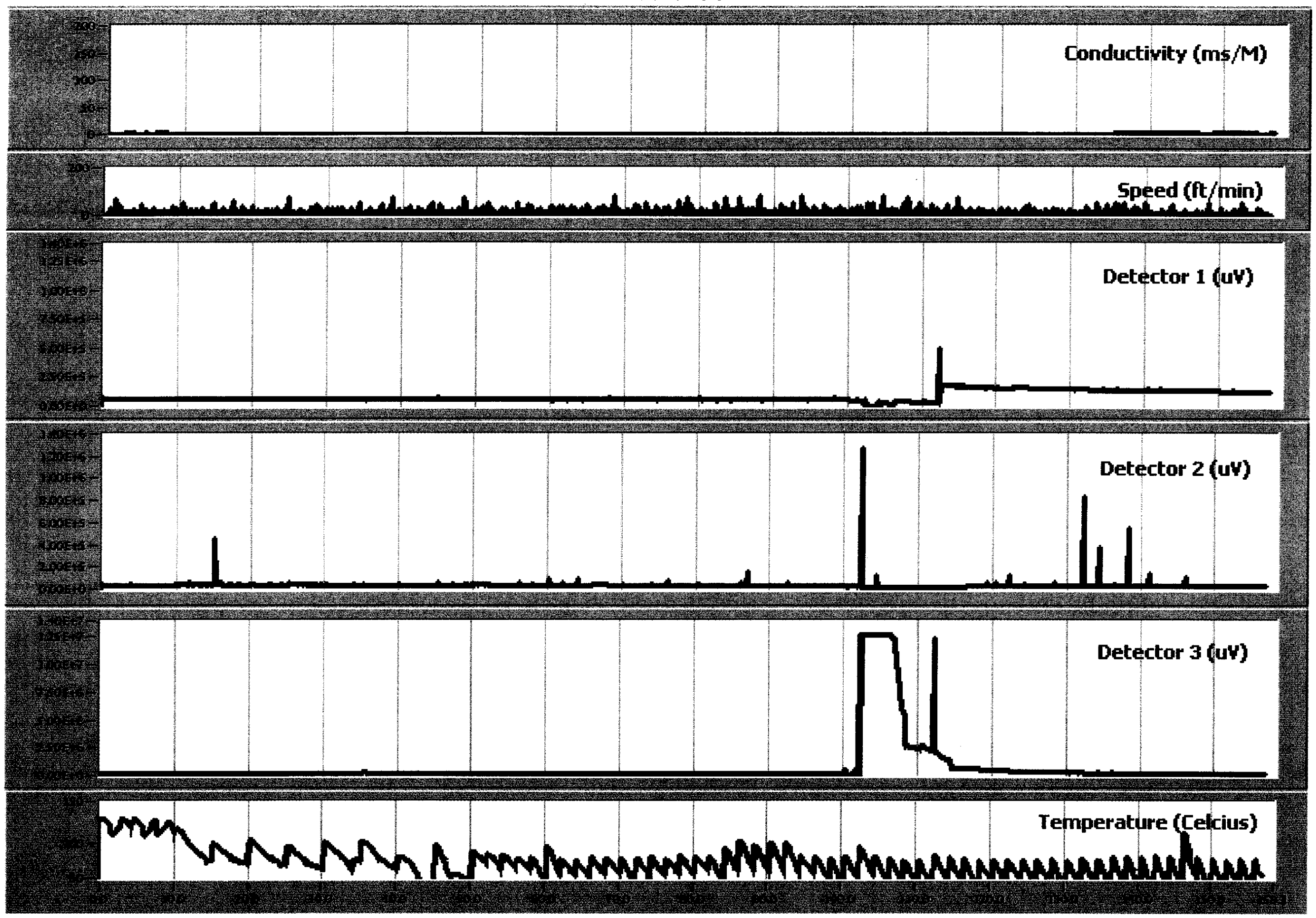
PGCPT-09



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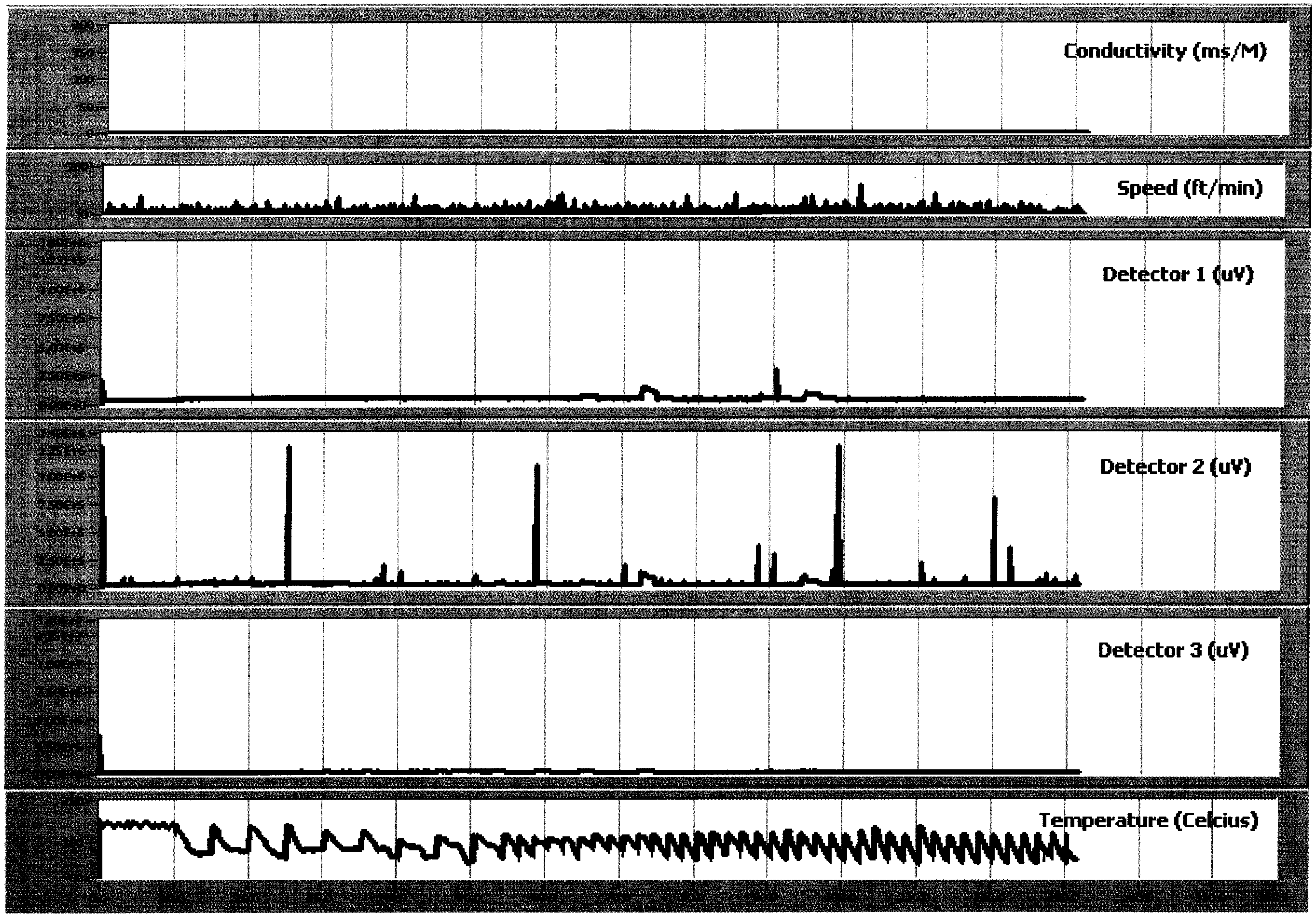
PGCPT-11



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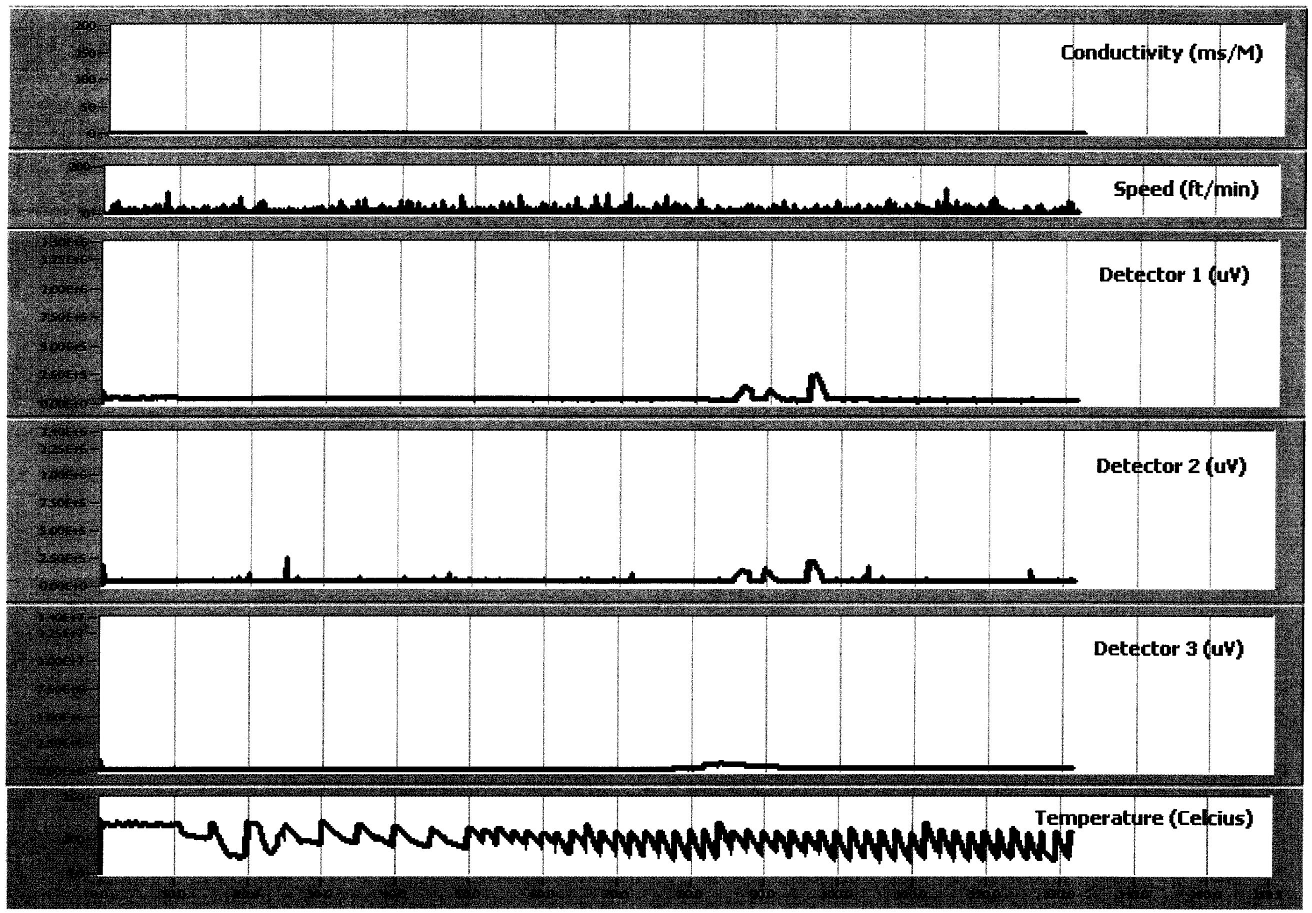
PGCPT-12



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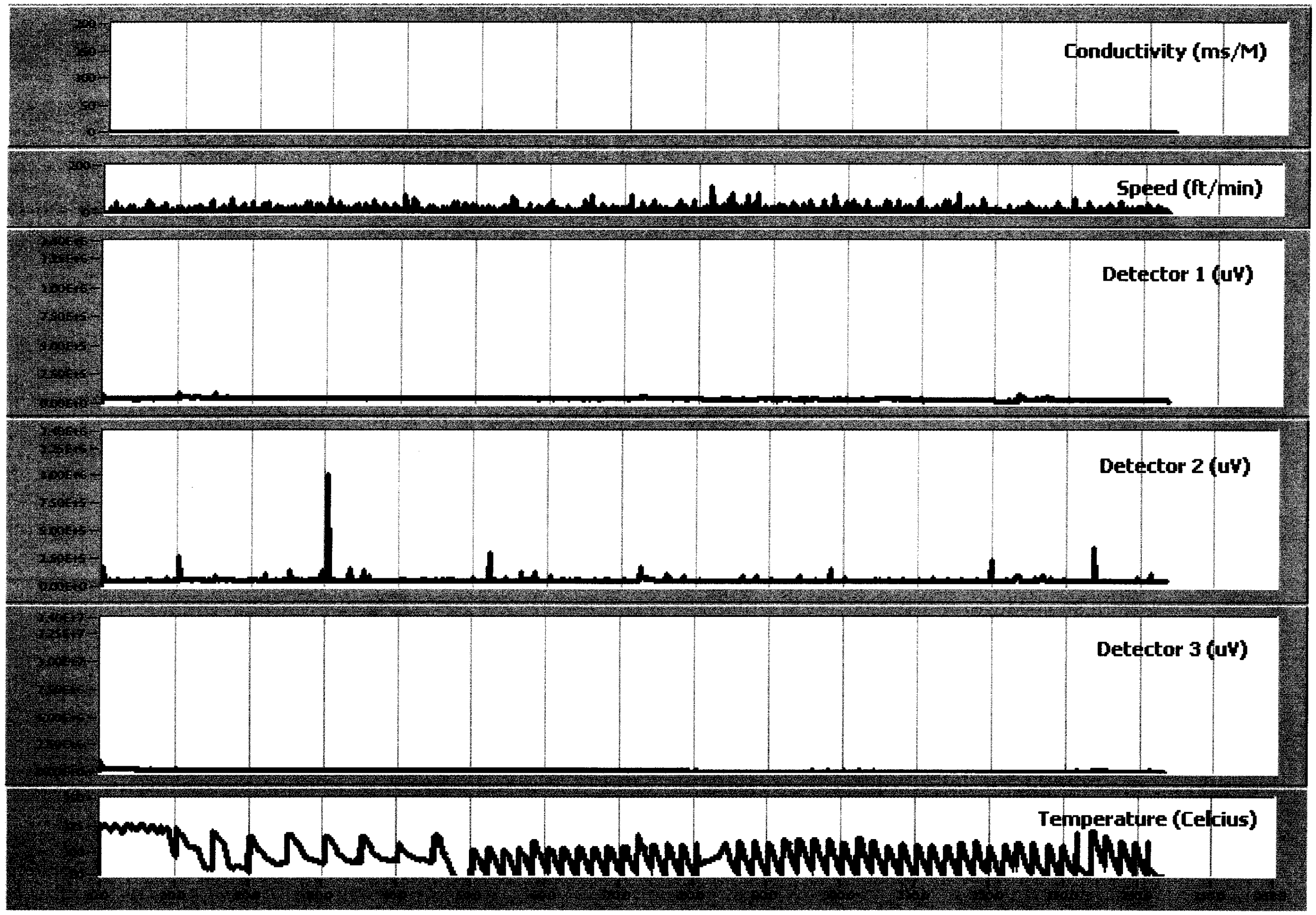
PGCPT-15



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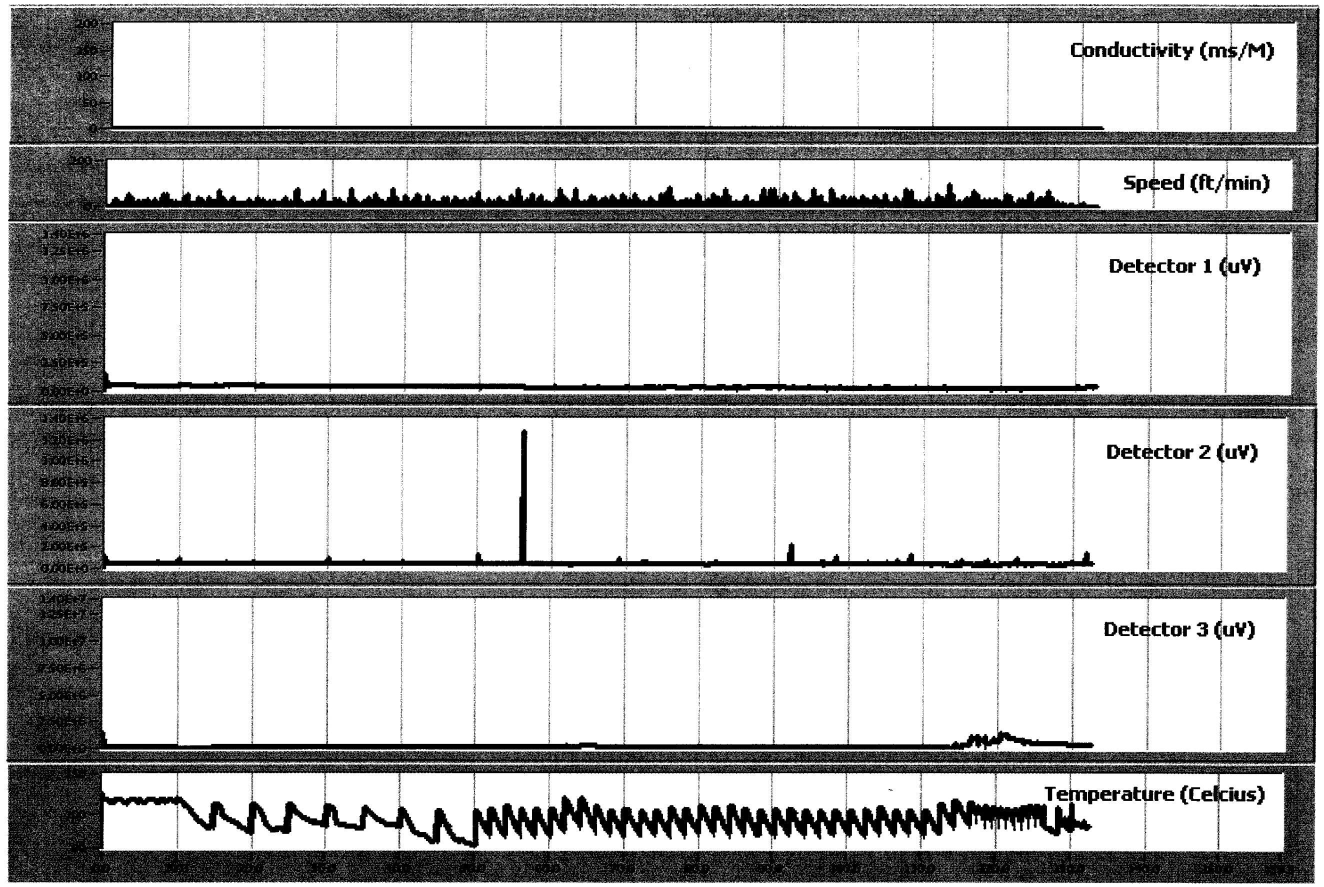
PGCPT-18



ECD responses from 114ft to end of log are most likely magnified due to unstable nitrogen flow

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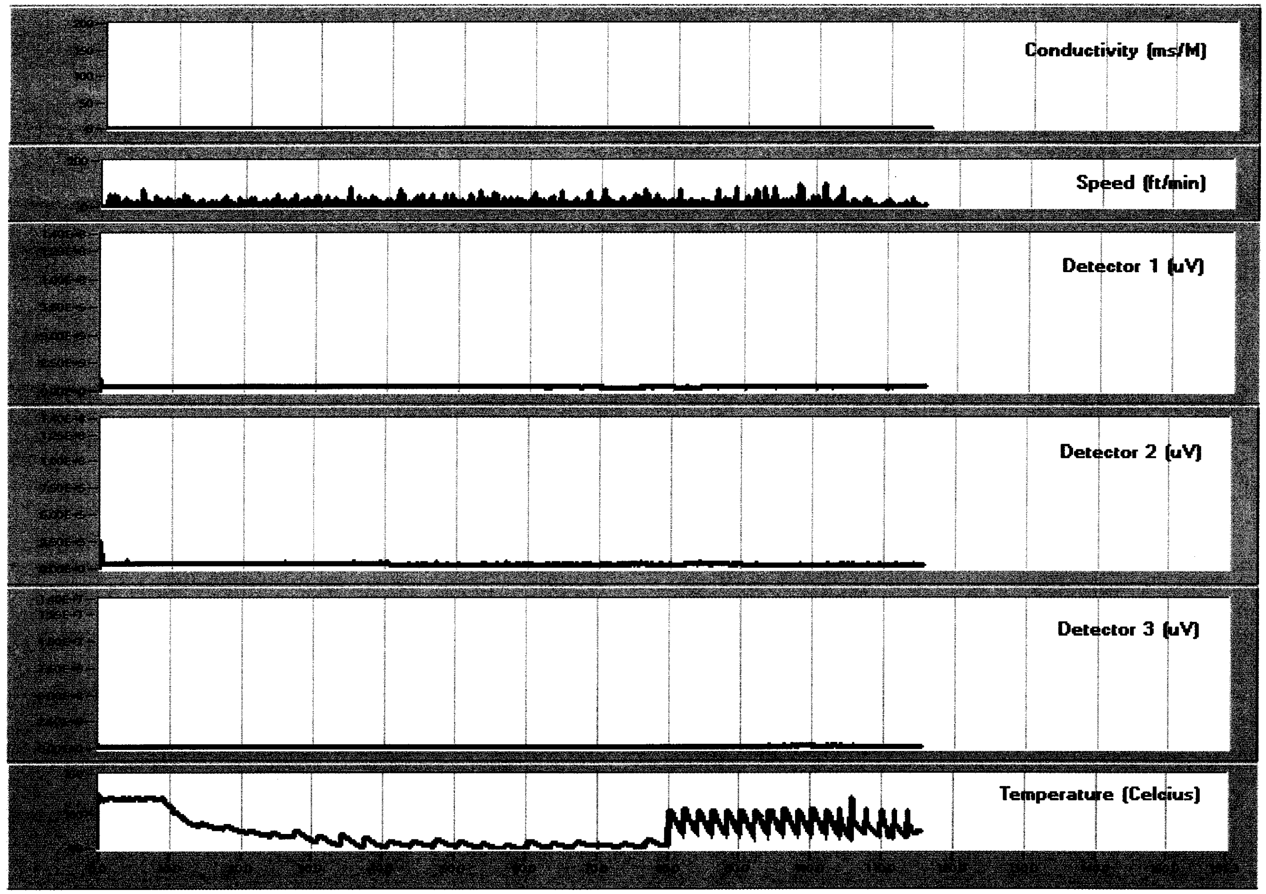
PGCPT-23



ECD responses from 88 ft to 106 ft are most likely magnified due to unstable nitrogen flow

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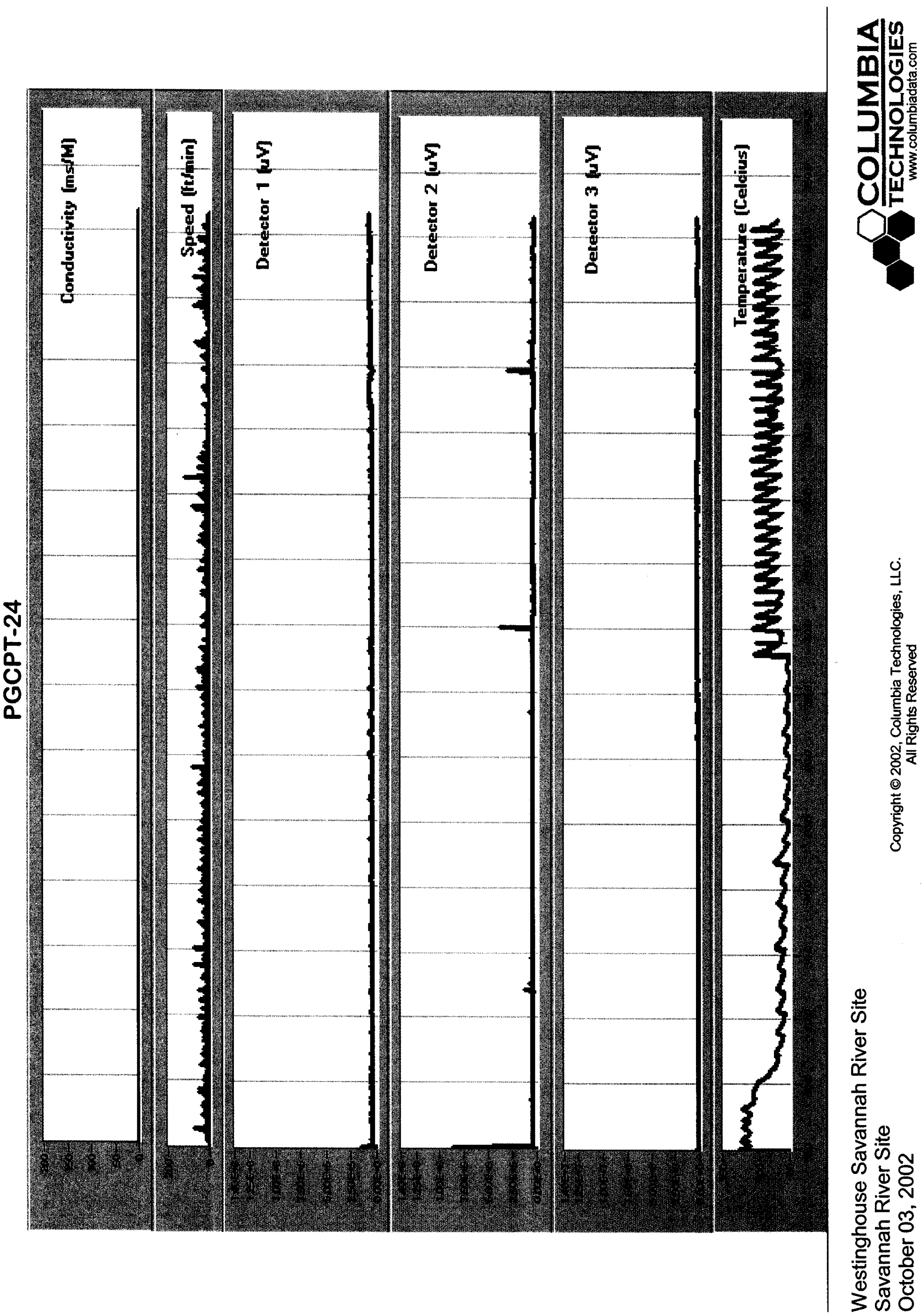
PGCPT-24
Conductivity (ms/M)
Speed (ft/min)
Detector 1 (uV)
Detector 2 (uV)
Detector 3 (uV)
Temperature (Celcius)
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Savannah River Site
October 03, 2002
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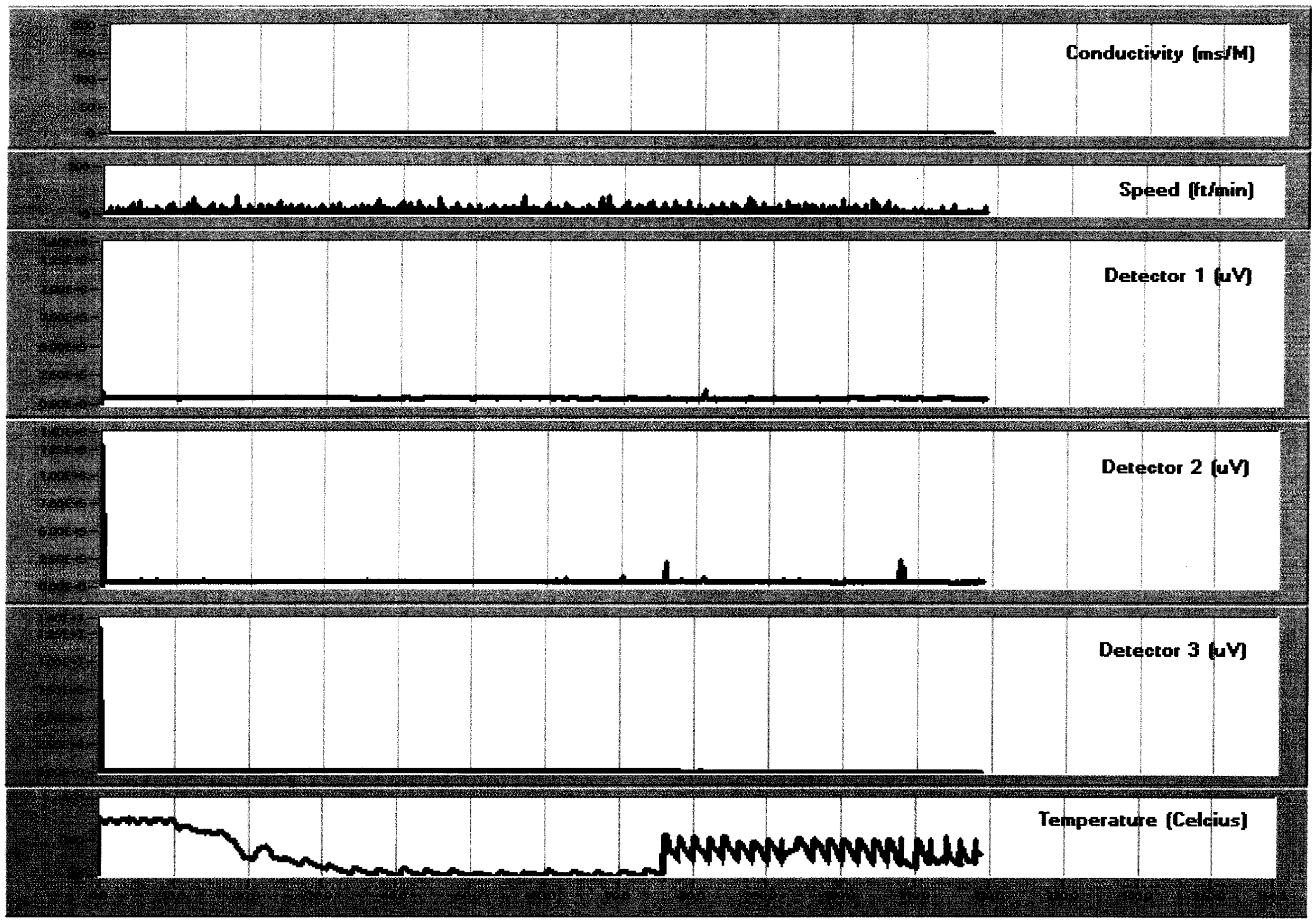
PGCPT-25



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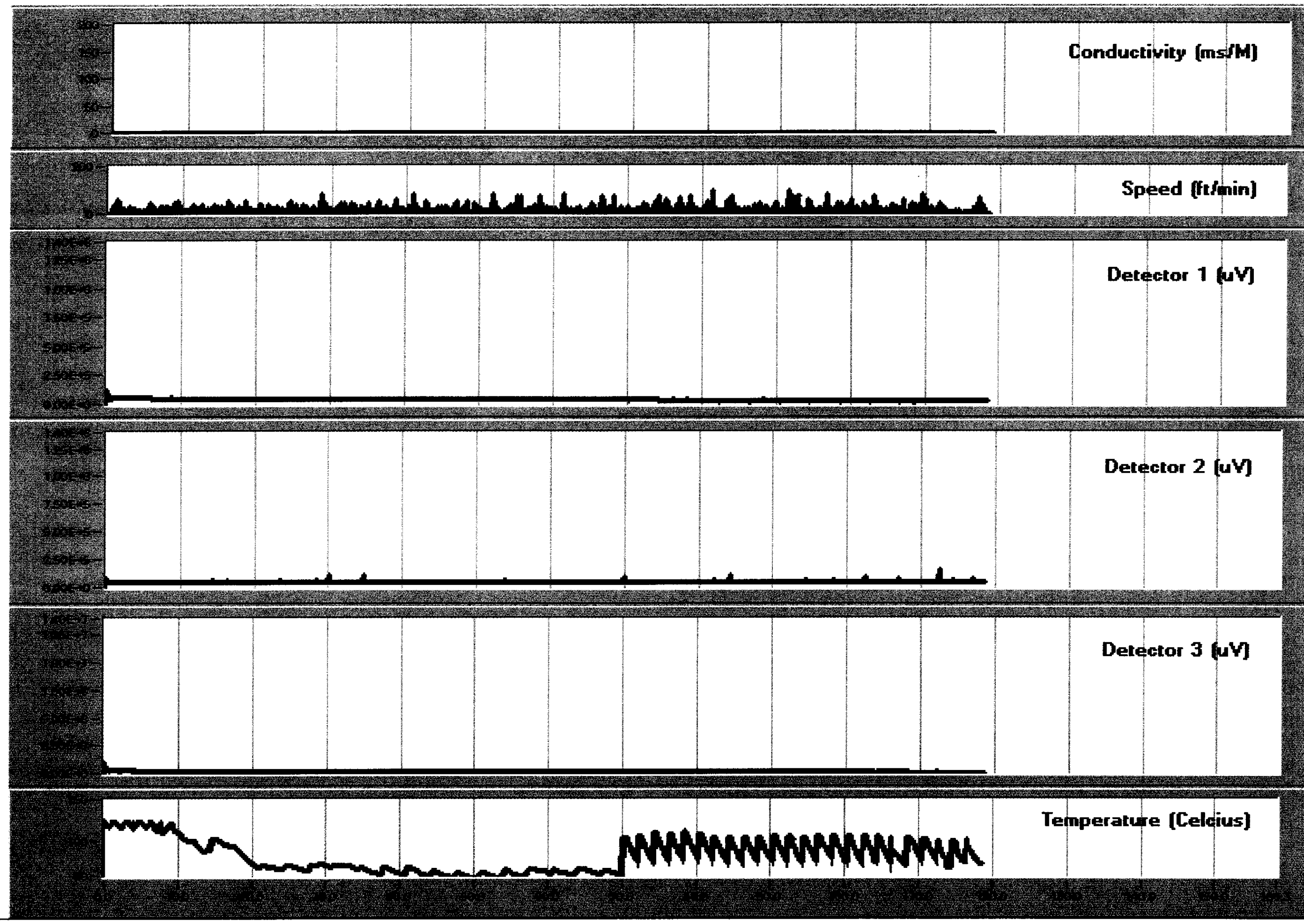
PGCPT-26



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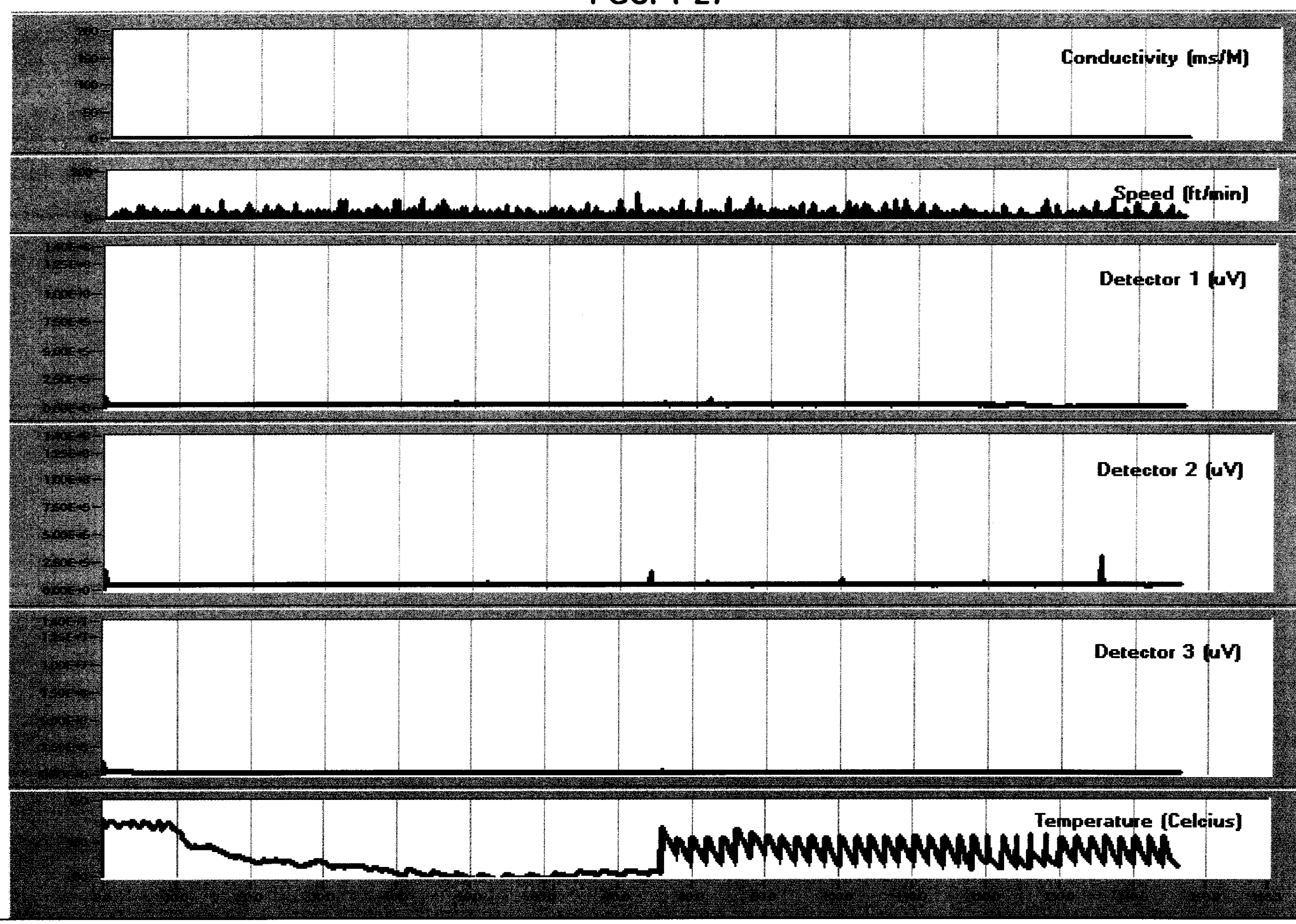
PGCPT-27



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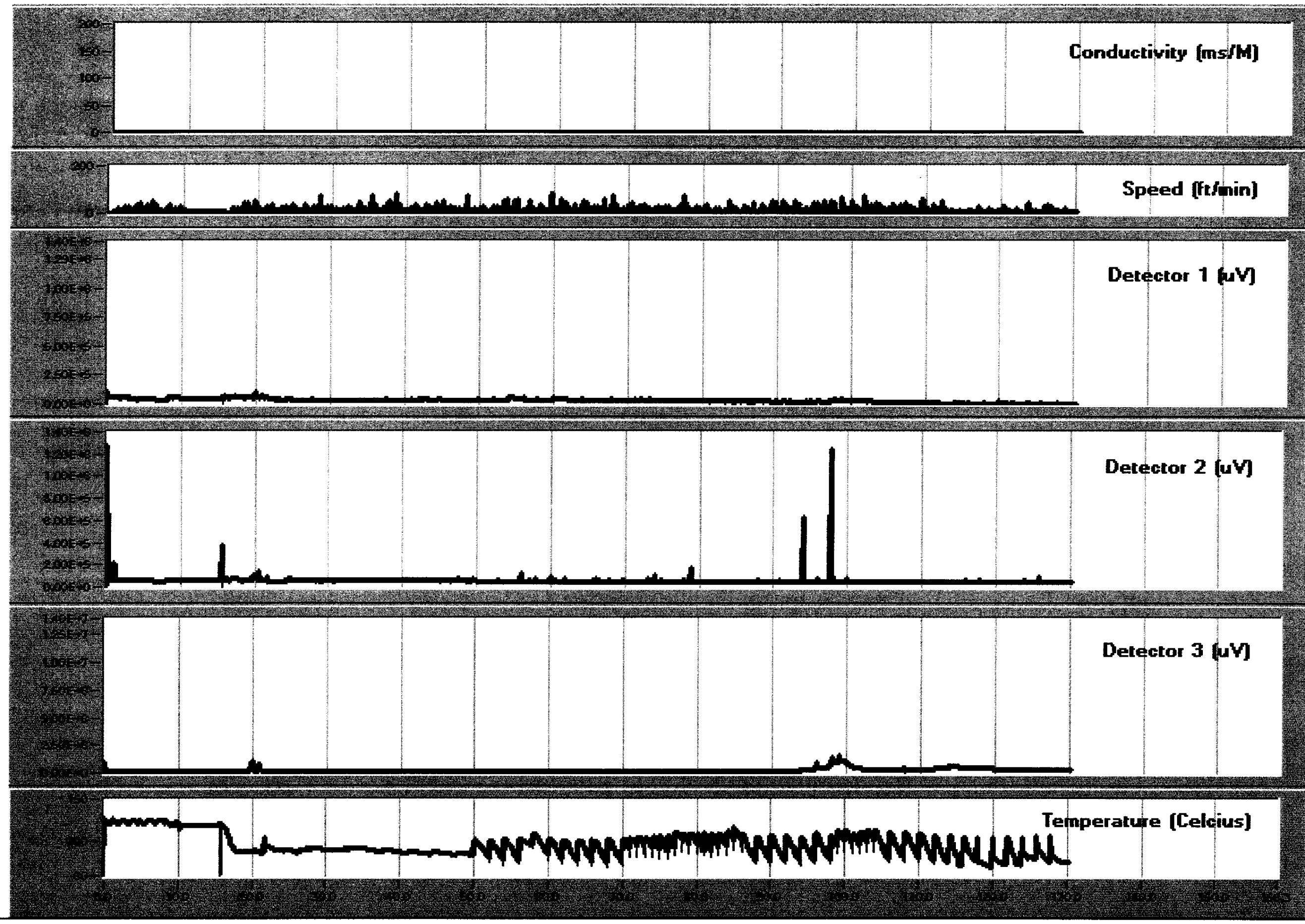
PGCPT-29



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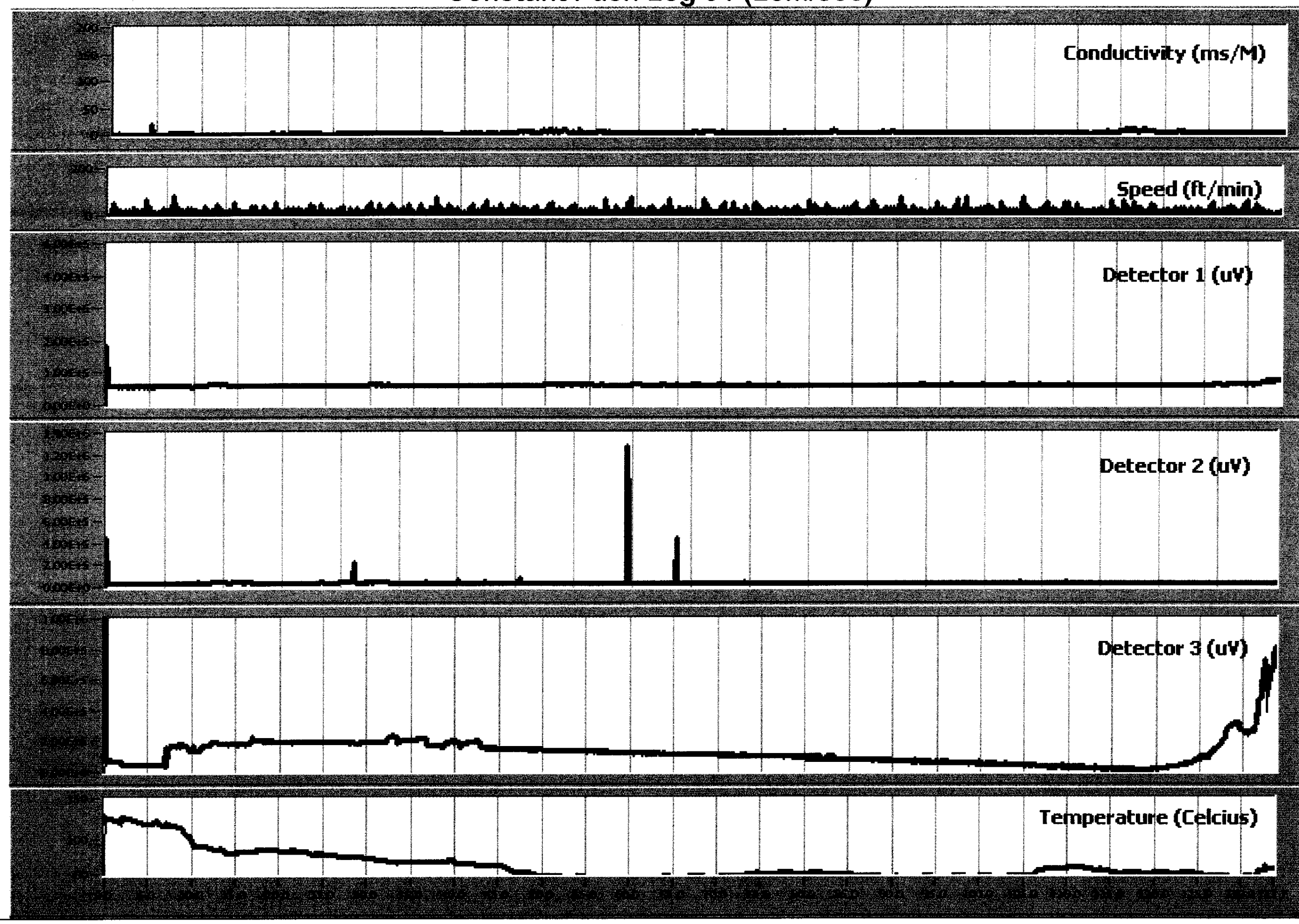
Appendix D: Comparison of MIP Detection with Laboratory Results

Comparison of MIP Responses with Laboratory Results						
Location	Top	Bottom	TCE (ug/L)	PCE (ug/L)	Total TCE+PCE	ECD Response (uV)
PG-CPT-01	61	63	28.55	347	375.55	1.40E+05
PG-CPT-01	98	100	10.5	1.7	12.2	0.00E+00
PG-CPT-01	123	125	2660	0	2660	1.20E+07
PG-CPT-01	130	132	21100	0	21100	1.20E+07
PG-CPT-02	78	80	0	9.76	9.76	0.00E+00
PG-CPT-02	91	93	7.07	1.51	8.58	1.20E+07
PG-CPT-02	100	102	1.75	13.7	15.45	4.60E+04
PG-CPT-02	121	123	5350	8.3	5358.3	1.20E+07
PG-CPT-02	130	132	17300	7.9	17307.9	1.20E+07
PG-CPT-02	136	138	15100	2.95	15102.95	1.20E+07
PG-CPT-03	76	78	25.7	8.29	33.99	0.00E+00
PG-CPT-03	86	88	227	2.97	229.97	3.00E+05
PG-CPT-03	94	96	347	0	347	2.00E+05
PG-CPT-03	107	109	4400	0	4400	1.00E+06
PG-CPT-03	115	118	12.8	3.58	16.38	0.00E+00
PG-CPT-03	127	129	2400	0	2400	2.20E+05
PG-CPT-04	50	52	941	0	941	0.00E+00
PG-CPT-04	62	64	18400	0	18400	1.00E+07
PG-CPT-04	82	84	6620	0	6620	1.50E+06
PG-CPT-04	96	98	3420	0	3420	1.20E+07
PG-CPT-04	122	124	16.7	21.1	37.8	0.00E+00
PG-CPT-05	62	64	9.13	0	9.13	0.00E+00
PG-CPT-05	76	78	3.43	1.17	4.6	1.40E+05
PG-CPT-05	111	113	4.47	29.85	34.32	1.50E+05
PG-CPT-05	120	122	2450	0	2450	3.20E+05
PG-CPT-05	124	126	4800	5.6	4805.6	1.30E+06
PG-CPT-05	134	136	35500	0	35500	6.00E+06
PG-CPT-06	56	58	0	0	0	9.30E+04
PG-CPT-06	84	86	0	2.17	2.17	0.00E+00
PG-CPT-06	121	123	2330	0	2330	1.00E+06
PG-CPT-06	133	135	6385	0	6385	2.00E+06
PG-CPT-07	63	65	0	0	0	0.00E+00
PG-CPT-07	89	91	0	0	0	0.00E+00
PG-CPT-07	106	108	0	0	0	0.00E+00
PG-CPT-07	118	120	0	0	0	2.00E+06
PG-CPT-07	135	137	1020	0	1020	1.20E+07
PG-CPT-07	143	145	2110	0	2110	0.00E+00
PG-CPT-09	63	65	0	0	0	0.00E+00
PG-CPT-09	94	96	0	0	0	0.00E+00
PG-CPT-09	104	106	0	1	1	1.20E+07
PG-CPT-09	115	118	0	0	0	0.00E+00
PG-CPT-09	120	122	0	0	0	0.00E+00
PG-CPT-11	70	72	0	0	0	0.00E+00
PG-CPT-11	87	89	0	0	0	0.00E+00
PG-CPT-11	95	97	0	0	0	0.00E+00
PG-CPT-11	126	128	0	0	0	0.00E+00
PG-CPT-12	79	81	0	0	0	0.00E+00
PG-CPT-12	88	90	0	0	0	0.00E+00
PG-CPT-12	126	128	0	0	0	0.00E+00

Location	Top	Bottom	TCE (ug/L)	PCE (ug/L)	Total TCE+PCE	ECD Response (uV)
PG-CPT-15	102	103.5	0	0	0	0.00E+00
PG-CPT-15	127	128.5	0	0	0	0.00E+00
PG-CPT-18	52	54	0	0	0	0.00E+00
PG-CPT-18	95	97	0	0	0	0.00E+00
PG-CPT-18	110	112	0	0	0	0.00E+00
PG-CPT-18	117	119	0	0	0	n/a (gas flucuations)
PG-CPT-18	125	127	0	0	0	n/a (gas flucuations)
PG-CPT-23	77	79	0	0	0	0.00E+00
PG-CPT-23	86	88	0	0	0	0.00E+00
PG-CPT-23	107	109	0	0	0	0.00E+00
PG-CPT-24	53	55	5.86	0	5.86	0.00E+00
PG-CPT-24	80	82	0	0	0	0.00E+00
PG-CPT-24	115	117	0	0	0	0.00E+00
PG-CPT-24	135	137	0	0	0	0.00E+00
PG-CPT-25	74	76	0	0	0	0.00E+00
PG-CPT-25	80	82	0	0	0	0.00E+00
PG-CPT-25	108	110	0	0	0	0.00E+00
PG-CPT-26	83	85	0	0	0	0.00E+00
PG-CPT-26	96	98	0	0	0	0.00E+00
PG-CPT-26	113	115	0	0	0	0.00E+00
PG-CPT-27	73	75	0	0	0	0.00E+00
PG-CPT-27	99	101	0	0	0	0.00E+00
PG-CPT-27	119	121	0	0	0	0.00E+00
PG-CPT-27	139	141	0	0	0	0.00E+00
PG-CPT-29	66	68	1.37	40.2	41.57	0.00E+00
PG-CPT-29	85.5	87.5	6700	0	6700	0.00E+00
PG-CPT-29	99	101	316	0	316	1.00E+06
PG-CPT-29	113	115	64.6	0	64.6	2.00E+05
PG-CPT-29	125	127	5.12	0	5.12	0.00E+00

Appendix E: Constant Push MIP Logs

Constant Push Log 01 (2cm/sec)



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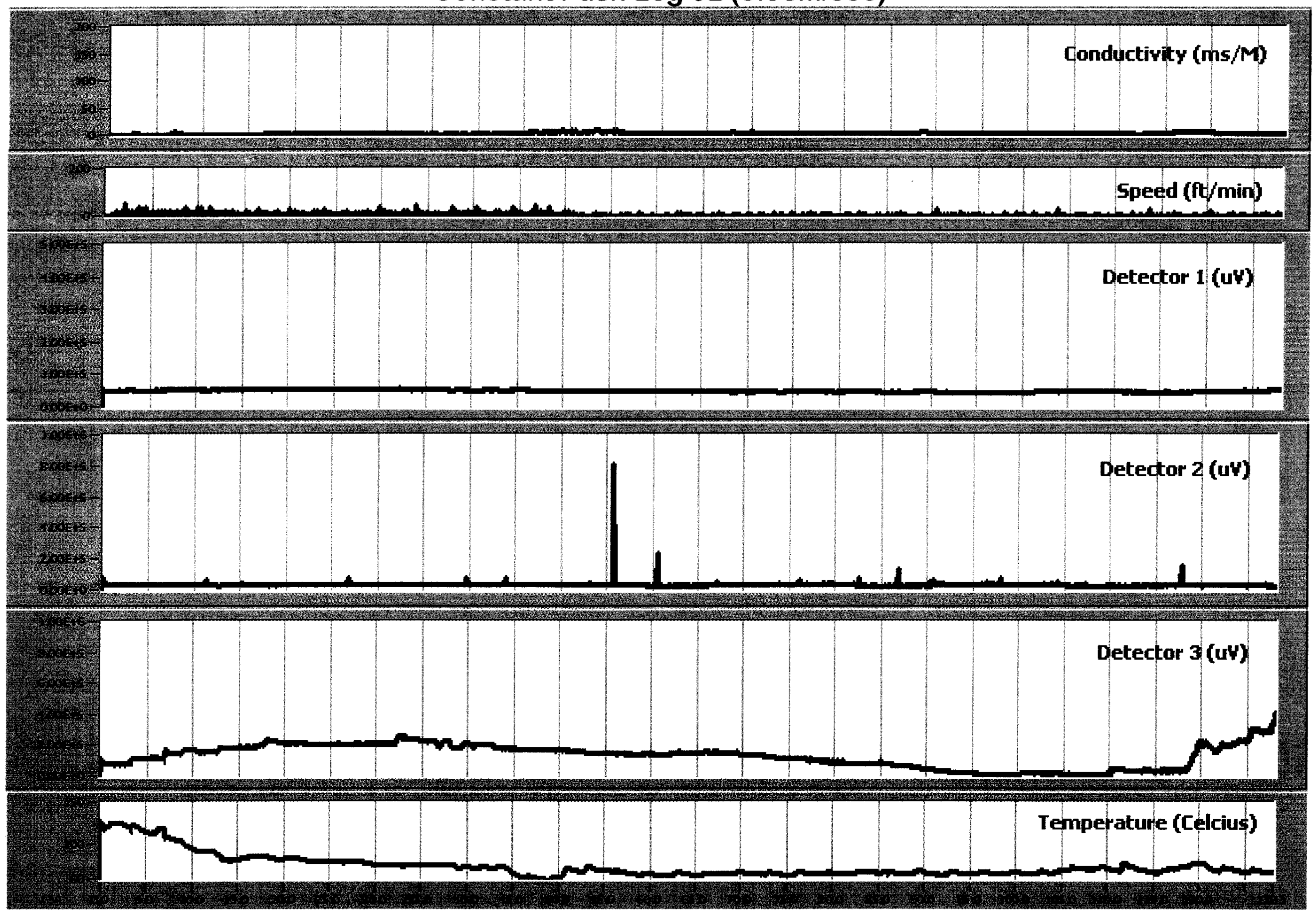
Constant Push Log 02 (0.5cm/sec)



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Savannah River Site
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