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Appendix D

Appendix D Screening Surveys

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Appendix D1 Surface Geophysical Survey - Landfill

Weston Geophysical
a Geophex company
ENGINEERS

325 West Main Street
Northborough, Massachusetts 01532
Phone (508) 393-4600
Fax (508) 393-7674

August 26th, 2003

Ms. Alison L. Dunn, P.G.
Senior Hydrogeologist
Shield Environmental Associates, Inc.
2456 Fortune Drive, Suite 100
Lexington, Kentucky 40509

Subject: Geophysical Investigation at the Peterson / Puritan OU-2 Facility
Cumberland, Rhode Island

Dear Ms. Dunn:

In accordance with your authorization, Weston Geophysical Engineers conducted a geophysical investigation at the above referenced site. The purpose of the geophysical survey is to provide electromagnetic earth conductivity information on possible zones of leachate downgradient from the landfill and to assist in the delineation of the boundary of landfill material.

The enclosed report documents our findings and provides recommended locations for further investigation. The field effort was completed on August 13th, 2003 and preliminary results were submitted to Shield on August 18th, 2003.

We appreciate this opportunity to provide you with our services, please call the undersigned if you have any questions.

Sincerely,

WESTON GEOPHYSICAL ENGINEERS

Peter B. Hubbard
Project Geophysicist

pbh:W351:enclosure

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TABLE OF CONTENTS

US EPA ARCHIVE DOCUMENT

Geophysical Investigation
Electromagnetic Induction Survey
at the
Peterson / Puritan OU-2 Facility
Cumberland, Rhode Island

submitted to

Shield Environmental Associates, Inc.
2456 Fortune Drive
Lexington, Kentucky 40509

Weston Geophysical Engineers
325 West Main Street
Northborough, Massachusetts 01532

Tel: (508) 393-4600
Fax: (508) 393-7674

August, 2003

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Introduction

The purpose of this investigation was to locate possible leachate conditions downgradient of the landfill between the toe of the landfill and the Blackstone River through the implementation of an electromagnetic induction survey (EMI). The EMI method is capable of detecting electrical conductivity contrasts between contaminated and uncontaminated soils and other earth materials. This information is anticipated to help support the Remedial Investigation/Feasibility Study (RI/FS) activities at the site by providing possible leachate locations to focus further intrusive investigations at the site.

Prior to the geophysical investigation, three survey line paths were established to provide easy access and to clear a majority of the surface metal debris from the survey area. The extent of the vegetation and the debris encountered along the proposed profile line locations prohibited the creation of three continuous parallel survey lines. Shield environmental established the lines throughout the survey area. The geophysical field effort was completed on August 12th and 13th, 2003.

Geophysical Survey Methodology

The area investigated included an approximate 2,900-foot by 100-foot area between the toe of the landfill and the Blackstone River. One continuous EMI profile line (2,900 feet) along the recently constructed road was acquired as well as two other profile lines; one along the southern portion starting near Station 600 continuing along the river bank, the other profile line started adjacent to Station 2000 and continued on part of the landfill slope while remaining parallel to the longer continuous profile line.

Survey control points were established at 50-foot increments for each profile line; with wooden survey stakes placed at 200-foot increments, survey lines end points and corners, 50-foot points were marked with plastic pin flags. Field notes were recorded to indicate the location of the survey lines relative to existing cultural features.

The area of geophysical investigation is shown on Figure 1. The point locations indicated on the plan map correspond to geophysical profile line stationing at every 200 feet. These points were placed in the field by measured distances along the line and later located relative to the site coordinates by differentially corrected GPS measurements provided by Shield Environmental.

An EMI survey was conducted along each of the survey lines. EMI data were processed by custom designed software that converts the raw EMI data to user specified coordinate data with in-phase and quadrature component electromagnetic conductivity values. The data were organized for import into commercially available contour software packages through the use of command language processing routines. Preliminary profile data was available for examination at the conclusion of each survey line. Color-coded conductivity profile lines of the various EMI components were generated for inclusion in this report.

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A Geophex GEM-2 multifrequency electromagnetic induction instrument was used because it offers increased detection and characterization capabilities over other, commercially available EMI instruments. This multi-frequency and high speed data acquisition system provides higher resolution data than the other systems, enabling additional data on possible depth parameters and closer spaced sampling. The GEM-2 multifrequency electromagnetic instrument is a self-contained lightweight programmable digital recording system capable of recording EMI response data at up to 10 transmitter frequencies (270 to 18,210 Hz) and at a sampling rate of 0.2 second.

The optimum EMI frequency settings for this investigation were determined through a test profile along the centerline path prior to the acquisition of the EMI data. Five frequencies were selected from this test because of their low signal to noise ratio. The five frequencies (330, 930, 2,790, 8,190, and 15,150 Hz) were then programmed into the GEM control unit set to record at 0.2 second intervals). Normal walking speed translates this sampling rate to a sample rate of approximately 1 sample every 1.5-foot.

Additionally, when configured with a low frequency (330Hz), the signal response at this low frequency is equivalent to the magnetic susceptibility for each of the data samples. This data can be useful in discriminating the leachate from possible buried metal objects.

The procedure for this investigation is further detailed in Appendix A – EMI Standard Operating Procedure.

Results

The results of this investigation can be shown through a number of presentation methods. The presentation used by Weston to indicate the possible leachate locations is best described as a composite graph indicating the summation of all of the inphase and quadrature components. Figure 2 shows this composite profile with all three profiles shown relative to each other as well as the indicated recommended locations for further intrusive investigation. This figure was submitted in a preliminary format on August 18th, 2003.

The profile data shown on Figure 2 are the "weighted-average" smoothed profile data. The weighted-average processing removed most of the high frequency noise generated by the abundant surface and near surface metallic debris.

Significant observations can be made from the interpretation of this figure; specifically, the near flat signal along Line 2 which is closer to the river bank, and where Line 1 is closest to the river shoreline, show that both of these areas have very little conductivity changes, indicating that the data are not indicative of landfill material and that there are no indications of zones of significant leachate contamination.

Additionally, the EMI profile data in the areas along the beginning of Line 1 and all of Line 3 are consistent with results anticipated for landfill material. This was visually confirmed while acquiring the data in these areas. Line 2 intersects a portion of an area described on the plan map as Pond B. The EMI signal in this area indicates a lower conductivity than that of the surrounding area; this may be an indication of concentration of leachate in the pond area.

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Recommendations

The recommended locations for further investigation are shown on Figure 2. This figure includes station locations for each of the three profile lines that we would recommend for further investigation to confirm the presence of higher concentrations of leachate or some other cause. The recommended locations typically are locations where the quadrature component is anomalously lower or higher than the adjacent areas. The anomalous quadrature areas were then compared to the inphase component to provide an indication of the source of the anomalous conductivity.

The following table summarizes the location shown on Figure 2:

Line 1 Station 0125	Confirmation of Debris Field 4
Line 1 Station 0250	Low Quadrature – Low Inphase
Line 1 Station 0550	Low Quadrature – High Inphase
Line 1 Station 1125	Low Quadrature
Line 1 Station 1400	Lowest Quadrature Component Values
Line 1 Station 1725	High Quadrature – Low Inphase
Line 2 Station 0350	Low Quadrature at Pond B
Line 3 Station 0350	Low Quadrature – High Inphase

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FIGURES

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Base Map provided by Shield Environmental Associates, Inc.

EMI Profile Line (Stations Values shown in Feet) L1 0200 L1 0000

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a Geophex company

Figure 1. Plan Map Showing Geophysical Survey Coverage

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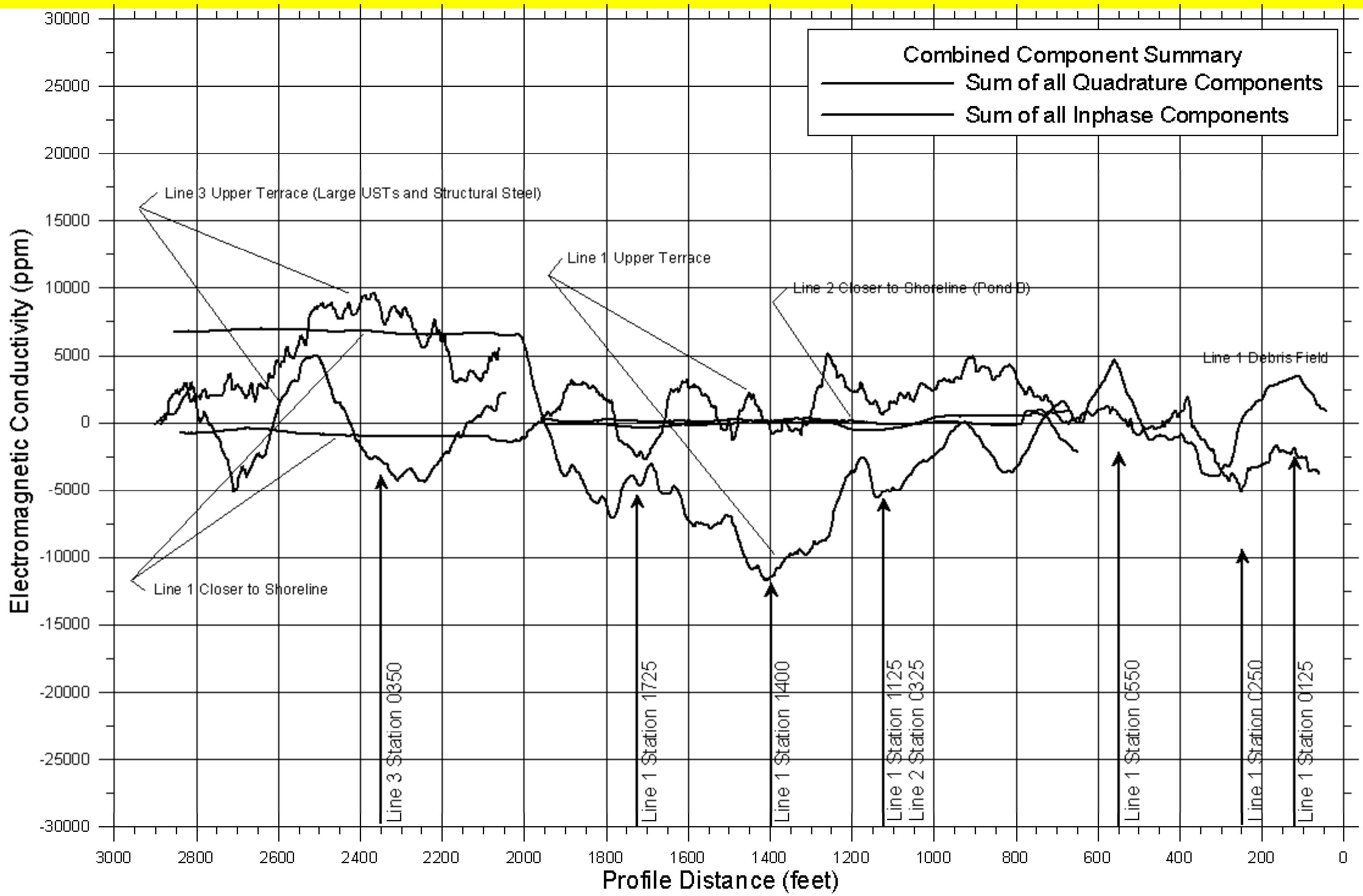

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Figure 2. Combined Inphase and Quadrature Components for all Profile Lines

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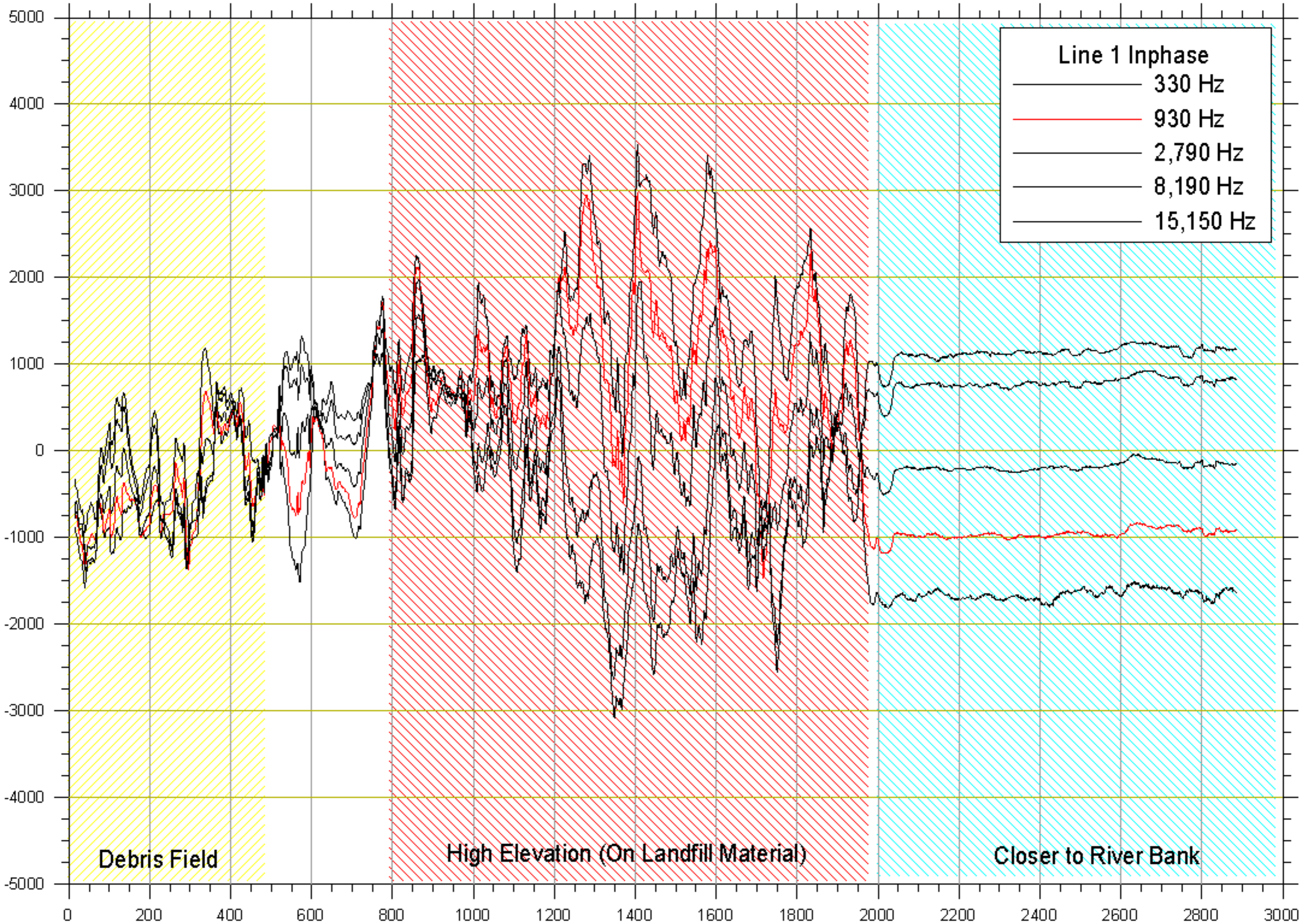

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Figure 3. Line 1 Inphase Components

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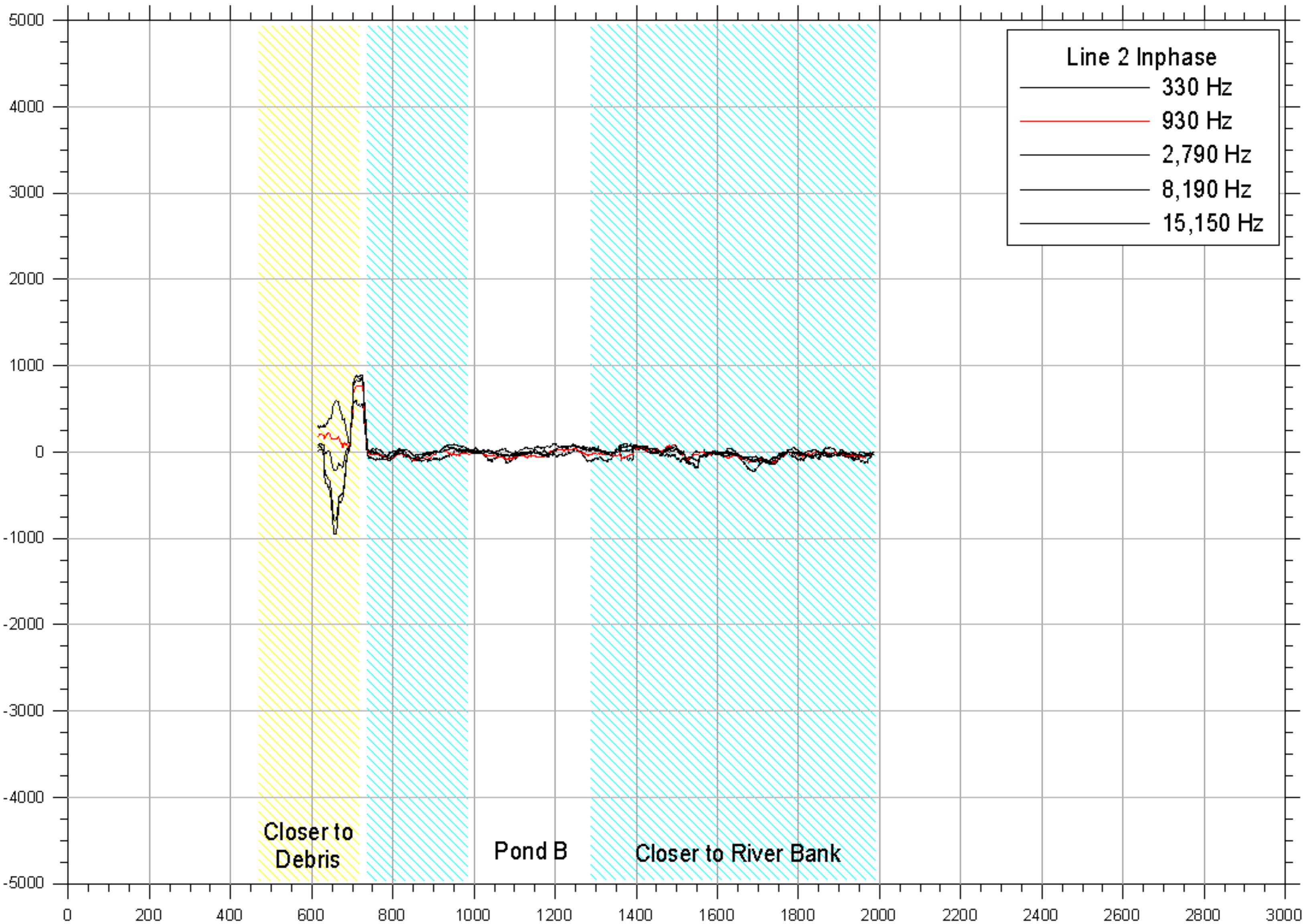

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Figure 4. Line 2 Inphase Components

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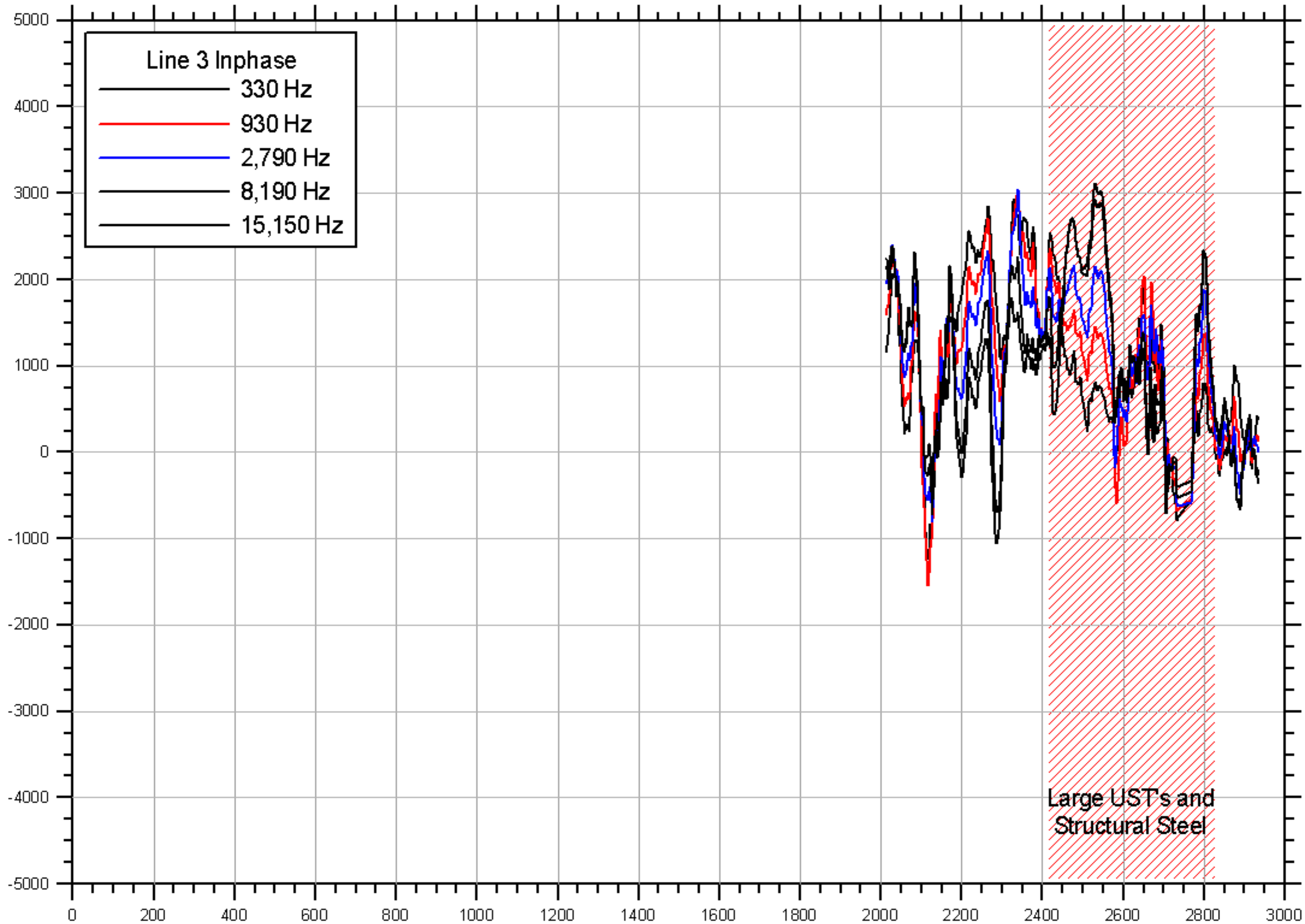

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Figure 5. Line 3 Inphase Components

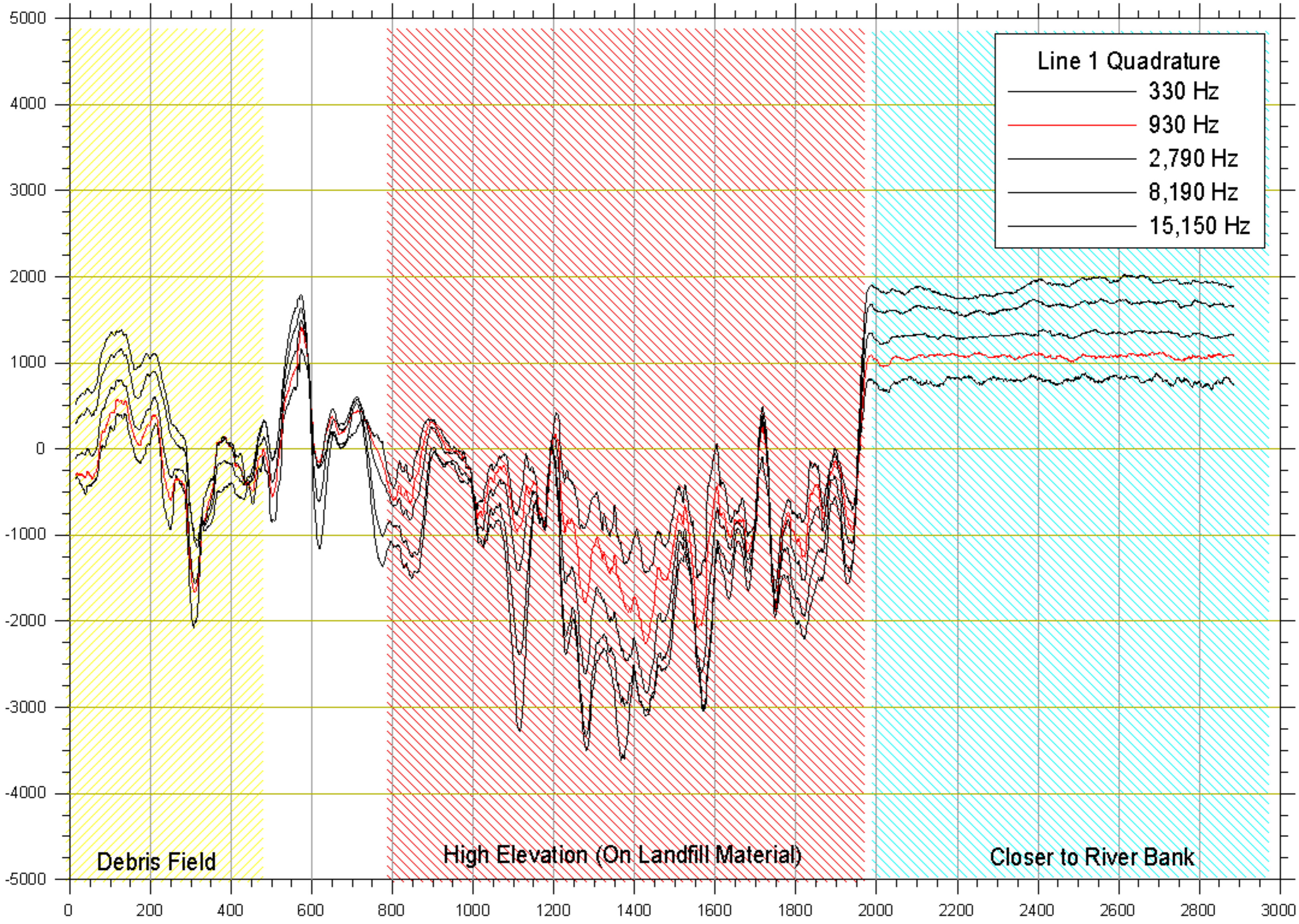

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Figure 6. Line 1 Quadrature Components

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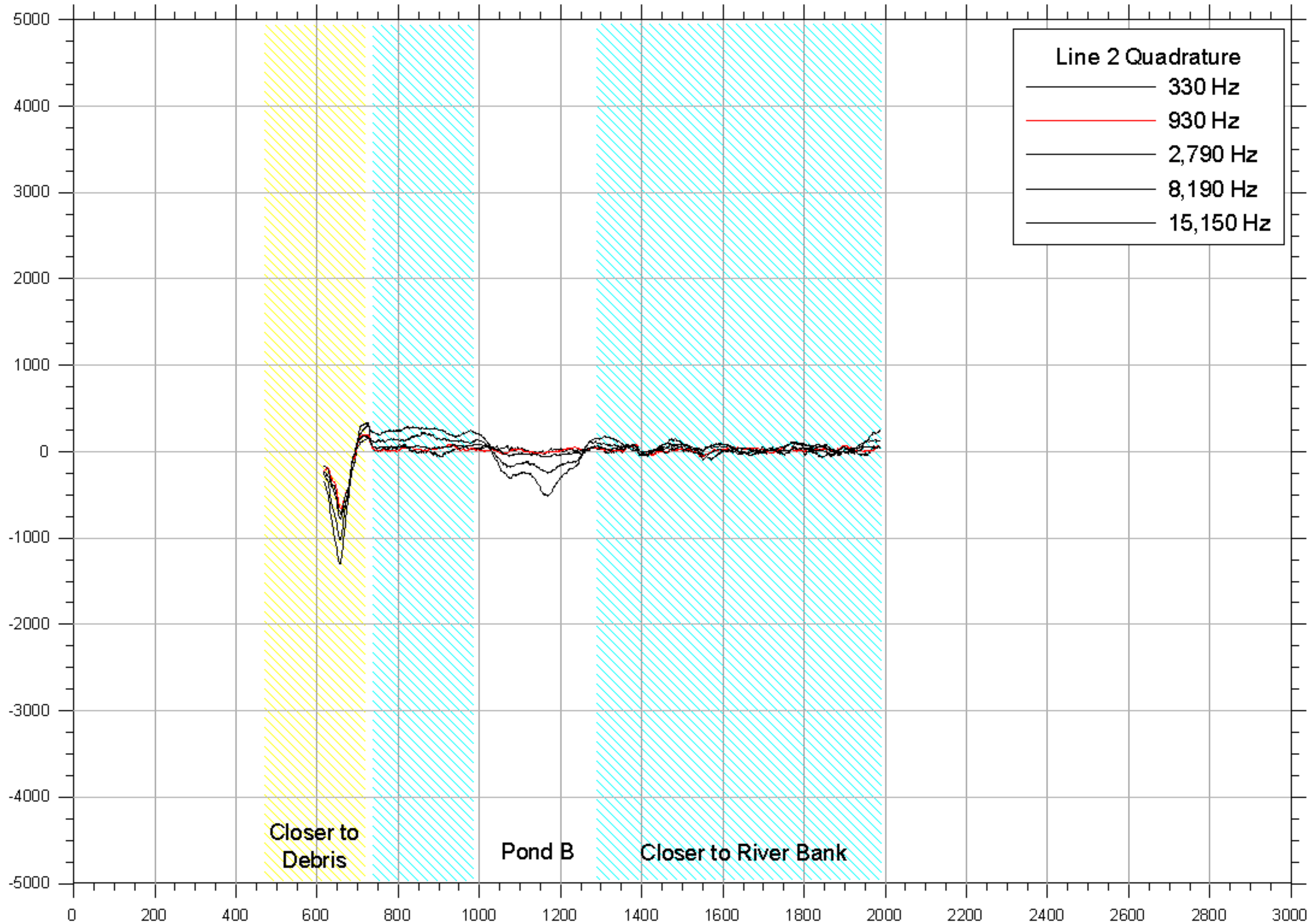

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Figure 7. Line 2 Quadrature Components

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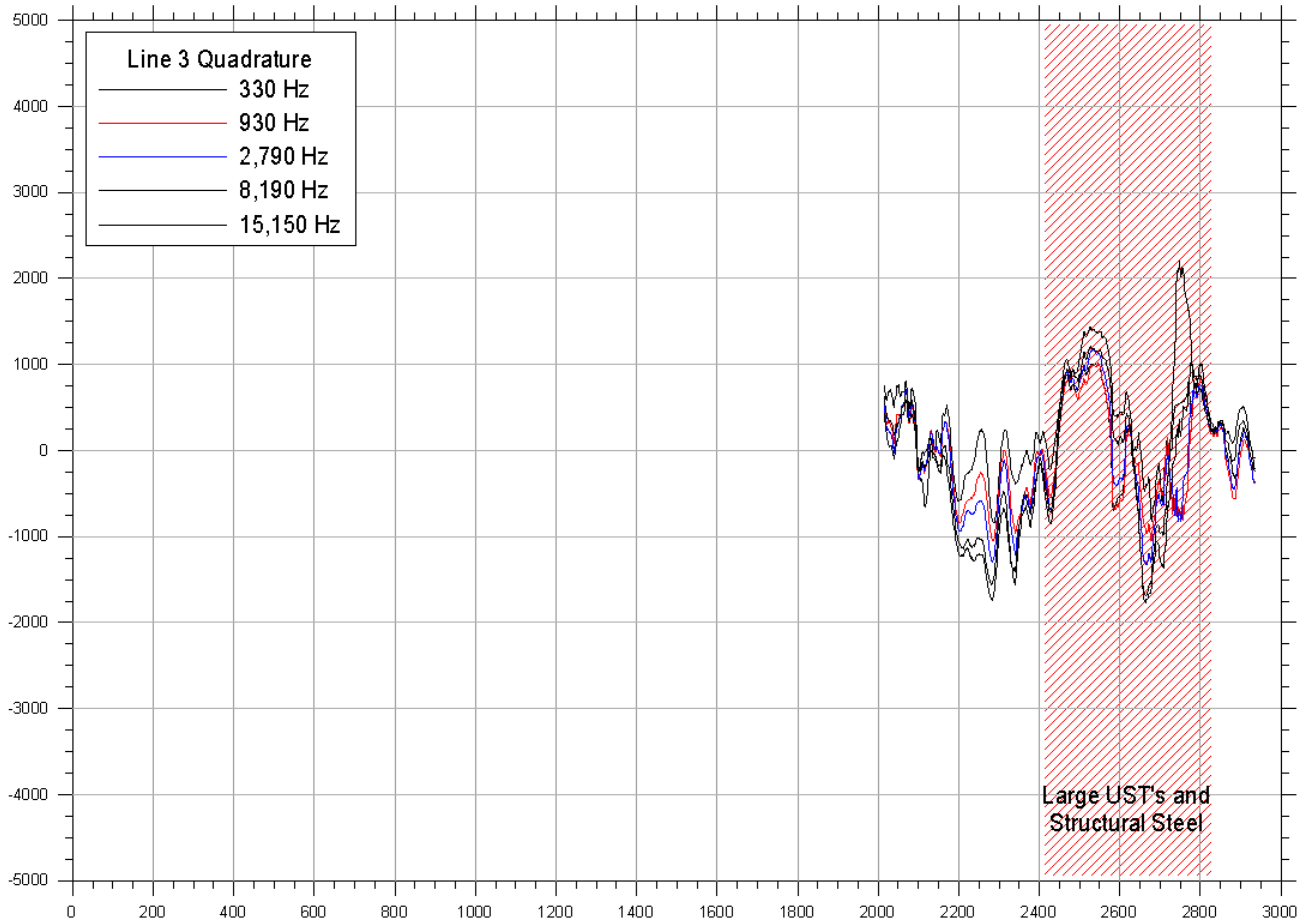

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Figure 8. Line 3 Quadrature Components

APPENDIX A

Electromagnetic Induction Standard Operating Procedure

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Application

This Scope of Work (SOP) is provided as a guide for conducting a geophysical electromagnetic induction (EMI) survey using a Geophex GEM-2 Conductivity Meter. A surface EMI survey can be conducted to locate buried materials or anomalies and/or to identify ground water plumes with elevated electrical conductivity characteristics.

Equipment and Supplies

The following equipment and supplies will be available for conducting an EMI survey:

- Project Scope of Work and Health and Safety Plan (HASP) as provided by SHIELD
- Geophex GEM-2 Conductivity Meter
- Personal protective equipment (PPE), as appropriate
- Field logbook
- Site map
- Camera
- Measuring tape(s)
- Global Positioning System (GPS) equipment
- Survey flags and other marking materials

Procedures

The following procedures will be adhered to when conducting an EMI survey:

1. The Scope of Work will be reviewed to determine survey parameters and location.

2. The required equipment will be assembled and tested in accordance with normal operating procedures.

3. The appropriate PPE will be donned. The appropriate level will be determined prior to arrival at the site.

4. Proposed EMI grid pattern traverses will be positioned by taped distance measurements relative to a pre-determined starting location relative to the toe of the slope of the landfill and further reference to roads, buildings, or other semipermanent features and the existing site coordinate system, if appropriate.

5. Bush cutting, if needed, will be performed by others before geophysical data collection to enable the field geophysicist to walk at a uniform pace.

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6. Uniform (every 50-feet) traverse stations will be marked on the ground surface using chalk, spray paint, or labeled pin flags or stakes, as appropriate. At this time the individual traverse line spacing is determined to be 40-feet. It is anticpated that the traverse lines may be separated into 3 sections to facilitate stationing around the three sides of the landfill. The traverse stations will be determined with a fiberglass measuring tape or distance-measuring wheel, as appropriate. Traverse deviations (i.e., obstacles or traverse bends) will be noted in the field logbook or data sheet. Traverse orientations will be recorded in the field logbook or data sheet, or on a plan map (if available).

7. Site conditions will be observed for power lines or aboveground metal objects within approximately 20 feet of a survey traverse since they may adversely affect EMI conductivity measurements. Anomalies caused by buried metal objects within those regions may be difficult to distinguish from anomalies caused by aboveground objects or subsurface lines or utilities.

8. The Geophex GEM-2 instrument will be assembled and functionally checked in accordance with the manufacturer's instructions prior to a survey.

9. The instrument will be set to record data in the vertical dipole mode.

10. The instrument will be set to record both inphase and quadrature components of the EMI field data. The instrument will be configured to record each of these components at 4 separate transmitter frequencies. Typically, one at a very low frequency for magnetic susceptibility, and the other three to cover a wide range of frequencies (1,000 to 15,000 Hz).

11. The traverse will be walked at a steady pace with the instrument held approximately 3 feet above the ground. Data values are recorded at 0.2-second time intervals (approximately 1-foot distance intervals at an ordinary walking pace). The beginning and end of each traverse will be denoted as well as intermediate distance marks at periodic intervals appropriate to the survey scale.

12. A field logbook or data sheet will be maintained during each survey to record EMI traverse positions and nearby features such as monitoring wells, surface metal, or other field observations.

Quality Assurance/Quality Control (QA/QC)

The following QA/QC procedures will be adhered to:

1. The Geophex GEM-2 instrument is calibrated at the time of manufacture and does not require additional calibration. The instrument however can be tuned to a site-specific conductivity. The Geophex GEM-2 instrument is tuned at the start of each day by recording the effect of a ferrite rod placed over the receiving coil. The deviation of the quadrature and inphase measurement can then applied to the field data prior to final presentation of the data.

2. EMI data values are visible on a digital screen as the data are acquired. The operator will observe the values as they are acquired to confirm proper functioning of the EMI instrument.

3. Digitally recorded EMI data will be transferred in the field to a laptop computer for contouring or plotting. Draft EMI contour maps of each component as well as a sum of all the quadrature components and magnetic susceptibility are typically prepared on the site using Golden Software Surfer contouring program with a Kriging grid algorithm. These contour maps (if prepared) will be examined for EMI anomalies that resemble metallic objects, areas of elevated conductivity, or other conditions judged to be relevant to the client's survey objectives. A second geophysicist will check all preliminary EMI interpretations prior to determining final interpretations.

References

The selected references provide a background for Weston Geophysical normal operating procedures for land base EMI investigations. All references are available at the Geophex, Ltd. website (www.geophex.com) in the publications section.

Geophex, Ltd.; 2003, GEM-2 Operator's Manual.

I.J. Won, D.A. Keiswetter, G.R.A. Fields, and L.C. Sutton, 1996, GEM-2: a new multifrequency electromagnetic sensor, Jour. of Environmental and Engineering Geophysics, v. 1, No. 2, p. 129-138.

Haoping Huang and I.J. Won, 2001, Conductivity and susceptibility mapping using broadband electromagnetic sensors, Journal of Environmental and Engineering Geophysics, v. 5, Issue 4, p. 31-41.

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Appendix D2 Surface Geophysical Survey - Unnamed Island

Weston Geophysical
a Geophex company
ENGINEERS

325 West Main Street
Northborough, Massachusetts 01532
Phone (508) 393-4600
Fax (508) 393-7674

October 8th, 2003

Ms. Alison L. Dunn, P.G.
Senior Hydrogeologist
Shield Environmental Associates, Inc.
2456 Fortune Drive, Suite 100
Lexington, Kentucky 40509

Subject: Geophysical Investigation at the Un-named Island
Peterson / Puritan OU-2 Facility, Cumberland, Rhode Island

Dear Ms. Dunn:

In accordance with your authorization, Weston Geophysical Engineers conducted additional geophysical investigation at the above referenced site, specifically around the perimeter of the Un-named Island. The field effort was completed on October 7th, 2003. The purpose of the geophysical survey was to provide electromagnetic earth conductivity information on the extent of possible buried debris zones around the "Pond A" area.

The attached summary and figures documents our findings and provides recommended locations for further investigation. The summary and figures were prepared with the same criteria as our report for the landfill investigation. This submission can be inserted as an addendum to the landfill report.

We appreciate this opportunity to provide you with our additional services, please call the undersigned if you have any questions.

Sincerely,

WESTON GEOPHYSICAL ENGINEERS

Peter B. Hubbard
Project Geophysicist

pbh:W351: attachment

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Introduction

The purpose of this investigation was to locate possible buried debris around the perimeter of the Un-named Island adjacent to the OU-2 facility through the implementation of an electromagnetic induction survey (EMI). The EMI method is capable of detecting electrical conductivity contrasts between contaminated and uncontaminated soils and other earth materials. This information is anticipated to help provide additional subsurface information in the areas where additional buried debris was found on the island.

Prior to the geophysical investigation, a survey line path was established to provide easy access to the survey area. The geophysical field effort was completed on October 7th, 2003.

Geophysical Survey Methodology

The area investigated included an approximate 2,870-foot continuous profile line around the island starting in the southeast continuing counter clockwise around the island and ending in the southwest. One continuous EMI profile line (2,900 feet) was acquired as well as an additional 200-foot line extending from the gravel road to a point believed to be off the buried debris material.

Survey control points were established at 100-foot increments for each profile line; with wooden survey stakes placed at 300-foot increments, survey lines end points and corners, 100-foot points were marked with plastic pin flags. Field notes were recorded to indicate the location of the survey lines relative to existing cultural features.

The wooden stake points will be surveyed using GPS. These points were placed in the field by measured distances along the line and later located relative to the site coordinates by differentially corrected GPS measurements provided by Shield Environmental.

An EMI survey was conducted along each of the survey lines. EMI data were processed by custom designed software that converts the raw EMI data to user specified coordinate data with in-phase and quadrature component electromagnetic conductivity values as well as apparent conductivity and magnetic susceptibility. The data were organized for import into commercially available contour software packages through the use of command language processing routines. Preliminary profile data was available for examination at the conclusion of each survey line. Color-coded conductivity profile lines of the various EMI components were generated for inclusion in this report.

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A Geophex GEM-2 multifrequency electromagnetic induction instrument was used because it offers increased detection and characterization capabilities over other, commercially available EMI instruments. This multi-frequency and high speed data acquisition system provides higher resolution data than the other systems, enabling additional data on possible depth parameters and closer spaced sampling. The GEM-2 multifrequency electromagnetic instrument is a self-contained lightweight programmable digital recording system capable of recording EMI response data at up to 10 transmitter frequencies (270 to 18,210 Hz) and at a sampling rate of 0.2 second.

The optimum EMI frequency settings for this investigation were determined through a test profile along the centerline path prior to the acquisition of the EMI data. Five frequencies were selected from this test because of their low signal to noise ratio. The five frequencies (330, 930, 2,790, 8,190, and 15,150 Hz) were then programmed into the GEM control unit set to record at 0.2 second intervals). Normal walking speed translates this sampling rate to a sample rate of approximately 1 sample every 1.5-foot.

Additionally, when configured with a low frequency (330Hz), the signal response at this low frequency is equivalent to the magnetic susceptibility for each of the data samples. This data can be useful in discriminating the leachate from possible buried metal objects.

Results

The results of this investigation can be shown on the composite graph indicating the summation of all of the inphase and quadrature components. Figure 1 shows this composite profile for the perimeter Line 1. Figure 2 show the results of the profile along Line 2. Additional figures are provided of Line 1 in more detail showing 300-foot sections of the line.

The profile data shown on Figures 1 and 2 are the "weighted-average" smoothed profile data. The weighted-average processing removed most of the high frequency noise generated by the abundant surface and near surface metallic debris.

The following table summarizes the anomalous location shown on Figure 1 and 2:

Line 1 Stations 0700 to 1700	High Frequency – High Conductivity signal
Line 2 Stations 0000 to 0120	High Frequency – High Conductivity signal

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FIGURES

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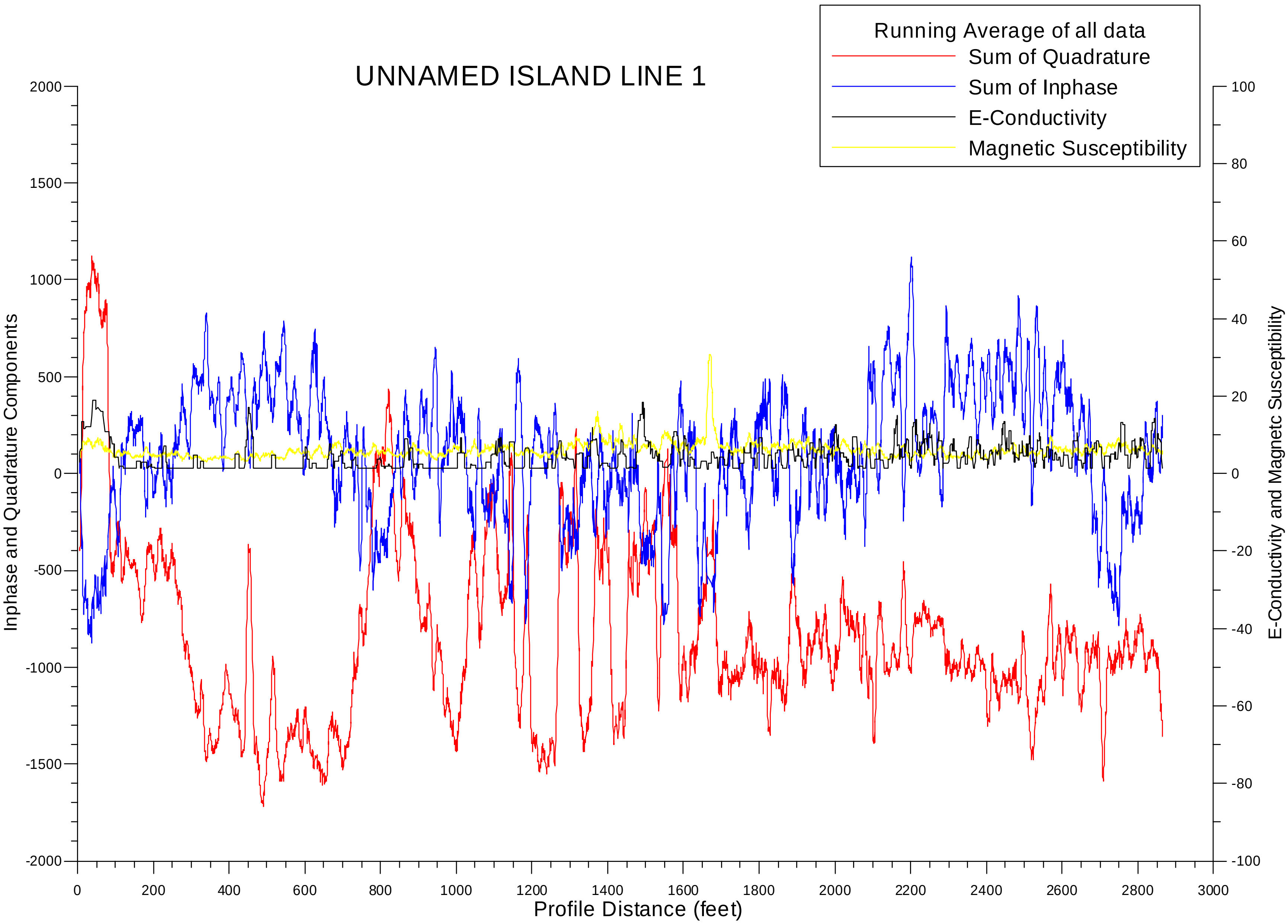

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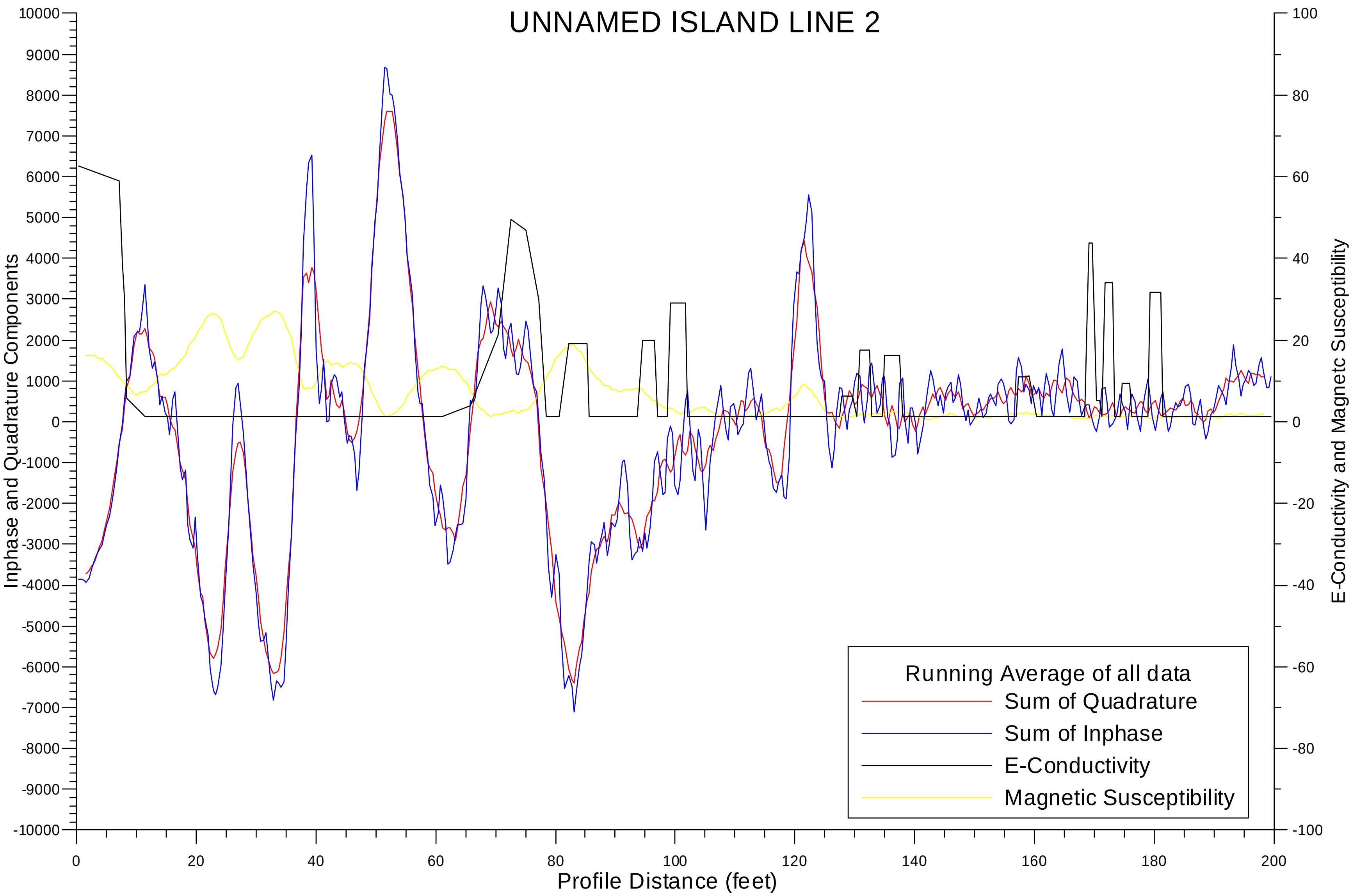

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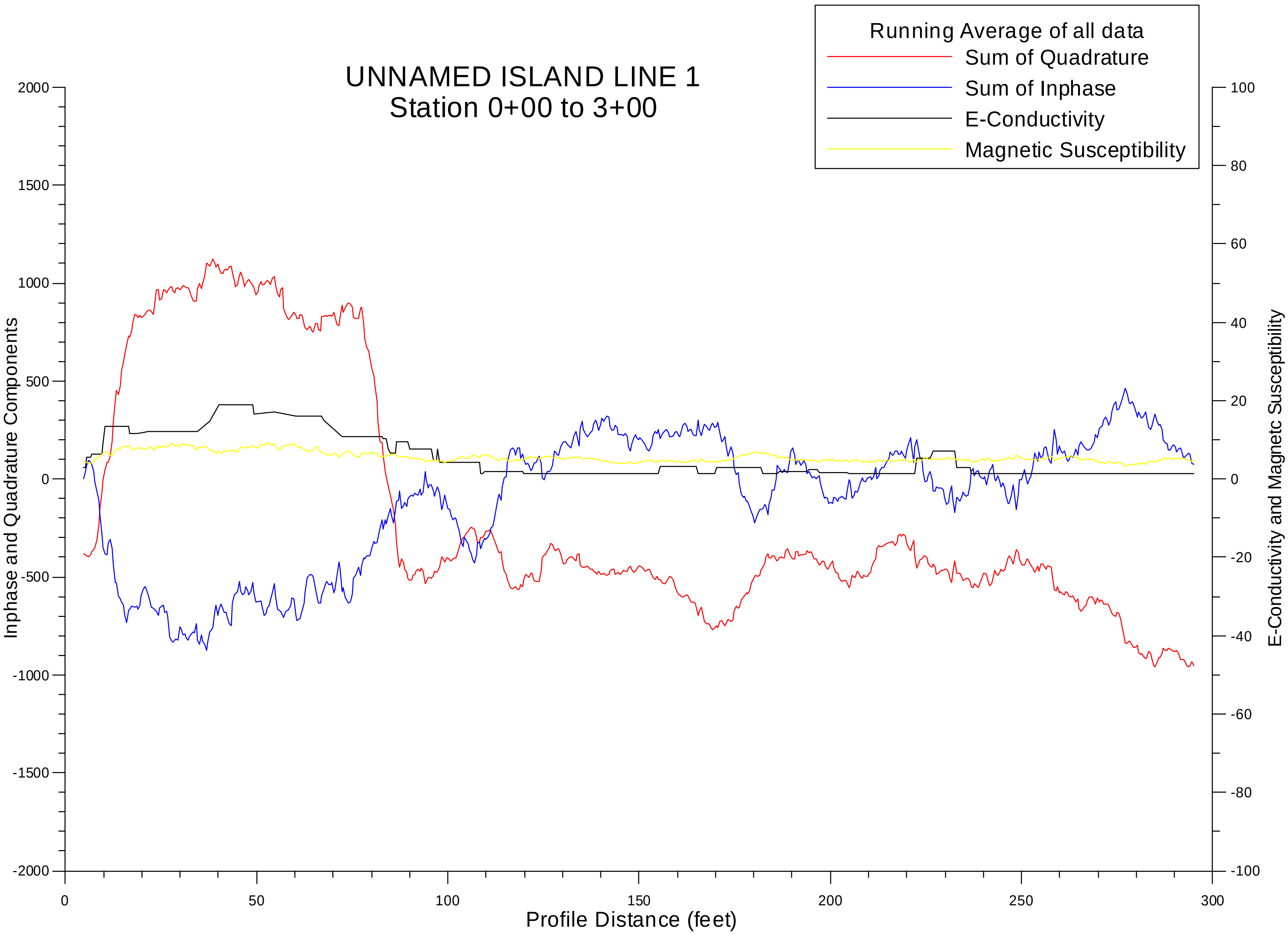

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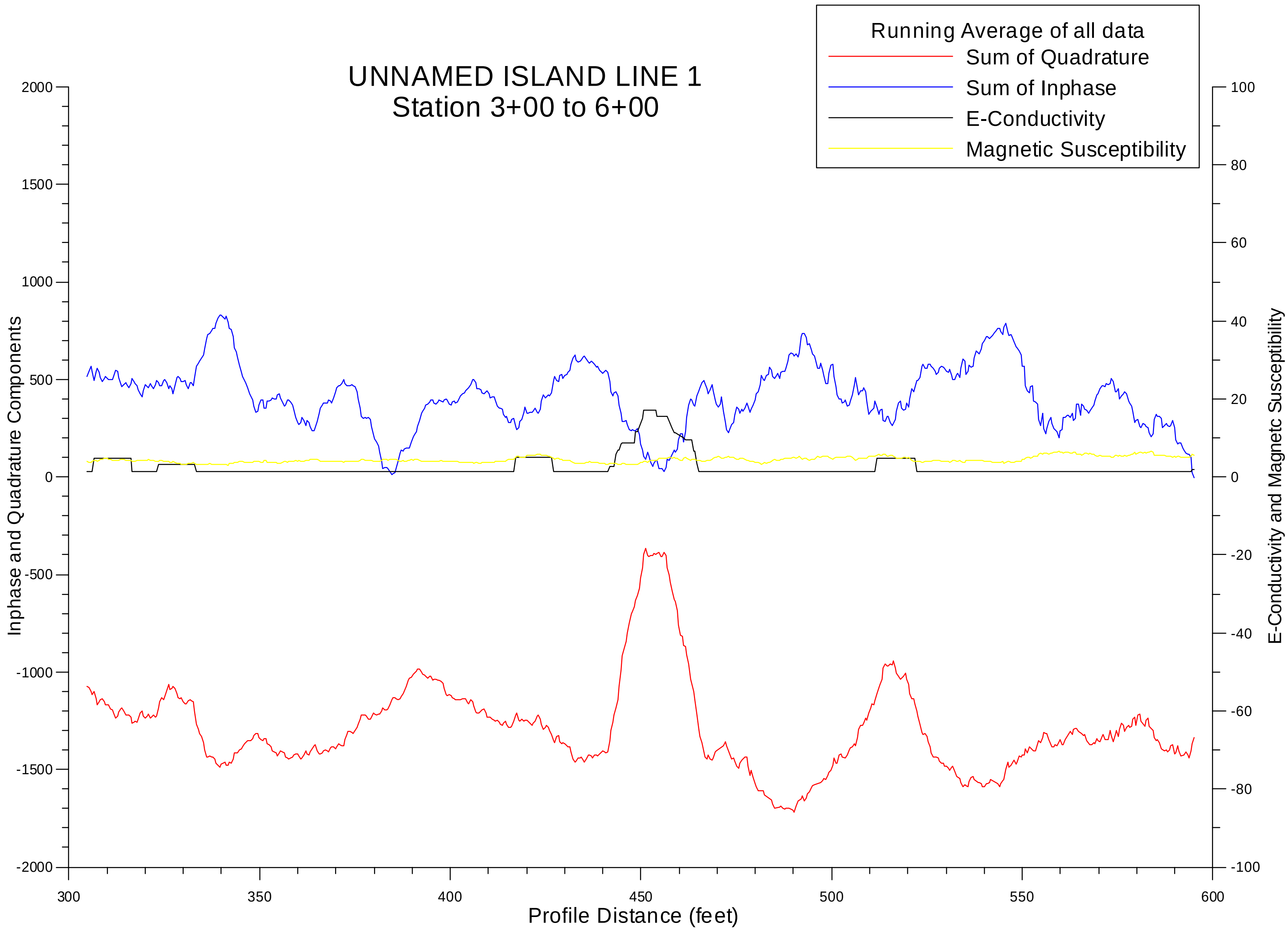

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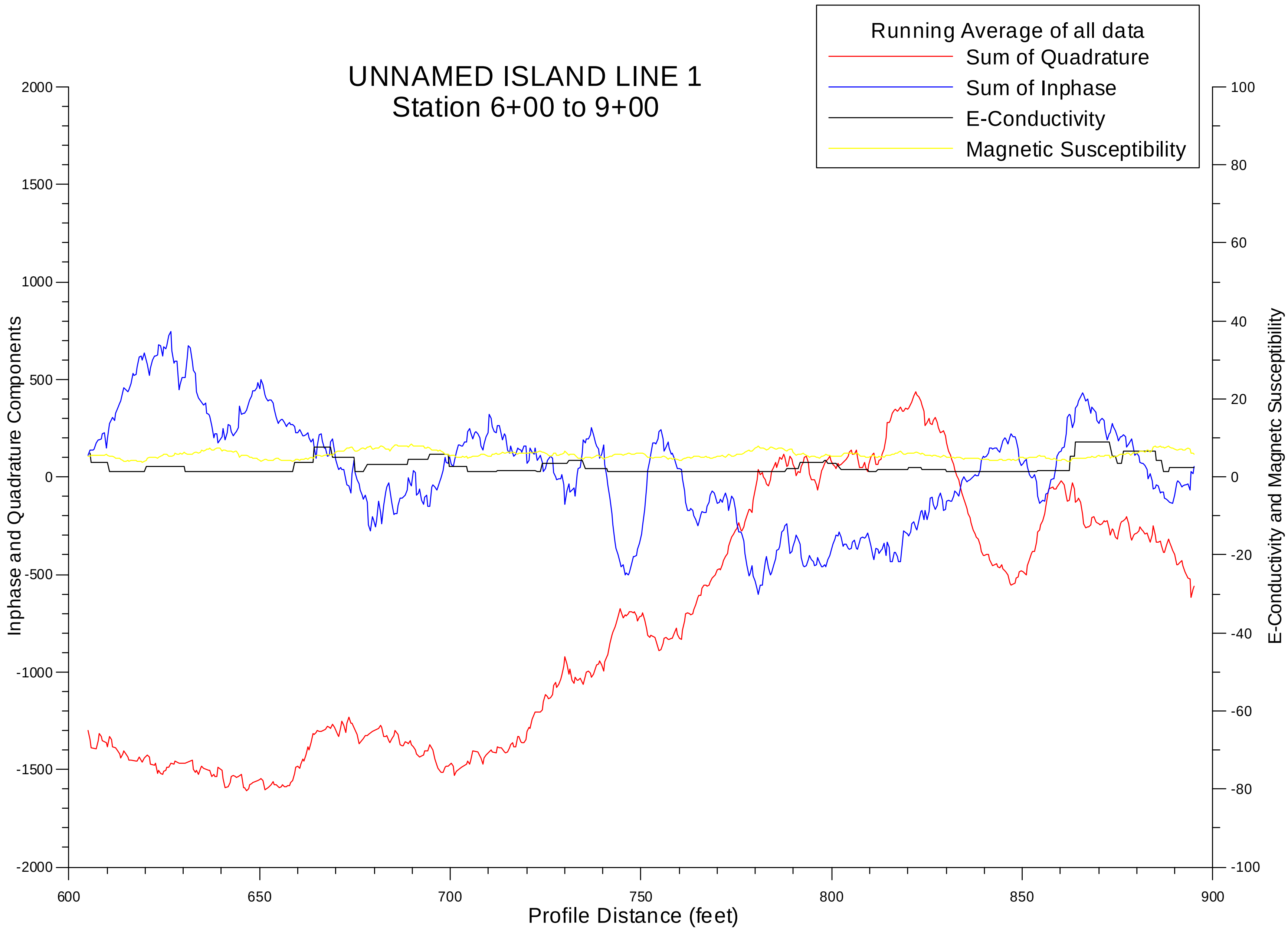

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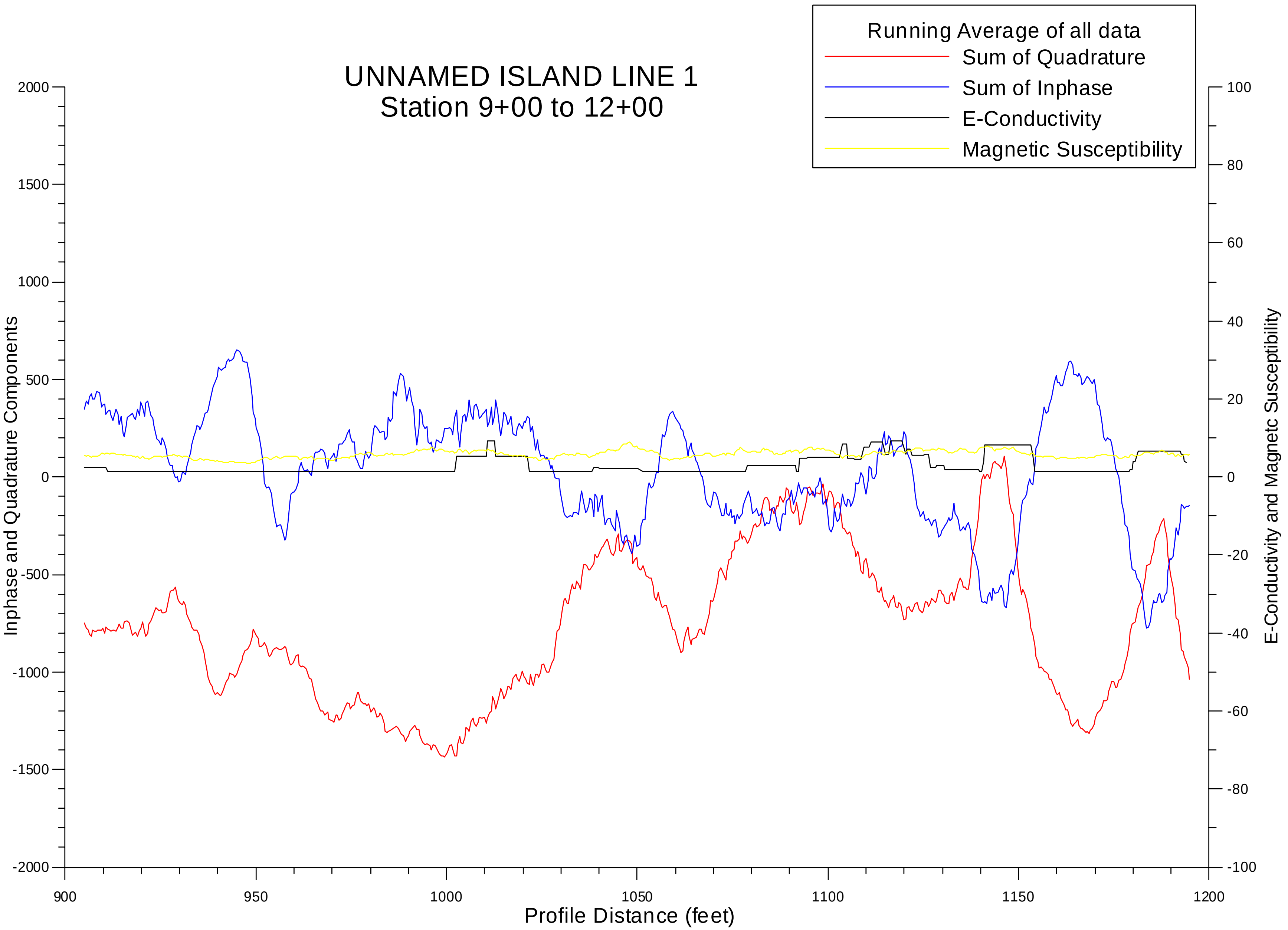

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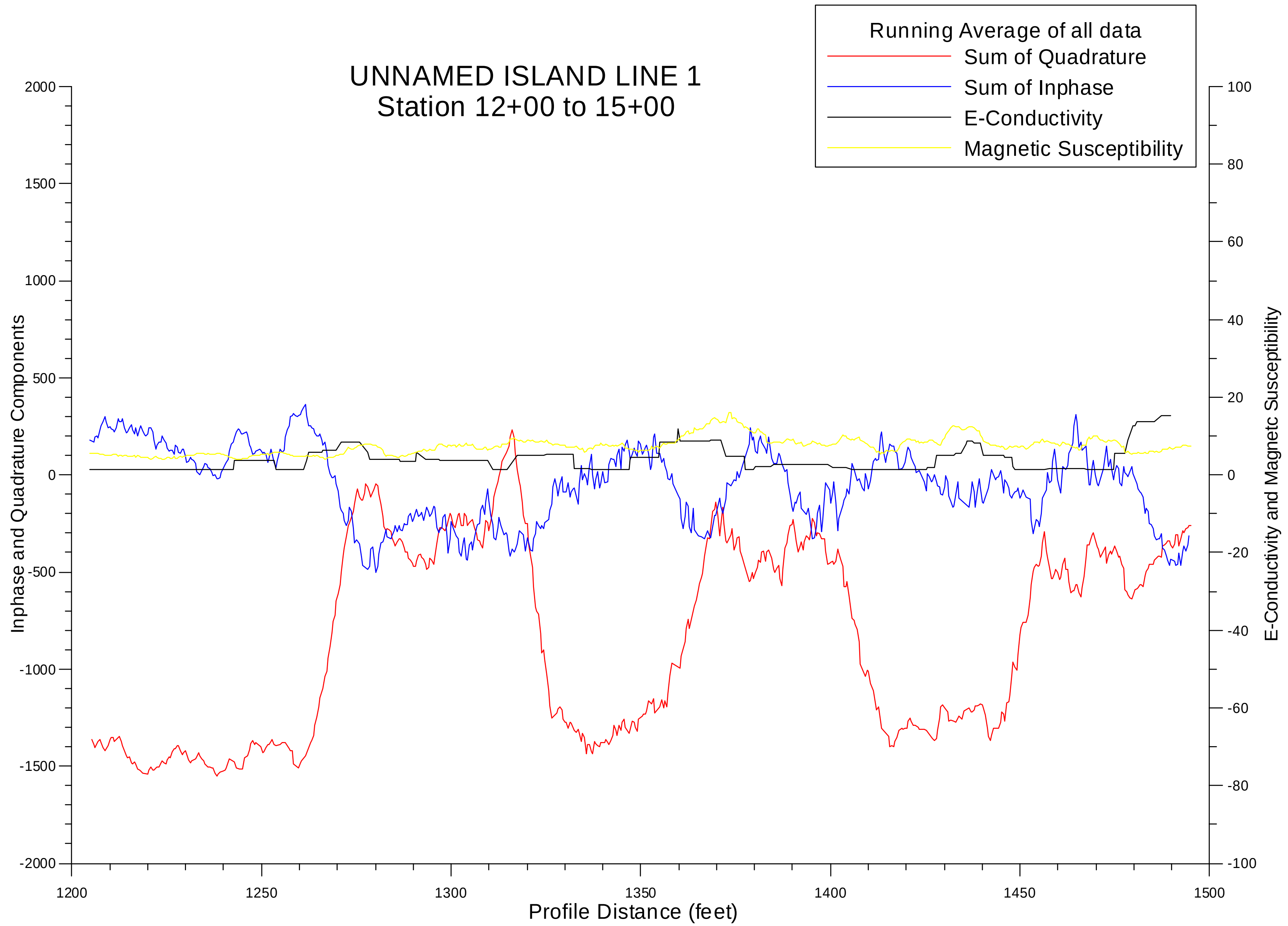

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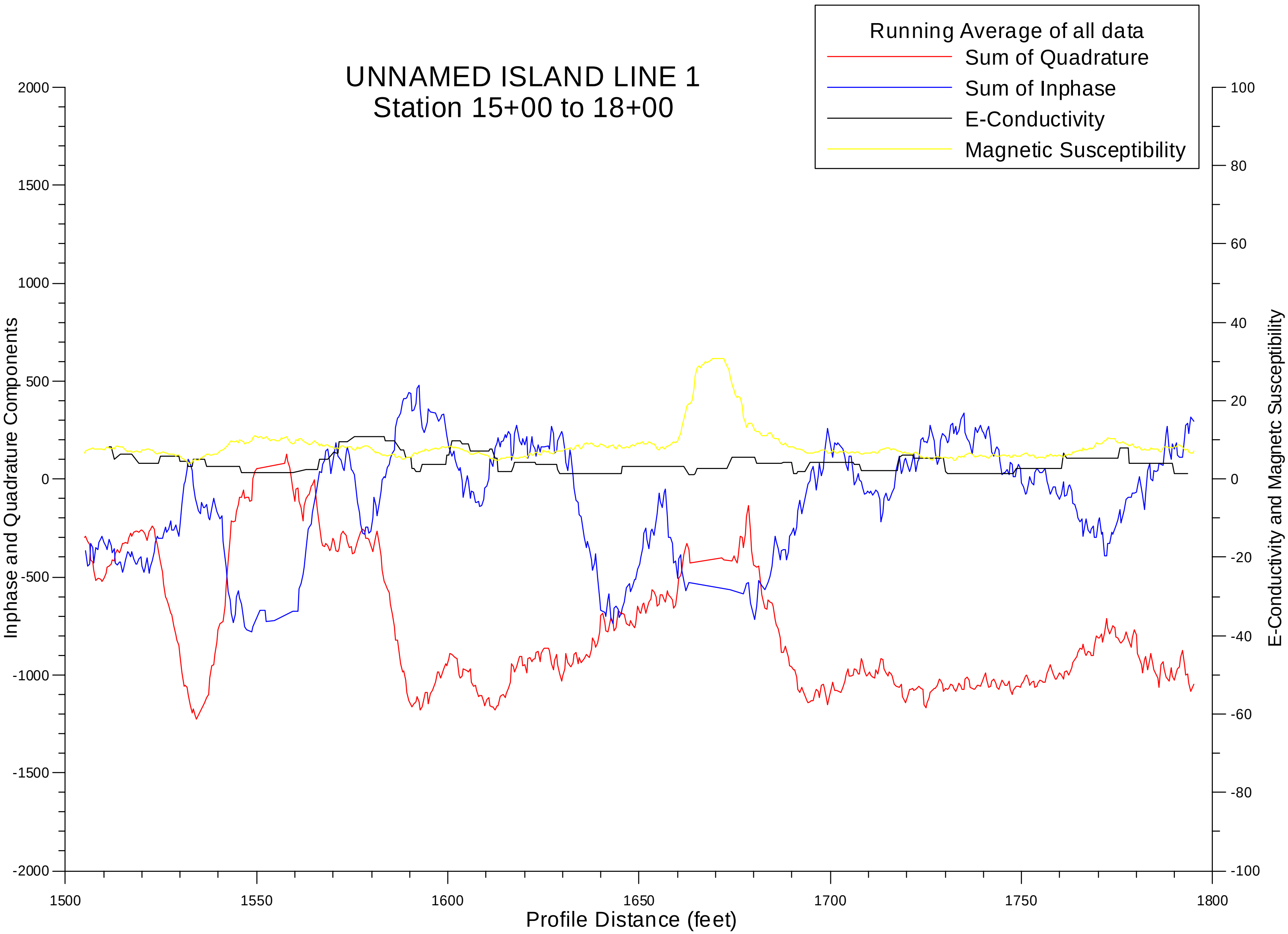

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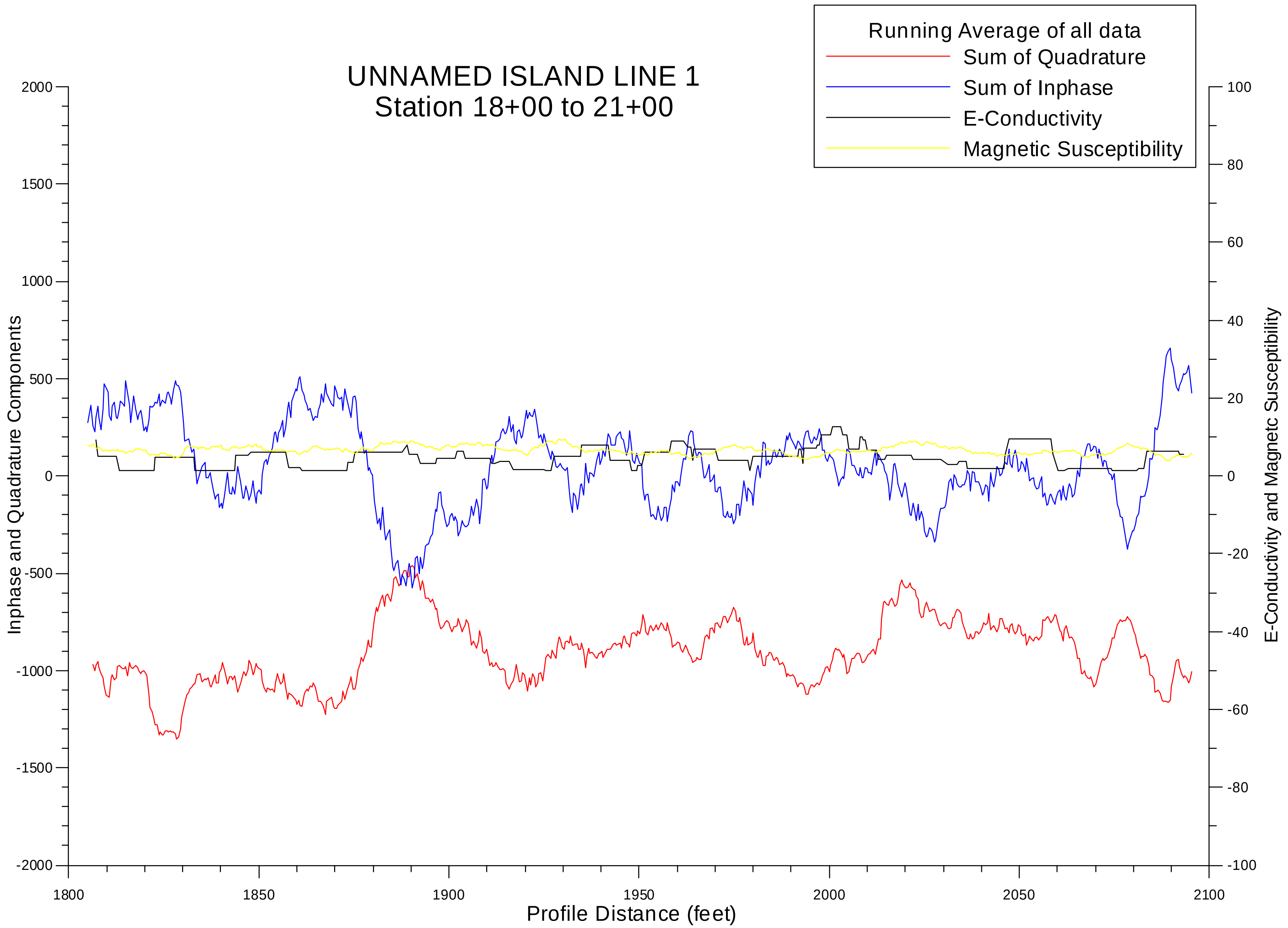

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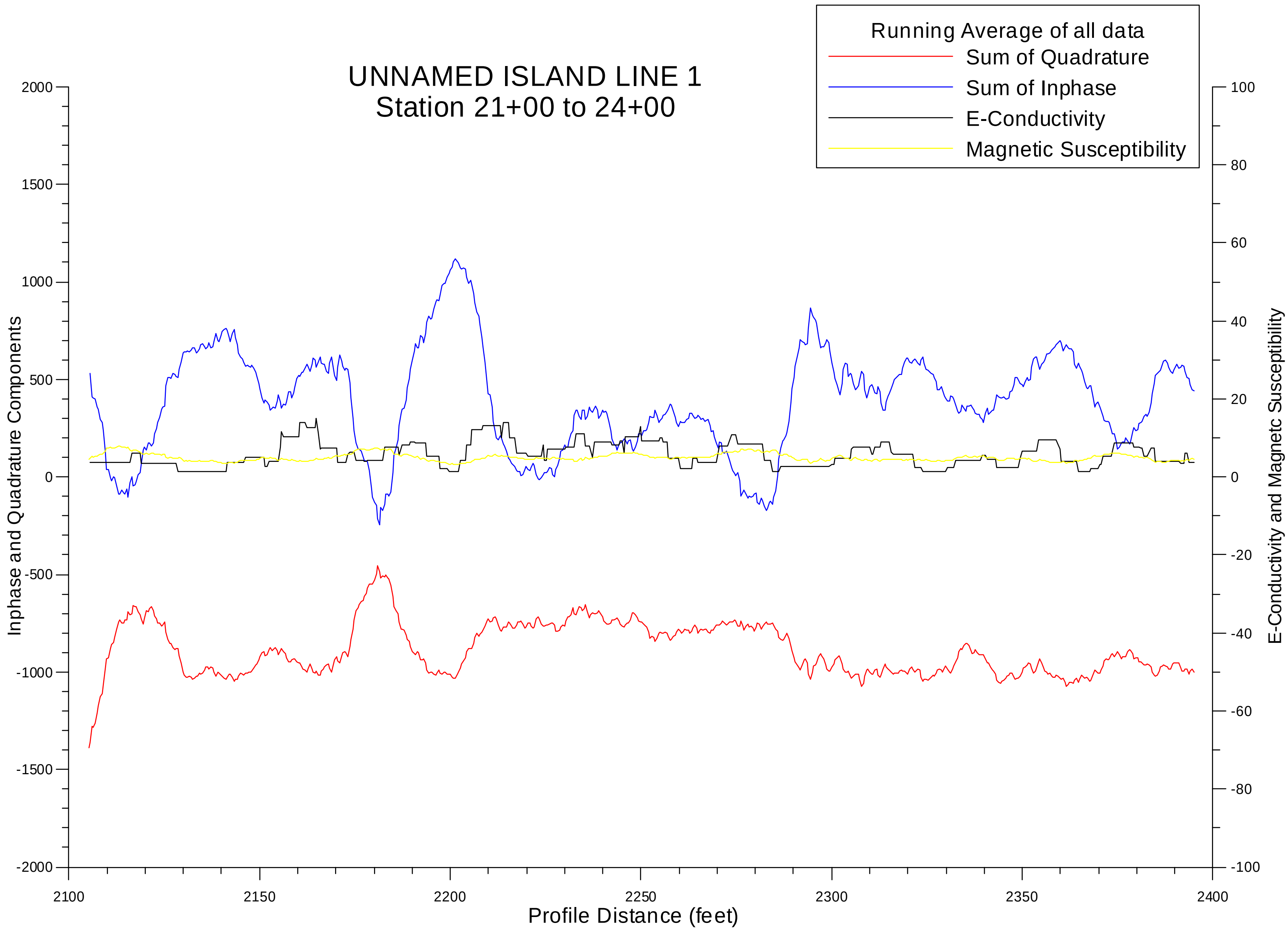

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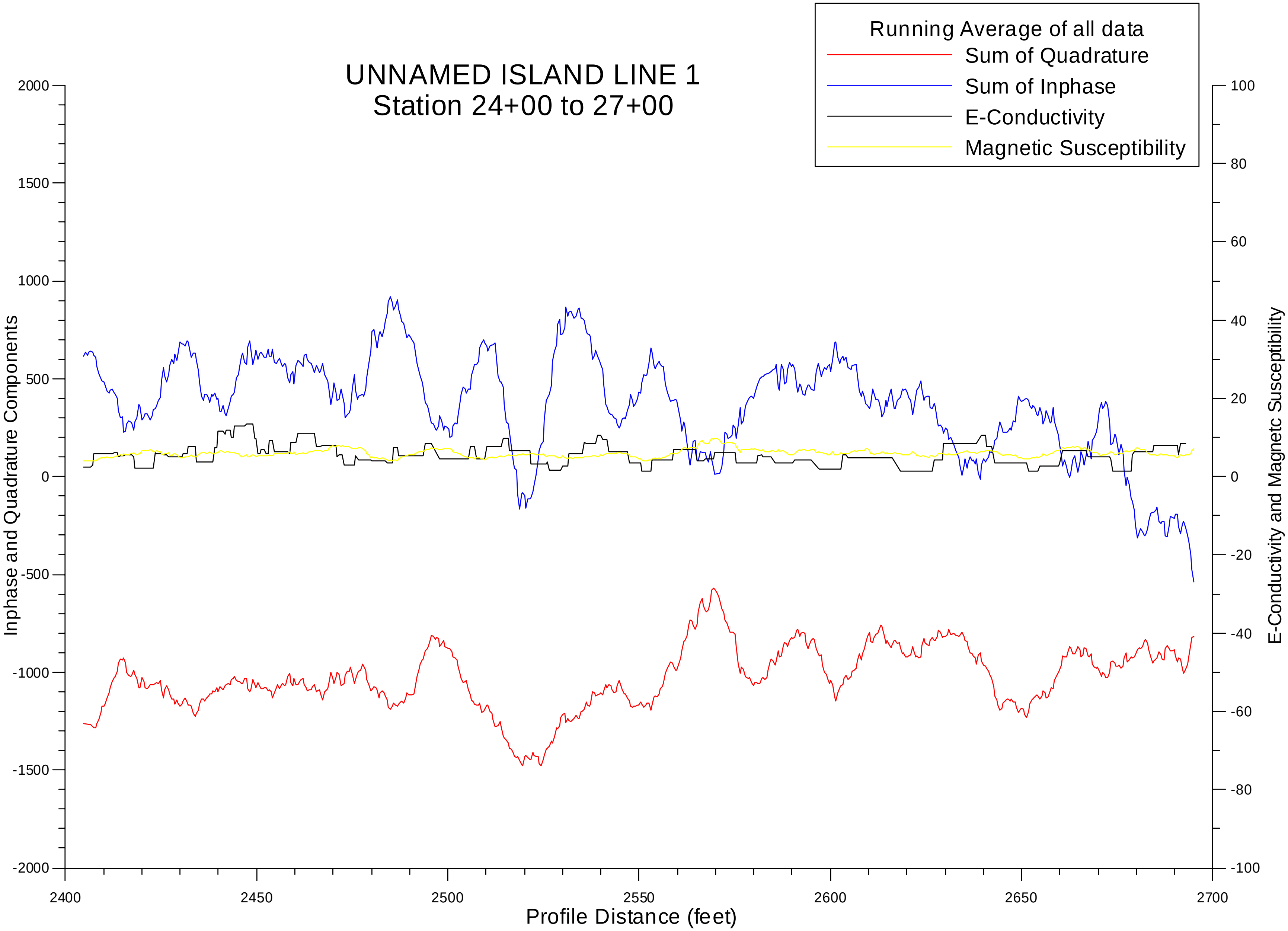

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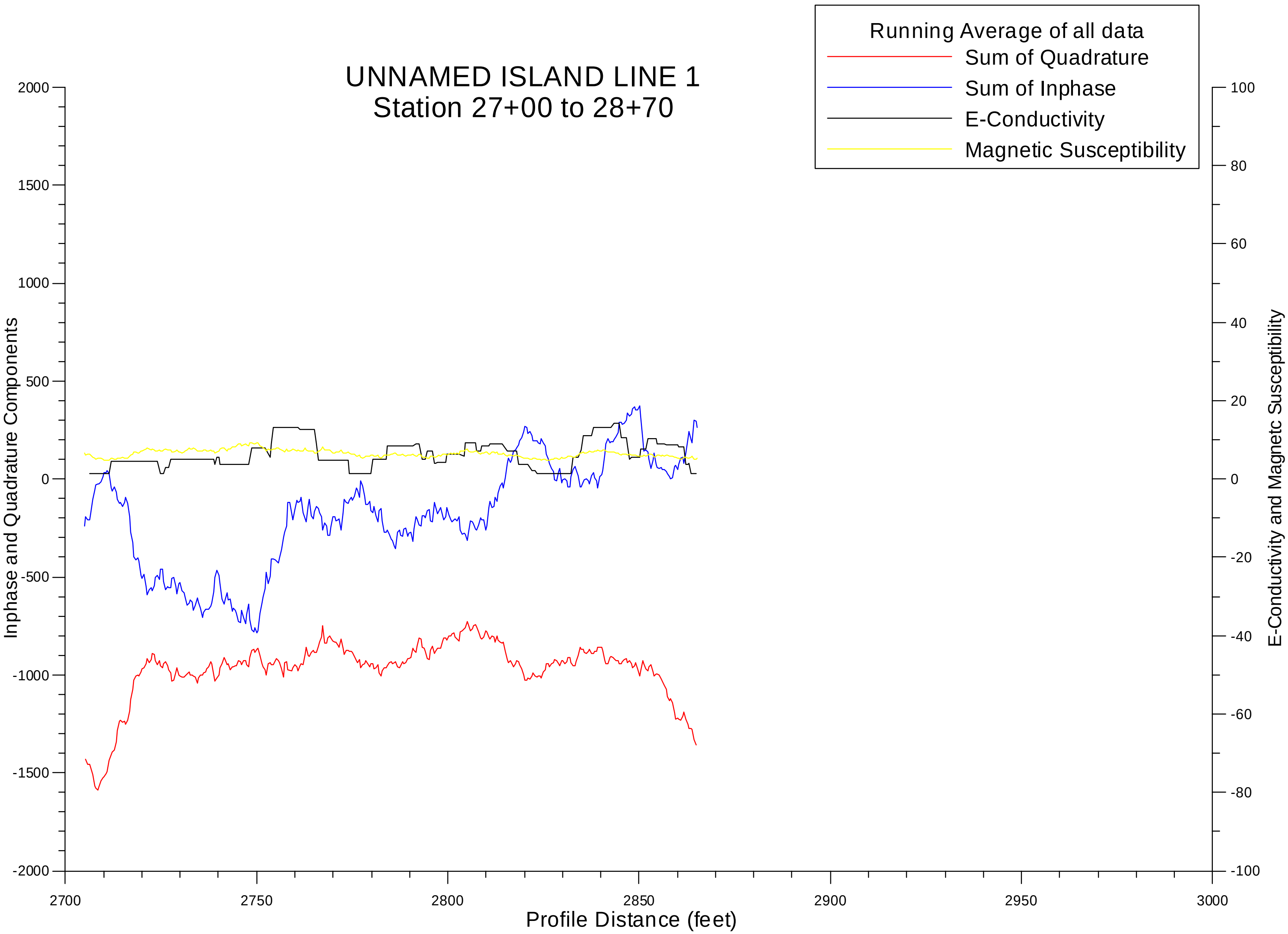

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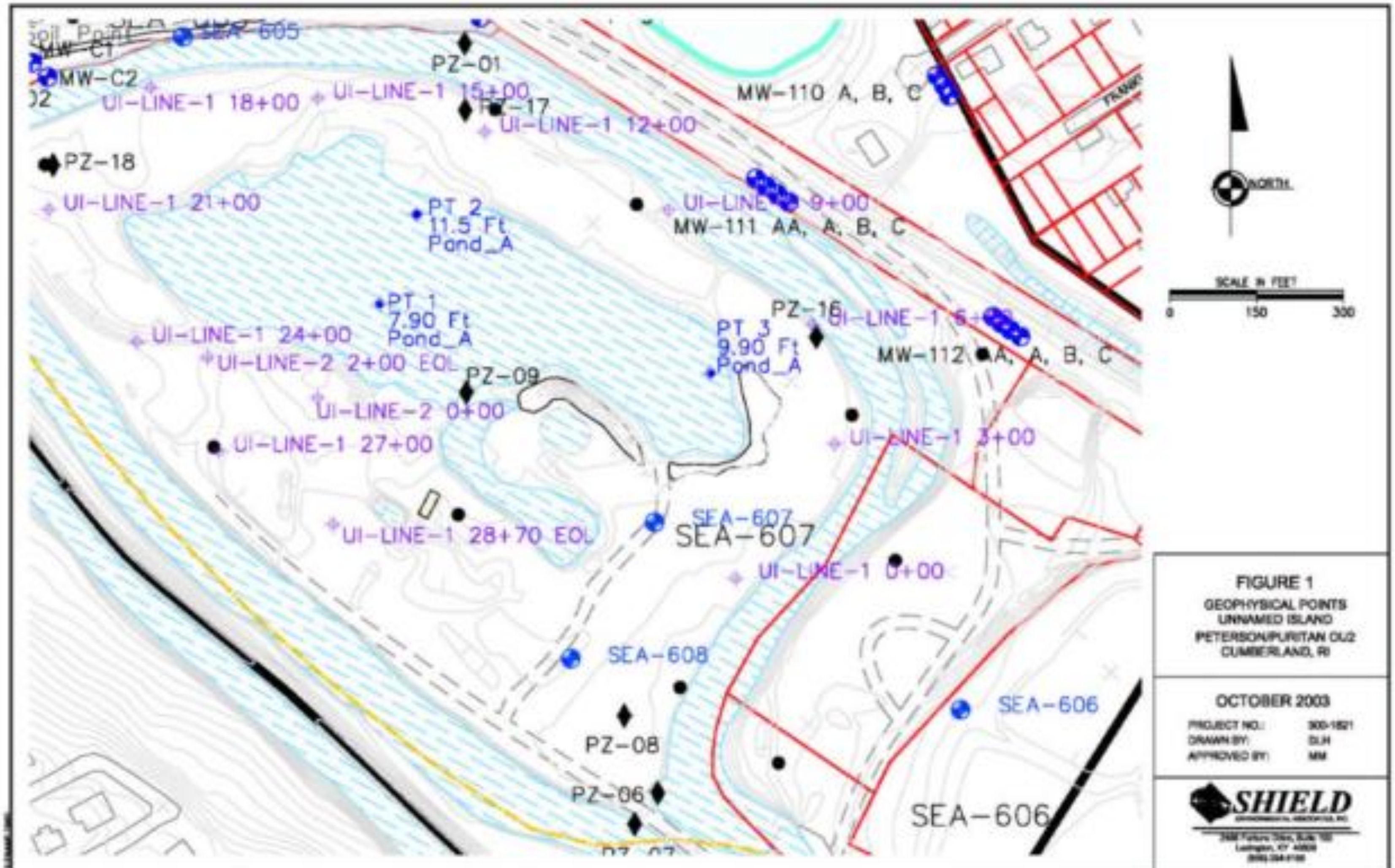

Appendix D3 MIP Survey - Landfill

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Appendix D3 MIP Survey - Landfill

ZEBRA Environmental Corp.

Shield Environmental Associates
2456 Fortune Drive, Suite 100
Lexington, Kentucky 40509

September 23, 2003

Attention: Ms. Alison Dunn

RE: Summary Report for Direct Sensing Services
J. M. Mills Landfill
Cumberland, Rhode Island
ZEBRA Proposal #: DS07230

Dear Ms. Dunn:

The following is a summary of site activities performed by ZEBRA Environmental at the J.M. Mills Landfill, Cumberland, Rhode Island. The work was performed on August 19 –28, 2003.

PROJECT PERSONNEL ON SITE:

Mr. Mike Morris, Shield Environmental
Mr. Chad Veller, Shield Environmental
Mr. Joseph Sakellis, ZEBRA Environmental
Mr. Daryl VanVranken, ZEBRA Environmental

SUMMARY OF SITE ACTIVITIES

ZEBRA mobilized a fully equipped Electrical Conductivity/Membrane Interface Probe System (EC/MIP) mounted in a 4x4 GMC Van to the site. The "data acquisition vehicle" carried the system controller unit, notebook computer, printer, O.I. Analytical Model 4430 Photoionization Detector (PID) and Flame Ionization Detector (FID), Hewlett Packard Model G1223A, Electron Capture Detector (ECD), generator and all required compressed gases, two (2) complete assemblies of MIP probes, probe rods and trunk lines, as well as all the tools and supplies needed for the EC/MIP logging. The ZEBRA field team utilized a truck mounted Model 5400 Geoprobe unit to advance the EC/MIP probes into the subsurface.

The project involved collecting EC/MIP logs at forty-five (45) locations identified by the representatives of Shield Environmental Associates. Shield Environmental Associates recorded the location of the logging/sampling locations on a site plan.

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At each location the EC/MIP probe was advanced to the target depth in 1 foot intervals. As the probe was being driven to depth, the electrical conductivity data and detector responses were being continuously recorded by the system's data acquisition hardware and software. Upon completion of the logging, the probe rod assembly was extracted form the ground and cleaned, and the borehole filled with Portland grout.

The Membrane Interface Probe (MIP) is a percussion tolerant VOC sensor that can continuously log volatile organics that diffuse through a semi-permeable membrane. Using a carrier gas, the VOC's are brought to the surface through tubing, which is connected to a laboratory grade Photoionization Detector (PID), and Electron Capture (ECD), Flame Ionization Detector (FID) for immediate screening. All three of these detectors are mounted in a Hewlett Packard 5890 Series II Gas Chromatograph cabinet.

An integral part of the MIP system is the direct sensing soil conductivity system. This system utilizes a specially designed probe that will withstand the rigors of percussion probing while taking continuous measurements of soil conductivity as it is being driven into the ground. The sensing probe is linked to a control box where the signal is received by a lap top computer. The signal from the probe is matched with precise depth measurements and logged on the screen. The consultant is able to read real time data showing changes in soil conductivity/resistivity. These changes can be used to identify lithology, contaminant plumes, salt-water intrusion, or any other subsurface condition that displays a change in conductivity/resistivity.

A summary of the logging point name and the terminal depth achieved is included below:

Point Name	Final Depth	Point Name	Final Depth	Point Name	Final Depth
L12895 MIP1	13.39'	L12650 MIP9	30.27'	L12100 MIP17	10.36'
L12850 MIP2	13.13'	L12450 MIP10	10.26'	L12050 MIP18	30.27'
L12800 MIP3	13.33'	L12400 MIP11	10.63'	L12000 MIP19	10.50'
L12750 MIP4	10.53'	L12350 MIP12	30.42'	L21000 MIP20	30.20'
L12700 MIP5	10.14'	L12300 MIP 13	10.34'	L20950 MIP21	10.60'
L12595 MIP6	10.42'	L12250 MIP 14	12.18'	L20900 MIP22	10.00'
L12550 MIP7	9.90'	L12200 MIP15	10.37'	L20850 MIP23	14.60'
L12500 MIP8	10.26'	L12150 MIP 16	16.34'	L20750 MIP24	11.30'

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Point Name	Final Depth	Point Name	Final Depth	Point Name	Final Depth
L20715 MIP25	30.55'	L20100 MIP32	10.16'	L10300 MIP39	10.51'
L20800 MIP26	10.28'	L20050 MIP33	1.35'	L10250 MIP40	10.52'
L20360 MIP27	11.89'	L20048 MIP34	1.04'	L10200 MIP41	10.45'
L20300 MIP28	6.33'	L20047 MIP35	10.69'	L10150 MIP42	21.38'
L20250 MIP29	10.42'	L20000 MIP36	10.28'	L10100 MIP43	10.74'
L20200 MIP30	10.45'	L10400 MIP37	10.57'	L10050 MIP44	11.34'
L20150 MIP31	30.33'	L10350 MIP38	10.44'	L10000 MIP45	12.31'

Data Presentation

A Summary Log displaying four channels of data for each location has been prepared for each location. The channels include the soil conductivity log measured in mS/M, the PID, ECD, and FID detector response reported in uV. The Summary Log has been presented in a horizontal format with four channels. The depth below grade is depicted on the X - axis with 0 feet (land surface) located at the bottom left of the page. The maximum depth logged below grade is at the bottom right of the page. Regarding electronic data transfer, all data collected on site has been compiled in an Excel spread sheet and submitted to you.

All logs were left in the custody of Shields on site representative and all drilled holes were sealed and prior to leaving the site.

Data Interpretation

For this project the detectors were run using the highest sensitivity settings. The logs show a negligible response above the baseline for the PID and ECD detectors. If there are volatile organic compounds (VOCs) present, they are below the MIP systems detection limits. Below is a brief overview of the PID and ECD's operation:

Photo Ionization Detector (PID)

Highly sensitive detector used to detect Hydrocarbons (ionization potential < 10.6 eV)
Compounds of Interest: Volatile Organic Hydrocarbons (Aromatic)
Detection Sensitivity: > 250 PPB
Detection Range: approximately 10^5

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The Photo Ionization Detector (PID) responds to molecules whose ionization potential is below 10.6eV, including aromatics and molecules with carbon double bonds. The PID is nondestructive, so the sample can be routed through the PID and passed on, in series, with the FID.

Electron Capture Detector (ECD)
Highly sensitive detector used to detect Halogenated Solvents
Compounds of Interest: Volatile Halogenated Compounds (F, Cl, Br, and I)
Detection Sensitivity: > 100 PPB
Detection Range: approximately 10^5

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, PCE, TCE or Vinyl Chloride enter the cell, they immediately combine with some of the free electrons, temporarily reducing the number remaining in the electron cloud. The detector electronics maintain a constant current (of about 1 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 that is connected to the data system.

The FID did however respond, although at very low levels, to compounds at a depth of about 4 – 5 feet below ground surface. Given that the investigation was performed in a landfill area and ruling out the presence of aromatic and halogenated compounds (PID and ECD) it may be assumed that the FID was indicating the presence of natural gases created by the decomposition of landfill materials. Landfill gas may contain up to 30-40% carbon dioxide (CO_2), and small amounts of non-methane volatile organic compounds such as Hydrogen Sulfide (H_2S). These gases are denser than air and tend to sink. Combining this information with the EC logs one can see a nice correlation to back up this hypothesis. The EC log shows thin clay lenses near the surface. The FID traces for the same locations indicate the presence of compounds lying directly on top of these lenses, as a denser than air landfill gas might behave. When analyzing the more interesting scans the L1 0000 – L1 1800 and the L2 1000 – L2 0715 transects, the pattern that we see is natural gas overlying thin, near surface clay lenses which in turn overlay somewhat silty to clean sands.

Below is a brief overview of the FID and EC:

Flame Ionization Detector
Highly sensitive detector used to detect Hydrocarbons
Compounds of Interest: Volatile Organic Hydrocarbons
Detection Sensitivity: > 200 PPB
Detection Range: approximately 10^7

The FID responds to carbon and therefore produces a signal for all carbon containing compounds. The linear response of the detector is 10^7 and it responds to compounds with

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concentrations in the nanogram range depending on the compound. The FID responds to any molecule with a carbon-hydrogen bond, but its response is either poor or nonexistent to compounds such as CCl_4 or NH_3. Since the FID is mass sensitive, and not concentration sensitive, changes in the carrier gas flow rate have little effect on the detector response. It is preferred for general hydrocarbon analysis, with a detection range from 0.2 ppm to almost 100%. The FID response is stable from day to day. It is generally robust and easy to operate. But because it uses a hydrogen diffusion flame to ionize compounds for analysis, it destroys the sample in the process.

Electrical Conductivity (EC) - Overview

Soil conductivity and resistivity (the inverse of conductivity) have long been used as tools to classify soils. Higher electrical conductivities are representative of finer grained sediments, such as silts or clays, while sands and gravels are characterized by distinctly lower electrical conductivities. A few site-specific core samples, either from discrete depths or a continuous core, can be used to verify the lithology represented by electrical conductivity values at a site. The electrical logs are then correlated across the site to show changes in thickness or elevation of lithologic units of interest.

EC logs are used to define zones of lower conductivity, equivalent to coarser grained, more permeable sediments, which will allow the movement of contaminants (hydrocarbons, chlorinated VOC's, or metals) in the subsurface. This information will also assist in the proper placement of monitoring, sparging, or extraction wells.

ZEBRA appreciates the opportunity to provide these services and looks forward to working with Shield Environmental Associates in the future. Should there be any questions regarding this project or our other services, please do not hesitate to contact us.

Sincerely yours,

Joseph G. Sakellis
ZEBRA Environmental Corp.

PLF:cc

cc: Matt Ednie, ZEBRA – Albany, NY

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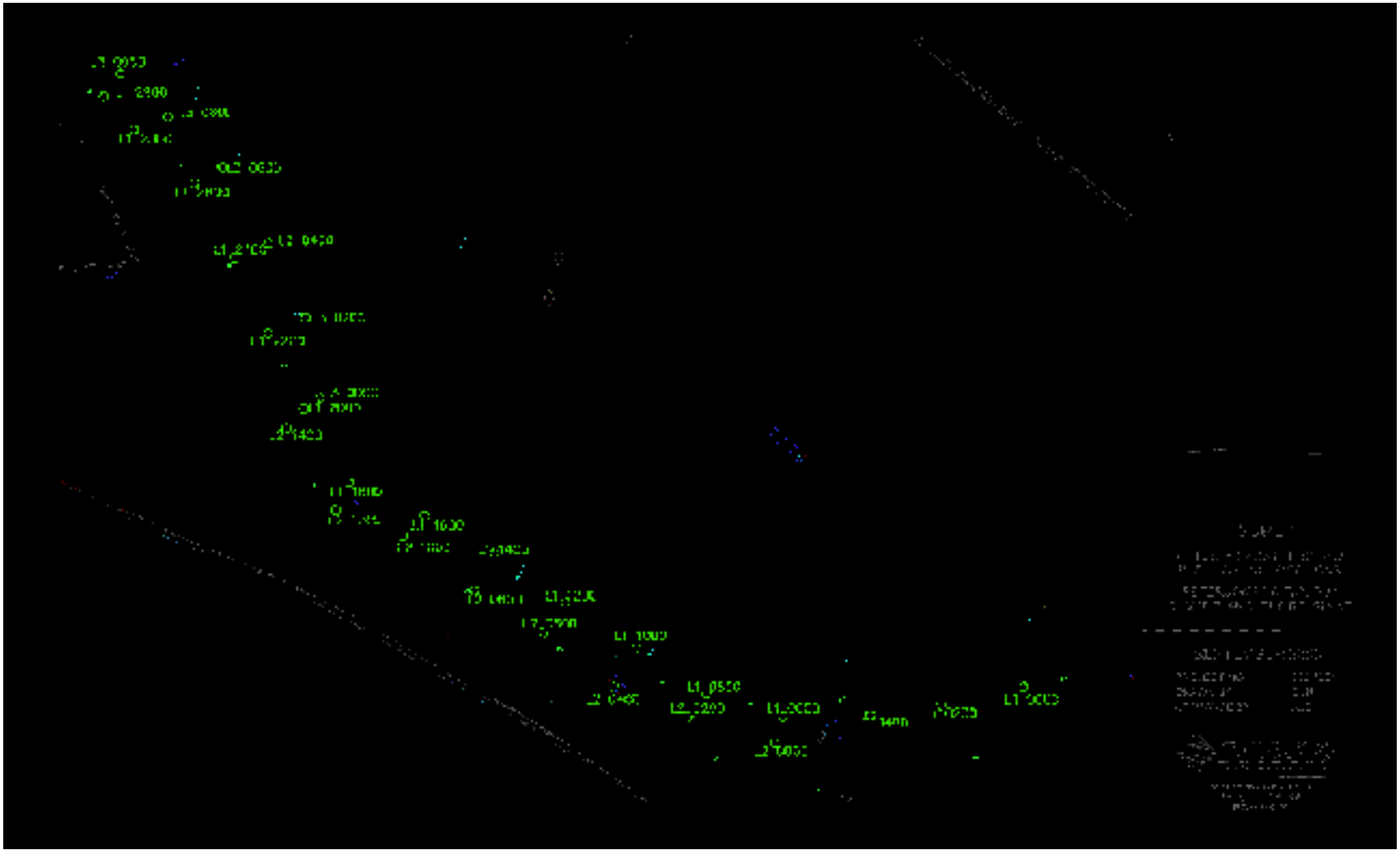
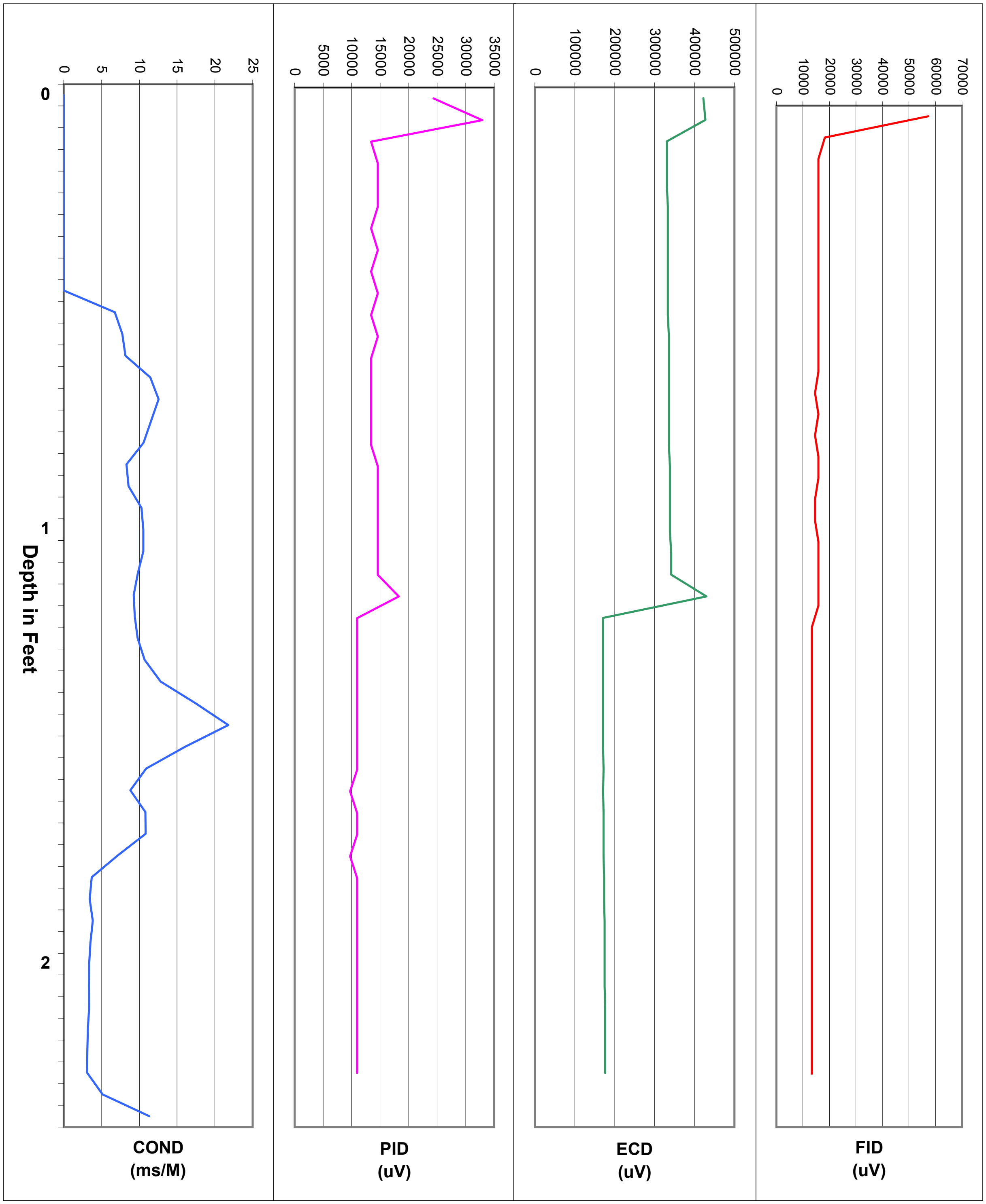


ZEBRA EC/MIP Summary Log, Point L1 2895
Cumberland, RI



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ZEBRA EC/MIP Summary Log, Point L1 2895
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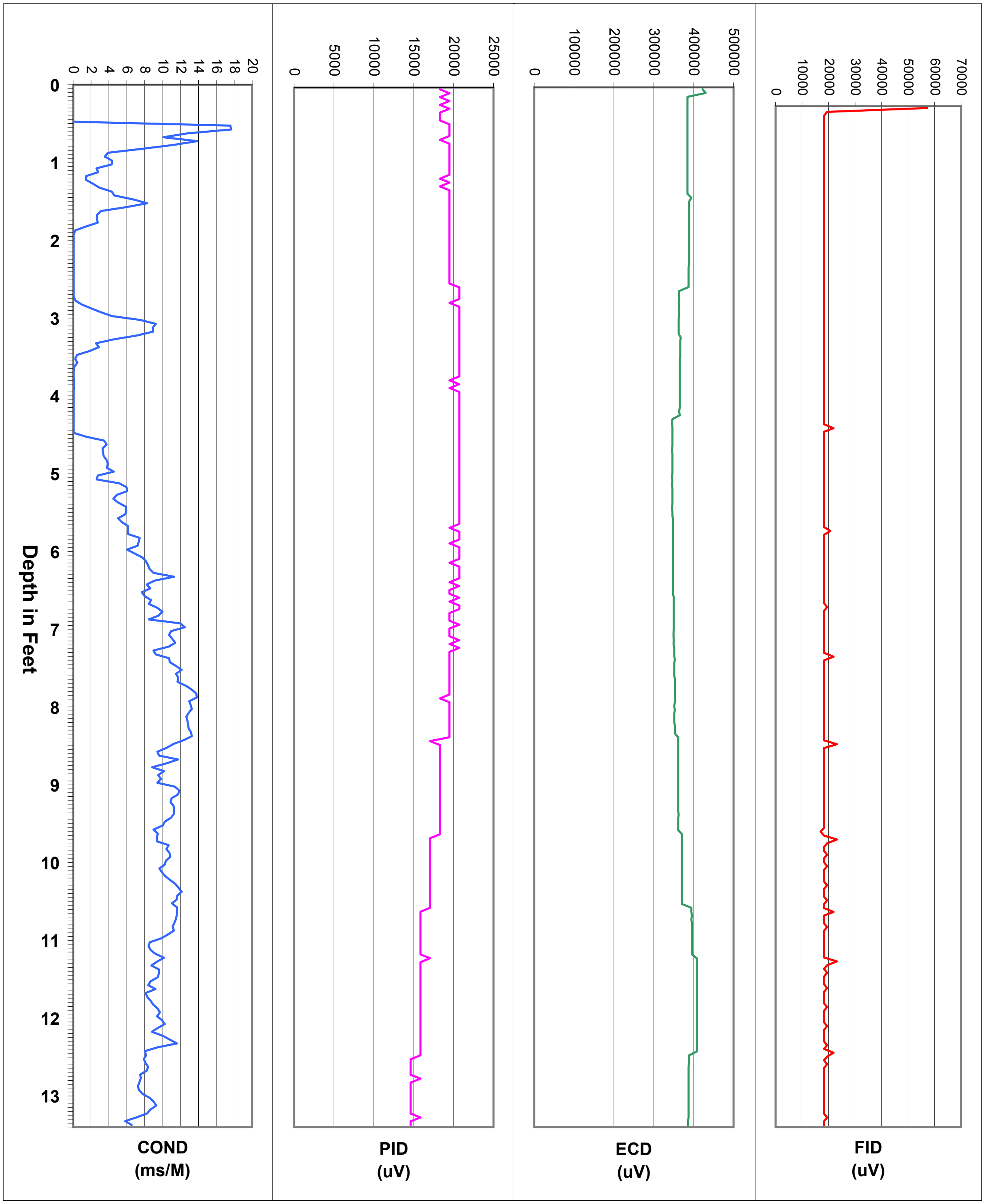

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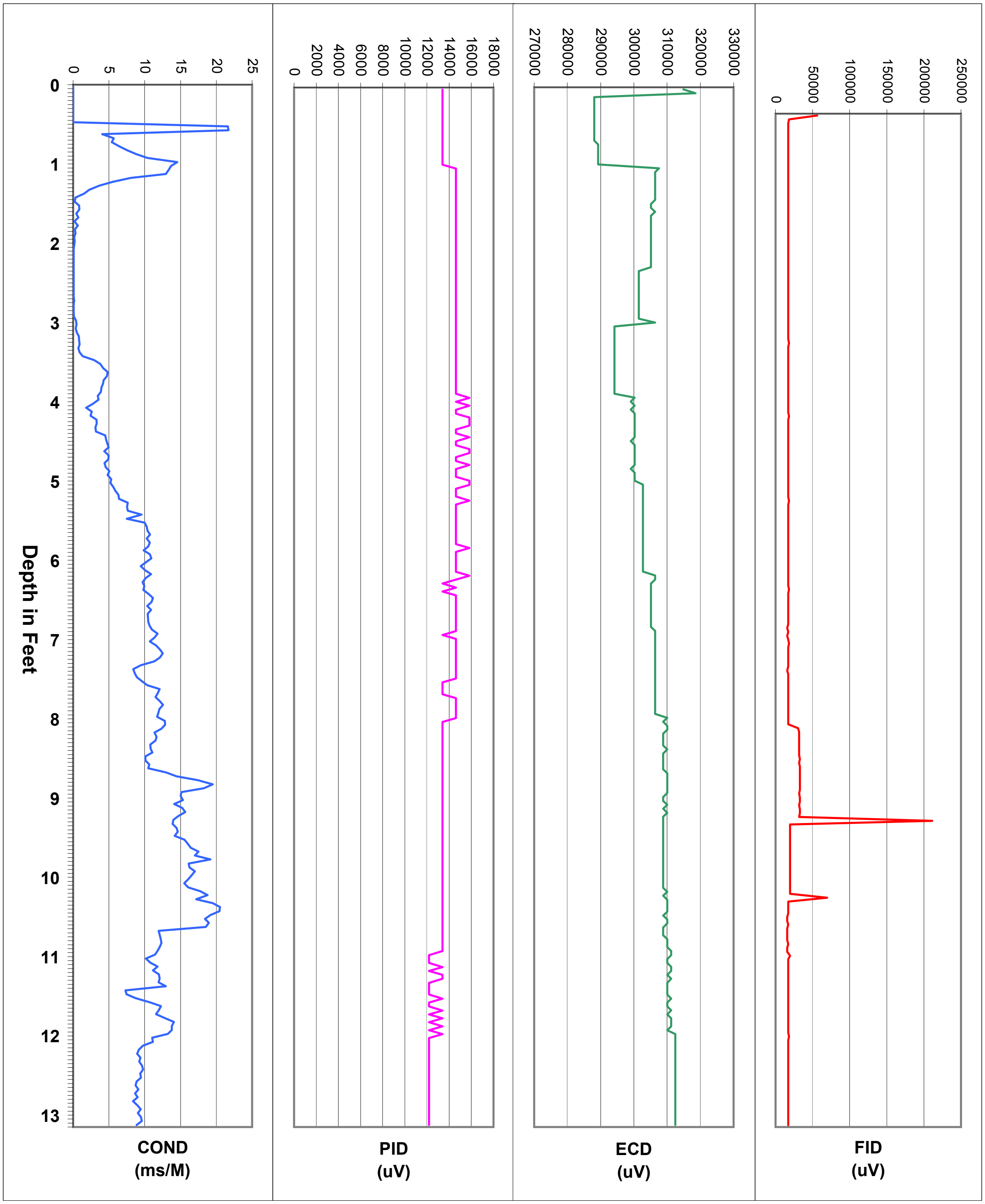
ZEBRA EC/MIP Summary Log, Point L1 2850
Cumberland, RI



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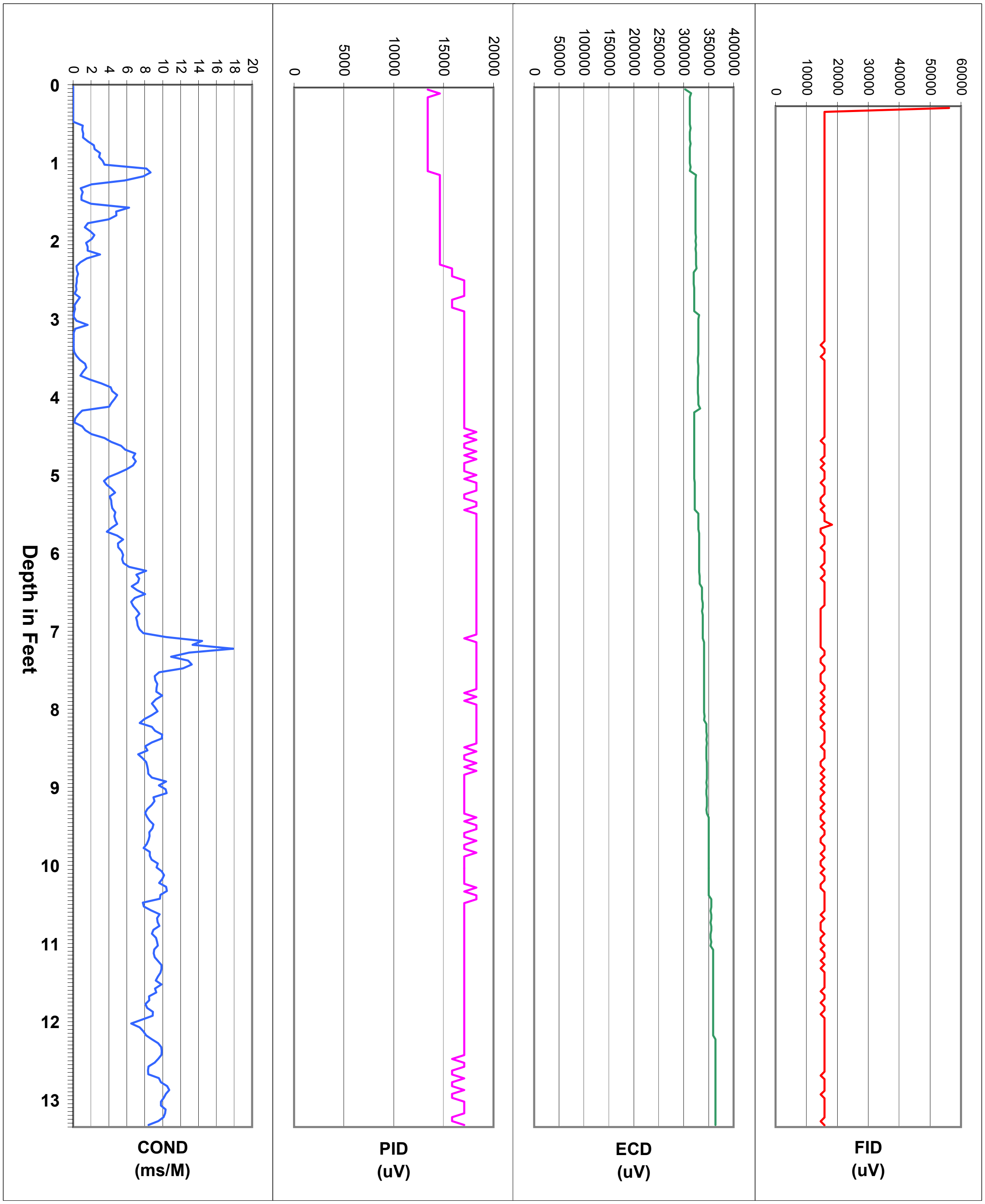
ZEBRA EC/MIP Summary Log, Point L1 2800
Cumberland, RI



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ZEBRA EC/MIP Summary Log, Point L1 2750
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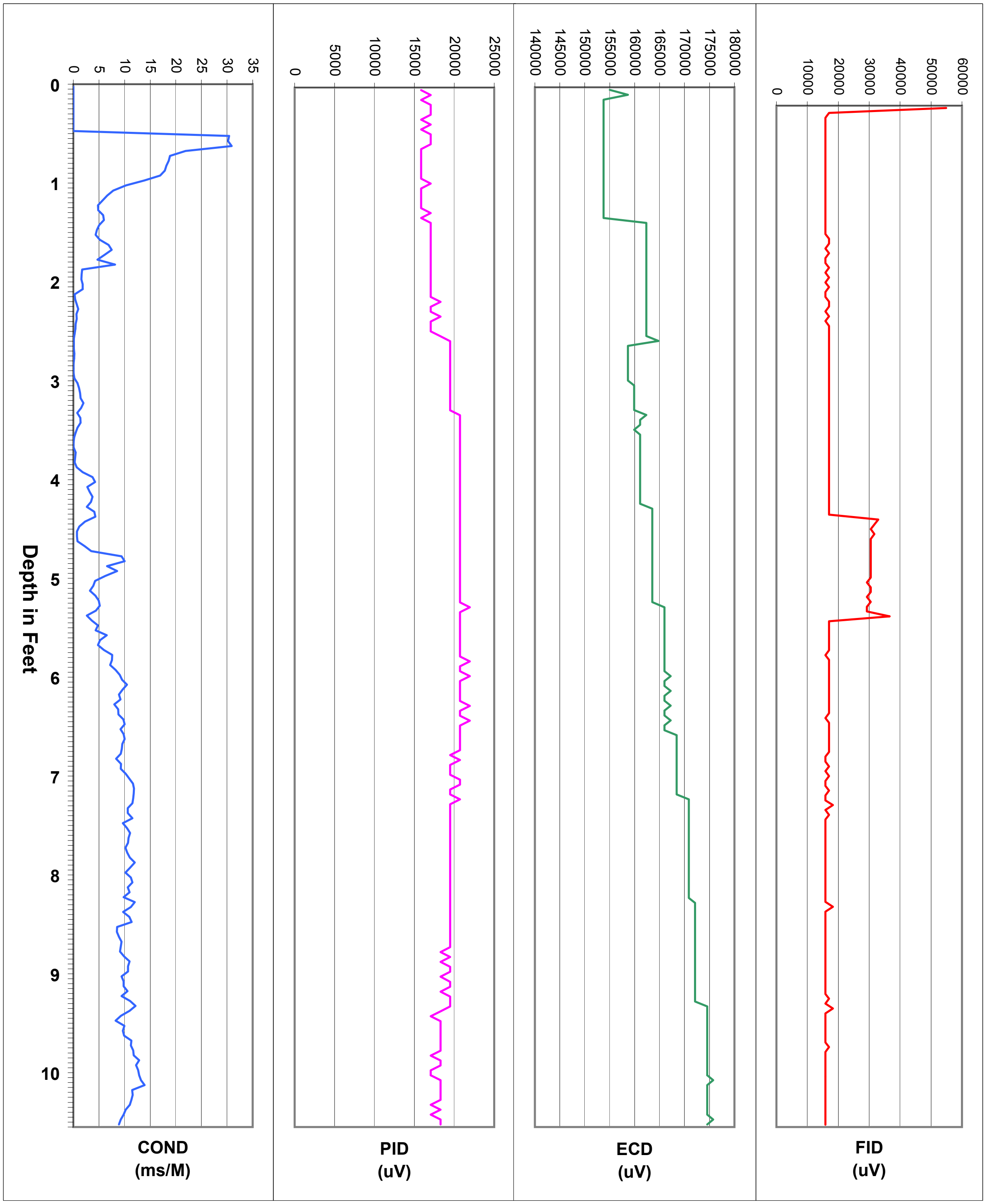

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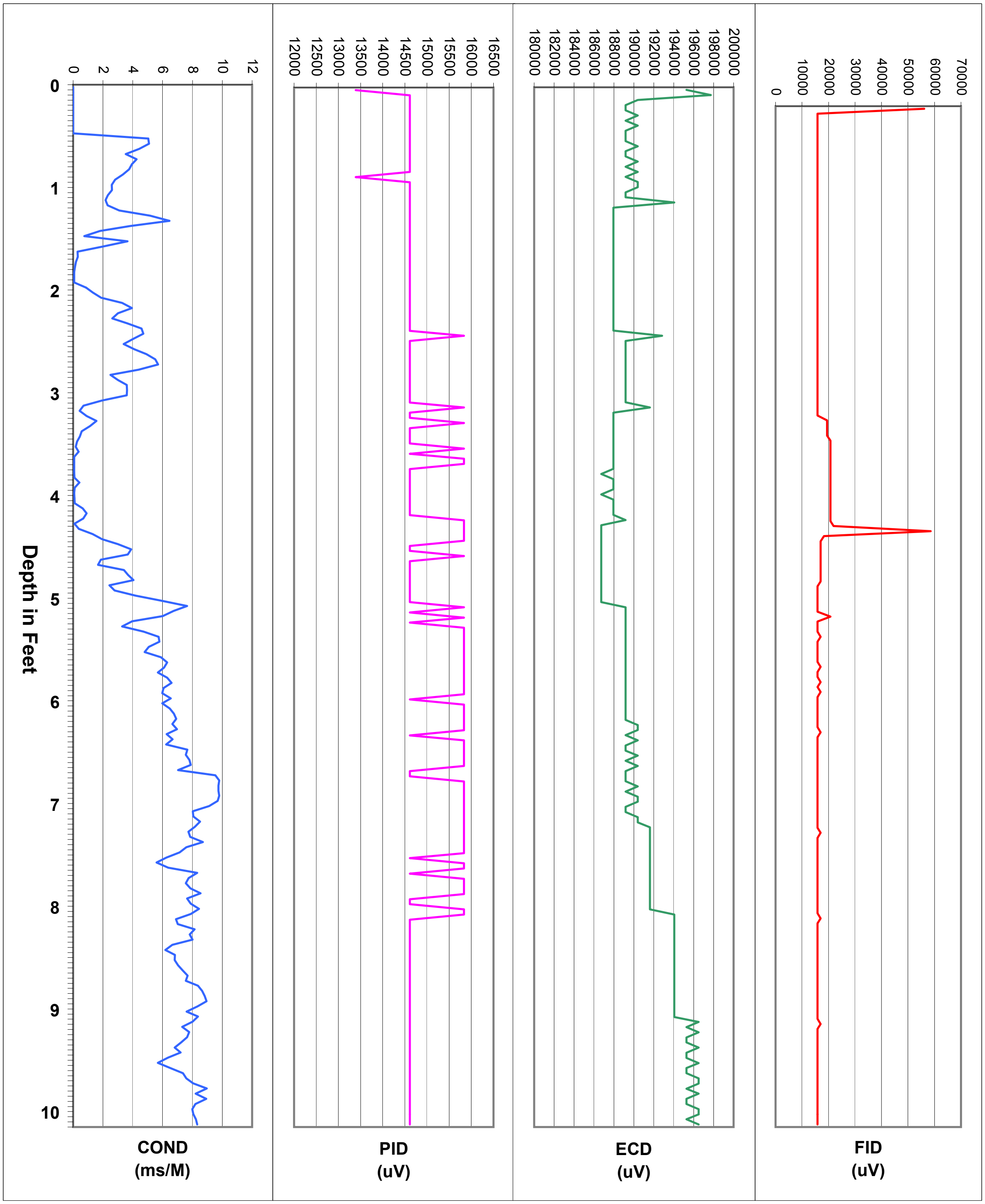
ZEBRA EC/MIP Summary Log, Point L1 2700
Cumberland, RI



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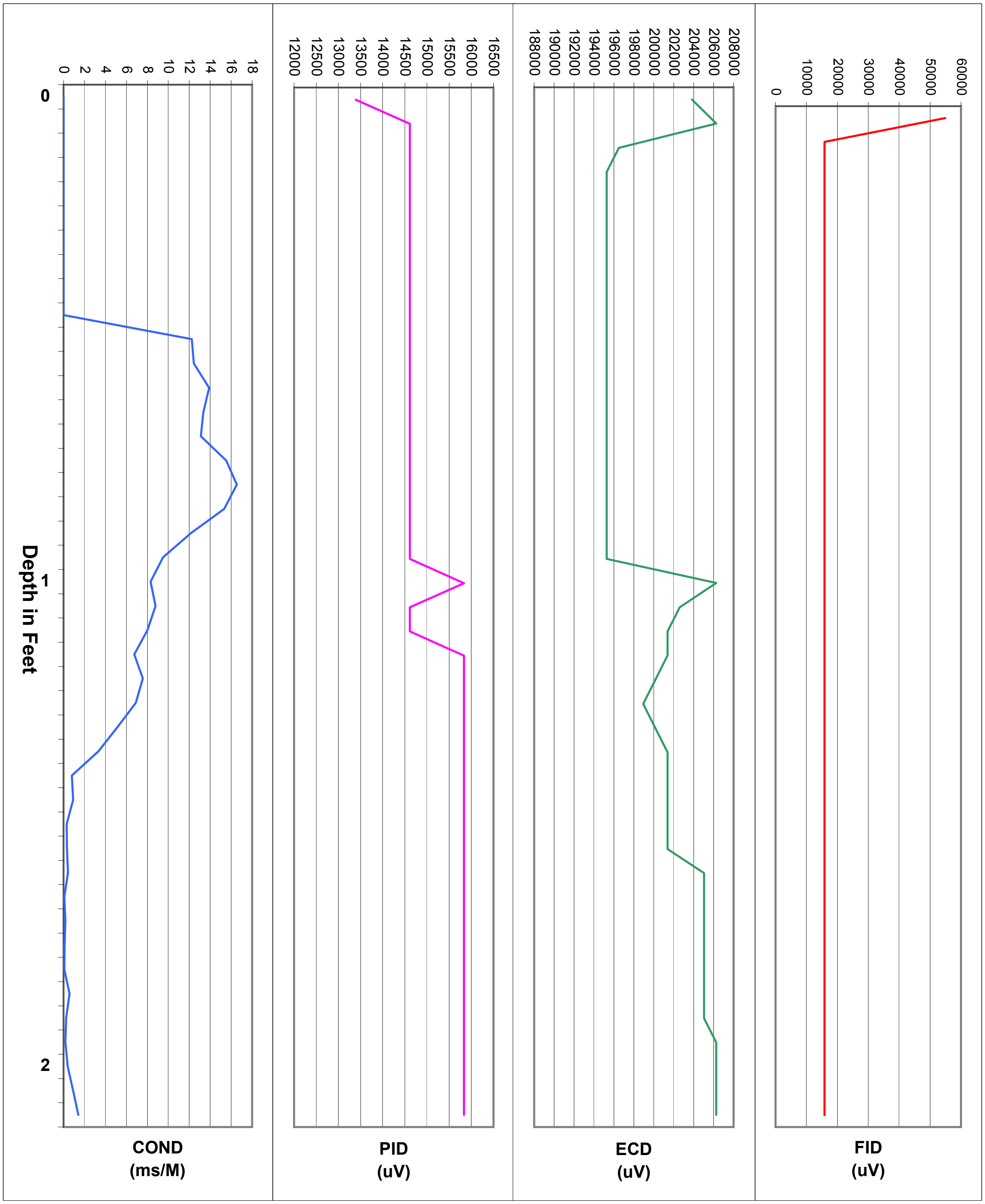
ZEBRA EC/MIP Summary Log, Point L1 2600
Cumberland, RI



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ZEBRA EC/MIP Summary Log, Point L1 2595
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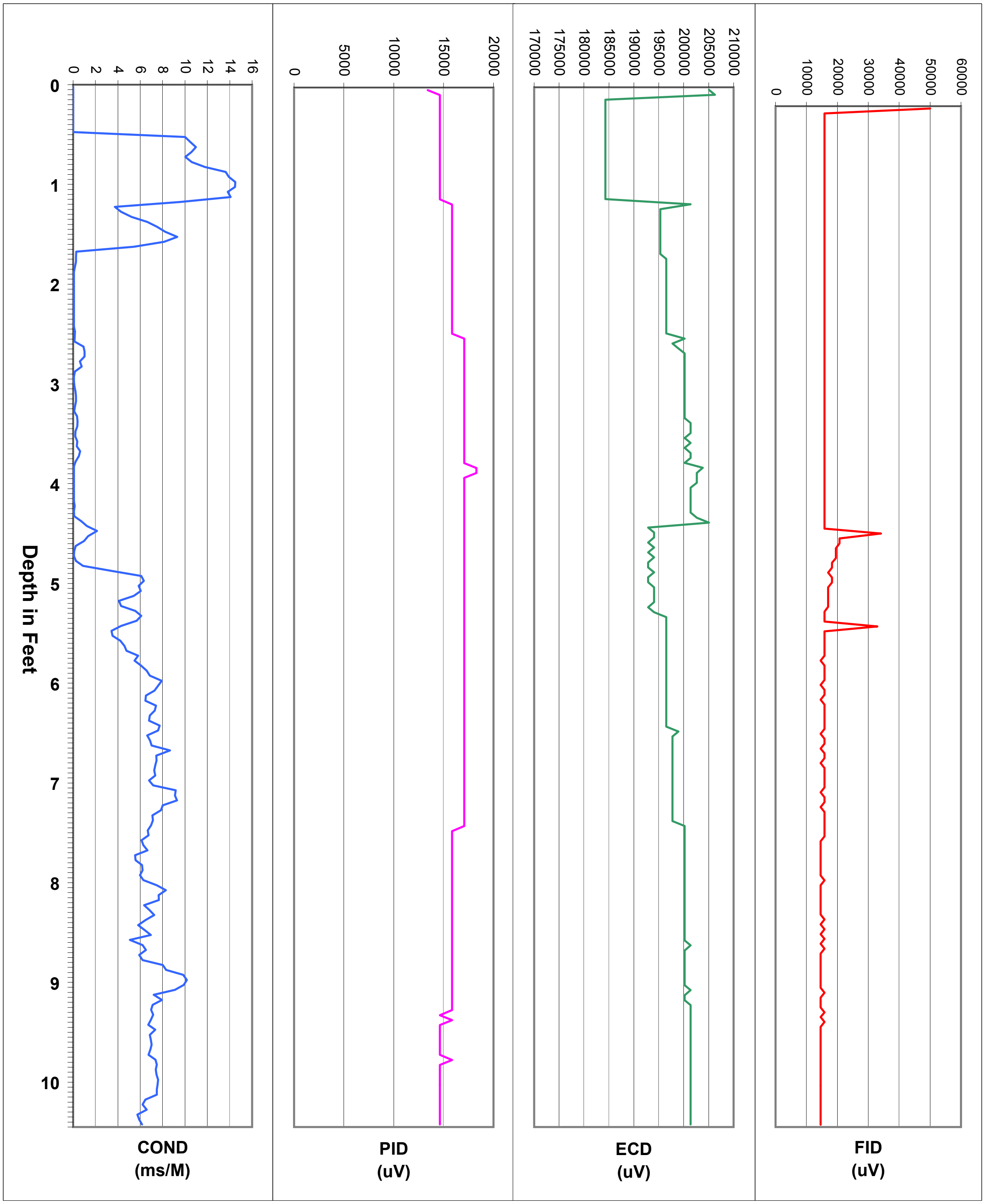

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ZEBRA EC/MIP Summary Log, Point L1 2550
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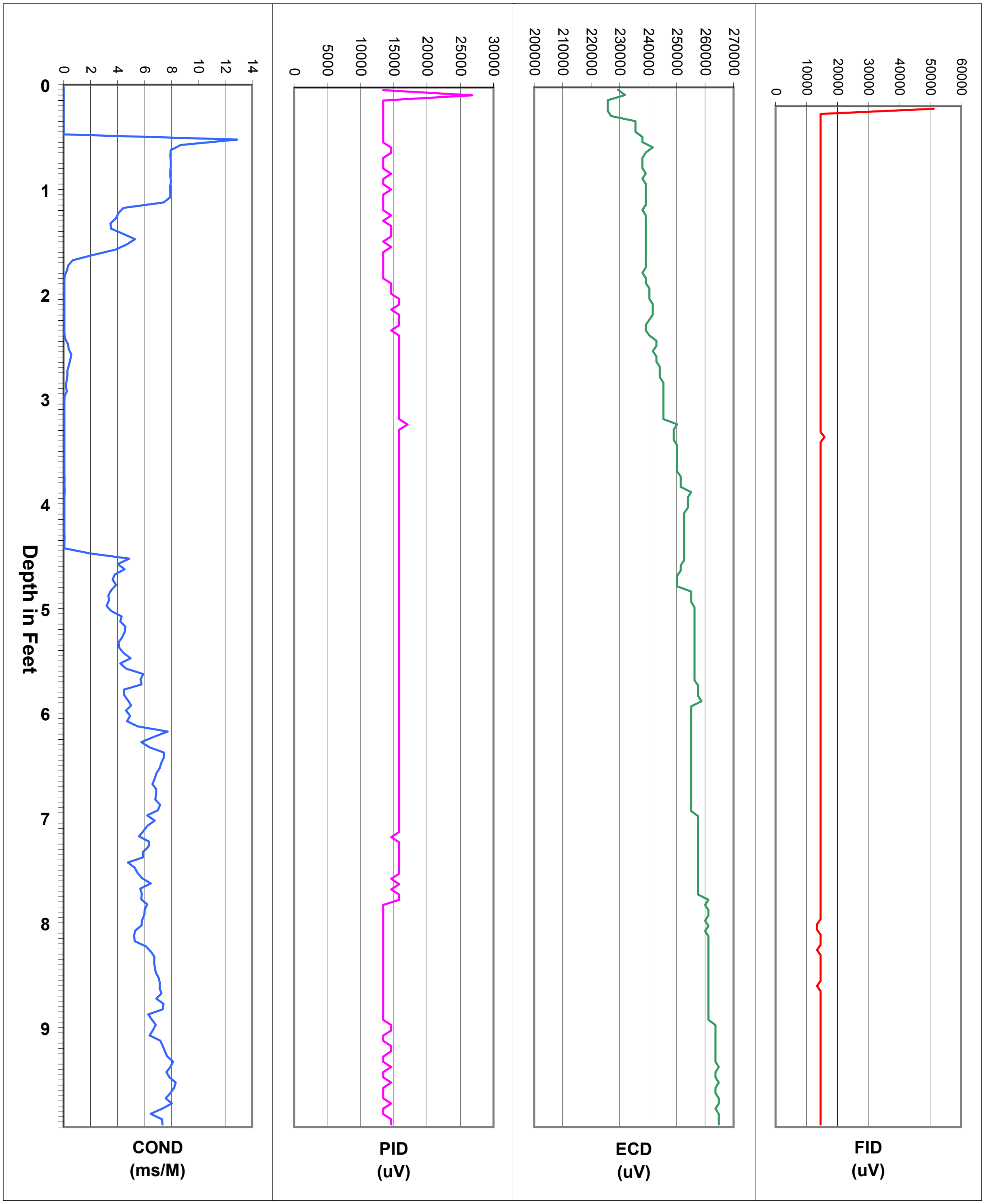

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Point 9 of 48

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ZEBRA EC/MIP Summary Log, Point L1 2500
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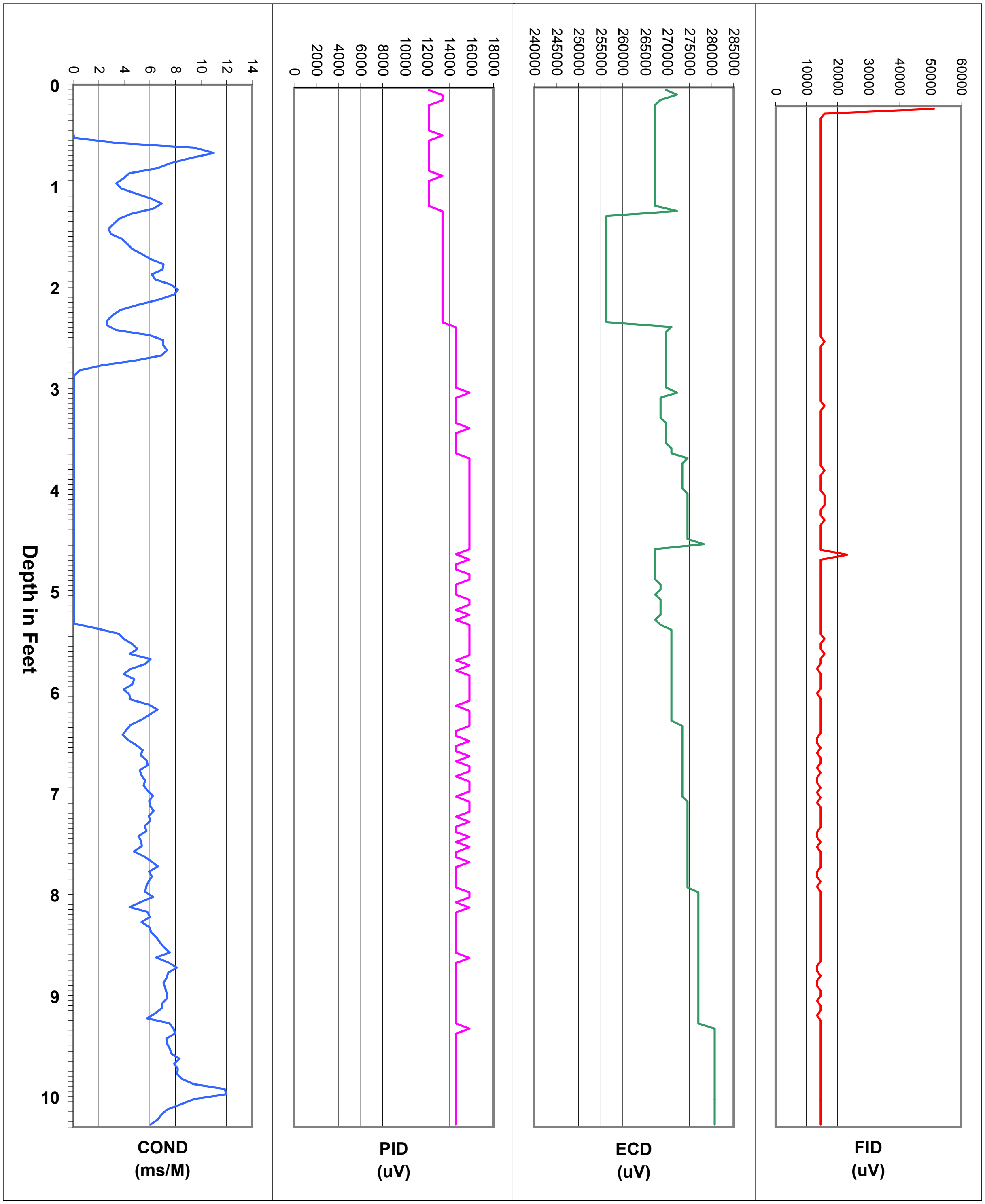

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Point 10 of 48

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ZEBRA EC/MIP Summary Log, Point L1 2650
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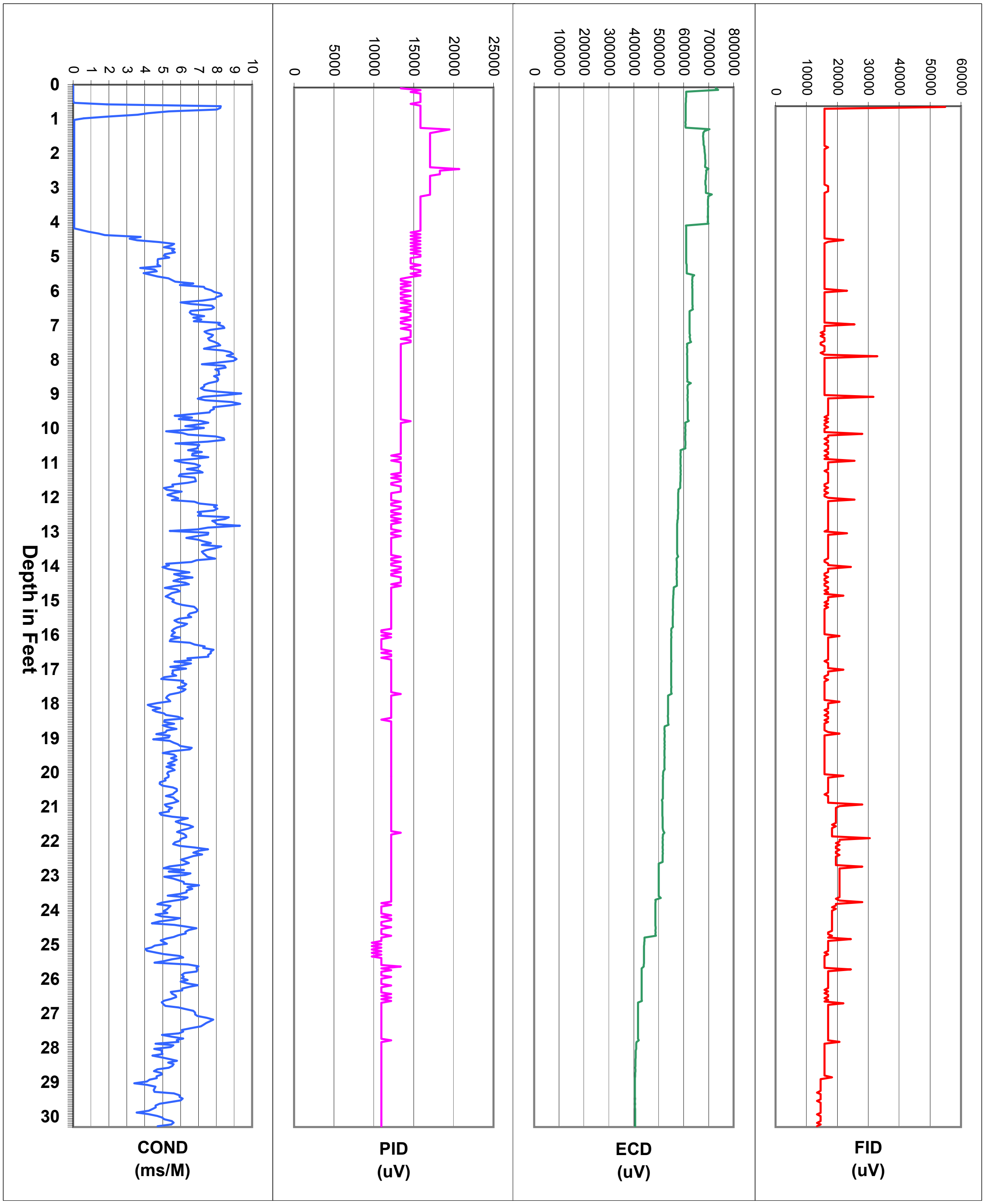

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Point 11 of 48

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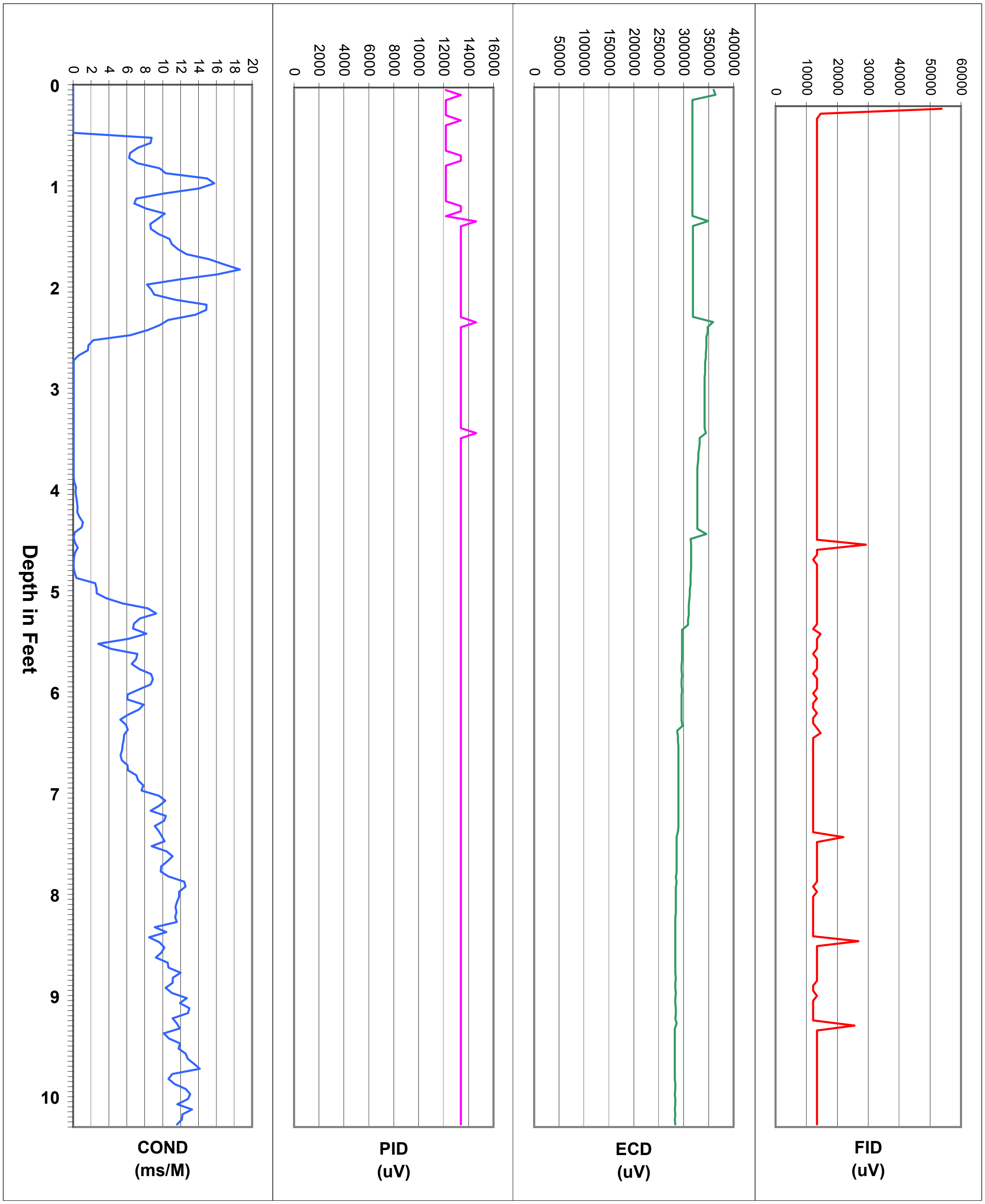
ZEBRA EC/MIP Summary Log, Point L1 2450
Cumberland, RI



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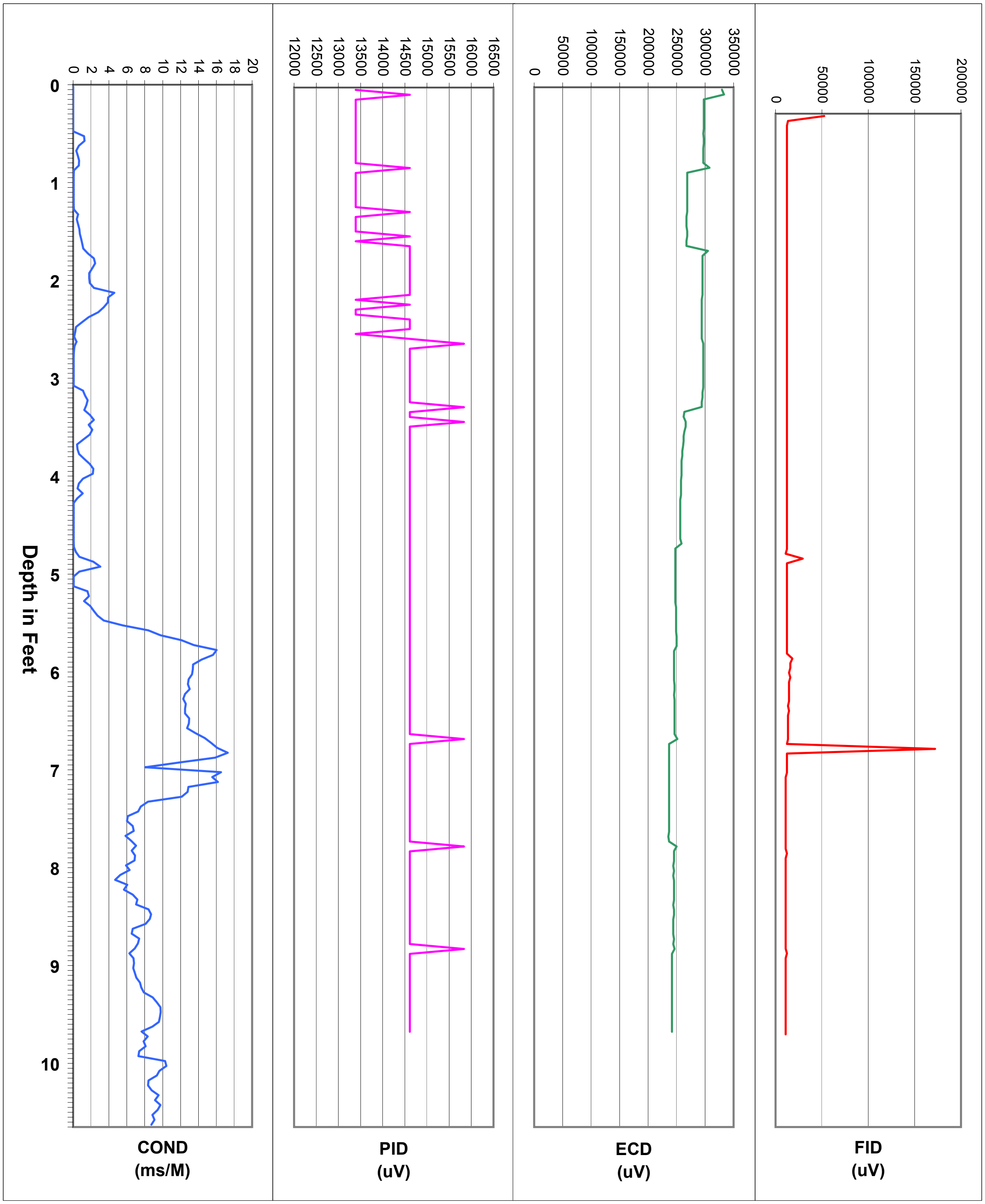
Point 12 of 48

ZEBRA EC/MIP Summary Log, Point L1 2400
Cumberland, RI



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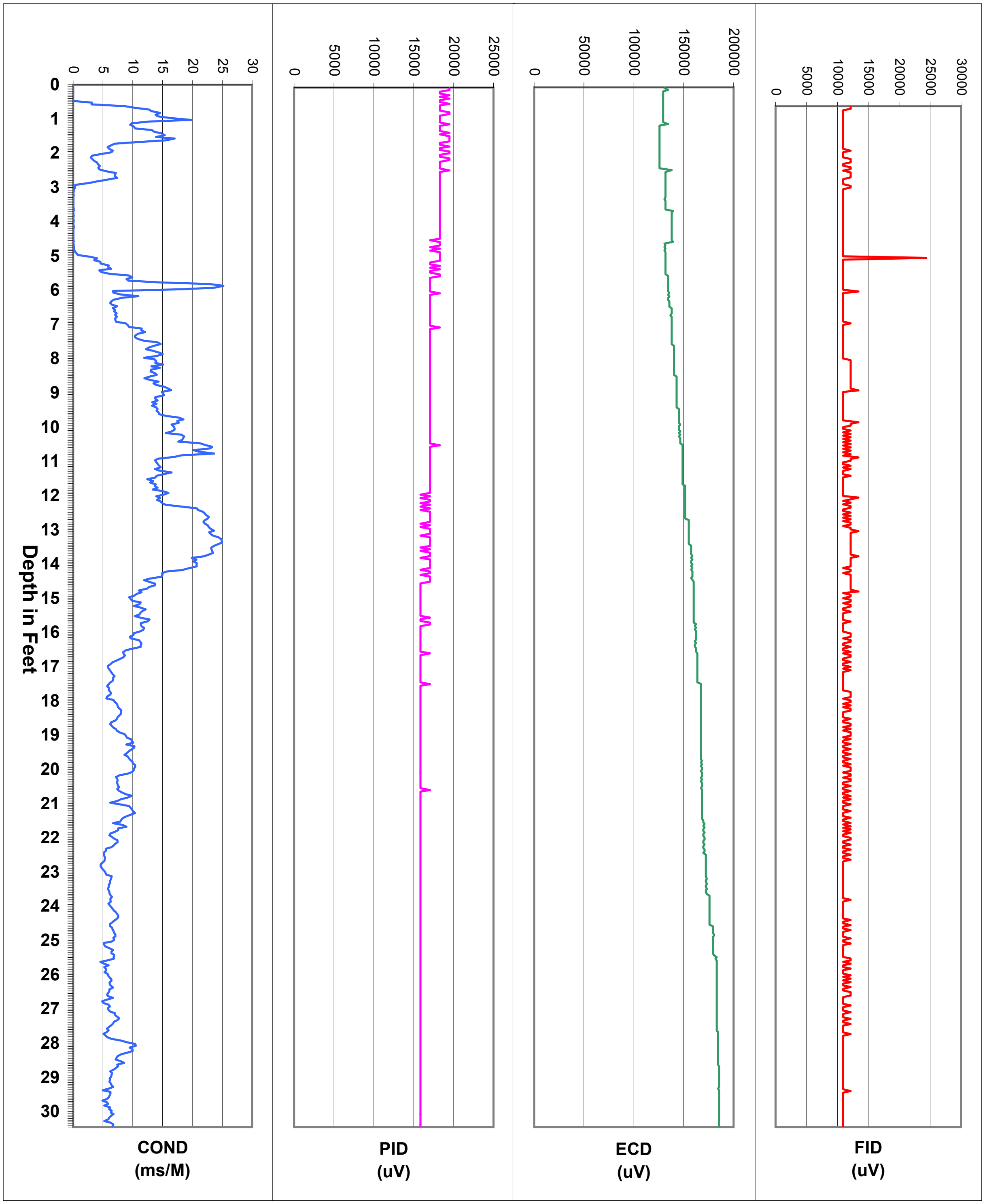
ZEBRA EC/MIP Summary Log, Point L1 2350
Cumberland, RI



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ZEBRA EC/MIP Summary Log, Point L1 2300
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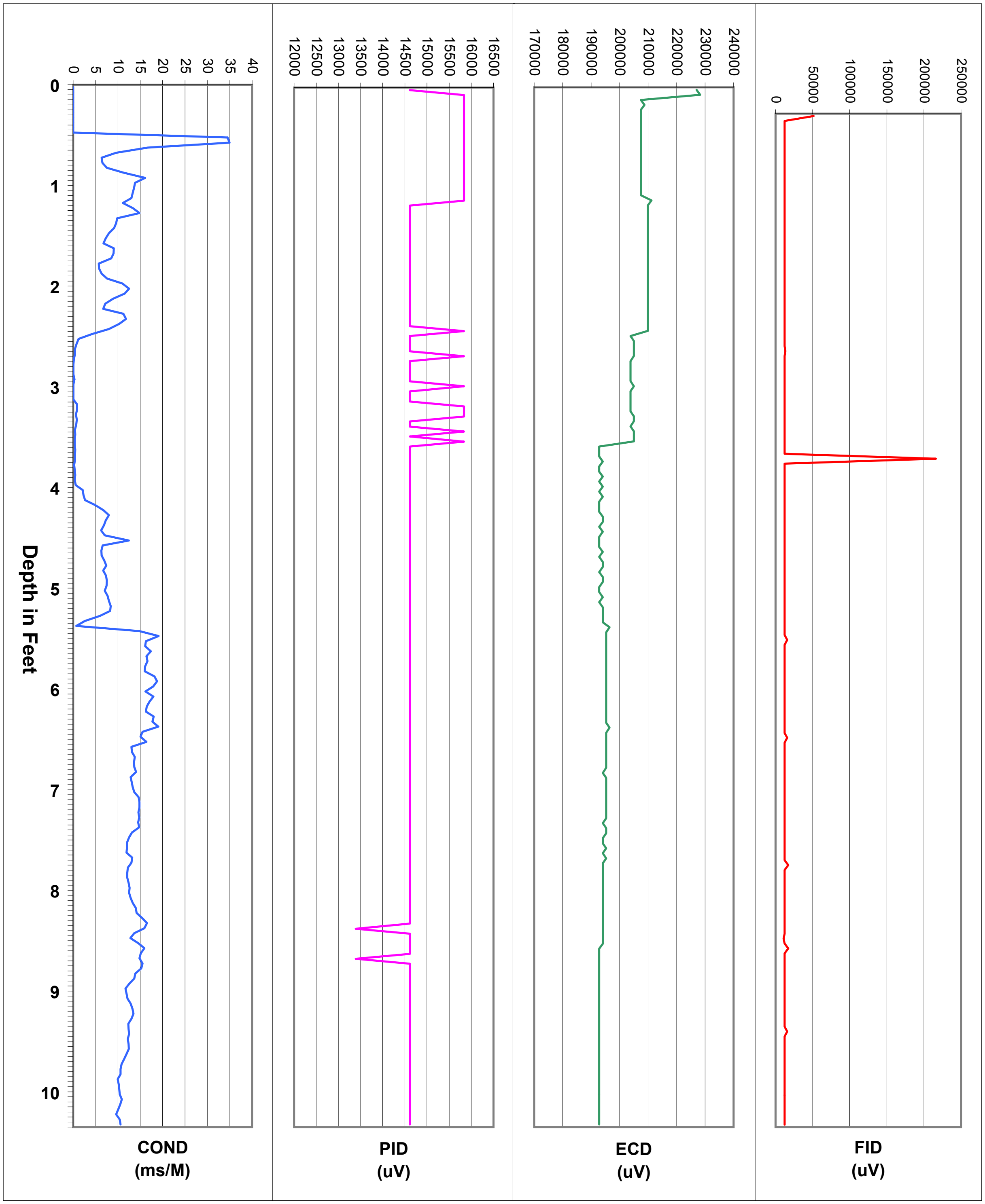

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Point 15 of 48

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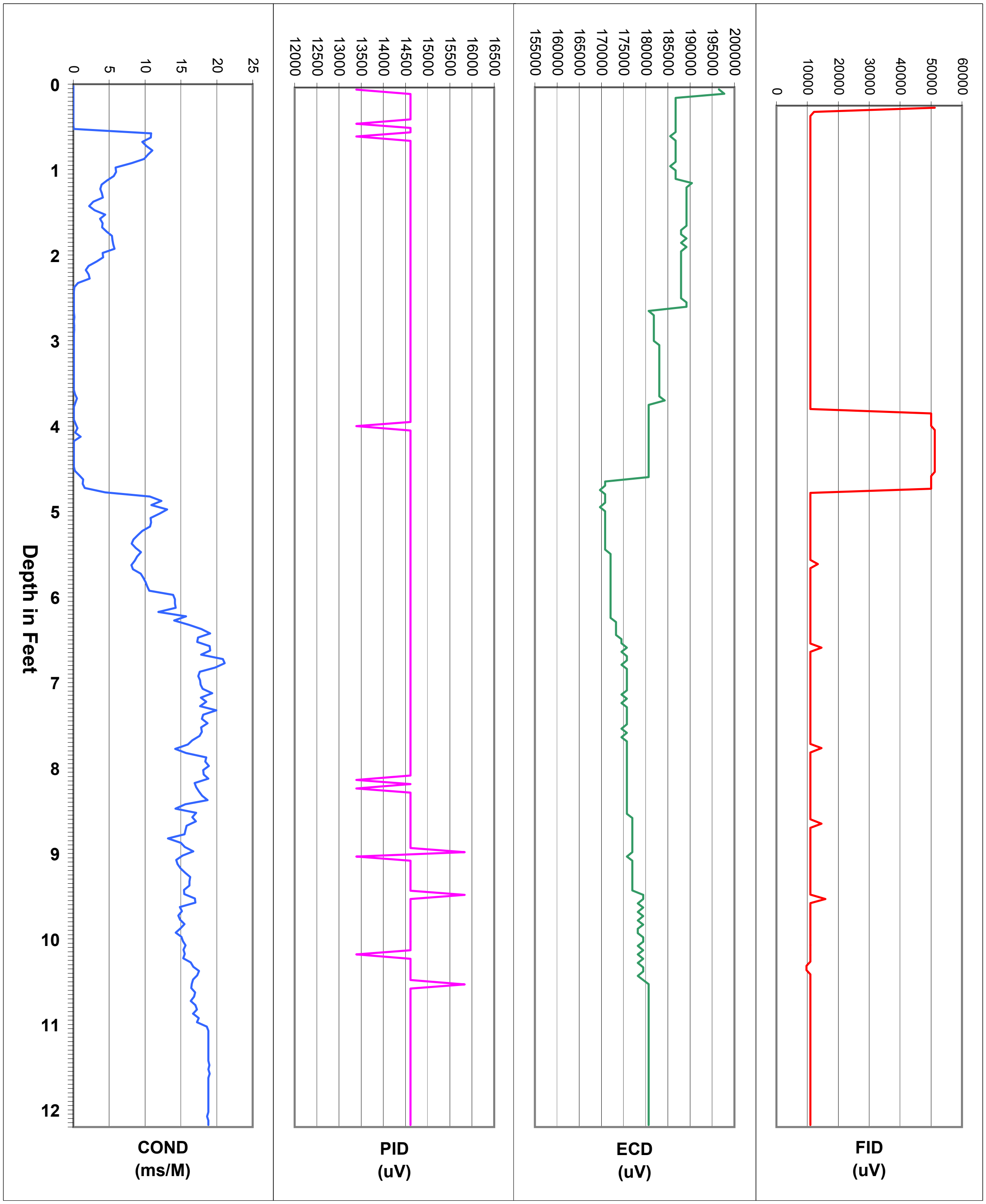
ZEBRA EC/MIP Summary Log, Point L1 2250
Cumberland, RI



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Point 16 of 48

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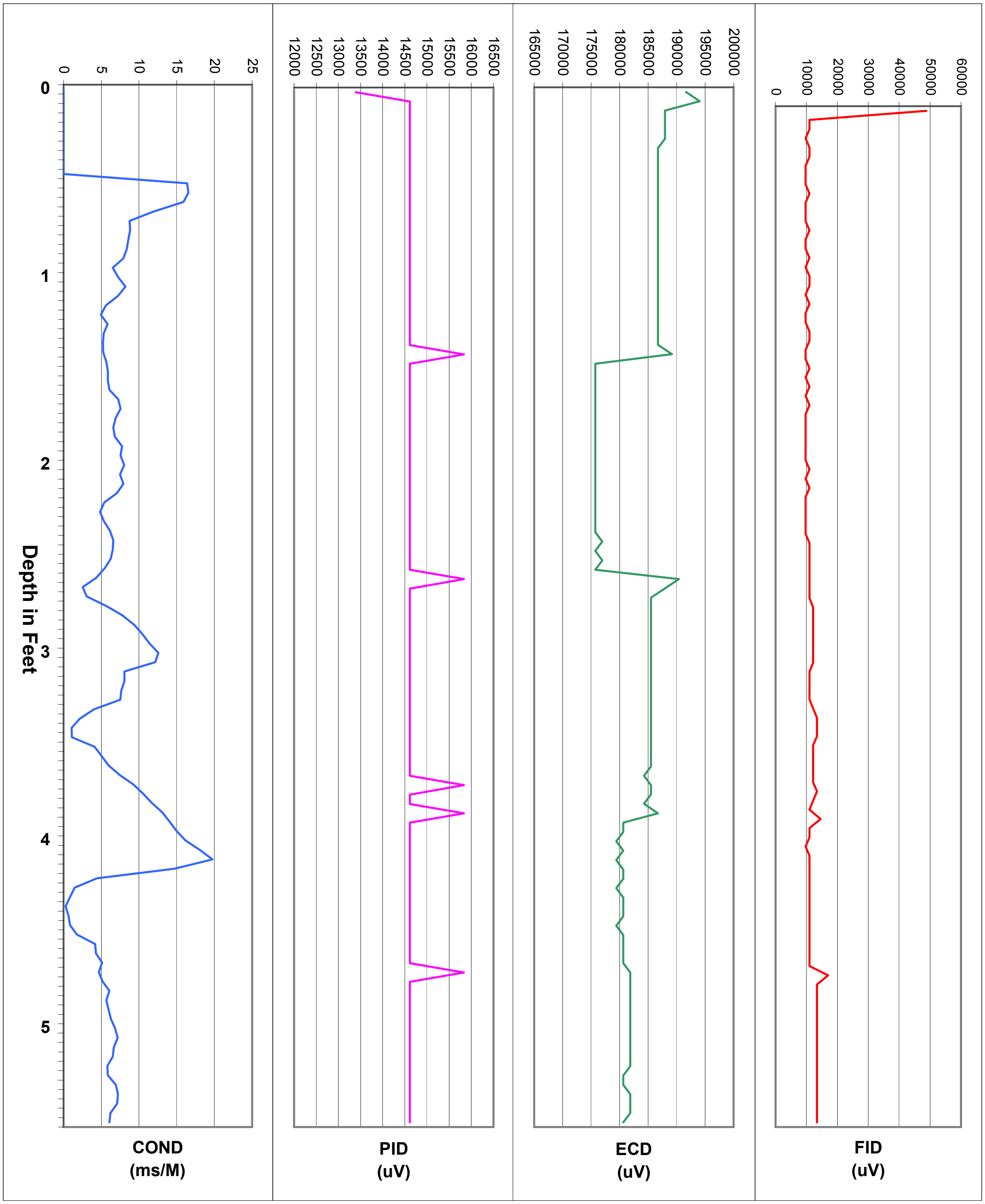
ZEBRA EC/MIP Summary Log, Point L1 2200
Cumberland, RI



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Point 17 of 48

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ZEBRA EC/MIP Summary Log, Point L1 2200
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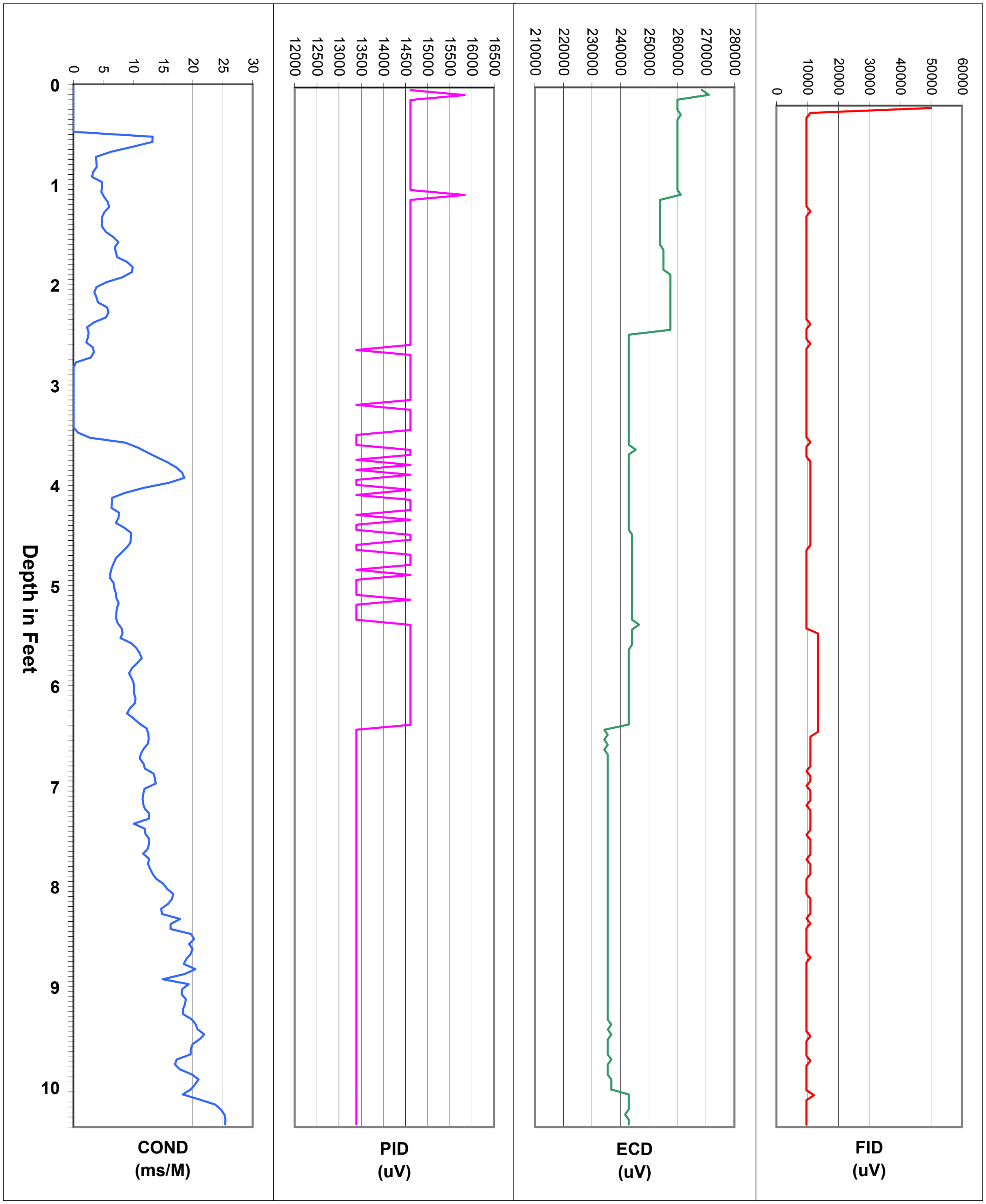

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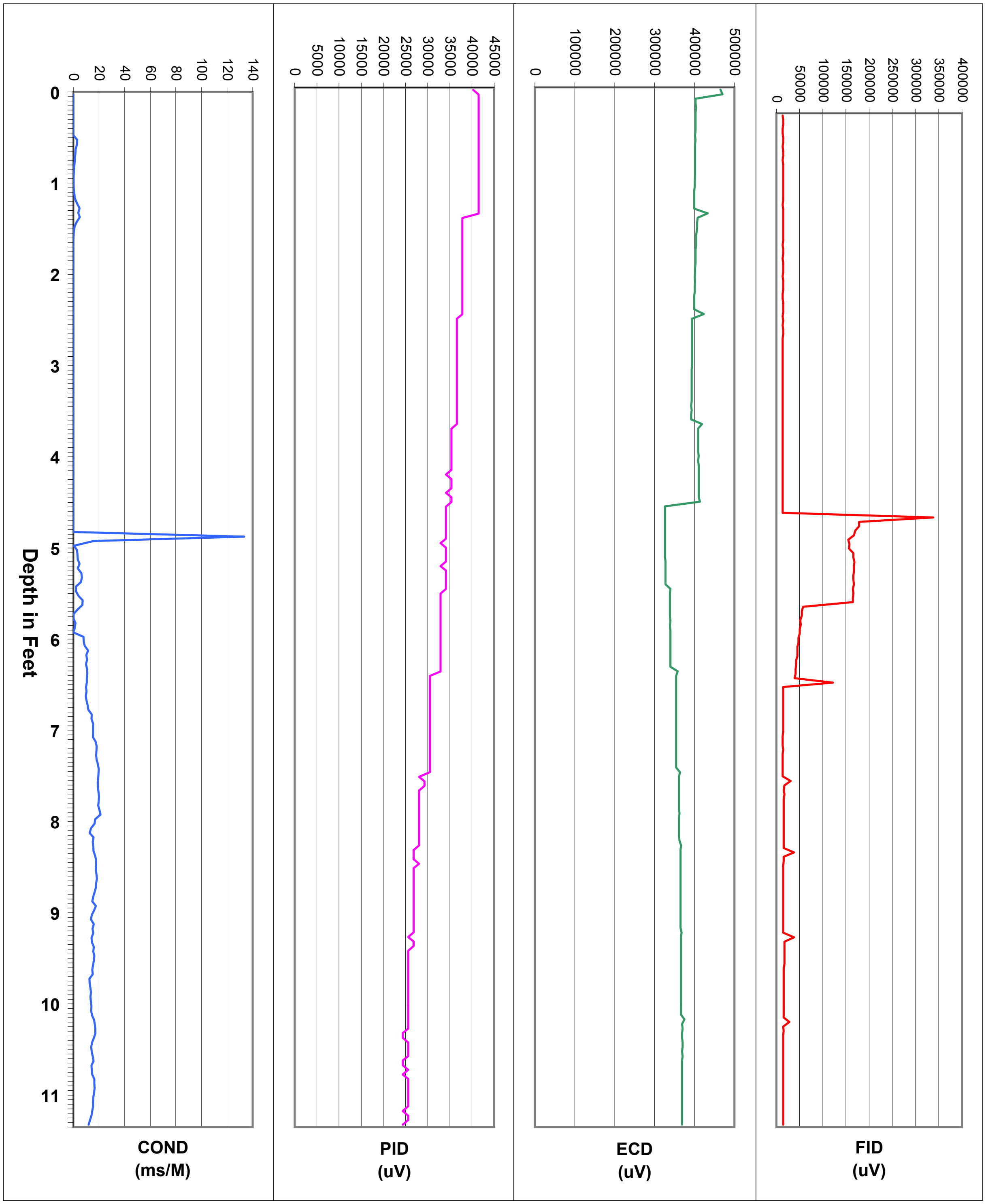
ZEBRA EC/MIP Summary Log, Point L1 2150
Cumberland, RI



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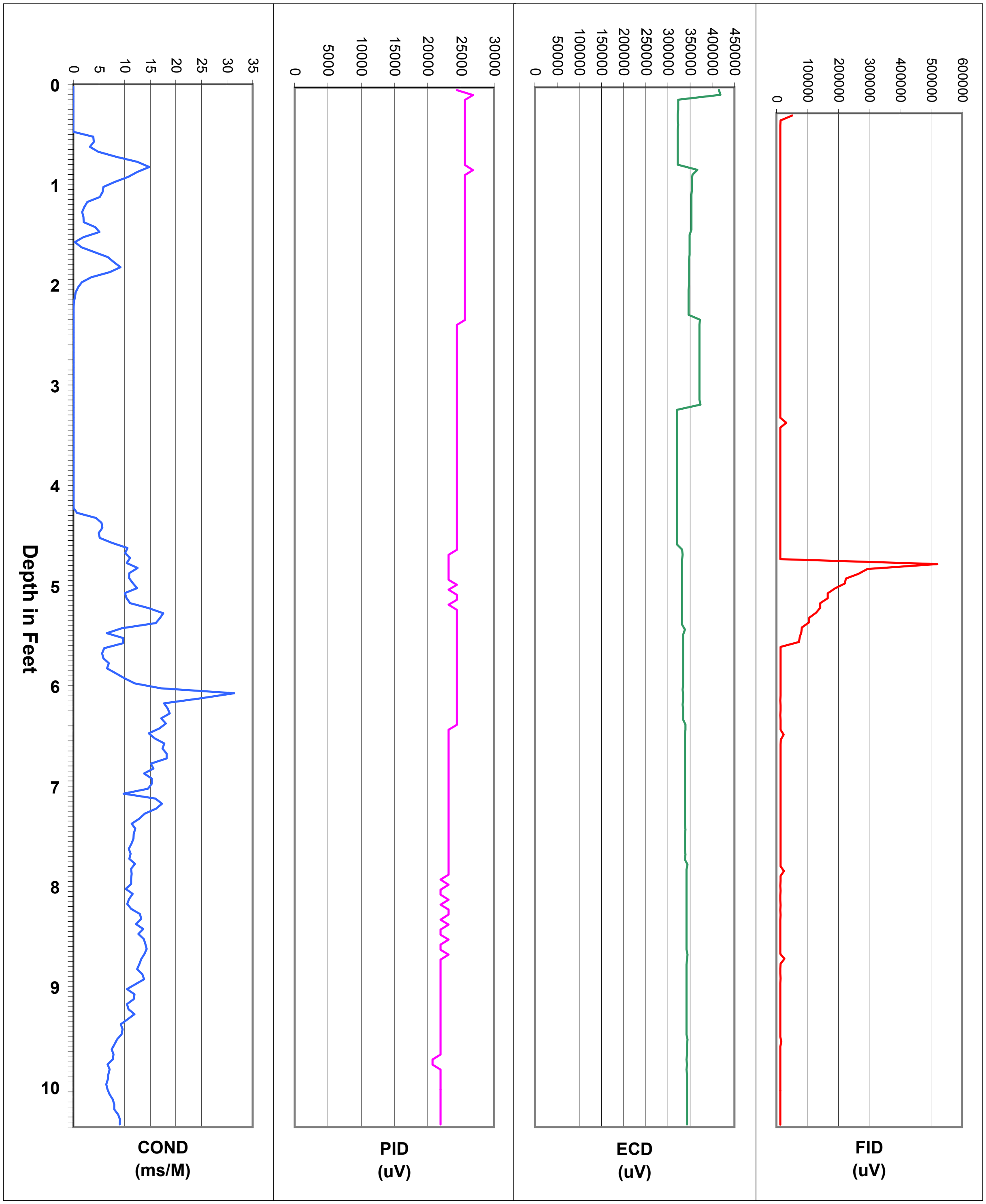
ZEBRA EC/MIP Summary Log, Point L1 2100
Cumberland, RI



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ZEBRA EC/MIP Summary Log, Point L1 2050
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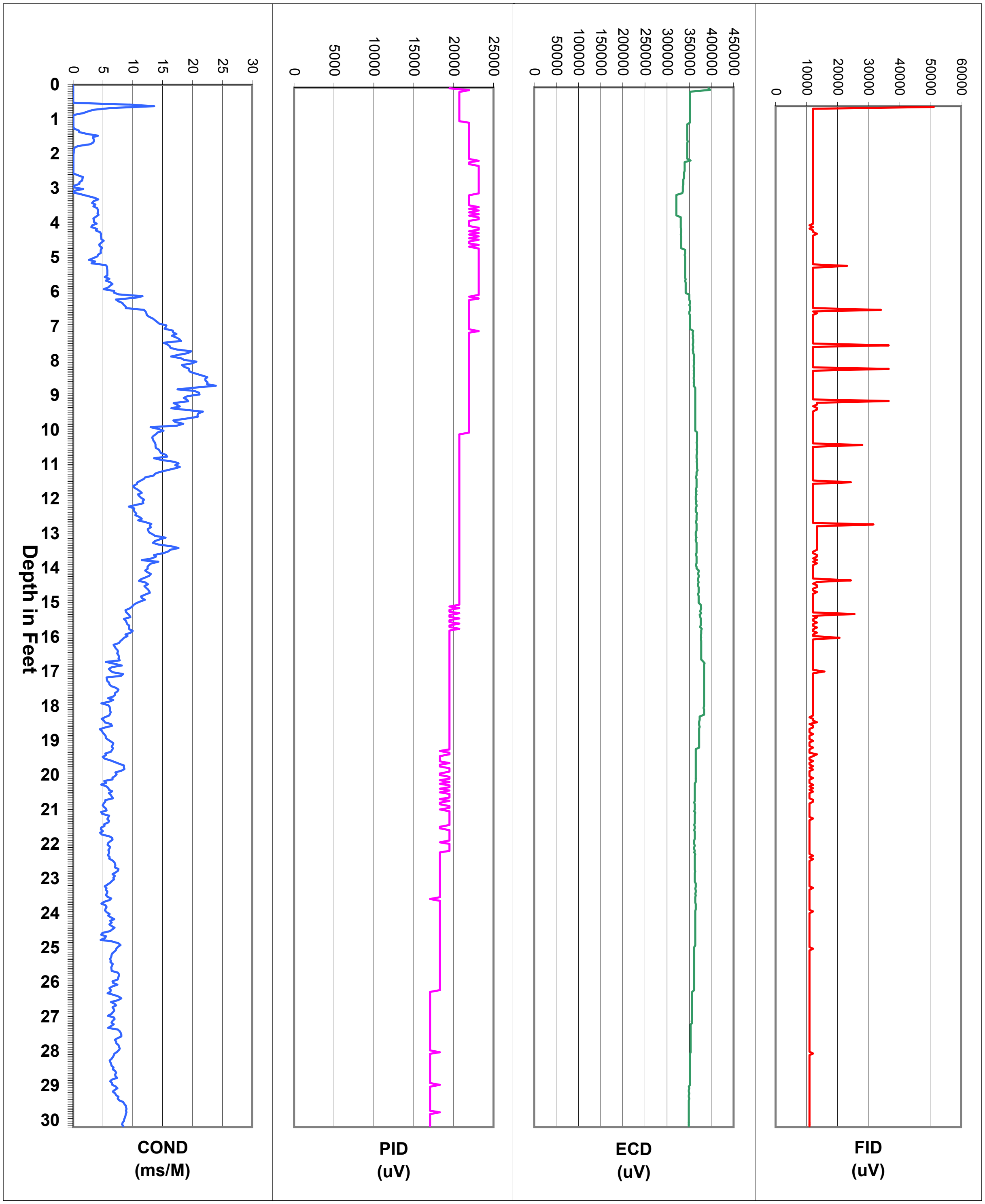

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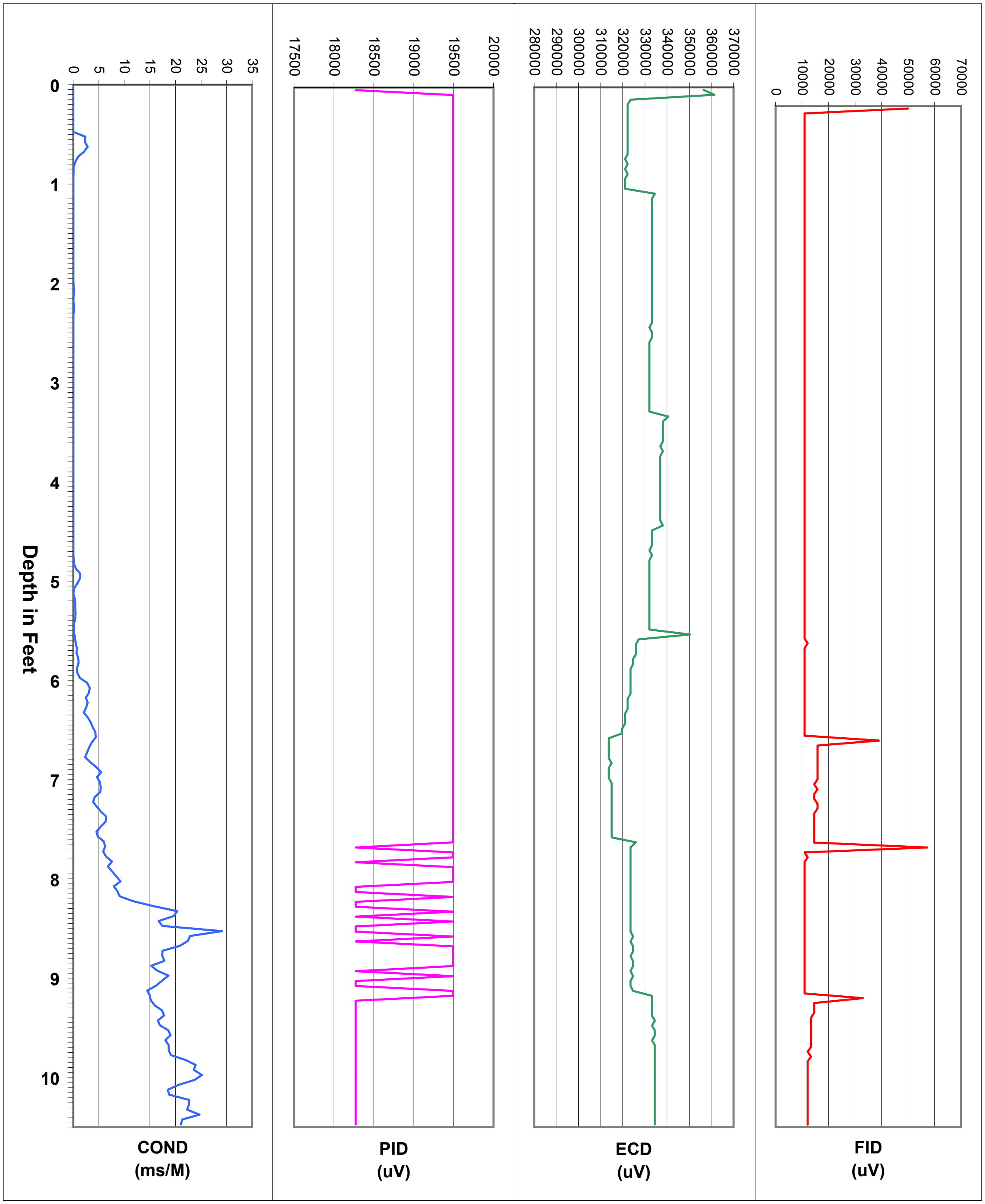
ZEBRA EC/MIP Summary Log, Point L1 2000
Cumberland, RI



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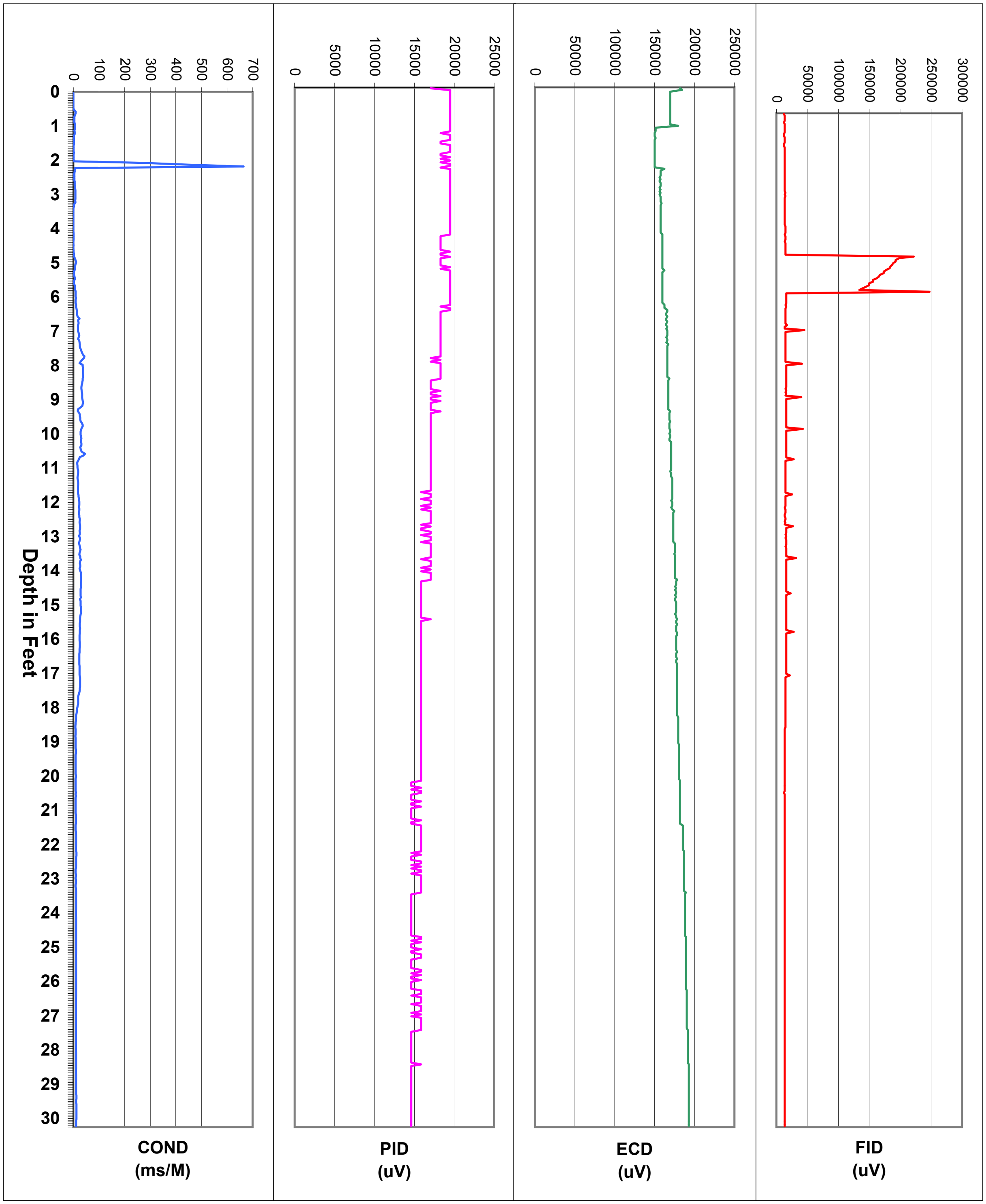
Point 22 of 48

ZEBRA EC/MIP Summary Log, Point L2 1000
Cumberland, RI



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Point 23 of 48

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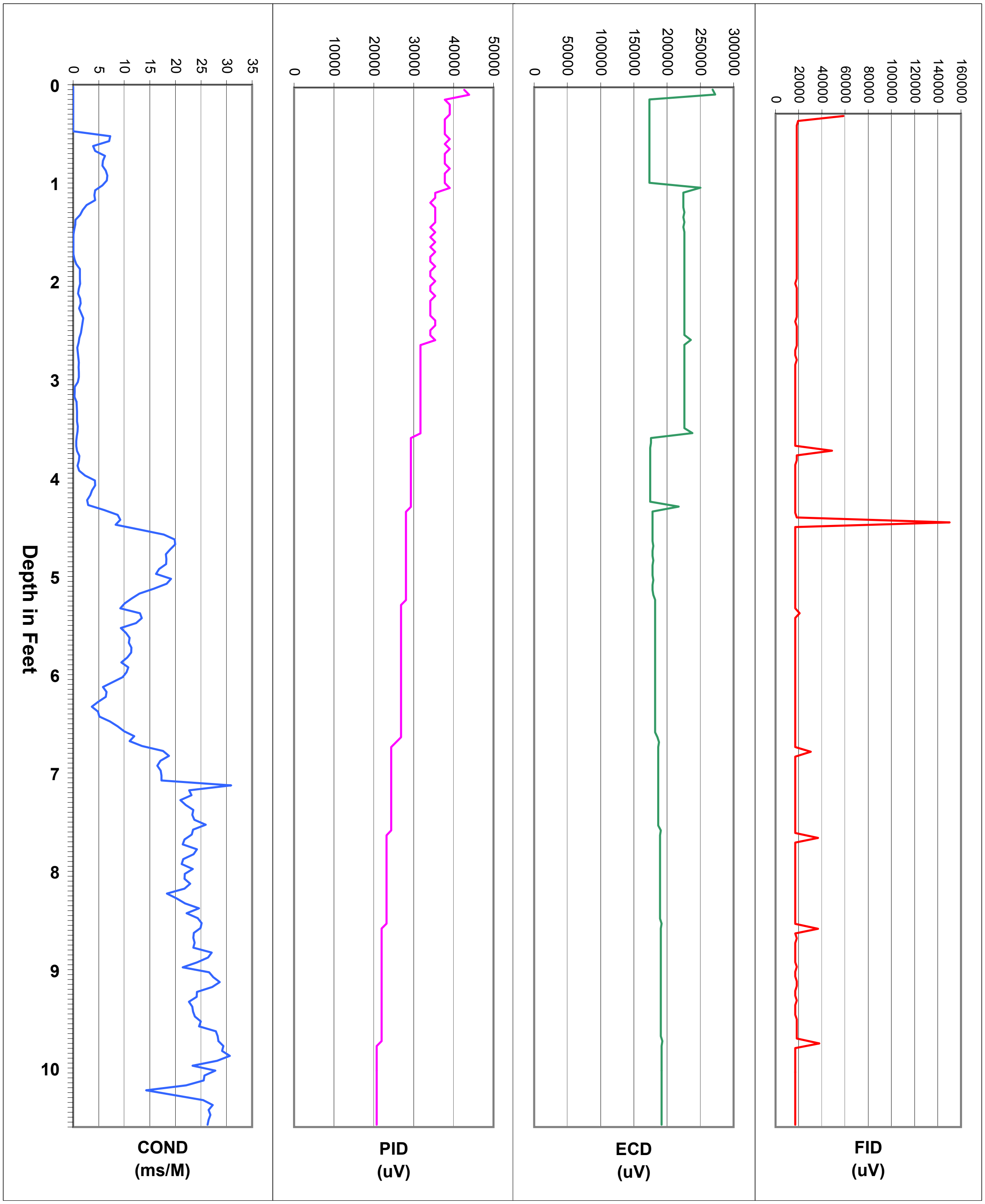
ZEBRA EC/MIP Summary Log, Point L2 0950
Cumberland, RI



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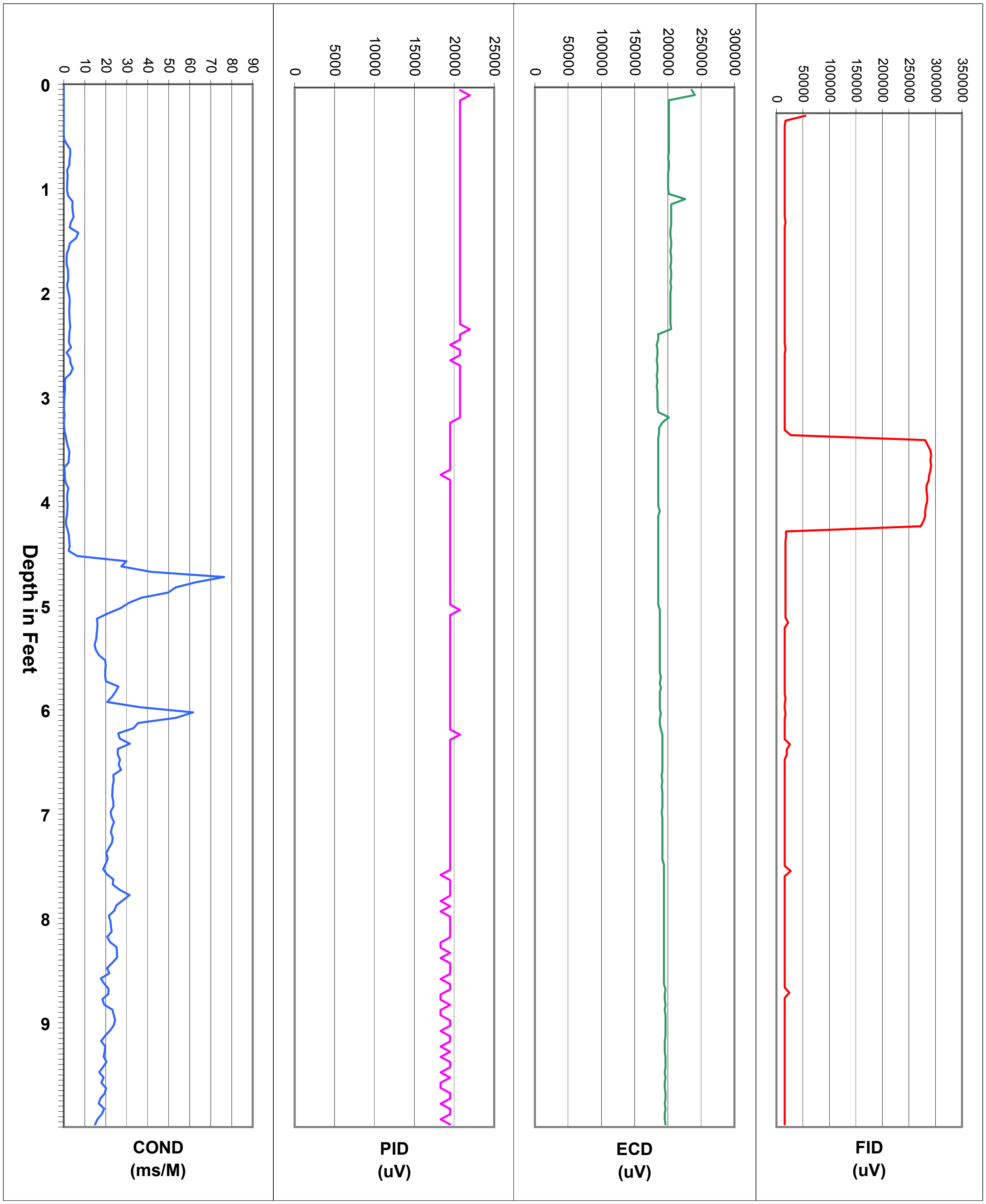
ZEBRA EC/MIP Summary Log, Point L2 0900
Cumberland, RI



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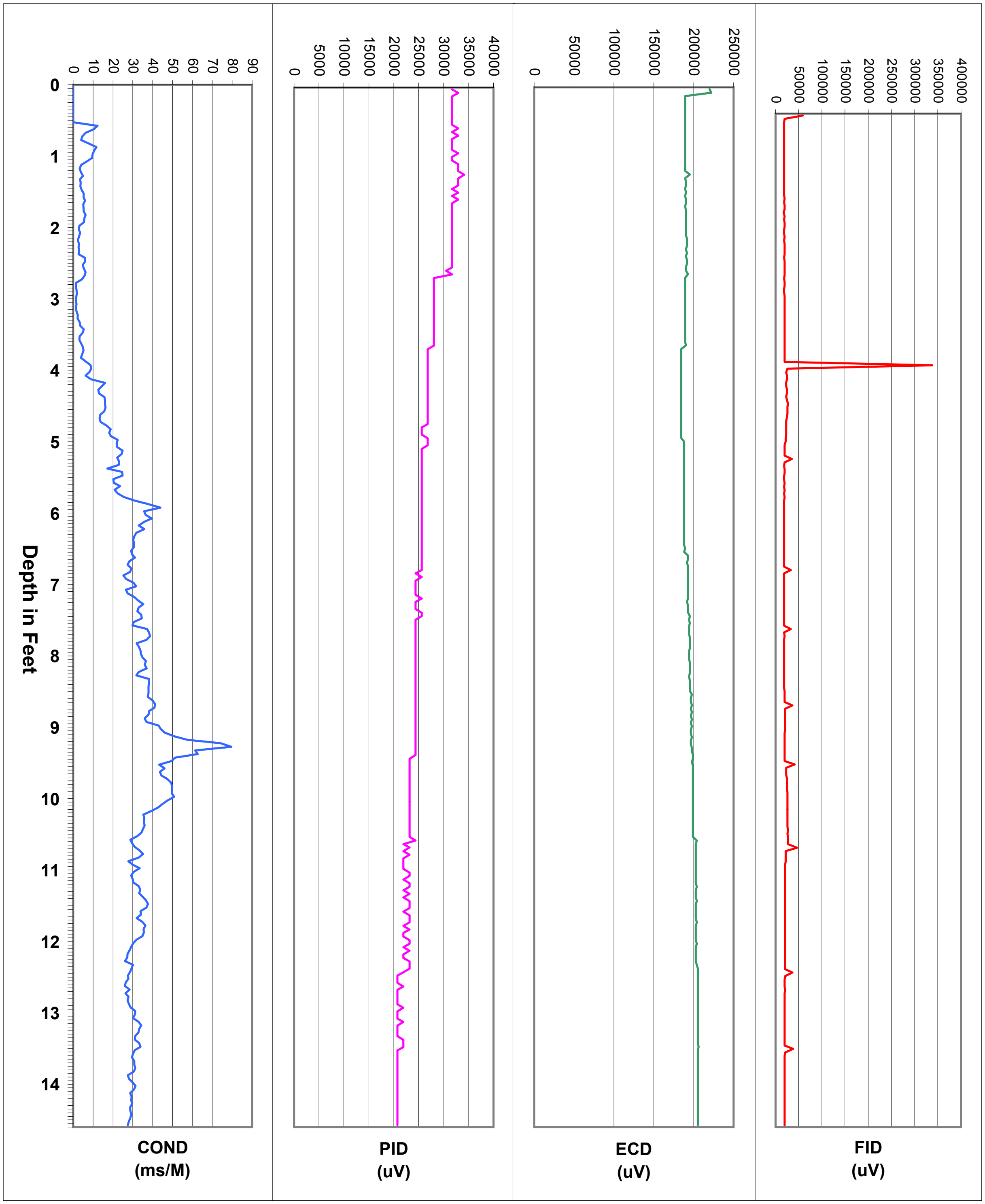
Point 25 of 48

ZEBRA EC/MIP Summary Log, Point L2 0850
Cumberland, RI



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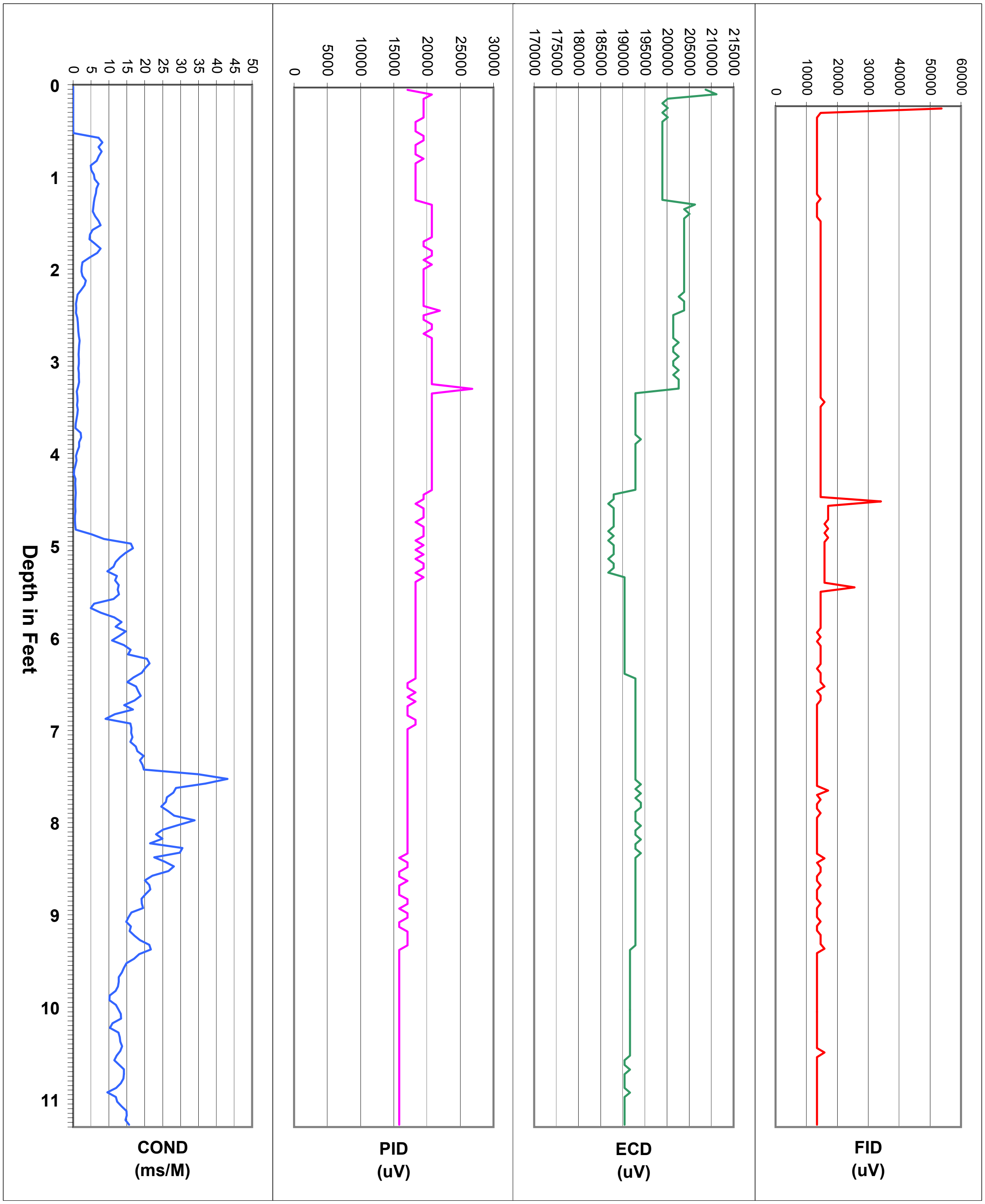
ZEBRA EC/MIP Summary Log, Point L2 0750
Cumberland, RI



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Point 27 of 48

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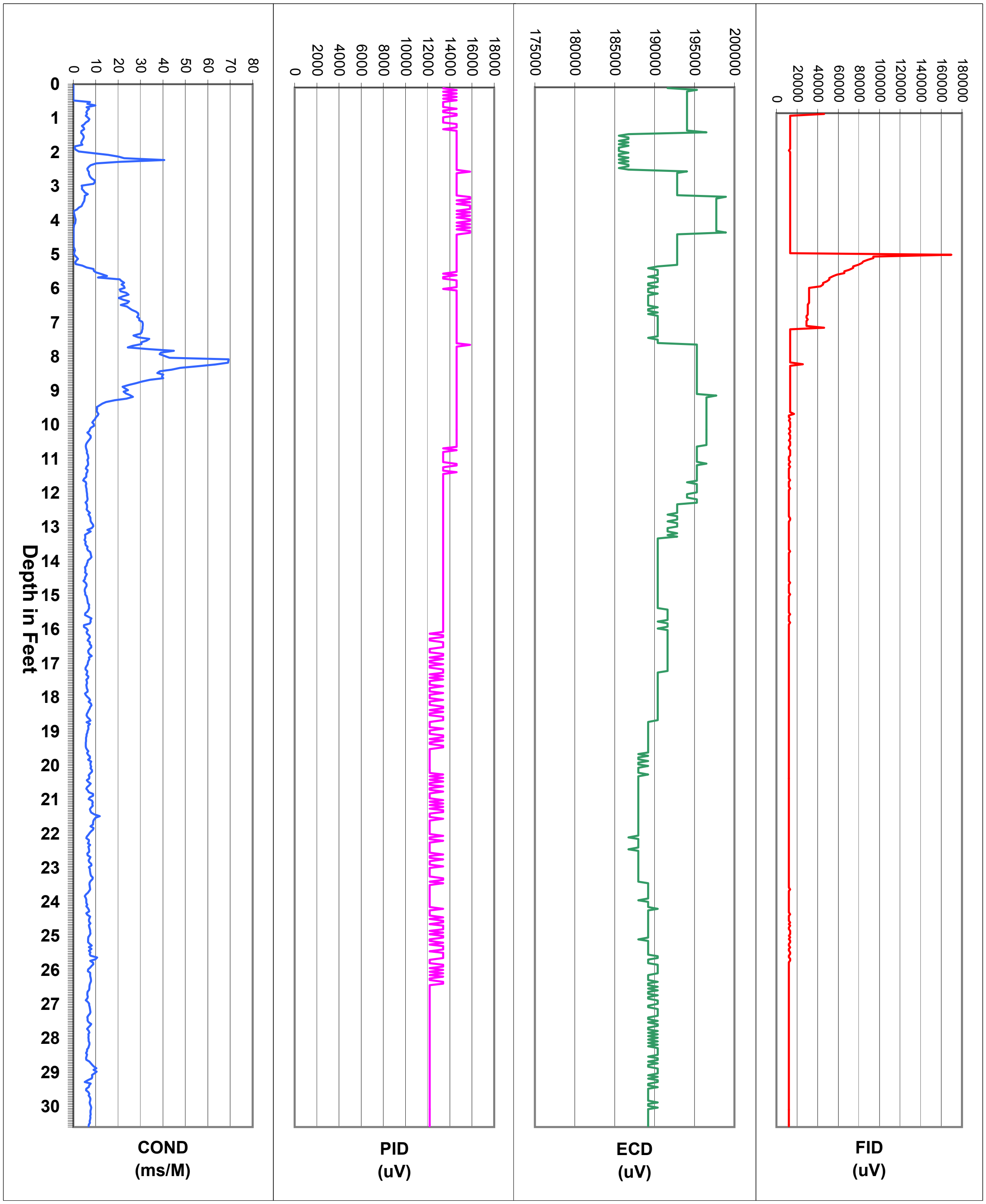
ZEBRA EC/MIP Summary Log, Point L2 0715
Cumberland, RI



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Proj. #: ZDS07230
Operators: JS
Point 28 of 48

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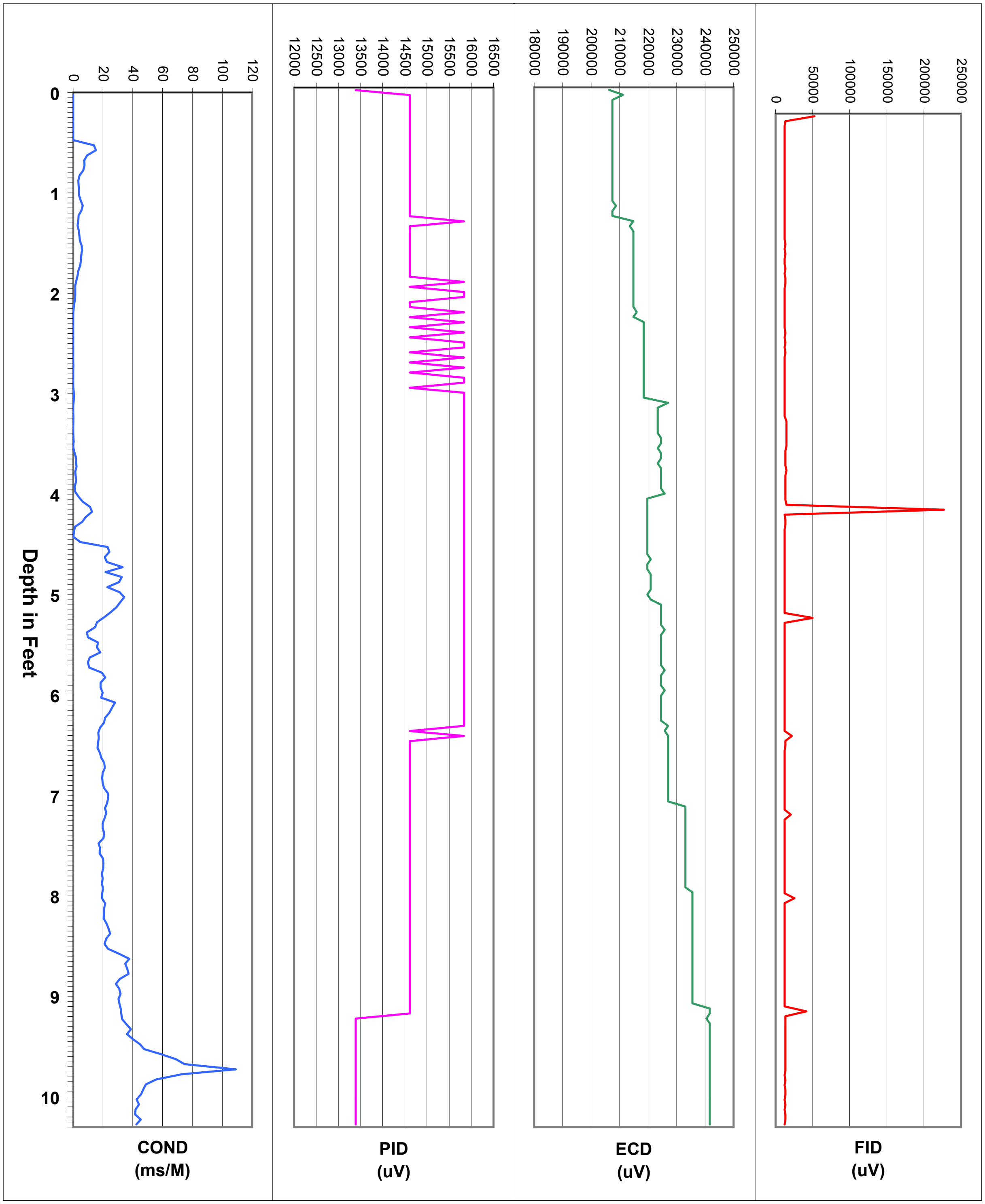
ZEBRA EC/MIP Summary Log, Point L2 0800
Cumberland, RI

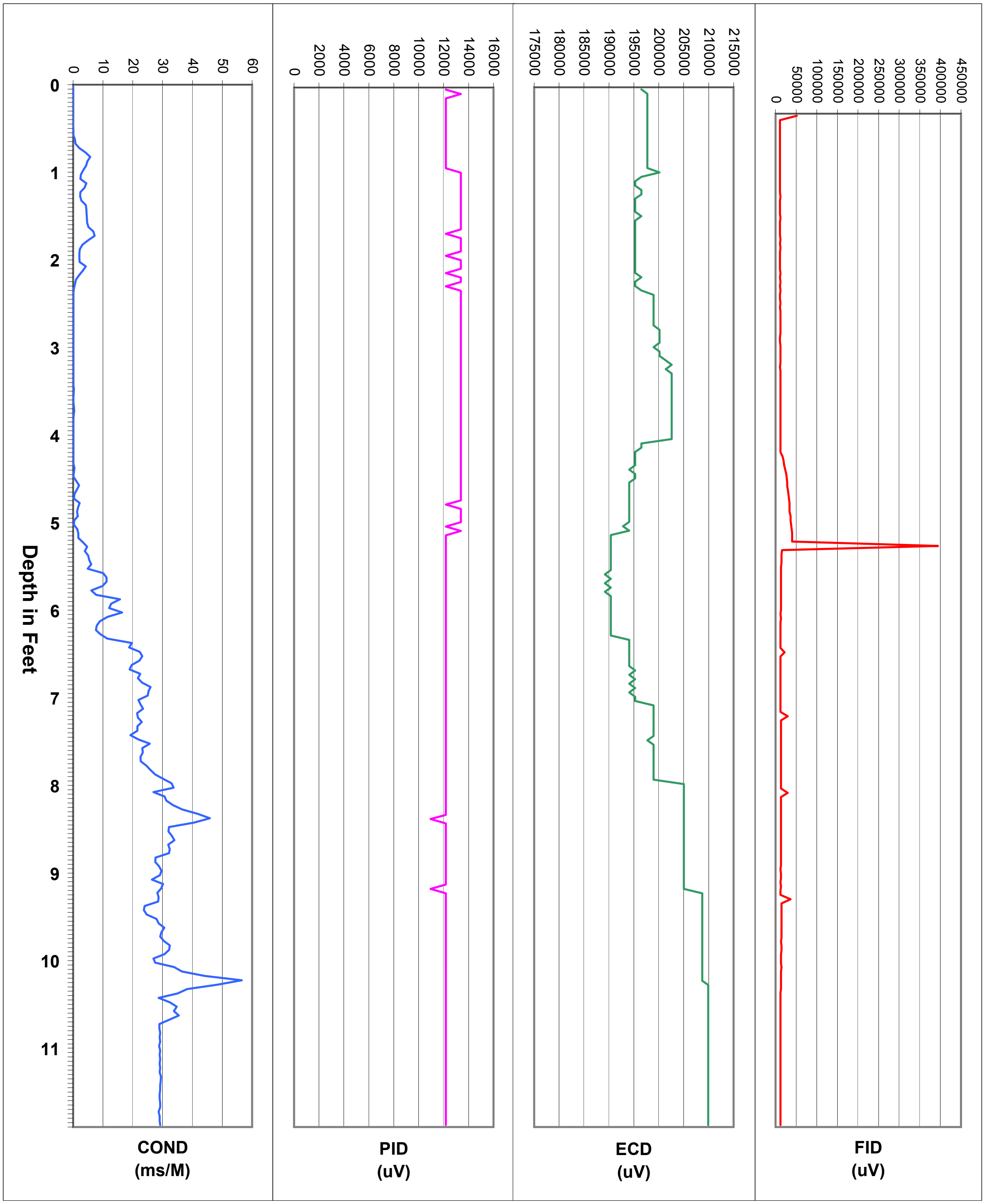


ZEBRA

for: Shield Env.
by: Zebra Environmental
30 No. Prospect Avenue
Lynbrook, NY 11563
(516) 596-6300

Date: 8/26/2003
Proj. Name: Shield/Cumberland
Proj. #: ZDS07230
Operators: JS
Point 29 of 48

ZEBRA EC/MIP Summary Log, Point L2 0360
Cumberland, RI



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for: Shield Env.
by: Zebra Environmental
30 No. Prospect Avenue
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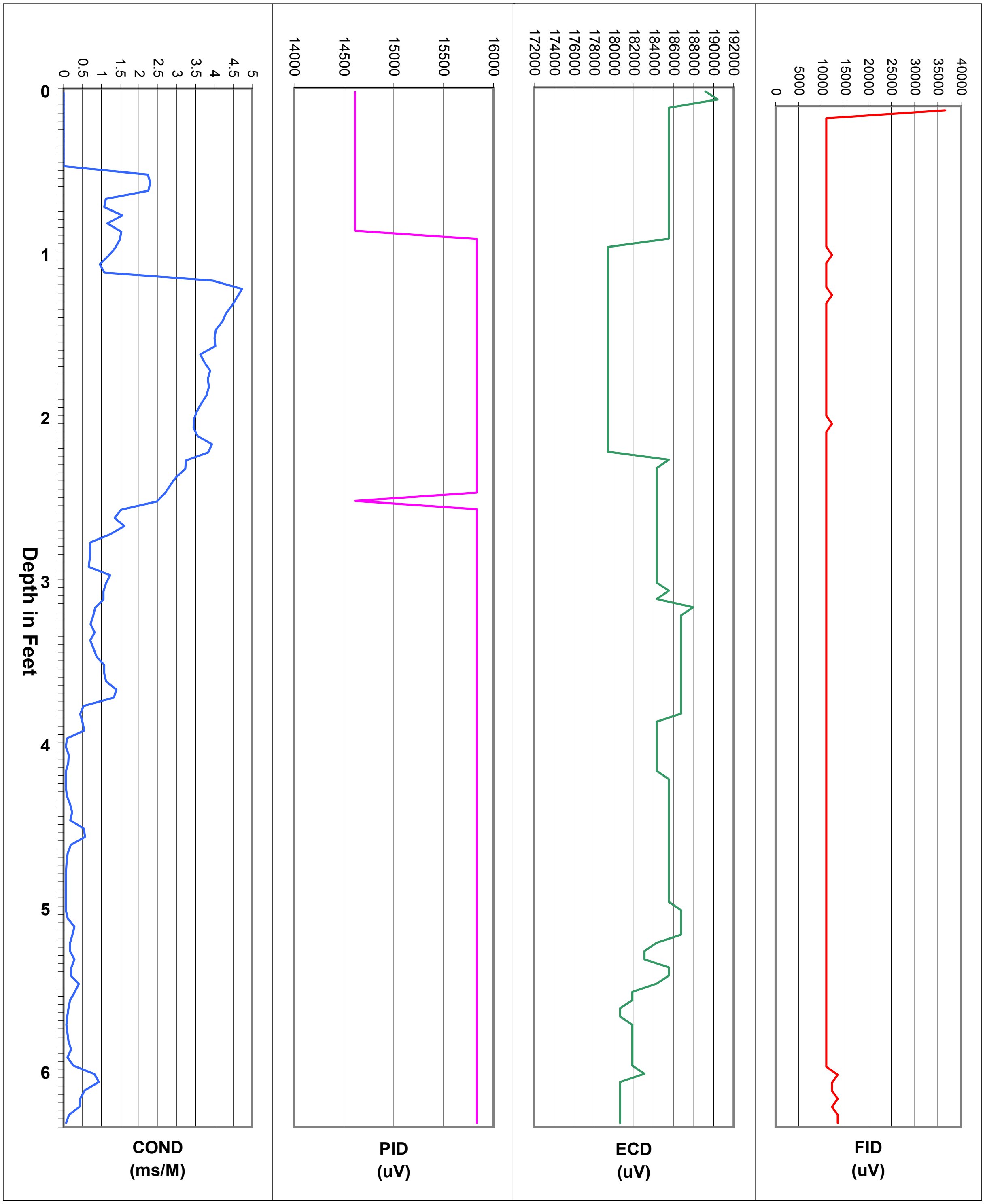
(516) 596-6300

Date: 8/26/2003
Proj. Name: Shield/Cumberland
Proj. #: ZDS07230
Operators: JS
Point 30 of 48

ZEBRA EC/MIP Summary Log, Point L2 0300
Cumberland, RI



for: Shield Env.
by: Zebra Environmental
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(516) 596-6300

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Proj. Name: Shield/Cumberland
Proj. #: ZDS07230
Operators: JS
Point 31 of 48

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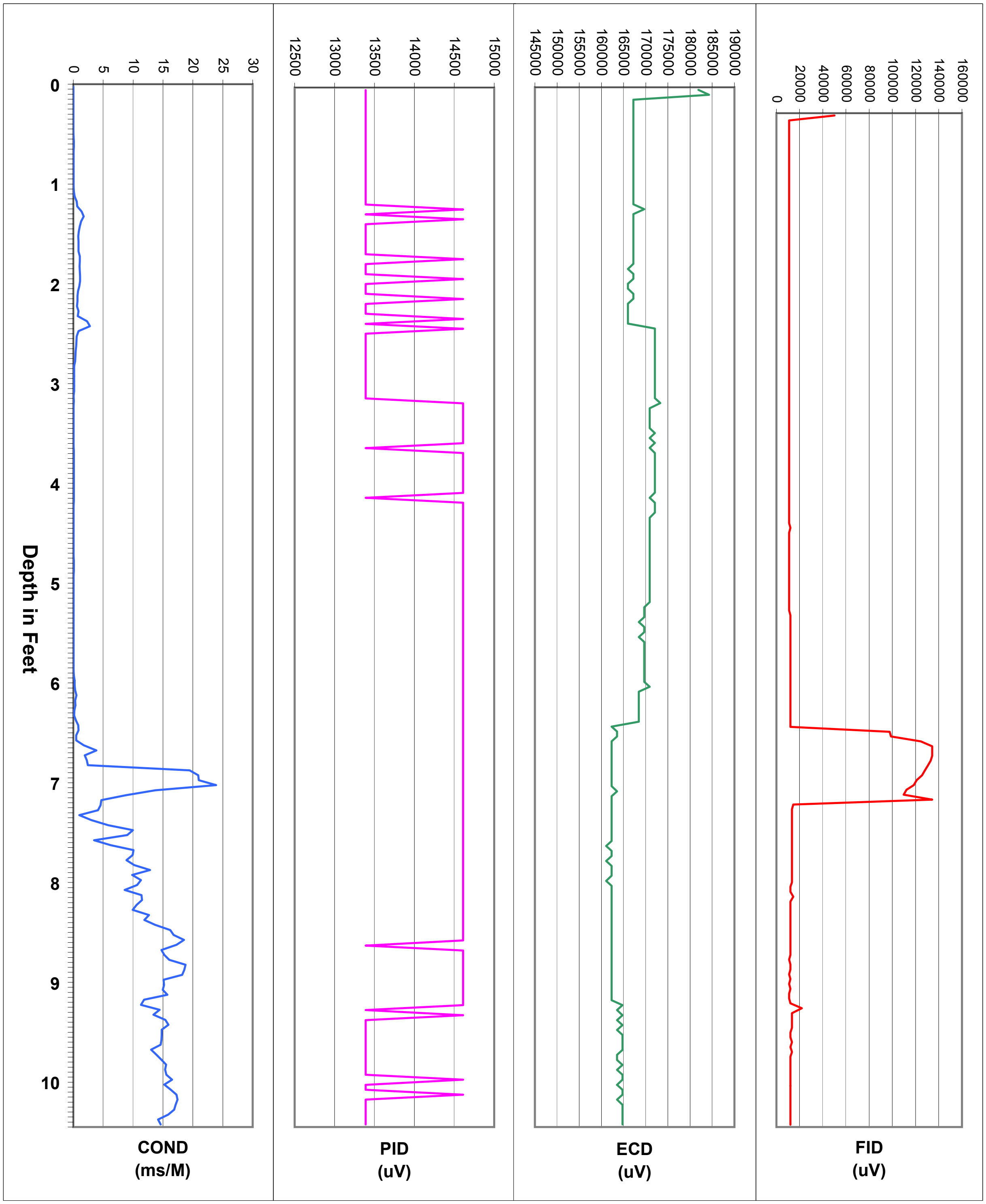
ZEBRA EC/MIP Summary Log, Point L2 0250
Cumberland, RI



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Proj. Name: Shield/Cumberland
Proj. #: ZDS07230
Operators: JS
Point 32 of 48

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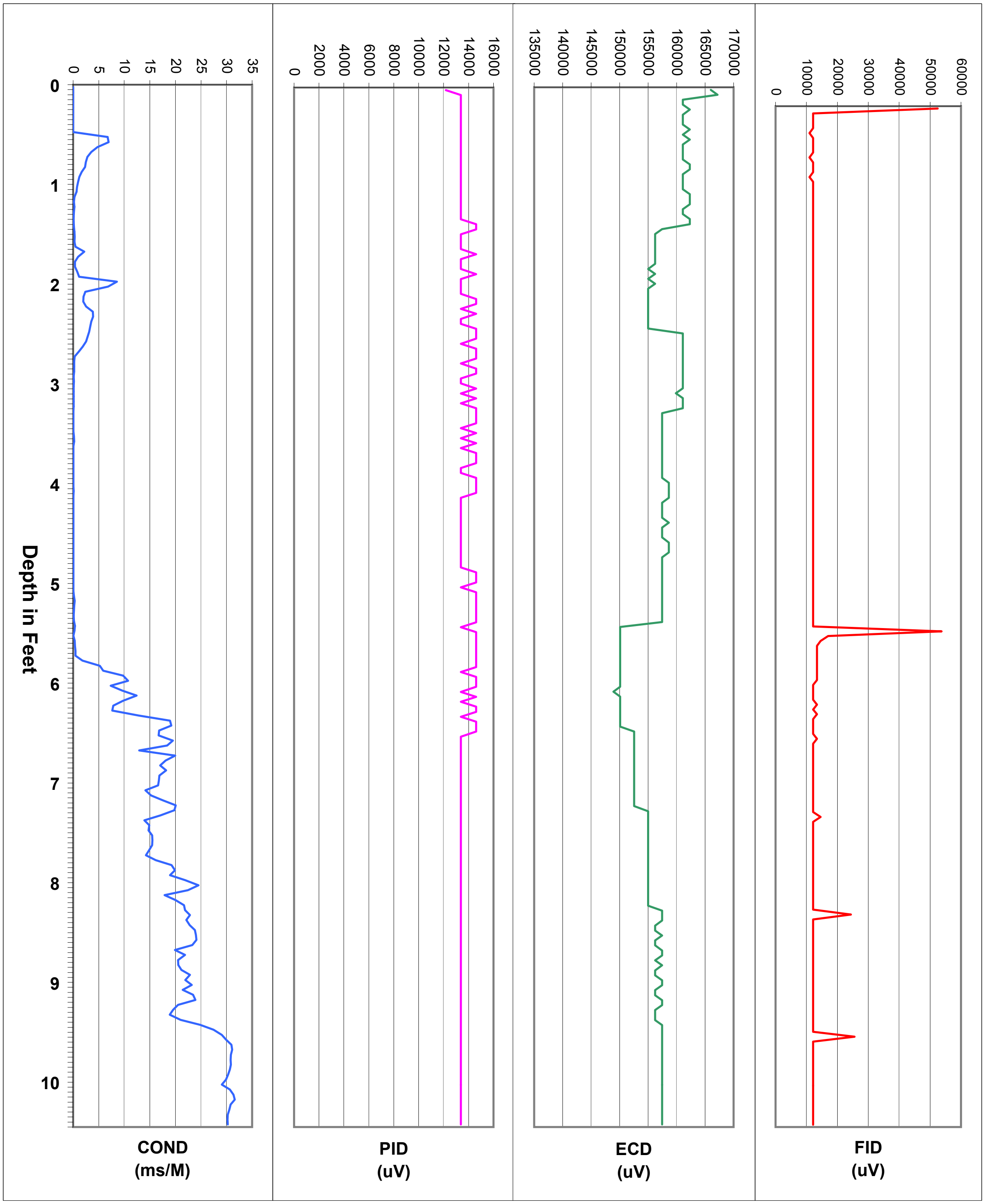
ZEBRA EC/MIP Summary Log, Point L2 0200
Cumberland, RI



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Point 33 of 48

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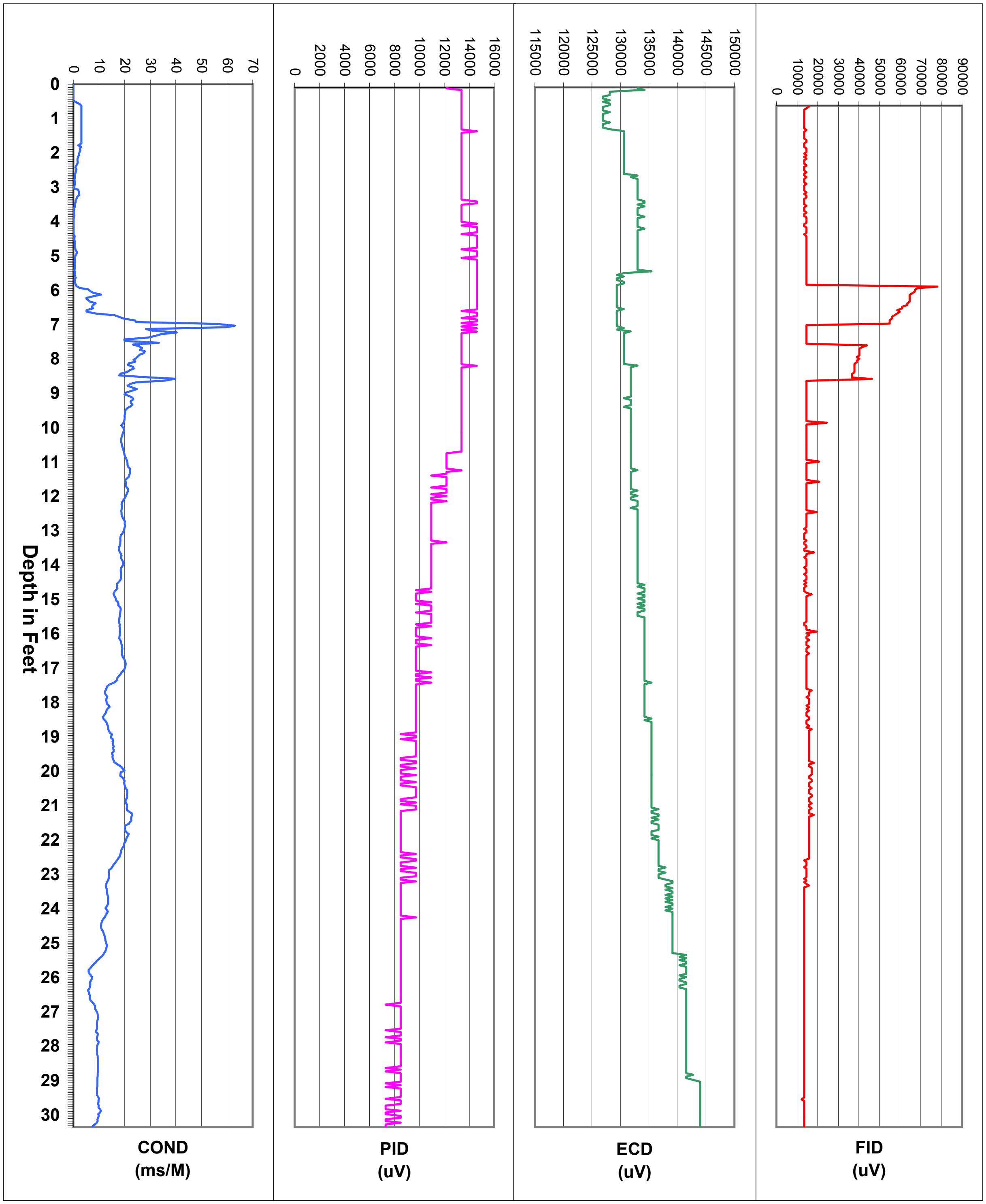
ZEBRA EC/MIP Summary Log, Point L2 0150
Cumberland, RI



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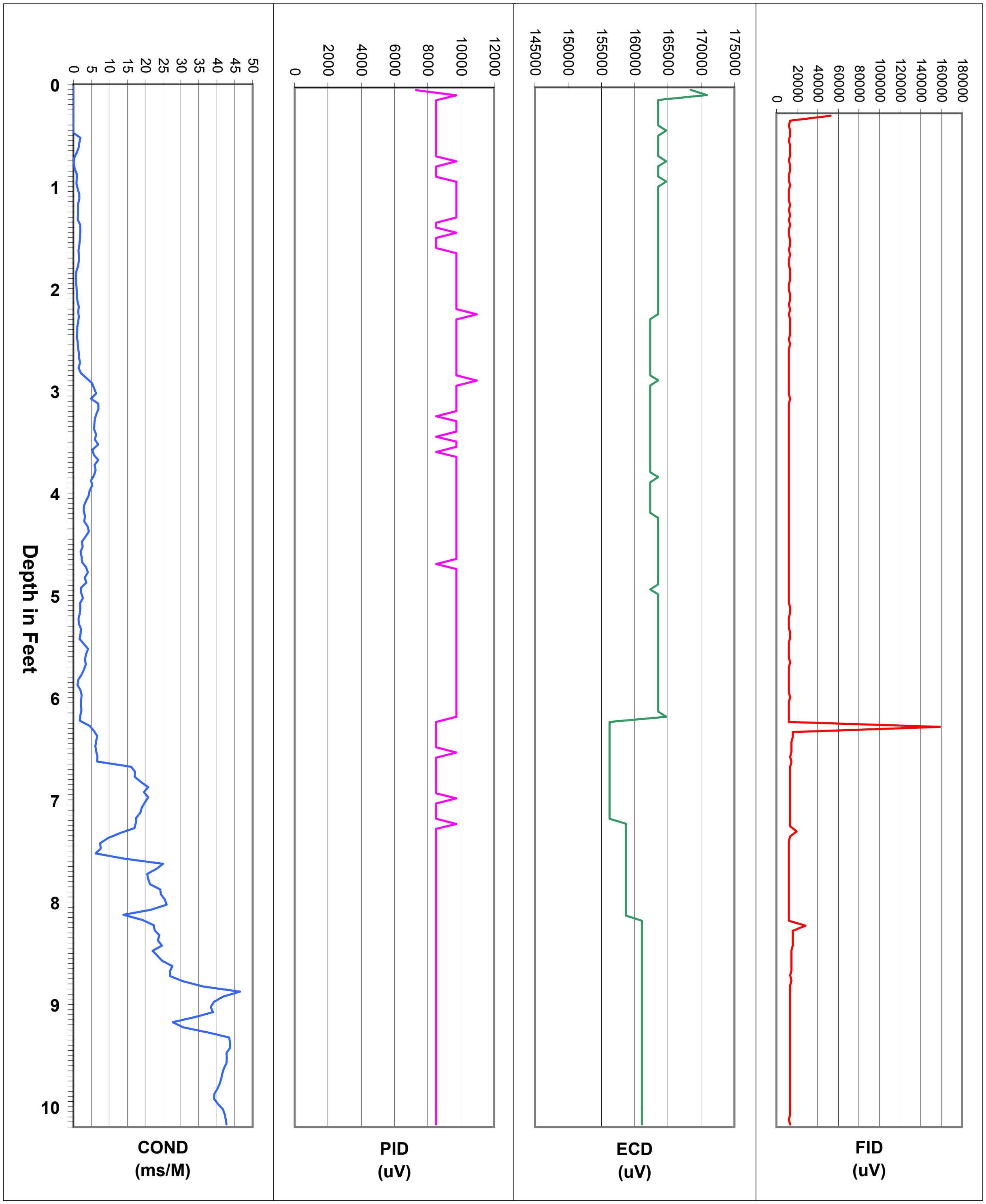
Proj. Name: Shield/Cumberland
Proj. #: ZDS07230
Operators: JS
Point 34 of 48

US EPA ARCHIVE DOCUMENT

ZEBRA EC/MIP Summary Log, Point L2 0100
Cumberland, RI



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by: Zebra Environmental
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Date: 8/27/2003
Proj. Name: Shield/Cumberland
Proj. #: ZDS07230
Operators: JS
Point 35 of 48

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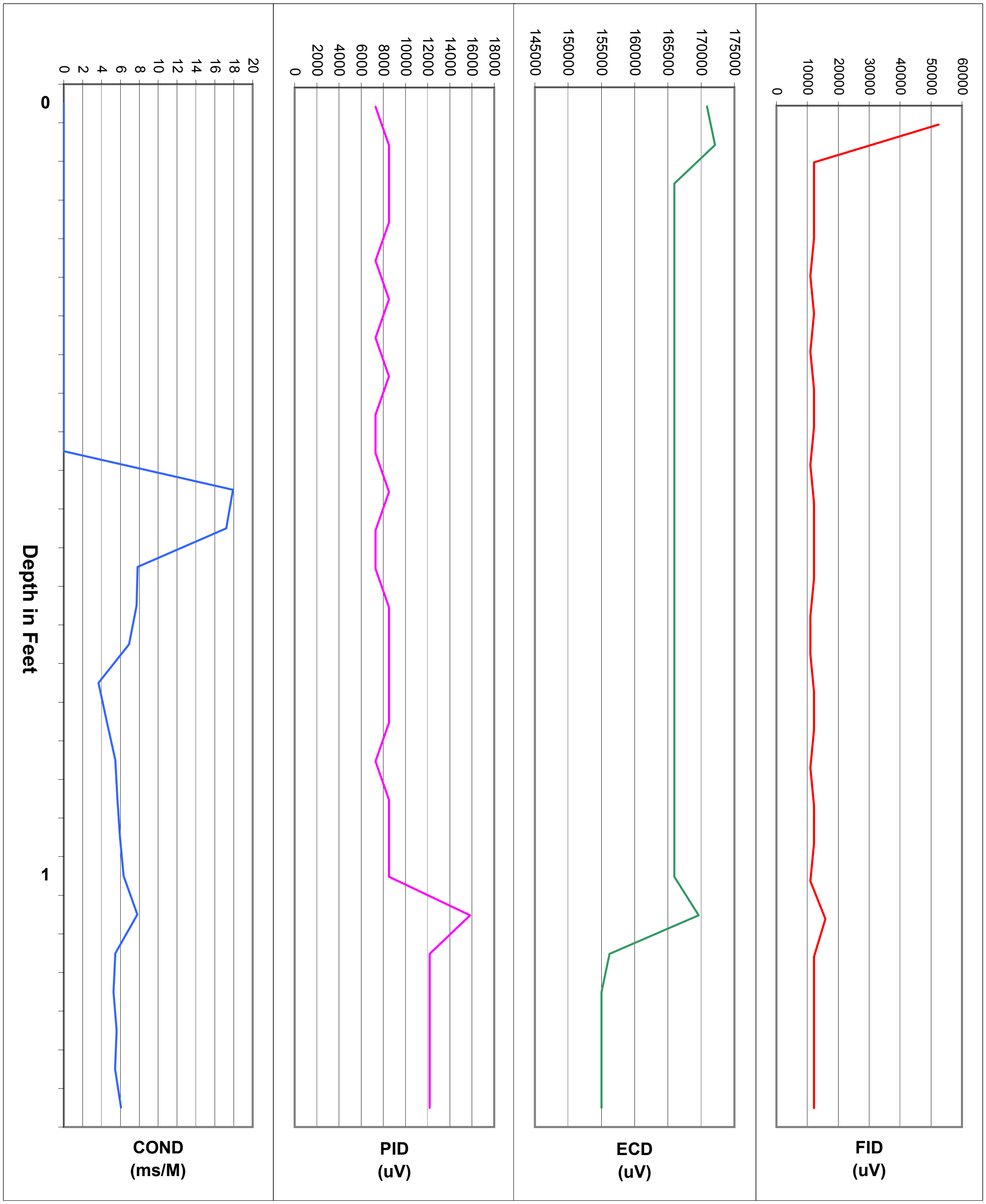
ZEBRA EC/MIP Summary Log, Point L2 0050
Cumberland, RI



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Proj. Name: Shield/Cumberland
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Point 36 of 48

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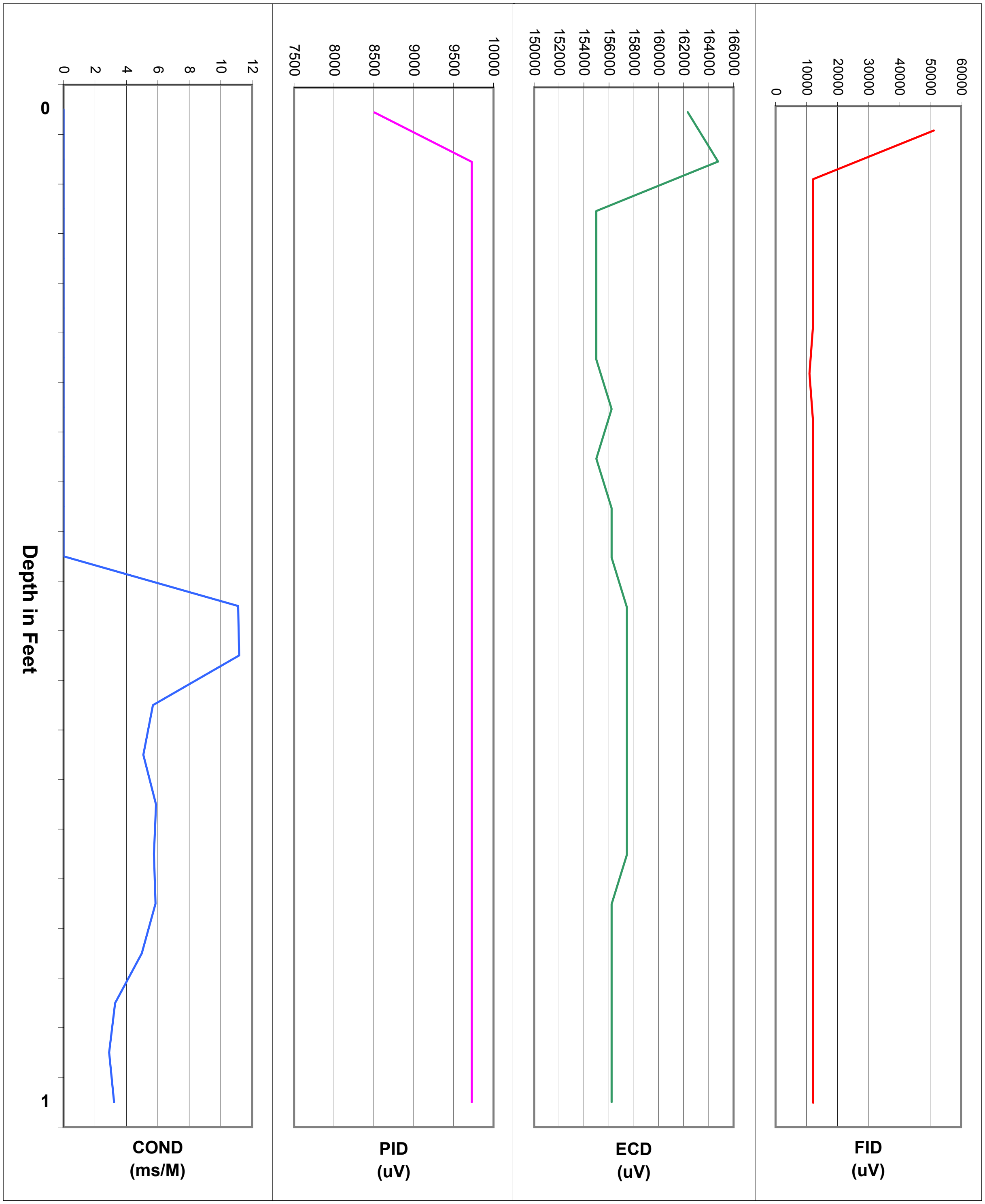
ZEBRA EC/MIP Summary Log, Point L2 0048
Cumberland, RI



for: Shield Env.
by: Zebra Environmental
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Date: 8/27/2003
Proj. Name: Shield/Cumberland
Proj. #: ZDS07230
Operators: JS
Point 37 of 48

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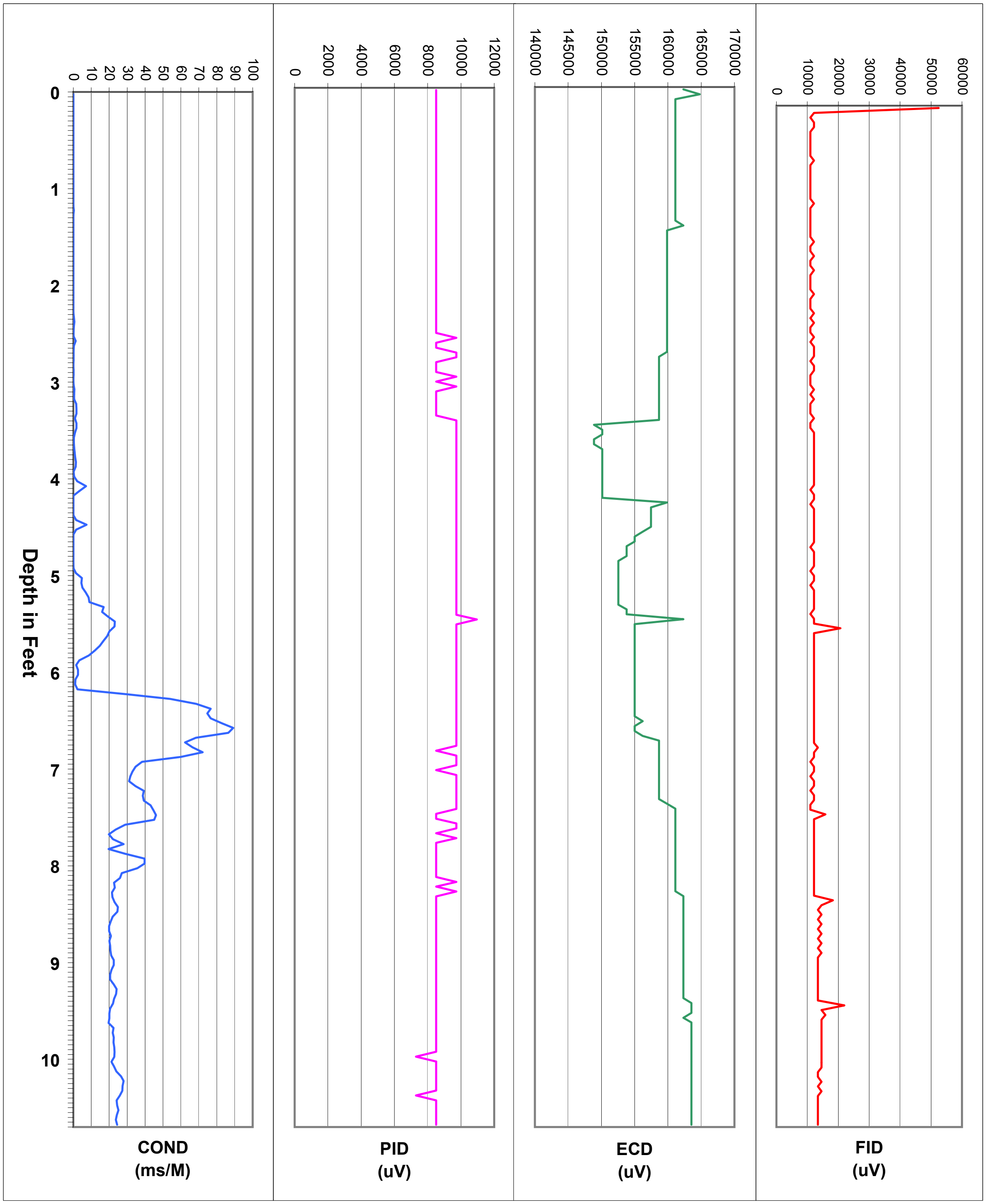
ZEBRA EC/MIP Summary Log, Point L2 0047
Cumberland, RI



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Proj. Name: Shield/Cumberland
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Point 38 of 48

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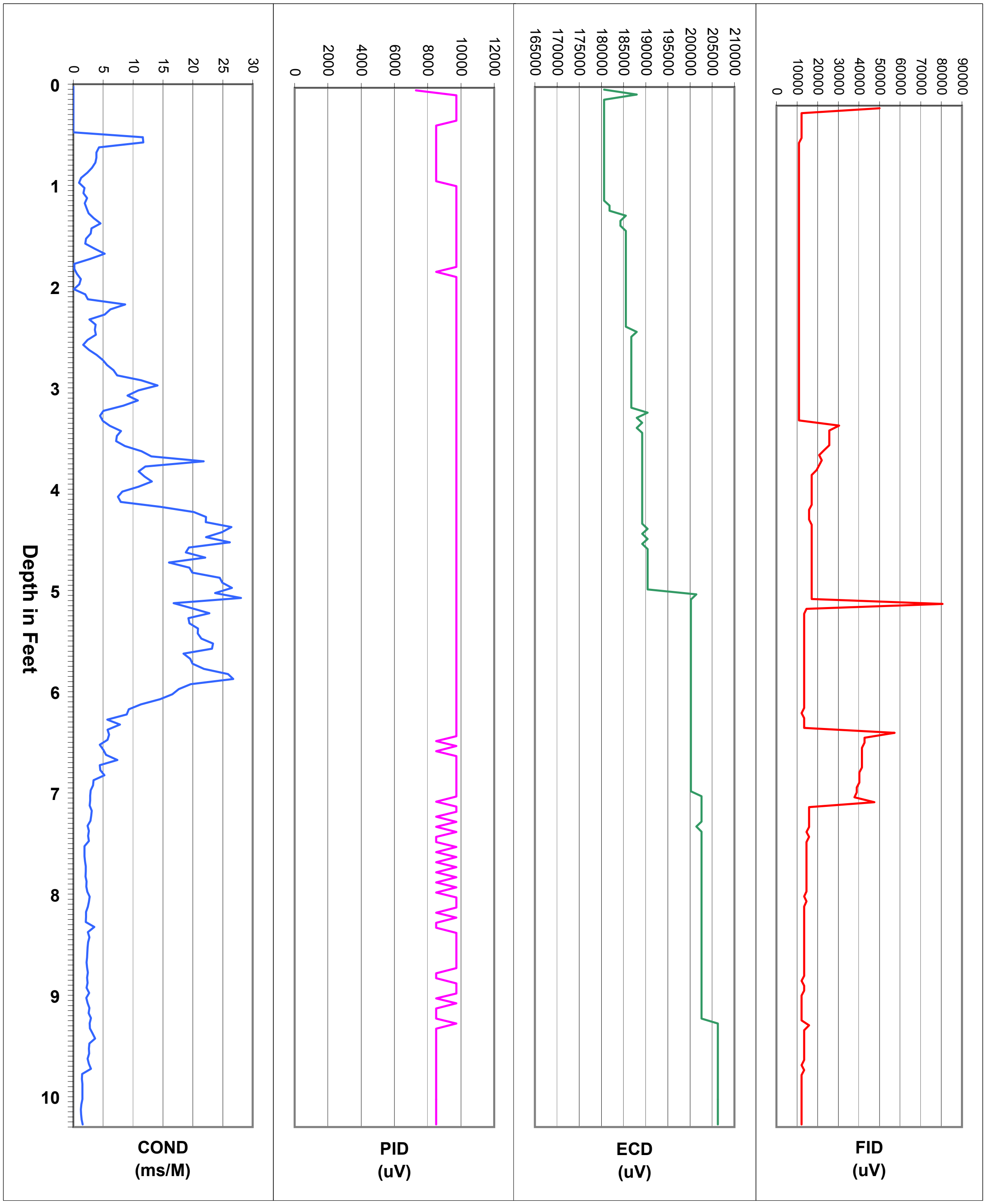
ZEBRA EC/MIP Summary Log, Point L2 0000
Cumberland, RI



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Proj. Name: Shield/Cumberland
Proj. #: ZDS07230
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Point 39 of 48

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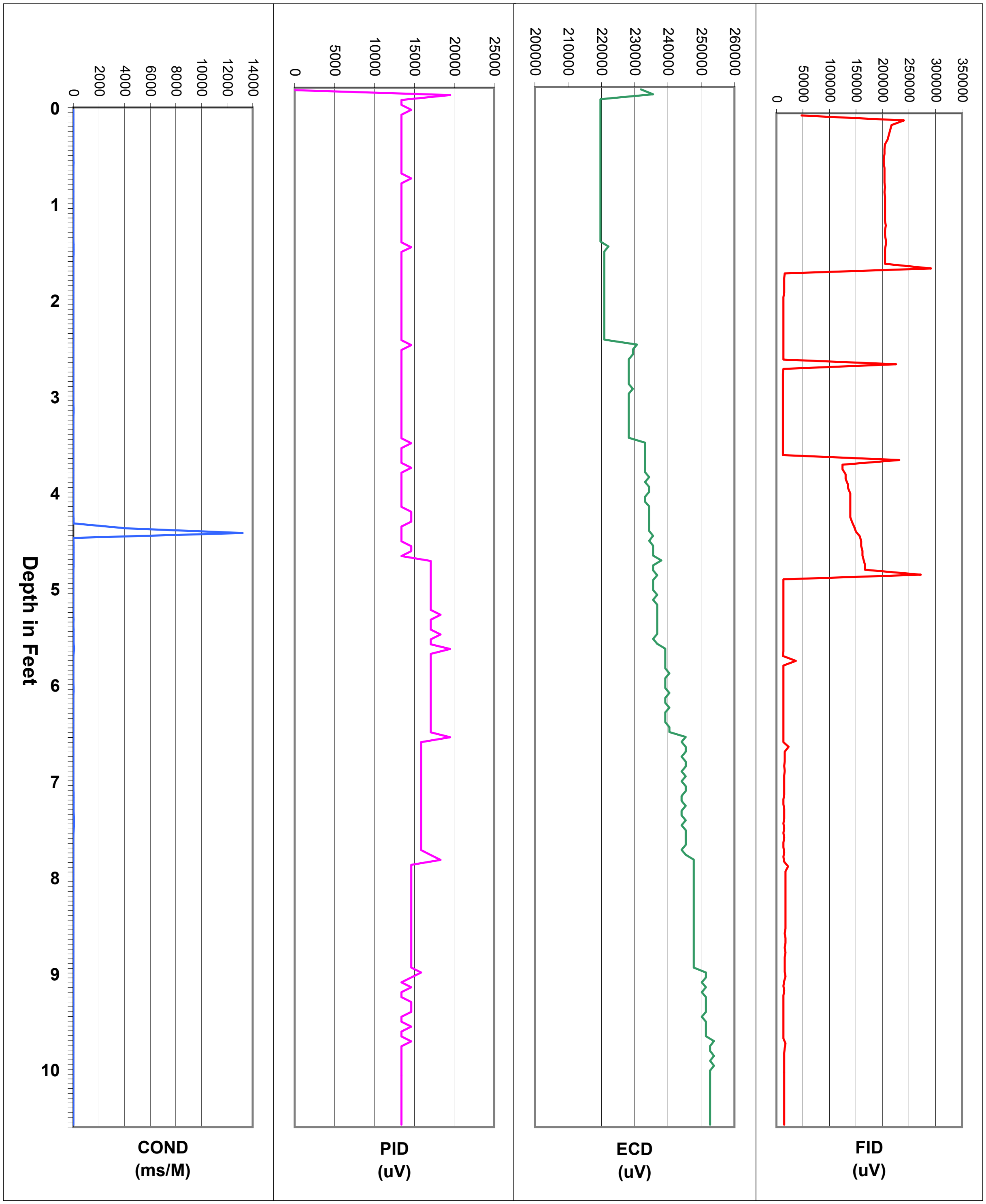
ZEBRA EC/MIP Summary Log, Point L1 0400
Cumberland, RI



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Proj. Name: Shield/Cumberland
Proj. #: ZDS07230
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Point 40 of 48

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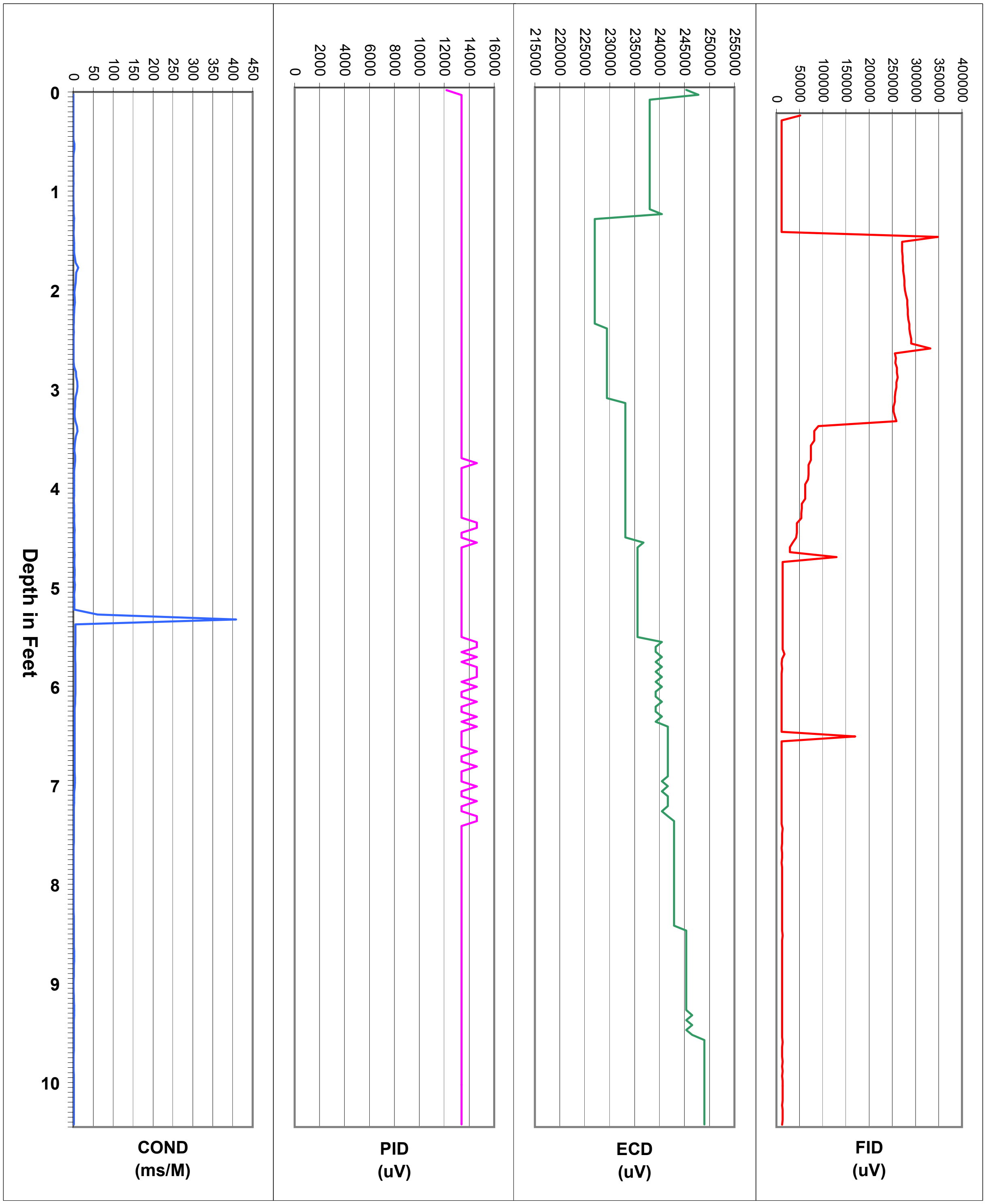
ZEBRA EC/MIP Summary Log, Point L1 0350
Cumberland, RI



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Proj. Name: Shield/Cumberland
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Point 41 of 48

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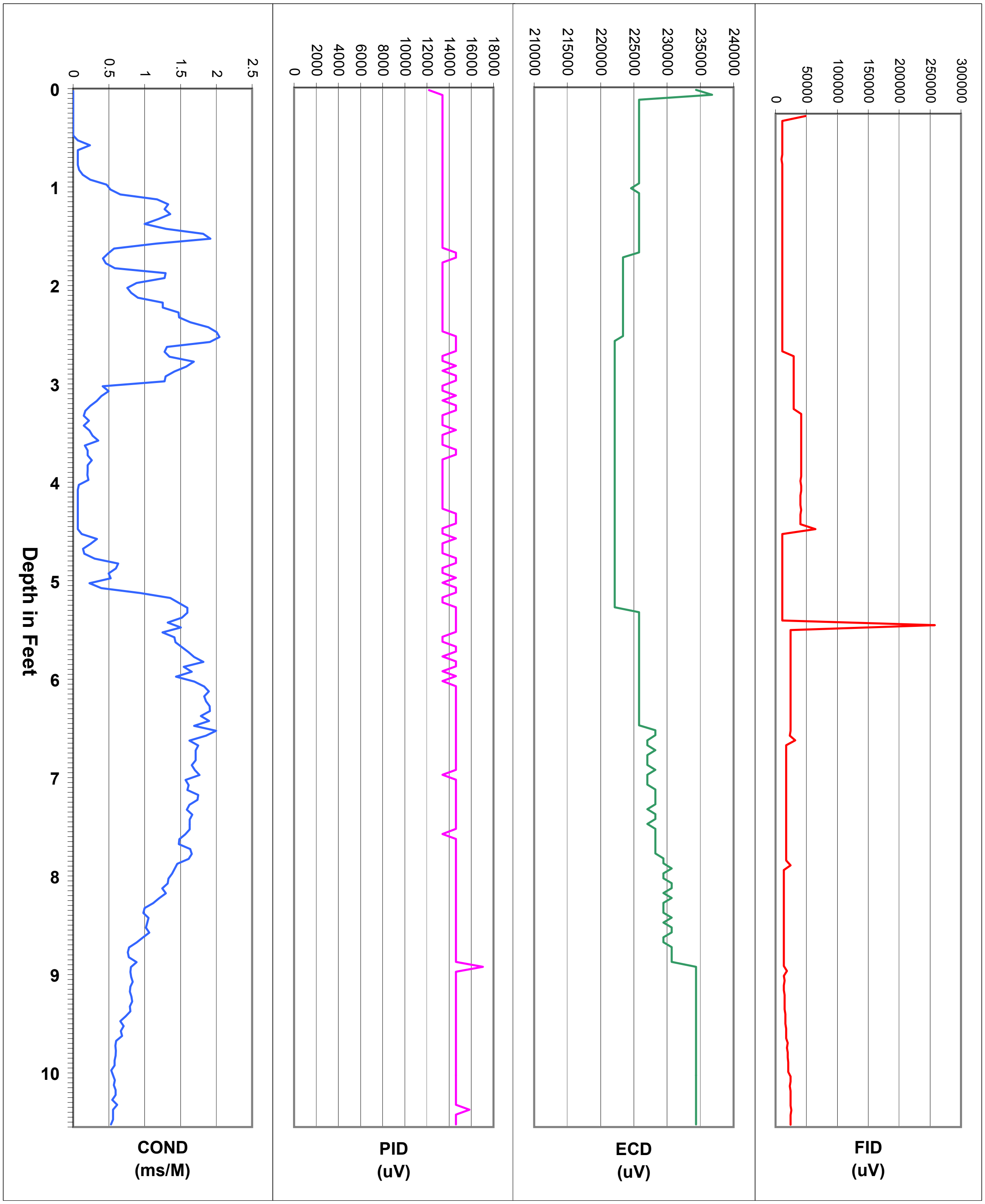
ZEBRA EC/MIP Summary Log, Point L1 0300
Cumberland, RI



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by: Zebra Environmental
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Date: 8/27/2003
Proj. Name: Shield/Cumberland
Proj. #: ZDS07230
Operators: JS
Point 42 of 48

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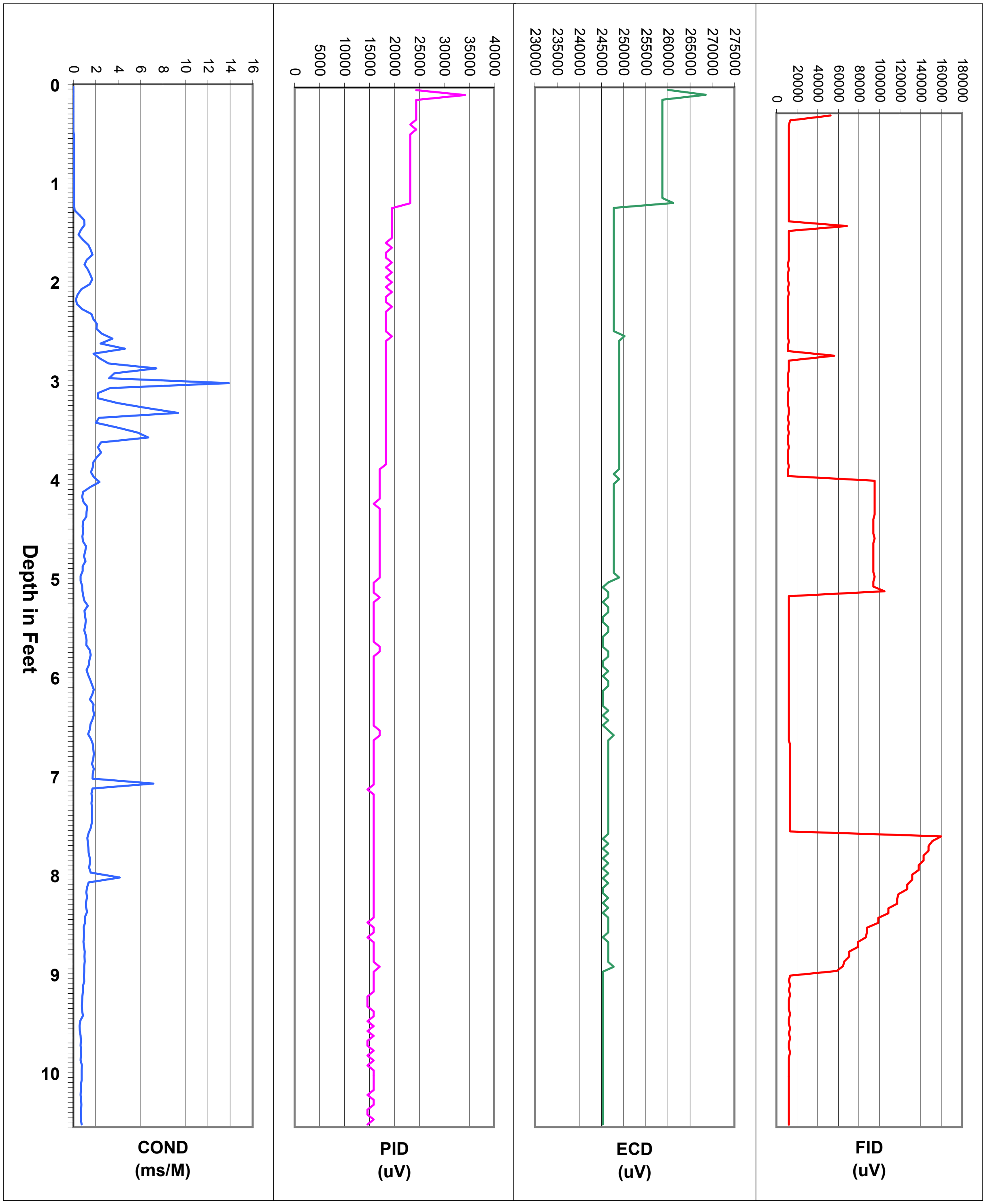
ZEBRA EC/MIP Summary Log, Point L1 0250
Cumberland, RI



for: Shield Env.
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Date: 8/27/2003
Proj. Name: Shield/Cumberland
Proj. #: ZDS07230
Operators: JS
Point 43 of 48

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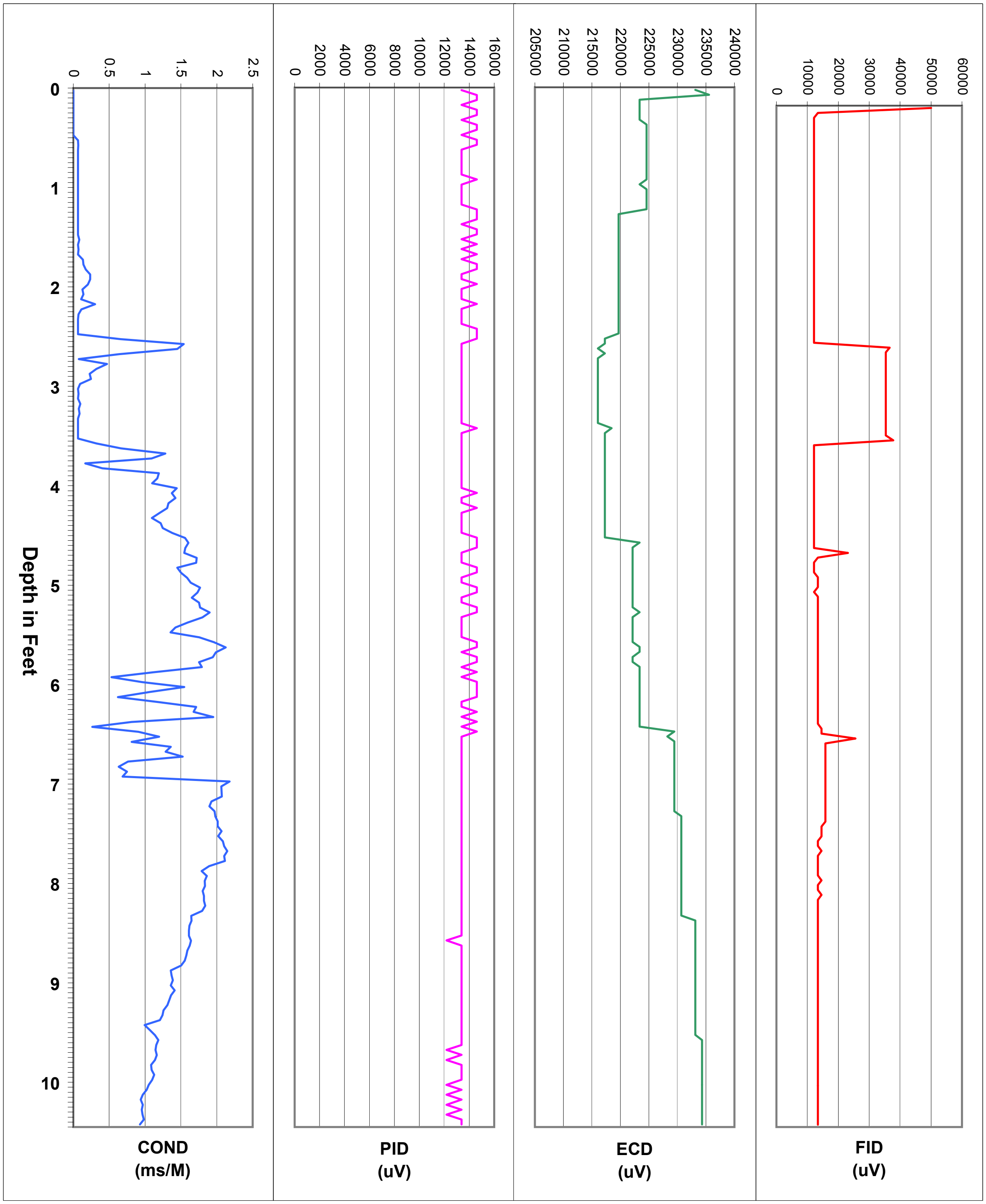
ZEBRA EC/MIP Summary Log, Point L1 0200
Cumberland, RI



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Date: 8/27/2003
Proj. Name: Shield/Cumberland
Proj. #: ZDS07230
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Point 44 of 48

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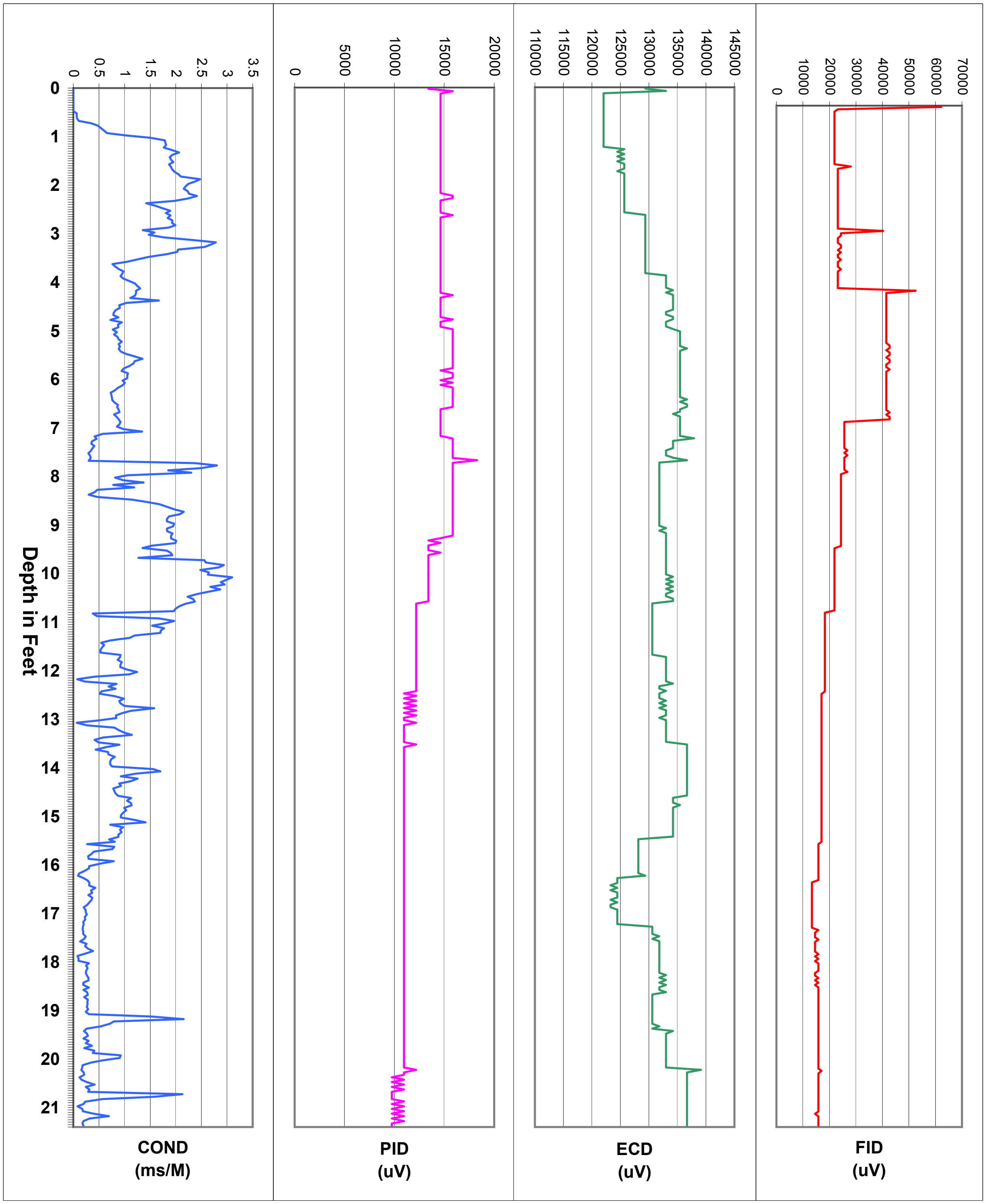
ZEBRA EC/MIP Summary Log, Point L1 0150
Cumberland, RI



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Date: 8/28/2003
Proj. Name: Shield/Cumberland
Proj. #: ZDS07230
Operators: JS
Point 45 of 48

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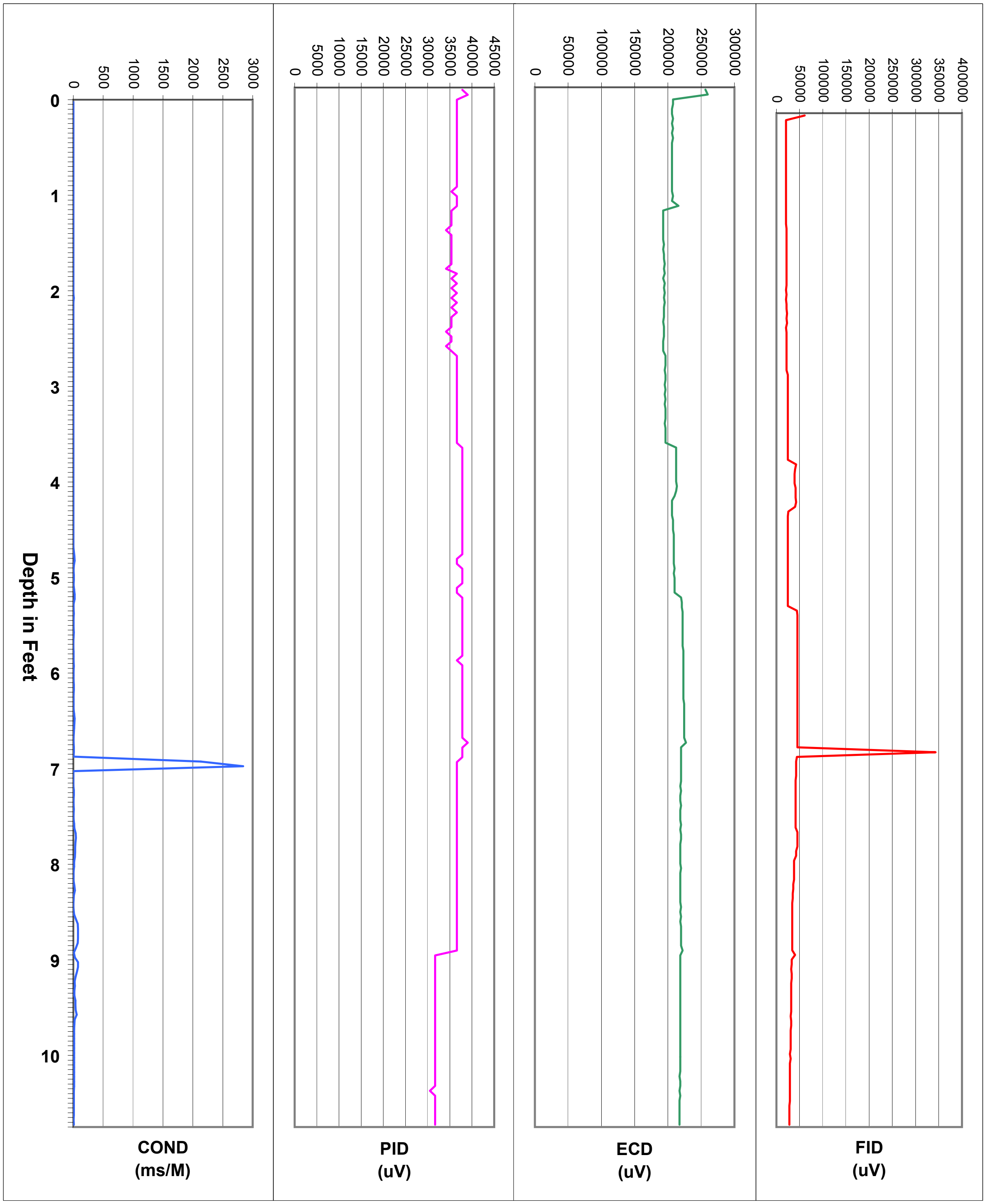
ZEBRA EC/MIP Summary Log, Point L1 0100
Cumberland, RI



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Date: 8/28/2003
Proj. Name: Shield/Cumberland
Proj. #: ZDS07230
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Point 46 of 48

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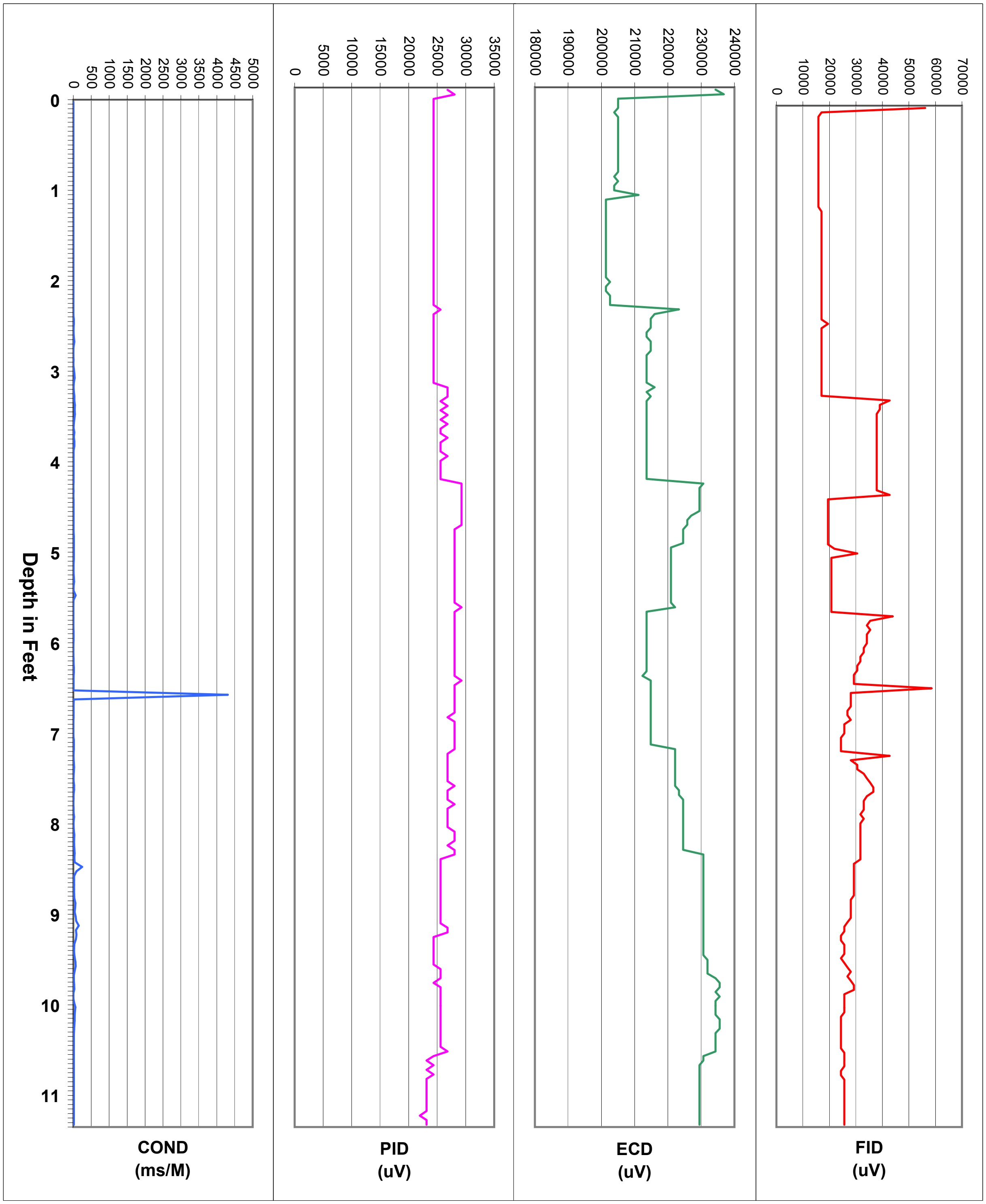
ZEBRA EC/MIP Summary Log, Point L1 0050
Cumberland, RI



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by: Zebra Environmental
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Point 47 of 48

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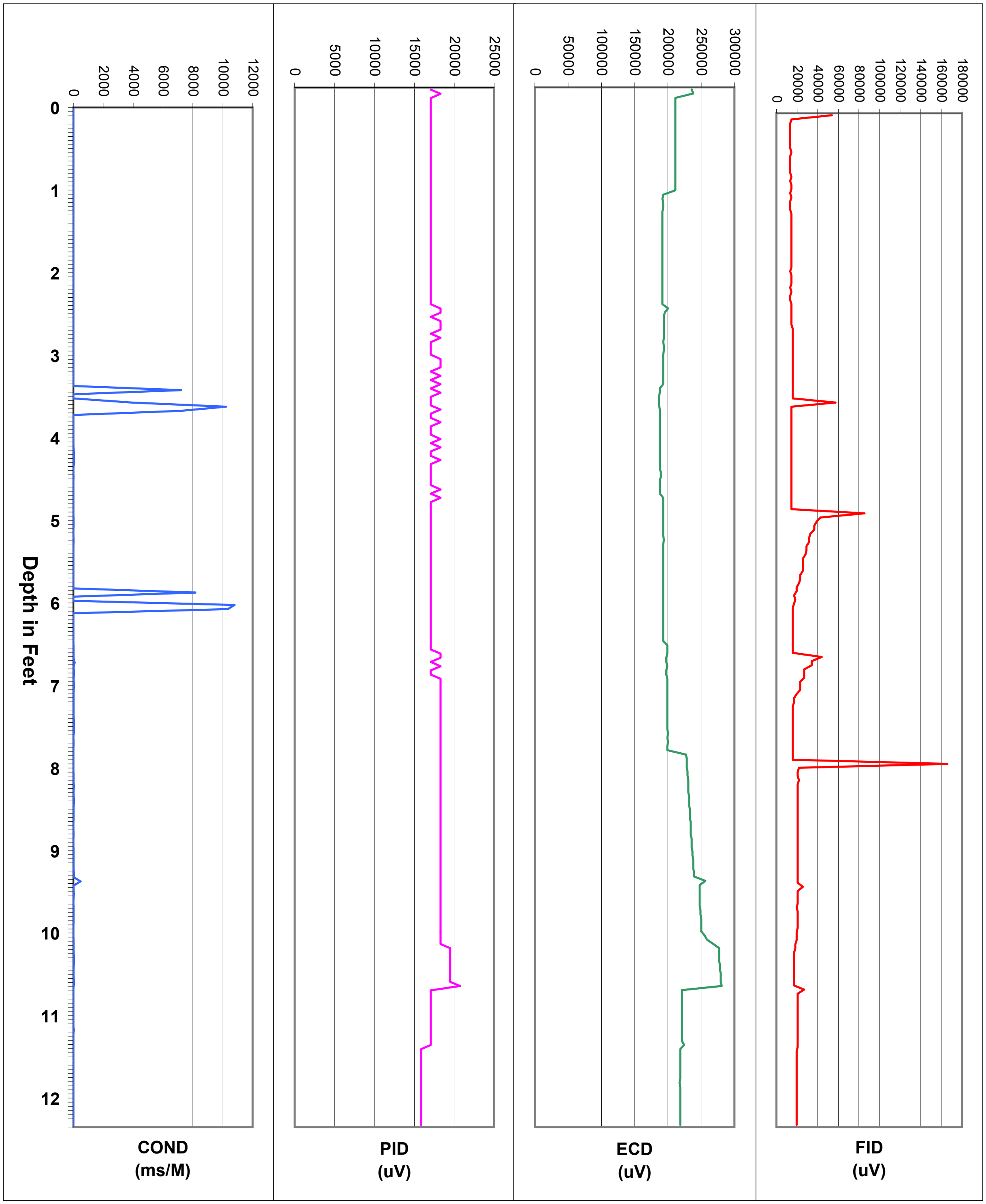
ZEBRA EC/MIP Summary Log, Point L1 0000
Cumberland, RI



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by: Zebra Environmental
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Point 48 of 48

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