Appendix C

Pump Rates & Observed Drawdown During Pumping Flowmeter Tests

Pumping rates & maximum observed drawdown
Indian Point borehole geophysics project
2nd report wells

filename = pumprates+drawdown.xls
updated 7/18/07

well name	pumping rate (gpm)	maximum drawdown (feet)
MW-46	0.42	2.1
MW-53	0.44	3.75
MW-54	0.77	1.28
MW-55	0.71	0.97
MW-56	0.43	0.92
MW-57	0.41	0.34
MW-58	0.6	2.35
MW-59	0.67	0.4
MW-60	0.52	3.75
MW-62	0.43	3.94
MW-63	0.58	0.05
MW-65	initially 0.21, dropped to 0.15 by end of tests	3.95
MW-66	0.54	0.55
MW-67	0.54	0.52
RW-1	0.6	1.93

GEOPHYSICAL APPLICATIONS INCORPORATED

November 28, 2007

Dr. David Winslow, PG
GZA GEOENVIRONMENTAL OF NEW YORK
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Subject: Borehole Geophysics Logging Report
Second Work Phase
Indian Point Energy Center
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Dear Mr. Winslow:

This report describes borehole geophysics logging performed by Geophysical Applications, Inc. at the above-noted site. The primary objective of this survey was to help GZA identify hydraulically active fracture depths and orientations encountered by 15 uncased bedrock boreholes. The logged wells included:

MW-46	MW-53	MW-54	MW-55	MW-56	MW-57
MW-58	MW-59	MW-60	MW-62	MW-63	MW-65
MW-66	MW-67	RW-1			

The upper portion of well MW-61 was also examined (with conventional video and optical televiewer only), to help GZA evaluate the depth and condition of drilling apparatus that broke inside that attempted well.

The borehole-logging suite performed at each remaining well included: fluid temperature (FTemp), fluid resistivity (FRes), acoustic televiewer (ABI), and heat-pulse flowmeter testing. The flowmeter testing was performed during both ambient and pumping conditions. Optical televiewer logging was also performed at most boreholes (excluding MW-46, MW-53, MW-57, and MW-58).

METHODS OF INVESTIGATION

Survey Control

All borehole logs were referenced to depths below approximate ground surface. The geophysical logging winch contains an optical depth encoder, to maintain depth measurements accurate within approximately ± 0.2 feet throughout a borehole.

Borehole Geophysics Logging

A Mount Sopris model 4MXA or 4MXB logging winch equipped with a Mount Sopris model MGX-II electronics console recorded conventional logs at each well. All conventional log data

were recorded at 0.1-foot depth increments, as determined by the logging winch's digital depth encoder.

FTemp and FRes logs were recorded during the first downward logging run at each borehole, using a Mount Sopris caliper probe with a fluid temperature and fluid resistivity subassembly. These fluid logs were obtained using a downward logging speed of approximately 4 to 5 feet per minute. Caliper data were subsequently recorded while pulling the same probe upward at approximately 10 feet per minute.

Acoustic televiewer (ABI) data were obtained using an Advanced Logic Technologies (ALT) model ABI40 acoustic televiewer probe, with the Mount Sopris winch and an ALT model Abox electronics console. ATV data were recorded at 0.01-foot depth intervals, with 288 pixels for each 360-degree scan around the borehole wall. Logging speeds were approximately 4 feet per minute with this probe.

An optical televiewer log was recorded in most wells using an ALT model OBI40 probe, also with a Mount Sopris winch and the ALT electronics console. OBI data were stored at depth increments of 0.007 feet, with 360 pixels for each 360-degree scan around the borehole wall. OBI logging speeds were also approximately 4 feet per minute.

A pair of centralizer assemblies positioned the ABI and OBI probes near the middle of a borehole. Each centralizer included four stainless-steel bow springs, clamped to the probe housings with brass compression fittings, at positions recommended by the probe manufacturer to minimize the risk of interference with the probes' internal three-component magnetometers.

Conventional video logs were recorded at MW-61 to help evaluate the depth and condition of broken drilling apparatus in that well. These images were obtained using a GeoVisions Jr. black-and-white borehole video system.

Flowmeter data were recorded with a Mount Sopris model HPF-2293 heat-pulse flowmeter probe, at specific depths selected from field plots of the caliper, FTemp, and FRes logs. Flowmeter data were initially recorded under ambient conditions. The same test depths were subsequently repeated while pumping at approximately 0.2 to 0.8 (gpm) with a Grundfos or Fultz variable-speed pump. The pump was positioned a few feet below the observed static water level in each well. In some cases, the pump was operated so as to maintain the water level at a consistent depth below the static level (if the well produced little water and the water level would otherwise be constantly dropping while pumping).

All geophysical log data were recorded on a laptop computer's hard drive, and copied to CD-ROM as a backup precaution.

Post-survey plot scales were adjusted to display as much detail as possible. All conventional logs and flowmeter data were merged onto one plot, to aid data correlation. Televiewer logs are presented on separate pages, at an enlarged scale, for clarity.

Quality Assurance Checks

A variety of checks were performed periodically during the fieldwork, to help assure that the geophysical logging probes were functioning properly:

The caliper probe calibration was checked using two rings of known diameter (3.51 and 10.25 inches).

The ABI probe was visually examined prior to each logging run, to confirm that the mirror's motor was rotating in the proper direction. Following this check, the probe was not turned off until data collection was complete.

The ABI and OBI probes' magnetometers were functionally checked by comparing the azimuths reported by those probes (while stationary, typically on top of a plastic shipping box) with the probe's azimuth as measured by a handheld compass.

Equipment Decontamination Procedures

Decontamination consisted of an Alconox scrub and tap water rinse of the logging cable and probes between logging runs.

SURVEY LIMITATIONS

Measured geophysical-log depths are estimated to be accurate within ± 0.2 feet at this site, allowing for some slippage of the winches' depth-measurement wheels.

The caliper-probe arms can measure borehole diameters up to approximately 16 inches. Caliper logs can most-confidently detect fractures that cross a borehole at moderate angles, e.g. less than approximately 70 degrees from horizontal. Caliper logs may not accurately detect near-vertical fractures.

The heat-pulse flowmeter probe can measure vertical (i.e. upward or downward) water flow rates between 0.02 and approximately 1.2 gallons per minute (gpm). Higher flow rates may be erroneously characterized as zero flow by this probe. This device does not measure horizontal water flow rates or directions.

Hydraulically-active fracture zones were inferred by correlating numerous geophysical logs. These interpretations are a subjective judgment based upon available data.

Acoustic and optical televiewer probes rely on a three-component magnetometer to orient the recorded images with respect to magnetic north. These images become distorted when the magnetometers approach the bottom of steel casing, typically beginning approximately 4 to 6 feet below the steel. The upper portion of each unoriented televiewer image was imported into the WellCAD log-plot software and manually rotated to match a distinctive feature below the magnetically distorted interval, to provide usable images throughout the entire water-filled and uncased borehole depth ranges. Dip orientations of televiewer-inferred features within 2.5 feet of a steel casing are therefore approximate.

Calculated down-dip compass azimuths of nearly-horizontal planar features have larger uncertainties than azimuths of steeper-dipping features.

RESULTS

Geophysical log data and generalized log interpretations are described below. Specific interpretations regarding hydraulically-active fracture depths are listed in the "comments" column on the conventional log plots. Most caliper logs show a one- or two-inch diameter range (i.e. 3.5 to 4.5, or 3 to 5, inches in diameter). Horizontal plot scales for the remaining logs were adjusted to show the full range of observed variations at each borehole.

All geophysical logs described in this report are presented in Appendix A, and summary televiewer interpretations are provided in Appendix B. These televiewer-interpretation tables are Excel

spreadsheets listing observed planar-feature depths, down-dip compass directions for each inferred planar feature (note that this is perpendicular to the strike direction), feature dip angles with respect to horizontal, and whether an inferred feature was judged to be relatively open or less-open.

Caliper log data are presented in the left conventional log-plot column. Caliper inflections to the right indicate borehole enlargements, for example at casing joints, or where the drill bit passed through a fracture zone.

Fluid temperature (FTemp) and fluid resistivity (FRes) logs are presented in the next conventional-log plot column. Localized inflections or changes in slope of FTemp or FRes logs typically represent water entering or exiting a borehole. Large inflections at the very bottom of a borehole may represent only accumulated sediments with temperature or electrical properties that contrast with the water column.

Heat-pulse flowmeter data are presented on the caliper panel (ambient flow measurements) and on the FTemp/FRes panel (flow measurements while pumping). Shaded boxes to the left of centerline on either panel represent downwards water flow, with the box length indicating the flow magnitude in gpm. Shaded boxes to the right of a panel's centerline represent upwards water flow. Filled circles represent depths where "zero" flow was observed (i.e., flow less than the probe's minimum detectable rate, approximately 0.02 gpm). Flowmeter test depths were selected on-site using field plots of the caliper, fluid temperature, and fluid conductivity logs. Note that the plotted flow magnitudes shown are as reported by the acquisition software. Pumping rates and observed drawdown (from the 15 wells where pumping flowmeter tests were performed) are listed in Appendix C, Table 1.

Acoustic televiewer data are presented via two columns (ABI40 "traveltime" and "amplitude"), where each column represents a cylindrical image sliced down the north edge and laid flat on the printed page. Magnetic north is at the left edge of each column, and the plots progress through east, south, west, and back to north at the right-hand edge.

Acoustic televiewer data were evaluated using WellCAD's image-processing module, to measure planar feature dip angles and down-dip azimuths. All down-dip azimuths are referenced to magnetic north. Measured feature orientations are indicated by tadpole plots, where each filled-circle indicates a feature's dip angle from horizontal (plotted on a graph that ranges between zero and 90 degrees from left to right). Each tadpole tail points in the feature's down-dip azimuth, assuming that magnetic north is straight up on the printed page. Note that the down-dip azimuth indicated by each tadpole tail is perpendicular to the feature's strike direction. Also note that the tadpole orientations were corrected for borehole deviation from a vertical orientation.

Optical televiewer data are presented in a single column (labeled "OBI40 image"), showing geologic elements with contrasting color properties. The OBI40 image orientation is comparable to the ABI40 log, with magnetic north at the left edge, progressing through east, south, west, and back to north at the right-hand edge.

Planes represented on both the ABI travel-time and amplitude plots are denoted as "open" features. Features represented only on the ABI amplitude plots are likely to have smaller apertures (or possibly represent bedding, foliation or mineral-filled joints), and are therefore judged relatively "less open". Red tadpoles, and red sine-curve lines superimposed on the ABI plots, represent inferred "open" fractures. Black tadpoles, and black sine curves on the ABI plots, represent interpreted "less-open" features. The tadpoles are also shown on the conventional log plots, to help indicate

possible orientations of planar features that contributed to groundwater flow observed in each borehole.

Most planar feature orientations were interpreted from the acoustic televiewer logs, because the open or less-open nature of a fracture is more readily evaluated by the ABI data than the OBI40 images (open fractures can be difficult to distinguish based on color alone, particularly when the rock is dark-colored). OBI40 interpretations provided estimates of bedding plane orientations, and possibly some fractures, above the water level (particularly at RW-1, per GZA's request).

Televiewer interpretations are summarized using rose diagrams, to indicate the predominant down-dip azimuth(s) of features observed in a borehole. These rose diagrams are presented with magnetic north oriented straight up on the printed page. The red rose diagram represents inferred open features, and the black rose diagram represents inferred less-open features (e.g. bedding).

A stereoplot also summarizes the open and less-open feature orientations inferred from the televiewer logs. Each stereoplot was prepared using an equal-angle (Schmidt) projection on the southern hemisphere, with north oriented straight up on the printed page. The pole to a horizontal feature would plot near the diagram's center, whereas a vertical feature's pole would plot at the diagram's outer edge, opposite the feature's down-dip compass direction.

Annotations on the conventional log plot describe interpreted hydraulically-active fracture depths, based on correlations between all of the available log data. Selected observations that may be of particular interest are described below.

MW-46

This borehole's caliper log shows several minor enlargements between the casing bottom and 16 feet deep, with a distinct enlargement near 10 feet.

FTemp inflections or slope changes judged to possibly represent hydraulically-active zones were inferred near 10, possibly 19 to 21, possibly 24, and possibly 26.5 feet deep.

FRes data values are not shown for this borehole, because the recorded data values exhibited very unusual variations. Negative FRes data values were observed at depths less than 25 feet; this suggests that the borehole fluids were more conductive than the probe manufacturer's lower calibration limit for the FRes data channel. FRes data values greater than 25 feet deep appeared to exceed the probe's upper measurement limit. An electrically-resistive material covering the probe's measurement electrodes could cause this, but it seems unlikely at this site.

Measurable water flow was not observed during ambient conditions in this borehole.

Inflow while pumping originated between 22 to 29 feet deep, and may have increased slightly between 17 to 22 feet. Most inflow while pumping apparently entered less than 12 feet deep (the shallowest possible flowmeter test depth while pumping, due to insufficient space for the pump and probe when the water level was lowered by pumping).

Interpreted less-open planar features (black rose diagram) dip down towards the north, north-northeast, south-southeast, southeast, north-northwest, and south.

Two open planar features (red rose diagram) were interpreted, dipping down towards the north-northeast and east-northeast.

The stereoplot diagram shows two general clusters of feature poles. The black poles in the diagram's upper left quadrant represent less-open planes that dip down towards the southeast and

south-southeast, between approximately 45 to 75 degrees from horizontal. A group of red and black poles near the bottom of the stereoplot represents open and less-open planes that dip down towards the north and north-northeast, between approximately 40 to 65 degrees from horizontal.

MW-53

This well's caliper log shows several enlargements between the casing bottom and 44 feet deep. The smaller-diameter, cored portion of the borehole below 44 feet was quite smooth.

FTemp and/or FRes inflections or slope changes judged likely to represent hydraulically-active zones were observed near the following depths: 64, 67.5, possibly 80, possibly 84 to 87, 91.5, 96, 98.5, possibly 102, 105, possibly 111, possibly 115, and possibly 121 feet. All FRes data values appear to be less than zero on this well's conventional log plot; this indicates that the fluid resistivity was less than the probe's lower calibration limit provided by the probe manufacturer.

Weak ambient inflow entered less than 63 feet deep, and flowed downward. Some of this downward flow exited at a zone of lower hydraulic head between 63 to 66 feet deep, and the remainder exited between 70 to 79.5 feet.

Inflow while pumping originated between 100 to 110.5 feet deep, but most inflow while pumping entered between 70 to 79.5 feet. Additional inflow while pumping entered between 66 to 70 feet, and possibly 90 to 100 feet.

Most interpreted less-open planar features (black rose diagram) dip down towards the east, east-northeast, west-northwest, and northwest.

Open planar features were not interpreted below the water level in this borehole.

The stereoplot diagram shows at least three clusters of black (less-open) feature poles. A group of poles near the diagram's left edge represents less-open planes that dip down towards the east and east-northeast between approximately 35 to 75 degrees from horizontal. A group of poles in the stereoplot's lower right quadrant represents less-open planes that dip down towards the northwest and west-northwest between roughly 20 to 50 degrees from horizontal. A small cluster of black poles near the diagram's upper right edge represent less-open planes that dip down towards the west-southwest at approximately 75 to 80 degrees from horizontal.

MW-54

This well's caliper log shows modest enlargements near the casing bottom, and also near 37.5, 145, 160 to 163, and 199 to 201 feet deep. Big enlargements were observed between 173 to 176 and 190 to 192.5 feet.

FRes (and sometimes FTemp) inflections judged likely to represent hydraulically-active zones were observed near the following depths: 21, possibly 36.5 and 40 to 42, 54 to 59, 145, possibly 165, 175, 190.5, and possibly 196 to 201 feet.

Downward ambient flow was observed at most flowmeter test depths in this borehole. Ambient downward inflow originated between the casing bottom and 23 feet deep, and increased between the following depth ranges: 23 to 35, 35 to 45, 52 to 62, and 62 to 70 feet. Portions of this downward ambient flow exited at zones of lower hydraulic head at the following depth intervals: 120 to 130, 130 to 140, 140 to 150, 150 to 159, 170 to 179, and 185 to 195 feet.

Inflow while pumping originated greater than 195 feet deep, and increased between the following depth intervals: 170 to 179, 150 to 159, 140 to 150, 130 to 140, 120 to 130, 62 to 70, 52 to 62, 35 to 45, 23 to 35, and between the casing bottom to 23 feet deep.

Most interpreted less-open planar features (black rose diagram) dip down towards the east-southeast, east, southeast, north-northwest, and northwest.

Most of the interpreted open planar features (red rose diagram) dip down towards the southeast, east-southeast, east, and west-northwest.

The stereoplot diagram shows two general regions that contain most of the plotted poles. The dense cluster of black and red poles on the stereoplot's left side represents less-open and open planes that dip down towards the east-southeast, southeast, and east-northeast at approximately 30 to 80 degrees from horizontal. The black and red poles that occupy most of the stereoplot's lower right quadrant represent less-open and open planes that dip down towards the northwest, north-northwest, and west-northwest, also at dip angles between 30 to 80 degrees from horizontal.

MW-55

This borehole's caliper log shows only minor enlargements in diameter throughout the logged depth range. A stepwise decrease in average borehole diameter near 54 feet deep may represent a change to a slightly smaller core barrel.

Very distinct changes in FRes data values likely represent hydraulically-active zones near 12, 15.5, and 33.5 feet deep.

Weak ambient inflow may have entered between 14.5 to 19 feet deep, and flowed downward. Additional ambient inflow may have entered between 40 to 48 feet deep, and flowed upward. Both the downward flow from above, and the upward flow from below, apparently exited at a zone of lower hydraulic head between 28 to 40 feet deep.

Weak inflow while pumping originated greater than 69 feet deep, but most inflow while pumping entered between 40 to 48 feet deep. Additional inflow while pumping entered between 28 to 40 and 14.5 to 19 feet deep.

Most interpreted less-open planar features (black rose diagram) dip down in three general directions: northwest, east, and south. Smaller numbers of additional less-open planes dip down in nearly all compass azimuths.

Three open planar features were interpreted in this well, dipping down towards the east and east-northeast.

The stereoplot diagram shows many feature poles throughout the diagram, but at least four general groups of common feature poles can be inferred. A group of black and red poles near the diagram's left edge represents less-open and open planes that dip down towards the east-northeast, east and east-southeast between approximately 30 to 80 degrees from horizontal. Numerous black poles above the stereoplot's center represent less-open planes that dip down towards the southeast, south-southeast, south, and south-southwest at dip angles between 10 to 80 degrees from horizontal. A small, tight cluster of black poles located slightly right and above the stereoplot's center represent less-open planes that dip down towards the west-southwest and southwest, at roughly 15 to 35 degrees from horizontal. A closely-spaced group of black poles in the stereoplot's lower right quadrant represents less-open planes that dip down primarily towards the northwest, between approximately 35 to 80 degrees from horizontal.

MW-56

This well's caliper log indicates a couple of enlargements between the casing bottom and 34 feet deep, and a very smooth borehole wall at greater depths.

FRes inflections judged likely to represent hydraulically active zones were interpreted near the following depths: possibly 52, possibly 56 to 57, possibly 69, 73.5, 75, 76, and 84 feet.

Weak inflow entered less than 51 feet deep, and flowed downward. Weak inflow also entered greater than 83 feet deep, and flowed upward. This ambient downward and upward flow apparently exited at a zone of lower hydraulic head between 66 to 74 feet deep, possibly near the 69 and/or 73.5-foot deep FRes inflections.

Inflow while pumping originated greater than 83 feet deep, and increased between the following depth ranges: 74 to 83, 66 to 74, and 55 to 60 feet. Additional inflow while pumping likely entered less than 55 feet deep (the shallowest flowmeter test depth that could be occupied with the pump in this borehole).

Less-open planar features (black rose diagram) exhibited numerous down-dip azimuths, but most less-open planes dip down towards the south, southwest, north, north-northwest, west, and south-southeast.

Only one open planar feature (red rose diagram) was interpreted below the water level, dipping down towards the southeast.

The stereoplot diagram shows numerous feature poles that represent a wide variety of dip angles and down-dip azimuths. At least three possibly clusters of feature poles are visible on this diagram. The black poles near the stereoplot's center represent less-open planes that dip less than 10 degrees from horizontal in numerous directions. The black poles near the top of the stereoplot represent less-open planes that dip down towards the south or south-southeast, between approximately 50 to 80 degrees from horizontal. A small cluster of black poles near the bottom of the stereoplot represents less-open planes that dip down towards the north or north-northeast, at roughly 60 to 80 degrees from horizontal.

MW-57

The caliper log for this borehole shows only a few relatively minor enlargements throughout the logged interval.

Distinct FTemp and/or FRes inflections judged likely to represent hydraulically-active zones were interpreted near the following depths: 8, 11 to 12.5, and 20 feet deep. Other subtle FRes inflections or slope changes may represent additional transmissive zones, as noted in the comments column of the conventional log plot.

Ambient inflow entered between 10 to 18 feet deep, flowed upward, and exited at a zone of lower hydraulic head near the casing bottom. Additional ambient inflow entered between 18 to 22 feet deep, flowed downward, and exited at a zone of lower hydraulic head below 42 feet deep.

Weak downward flow while pumping may have entered between 31 to 37.5 feet deep, and possibly exited between 37.5 to 42 feet deep at a zone of lower hydraulic head. Weak upward flow while pumping originated between 18 to 22 feet deep, but most upward flow while pumping entered between 10 to 18 feet deep.

Most interpreted less-open planar features (black rose diagram) dip down towards the northwest, west-northwest, east, and east-southeast.

Four open planar features (red rose diagram) were interpreted, dipping down towards northeast, west-northwest, and northwest.

The stereoplot diagram shows at least three possible clusters of feature poles. Black poles near the diagram's left edge represent less-open planes that dip down towards the east, east-northeast, east-southeast, and southeast, at approximately 50 to 80 degrees from horizontal. Red and black poles plotted slightly below the diagram's center represent open and less-open planes that dip down towards the north, north-northwest, north-northeast, and northeast at roughly 10 to 30 degrees from horizontal. Numerous black poles plotted in the diagram's lower right quadrant represent less-open planes that dip down towards the northwest and west-northwest at dip angles ranging from approximately 10 to nearly 90 degrees from horizontal.

MW-58

This well's caliper log shows minor anomalies between the casing bottom and 20 feet deep, and a relatively smooth borehole wall at greater depths.

Distinct FRes and/or FTemp inflections near the following depths are judged likely to represent hydraulically-active zones: 17, 20, 31.5, 34.5, 46, possibly 48, and possibly 62 to 64 feet.

Ambient inflow entered between 18 to 22 feet deep, flowed up, and apparently exited at a zone of lower hydraulic head between the casing bottom and 18 feet deep. Additional weak ambient inflow entered between 32 to 37 feet deep, and flowed downward. Additional downward ambient inflow entered between 45 to 53 feet deep; all of this downward ambient flow exited at a zone of lower head between 53 to 61 feet deep.

Weak inflow while pumping originated between 61 to 67 feet deep, and increased between the following depth ranges: 53 to 61, 45 to 53, 37 to 45, 32 to 37, 22 to 32, and 18 to 22 feet. Most inflow while pumping entered in the 45 to 53-foot depth range.

Most less-open planar features (black rose diagram) are interpreted to dip down towards the northwest, north-northwest, east-southeast, and south-southeast.

Three interpreted open planar features (red rose diagram) dip down towards the north-northwest and northwest.

The stereoplot diagram shows that nearly all observed feature poles fall into one of two clusters. The cluster located in the diagram's lower right quadrant represents less-open and open planes that dip down towards the northwest, north-northwest, and west-northwest at dip angles between approximately 25 to 65 degrees from horizontal. Black poles in the stereoplot's upper left quadrant represent less-open planes that dip down towards the east-southeast, south-southeast, and southeast at roughly 60 to 75 degrees from horizontal.

MW-59

This borehole's caliper log shows several enlargements between the casing bottom and 30.5 feet deep, and a smooth borehole wall at greater depths.

Distinct FRes and/or FTemp inflections are judged likely to represent hydraulically-active zones near the following depths: 21, possibly 24, 31 to 32, 41 to 42, 55 to 57, 59, possibly 68, and possibly 73 feet.

Upward ambient flow originated between 64 to 73 feet deep, and increased between the following depths: 54 to 64, possibly 45 to 54, and 35 to 45 feet. Weak ambient flow also apparently entered between the casing bottom and 19.5 feet deep, and flowed both up and down towards zones of lower hydraulic head (the upward flow probably exited at a casing joint). Strong upward ambient flow from below, and weak downward ambient flow from above, apparently exited at a zone of lower hydraulic head between 19.5 to 26 feet deep.

Inflow while pumping also originated between 64 to 73 feet deep, and increased between the following depth ranges: 54 to 64, 35 to 45, and 19.5 to 26 feet. Most inflow while pumping entered between 19.5 to 26 feet deep, coincident with the biggest caliper enlargement observed in this borehole.

Most interpreted less-open planar features (black rose diagram) dip down towards the northwest, southeast, and south-southwest.

Interpreted open planar features (red rose diagram) dip down towards the northwest, west-southwest, and southwest.

The stereoplot diagram indicates at least three possible clusters of feature poles. The dense cluster in the stereoplot's lower right quadrant represents mostly less-open planes that dip down towards the northwest and north-northwest, at approximately 20 to 50 degrees from horizontal. The group of poles in the diagram's upper left quadrant represents less-open planes that dip down towards the southeast and south-southeast at roughly 25 to 70 degrees from horizontal. A third group of poles, near the stereoplot's upper right edge, represents mostly less-open planes that dip down towards the south-southwest and southwest between 40 to approximately 85 degrees from horizontal.

MW-60

This well's caliper log shows an enlargement to approximately 8.5 inches near 55 feet deep, and smaller enlargements near the casing bottom and 156 feet. The remainder of this borehole's uncased interval is relatively smooth.

Distinct FRes inflections judged to represent hydraulically active zones were interpreted near 34 to 37, 53, and 77 feet deep.

Weak ambient inflow may have entered between 11.5 to 25 feet deep, flowed upward, and exited near the static water level (11 feet deep at the time of logging).

Inflow while pumping entered between 180 to 196.5 feet deep, and probably increased between the following depth ranges: 149 to 165, 106 to 121, 92 to 106, 80 to 92, 65 to 80, 50 to 65, and possibly 21 to 25 feet.

Most interpreted less-open feature planes (black rose diagram) dip down towards the southeast, east-southeast, and northwest.

Interpreted open planar features (red rose diagram) dip down towards the east-southeast, south-southeast, north-northwest, and northwest.

At least three clusters of planar-feature poles are evident on the stereoplot diagram. The dense group of black and red poles in the diagram's upper left quadrant represent less-open and open planes that dip down towards the southeast, east-southeast, and south-southeast at dip angles ranging between 25 to approximately 70 degrees from horizontal. A dense cluster of poles in the

stereoplot's lower right quadrant represents mostly less-open planes that dip down towards the northwest and north-northwest between 20 to 80 degrees from horizontal. A small group of black poles near the stereoplot's right edge represents less open planes that dip down towards the west and west-northwest, at approximately 60 to 70 degrees from horizontal.

MW-61

This well was logged twice with an optical televiewer (10/6/06 and 4/12/07), and twice with a conventional borehole video camera (10/10/06 and 4/24/07). The purpose of this logging was to help GZA evaluate this borehole's condition, after some drilling apparatus broke and became lodged.

Both optical televiewer logs accompany this report. The video logs were previously supplied to GZA (the first one on VHS-format videotape, the second one on a DVD-ROM).

The first optical televiewer log (10/6/06) was recorded throughout the accessible depth range of the borehole, ending near 57 feet deep, slightly above the broken drilling equipment. The drilling equipment was visible on the conventional borehole video image from 10/10/06; the upper edge of the drilling steel was cut and twisted in a manner that partially obstructed the center of the borehole. The drilling steel doesn't appear on the optical televiewer log because the OBI40 probe looks horizontally at the borehole wall, instead of downward.

The optical televiewer log was repeated on 4/12/07 after an effort had been made to overcore the broken drilling apparatus. This televiewer log shows that the overcore hole actually sliced through one side of the drilling steel; note the shadow that represents the original cored hole, near the middle of the OBI40 image, below approximately 52.3 feet deep. The cut edges of the broken drill steel are visible below approximately 62.3 feet deep. The interior of the cut drill steel is represented by the black vertical stripe near the center of the OBI40 image, below approximately 62.3 feet.

A polar deviation plot was prepared for this well from the 10/6/06 OBI log, and is included with this report. The deviation plot is accurate only where steel casing did not influence the OBI40 probe's magnetometers, e.g. below approximately 49 feet deep. In that uncased interval, the original borehole trended slightly towards the west-southwest.

MW-62

The caliper log from this borehole showed notable enlargements immediately below the casing bottom, and a very smooth borehole wall at greater depths. Note that the 6-inch casing ends near approximately 40.5 feet deep, and the 4-inch diameter uncased borehole begins near 45 feet.

Numerous FRes and FTemp inflections and slope changes between 49 to 86 feet deep are judged likely to represent hydraulically-active zones. Fluid-log anomalies near the following depths are also judged to possibly represent additional hydraulically-active zones: 42.5, 127, 137.5 to 139, and 182 feet.

Weak ambient inflow entered between the casing bottom and 45 feet deep, flowed downward, and exited at a zone of lower hydraulic head between 45 to 57 feet.

Inflow while pumping originated greater than 194 feet deep, and increased between 179 to 194, 163 to 179, 149 to 163, 135 to 149, 120 to 135, possibly between 107 to 120, 92 to 107, possibly between 80 to 92, 70.5 to 80, and 45 to 57 feet.

Most interpreted less-open planar features (black rose diagram) dip down towards the east-southeast, northwest, and north-northwest.

Only two open planar features (red rose diagram) were interpreted. They dip down towards the north and northwest.

The stereoplot diagram shows at least three groups of feature poles. The largest group occupies most of the stereoplot's lower right quadrant, and represents mostly less-open planes that dip down towards the north-northwest, northwest, and west-northwest at dip angles between 15 to 80 degrees from horizontal. A second distinct cluster of poles is located near the stereoplot's left edge, representing less-open planes that dip down towards the east-southeast, east, and southeast at dip angles of approximately 50 to 80 degrees from horizontal. A small cluster of black poles near the stereoplot's upper right edge represents less-open planes that dip down towards the south-southeast and southeast, at roughly 55 to 80 degrees from horizontal.

MW-63

This well's caliper log shows numerous enlargements between 87 to 98 feet deep, and a relatively smooth borehole wall at most remaining depths. Note that the uncased section of this well is approximately 4 inches in diameter, but the casing diameter is approximately 6 inches.

Several FTemp or FRes slope changes or inflections are judged likely to represent hydraulically-active zones, including near the following depths: possibly 36 (at the casing bottom), 52 to 54, approximately 85, approximately 93, 112 to 115, 123 to 132.5, 159 to 164, 172 to 178, and possibly 190 feet deep.

Upward ambient inflow originated greater than 191 feet deep, and increased between each of the shallower flowmeter test depths except for 180 to 191, 132.5 to 142.5, and 37.5 to 47.5 feet.

Inflow while pumping also originated greater than 191 feet deep, and increased between the following depth ranges: 180 to 191, 168 to 180, 153 to 168, 119.5 to 132.5, 110 to 119.5, 84 to 100.5, 70.5 to 84, and 47.5 to 58.5 feet. Note that most inflow while pumping apparently entered at the zone of caliper enlargements and interpreted open planar features near 87 to 93 feet deep.

Most interpreted less-open planar features (black rose diagram) dip down towards the east-southeast, east, and northwest.

Most interpreted open planar features (red rose diagram) dip down towards the southeast, south-southeast, and northwest.

The stereoplot diagram shows at least three possible clusters of feature poles. A large group of black and red poles, located mostly throughout the diagram's lower right quadrant, represents less-open and open planes that dip down towards the west, west-southwest, northwest, and north-northwest at dip angles ranging between approximately 15 to 80 degrees from horizontal. A dense cluster of black poles located to the left of the stereoplot's center represents less-open planes that dip down towards the east-southeast and east, at dip angles between roughly 30 to 75 degrees from horizontal. A third possible cluster of black and red poles is located near the stereoplot's upper left edge, representing less-open and open planes that dip down towards the southeast and south-southeast at dip angles ranging from 45 to 80 degrees from horizontal.

MW-65

This borehole's caliper log shows an enlargement shortly below the casing bottom (between 34.5 to 38 feet deep), and a very smooth borehole wall at greater depths.

FRes inflections judged likely to represent hydraulically active features were observed near 36, 41.5, possibly 43 to 44, possibly 61, and 70 feet deep.

Weak downward flow was observed at all flowmeter test depths during ambient conditions. This indicates that water was entering the well near the casing bottom, flowing down, and exiting at a zone of lower hydraulic head greater than 80 feet deep.

During pumping conditions, water entered between 65 to 70 feet deep and flowed both down towards a zone of lower hydraulic head, and up towards the pump. Upward flow while pumping increased between 60 to 65, and also 46 to 50 feet deep. Shallower flowmeter test depths could not be performed while pumping, due to the lowered water level and space required for both the pump and flowmeter probe.

Less-open planar features (black rose diagram) mostly dip down towards the southeast, consistent with the bedding orientation. Some less-open planes also dip down towards the south, northwest, north-northwest, and east-northeast.

Only one open planar feature was interpreted in this well, near 44.5 feet deep; it dips down towards the southeast at roughly 32 degrees from horizontal.

The stereoplot shows one distinct cluster of feature poles, located above and left of the diagram's center. This cluster represents less-open and open planes that dip down towards the southeast, at approximately 30 to 50 degrees from horizontal.

MW-66

This borehole's caliper log shows a distinct increase immediately below the casing, and another near 43 feet deep. Only smaller enlargements were observed at greater depths; the 136-foot deep enlargement appears to be hydraulically active based on a corresponding FRes inflection.

FTemp and/or FRes inflections judged likely to represent hydraulically-active features were observed at the following depths: 43.5, 89, 97, 100 to 102, 110, 118, 125, possibly 131.5, 135, possibly 157, 165, 170, 182, and possibly 184 feet deep.

The vertical streaks on the OBI40 image probably represent floating materials that adhered to the probe's lens when it was lowered into the water column.

Interpreted less-open planar features (black rose diagram) dip down in three general directions: northwest and north-northwest, east-southeast, and south-southeast to south-southwest.

Most observed open planar features (red rose diagram) dip down towards the south-southwest, north-northwest, and north.

The stereoplot diagram shows four possible clusters of planar feature poles. A large cluster in the diagram's lower right quadrant represents less-open and open planes that dip down towards the north-northwest, northwest, and west-northwest, mostly at dip angles between 15 to 65 degrees from horizontal. A cluster located near the diagram's left edge represents less-open planes that dip down towards the east-southeast and southeast between 35 to 70 degrees from horizontal. A group of mostly black poles near the top of the stereoplot represents mostly less-open planes that dip down towards roughly the south, at dip angles greater than 55 degrees from horizontal. A fourth

possible cluster is located above and right of the diagram's center, representing less-open planes that dip down towards the south-southwest and southwest at roughly 35 to 55 degrees from horizontal.

MW-67

This well's caliper log shows a few enlargements, particularly less than 42 feet deep. Additional small enlargements near 106, 110, and 269 feet deep correlate with fluid-log anomalies, and therefore are likely to be hydraulically active.

FTemp and FRes inflections judged to represent hydraulically active zones were observed at the following depths: possibly 61 or 66, possibly 73, 90 to 92, 97 to 101, 104 to 113, 133, 139, 148 to 149, possibly 154, 162, possibly 173, 176, 216 to 219, 222 to 242, 253 to 260, 269, 277 to 279, possibly 282 to 284, possibly 294, 300, 304, 307, 316, 323, 329, and 334 feet.

Ambient flowmeter tests disclosed upward flow throughout this borehole. Upward ambient flow originated greater than 330 feet deep, and increased between many of the shallower test depths (particularly between 275 to 290, 264 to 275, 250 to 264, 102 to 115, and also between the casing bottom and 38 feet deep). Note that strong upward ambient flow was observed within the steel casing, indicating that some upward ambient flow was exiting at one or more casing joints.

Inflow while pumping showed a similar pattern, with slightly higher (compared to ambient) flow rates observed at all depths except 330 feet. The strongest increases in inflow while pumping were observed at the following depth ranges: 275 to 290, 264 to 275, 250 to 264, 215 to 221, 175 to 190, 127 to 132, possibly 102 to 115 feet, and between the casing bottom and 38 feet.

Most interpreted less-open planar features (black rose diagram) dip down towards the north-northwest, east-southeast, and roughly south.

Most interpreted open planar features (red rose diagram) dip down towards the northwest.

The stereoplot diagram shows at least four generalized clusters of feature poles. A dense cluster located left and slightly above the diagram's center represents less-open planes that dip down towards the east-southeast and southeast at approximately 25 to 80 degrees from horizontal. A loosely-grouped cluster of poles near the top of the diagram represents mostly less-open planes that dip down towards the south-southeast, south, and south-southwest at dip angles between 20 to 85 degrees from horizontal. A dense cluster of poles near the bottom of the stereoplot represent mostly less-open planes that dip down towards the north-northwest, between 25 to 85 degrees from horizontal. A fourth possible cluster, located to the right of and below the diagram's center, represents mostly less-open planes that dip down towards the northwest and north-northwest at 25 to 80 degrees from horizontal.

RW-1

This borehole's caliper log shows numerous small irregularities, particularly between the casing bottom and 30 feet deep, and from 63 feet deep to the bottom of the logged interval.

Note that the water level was near 70 feet deep at the time of logging, therefore this well had an unusually long unsaturated and uncased interval (approximately 12 to 70 feet deep).

Distinct FTemp and/or FRes inflections judged likely to represent hydraulically-active zones were observed near the following depths: 73, possibly 76.5, 91.5, possibly 96, 100.5, and possibly 114 to 115 feet.

This borehole exhibited numerous zones of water flow during ambient conditions. Both downward ambient inflow that entered less than 77 feet deep, and upward ambient inflow that entered between 83 to 93 feet deep, exited at a zone of lower hydraulic head between 77 to 83 feet. Downward ambient inflow also entered between 98 to 107 feet deep, increased between 107 to 118 feet, and exited at a zone of lower head between 118 to 128 feet deep. Weak ambient downward flow also apparently entered between 128 to 136.5 feet deep, and exited at a zone of lower head below 136.5 feet.

Inflow while pumping originated greater than 136.5 feet deep, and increased between all successive, shallower measurement depths. Most inflow while pumping entered between 98 to 107 feet deep.

The optical televiewer (OBI40) image appears to show concrete between the casing bottom and approximately 30 feet deep. The lack of image clarity between the casing bottom and the water level was probably caused by condensation on the OBI probe's lens, as it was lowered from a cold work area into the warm and moist air in the borehole. A few planar features that resembled fractures are visible on the OBI40 image, near 62 to 66 feet deep; all interpreted planar features above the water level are identified as "less-open" planes on the black rose diagram and stereoplot.

Staining (possibly from iron oxide) appears to be visible at numerous depths on the OBI40 image, particularly at a dipping fracture centered near 74 feet deep.

Interpreted less-open planar features (black rose diagram) dip mostly down towards the south-southeast, south, south-southwest, southeast, and west-northwest. Interpreted open planar features (red rose diagram) dip down towards the northwest and south-southeast.

The stereoplot diagram shows two possible clusters of common planar features. Loosely grouped black poles located to the right of (and slightly below) the stereoplot's center, represent less-open planes that dip down towards the west-northwest and northwest between 25 to 70 degrees from horizontal. Black and red poles located above and left of the stereoplot's center represent mostly less-open planes that dip down towards the southeast, south-southeast, and south-southwest at approximately 30 to 65 degrees from horizontal.

* * * * *

We appreciate this opportunity to provide geophysical services. Please call the undersigned at 508/429-2430 if we may provide additional information that would benefit GZA's project.

Sincerely,

GEOPHYSICAL APPLICATIONS, INC.

Mark E. Blackey
Principal and Geophysicist

105836 - 105836b.rpt.doc

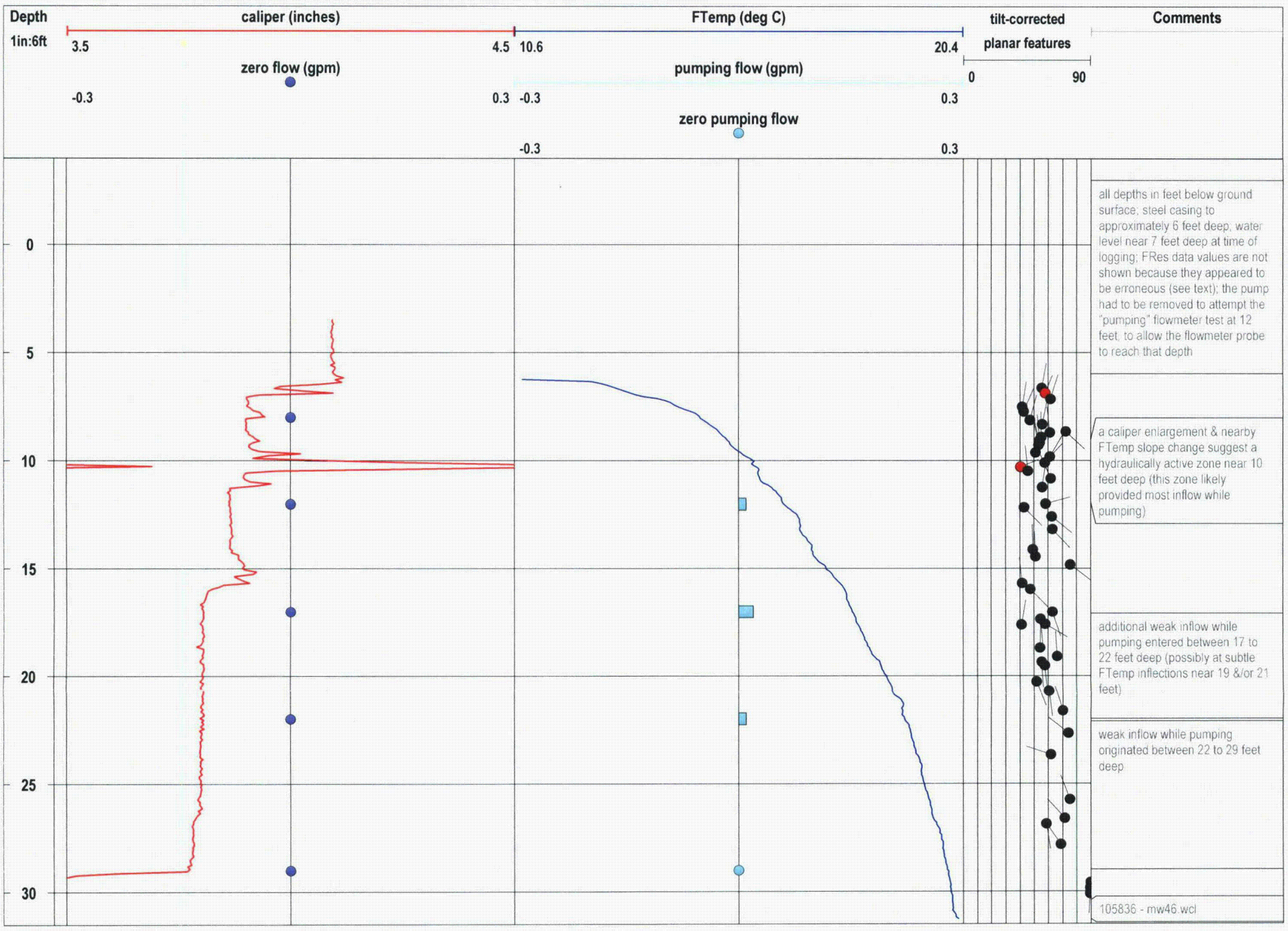
Borehole Geophysics Logging Report
Second Work Phase
Indian Point Energy Center
Buchanan, New York

Prepared for
GZA GEOENVIRONMENTAL OF NEW YORK
November 2007

Appendix A

Borehole Geophysics Log Plots

Project - Well: GZA / Buchanan, NY - MW-46 conventional logs



Well: GZA / Buchanan, NY - MW-46 conventional logs

Project - Well: GZA / Buchanan, NY - MW-46 acoustic televiewer log

Depth
1in:1.5ft

less-open feature rose
Azimuth Count - Percent Interval
open feature rose
Azimuth Count - Percent Interval
stereoplot
Schmidt Plot - Lower Hemisphere

tilt-corrected planar features
0
90

ABI40 traveltime
0° 90° 180° 270° 0°
planar ABI40 features#1
0° 90° 180° 270° 0°

ABI40 amplitude
0° 90° 180° 270° 0°
planar ABI40 features
0° 90° 180° 270° 0°

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8
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16
18
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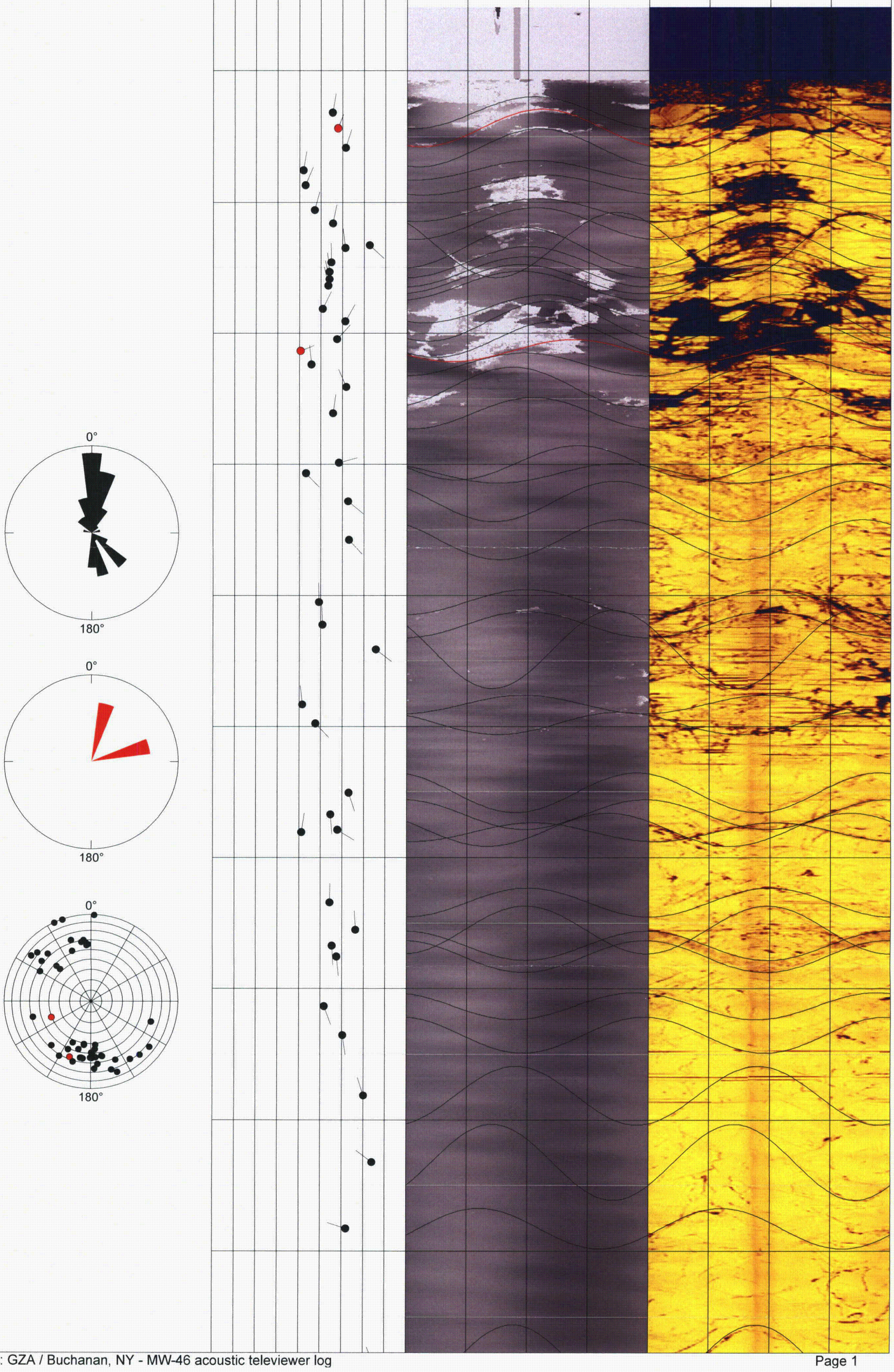
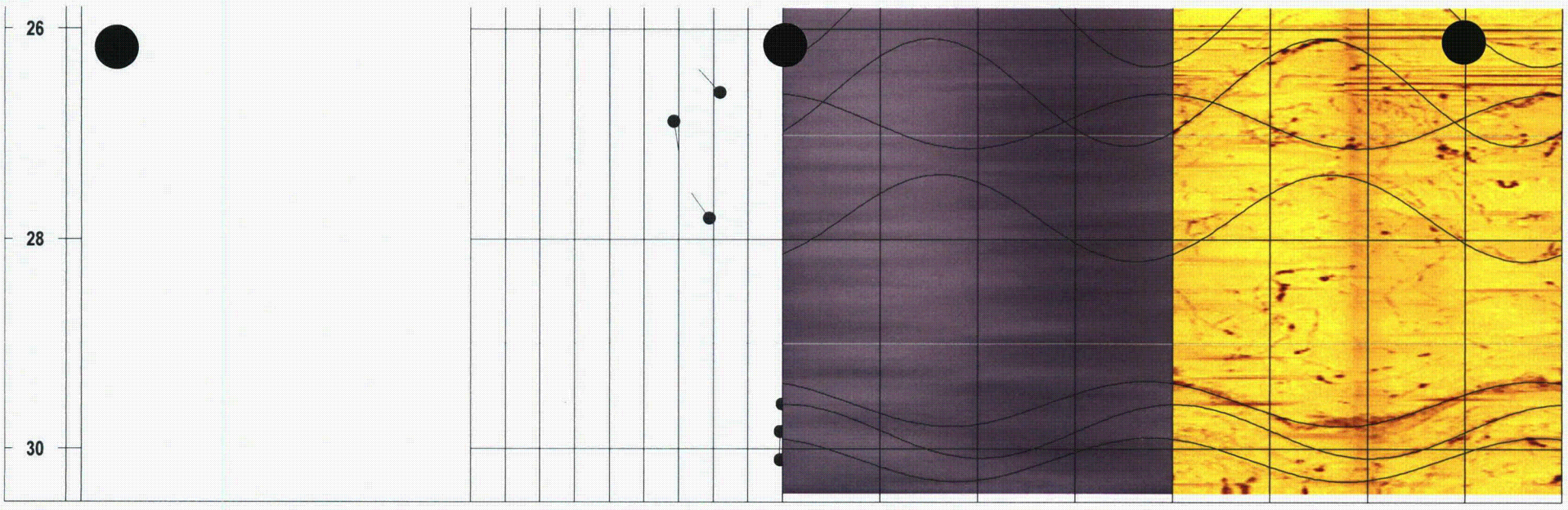
24

0°
180°

0°
180°

0°
180°

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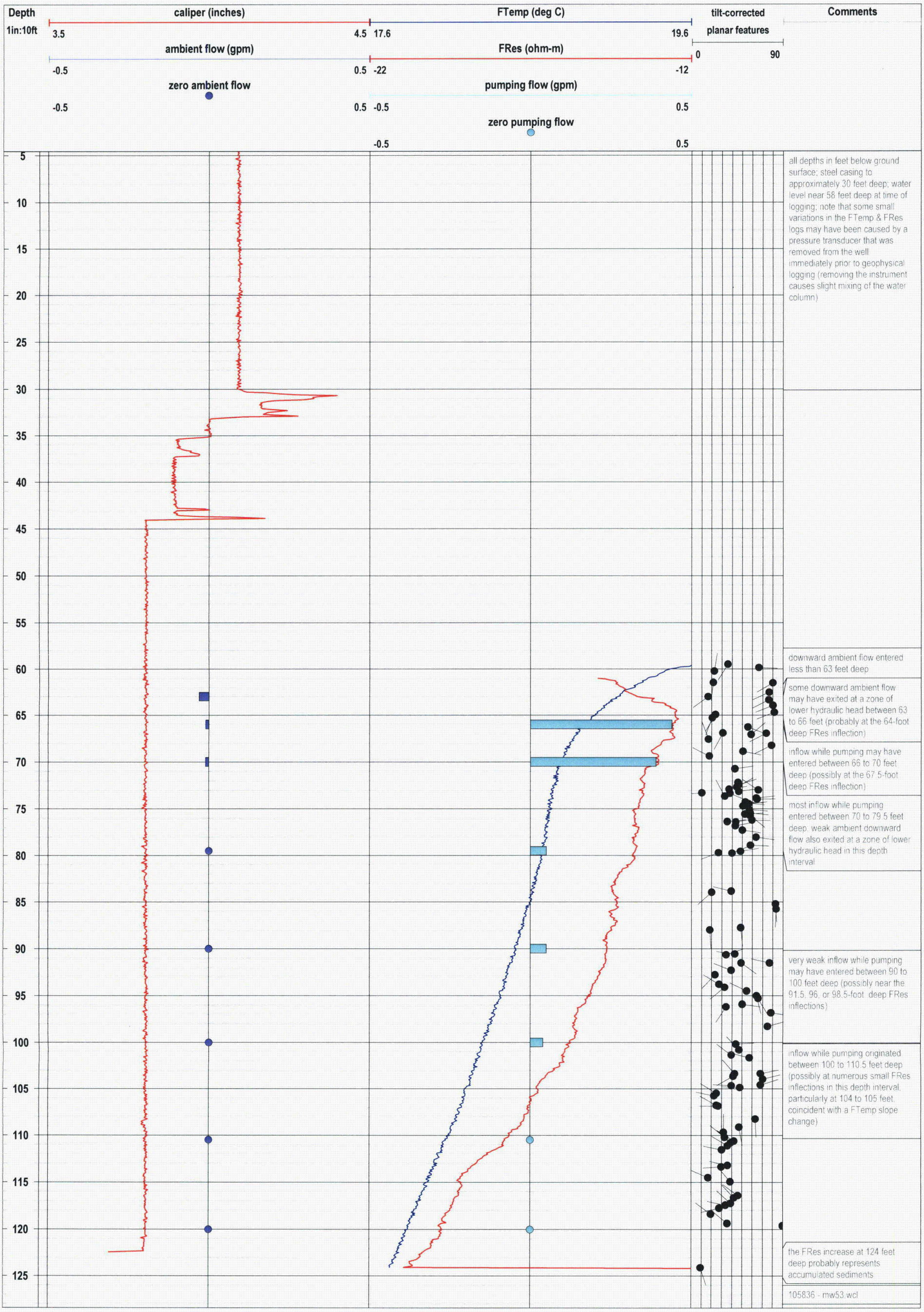
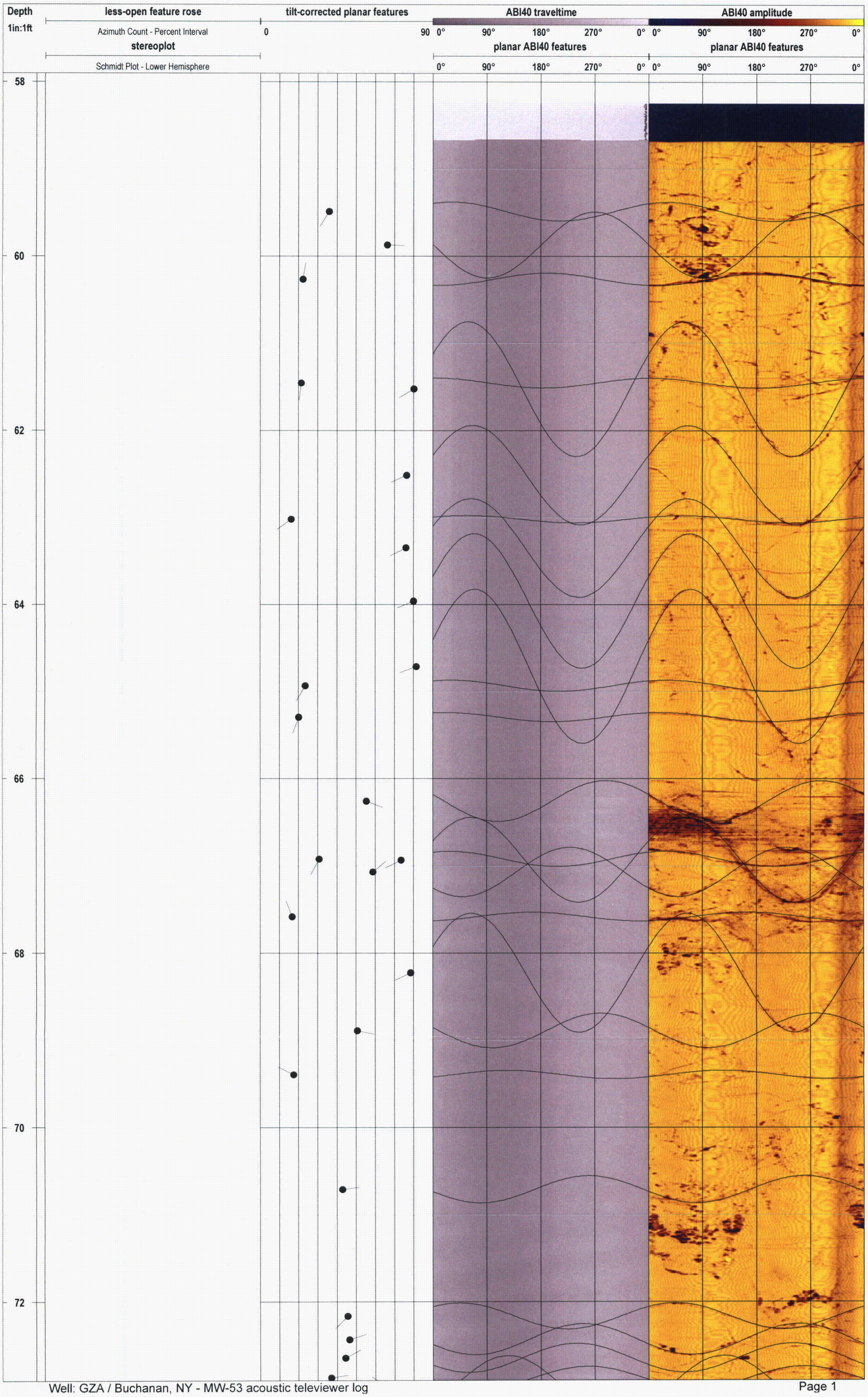
Project - Well: GZA / Buchanan, NY - MW-53 conventional logs



Well: GZA / Buchanan, NY - MW-53 conventional logs

Project - Well: GZA / Buchanan, NY - MW-53 acoustic televiewer log



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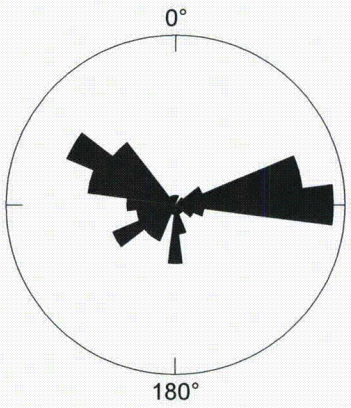

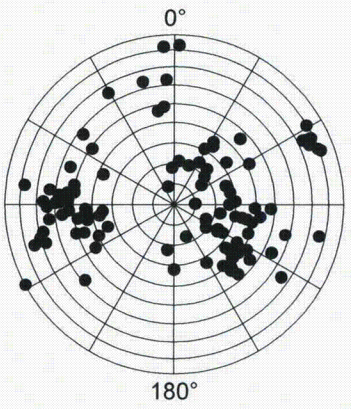

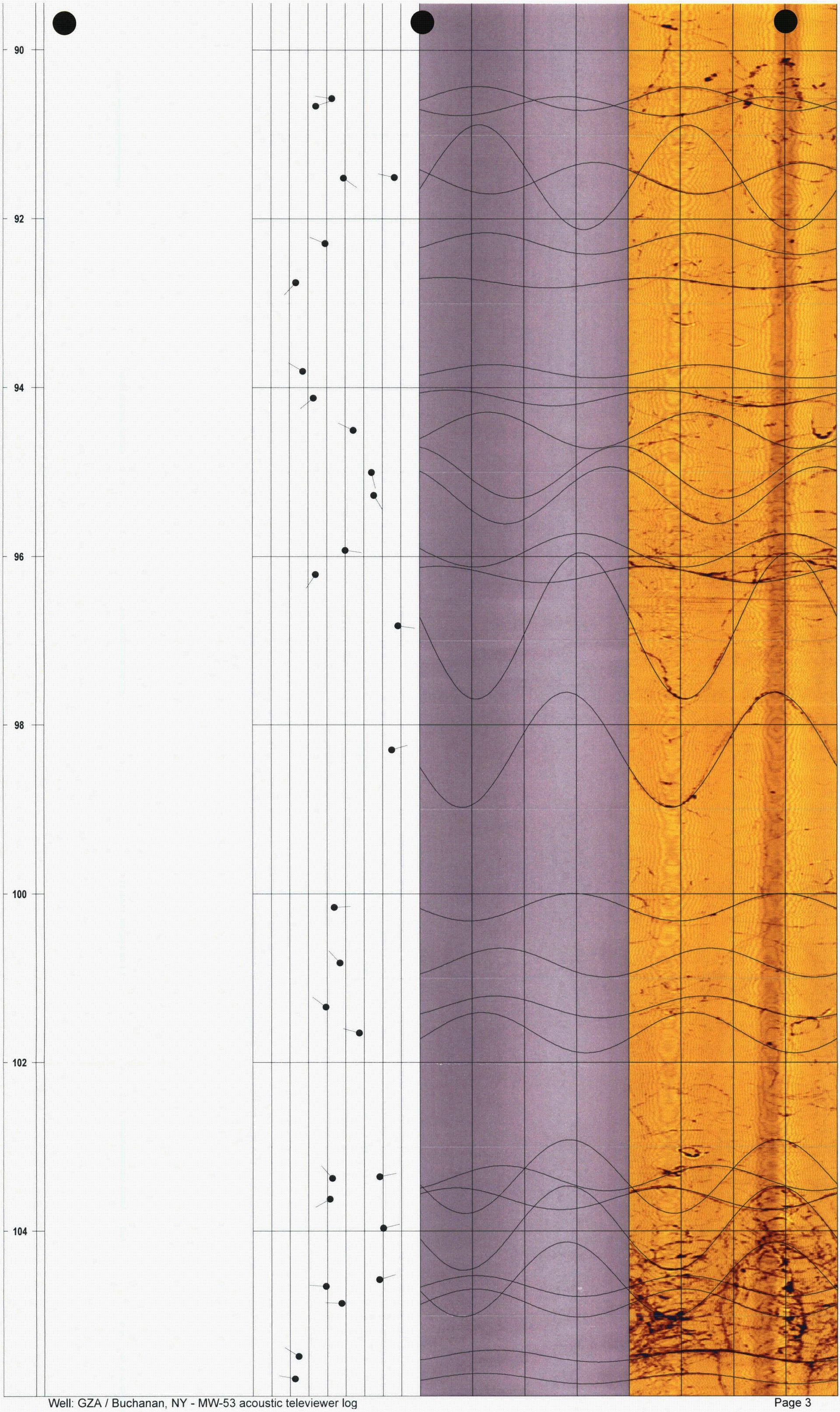
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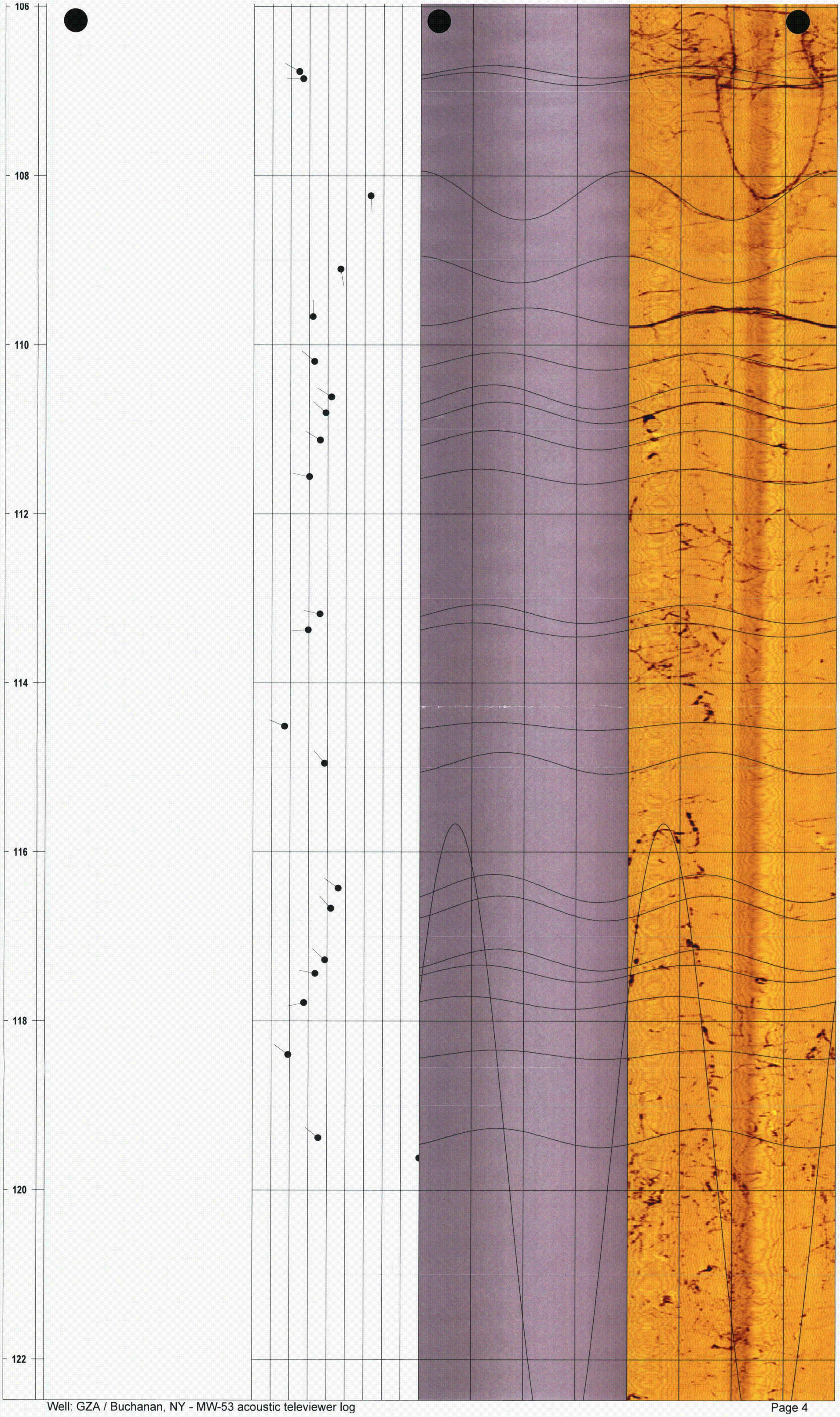
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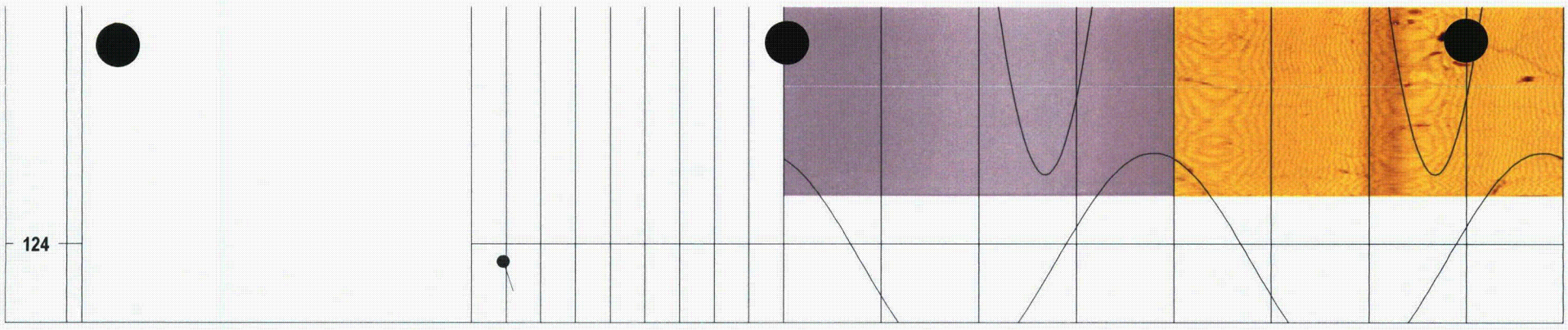
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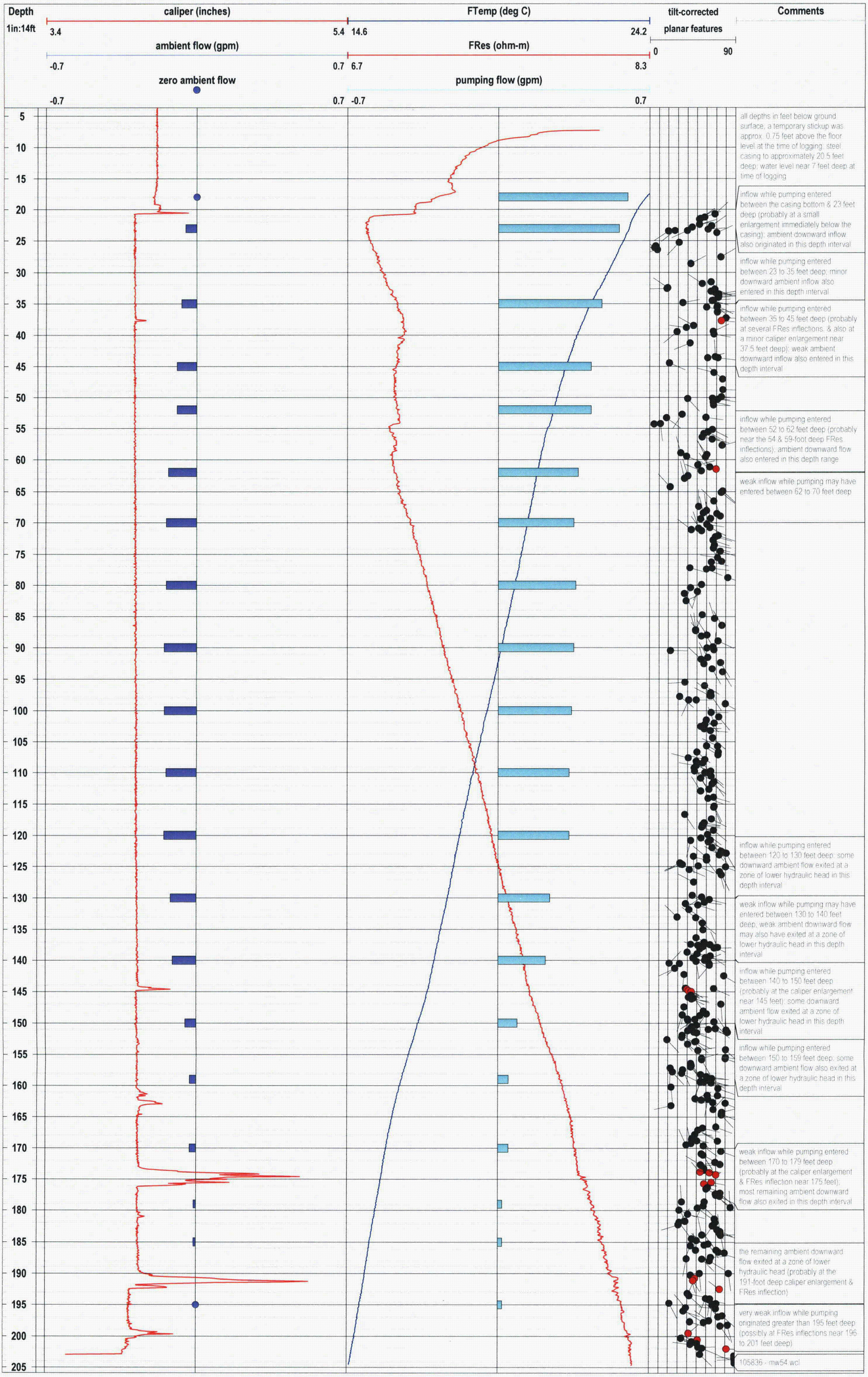
Project - Well: GZA / Buchanan, NY - MW-54 conventional logs



Well: GZA / Buchanan, NY - MW-54 conventional logs

Project - Well: GZA / Buchanan, NY - MW-54 optical & acoustic televiewer logs

Depth
1in:1.5ft

less-open feature rose
Azimuth Count - Percent Interval
open feature rose
Azimuth Count - Percent Interval
stereoplot
Schmidt Plot - Lower Hemisphere

tilt-corrected planar features
0 90

OBI40 image
0° 90° 180° 270° 0°

ABI40 traveltime
0° 90° 180° 270° 0°
planar ABI40 features
0° 90° 180° 270° 0°

ABI40 amplitude
0° 90° 180° 270° 0°
planar ABI40 features
0° 90° 180° 270° 0°

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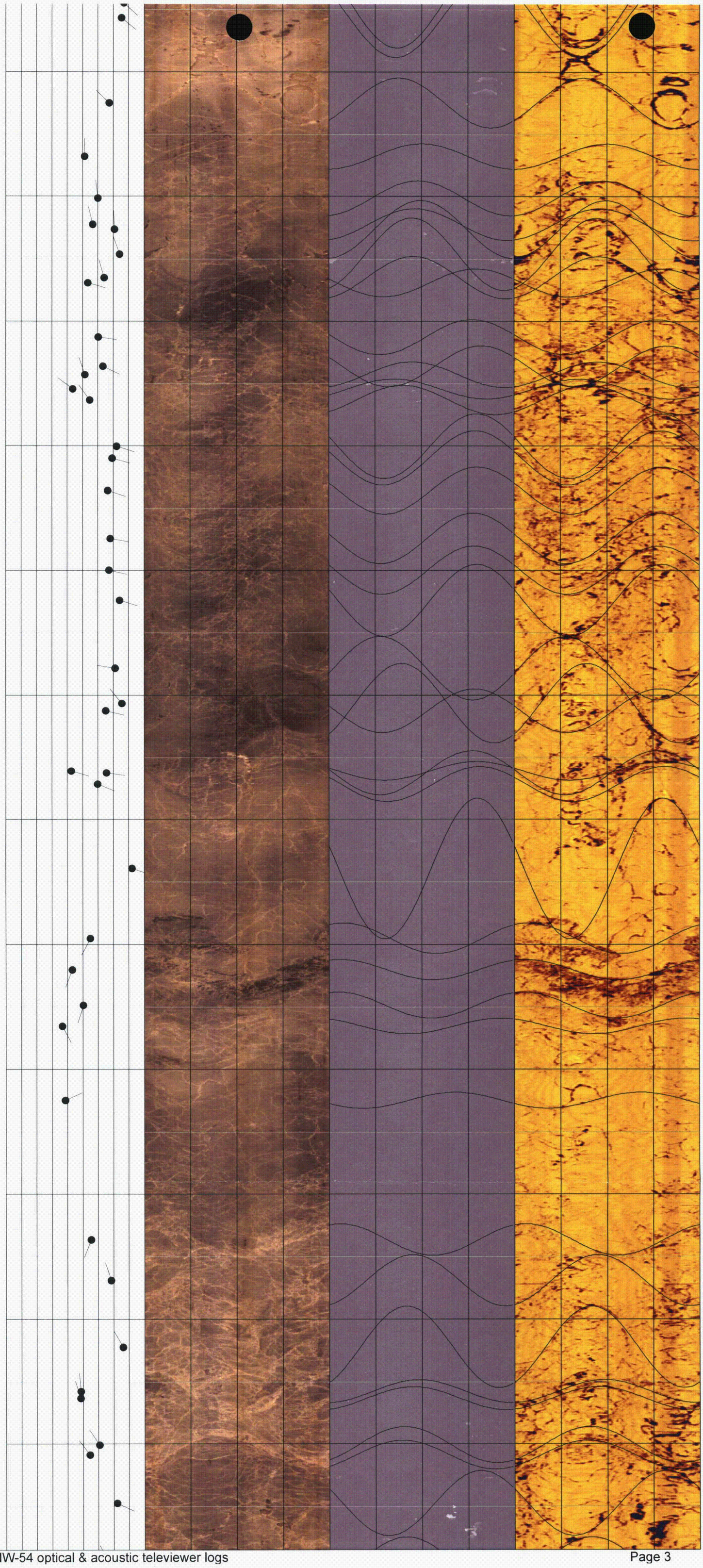

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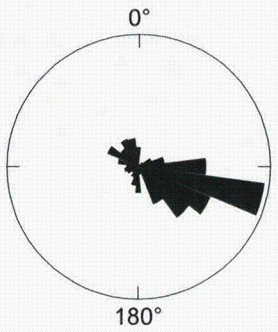

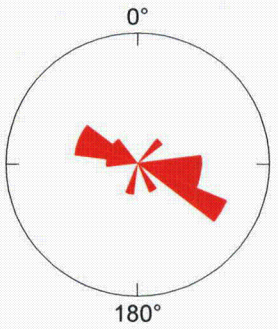

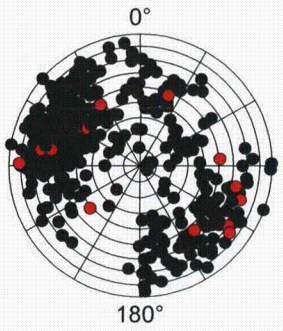

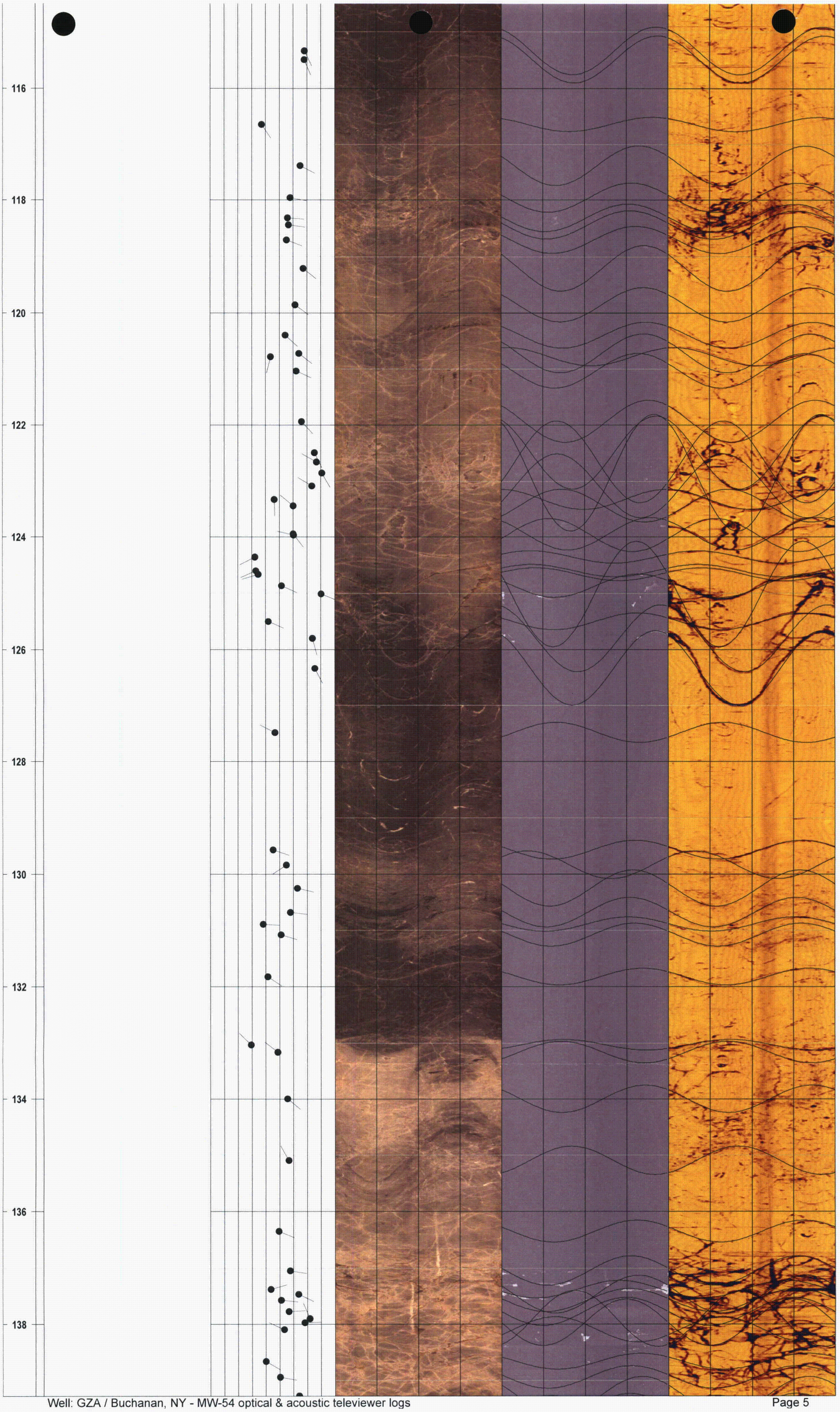
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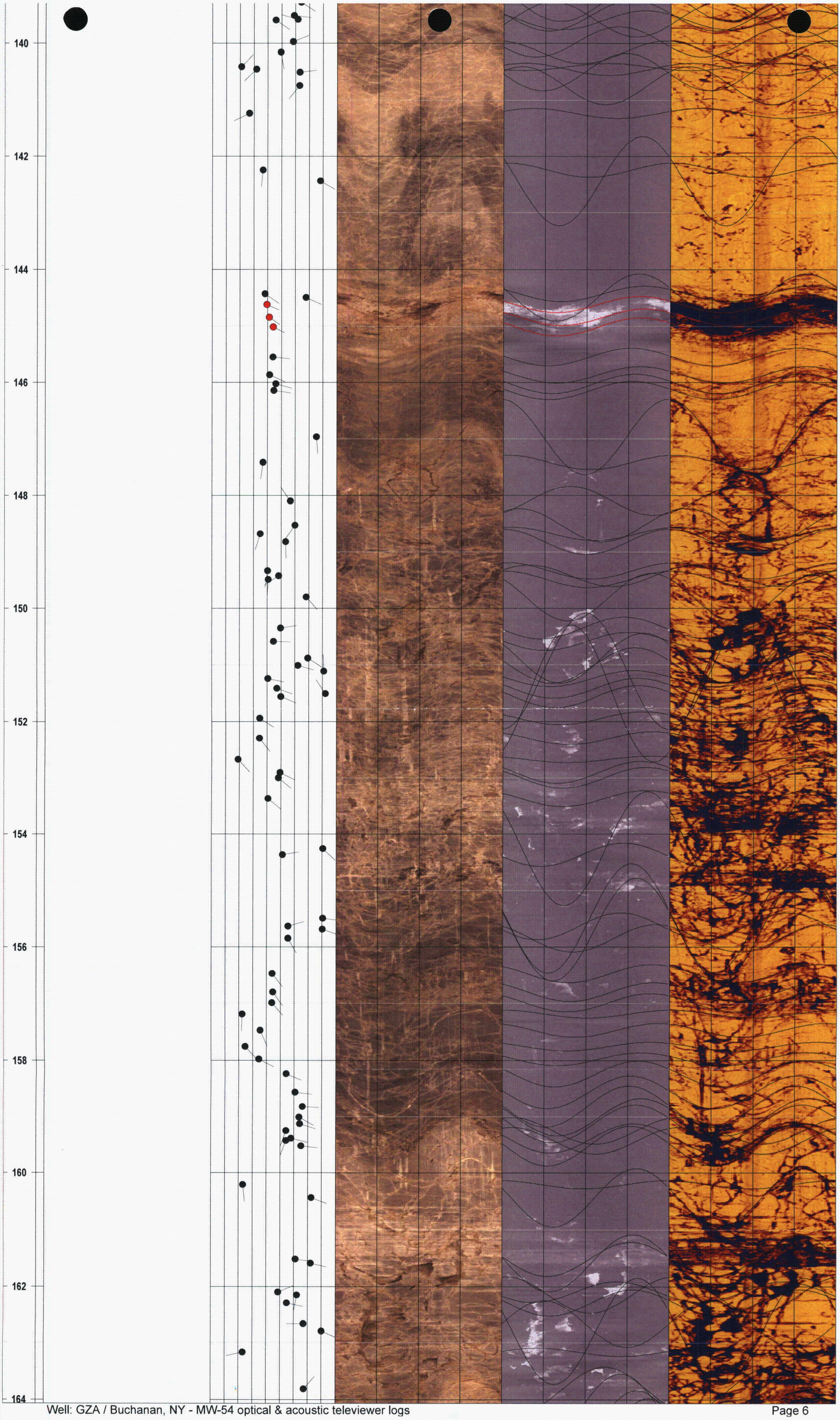
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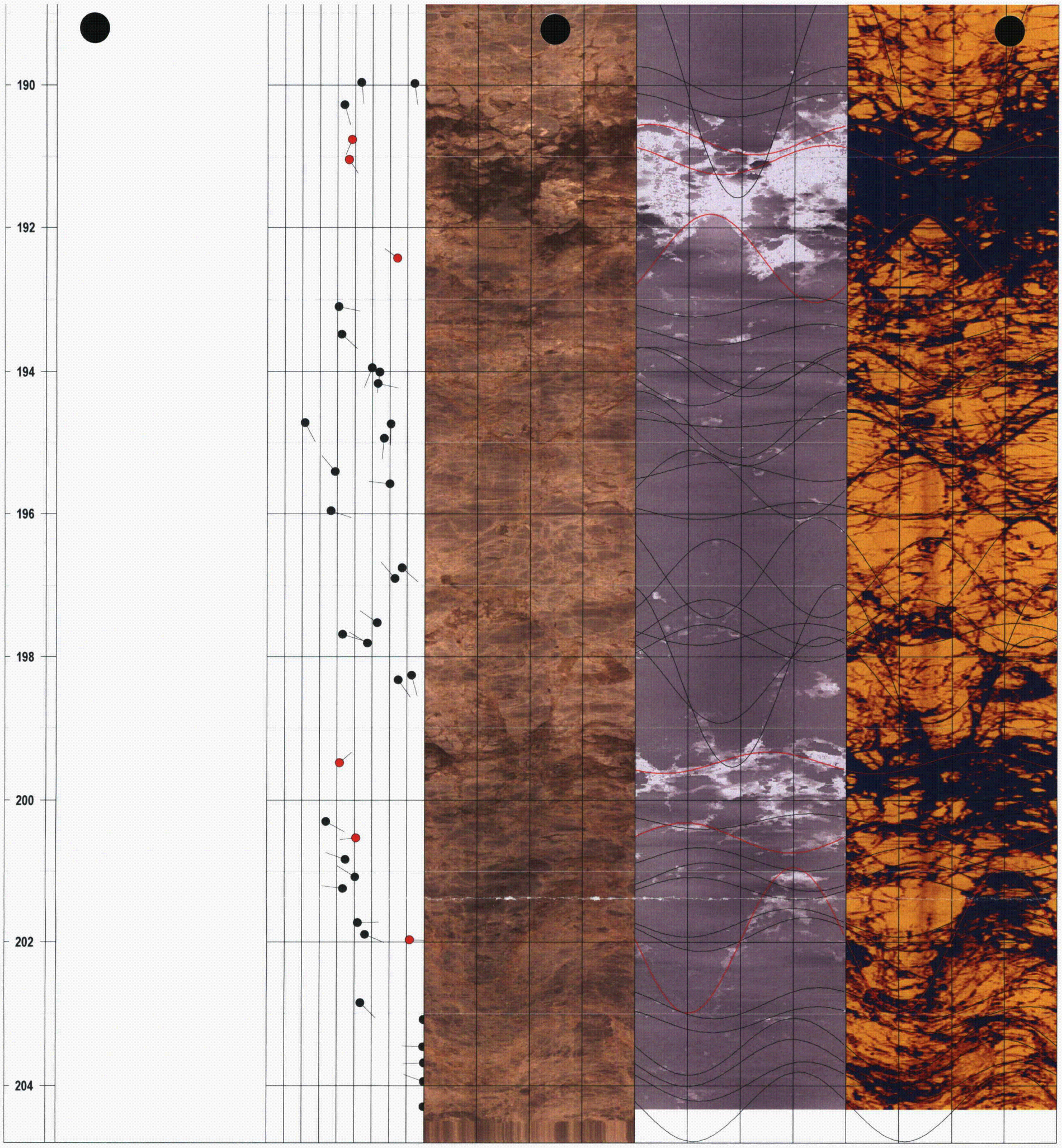
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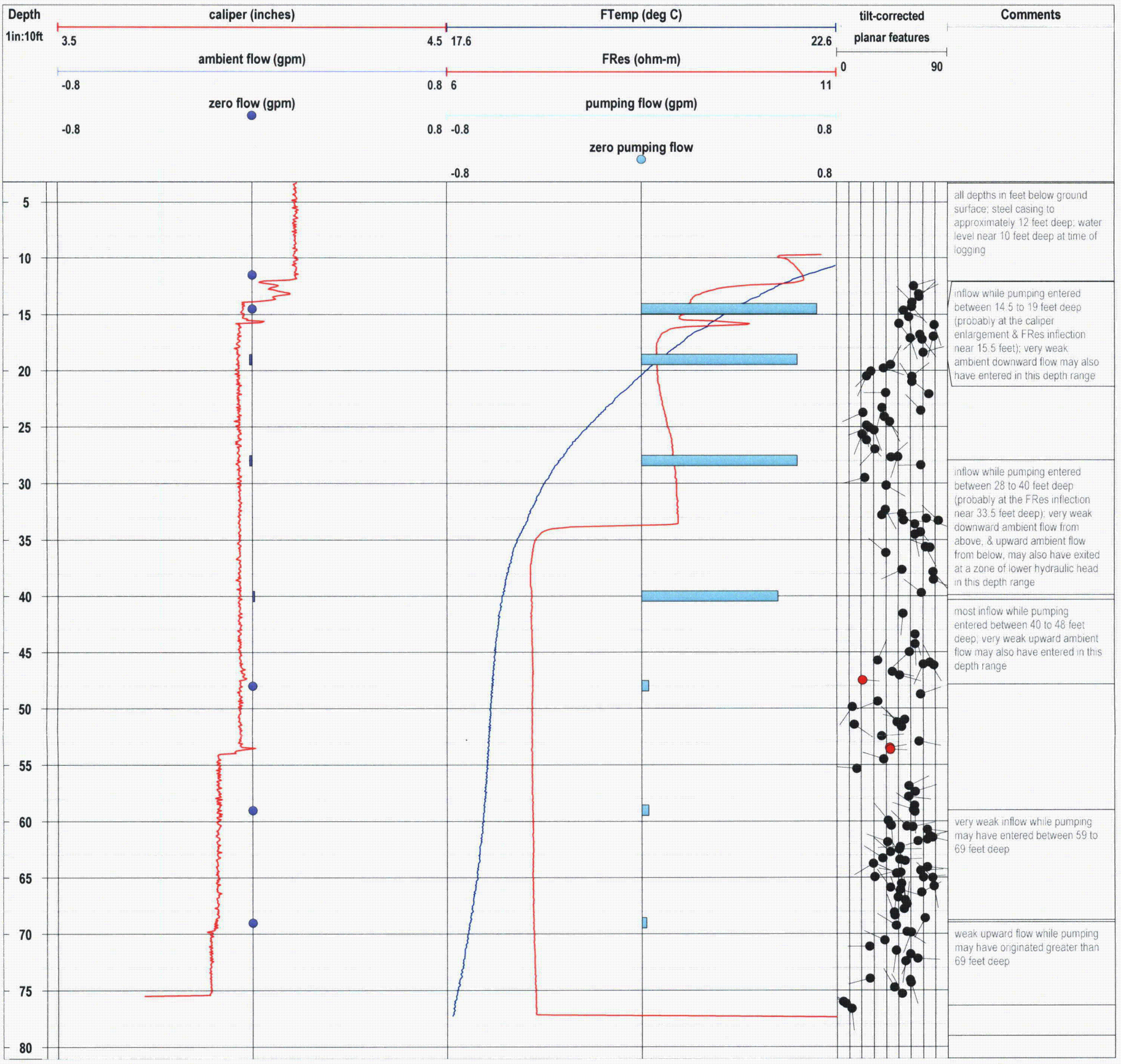
Project - Well: GZA / Buchanan, NY - MW-55 conventional logs



Well: GZA / Buchanan, NY - MW-55 conventional logs

Project - Well: GZA / Buchanan, NY - MW-55 optical & acoustic televiewer logs