U.S. Army Corps of Engineers

New England District
Concord, Massachusetts

Former LO-58 Nike Battery Launch Site
Formerly Used Defense Site (FUDS)
Caribou, Aroostook County, Maine

Contract No. W91236-05-D-0036
Task Order No. 0036
DCN: MEFUDS36-080511-AACB

FINAL
CONCEPTUAL SITE MODEL REPORT

August 2011

01M-0007

WESTON SOLUTIONS®

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Prepared for:

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August 2011

Work Order No. 03886.184.001

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LIST OF ACRONYMS

AFNS	Acid Fueling/Neutralization Station
AMAC	Adult Multiple Alternative Center
amsl	above mean sea level
Analytics	Analytics Environmental Laboratory, LLC
AST	aboveground storage tank
bgs	below ground surface
BOH	Board of Health
BTEX	benzene, toluene, ethylbenzene, or xylene
CDC	Center for Disease Control
CDCP	Center for Disease Control and Prevention
CENAE	United States Army Corps of Engineers, New England District
cis-1,2-DCE	cis-1,2-dichloroethylene
COLOG	COLOG Division of Layne Christensen Company
COPC	contaminants of potential concern
CSM	Conceptual Site Model
DERP	Defense Environmental Restoration Program
DO	dissolved oxygen
DOD	Department of Defense
DRO	diesel-range organics
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
FEC	fluid electrical conductivity
fractures/ft	fractures per foot
ft	foot/feet
ft^2/day	square feet per day
FUDS	Formerly Used Defense Sites
Generator Building	Generator & Frequency Changer Building
gpm	gallons per minute
GPR	ground-penetrating radar
GRO	gasoline-range organics
HHRA	human health risk assessment
HPL	hydrophysical logging
HTRW	Hazardous, Toxic, and Radioactive Waste
INPR	*Inventory Project Report*

LIST OF ACRONYMS
(Concluded)

JCI	Johnson Companies, Inc.
LO-58 Site	Former LO-58 Nike Battery Launch Site
LTMP	Long-Term Monitoring Program
MACTEC	MACTEC Engineering and Consulting, Inc.
Maine HETL	Maine Health and Environmental Testing Laboratory
MassDEP	Massachusetts Department of Environmental Protection
MCL	Maximum Contaminant Limits
MEDEP	Maine Department of Environmental Protection
MEG	maximum exposure guideline
MGS	Maine Geologic Survey
NAPL	non-aqueous phase liquid
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
ORP	oxidation-reduction potential
OTV	Optical Televiewer
PCB	polychlorinated biphenyls
PDT	project delivery team
POE	point-of-entry
PSI	Preliminary Site Investigation
RAG	Remedial Action Guidelines
RL	reporting limit
SOW	*Scope of Work*
TCE	trichloroethylene
Test Building	Missile Assembly & Test Building
U.S.	United States
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
UST	underground storage tank
VFW	Veterans of Foreign Wars
VOC	volatile organic compound
WESTON®	Weston Solutions, Inc.
WSP	wire-line straddle packer

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

This Conceptual Site Model (CSM) Report was prepared by Weston Solutions, Inc. (WESTON®) to summarize relevant property information, historical operations, hydrogeological conditions, and environmental activities that have taken place at the Former LO-58 Nike Battery Launch Site (LO-58 Site) in Caribou, Maine, which is one of several Formerly Used Defense Sites in northern Aroostook County, Maine. This CSM Report has been prepared for the United States (U.S.) Army Corps of Engineers, New England District (CENAE) in accordance with the *Statement of Work* issued by CENAE to WESTON on 19 March 2007 (CENAE, 2007a; 2007b). This CSM Report was prepared according to the methodology provided in U.S. Army Corps of Engineers Engineering Manual No. 1110-1-1200, *Conceptual Site Models for Ordnance and Explosives (OE) and Hazardous, Toxic, and Radioactive Waste (HTRW) Projects*.

Construction of the LO-58 Nike Battery Launch began in 1955, and by 1957 it became operational as an anti-aircraft guided missile launching facility. The LO-58 Site was deactivated by the Department of Defense in 1966 and decommissioned as a military facility in 1969. The missile magazines were closed during a CENAE project performed in 1994.

In 1970, the property was purchased by the current owner, the Lister-Knowlton Veterans of Foreign Wars (VFW) Post 9389. The VFW currently uses the former Barracks Building as their headquarters for meetings and functions, and leases the former Generator & Frequency Changer Building to the Adult Multiple Alternative Center (AMAC); a daycare facility for handicapped adults. The LO-58 Site is provided with drinking water from two separate bedrock water supply wells. The VFW Building is provided potable drinking water from a 6-inch-diameter, 283-foot (ft) deep bedrock well, designated DW-2 (WESTON, 2007). In 1996, a 6-inch-diameter, 58-ft deep bedrock water supply well, designated DW-1, was installed approximately 25 ft east of the AMAC Building. Historically, concentrations of diesel-range organics (DRO) and trichloroethylene (TCE) in groundwater from well DW-1 have exceeded their applicable Maine Department of Environmental Protection (MEDEP) action levels of 50 and 2.5 micrograms per liter, respectively [Board of Health (BOH), 1992; Maine Center for Disease Control and Prevention (CDCP), 2010; WESTON, 2007]. A point-of-entry (POE), activated carbon water filtration system was installed, maintained, and monitored by MEDEP until fall 2008 to remove organic contaminants which are present in drinking water well DW-1 In 2009, CENAE took over the maintenance and monitoring of the POE at the AMAC Building (Hewett, 2011).

Based on the results of previous environmental investigations, the contaminants of potential concern (COPC) attributable to releases from the LO-58 Site are volatile organic compounds (VOC) associated with fuels formerly used and stored in underground storage tanks (UST) and aboveground storage tanks (AST) at the LO-58 Site and chlorinated solvents associated with missile maintenance (WESTON, 2000). For the purposes of this CSM Report, the former USTs themselves are no longer considered sources because they have been removed from the LO-58 Site. Residual contamination in LO-58 Site soils relating to the former USTs and ASTs remain sources of fuel-related COPCs in four areas: south of the AMAC Building, northwest of the former Warhead Building and Fueling Platform, and three distinct locations surrounding the former Launcher Area. Residual contamination in LO-58 Site soils associated with missile maintenance remains a source of chlorinated solvent-related COPCs in two areas: south of the AMAC Building and the eastern portion of the former Launcher Area.

Soil Exposure

On-site soils have been documented to contain VOCs related to fuel and, to a lesser extent, chlorinated solvents related to missile maintenance. Importantly, TCE was not detected in soil samples at concentrations above the applicable MEDEP Remedial Action Guidelines (RAG), but DRO were detected at two locations at concentrations above the MEDEP cleanup levels [MACTEC Engineering and Consulting, Inc. (MACTEC), 2010; MEDEP, 2010a]. The depth of the soil samples that contain fuel-related COPCs at the LO-58 Site range from 0 to 4 ft below ground surface (WESTON, 2001). The circumstances where soil exposure to COPCs from the LO-58 Site may occur include direct contact with soils containing VOCs, and incidental ingestion of soils containing VOCs. Due to the availability of soil analytical results that document the nature and extent of the soil source and potential human and environmental targets, soil exposure is considered a complete exposure pathway.

Groundwater Exposure

Groundwater beneath the LO-58 Site has been documented to contain VOCs related to fuel and chlorinated solvents. The COPCs have previously been detected above the applicable Maine Maximum Exposure Guidelines (MEG) in bulk drinking water samples collected from on-site drinking water well DW-1 and groundwater samples collected from on-site monitoring wells; groundwater data from individual fractures within drinking water wells DW-1 and DW-2 indicate the presence of gasoline-range organics and/or DRO above Maine MEGs (BOH, 1992, Maine CDCP, 2010). The POE treatment at well DW-1 serves to mitigate potential exposure to contaminated groundwater (WESTON, 2001). The most recent, available groundwater analytical results, collected in May and July 2010, indicate that VOCs and DRO are present in groundwater at the LO-58 Site above Maine MEGs (The Johnson Company (JCI), 2010d; Analytics Environmental Laboratory, LLC, 2010; Maine CDCP, 2010). Due to the availability of groundwater analytical results that document the nature and extent of groundwater contamination, actual and potential human targets, and potential environmental targets, groundwater exposure is considered a complete exposure pathway.

Sediment/Surface Water Exposure

No known samples of sediment or surface water downstream of the LO-58 Site have been collected to date. The distance to the nearest sediment/surface water is approximately 0.18 mile to the northeast, in the floodplain of Hardwood Brook, although surface water runoff from the western portion of the LO-58 Site flows northward approximately 0.5 mile along a natural valley toward Hardwood Brook. Available groundwater flow data indicate that groundwater from eastern and central portions of the LO-58 Site flows north-northwestward toward Hardwood Brook, and groundwater beneath the western portion of the site flows northwestward toward Hardwood Brook. Groundwater analytical results indicate that groundwater beneath the western portion of the LO-58 Site contains detectable concentrations of COPCs. There has been no investigation of the possibility that this groundwater may discharge to surface water between the LO-58 Site and Hardwood Brook. The natural valley north of the site, located between the VFW Building and the AMAC Building, is the likely location where such groundwater discharge may occur. Based on the available data, it cannot be determined whether the nearest sediment and/or surface water have been impacted by the LO-58 Site; combined with documentation of potential human and environmental targets, sediment/surface water exposure is considered only a potential exposure pathway.

Air Exposure

The COPCs attributable to releases from the LO-58 Site are volatile compounds. As such, both VOCs associated with fuel and chlorinated solvents associated with missile maintenance are subject to volatilization and may, under certain circumstances, become an inhalation hazard. The circumstances where air exposure to COPCs from the LO-58 Site may occur are:

- Volatilization to air from soils containing VOCs.
- Volatilization to air from groundwater containing VOCs, either through the vadose zone or from groundwater pumped from the subsurface (i.e., use of groundwater for showering).
- Volatilization to air from sediments/surface water containing VOCs.

Soil vapor data collected in 1999 confirms that VOCs are present in the vicinity of the soils impacted by VOCs at the LO-58 Site. Based on MEDEP vapor intrusion preliminary screening evaluation criteria, it may also be concluded that there is potential for vapor intrusion/air migration at the LO-58 Site. Based on the available information, which cannot document a release to air but nonetheless document potential human and environmental targets, air exposure via volatilization from soil and groundwater is considered to be a potential exposure pathway.

Biotic Exposure

The biotic medium is important when considering the potential for transfer of contaminants through the food chain. Additionally, bioaccumulation and bioconcentration of some contaminants in plants or animals can result in exposure of other receptors to harmful contaminant concentrations. The COPCs attributable to the LO-58 Site are VOCs which have relatively low bioaccumulation potential. Further, the existing and foreseeable future land use at the LO-58 Site does not include hunting, fishing, gardening, or the collection of any biota for human consumption. Thus, current or reasonably foreseeable uses of the site suggest that biotic exposure is an incomplete exposure pathway for the LO-58 Site.

Recommendations

WESTON has the following recommendations for additional activities at the LO-58 Site, in response to the conclusions of the CSM Report.

In order for the LO-58 Site to comply with MEDEP regulations, the current nature and extent of MEDEP RAGs or cleanup levels exceedances should be determined. WESTON recommends the collection of replicate soil samples from previous sample locations SB-13and SB-55, for laboratory analysis for extractable petroleum hydrocarbons (EPH) by the Massachusetts Department of Environmental Protection’s (MassDEP) Method for the Determination of EPH. If the soil analytical results indicate that the soil meets MEDEP or cleanup levels, the results can be used to support a conclusion that natural attenuation has reduced concentrations of COPCs in soil, and that no further soil remedial investigations are necessary at the LO-58 Site. If one or more of the samples indicate that the soil still exceeds MEDEP cleanup levels, additional soil samples should be collected to determine the extent of soil impacts greater than their MEDEP cleanup levels.

In order to address the lack of soil polychlorinated biphenyl (PCB) data in the vicinity of the AMAC Building, WESTON proposes that five shallow (0 to 2 ft) soil samples be collected and analyzed for PCBs.

In order to determine whether potentially-contaminated groundwater from Site LO-58 have impacted the nearest off-site drinking water well, WESTON recommends that a drinking water sample be collected from this well, and analyzed for VOCs (TCE and its breakdown products) and EPH.

In order to determine whether potentially-contaminated groundwater may discharge to surface water between the LO-58 Site and Hardwood Brook, WESTON recommends the installation of an overburden monitoring well located within the valley northeast of the VFW Building.

In order to assess potential surface water and sediment impacts related to the LO-58 Site, WESTON recommends the collection of a limited number of surface water and sediment samples. An estimated six surface water and sediment samples (SW-01 through SW-03 and

SD-01 through SD-03, respectively), collected in the late summer when regional precipitation is at its annual low and groundwater discharge to surface water is greatest, from the three nearest identified surface water and wetland soil locations northwest of the LO-58 Site.

In order to determine whether potentially-contaminated groundwater may result in air impacts in the vicinity of the AMAC Building, WESTON recommends the collection of two sub-slab soil vapor samples and an indoor air sample from the AMAC Building.

The additional data proposed for collection above will be combined with the available data to create a more complete dataset. These data should be applied to update the CSM, which will include recommendations regarding the need for further actions at the LO-58 Site.

SECTION 1

INTRODUCTION

1. INTRODUCTION

1.1 SCOPE OF WORK AND PURPOSE

This Conceptual Site Model (CSM) Report was prepared by Weston Solutions, Inc. (WESTON®) to summarize relevant property information, historical operations, hydrogeological conditions, and environmental activities that have taken place at the LO-58 Nike Battery Launch Site (LO-58 Site) in Caribou, Maine, which is one of several Formerly Used Defense Sites (FUDS) in northern Aroostook County, Maine (Figure 1-1). This CSM Report has been prepared for the United States (U.S.) Army Corps of Engineers, New England District (CENAE) in accordance with the *Statement of Work* issued by CENAE to WESTON on 19 March 2007 (CENAE, 2007a; 2007b).

1.2 LIMITING CONDITIONS AND METHODOLOGY USED

This CSM Report was prepared according to the methodology provided in the U.S. Army Corps of Engineers (USACE) Engineering Manual No. 1110-1-1200, *Conceptual Site Models for Ordnance and Explosives* (*OE*) and *Hazardous, Toxic, and Radioactive Waste (HTRW) Projects*. As such, the CSM Report is a description of the LO-58 Site and its environment that is based on existing knowledge. It describes sources and receptors, and the interactions that link them. The CSM provides a planning tool to integrate information from a variety of resources, evaluates the information with respect to project objectives and data needs, and responds through an iterative process for further data collection or action. The target audience is the project delivery team (PDT), and the CSM assists the PDT in planning, interpreting data, and communicating (USACE, 2003).

The CSM was directed by Mr. Joseph Schmidl, a State of Maine Certified Geologist (Certificate Number GE436). The information compiled within this CSM Report was gathered by reviewing previous reports submitted by CENAE contractors, reviewing available documents at the Maine Geologic Survey (MGS) offices and online sources, and by performing interviews and investigations at the LO-58 Site. The information included in the CSM Report is limited by the quality of the previous investigations and the material that was available for review. In addition, current site conditions are based on the date of site investigation, the date of file reviews performed, and the information that was available for review at that time. Site conditions noted in this CSM Report cannot be guaranteed to cover future activities being performed at or uses of each site.

1.3 REPORT ORGANIZATION

This CSM Report has been written to support the refinement of the CSM for the LO-58 Site. Section 2 of the CSM Report summarizes the historical environmental investigations performed to date and profiles the information used to support the LO-58 Site CSM. Section 3 contains the pathway summary for the LO-58 Site. Section 4 of the CSM Report presents conclusions and Section 5 presents a data gaps analysis. Section 6 presents recommendations to address data gaps of the LO-58 Site CSM. Section 7 of the CSM Report includes the references cited to support the CSM for the LO-58 Site.

SECTION 2

LO-58 SITE PROFILES

2. LO-58 SITE PROFILES

The LO-58 Site was operated as a Nike Missile Battery Launch facility from 1955 to 1969, when it was conveyed to the City of Caribou and used for storage of municipal property. In 1970, the property was purchased by the current owner, the Lister-Knowlton Veterans of Foreign Wars (VFW) Post 9389. The Nike Missile Battery Launch facility was originally designed to carry and deploy the Ajax-type guided missile; however, in approximately 1960, the operation was converted to operate the bigger, nuclear-capable Hercules-type missiles. Operation and maintenance of these missiles required the storage and use of hazardous materials including various fuels and chlorinated solvent cleaning solutions. Over the years, some of these hazardous materials were released to the environment.

Development of the CSM requires the evaluation of several site “profiles” or descriptions. These profiles include:

- Facility Profile
- Physical Profile
- Release Profile
- Land Use and Exposure Profile
- Ecological Profile

The profile descriptions are presented in detail in this section.

2.1 HISTORICAL INFORMATION SOURCES

The information used to develop the LO-58 Site profiles was obtained through a series of environmental investigations conducted at the LO-58 Site by various parties, which are summarized in Subsections 2.1.1 through 2.1.10.

2.1.1 Summary of Pre-1996 Investigations

According to available documents, including an *Inventory Project Report* (*INPR*) (CENAE, 1993) for the LO-58 Site, at least three site visits had been performed between the mid-1980s and 1993 for the purpose of identifying environmental hazards associated with the former defense site. The inspections noted that plans for the LO-58 Site indicated that three fuel storage tanks were historically used at the facility and included the following: a 2,000-gallon underground storage tank (UST) associated with the former Barracks Building, a 500-gallon fuel oil aboveground storage tank (AST) located outside the former Missile Assembly & Test Building (Test Building), and a 4,000-gallon fuel UST located adjacent to the southwest corner of the former Generator & Frequency Changer Building (Generator Building). According to available records, including the *INPR* (CENAE, 1993) and site summary sheets, the former Generator Building had been expanded and an AST had been installed to fuel the building's heating system (WESTON, 2007).

Records reviewed indicated that the 2,000-gallon UST had been removed, and the 500-gallon AST had been utilized by a previous tenant at the property, and therefore was not eligible for removal under the Defense Environmental Restoration Program (DERP). Representatives from CENAE did not find any indication that the 4,000-gallon UST was still present at the property and assumed that it had been removed, although no specific documents confirming the removal were found, nor any records of the means used by CENAE personnel to make this determination. Based on these findings, CENAE recommended that no further federal action be taken regarding the remaining 500-gallon AST (WESTON, 2007). See Subsections 2.1.4, 2.1.7, 2.2.7.1, and 2.2.7.2 for further details regarding the disposition and current status of ASTs and USTs at the LO-58 Site.

In addition to identifying former fuel storage tanks, the pre-1996 CENAE inspections also noted that the acid neutralization pit and refueling area were still in place, but concluded that they posed no threat to the environment and, therefore, required no further action. The only recommendation for action at the LO-58 Site made as a result of the inspections was regarding the three former missile magazines. The VFW indicated that they had no beneficial use of the magazines, and therefore the inspections recommended that the hydraulic fluid be drained and the magazines sealed (WESTON, 2007).

2.1.2 Site Closure Activities

Closure activities associated with the three missile magazines at the LO-58 Site were performed by Mason and Maine Environmental Engineering Company between August 1994 and October 1994. The closure of each missile magazine included the collection of samples of infiltrated water within each of the three magazines with laboratory analysis for polychlorinated biphenyls (PCB) and flashpoint, removal and disposal of the water within the magazines, removal and disposal of hydraulic systems, and capping the three magazines with concrete planks. Aboveground magazine closure demolition work was also conducted which consisted of removing of several vent pipes, manholes, and bulkhead doors (Mason Environmental Services, Inc., 1995).

2.1.3 1996 Groundwater Investigation

In fall 1996, the Maine Department of Environmental Protection (MEDEP) responded to a complaint made by the current owner concerning odors in the water from drinking water well DW-1, which serves the Adult Multiple Alternative Center (AMAC) Building. Two rounds of groundwater sampling and analysis [U.S. Environmental Protection Agency (EPA) Method 8260] performed by MEDEP documented and confirmed the presence of trichloroethylene (TCE) contamination. The first round of sampling was performed on 8 October 1996. The analytical results of this sample indicated the presence of TCE at a concentration of 8.6 micrograms per liter (µg/L), which was above the Maine maximum exposure guideline (MEG) of 5 µg/L. The results of the second round of sampling, performed on 21 October 1996, indicated the presence of TCE at 8.8 µg/L. MEDEP immediately installed a dual, granular-activated carbon filtration point-of-entry (POE) treatment system and initiated a quarterly monitoring program. Since 1996, TCE has consistently been detected in samples of untreated water collected as part of this quarterly monitoring program, with concentrations remaining fairly steady over time (WESTON, 2007). According to CENAE, the post-treatment drinking water samples collected generally did not contain detectable concentrations of TCE.

2.1.4 1998 Maine Department of Environmental Protection Geophysical Investigation

During a site visit on 21 May 1998, MEDEP staff investigated an area located southwest of the former Generator Building, where the 4,000-gallon fuel UST was located during the time the LO-58 Site was operated by the military. Although this tank had reportedly been removed, a magnetometer survey of the area detected a significant anomaly approximately 3 feet (ft) east and 9 ft south of the southwest corner of the building. This magnetometer “hit” suggested that a large metal object may still exist in this portion of the property.

2.1.5 Expanded Water Supply Monitoring

Following the 21 May 1998 site visit, drinking water well DW-2 which serves the VFW Building was added to the ongoing quarterly monitoring program. Due the fact that this well is located topographically downhill from DW-1, where TCE had been identified in groundwater, it was added to the program as a precautionary measure to determine if the VFW drinking water well had also been impacted. The well was sampled seven times between 17 August 1998 and 2 February 2000 for volatile organic compounds (VOC) by EPA Method 8260 [Maine Health and Environmental Testing Laboratory (Maine HETL), 1998a; 1998b; 1999a; 1999b; 1999c; 1999d; 2000]. No VOCs were detected in the samples which had reporting limits (RL) between 1 and 5 µg/L with a single exception. The sample collected on 8 July 1998, contained 1 µg/L dichloromethane which was below its 48 µg/L MEG (Maine HETL, 1998c).

2.1.6 1998 Site Inspection

In October 1998, representatives of WESTON and MEDEP performed a walkover at the LO-58 Site to identify potential areas of concern regarding the release of hazardous substances to the subsurface. During the site walk, several areas of the LO-58 Site were identified as potential sources of contamination including the former Launcher Area, the former Acid Fueling/Neutralization Station (AFNS), and the former Test Building. At the former Launcher Area, ten catch basins were located on the concrete pad adjacent to the missile magazines. The catch basins were connected to drainage pipes that carried runoff away from the pad and into drainage swales along the northwestern and northeastern corners of the former Launcher Area. Because historical information pertaining to the use and maintenance of the missiles suggested that they were periodically cleaned with a TCE-based solution, it was hypothesized that runoff of this solution could have entered the catch basins where it would have migrated to the drainage swales in the grassy areas surrounding the pad. One of the drainage swales was observed to be between the former Launcher Area and the former Generator Building (currently operated as the AMAC) in the approximate location where the bedrock water supply well for the AMAC facility was installed. This suggested that the TCE concentrations detected in the water supply could be due to historic use of TCE at the LO-58 Site.

Additional areas of concern identified during the site walk included two additional drainage pipe outfalls and drainage swales located adjacent to the former AFNS, the former Test Building and associated missile transfer rack (due to the unclear nature of "tests" that were performed at this location), the former Acid Storage Shed, and former Generator Building UST and septic system (WESTON, 1999).

2.1.7 1999 Preliminary Site Investigation

WESTON performed a Preliminary Site Investigation (PSI) at the property in the summer of 1999 to evaluate subsurface conditions at the LO-58 Site by performing geophysical and passive soil vapor surveys, as well as a Geoprobe® soil boring and soil sampling program. Figure 2-1 illustrates the sampling locations for the PSI at the LO-58 Site. The objective was to assess if the source of the TCE contamination detected in the on-site bedrock water supply well was due to former activities of the Department of Defense (DOD) during its operation of the property, and to assess if additional investigations are warranted.

WESTON subcontractor Northeast Geophysical Services of Bangor, Maine performed a geophysical survey near the former Generator Building on 23 June 1999. The geophysical survey consisted of two phases of investigation: a preliminary metal detection survey to identify the location of medium to large buried metal objects, and a more sensitive ground-penetrating radar (GPR) survey to identify physical characteristics of those objects. The results of the GPR survey indicate that the metallic response observed during the magnetometer survey by representatives of MEDEP was not due to the presence of an UST in the area. The GPR profiles in this area showed strong but narrow hyperbolic reflectors that are indicative of a small-diameter metal pipe extending outwards from the corner of the former Generator Building.

WESTON initiated a passive soil vapor survey at the LO-58 Site on 22 June 1999. A total of 75 EMFLUX® soil vapor probes were installed at locations AS-01 to AS-10, FP-01 to FP-12, GB-01 to GB-09, LP-01 to LP-22, MA-01 to MA-03, PR-01 to PR-08, and WB-01 to WB-04, in the vicinity of former Generator Building and surroundings; the former Test Building and surroundings; the former Acid Storage Shed and surroundings; the former AFNS area and surroundings; the former Launcher Area; and the drainage system outfalls and associated drainage swales located around the perimeter of the operations area. Figure 2-1 depicts the locations of these soil vapor sample locations. WESTON removed all but 16 of the soil vapor samplers on 12 July 1999 (The 16 remaining soil vapor probes could not be located.), and shipped them for laboratory analysis of VOCs by EPA Method 8260B. The analytical results of the soil vapor survey indicated that low levels of benzene, toluene, ethylbenzene, and xylenes or xylene (BTEX) compounds, TCE, tetrachloroethane, naphthalene, chloromethane, 1,2,4-trimethylbenzene, and 1,3,5-trimethylbenzene may exist in the subsurface. Appendix A includes a summary of the soil vapor results and maps of their distribution.

In October 1999, a Geoprobe soil boring and soil sampling investigation was performed to characterize the site soils, determine the depth of the overburden groundwater table (if present), explore the depth to bedrock at the property, and sample potentially contaminated soil zones identified by the passive soil vapor survey. Under the direction of a WESTON geologist, a total of 40 soil borings, identified as SB-01 to SB-40, were advanced in the overburden at the LO-58 Site. Figure 2-1 depicts the locations of these soil borings. The borings were advanced to the top of the bedrock surface at each location, which was encountered at depths ranging between approximately 1 and 19 ft below ground surface (bgs). Soil samples were collected continually from the ground surface to the bottom of each boring and screened in the field using photoionization detector, but the readings were all very low. Soil samples were collected from the 0- to 4-ft depth interval from 15 of the 40 soil borings locations and submitted to ESS Laboratory for laboratory analysis of VOCs by EPA Method 8260B, gasoline-range organics (GRO) by Maine HETL Method 4.2.17, and diesel-range organics (DRO) by Maine HETL Method 4.1.25.

The analytical results of the soil samples collected indicated the presence of acetone in 14 of the 15 samples collected at concentrations ranging from approximately 0.0068 to 0.0551 milligrams per kilogram (mg/kg), and TCE was detected in two soil samples, SB-13 and SB-34, at concentrations of 0.0011 and 0.009 mg/kg, respectively. Neither of these substances were detected above their respective MEDEP Remedial Action Guidelines (RAG). No other VOCs were detected in the soil samples collected from the LO-58 Site. Diesel-range organics were detected in soil samples SB-04, SB-09, and SB-13 at concentrations of 4, 10, and 36 mg/kg, respectively. The MEDEP Remediation Standard for DRO at the time was 10 mg/kg, but was superceded by a MEDEP cleanup level of 28 mg/kg in 2010 (MEDEP, 2008; 2010a). There were no other detections of DRO, and no detections of GRO in the 17 soil samples collected from the LO-58 Site. Appendix A includes a summary of the soil sample results.

Based on the results of the soil vapor survey and Geoprobe soil boring investigation, WESTON concluded that low levels of VOCs and/or DRO may exist in bedrock groundwater beneath the LO-58 Site. In addition, two soil samples collected from the property were found to contain concentrations of DRO in exceedance of the MEDEP Remediation Standard. WESTON therefore recommended the installation and sampling of bedrock monitoring wells at the property (WESTON, 2000).

2.1.8 2001 Supplemental Site Investigation

WESTON conducted a supplemental site investigation at the LO-58 Site between October 2000 and May 2001, to supplement the information obtained during the PSI performed in 1999. In addition to the information obtained during the PSI, MEDEP performed an investigation at the property in the spring of 2000 that indicated the presence of fuel-impacted soils in the vicinity of a former UST which was reportedly removed in 1994.

The objectives of the supplemental site investigation activities at the LO-58 Site were to further evaluate the source of TCE in the on-site drinking water well, to obtain further information regarding hydrogeologic conditions in bedrock, and to fill data gaps caused by the loss of 16 soil vapor probes during the PSI. The additional site investigation activities included a Geoprobe soil boring and soil sampling program; the installation of five bedrock groundwater monitoring wells; and the collection of soil, groundwater, and drinking water samples for laboratory analysis of VOCs, DRO, and GRO.

The Geoprobe investigation was performed to address concerns expressed by MEDEP regarding soil quality at the LO-58 Site. In particular, evaluations of soil in the vicinity of the former Launcher Pad and the AMAC were conducted. Additional areas of the property that were included in the investigation were the former Test Building and surroundings, the former Warhead Building and surroundings, and the grassy area located to the southwest of the AMAC Building. Under the direction of a WESTON geologist, a total of 16 soil borings, identified as SB-41 to SB-56, were advanced in the overburden at the LO-58 Site. Figure 2-1 depicts the locations of these soil borings. The analytical results of soil samples collected during the investigation indicate the presence of DRO at three boring locations, SB-45, SB-54, and SB-55, at concentrations of 11, 24, and 133 mg/kg, respectively; concentrations in excess of MEDEP RAGs at the time (10 mg/kg), which was superceded by a MEDEP cleanup level of 28 mg/kg in 2010 (MEDEP, 2008; MACTEC, 2010). Appendix A includes a summary of the soil sample results.

The bedrock monitoring well installations were performed using air-hammer drilling techniques. The wells, identified as MW-01 to MW-05, were installed at the LO-58 Site to evaluate the nature and extent of groundwater contamination at the LO-58 Site, as well as to determine the direction of groundwater flow in the local bedrock water-bearing zone. Figure 2-1 depicts the locations of these monitoring wells. Groundwater samples were collected from the bedrock monitoring wells in October 2000 and in May 2001 and submitted for laboratory analysis of VOCs, DRO, and GRO. The analytical results of the sampling indicated the presence of VOCs, DRO, and GRO in the samples. No VOCs were detected at concentrations above MEGs, but DRO and GRO were each detected in monitoring well MW-05 during both rounds at a concentration in excess of their respective MEGs. Gasoline range organics were also detected in MW-03 during the May 2001 sampling event at a concentration that exceeded its MEG. Drinking water samples were also collected from the two on-site bedrock drinking water supply wells DW-1 and DW-2. The analytical results of samples of untreated water collected from drinking water well DW-1 indicated the presence of TCE and cis-1,2-dichloroethylene (cis-1,2-DCE) at concentrations below the MEDEP MEG (MEDEP, 2008). There were no detections of DRO in the samples of untreated water collected from drinking water well DW-1, and no detections of VOCs or DRO in the untreated water samples collected from the drinking water well DW-2. Appendix A includes a summary of the groundwater and drinking water sample results.

Based on the results of the site investigation conducted by WESTON in October 1999 and the supplemental site investigation activities conducted by WESTON in October 2000 and May 2001, the following conclusions were reached:

- No source areas of the chlorinated solvents detected in the AMAC drinking water supply well had been detected in overburden soils at the LO-58 Site.
- Several areas existed where DRO had been detected in overburden soils at concentrations that equaled or exceeded the MEDEP RAG of 10 mg/kg.
- Diesel-range organics and GRO were detected in groundwater at the LO-58 Site at concentrations that exceeded MEDEP MEGs.
- Volatile organic compounds were detected in groundwater at the LO-58 Site, but at concentrations below MEDEP MEGs.
- Volatile organic compounds were detected in the AMAC drinking water supply well, but at concentrations below MEDEP MEGs (MEDEP uses half the Maine MEG or Federal MCL as an action level).
- The general direction of groundwater across the LO-58 Site was to the north and west.

WESTON concluded that no further action was warranted to locate source areas of VOC or total petroleum hydrocarbon contamination in LO-58 Site overburden soils, and recommended the continued monitoring of the five bedrock monitoring wells and two on-site drinking water supply wells to evaluate the nature and extent of fuel-related substances within the bedrock water-bearing zone (WESTON, 2001).

2.1.9 Long-Term Monitoring Program

After completion of the site investigations performed by WESTON, the Long-Term Monitoring Program (LTMP) for the Maine FUDS program was subsequently developed and included the LO-58 Site with four other Maine FUDS locations. The LTMP included monitoring of the five bedrock monitoring wells and the two drinking water supply wells at the LO-58 Site on a semiannual basis for a period of at least 2 years to assess whether or not a remedial action was required in accordance with MEDEP regulations. In conjunction with the LTMP, WESTON performed groundwater sampling at the monitoring and drinking water wells in December 2002, April 2003, September 2003, and May 2004 and submitted samples for laboratory analysis of

GRO, DRO, and VOCs. Laboratory analytical results for samples collected during these events indicated that concentrations of DRO and GRO remain above the applicable standards in samples collected from MW-05. Laboratory analytical results for samples collected from the AMAC drinking water well indicated that concentrations of TCE consistently remained at or slightly above the applicable standard of 5.0 µg/L during each sampling event. Appendix A includes a summary of the groundwater and drinking water sample results.

In June 2004, WESTON submitted a cost proposal to CENAE to continue the LTMP for an additional 2 years in addition to performing more work at some of the other sites included in the Maine FUDS program. However, following the submittal of WESTON's proposal, MEDEP requested that CENAE re-evaluate the LTMP to ensure that it complied with recent guidance issued by EPA regarding the FUDS program. These requirements include the collection of supplemental site characterization data prior to the installation of additional groundwater monitoring wells. The characterization data required included site operational histories, the identification of potential downgradient receptors, and refinement of hydrogeologic site conceptual models to better understand the nature and direction of groundwater flow at each property.

In September 2004, representatives from CENAE, MEDEP, and WESTON met at MEDEP's Regional Office in Portland, Maine to discuss existing data gaps at each of the Maine FUD sites and possible revision of the sampling program. The program presented in the *Scope of Work* (*SOW*) (CENAE, 2004) was an extension of the 2-year semiannual program conducted by WESTON between fall 2002 and spring 2004. During that time period, several of the sampling locations displayed concentrations of suspected site contaminants that were either non-detect or below MEDEP's action levels for continued monitoring. As such, MEDEP agreed that continued monitoring of several sampling points at the five DERP-FUDS could be, at least temporarily, discontinued while the additional site characterization work is conducted. As part of the agreement between MEDEP and CENAE, monitoring wells MW-01, MW-02, and MW-04 were discontinued from the sampling program. Following the spring 2006 sampling round, MW-03 was discontinued from the sampling program due to four consecutive rounds exhibiting non-detect concentrations for all compounds analyzed for. Per the request of MEDEP, MW-03 was restored to the monitoring program in the spring 2007 sampling round (WESTON, 2005; 2006). Appendix A includes a summary of the groundwater and drinking water sample results.

2.1.10 2008 Geophysical/Hydrophysical Investigation

Geologic, geophysical, and hydrophysical investigations were conducted at the LO-58 Site in May 2008. The purpose of the investigation was to gather additional site-specific hydrogeologic information to further refine the CSM for groundwater flow. The investigations relied heavily on the work of COLOG, a division of Layne Christensen Company, (COLOG) which summarized the results of the geophysical and hydrophysical investigations in the *HydroPhysics*^{TM} *and Geophysical Logging Results* report, which is included in Appendix B (COLOG, 2009; WESTON, 2010).

The geologic investigation included background research among available geologic references; observation and characterization of exposed bedrock at the LO-58 Site; measurement of bedrock features, including bedding planes, fold axes, and fractures; and the measurement of water levels in five bedrock monitoring wells and two bedrock drinking water wells during geophysical and hydrophysical investigations. The geophysical investigation included downhole geophysical logging of five bedrock monitoring wells (MW-01 through MW-05) and the two drinking water wells (DW-1 the AMAC Well, and DW-2 the VFW Well) at the LO-58 Site.

The hydrophysical investigation included hydrophysical logging (HPL) of two bedrock drinking water wells (DW-1 and DW-2) at the LO-58 Site. The HPL included ambient flow characterization, pumping flow characterization, and wire-line straddle packer (WSP) testing techniques. Based on the results of the HPL investigation described above, the highest-producing zones in each well were targeted for WSP testing, with the objective of distributing sampling points along the entire length of the borehole to the extent possible, and WESTON performed WSP sampling at both of the drinking water wells in May 2008. The zones targeted for WSP testing were first isolated and sampled utilizing low-flow methodology, and groundwater parameters were measured to confirm equilibrium conditions were achieved during low-flow sampling. After collecting the samples, each zone was tested for transmissivity and hydraulic conductivity.

The groundwater samples were submitted to TestAmerica Laboratories, Inc. and Analytics Analytical Laboratories, LLC (Analytics) for analysis for VOCs by EPA Method 524.2, 1,2-ethylene dibromide, 1,2-dibromo-3-chloropropane, and 1,2,3-trichloropronane by EPA Method 504.1, GRO by the Maine HETL Method 4.1.17 and DRO by Maine HETL Method 4.1.25. The analytical results were validated according to EPA Region 1 functional guidelines and were found to be useable, as qualified. Appendix A includes a summary of the groundwater sample results.

The analytical results for drinking water well DW-1 were consistent with previous analytical results for this well. Laboratory analytical results from the WSP sampling of drinking water well DW-1 indicate the presence of chloroform, cis-1,2-DCE, TCE, toluene, GRO, and DRO in one or more samples collected from DW-1, and generally have identifiable groundwater geochemical patterns (WESTON, 2010). None of the VOCs were detected above their applicable Maine MEGs or EPA Maximum Contaminant Limits (MCL) for drinking water. However, GRO or DRO concentrations in five samples exceeded their applicable 50 µg/L Maine MEG.

The analytical results for drinking water well DW-2 were generally consistent with previous analytical results, with one anomaly. Laboratory analytical results from the WSP sampling of drinking water well DW-2 indicate the presence of cis-1,2-DCE, toluene, and DRO in one or more samples collected from DW-2. None of the VOCs were detected above their Maine MEGs or EPA MCLs for drinking water [Board of Health (BOH), 1992; Maine Center for Disease Control (CDC), 2010; EPA, 2003]. However, GRO or DRO concentrations in five samples exceeded their applicable 50 µg/L Maine MEG (There is no EPA MCL for GRO or DRO) (BOH, 1992; Maine CDCP, 2010; EPA, 2003; WESTON, 2010).

2.1.11 2008 to 2010 Groundwater Long-Term Monitoring Program

As part of the continuing semiannual groundwater monitoring performed at the LO-58 Site, in April and October 2008, May and October 2009, and May and July 2010, additional groundwater samples were collected from monitoring wells MW-03, MW-05, and drinking water wells DW-1 and DW-2, for analysis of GRO, DRO, and VOCs [WESTON, 2008; The Johnson Company, Inc. (JCI), 2010a; 2010b; 2010c; 2010d]. During these events, the groundwater elevation and field parameters for these wells remained consistent with previous measurements. The groundwater analytical results indicate that the concentrations of hazardous materials continued to decrease in each of these wells, with the GRO, DRO, and VOCs results rarely exceeding Maine MEGs during this period. In October 2009, the concentration of DRO detected in drinking water well MW-05 exceeded the 50 µg/L Maine MEG (JCI, 2010d). Further, in July 2010, the concentration of TCE detected in drinking water well DW-1 (6.6 µg/L) was greater than its 5.0 µg/L EPA MCL, but below its Maine MEG (32 µg/L) (Analytics, 2010; Maine CDCP, 2010). Sampling of the AMAC Building POE treatment system between the serial filters and after the second filter was initiated in fall 2009, and indicated no detectable VOCs in the between-the-filters or post-treatment water (JCI, 2010c; 2010d). Appendix A includes a summary of the groundwater elevations and monitoring and drinking water sample results.

2.2 FACILITY PROFILE

The Facility Profile is based on information updated during WESTON's most recent site investigations at the LO-58 Site conducted in May 2008. The purpose of the investigation was to observe and document the current property conditions and gather subsurface information using geophysical and hydrophysical methods. WESTON visually examined select portions of the property and recorded the observations in a site logbook. Nearby land use was also documented. During a portion of the May 2008 field investigation, WESTON was accompanied by CENAE personnel.

2.2.1 Location and Legal Description

The LO-58 Site is a 17-acre parcel of land located at 253 Van Buren Road (Route 1) in Caribou, Aroostook County, Maine (Figure 2-1). The LO-58 Site is owned by the Lister-Knowlton VFW Post 9389 and is identified by the City of Caribou Assessor's Office as Map 14, Lot 50 (WESTON, 2007). In May 2007, the VFW entertained a proposal to subdivide an approximately 2-acre parcel in the eastern portion of the larger parcel, but the proposal was not acted upon (Fuller, 2008). The entrance to the LO-58 Site from Van Buren Road is located at latitude 46º 52′ 55″ North and longitude 68º 0′ 38″ West [U.S. Fish and Wildlife Service (USFWS), 2008]. The magnetic declination at Caribou, Maine is 18º 12′ West; however, for the purposes of this report, geophysical data based on compass readings were adjusted by 20º West (National Geophysical Data Center, 2009).

2.2.2 General Site Characteristics and Ownership History

The property was acquired from the Town of Caribou in 1955 by the U.S. Government for the construction of a Nike Missile Launch Battery. The LO-58 Nike Missile Launch Battery was a part of the LO-58 Site facility which also included a control area and housing area located approximately 2 miles east of the launch area. The LO-58 Site control and housing areas are still operated by DOD; therefore, they do not qualify for investigation under the DERP and have not been included in any investigations associated with the LO-58 Site, including this investigation. The LO-58 Nike Missile Launch Battery was deactivated by DOD in 1966 and, following its decommissioning as a military facility in 1969, the LO-58 Site was conveyed to the City of Caribou and used for storage of municipal property. In 1970, the property was purchased by the current owner, the Lister-Knowlton VFW Post 9389. At the time of its closure, the major components of the LO-58 Site comprised the former Nike Missile Launcher Area, the former Generator Building, the former Test Building, the AFNS, the former Warhead Building, and the former Barracks Building (Figure 2-1). Additional minor components of the LO-58 Site comprised the former Sentry Station, the former Canine Kennel and Exercise Area, the former Ajax Transfer Rack, and the former Acid Storage Shed which have been reduced to concrete pads and footings. Several components of the former launch site have since been deconstructed, including the subsurface portion of the former Nike Missile Launcher Area, which was closed by filling with soil in 1994, and the aboveground portion of the former Warhead Building which was demolished in spring 2007 (following a fire during the summer of 2006), leaving only the concrete foundation slab in place. The only other activity at the LO-58 Site since the decommissioning of the Nike Missile Battery Launch facility was a small farm machinery repair shop that operated for less than a year in the former Test Building (WESTON, 2007).

Construction of the LO-58 Nike Missile Launch Battery began in 1955, and by 1957 it became operational as an anti-aircraft guided missile launching facility. Nike Missile Launch Batteries were originally designed to carry and deploy the Ajax-type guided missile; however, in approximately 1960, operations were converted to operate the bigger, nuclear-capable

Hercules-type missiles. Historical information regarding missile launcher facilities indicates that the AFNS relates to the earlier Nike Ajax missiles which had a liquid fuel sustainer (rocket) motor. The Ajax missile used a blend of jet petroleum (JP-4), inhibited red fuming nitric acid, and approximately one pint of unsymmetrical dimethylhydrazine to make the mixture hyperbolic, and hence capable of spontaneous ignition without the need for an additional ignition source. Reportedly, the missiles were periodically defueled at the AFNS so that maintenance checks could be performed. For safety reasons, these checks could not be performed on fueled missiles (WESTON, 2007).

According to information provided to WESTON by Mr. Donald Bender (a researcher of military history at Farleigh Dickinson University), several changes occurred at Nike Missile Launch Batteries sites as a result of the conversion from Nike Ajax to Nike Hercules missiles. These changes included the construction of a Warhead Building within the AFNS area, the construction of a larger Test Building, and an upgrade to the launchers, missile elevators, motors, and related power elements associated with the three on-site missile magazines. Historical information relating to the type and configuration of the missile magazines at the LO-58 Site indicates that there were approximately 10 Nike Ajax missiles in each of the magazine at the Nike Missile Launcher Area. Approximately six of the larger Nike Hercules missiles were in each magazine after the Nike Missile Launcher Area had been converted. Information provided in the *SOW* (CENAE, 1996) indicated that the missile magazines were closed during a CENAE project performed in 1994 (WESTON, 2007).

2.2.3 Current Conditions

The VFW currently uses the former Barracks Building as their headquarters for meetings and functions, and leases the former Generator Building to the AMAC, a daycare facility for handicapped adults. The only other building that remains standing besides the former sentry station and former barracks is the former Test Building. A 500-gallon fuel oil AST is located behind the former Test Building. As mentioned previously, the former Warhead Building was demolished in 2007, and only the concrete foundation slab remains in place (WESTON, 2010). Each of the underground missile vaults at the former Launcher Area has been decommissioned and the vaults are no longer accessible. The only other portion of the LO-58 Site that is currently used is the southernmost portion of the former Launcher Area which is used as a shooting range by the City of Caribou Police Department (WESTON, 2007).

2.2.4 Water Supply/Sanitary Sewer

The LO-58 Site is provided with drinking water from two separate bedrock water supply wells. The VFW Building is provided potable drinking water from a 6-inch-diameter, 283-ft deep bedrock well, in which the pump is set at 62.5 ft bgs. The well is designated DW-2 and is located approximately 100 ft southwest of the building in the parking area (Figure 2-1). The well is situated in a 4-ft by 4-ft concrete vault beneath the parking area and access to the wellhead is acquired through a manhole. A POE chlorine-based, water-softening and bacterial treatment system has been installed on the water supply to address hardness and elevated bacteria levels which have been reported in the water supply; no other treatment has been part of this system. The treatment system is located in a utility room located in the eastern corner of the building (WESTON, 2007).

In 1996, a 6-inch-diameter, 58-ft deep bedrock water supply well, in which the pump is set at 50 ft bgs, was installed approximately 25 ft east of the former Generator Building to provide water service to the AMAC which occupies the building (Figure 2-1). This building was previously served by drinking water well DW-2; however, the supply line that carried water from the well to the AMAC was reportedly damaged when a portion of it froze during the winter and no longer functioned properly. No damage has been reported to the supply line that serves the VFW Building, and currently the former Barracks Building is still served by well DW-2 (WESTON 2007; 2010). A POE activated carbon water filtration system was installed, maintained, and monitored by MEDEP to remove any contaminants which are present in well DW-1. In 2009, CENAE took over the maintenance and monitoring of the POE at the AMAC Building (Hewett, 2011). Historically, concentrations of TCE in untreated water have exceeded the applicable MEDEP action level of 2.5 µg/L (BOH, 1992; Maine CDCP, 2010; WESTON, 2007). According to CENAE, the post-treatment drinking water samples collected by MEDEP occasionally contain detectable concentrations of TCE.

The VFW Building is served by a private septic system which is located to the east of the building (Figure 2-1). The system was installed in 2008, but WESTON was unable to determine the exact location, construction, or maintenance details for the septic system, as there are no known as-built plans for the system. The AMAC Building is served by a separate private septic system which includes 1,000-gallon and 750-gallon capacity septic tanks located to the west of the building (Figure 2-1). A leaching bed for the septic system is situated to the northwest of the building across the access road. The current septic system for the AMAC Building was installed in 2005 as a replacement for the original septic system. The original septic system consisted of a 1,000-gallon septic tank and a leaching trench. WESTON was unable to determine the location of the original leaching trench for the AMAC Building. The location of the current leach field is depicted on Figure 2-1 (WESTON, 2007).

All properties in the area of the LO-58 Site are served by private drinking water supplies and private septic systems, as municipal water supply and sanitary sewer are not available to any properties in the vicinity of the LO-58 Site. The nearest off-site drinking water well is located at the Morin’s Auto Detailing property which abuts the LO-58 Site to the southwest. The drinking water well for this property is located approximately 750 ft west of the former Launcher Area (WESTON, 2007).

2.2.5 Storm Water

Storm water that falls at the LO-58 Site either infiltrates the subsurface in unpaved portions or follows overland flow routes into catch basins and drainage swales. Following the topography at the LO-58 Site, surface water runoff flows generally north and northwest except from the former Barracks Building where runoff flows eastward. Catch basins and drainage swales direct surface water runoff from the LO-58 Site to an apparently natural valley located between the former Barracks Building and the base of the hill below the former Test Building and Launcher Area, which directs surface water off of the property to the north (WESTON, 2007).

2.2.6 Heating/Air Conditioning/Ventilation Systems

The VFW Building is heated by an oil-fired forced hot water furnace. The furnace is provided fuel from two 275-gallon ASTs located in the southeastern portion of the building. WESTON did not observe any additional air conditioning or ventilation systems in the VFW Building during site reconnaissance. The AMAC Building is heated by an oil-fired furnace located in the eastern portion of the building. WESTON did not observe any air conditioning or ventilation systems in the AMAC Building (WESTON, 2007).

According to available documents, the former Test Building had an oil-fired heating system. The heating system was provided fuel via a 500-gallon AST situated on a concrete cradle behind the building. WESTON was unable to gain access to this building during site reconnaissance to confirm the presence or absence of a heating system. There is no evidence that air conditioning or ventilation systems are present in the former Test Building (WESTON, 2007).

2.2.7 Hazardous Materials Storage and Usage

WESTON observed minimal amounts of hazardous materials being stored and used during current site operations. Hazardous materials currently utilized at the LO-58 Site include fuel oils for heating systems, small amounts of typical household cleaners, and gasoline for an all-terrain vehicle and lawn maintenance equipment. It does not appear that any of the hazardous materials currently stored and used at the LO-58 Site pose a threat to the surrounding environment (WESTON, 2007).

Previous investigations at the LO-58 Site indicated additional storage and use of hazardous materials at the property as part of historic operations. According to available documents and site plans for the LO-58 Site, approximately three fuel oil tanks were present while the property was under control by DOD. These included a 2,000-gallon UST associated with the former Barracks Building, a 500-gallon fuel oil AST located outside the former Test Building, and a 4,000-gallon fuel UST located adjacent to the southwest corner of the former Generator Building. The two USTs were both removed from the property, and the 500-gallon AST associated with the former Test Building still remains at the LO-58 Site. According to the government *INPR* (CENAE, 1993) for the LO-58 Site, the AST was used by the tenant after DOD had relinquished ownership; therefore, they were not responsible for removing it (WESTON, 2007).

2.2.7.1 Above Ground Storage Tanks

Both the VFW and AMAC Buildings are provided fuel oil via 275-gallon ASTs. Each AST currently used at the LO-58 Site is situated indoors where it is protected from the elements and concrete floors provide secondary containment for potential releases. A 500-gallon fuel oil AST, which is no longer used, is located on a concrete cradle behind the former Test Building. WESTON observed minor staining on the tank but did not observe any notable odors or staining in surficial soils located beneath it (WESTON, 2007).

2.2.7.2 Underground Storage Tanks

There are currently no USTs at the LO-58 Site. Historical reports indicate that a 2,000-gallon heating oil tank was located east of the VFW Building. Historical reports indicate that a 4,000-gallon diesel fuel tank, identified as a 1,000-gallon tank in a 1956 plan of the facility, was located near the southwest corner of the AMAC facility (U.S. Army, 1956). Both of these USTs have reportedly been removed (WESTON, 2007).

2.2.7.3 Polychlorinated Biphenyls-Containing Equipment

WESTON did not observe any potentially PCB-containing equipment (i.e., transformers) during site reconnaissance, although fluorescent lights with ballasts, which may potentially contain PCBs, are located in the VFW Building. According to historical reports documenting remedial actions at the LO-58 Site, the hydraulic fluid from the former missile launcher area lifts was removed during decommissioning activities and infiltrated water was submitted for analysis of PCBs for disposal purposes. Polychlorinated biphenyls were not detected above the laboratory RL in any of the samples analyzed (WESTON, 2007). WESTON was unable to obtain any information regarding the former Generator Building and whether potential PCB-containing equipment was formerly present there, although a brief review of technical literature confirms that PCBs were historically used in generator coolant oils (WESTON, 2007).

2.3 PHYSICAL PROFILE

The physical profile includes a discussion of the physical characteristics of the LO-58 Site, including the topography and the geologic and hydrogeologic setting. The physical profile was developed based on data and information obtained from the historical environmental investigations.

2.3.1 Topography

Consistent with the typical location of Nike Missile Batteries, the LO-58 Site is located on a topographic high east of Van Buren Road (see Figure 1-1). Elevations at the LO-58 Site vary by approximately 60 ft, from approximately 540 ft above mean sea level (amsl) at the former Barracks Building, which is located at the bottom of the hill near Van Buren Road, to approximately 600 ft amsl at the former Launcher Area, which is situated at the topographic high for the property (WESTON, 2007).

2.3.2 Soil and Overburden Geology

2.3.2.1 Soil Description

Based on the *Aroostook County Soil Survey, Northeastern Part* [U.S. Department of Agriculture (USDA), 2008a], soils at the LO-58 Site are primarily mapped as Caribou gravelly loam, with slopes varying from 0 to 15%. Caribou soils are well drained soils formed on loamy till plains and ridges and have moderate permeability (0.6 to less than 2.0 inches per hour) (USDA, 2008b).

2.3.2.2 Overburden Geology

Based on the *Surficial Geologic Map of Maine* (MGS, 1985a), overburden underlying the property is primarily glacial till consisting of a heterogeneous mix of sand, silt, clay, and stones with local occurrences of boulders and was deposited directly by glacial ice. The till is generally massive, but may contain beds and lenses of variably washed and stratified sediments. Subsurface investigations performed at the LO-58 Site have generally confirmed these mapped subsurface conditions, although no inclusions of washed or stratified sediments have been noted. Site-specific observations document that overburden thickness at the LO-58 Site varies depending on location and ranges from 0 ft bgs at the former Launcher Area to approximately 16 ft bgs near the former Test Building. Bedrock outcrops are present along the southern edge of the former Launcher Area (WESTON, 2007). Figure 2-2 presents an isopach map of overburden thickness at the LO-58 Site.

Please refer to Subsection 3.1 for a discussion of the nature and extent of overburden contamination related to the LO-58 Site.

2.3.2.3 Overburden Hydrogeology

Subsurface investigations into overburden groundwater at the LO-58 Site have indicated that there is little or no saturated thickness in the overburden (WESTON, 2007). WESTON concludes that surface water that infiltrates the overburden percolates downward until coming in contact with the bedrock surface. At the bedrock surface, groundwater flows along the surface of the bedrock beneath the LO-58 Site until reaching a point of infiltration, such as a fracture (WESTON, 2007).

2.3.3 Bedrock Geology

As noted above, the depth to bedrock at the LO-58 Site varies depending on location ranging from 0 ft bgs at the former Launcher Area to approximately 16 ft bgs near the former Test Building (WESTON, 2007). Figure 2-3 presents a contour map of bedrock elevations at the LO-58 Site. Observation of the bedrock surface can be made in the vicinity of the former Launcher Area, and previous soil boring records indicate that there is little or no weathered bedrock at the overburden-bedrock interface. This is consistent with the geologic history of the LO-58 Site, which indicates that any weathered bedrock would have been eroded during the final Wisconsin-age glacial advance, and that there has been insufficient time for appreciable bedrock weathering during the subsequent 12,000 years. This condition is to be expected on the northwest face of a bedrock-cored drumlin which was subject to glacial action approximately 12,000 years ago. Vertical seismic profiling did not identify acoustically-incompetent bedrock at the LO-58 Site (WESTON, 2007). No rock quality designation data are available for any of the bedrock wells at the LO-58 Site.

Finally, a notable linear depression in the bedrock surface is present between locations SB-22 and SB-43 which may be indicative of a fracture zone.

2.3.3.1 Lithology

Based on the 1:500,000-scale *Bedrock Geologic Map of Maine,* bedrock underlying the property is mapped as the Siluro-Ordivician Carys Mills Formation, and the datalayer used to generate Figure 1 of the *SOW* used this reference (MGS, 1985b). However, based on the 1:62,500-scale *Geologic Map of the Caribou and Northern Presque Isle Quadrangles, Maine*, bedrock beneath the LO-58 Site is mapped as the Silurian Spragueville Formation (MGS, 1985c). To reconcile the conflicting references, WESTON relied on the larger-scale map which not only provides greater control but used more recent data, including outcrops at the LO-58 Site to determine the contact boundary between the Spragueville and Carys Mill Formations; thus, WESTON concludes the bedrock beneath the LO-58 Site is part of the Spragueville Formation as depicted in Figure 2-4. The Spragueville Formation comprises interbedded pelite and limestone and/or dolostone rocks of Silurian age (MGS, 1985b). This formation is weakly metamorphosed and contains local occurrences of prehnite and pumpellyite. The Spragueville Formation contains distinctive, rounded nodules resulting from bioturbation (Lopez, 2003). The Spragueville Formation is interpreted as submarine fan sediments that are closely related to the older Carys Mills Formation (Lopez, 2003).

Observations of bedrock in outcrops at the LO-58 Site confirm that the local bedrock is gray, “nubbly”, interbedded, weakly metamorphosed mudstone and limestone. The bedding surfaces are clearly visible in the rock, both in outcrops and in Optical Televiewer (OTV) logs of boreholes, and contain the “nubbly” bioturbation features associated with the Spragueville Formation (Lopez, 2003). Consistent with available information regarding the thickness and extent of the Spragueville Formation, no geologic contacts were encountered on or beneath the LO-58 Site. Consistent with descriptions of the Spragueville Formation, the limestone beneath the LO-58 Site does not exhibit karst features neither in on-site outcrops nor in the Optical or Acoustical Televiewer logs. The nearest contact with another geologic unit, the Siluro-Ordivician Carys Mills Formation, is located approximately 900 ft northwest of the LO-58 Site (MGS, 1985c).

2.3.3.2 Bedrock Fabric

Based on the *Geologic Map of the Caribou and Northern Presque Isle Quadrangles, Maine* and other geologic references (MGS, 1985b; 1985c; Lopez, 2003), bedrock underlying the property is located on the east limb of the Chapman Synclinorium. The axis of the synclinorium trends north-northeast and dips to north. The Chapman Synclinorium was formed during the first deformational or compressional phase of the Acadian Orogeny, which occurred during the lower to middle Devonian Period, and resulted in a major, single, and steeply dipping north-south cleavage in the bedrock (Lopez, 2003).

The *Geologic Map of the Caribou and Northern Presque Isle Quadrangles, Maine* identifies the bedrock bedding at the LO-58 Site as striking North 70º East and dipping 12º East, as well as a foliation striking North 5º West and dipping 78º West (MGS, 1985c). Site-specific observations, from both bedrock outcrops and OTV logs, indicate that the local bedrock is folded in two directions: the major folds are broad to tight with axes oriented North 30º East, parallel to the axis of the Chapman Synclinorium; the fold axes are also folded broadly on North 20º West axes.

Three joint sets are present in the local bedrock: a near vertical set striking North 45º East and dipping 80º West which is associated with the Acadian Orogeny; another steeply-dipping set striking North 45º East and dipping 85º East which is roughly perpendicular to the first; and a shallow-dipping set of sheeting joints that is roughly parallel to the ground surface and bedding and decreases in frequency with depth, related to the relief of downward pressure due to erosion and glacial unloading (Billings, 1972; COLOG, 2009). The near-vertical sets of joints, particularly the set striking North 45º East and dipping 85º East, are often filled with calcite.

The planar features in bedrock that are intercepted by drinking water wells DW-1 and DW-2 were measured by COLOG, and plotted as tadpoles on the geophysical logs, as well as plotted onto Schmidt stereonets. Figure 2-5 presents a stereonet plot of bedding planes and measured joints. The stereonet plots for well DW-1 show two clusters of data: one for the low-angle features (near-horizontal joints and bedding) which has about 90º of variability from North 45º West to North 45º East, dipping West, and a second pair of steeply dipping features (near-vertical joints) which are further grouped in two clusters, one at North 25º West and a smaller cluster at North 65º West, both dipping East. The feature ranks (ranked from 0 for fractures with minimum flow capacity to 5 for fractures with maximum flow capacity) indicate that both the low angle and steeply-dipping features contain members where significant flow is present (COLOG, 2009). The stereonet plots for well DW-2 are appropriately more complicated, inasmuch as they represent a greater length of bedrock borehole data. The primary data cluster for well DW-2 is centered on steeply-dipping features (near-vertical joints) oriented North 45º East and dipping East which has approximately 45º of lateral spread. The feature rank plot reveals that there are a small number of features which do not appear on the contour plot due to low frequency. Within these data are a set of steeply-dipping features (North 45º West to North 45º East, with a slight concentration around North 45º East, dipping West); there are relatively few low-angle features in this dataset (WESTON, 2010).

Conceptually, the upper 60 ft of bedrock have similar fracturing characteristics at drinking water well locations DW-1 and DW-2: moderate fracture density, including common, sub-horizontal sheeting fractures, as well as generally wider fractures of all orientations. However, the deeper bedrock (below approximately 70 ft) surrounding well DW-2, while also moderately fractured, contains very few sheeting fractures, and the aperture and water-bearing potential of the steeper fractures are not as significant resulting in different fracturing characteristics which, by nature of its depth, do not appear in the bedrock surrounding well DW-1.

Further, as noted in Subsection 2.3.3, Figure 2-3 indicates a linear depression in the bedrock surface is present between locations SB-22 and SB-43 which may be indicative of a fracture zone. The orientation of the linear depression is approximately North 70º West, is near-coincident with the North 65º West cluster of joints noted in the geophysical log of well DW-1, described above, supporting the hypothesis that the feature is surficial expression of a fracture zone.

2.3.4 Bedrock Hydrogeology

As noted in Subsection 2.3.3, there are no significant deposits of weathered bedrock at the LO-58 Site, and overburden groundwater is assumed to discharge directly from the glacial till overburden to competent bedrock. Groundwater flow through bedrock at the LO-58 Site is solely via fracture flow; the mudstone and limestone beneath the LO-58 Site are not reported to have any primary porosity. In addition, although solution cavities are common in certain limestone deposits, neither the available geologic literature nor local or regional observations of karst topography indicate that the limestone of the Spragueville Formation is subject to solution cavities (MGS, 1985b). Thus, it may be concluded that the orientation, length, width, and interconnectedness of joints in the bedrock beneath the LO-58 Site exert significant control over both groundwater flow direction and contaminant distribution within groundwater (Freeze & Cherry, 1979).

2.3.4.1 Depth to Bedrock Groundwater

Figure 2-6 depicts the bedrock groundwater potentiometric surface contours for May 2008. Bedrock groundwater depths were measured in each of the five monitoring wells at the LO-58 Site on 30 April 2008, upon installation of the pressure transducers, and on 21 May 2008, upon the retrieval of same. Bedrock groundwater depths were measured in drinking water wells DW-1 and DW-2 at the LO-58 Site on 6 and 5 May 2008, respectively, upon installation of the pressure transducers, and on 21 May 2008, upon the retrieval of same. It should be noted that the screened intervals of the five available bedrock monitoring wells do not intercept the potentiometric surface, and that such potentiometric surface measurements should be considered approximate. The first groundwater depths for the drinking water wells were measured shortly following their shut down and the removal of their pumps and associated piping, and are not considered to represent equilibrium conditions; thus, only the 21 May 2008 groundwater depth data are considered sufficient for the calculation of groundwater flow directions. Table 2-1 summarizes the groundwater depth data and groundwater elevation calculations. Note that the elevation measurements for the drinking water wells are estimated from available maps and are not the result of a precise survey; therefore, groundwater elevations calculated for those wells are considered approximate. Rainfall was limited between 30 April and 21 May 2008, which is reflected in the roughly 10 ft drop in water levels across the LO-58 Site during this period. This substantial drop in groundwater elevations over a roughly 1-month period with limited recharge suggests a very low storage coefficient for the bedrock consistent with observed secondary fracture porosity. Bedrock groundwater elevations range from approximately 569 to 537 ft amsl on 30 April and 564 to 531 ft amsl on 21 May 2008. Figure 2-6 depicts the groundwater elevations measured on 21 May 2008.

2.3.4.2 Bedrock Groundwater Flow Velocity and Transmissivity

The hydrophysical logs at ambient conditions for drinking water wells DW-1 and DW-2 provide the data required to calculate volumetric flow rates and specific discharge rates for the bedrock fractures examined. The hydrophysical logs under pumping conditions for drinking water wells DW-1 and DW-2 provide the data required to calculate interval-specific inflow rates. Finally, an estimation of transmissivity of the fractures at each well can be made using an equation after Hvorslev, assuming steady-state radial flow in an unconfined aquifer. By applying the HPL results under the two pressure conditions (ambient and production conditions), the interval specific transmissivity can be calculated for each identified water-producing interval (COLOG, 2009).

Beyond the measurements and calculations performed within drinking water wells DW-1 and DW-2, WESTON obtained precipitation records from the Caribou Airport for the period that the pressure transducers were in place, and noted that precipitation of greater than 0.5-inches occurred on 8 and 20 May 2008 which are summarized in Table 2-2. Comparison of the precipitation records to the pressure transducer data summaries indicated that there appear to have been a fairly rapid (approximately 6-hour) response in wells DW-1 and DW-2 to the rainfall event on 8 May, where a slight increase in potentiometric elevation was noted. However, a similar response was not noted to the 20 May rainfall event in part due to interference by pumping activities at well DW-1. The relatively rapid response is consistent with the relatively thin overburden deposits at the LO-58 Site and the limited storage capacity of the bedrock (WESTON, 2010).

AMAC Well (DW-1)

The HPLs for well DW-1 illustrate significant change at several intervals throughout the length of the borehole. These dramatic changes in the fluid electrical conductivity (FEC) profiles with respect to time are associated with ambient horizontal flow occurring within the borehole. Numerical modeling of the reported field data suggests the volumetric flow rates, specific discharges (correcting for convergence of flow at the wellbore and factoring the length of the interval) observed in the wellbore were as follow:

Depth Interval (ft bgs)	Volumetric Flow Rate (gallons per minute)	Specific Discharge (feet per day)	Transmissivity (square feet per day)
27.3 to 31.7	0.207	2.84	8.51
34.6 to 35.0	0.195	3.91	12.8
37.4 to 38.4	0.745	0.75	51.8
40.4 to 48.6	2.00	2.53	129
49.0 to 50.2	0.416	2.28	27.6
52.7 to 53.6	1.65	9.56	111
54.4 to 58.1	0.838	0.84	58.2

(COLOG, 2009)

During production testing, seven inflow zones were identified from the well DW-1 hydrophysical logs. The logs indicate the interval 40.4 to 48.6 and 52.7 to 53.6 ft bgs dominated flow during pumping producing 3.65 gallons per minute (gpm) or 60% of the total flow. The transmissivity calculations for well DW-1 indicate that the intervals 40.4 to 48.6 and 52.7 to 53.6 ft bgs exhibited the highest transmissivities of approximately 129 and 111 square feet per day (ft^2/day), respectively (WESTON, 2010).

VFW Well (DW-2)

The hydrophysical logs for well DW-2 also illustrate significant change at several intervals throughout the length of the borehole. These dramatic changes in the FEC profiles with respect to time are associated with ambient vertical flow occurring within the borehole. Formation water migration as a result of downward vertical flow within the fluid column is indicated by the increase in FEC over time, beginning near the base of casing and at 31 ft. Numerical modeling of the reported field data suggests the volumetric flow rates, specific discharges (correcting for convergence of flow at the wellbore and factoring the length of the interval) observed in the wellbore were as follow:

Depth Interval (ft bgs)	Volumetric Flow Rate (gallons per minute)	Specific Discharge (feet per day)	Transmissivity (square feet per day)
19.5 to19.6	0.03	0.10	2.95
30.4 to 31.6	0.3	5.69	216
38.2 to 41.8	0.02	0.37	14.3
44.9 to 51.4	0.07	0.08	0.28
96.4 to 97.0	-0.4	0.00	14.8
143.3 to 144.3	0.0	0.01	0.32
179.2 to 183.0	0.0	0.02	0.60
189.5 to 191.0	0.2	0.05	9.45
191.4 to 218.3	-0.2	0.01	0.32
227.4 to 228.2	0.0	0.01	0.20
243.7 to 279.2	0.0	0.02	0.96

(COLOG, 2009)

Numerical modeling of the reported field data suggests groundwater enters the wellbore at 19.5 to 19.6, 30.4 to 31.6, 38.2 to 41.8, and 44.9 to 51.4 ft bgs. The combined inflow of 0.413 gpm of these four intervals is observed to migrate vertically downward through the borehole based on the migration of the center of mass of the area under the curve. The modeling suggests groundwater exits the borehole at depths of 96.4 to 97.0 and 189.5 to 191.0 ft bgs. Evidence for these outflow zones is observed in the logs for well DW-2, where the velocity of the water slows within the borehole (“downstream” of an outflow zone), and a change in slope, or truncation, of the FEC log is observed. The flow rates are based on the rate of increase of mass at their respective intervals. Of particular note is the FEC anomaly observed at the base of the borehole at 280 ft. This early increase in mass is not the result of ambient flow. Notice the mass at this depth, or area under the curve, does not increase with time but instead disperses. During removal of the plumbing at the conclusion of the emplacement, groundwater was momentarily allowed to enter the borehole at this depth near the bottom of the borehole. Over the course of the ambient flow characterization however, no additional groundwater entered the borehole at this depth. As such, this water-bearing interval is not considered to produce groundwater to the borehole under ambient conditions (COLOG, 2009).

During production testing, 11 inflow zones were identified from the DW-2 hydrophysical logs, ranging in flow from 0.005 to 5.69 gpm, with the dominant inflow zone at 30.4 to 31.6 ft, producing 5.69 gpm, or 90% of the total formation production rate. The transmissivity calculations for well DW-2 indicate that the interval 30.4 to 31.6 ft bgs exhibited the highest transmissivity, approximately 216 ft^2/day (COLOG, 2009).

Bedrock Fracture Interconnectivity

Three sources of data collected during May 2008 provide information regarding the interconnectivity of bedrock fractures: synoptic potentiometric head measurements from the five bedrock monitoring wells and two drinking water wells, the results of ambient and pumping HPL flow characterization, and the results of WSP groundwater sampling.

Potentiometric head measurements were collected via pressure transducers/data loggers installed in the monitoring and drinking water wells on 30 April and 6 May 2009, respectively, and removed on 21 May 2009. The transducers were programmed to record measurements at 1-minute intervals. Hydrophysical logging flow characterization was performed in well DW-1 on 14 May 2009, and in well DW-2 on 15 May 2009. Wire-line straddle packer testing was performed in well DW-1 from 18 to 20 May 2009, and in well DW-2 from 16 to 17 May 2009. Pumping performed during HPL and WSP testing provided hydraulic impulses in the drinking water well being tested, which provided interconnectivity data for the pressure transducers in the five monitoring wells and the drinking water well which was not being tested.

Synoptic Potentiometric Head Observations

The most notable change in water table elevation, not including the start/stop and removal of the transducers themselves, occurred on 14 May 2008, during the production testing of DW-1, as summarized in Table 2-3. Data measurements collected from MW-01, MW-03, and MW-05 indicate that when production testing began in DW-1, potentiometric head elevations decreased almost immediately in each of the three wells, to maximum drawdown values at approximately 13:37 hours, at the conclusion of the test (which did not reach equilibrium), which define the minimum cone of depression of the well under test pumping conditions. As expected, after the completion of production testing in DW-1, the potentiometric head elevations rebounded to the static level. The same relationship was observed in these wells during the transmissivity and hydraulic conductivity testing performed in DW-1 with the WSP on 19 and 20 May 2008, also summarized in Table 2-3. The strongest relationship during the transmissivity and hydraulic conductivity evaluation was observed when the 41.2- to 51.9-ft and the 51-ft to 58.1-ft intervals were isolated with the WSP system. A slightly weaker correlation between the three monitoring wells and DW-1 was observed during the isolation of the 33.75- to 38.5-ft interval. However, the 33.75- to 38.5-ft interval also produced less than half the yield of the two deeper intervals. No other significant bedrock fracture interconnectivity was noted within the synoptic potentiometric head measurements (WESTON, 2010).

As noted in Subsection 2.3.3.2, Figure 2-3 indicates a linear depression in the bedrock surface is present between locations SB-22 and SB-43 which has been interpreted as the expression of a fracture zone. The orientation of the linear depression is approximately North 70º West which is oriented so as to link wells DW-1 and MW-01. Based on the observations from the synoptic potentiometric head measurements, WESTON concludes that the North 65 to 70º West fracturing present in bedrock creates strong anisotropy in the groundwater flow in the vicinity of well DW-1. Further, at well DW-1, the shallower fractures do not appear to have any interconnectivity with fractures in other wells, while the deeper fracture intervals are interconnected with fractures that reach as far as monitoring wells MW-01, MW-03, and MW-05.

Flow Characterization Observations

Ambient HPL testing identified primarily horizontal flow across well DW-1 and downward vertical flow within the fluid column in well DW-2. The direction of groundwater flow within a well is an indicator of the interconnectedness of the individual fractures surrounding the well and the hydraulic gradient between the fractures.

Quantitative analysis of the fracture densities and relative apertures (ranks) documented that the overall fracture (ranks 1 to 5) density in well DW-1 is 0.67 fractures per foot (fractures/ft), and the overall fracture density in well DW-2 is 0.57 fractures/ft, such that the overall fracture density in well DW-1 is only 15% greater than the overall fracture density in well DW-2. Further, there are a total of six rank 3 and 4 fractures in well DW-2 (only two of which are located in the uppermost 58 ft), compared to a total of six rank 3 (but no rank 4) fractures in well DW-1, which also supports a conclusion that the bedrock at wells DW-1 and DW-2 are similarly fractured. Considering fractures with dips greater than or equal to 60º to be “high-angle”, and only considering open fractures (ranks 1 to 5), the high-angle fracture density in well DW-1 is 0.26 fractures/ft, and the high-angle fracture density in well DW-2 is 0.43 fractures/ft. These calculations demonstrate that the high-angle fracture density in well DW-1 is only 60% that of well DW-2, which is the result of well DW-2 extending into deeper bedrock than well DW-1, with sheeting fractures rare below 70 ft bgs. When high-angle fracture density in the top 58 ft of both wells is compared, the high-angle fracture density is identical, but the well DW-1 fractures tend to be larger (WESTON, 2010).

The fractured bedrock surrounding the borehole in DW-1, and the number of those water-bearing fractures that are high-angle fractures, results in an interconnected network of fractures around the well that have pressure-equilibrated outside the influence of the borehole. The weak differential potentiometric head that exists between the fractures results in primarily horizontal groundwater flow within the well. In well DW-2, the fracture characteristics of the shallow bedrock are similar to those surrounding the borehole at well DW-1. However, although there are some high-angle fractures identified, their aperture and water-bearing potential are not as significant, and the upper and lower portions of the well have substantially different potentiometric heads. The relatively strong differential potentiometric head that exists in well DW-2 between the upper and middle fractures results in vertical groundwater flow from the upper fractures to the middle fractures within the well (COLOG, 2009).

Wire-Line Straddle Packer Sampling Observations

The migration of groundwater is often much more complicated in fractured bedrock than in porous media, and the inconsistencies in trends observed in the discussion of the following groundwater analytical results may well be due to such complications. The WSP groundwater analytical results discussed below are included in Appendix A.

In May 2008, toluene and GRO were detected in drinking water well DW-1 in four of the five depth intervals tested with concentrations decreasing with depth from the shallowest to deeper intervals, not detected in the second deepest interval, but appearing again in the deepest interval. This pattern of concentrations suggests that the primary source of these substances is proximal to the shallowest bedrock fractures, and that there is very limited communication between the uppermost fractures and the deepest fractures tested, but perhaps not in the vicinity of well DW-1. Thus, the shallow concentrations, in combination with the pressure transducer data, suggest that the primary source of the toluene and GRO contamination is proximal to the well, and that the deeper source of the toluene and GRO contamination may be from a more distant source (WESTON, 2010).

Conversely, in May 2007, DRO was only detected in the middle interval (41.2 to 51.9 ft bgs) of drinking water well DW-1 and the deepest interval (56.6 to 58.0 ft bgs), where it was greatest. The deep concentrations suggest that the primary source of the DRO contamination is distal to this well and represents a separate source from the toluene and GRO detected in shallow bedrock (WESTON, 2010). Other alternative explanations for the variation in DRO and GRO concentrations with depth are possible including differential migration of DRO and GRO from a single source due to variations in their physical properties, with GRO compounds being generally less dense than DRO compounds. It is also possible that the DRO at depth represents a more weathered component of a single fuel source from which the GRO also originated, which may be due to differential weathering of GRO to DRO from a single source (Hewett, 2011). None of the VOC were detected above their Maine MEG or the EPA MCL for drinking water (BOH, 1992; Maine CDCP, 2010; EPA, 2003). However, DRO concentrations in samples collected from the fourth (41.2 to 51.9 ft bgs) and deepest (56.6 to 58.1 ft bgs) depth intervals and GRO concentrations in the sample collected from the shallowest (24.98 to 33.15 ft bgs) depth interval exceeded the 50 μg/L Maine MEG (There is no EPA MCL for DRO or GRO) (BOH, 1992; Maine CDCP, 2010; EPA, 2003; WESTON, 2010).

The concentrations of cis-1,2-DCE and TCE detected in drinking water well DW-1 are relatively low, ranging from a few times the reporting limit to just below the reporting limit, which makes any conclusions regarding these data tentative. The analytical results for drinking water well

DW-1 are presented graphically in Figure 2-7. The concentrations of cis-1,2-DCE and TCE in drinking water well DW-1 increased from the shallowest interval to the middle interval (41.2 to 51.9 ft bgs) and decreased in the intervals below the middle interval. Of further interest is the lower ratio of cis-1,2-DCE to TCE in the 33.75 to 38.5 ft depth interval than in the 41.2- to 51.9-ft, 51- to 58.1- ft, and 56.6- to 58.1-ft depth intervals, as depicted in Figure 2-8. A higher cis-1,2-DCE to TCE ratio would indicate a relatively higher concentration of daughter to parent compound, and imply greater degradation and distance from the TCE source. The slight variations in cis-1,2-DCE to TCE ratios shown in Figure 2-8 were found to be statistically insignificant (WESTON, 2010).

In drinking water well DW-1, the peak toluene and GRO concentrations were in shallow bedrock fractures, the peak chlorinated solvent concentrations were in the middle bedrock fractures, and the peak DRO concentrations were in deep bedrock fractures. This pattern of contamination indicates that the well may be impacted with hazardous substances from three separate and increasingly distant sources at the LO-58 Site. Further, the differnces between contaminant concentrations at successive depth intervals demonstrates that concentration gradients exist between adjacent fractures. However, the slight variations in contaminant concentrations and the small number of measurement points were found to be inadequate to make statistically significant conclusions (WESTON, 2010).

The laboratory analytical results from the WSP sampling of drinking water well DW-2 (see Appendix A) indicate the presence of cis-1,2-DCE, toluene, and DRO in one or more samples collected from DW-2. The detection of cis-1,2-DCE was anomalous for well DW-2 as chlorinated solvents had not previously been detected in samples collected from this well. None of the VOC were detected above their Maine MEG or EPA MCL for drinking water (BOH, 1992; Maine CDCP, 2010; EPA, 2003). However, DRO concentrations in samples collected from the shallowest (16.0 to 20.0 ft bgs) and deepest (265.0 to 284.0 ft bgs) depth intervals exceeded the 50 µg/L Maine MEG (There is no EPA MCL for DRO) (BOH, 1992; Maine CDCP, 2010; EPA, 2003; WESTON, 2010).

In addition, groundwater parameters collected during sample collection, also included in Appendix A, may provide further evidence of the nature of groundwater flow at the LO-58 Site.

First, there appears to be an inverse relationship between pH and temperature. In both drinking water wells DW-1 and DW-2, temperatures were lowest and pHs were highest in the deepest intervals, although comparably low pH and the second lowest temperatures are noted in the shallowest interval of well DW-1 as well. However, the opposite relationship was not as clear in either well. In drinking water well DW-1, the highest temperatures are associated with the second lowest pHs (in the 33.8 to 38.5 ft interval), but equally low pH is associated with mid-range temperatures in the 51.0 to 58.1 ft interval. In drinking water well DW-2, second highest temperature and lowest pH was noted in the third deepest interval (37.0 to 41.7 ft bgs), while the highest temperatures occurred in the shallowest interval, associated with mid-range pH values. High temperature and low pH may indicate shallow, short flow paths from surface water infiltration, and low temperature and high pH are typically found in deeper, longer-flow paths from areas of groundwater recharge. The deepest intervals in both wells support the longest flow path conclusion, while the shallowest intervals do not, emphasizing the complexity of groundwater flow through fractured bedrock (WESTON, 2010).

Second, dissolved oxygen (DO) and oxidation-reduction potential (ORP) results collected during sample collection were also assessed for each well location. In drinking water well DW-1, DO and ORP were lowest in the middle interval (41.2 to 51.9 ft bgs) which corresponded to the highest concentration of dissolved chlorinated solvents. In drinking water well DW-2, DO and ORP were lowest in the second deepest interval (187.5 to 192.2 ft bgs) which corresponded to the only detection of dissolved chlorinated solvents in this well. Typically, DO and ORP values decrease as a result of the consumption of oxygen (an electron receptor) during aerobic biodegradation of petroleum hydrocarbons, such as DRO and GRO (which are electron donors). As aerobic biodegradation processes consume available oxygen, bacteria are forced to shift toward reductive chlorination which allows the biodegradation of chlorinated solvents (which are less efficient electron receptors) (Wedemeier, et al., 1997). It is suspected that the general lack of DO and ORP reduction is due to the relatively low DRO and GRO concentrations detected in groundwater which provide insufficient carbon load to reduce the DO and ORP in the groundwater. The lower DO and ORP values noted in the middle depth interval of well DW-1 and second deepest interval of well DW-2 may be indicative of higher contaminant concentrations in an upgradient area where substantial biodegradation has occurred (WESTON, 2010).

The pattern of contaminant concentrations for drinking water well DW-2 display the opposite pattern to those of well DW-1. Toluene and DRO were detected in the sample collected from the shallowest (16.0 to 20.0 ft bgs) depth interval of well DW-2. Toluene was also detected in the middle depth interval (94.5 to 98.5 ft bgs), and DRO was detected in the deepest (265.0 to 284.0 ft bgs) depth interval. A trace concentration of cis-1,2-DCE was detected in well DW-2 in the second deepest (187.9 to 192.2 ft bgs) depth interval. Based on the lack of concentration gradients between adjacent fractures, these results demonstrate the lack of interconnection between adjacent fractures. Further, the trace detection of cis-1,2-DCE in a relatively deep fracture, with no detectable TCE, displays a continuation of the possible pattern of an increasing ratio of cis-1,2-DCE to TCE with depth and presumably distance from the source. In this case, TCE degradation appears nearly complete. Refer to Subsection 2.4.3 for further discussion of these results.

2.3.4.3 Bedrock Groundwater Horizontal Gradients

In porous media aquifers, the vertical and horizontal vectors comprising the overall groundwater flow direction, as determined by water table elevations, is fairly constant near and between wells. For this reason, overburden groundwater horizontal gradients can often be clearly defined and depicted graphically. However, in fractured bedrock aquifers, water-bearing fractures penetrated by wells can have similar to nearly opposite local flow vectors or directions depending on fracture orientation, recharge zone locations, ambient or pumping conditions, and fracture interconnectivity. Because of the complex, anisotropic flow systems in bedrock aquifers, it is difficult to make specific statements regarding groundwater horizontal gradients without comprehensive, site-specific data such as that collected using HPL methods (WESTON, 2010).

Figure 2-6 depicts the overall bedrock groundwater horizontal potentiometric gradients for May 2008. The overall bedrock groundwater horizontal potentiometric gradient at the LO-58 Site is northerly beneath the eastern and central portions of the LO-58 Site, and north-westerly beneath the western portion of the LO-58 Site, generally consistent with topography

(WESTON, 2010). Data required to assess seasonal variations in groundwater elevations have not been collected at the LO-58 Site (WESTON, 2007).

The complexity of the bedrock groundwater horizontal potentiometric gradients is illustrated by the results of synoptic potentiometric head measurements performed during pumping tests performed by WESTON in May 2008. The location of drinking water well DW-1 near the center of the LO-58 Site monitoring network is nearly ideal for the characterization of bedrock groundwater horizontal potentiometric gradients and flow directions, as it is uniquely surrounded by other bedrock groundwater monitoring points. As described in Subsection 2.3.4.2, synoptic potentiometric head measurements during test pumping of drinking water well DW-1, three bedrock monitoring wells, (MW-01, MW-03, and MW-05) showed strong responses (ranging from 0.154 to 0.637 ft, as summarized in Table 2-3) indicating that these three locations are within the cone of depression for well DW-1 under test pumping conditions and hydraulically-connected. In contrast, during the same synoptic potentiometric head measurement period, there was no observable response at drinking water well DW-2, which is located to the west, and either hydraulically-downgradient or cross-gradient of well DW-1. Although the May 2008 overall bedrock groundwater horizontal potentiometric gradient indicates that the potentiometric head in the vicinity of well DW-1 is greater than the potentiometric head in the vicinity of well DW-2, the synoptic potentiometric head measurements (which represent actual, rather than theoretical conditions, and thus bear much greater weight) do not indicate such a connection (WESTON, 2010).

As noted previously, ambient HPL testing identified primarily horizontal flow across well DW-1 and the portion of well DW-2 in shallow bedrock, at least in the proximity of the well. The fractured bedrock surrounding the borehole in DW-1 and the number of those water-bearing fractures that are high-angle fractures, results in an interconnected network of fractures around the well that have pressure-equilibrated outside the influence of the borehole. The weak differential potentiometric head that exists between the fractures results in primarily horizontal groundwater flow within the well. Conversely, ambient HPL testing identified primarily vertical flow within well DW-2 (COLOG, 2009).

2.3.4.4 Bedrock Groundwater Vertical Gradients

Hydrophysical, pressure transducer, and groundwater parameter data collected from drinking water wells DW-1 and DW-2 provides information regarding the variations in hydraulic head between individual fracture zones at the LO-58 Site which can be used to document bedrock groundwater vertical potentiometric gradient.

The fractured bedrock surrounding the borehole in DW-1, and the number of those water-bearing fractures that are high-angle fractures, results in a highly interconnected network of fractures around the well that have pressure-equilibrated outside the influence of the borehole. This has resulted in weak differential potentiometric head between the fractures, meaning groundwater flow within the well is primarily horizontal (COLOG, 2009). The exception to this general statement is the shallowest depth interval of well DW-1, which has temperature/pH and pressure transducer data which appears to indicate that it is to be isolated from the fractures immediately below it.

In well DW-2, the fracture characteristics of the shallow bedrock are similar to those surrounding the borehole at well DW-1. However, although there are high-angle fractures identified in the deeper bedrock surrounding well DW-2, their aperture and water-bearing potential are not as significant, and the upper and lower portions of the well have substantially different potentiometric heads. The differential head, the difference between ambient and production pressure (converted to ft), gradually increases with depth with the deepest fracture interval (265.0 to 284.0 ft bgs) having a pressure head of approximately 130 ft. The relatively strong differential potentiometric head that exists between the upper and middle fractures results in vertical groundwater flow from the upper fractures to the middle fractures within the well (COLOG, 2009).

2.4 RELEASE PROFILE

The release profile includes a description of the various potential release areas at the site. The potential release areas were identified based on data and information included in the historical environmental reports and WESTON’s site inspection, and includes areas where hazardous materials were known or suspected to have been stored or used.

2.4.1 LO-58 Site Closure

As described in detail in Subsection 2.2.7, the LO-58 Site historically included three fuel storage tanks: a 2,000-gallon UST associated with the former Barracks Building, a 500-gallon fuel oil AST located outside the former Test Building, and a 4,000-gallon fuel UST located adjacent to the southwest corner of the former Generator Building. Records indicate that the 2,000-gallon UST has been removed, the 500-gallon AST remains in place, and a series of geophysical investigations have failed to locate the 4,000-gallon UST which is presumed to have been removed.

There is no documentation of soil conditions noted during the removal of USTs at the LO-58 Site which would provide evidence of the actual release mechanisms for the fuels and chlorinated solvents (i.e., spills vs. subsurface leaks vs. deliberate on-site disposal). It is presumed that a combination of surficial spills and discharges, as well as subsurface discharges (i.e., via disposal to on-site septic system, leaking USTs or ASTs, or product transfer piping) resulted in the observed distribution of contaminants of potential concern (COPC) in soil/overburden at the LO-58 Site.

Closure activities associated with the three missile magazines at the LO-58 Site were performed between August 1994 and October 1994. The closure of each missile magazine included the collection of samples of infiltrated water within each of the three magazines with laboratory analysis for PCBs and flashpoint, removal and disposal of the water within the magazines, removal and disposal of hydraulic systems, and capping the three magazines with concrete planks. Aboveground magazine closure demolition work was also conducted which consisted of removing several vent pipes, manholes, and bulkhead doors.

2.4.2 LO-58 Site Soil Releases

As described in Subsection 2.1.7, the results of a 1999 passive soil vapor survey at the LO-58 Site indicated that low levels of BTEX compounds, TCE, tetrachloroethane, naphthalene, chloromethane, 1,2,4-trimethylbenzene, and 1,3,5-trimethylbenzene may exist in the subsurface. Appendix A includes a summary of the soil vapor results and maps of their distribution. Soil samples collected in 1999 indicated the presence of acetone in 16 of the 17 samples collected at concentrations ranging from approximately 0.0068 to 0.0551 mg/kg, and TCE was detected in two soil samples, SB-13 and SB-34, at concentrations of 0.0011 and 0.009 mg/kg, respectively. Neither of these substances were detected above their respective 2010 MEDEP RAG (1.5 mg/kg) (MEDEP, 2010a). Diesel-range organics were detected in soil samples SB-04, SB-09, and SB-13 at concentrations of 4, 10, and 36 mg/kg, respectively, one of which was in exceedance of its 2010 MEDEP DRO cleanup level (28 mg/kg) (MACTEC, 2010). As described in Subsection 2.1.8, additional soil samples collected between October 2000 and May 2001, indicated the presence of DRO at three boring locations, SB-45, SB-54, and SB-55, at concentrations of 11, 24, and 133 mg/kg, respectively, one of which was in excess of MEDEP cleanup level (28 mg/kg) (MACTEC, 2010). Appendix A includes a summary of these soil sample results.

As depicted in Figure 2-1, available soil analytical results document several areas of soil contamination with either fuel or missile maintenance-related COPCs. As noted in Subsection 2.4.1, it is presumed that a combination of surficial spills and discharges, as well as subsurface discharges (i.e., via disposal to on-site septic system, leaking USTs or ASTs, or product transfer piping) resulted in the observed distribution of COPCs in soil/overburden at the LO-58 Site.

2.4.3 LO-58 Site Groundwater Releases

As described in detail in Subsections 2.1.3 through 2.1.11, the analytical results of untreated groundwater samples collected from drinking water well DW-1 since 1996 have indicated the presence of TCE and other chlorinated solvents, with TCE concentrations above the Maine MEG of 5 µg/L. Bulk drinking water samples collected from well DW-2 since 1996 did not detect any VOCs above laboratory RLs. However, WSP groundwater samples collected from Well DW-1 in 2008 from all fracture intervals detected concentrations of chlorinated solvents (all below their respective Maine MEGs), from several fracture intervals detected GRO (above its Maine MEG in the shallowest interval), and from two intervals detected DRO (both above their Maine MEGs). The WSP groundwater samples collected from well DW-2 in 2008 from a single, intermediate-depth fracture interval detected a trace concentration of cis-1,2-DCE (below its Maine MEG), from several fracture intervals detected toluene (below its Maine MEG), and from two intervals (the shallowest and the deepest) detected DRO (both above their Maine MEGs). Appendix A includes a summary of the drinking water sample results.

As described in detail in Subsections 2.1.8 and 2.1.9, groundwater samples collected from the bedrock monitoring wells indicated the presence of VOCs, DRO, and GRO in the samples. No VOCs were detected at concentrations above Maine MEGs, but DRO and GRO have each been detected in monitoring well MW-05 during both rounds at a concentration in excess of their respective Maine MEGs. Appendix A includes a summary of the groundwater water sample results.

2.5 LAND USE AND EXPOSURE PROFILE

The land use and exposure profile is a description of the current land use and human population at the LO-58 Site and in the immediate vicinity that could potentially be exposed to hazardous materials that have been released at the LO-58 Site. The exposure profile identifies the potential receptor populations.

2.5.1 LO-58 Site Land Use

The LO-58 Site is used regularly by a variety of people. Members of the VFW use the former Barrack Building regular for social functions, and members of the community regularly attend bingo games in the building. In addition, members of the VFW perform landscaping activities, including lawn maintenance, in the vicinity of the former Barracks Building. Staff and clients at the AMAC use the former Generator Building 5 days a week, and regularly take walks around the eastern portion of the LO-58 Site.

According to the City of Caribou Zoning Map, the LO-58 Site and its immediate vicinity are in Residential District 3. Residential District R-3 is intended for the kinds of uses which have traditionally predominated in rural New England; forestry and farming, farm residence, and a scattering of varied uses not inconsistent with a generally open, non-intensive pattern of land use. According to the Caribou Land Use Table, the current uses of the property, Private Club and Day Care, are permitted within R-3 Residential District (City of Caribou, 2008).

2.5.2 Surrounding Properties Land Use

Properties in the vicinity of the LO-58 Site include a mix of commercial and residential uses. The area is zoned by the City of Caribou as an R-3 Residential District which encompasses most of the area outside the urban center and is intended for the kinds of uses which have traditionally predominated in rural New England; forestry and farming, farm residence, and a scattering of varied uses not consistent with a generally open, non-intensive pattern of land use (WESTON, 2007).

WESTON performed a visual survey of the surrounding properties during site reconnaissance on 31 July 2007. Residential properties and associated farm land abut the LO-58 Site along Route 1 to the north and west. The property that abuts the LO-58 Site to the south is used as a single family residence and an automobile maintenance facility identified as Morin’s Auto Detailing. Approximately 30 to 40 end-of-life vehicles were observed behind the Morin’s Auto Detailing shop. Haney’s Building Supply is located adjacent to the LO-58 Site to the southwest. This property includes a residence and a building materials showroom and storage. The remaining property to the northeast, east, and southeast comprises undeveloped land and farmland (WESTON, 2007).

According to the City of Caribou Zoning Map, the LO-58 Site and vicinity is located within Residential District R-3. According to the Caribou Land Use Table, the current, non-residential uses of parcels in the immediate vicinity of the property, Automobile (Vehicle) Body Shop or Graveyard and Building Materials, Storage and Sale, are permitted within Residential District R-3 with Planning Board approval (City of Caribou, 2008).

2.5.3 Exposure Profile

The exposure profile identifies the available receptors at and near a site. A receptor is a person or population that is or may be exposed to a release. Based on the previous subsections, the following current receptors are present at the LO-58 Site and its vicinity: non-residential adult workers (including utility workers and groundskeepers), students, and trespassers; and non-residential youth/child students and trespassers. In addition, the following potential future receptors may be present at the LO-58 Site and its vicinity under foreseeable future conditions: residential adults and youth/children.

2.6 ECOLOGICAL PROFILE

The ecological profile describes the ecological setting at the LO-58 Site and identifies potential biological receptors.

Unpaved areas of the LO-58 Site consist of grassland and shrub-scrub habitat, as forest succession takes place in formerly mowed areas. There are no surface water bodies or wetlands present at the LO-58 Site (USFWS, 2008). The nearest wetlands to the LO-58 Site are palustrine, forested, needle-leaved and broad-leaved, deciduous, seasonally-flooded/saturated wetlands, located approximately 0.18 mile to the northeast, within the floodplain of Hardwood Brook (USWFS, 2008). Available information from MEDEP and on-site observations do not indicate that Significant Wildlife Habitat is present at the LO-58 Site or in its vicinity (MEDEP, 2007). According to the Critical Natural Resources Map for the City of Caribou, Maine, there are no critical natural resource areas at the LO-58 Site, but such areas are located along Hardwood Brook located north of the LO-58 Site (City of Caribou, Maine, undated). Based on these results, WESTON concludes there are no ecological receptors of particular significance at the LO-58 Site, but there may be in areas downgradient of the LO-58 Site.

SECTION 3

LO-58 SITE PATHWAY ANALYSIS

3. LO-58 SITE PATHWAY ANALYSIS

The pathway analysis section of this CSM Report uses information from Section 2, LO-58 Site Profiles, to identify known complete, potentially complete, or incomplete source–receptor interactions for the LO-58 Site, for both current and reasonably anticipated future land use. An exposure pathway is the course a chemical or physical agent takes from a source to a receptor. Each pathway for the LO-58 Site includes a source, an exposure medium, an exposure route, and a receptor, as well as a release mechanism (e.g., volatilization) and a transport medium (e.g., air), where the point of exposure is not at the same location as the source. The following definitions are important to understanding the objectives of the pathway analysis (USACE, 2003).

- *Sources* are those areas where HTRW has entered (or may enter) the physical system. Information on sources and source areas is collected when the Facility, Physical, and Release Profiles are generated. Even though a source may be easily labeled, it is extremely important that the Release Profiles provide as much information about the source as possible, including probable contaminants. It is necessary for the CSM Report to document what is known and what is assumed about each source.

- *Interaction* describes ways that receptors come into contact with a source. Information from the Release Profiles will assist in identifying source-receptor interactions. There can be substantial movement of hazardous materials from sources through natural processes, such as frost heave, tidal action, and erosion, or from human activity. Environmental contaminants often undergo various processes (e.g., volatilization, migration) such that media other than the source area can become contaminated. Therefore, the Pathway Analysis considers all potentially-contaminated media (exposure media) as well as all exposure routes (including ingestion, inhalation, and dermal contact) in evaluating the source-receptor interactions at the LO-58 Site.

- A *Receptor* is an organism (human or ecological) that contacts a chemical or physical agent. The pathway evaluation considers both current and reasonably anticipated future land use, as receptors are determined on that basis. Appropriate human and ecological receptors are identified in the Land Use and Exposure, and Ecological Profiles. Human receptor subcategories can include residents, site workers, construction workers, recreational users, and trespassers.

3.1 SOURCES

Based on the results of previous environmental investigations summarized in Subsection 2.1 of this CSM Report, the COPC attributable to releases from the LO-58 Site are VOCs associated with fuels formerly used and stored at the LO-58 Site and chlorinated solvents associated with missile maintenance (WESTON, 2000). For the purposes of this CSM Report, the former USTs and ASTs themselves are no longer considered sources because they have been removed from the LO-58 Site. However, residual contamination in site soils relating to the former USTs and ASTs remain sources of fuel-related COPCs.

3.1.1 Fuel-Related Contaminants of Potential Concern

The COPCs associated with fuel include BTEX, naphthalene, and trimethylbenzenes. The COPCs associated with fuel have been detected in soil and soil vapor samples associated with former USTs located near the former Test Building, as well as soils in the vicinity of the former Launcher Area and former Fueling Platforms, and south-southeast of the AMAC Building at the LO-58 Site (WESTON, 2000). Figure 2-1 depicts the extent of the historic distribution of fuel and chlorinated solvent COPCs in soil at the LO-58 Site. These soils comprise a source of potential DRO and GRO that are available for release to the environment. These hazardous substances have also been detected in groundwater at the LO-58 Site, indicating that the compounds have been released from the source area (WESTON, 2000).

The fuel-related COPCs attributable to releases from the LO-58 Site are volatile and susceptible to both aerobic and anaerobic degradation, with aerobic processes being the most effective. Further, the solubility of the fuel-related COPCs in water is relatively low. Due to these characteristics, mobility of the COPCs is moderate. The attenuation factors for the fuel-related COPCs at the LO-58 Site are moderate to high. In the context of the CSM, the presence of dissolved DRO and GRO in groundwater at the LO-58 Site comprises evidence of a release to the environment has occurred (WESTON, 2010).

3.1.2 Missile Maintenance Contaminants of Potential Concern

Based on historical information, the primary chlorinated solvent associated with missile maintenance was TCE, although nitric acid and dimethylhydrazine were also used as missile fuels. Available references do not indicate that nitrate/nitrite or dimethylhydrazine have been included as soil or groundwater analytes during previous environmental investigations. The COPCs associated with missile maintenance (specifically, TCE) have been detected at soil sample locations SB-13, which is northwest and downslope of the former Launcher Area, and SB-34, which is immediately southwest of the AMAC Building. In addition, TCE was detected in soil vapor samples associated with soils in the vicinity of the former Launcher Area and south-southeast of the AMAC Building at the LO-58 Site (WESTON, 2000). Figure 2-1 depicts the extent of the historic distribution of fuel and chlorinated solvent COPCs in soil at the LO-58 Site. Tetrachloroethylene, commonly present in trace concentrations in solvent-grade TCE, as well as chloromethane, a breakdown product of TCE, are also COPCs for the LO-58 Site, due to their detection in on-site soils (WESTON, 2000). In addition to TCE, cis-1,2-DCE, and chloroform, which are biodegradation products of TCE and have been detected in groundwater in the vicinity of the LO-58 Site, are also considered COPCs (WESTON, 2007).

The missile maintenance-related COPCs attributable to releases from the LO-58 Site are volatile and susceptible to primarily anaerobic degradation, with the degradation rates of the chlorinated solvents substantially lower than those of the fuel-related VOCs. Further, the solubility of the missile maintenance-related COPCs in water is relatively low. Due to these characteristics, mobility of the missile maintenance-related COPCs is moderate. The attenuation factors for the missile maintenance-related COPCs are low. In the context of the CSM, the presence of dissolved chlorinated solvents in groundwater at the LO-58 Site comprises evidence of a release to the environment from the previously mentioned soil source, and the groundwater analytical data serve to quantify the extent of the release.

In addition, TCE was detected in soil vapor samples associated with soils in the vicinity of the former Launcher Area and south-southeast of the AMAC Building at the LO-58 Site (WESTON, 2000). Figure 2-1 depicts the extent of the historic distribution of fuel and chlorinated solvent COPCs in soil at the LO-58 Site.

The COPCs attributable to releases from the LO-58 Site are both volatile and susceptible to both aerobic and anaerobic degradation, with the degradation rates of the chlorinated solvents substantially lower than those of the fuel-related VOCs. Further, the solubility of the COPCs in water is relatively low. Due to these characteristics, mobility of the COPCs is moderate, and the attenuation factors for the COPCs at the LO-58 Site are moderate to high. In the context of the CSM Report, the presence of dissolved VOCs in groundwater at the LO-58 Site comprises evidence of a release to the environment from the previously mentioned soil source(s), and the groundwater analytical data serve to quantify the extent of the release.

3.2 INTERACTIONS

Identification of the source-receptor relationship interaction requires that exposure media and exposure routes be evaluated. Based on the information provided in Section 2 of this CSM Report, the following potential source-receptor interactions have been identified as current or foreseeable future conditions.

3.2.1 Exposure Media

Exposure media are those that contain the source, or those media that become contaminated through migration of the contaminant from the source area.

3.2.1.1 Soil Exposure

As noted in Subsection 2.4.2, on-site soils have been documented to contain VOCs related to fuel, and to a lesser extent, chlorinated solvents related to missile maintenance (WESTON, 2001). Importantly, TCE was not detected in soil samples at concentration above the 2010 MEDEP RAG, but DRO were detected in soil samples collected from two locations above the 2010 MEDEP cleanup levels (MACTEC, 2001; MEDEP, 2010a). The depth of the soil samples that contain fuel-related COPCs at the LO-58 Site range from 0 to 4 ft bgs (WESTON, 2001).

Notwithstanding future excavation and translocation of soil/overburden, the mechanisms for the potential migration/expansion of contaminated soil at the LO-58 Site include the erosion and migration of soil particles by surface water runoff or wind, which appear to have limited potential, due to the lack of non-vegetated or unpaved areas. The circumstances where soil exposure to COPCs from the LO-58 Site may occur include direct contact with soils containing VOCs; and incidental ingestion of soils containing VOCs.

3.2.1.2 Groundwater Exposure

As noted in Subsection 2.4.3, groundwater beneath the LO-58 Site has been documented to contain VOCs related to fuel and chlorinated solvents (WESTON, 2001). The circumstances where groundwater exposure to COPCs from the LO-58 Site may occur are volatilization to soil vapor and thence to indoor air from groundwater containing VOCs, direct contact, ingestion, and direct volatilization to indoor air (i.e., during showering).

Contaminants of potential concern have historically been detected above the applicable Maine MEGs in bulk untreated water samples collected from on-site drinking water well DW-1 and groundwater samples collected from on-site monitoring wells. Groundwater data from individual fractures within drinking water wells DW-1 and DW-2 indicate the presence of GRO and/or DRO above Maine MEGs (Maine CDCP, 2010). The POE treatment at well DW-1 serves to mitigate potential exposure to contaminated groundwater. The between-the-filters and post-treatment drinking water samples collected by JCI in fall 2008 and summer 2010 did not contain detectable concentrations of TCE (JCI, 2010d). Therefore, groundwater exposure via direct contact, ingestion, and direct volatilization to indoor air is considered to be a complete exposure pathway.

3.2.1.3 Sediment/Surface Water Exposure

No known samples of sediment or surface water downstream of the LO-58 Site have been collected to date. The distance to the nearest sediment/surface water is approximately 0.18 mile to the northeast, in the floodplain of Hardwood Brook, although surface water runoff from the western portion of the LO-58 Site flows northward approximately 0.5 mile along a natural valley toward Hardwood Brook. The circumstances where sediment/surface water exposure to COPCs from the LO-58 Site may occur are volatilization to sediment/surface water to air, direct contact, and incidental ingestion.

Available groundwater flow data indicates that groundwater from beneath the eastern and central portions of the LO-58 Site flows northward toward Hardwood Brook, and groundwater beneath the western portion of the LO-58 Site flows northwestward toward Hardwood Brook (see Figure 2-6). Groundwater analytical results indicate that groundwater beneath the northwestern portion of the LO-58 Site contains detectable concentrations of COPCs. There has been no investigation of the possibility that this groundwater may discharge to surface water between the LO-58 Site and Hardwood Brook; the natural valley to the north, between the VFW Building and the AMAC Building, is the likely location where such groundwater discharge may occur. Based on the available data, it cannot be determined whether the nearest sediment and/or surface water are subject to impact from the LO-58 Site.

3.2.1.4 Air Exposure

As noted in Subsection 3.1, the COPCs attributable to releases from the LO-58 Site are volatile. As such, both VOCs associated with fuel and chlorinated solvents associated with missile maintenance are subject to volatilization and may, under certain circumstances, become an inhalation hazard. The circumstances where air exposure to COPCs from the LO-58 Site may occur are volatilization to air from soils containing VOCs and use of groundwater for showering.

Soil vapor data collected in 1999 confirms that VOCs are present in the vicinity of the VOC-impacted soil at the LO-58 Site. This finding supports the possibility of volatilization to air from soils containing VOCs.

In addition, Table 1 of the *Vapor Intrusion Evaluation Guidance* (MEDEP, 2010b) provides three preliminary screening evaluation criteria to evaluate the likelihood of vapor intrusion. Using the three preliminary screening evaluation criteria:

1. Contaminants of concern at the LO-58 Site are volatile and toxic.
2. There is evidence of a release of contaminants to the LO-58 Site.
3. There are buildings, utilities, or other preferential pathways within 100 ft of non-petroleum contaminated media; the ground surface around the source and buildings is significantly covered by pavement, concrete or frost; and there is an existing building (intended for human occupancy) located within 100 ft of non-petroleum contaminated media.

Based on the affirmative answers to all three preliminary screening evaluation criteria, it may be concluded that there is potential for vapor intrusion/air migration at the LO-58 Site

(MEDEP, 2010b). Based on the above information, air exposure via volatilization from groundwater is considered to be a potential exposure pathway.

WESTON has screened the most recent shallow groundwater concentrations against EPA groundwater values found in Table 2a of the *RCRA Draft Supplemental Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway (Vapor Intrusion Guidance),* (EPA, 2001) in order to support the potential for air migration impacts via vapor intrusion. Based on this screening, WESTON finds that all groundwater concentrations of VOCs (DRO and GRO are not included in Table 2a) are all below the screening concentrations, supporting a conclusion that air migration pathway impacts are unlikely.

As noted in Subsection 3.2.1.3, sediment/surface water exposure is considered to be a potential exposure pathway due to lack of data which document a release to this media. Therefore, air exposure via volatilization from sediment/surface water is also considered to be a potential exposure pathway.

3.2.1.5 Biotic Exposure

The biotic medium is important when considering the potential for transfer of contaminants through the food chain. Additionally, bioaccumulation and bioconcentration of some contaminants in plants or animals can result in exposure of other receptors to harmful contaminant concentrations. The COPCs attributable to the LO-58 Site are VOCs which have relatively low bioaccumulation potential. Further, the existing and foreseeable future land use at the LO-58 Site does not include hunting, fishing, gardening, or the collection of any biota for human consumption. Thus, current or reasonably foreseeable uses of the LO-58 Site do not suggest that biotic exposure is a complete exposure pathway.

3.2.2 Exposure Routes

Exposure routes are those processes by which a contaminant or physical agent comes in contact with a receptor. For most environmental contaminants, these processes include ingestion, inhalation, and dermal contact. More than one exposure route may exist for any single pathway. Multiple receptors may be, and typically are, exposed through a single exposure route.

3.2.2.1 Ingestion

Ingestion is the consumption of contaminated food or water, as well as the incidental consumption of contaminated soil or other environmental media. Due to the availability of contaminated soil and potential availability of contaminated groundwater (during potential malfunctioning of on-site groundwater treatment systems), ingestion is considered a complete exposure route at the LO-58 Site.

3.2.2.2 Inhalation

Inhalation results from breathing air contaminated with COPC vapors or dust. As noted in Subsection 3.2.1.4, the volatile nature of the COPCs for the LO-58 Site results in potential air impacts under certain circumstances, including soil vapor or dust migration into ambient air, soil vapor migration into indoor air, or off-gassing of vapors from groundwater obtained from wells DW-1 or DW-2 (i.e., during showering/washing). Therefore, inhalation is considered a potential exposure route for the LO-58 Site.

3.2.2.3 Dermal Absorption

Dermal absorption occurs when contaminated soil or water contact unprotected skin and are absorbed into the body. Due to the availability of contaminated soil and potential availability of contaminated groundwater (during potential malfunctioning of on-site groundwater treatment systems or potential contact with contaminated groundwater should it discharge to surface water), dermal absorption is considered a potential exposure route at the LO-58 Site.

3.3 RECEPTORS

The receptors evaluated for the CSM were identified in the Land Use and Exposure Profile, as well as the Ecological Profile, and both human and ecological receptors have been considered. Evaluation of actual and potential receptors also considers both current and reasonably anticipated future land use.

3.3.1 Human Receptors

Human receptors are typically subdivided into several categories to represent varying degrees of potential exposure. These may include residents, site workers, construction workers, recreational users, and trespassers. The probability, frequency, and duration of each receptor's exposure to the contaminant are assessed in this manner.

3.3.1.1 Residents

There are no current residents on the LO-58 Site, and residential land use is not foreseen, although it would be among the permitted uses of the property under existing zoning regulations. Resident human receptors would have the greatest potential exposure to COPCs due to their high-frequency (typically between 16 and 24 hours per day), high-intensity use of the property. Potential future residents, particularly children and women of child-bearing age, would represent the worst-case scenario for potential exposure in risk assessment calculations.

3.3.1.2 On-site Workers and Students

There are currently on-site workers at the AMAC Building and the VFW Building, and the AMAC clients are considered as students for the purposes of receptor characterization. These human receptors would have less potential exposure to COPCs due to their low-frequency (typically 8 hours per day), high-intensity use of the property.

3.3.1.3 Construction Workers

The potential exists for construction or utility workers to be active at the LO-58 Site. These human receptors, particularly utility workers that might be required to excavate contaminated soil and work in such excavations, would have low-frequency, high-intensity use of the property.

3.3.1.4 Site Visitors

There are currently visitors to both the AMAC Building and the VFW Building, and the LO-58 Site is not secured, leaving it accessible to trespassers. These human receptors would have even less potential exposure to COPCs due to their lower-frequency, low-intensity use of the property, typically less than 4 hours per week.

3.3.2 Environmental Receptors

As noted in Subsection 2.6, available information does not indicate that there are any environmental receptors of particular significance at the LO-58 Site. The upland, shrub-scrub habitat that exists in the majority of the LO-58 Site likely supports a typical upland community of terrestrial flora and fauna. Based on field observations made in 2008 by WESTON, there is no evidence of any stress to the flora or fauna at the LO-58 Site. The few large fauna that may find their way to human receptors, such as deer, have home ranges many times larger than the LO-58 Site (such fauna would spend more time off-site than on-site) which would serve to minimize any adverse effects.

SECTION 4

LO-58 SITE REPRESENTATION OF THE CONCEPTUAL SITE MODEL

4. LO-58 SITE REPRESENTATION OF THE CONCEPTUAL SITE MODEL

This CSM is a summary of the existing body of knowledge for the LO-58 Site, presented in both illustrations and narratives. The exposure profiles included in Section 3 are based on reasonable hypotheses regarding potential for exposure and are further supported by available environmental sampling results including geophysical, hydrophysical, and groundwater analytical data collected between 1999 and 2008, as well as professional judgment. Where the results from the recent data collection confirm the predicted features of the CSM, the CSM has been updated to show that the hypothesis appears to be correct. However, where results do not support the predicted features, they may indicate the hypothesis was incorrect and should be reevaluated which is consistent with the iterative nature of the CSM. The following subsections summarize the current understanding of the LO-58 Site CSM. In addition, Figure 4-1 presents the same concepts in the form of a flow chart, Figure 4-2 presents the same concepts in the form of a block diagram, Figures 4-3 and 4-4 depict plan and cross-sectional representations of the CSM, and Figure 4-5 places the CSM into context with the area beyond the LO-58 Site boundary.

4.1 SOURCES OF CONTAMINATION

Based on the information provided in Section 3, the sources of the VOCs associated with fuels and chlorinated solvents associated with missile maintenance are surficial and subsurface soil/overburden at the LO-58 Site. There is no documentation of the actual release mechanisms for the fuels and chlorinated solvents (i.e., surface spills vs. subsurface leaks vs. improper on-site disposal); however, it is presumed that a combination of surficial spills and discharges as well as subsurface discharges (i.e., via disposal to on-site septic system, leaking USTs or ASTs or product transfer piping) resulted in the observed distribution of COPCs in soil/overburden at the LO-58 Site.

Based on soil vapor survey and soil analytical results, there appear to be two soil/overburden sources at the LO-58 Site: one located west of the AMAC Building and a second, broader source, located near the former Launcher Area and former Fueling Platform at the LO-58 Site (see Figure 2-1). The highest noted soil headspace readings were located in the upper 4 ft of the soil/overburden (where the soil/overburden exceeded 4 ft in total thickness). Further, the concentrations of COPCs detected in groundwater are well below their maximum solubilities. This distribution of contaminants supports the hypothesis that the hazardous materials released to soil/overburden did not reach the water table as a non-aqueous phase liquid (NAPL), and refute the possible presence of a NAPL source in the subsurface.

The WSP groundwater analytical results for the shallowest depth interval of drinking water well DW-2 suggest a nearby source of DRO contamination. Available historical information for the LO-58 Site does not indicate that any disposal activities occurred in the vicinity of the VFW Building (former Barracks Building). The presence of DRO contamination in well DW-2, which is located in a subgrade chamber in a parking lot, may be related to the use of the surrounding area for parking which continues to the present. Drinking water well DW-2 was modified following the field investigation by the extension of the well casing by approximately 4 ft in order to meet current installation standards and in an effort to alleviate future potential impacts to the well related to parked vehicles (WESTON, 2010). It is not known whether the DRO impact in DW-2 is related to parking lot impacts or a historical release resulting from the use of fuels at the LO-58 Site.

4.2 CONTAMINANT MIGRATION

4.2.1 Soil

With the termination of releases and/or disposal activities at the LO-58 Site in 1969, the concentrations of COPCs in soil at the LO-58 Site would have begun to decrease due to natural attenuation processes, including degradation, dissolution into vadose zone water, and volatilization, with such processes continuing to the present.

The concentrations of VOCs and GRO, and most of the concentrations of DRO, previously documented in soil/overburden are below MEDEP RAGs or cleanup levels (MACTEC, 2010; MEDEP, 2010a). This observation implies that, due to the period of time that has passed since the release of the fuel and solvents, the concentrations of hazardous substances have decreased to such a degree that they generally do not require remediation. However, the concentrations of DRO at soil sample locations SB-13, and SB-55 were documented between 1999 and 2001 to exceed current MEDEP cleanup levels; thus, may remain a potential source of soil and groundwater contamination and may require reevaluation or remediation (MACTEC, 2010; MEDEP, 2010a).

Notwithstanding future excavation and translocation of soil/overburden, the mechanisms for the potential migration/expansion of contaminated soil at the LO-58 Site include the erosion and migration of soil particles by surface water runoff or wind, which appear to have limited potential due to the lack of non-vegetated or unpaved areas.

4.2.2 Groundwater

As discussed in Subsections 2.4.3, groundwater beneath the LO-58 Site has been documented to contain VOCs related to fuel and chlorinated solvents. Because of the lack of documentation of on-site disposal procedures, WESTON assumes that the COPCs migrated from the contaminated soil/overburden source to groundwater by dissolution in vadose zone water which percolated through the contaminated soil to groundwater. The concentrations of COPCs detected in groundwater are well below their maximum solubilities, a condition which supports the conclusion that there is no NAPL source in the subsurface. Further migration of COPCs from groundwater may occur to soil vapor and the atmosphere via volatization.

In addition, the presence of increasing ratios of breakdown products of TCE in downgradient groundwater may indicate that degradation of TCE is occurring naturally at the LO-58 Site, although the limited data are insufficient to make statistically valid conclusions. However, since such degradation is typically favored by anaerobic conditions and available groundwater DO and ORP data do not indicate significant areas of anaerobic conditions, it is presumed that such breakdown is occurring within the soil source areas where the combination of DRO/GRO and chlorinated solvents may result in enhanced biodegradation (Wedemeier, et al., 1997).

4.2.2.1 Groundwater Flow Paths

Horizontal Flow

May 2008 groundwater elevation data indicate that the potentiometric head in the vicinity of the soil/overburden source west of the AMAC Building is westerly. During hydrophysical testing of drinking water well DW-1, groundwater flow within the well was shown to be primarily horizontal due to the interconnection of the common, low-angle fractures along the borehole by high-angle fractures. Further, as noted in Subsection 2.3.4.2, synoptic potentiometric head measurements during test pumping of drinking water well DW-1 indicate that three bedrock monitoring wells (MW-01, MW-03, and MW-05) showed strong responses, indicating that these locations are within the cone of depression for well DW-1 under test pumping conditions and hydraulically-connected by the same high-angle fractures which trend northeastward. Thus, under test pumping conditions ranging between 2.7 and 7 gpm, the horizontal component of groundwater flow in the vicinity of drinking water well DW-1 is interpreted to become anisotropic along a northeasterly axis, and this elongated cone of depression increases the width of the capture zone for well DW-1. Under test pumping conditions, the horizontal extent of the capture zone for well DW-1 extends at least as far as monitoring wells MW-01, MW-03, and MW-05, but does not appear to extend as far as drinking water well DW-2. This extension of the capture zone appears to coincide with the linear depression in the bedrock surface between locations SB-22 and SB-43. This linear depression has been interpreted as a fracture zone, based on its orientation North 70º West, which matches observed fractures in well DW-1, and would serve to promote anisotropic flow.

However, the extent of the cone of depression and resulting capture zone for well DW-1 under typical pumping conditions (the average pumping rate while in use as a drinking water supply well) is the important parameter to be considered in evaluating the capacity for well DW-1 to "typically" intercept impacted groundwater at the LO-58 Site. Since the AMAC Building is not equipped to measure its water use, a conservative estimate of 150 gallons per day (based on typical water use of 15 gallons per person per day for a school or day care which serves meals and a total of 10 staff and clients), yields an average pumping rate of 0.1 gpm (Env-Wq 1000, 2010). The drawdown data for each monitoring well needed to estimate cone of depression at the typical pumping rate has been estimated by using a conservative linear relationship to scale the expected drawdown in the monitoring wells using an adjusted ratio method and provide an estimation of the cone of depression, understanding that this method overestimates the drawdown. Non-equilibrium drawdown values at three different pumping rates (7.0, 6.3, and 2.7 gpm), and the estimated typical pumping rate of 0.1 gpm results in estimated drawdowns of less than 0.01 ft at the monitoring wells (see Table 2-3), confirming that the cone of depression under typical pumping conditions does not extend as far as wells MW-01, MW-03, and MW-05. This further results in a substantially smaller capture zone under typical pumping conditions, although it should be noted that the lack of closer bedrock groundwater potentiometric surface monitoring points leaves the extent cone of depression under typical pumping conditions poorly-defined. Figure 4-3 depicts (conceptually only) the estimated differences in the extent of the well DW-1 capture zone under typical and test pumping conditions in the vicinity of the LO-58 Site, and Figure 4-5 depicts the estimated full extents of these capture zones.

Conversely, the absence of synoptic potentiometric head response from well DW-2 during the same period indicates a lack of detectable hydraulic connection with the other bedrock wells at the LO-58 Site based on this dataset. However, the May 2008 overall bedrock groundwater horizontal potentiometric gradient (depicted in Figure 2-6), suggests the potential for flow from wells DW-1 to DW-2. The detection of cis-1,2-DCE in the second deepest (187.9 to 192.2 ft bgs) depth interval indicates that the horizontal extent of groundwater impacts from the sources at the LO-58 Site are widespread, but decrease in depth with distance. These conflicting data may be reconciled by considering the relatively small fraction (less than 1%) of groundwater that is provided to well DW-2 under pumping conditions from the 187.9 to 192.2 ft bgs depth interval which was not detectable during synoptic potentiometric head measurements.

The locations of the seven bedrock wells at the LO-58 Site limit the interpretation of horizontal groundwater flow to the vicinity of drinking water well DW-1. However, the conclusions regarding horizontal groundwater flow in the vicinity of drinking water well DW-1 can be extrapolated across the LO-58 Site. The northeast-southwesterly anisotropy of horizontal groundwater flow direction is presumed to exist under any pumping conditions across the LO-58 Site, as the bedrock fabric is consistent across the LO-58 Site. However, under typical pumping conditions, the overall bedrock groundwater horizontal potentiometric gradient is expected to have greater influence on groundwater flow than under test pumping conditions.

Vertical Flow

As discussed in Subsection 2.3.4.4, vertical groundwater flow appears to be negligible in the vicinity of drinking water well DW-1. The slight increase in the ratio of cis-1,2-DCE to TCE between shallower and deeper intervals in well DW-1 may indicate a relatively higher concentration of daughter to parent compound and may imply greater degradation and distance from the TCE source, which indicates that the dissolved chlorinated solvents are degrading as they migrate downward through bedrock fractures, although the limited data are insufficient to make statistically valid conclusions.

In well DW-2, the fracture characteristics of the shallow bedrock are similar to those surrounding the borehole at well DW-1. However, although there are some high-angle fractures identified in the deeper bedrock surrounding well DW-2, their aperture and water-bearing potential are not as significant, and the upper and lower portions of the well have substantially different potentiometric heads. The relatively strong differential potentiometric head that exists in well DW-2 between the upper and middle fractures results in vertical groundwater flow from the upper fractures to the middle fractures within the well. In addition, as discussed in Subsection 2.3.4.2, the detection of cis-1,2-DCE in the second deepest (187.9 to 192.2 ft bgs) depth interval indicates that the vertical extent of groundwater impacts from the sources at the LO-58 Site is significant at distance from the source area.

The downward vertical gradient noted in well DW-2 suggests that groundwater beneath the western portion of the LO-58 Site may discharge to soil/overburden at the valley located east of the VFW Building and eventually wetlands and surface water downstream.

4.2.2.2 Groundwater Contamination Nature and Extent

The combination of the available information regarding groundwater flow paths with the locations of the soil/overburden sources of COPCs identifies the contaminant migration paths for the LO-58 Site. The subsequent superposition of the available groundwater analytical results for the LO-58 Site further constrains conclusions regarding the nature and extent of COPCs in groundwater.

As noted in Subsection 4.2.2.1, beyond the influence of pumping from the two drinking water wells at the LO-58 Site, groundwater flow is presumed to follow the overall bedrock groundwater horizontal potentiometric gradient. Based on this assumption, groundwater flow beneath the portions of the contaminated soil/overburden source area located in the former Launcher Area is presumed to be northwesterly. This groundwater, characterized by downgradient monitoring wells MW-01 and MW-02, contained no detectable COPCs from 2000 to 2004. Part of this groundwater may be within the capture zone for drinking water well DW-1 under typical pumping conditions, which does not extend as far north as monitoring well MW-01. In addition, the portions of the contaminated soil/overburden source area located at the former Warhead Building and former AFNS, characterized by groundwater monitoring wells MW-05 and MW-01, respectively, are not located within the capture zone for drinking water well DW-1 under typical pumping conditions.

Available information does not identify the western extent of the capture zone for drinking water well DW-1 under typical pumping conditions. The second contaminated soil/overburden source area is located west of the AMAC Building. The increasing overall bedrock groundwater horizontal potentiometric gradient to the west and the northeast-southwest anisotropic shape of the well DW-1 cone of depression both suggest that the extent of the capture zone for drinking water well DW-1 may not extend as far to the west as the contaminated soil/overburden source area located west of the AMAC Building. Under this scenario, the contaminated groundwater beneath the western portion of the second soil/overburden source area may be subject to westward flow under the influence of the overall bedrock groundwater horizontal potentiometric gradient. This groundwater appears to be within the capture zone for drinking water well DW-2, which is not defined by the available data.

Available groundwater analytical results indicate that monitoring wells MW-03 and MW-05 and drinking water wells DW-1 and DW-2 have been impacted with COPCs from the LO-58 Site. However, these results also indicate that the COPC concentrations detected in on-site drinking water or monitoring wells were one to two orders of magnitude less than the applicable Maine MEGs in groundwater samples, with the exception of TCE, which has been recorded to be just below the Maine MEG between fall 2008 and spring 2010, and just above the Maine MEG in

July 2010 (JCI, 2010d). Further, continued pumping of drinking water from wells DW-1 and DW-2 appears to capture a fraction of the impacted groundwater and reduce overall groundwater impact.

Natural Attenuation of Groundwater Contaminants

Superimposition of the known nature and extent of groundwater impacts with groundwater parameter data collected simultaneously provides insight into the natural attenuation processes at work at the LO-58 Site. The two most important pairs of parameters in this regard are pH and temperature, and DO and ORP, the latter being generally high in groundwater across the LO-58 Site. As discussed in Subsection 2.3.4.2, there appears to be an inverse relationship between pH and temperature in groundwater beneath the LO-58 Site.

Also as previously discussed in Subsection 2.3.4.2, during the 2008 sampling activities, measured DO values at the LO-58 Site ranged from 2.97 to 11.60 milligrams per liter, and ORP values ranged from -4.8 to 215.0 millivolts which are generally within the range of unimpacted groundwater (WESTON, 2010). It is suspected that the general lack of DO and ORP reduction in groundwater at the LO-58 Site was due to the relatively low DRO and GRO concentrations detected in groundwater which provide insufficient carbon load to reduce the DO and ORP in the groundwater. In drinking water well DW-1, the lower DO and ORP values noted in the middle depth interval may be indicative of higher contaminant concentrations in an upgradient source area where substantial biodegradation has occurred. Further, the relatively low DO and ORP results in this depth interval correlate well with the chlorinated solvent concentrations detected in this depth interval, and provide a mechanism for the biodegradation of TCE to cis-1,2-DCE. Because the DO and ORP results do not appear to be reduced by aerobic DRO/GRO degradation, another source of organic material must be found to account for the reduced DO and ORP results. One potential source which is both proximal to and within the capture zone for drinking water well DW-1 and associated with chlorinated solvents is the septic system for the AMAC Building. WESTON concludes that the non-hazardous organic loading in the septic system may be the source of the anaerobic conditions which facilitate TCE biodegradation (WESTON, 2010).

In drinking water well DW-2, the relatively low DO and ORP results in the second deepest depth interval correlate well with the chlorinated solvent concentrations detected in this depth interval, and provide a mechanism for the biodegradation of TCE to cis-1,2-DCE. Based on the apparent isolation of the shallow and deepest sampling intervals of drinking water well DW-2 by the second deepest interval, it appears that the DRO detected in the deepest interval of well DW-2 is from an even more distal source (WESTON, 2010). WESTON concludes that the source(s) of cis-1,2-DCE in well DW-2 is the same as the source(s) for well DW-1, one or more of the chlorinated solvent source areas at the LO-58 Site.

In addition to the evidence presented above, the effects of physical dispersion and dilution of the groundwater plume along its length, which occur to a degree in all groundwater plumes, are presumed to be significant in reducing contaminant concentrations, as they cause the plume dimensions expand in the downgradient direction (Freeze & Cherry, 1979). WESTON concludes that natural attenuation of both petroleum hydrocarbons and chlorinated solvents is occurring at the LO-58 Site, both by the physical means of dispersion and dilution as well as via biodegradation. Based on the 40-year period since the deactivation of the LO-58 Nike Missile Battery Launch facility and the termination of associated releases of hazardous substances to the environment, WESTON concludes that the extent of groundwater impacts at the LO-58 Site is likely at equilibrium with the remaining source(s) of contamination, and that natural attenuation will continue to reduce that extent of groundwater impacts in the future.

4.2.3 Sediment/Surface Water

There are insufficient data to determine whether potentially-contaminated groundwater may discharge to surface water between the LO-58 Site and Hardwood Brook. Thus, it cannot be determined whether the nearest sediment and/or surface water are subject to impact from the LO-58 Site.

4.2.3.1 Sediment/Surface Water Flow Paths

There are no data regarding whether impacted groundwater may discharge to surface water between the LO-58 Site and Hardwood Brook. Although the downward vertical gradient noted in well DW-2 suggests that groundwater may not discharge to soil/overburden, streams in valley bottoms are typically considered to be groundwater discharge areas, and the most likely place for this discharge is at the natural valley between the VFW Building and the AMAC Building which eventually leads to wetlands and surface water downstream of the LO-58 Site, this datum is insufficient to confirm such a flow path.

4.2.3.2 Sediment/Surface Water Contamination Nature and Extent

No samples of sediment or surface water downstream of the LO-58 Site have been collected to date. Although shallow bedrock groundwater analytical results indicate that groundwater beneath the western portion of the LO-58 Site contains detectable concentrations of COPCs, there are insufficient data to determine whether sediment/surface water may be impacted. In addition, the distance to the nearest sediment/surface water is approximately 0.18 mile to the northeast in the floodplain of Hardwood Brook; the likelihood of detectable concentrations of volatile COPCs reaching the nearest surface water is estimated to be low.

4.2.4 Air

There are insufficient data to determine whether VOC-impacted soil or potentially-contaminated groundwater may discharge COPCs to ambient or indoor air at the LO-58 Site. Thus, it cannot be determined whether air is subject to impact from the LO-58 Site. However, the following anecdotal data may be used to evaluate the likelihood of air impacts:

- Soil vapor samples collected in 1999 indicated that VOCs are present in soil between 0 and 4 ft bgs at the LO-58 Site.
- The lack of reports of odors or any other observations suggest that air at the LO-58 Site has not been impacted by VOCs attributable to the release.
- The presence of a number of potential preferential pathways for the migration of soil vapor toward buildings at the LO-58 Site, including the fill surrounding subsurface water and sewer lines.
- Air monitoring for VOCs has been conducted during previous environmental investigations at the LO-58 Site with no reports of the detection of VOCs in ambient air, including air monitoring in areas of VOC-impacted soil and the subgrade chamber that contains the well head for drinking water well DW-2.

In addition, Table 1 of the *Vapor Intrusion Evaluation Guidance* (MEDEP, 2010b) provides three preliminary screening evaluation criteria to evaluate the likelihood of vapor intrusion. Using the three preliminary screening evaluation criteria:

1. Contaminants of concern at the LO-58 Site are volatile and toxic.
2. There is evidence of a release of contaminants to the LO-58 Site.
3. There are buildings, utilities, or other preferential pathways within 100 ft of non-petroleum contaminated media; the ground surface around the source and buildings is significantly covered by pavement, concrete or frost; and, there is an existing building (intended for human occupancy) located within 100 ft of non-petroleum contaminated media.

Based on the affirmative answers to all three preliminary screening evaluation criteria, it may be concluded that there is potential for vapor intrusion/air migration at the LO-58 Site (MEDEP, 2010b).

WESTON has screened the most recent shallow groundwater concentrations against EPA Target Groundwater Concentrations Corresponding To Target Indoor Air Concentration Where the Soil Gas to Indoor Air Attenuation Factor = 0.01 and Partitioning Across the Water Table Obeys Henry's Law found in Tables 2a through 2c of the *RCRA Draft Supplemental Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway (Vapor Intrusion Guidance)*, in order to support the potential for air migration impacts via vapor intrusion (EPA, 2001). Based on this screening, WESTON finds that groundwater concentrations of VOCs (DRO and GRO are not included in Tables 2a through 2c) were mostly below the screening concentrations with the exception of TCE in well DW-1. In July 2010, well DW-1 had a TCE concentration of 6.6 µg/L, which is above the 5 µg/L screening concentration, supporting a conclusion that air migration pathway impacts are possible.

4.2.4.1 Air Migration Paths

Soil vapor may discharge to ambient air at the LO-58 Site from soil/overburden contaminated with VOCs, GRO, or DRO. In addition, migration of VOCs, GRO, or DRO dissolved in shallow bedrock groundwater could result in soil vapors in soil/overburden at other locations at the

LO-58 Site, as well as downgradient areas where shallow bedrock groundwater may discharge to soil/overburden and subsequently to surface water.

4.2.4.2 Air Contamination Nature and Extent

No air samples have been collected to date at the LO-58 Site. The majority of the available anecdotal air data suggest that there may be air impacts at the LO-58 Site.

4.3 SOURCE-RECEPTOR INTERACTIONS

This section of the CSM evaluates the available media containing COPCs and the interactions which may provide exposure routes to potential receptors.

4.3.1 Potential Exposure to Contaminated Soils

A variety of means are available for the potential receptors at the LO-58 Site and its vicinity to be exposed to soil COPCs. On-site workers are subject to potential direct contact exposure to contaminated soils during maintenance, landscaping, and walking activities. Students and trespassers are subject to potential direct contact exposure to contaminated soils during walking and recreational activities. As depicted in Figure 4-1, this exposure pathway is considered complete for all receptors under both current and foreseeable future use scenarios.

4.3.2 Potential Exposure to Contaminated Groundwater

A variety of vectors are available for the potential receptors at the LO-58 Site and its vicinity to be exposed to groundwater COPCs in water obtained from drinking water wells DW-1 and DW-2. However, the POE filtration system in place at well DW-1 currently prevents such exposures, and available analytical results for well DW-2 indicate groundwater COPCs are well within acceptable limits. On-site workers and students are subject to potential exposure by direct contact (i.e., during bathing, etc.), by the ingestion of contaminated drinking water, and by inhalation of vapors from contaminated water (i.e., during showering, etc.). The use of POE treatment at well DW-1 mitigates the potential exposure via this well. Trespassers are not subject to potential groundwater exposure. As depicted in Figure 4-1, this exposure pathway is considered complete for all receptors under both current and foreseeable future use scenarios.

4.3.3 Potential Exposure to Contaminated Sediment/Surface Water

There is no known sediment or surface water at the LO-58 Site. However, the potential exists for the erosion and migration of soil particles by surface water runoff, although this vector has limited potential due to the lack of non-vegetated or unpaved areas. A more important migration route is the potential discharge of contaminated groundwater to surface water downstream of the LO-58 Site. Adult and youth/child receptors could potentially be exposed to contaminated sediment/surface water via direct contact, incidental ingestion, and inhalation of vapors. As depicted in Figure 4-1, this exposure pathway is considered potential for all receptors under both current and foreseeable future use scenarios.

4.3.4 Potential Exposure to Contaminated Air

A variety of means are available for the potential receptors at the LO-58 Site and its vicinity to be exposed to air COPCs. On-site workers, students, and trespassers are subject to potential inhalation exposure vapors or fugitive dust while present at the LO-58 Site. As depicted in Figure 4-1, this exposure pathway is considered potential for all receptors under both current and foreseeable future use scenarios.

SECTION 5

LO-58 SITE DATA GAPS ANALYSIS

5. LO-58 SITE DATA GAPS ANALYSIS

Section 5 of this CSM Report identifies a number of data gaps which preclude definitive statements regarding certain potential migration pathways. The following subsections summarize the identified data gaps by pathway and evaluate their relative importance.

5.1 SOIL/OVERBURDEN SOURCE AREAS

As discussed in Subsections 2.1.7 and 2.1.8, the concentrations of DRO at soil sample locations SB-13and SB-55 were documented between 1999 and 2001 to exceed current MEDEP cleanup standards, and thus, may remain a potential source of soil and groundwater contamination, and may require reevaluation or remediation (MACTEC, 2010). While the locations of these MEDEP cleanup level exceedances are documented, their actual extent is not known. Further, because of the semivolatile nature of DRO, natural attenuation may have reduced the DRO concentrations to levels below MEDEP cleanup levels. Thus, the current nature and extent of MEDEP cleanup level exceedances for DRO is a data gap.

The WSP groundwater analytical results for the shallowest depth interval of drinking water well DW-2 indicate a nearby source of DRO contamination, likely in shallow soils. The presence of DRO contamination in well DW-2, located in a subgrade chamber in a parking lot, may be related to the use of the surrounding area for parking which continues to the present. The modifications made to well DW-2 following the field investigation may alleviate further impact to the well. However, it is unclear whether the DRO impact is related to past or current activities at the LO-58 Site.

Review of soil analytical results for Site LO-58 indicates that soil samples collected in the vicinity of the former Generator Building (AMAC Building) have never been analyzed for PCBs. As noted in Subsection 2.2.7.3, PCBs were historically used in generator coolant oils, thereby confirming that a data gap exists. Further, available references do not indicate that nitrate/nitrite or dimethylhydrazine have been included as soil or groundwater analytes during previous environmental investigations, resulting in a data gap for these COPCs.

5.1.1 Importance

In order for the LO-58 Site to comply with MEDEP regulations, the current nature and extent of MEDEP cleanup level exceedances for DRO should be determined. This data gap is considered of high importance, because the available data indicate that MEDEP cleanup levels were exceeded, and MEDEP regulations require a response to this condition. Further, there are numerous uncertainties involved in estimating compliance with MEDEP current EPH cleanup levels from the 10-year old DRO analytical results. WESTON's recommendations for addressing this data gap are included in Subsection 6.1 of this CSM Report.

The source of DRO in the shallowest depth interval of drinking water well DW-2 is uncertain and may not be related to past activities at the LO-58 Site, but rather to current activities at the VFW Building. Because of the lack of attribution to previous site activities, this data gap, while important to the members and guests of the VFW, is of low importance from the perspective of addressing site-related impacts.

The lack of PCB analytical results for soils in the vicinity of the AMAC Building and nitrate/nitrite or dimethylhydrazine analyses are considered data gaps of relatively low importance. However, the relatively low cost of collecting a small number of soil samples from the vicinity of the AMAC Building results in a favorable cost-benefit, as is the addition of nitrate/nitrite and dimethylhydrazine analyses to future long-term groundwater monitoring at Site LO-58.

5.2 GROUNDWATER

As noted in Subsection 4.2.2.1, the capture zone for drinking water well DW-1 under typical pumping conditions does not extend as far north as monitoring well MW-01, or as far as monitoring wells MW-05 and MW-03, capturing an unknown fraction of the contaminated groundwater beneath the eastern portion of the LO-58 Site. Additional bedrock monitoring wells, located south of monitoring well MW-01 and east-northeast of monitoring well MW-03, could resolve the extent and effectiveness of the well DW-1 capture zone to the north.

In addition, available information does not identify the western extent of the capture zone for drinking water well DW-1. There is a small chlorinated solvent-contaminated soil/overburden source area located west of the AMAC Building. The increasing overall bedrock groundwater horizontal potentiometric gradient to the west and the north-south anisotropic shape of the well DW-1 capture zone both suggest that the extent of the capture zone for drinking water well DW-1 under typical pumping conditions may not extend as far to the west as the contaminated soil/overburden source area located west of the AMAC Building. Under this scenario, the contaminated groundwater beneath the western portion of the small chlorinated solvent-soil/overburden source area may be subject to westward flow under the influence of the overall bedrock groundwater horizontal potentiometric gradient (see Figure 2-1). This groundwater appears to be within the capture zone for drinking water well DW-2, which is not defined by available data. One additional bedrock monitoring well, located west-southwest of the AMAC Building, could resolve the extent and effectiveness of the well DW-1 capture zone and serve to partially define the extent of the well DW-2 capture zone. Further, the lack of definition of the extent of contamination results in a data gap regarding groundwater quality at the nearest off-site drinking water well.

Finally, based on the available synoptic potentiometric head data, none of the existing monitoring bedrock monitoring wells at the LO-58 Site are positioned to assess the cone of depression for drinking water well DW-2. Approximately five shallow bedrock monitoring wells would be required to assess the capture zone for drinking water well DW-2.

5.2.1 Importance

Drinking water well DW-1 captures an unknown portion of the contaminated groundwater beneath the LO-58 Site and, in this regard, acts as a de facto groundwater recovery system. Drinking water well DW-2 captures additional contaminated groundwater beneath the LO-58 Site and, in this regard, acts as a backup groundwater recovery system, and there are no other nearby potential groundwater receptors. For these reasons, the data gap regarding the completeness of the well DW-1 and DW-2 capture zones are considered of limited importance to decision-making regarding the likelihood of off-site migration of groundwater contamination, as it appears that a fraction of groundwater contamination is captured by one of the two wells, and the remainder may naturally-attenuate before it reaches off-site receptors. Coupled with the relatively high cost of bedrock monitoring well installation and sampling, the cost-benefit of such an effort is not favorable. However, the relatively low cost of collecting a drinking water sample from the nearest off-site drinking water well results in a favorable cost-benefit, and should be pursued.

5.3 SEDIMENT/SURFACE WATER

As noted in Subsection 4.2.3, there are insufficient data to determine whether potentially-contaminated groundwater may discharge to surface water between the LO-58 Site and Hardwood Brook. The most likely place for this discharge is at the natural valley between the VFW Building and the AMAC Building which eventually leads to wetlands and surface water downstream of the LO-58 Site. An overburden monitoring well, located within the valley northeast of the VFW Building, could resolve the question of whether impacted groundwater discharges to overburden at the LO-58 Site.

No samples of sediment or surface water downstream of the LO-58 Site have been collected to date. Although shallow bedrock groundwater analytical results indicate that groundwater beneath the western portion of the LO-58 Site contains detectable concentrations of COPCs, there are insufficient data to determine whether sediment/surface water may be impacted. In addition, the distance to the nearest sediment/surface water is approximately 0.18 mile to the northeast in the floodplain of Hardwood Brook; the likelihood of detectable concentrations of volatile COPCs reaching the nearest surface water is estimated to be low. Thus, it cannot be determined whether the nearest sediment and/or surface water are subject to impact from the LO-58 Site. An estimated six surface water and/or sediment samples, collected in the late summer when regional precipitation is at its annual low and groundwater discharge to surface water is greatest, would eliminate this data gap.

5.3.1 Importance

Information regarding potential discharge of impacted groundwater to surface water near the LO-58 Site is considered important due to the complete lack of data for this migration pathway. Because negative analytical results for a few samples collected at the nearest possible receptors would eliminate the potential pathway, the cost-benefit of such an effort is favorable.

5.4 AIR

As discussed in Subsection 4.2.4, there are insufficient data to determine whether VOC-impacted soil or potentially-contaminated groundwater may discharge COPCs to ambient or indoor air at the LO-58 Site, although available anecdotal air data suggest that there may be air impacts at the LO-58 Site. An estimated two sub-slab soil vapor samples and an indoor air sample analytical results collected at the only possible receptor where screening groundwater concentrations were exceeded, the AMAC Building, would eliminate the data gap.

5.4.1 Importance

Although no air samples have been collected to date at the LO-58 Site, the majority of the available anecdotal air data and the results of vapor intrusion evaluation suggest that there may be air impacts at the LO-58 Site. Because negative analytical results for a few soil vapor and indoor air samples collected at the nearest possible receptor, the AMAC Building, would eliminate the potential pathway, the cost-benefit of such an effort is favorable.

SECTION 6

LO-58 SITE CONCLUSIONS AND RECOMMENDATIONS

6. LO-58 SITE CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

Based on the results of previous environmental investigations, the COPCs attributable to releases from the LO-58 Site are VOCs associated with fuels formerly used and stored in USTs and ASTs and chlorinated solvents associated with missile maintenance (WESTON, 2000). For the purposes of this CSM Report, the former USTs and ASTs at the LO-58 Site are no longer considered sources, because they have been removed. However, the soils to which releases from the former USTs and ASTs occurred remain sources of fuel and missile maintenance-related COPCs.

6.1.1 Soil Exposure

On-site soils have been documented to contain VOCs related to fuel, and to a lesser extent, chlorinated solvents related to missile maintenance. Importantly, DRO were detected in soil samples collected from two locations at concentrations above its applicable MEDEP cleanup level (MACTEC, 2010; MEDEP, 2010a). The depth of the soil samples that contain fuel-related COPCs at the LO-58 Site range from 0 to 4 ft bgs (WESTON, 2001). The circumstances where soil exposure to COPCs from the LO-58 Site may occur include direct contact with soils containing VOCs and incidental ingestion of soils containing VOCs.

6.1.2 Groundwater Exposure

Groundwater beneath the LO-58 Site has been documented to contain VOCs related to fuel and chlorinated solvents. However, no fuel-related COPCs have been detected above the applicable MEDEP MEGs in bulk drinking water samples collected from on-site drinking water or groundwater samples collected from on-site monitoring wells, although groundwater data from individual fractures within drinking water wells DW-1 and DW-2 indicate the presence of GRO and/or DRO above MEDEP MEGs. Petroleum hydrocarbons in the DRO-range and the chlorinated solvent TCE have been detected above the applicable Maine MEGs in bulk drinking water samples collected from on-site drinking water well DW-1. The POE treatment at well DW-1 serves to mitigate potential exposure to contaminated groundwater, and available analytical results for well DW-2 indicate groundwater COPCs are well within acceptable limits (WESTON, 2001).

6.1.3 Sediment/Surface Water Exposure

No known samples of sediment or surface water downstream of the LO-58 Site have been collected to date. The distance to the nearest sediment/surface water is approximately 0.18 mile to the northeast, in the floodplain of Hardwood Brook, although surface water runoff from the western portion of the LO-58 Site flows northward approximately 0.5 mile along a natural valley toward Hardwood Brook. Available groundwater flow data indicates that groundwater from eastern and central portions of the LO-58 Site flow north-northwestward toward Hardwood Brook, and groundwater beneath the western portion of the LO-58 Site flows northwestward toward Hardwood Brook. Groundwater analytical results indicate that groundwater beneath the western portion of the LO-58 Site contains detectable concentrations of COPCs. There has been no investigation of the possibility that this groundwater may discharge to surface water between the LO-58 Site and Hardwood Brook; the natural valley north of the LO-58 Site, between the VFW Building and the AMAC Building, is the likely location where such groundwater discharge may occur. Based on the available data, it cannot be determined whether the nearest sediment and/or surface water are subject to impact from the LO-58 Site.

6.1.4 Air Exposure

The COPCs attributable to releases from the LO-58 Site are volatile. As such, both VOCs associated with fuel and chlorinated solvents associated with missile maintenance are subject to volatilization and may, under certain circumstances, become an inhalation hazard. The circumstances where air exposure to COPCs from the LO-58 Site may occur are:

- Volatilization to air from soils containing VOCs.
- Volatilization to air from groundwater containing VOCs, either through the vadose zone or from groundwater pumped from the subsurface (i.e., use of groundwater for showering).
- Volatilization to air from sediments/surface water containing VOCs.

Soil vapor data collected in 1999 confirms that VOCs are present in the impacted soil at the LO-58 Site. Therefore, volatilization to air from soils containing VOCs is considered a potential exposure pathway. The concentrations of TCE in groundwater in well DW-1 at the LO-58 Site meet the three MEDEP screening criteria for potential vapor intrusion and are above EPA screening concentrations for possible vapor intrusion impacts. Therefore, air exposure via volatilization from groundwater is considered to be a potential exposure pathway. Sediment/surface water exposure is considered to be a potential exposure pathway due to lack of data which document a release to this media. Therefore, air exposure via volatilization from sediment/surface water is also considered to be a potential exposure pathway.

6.1.5 Biotic Exposure

The biotic medium is important when considering the potential for transfer of contaminants through the food chain. Additionally, bioaccumulation and bioconcentration of some contaminants in plants or animals can result in exposure of other receptors to harmful contaminant concentrations. The COPCs attributable to the LO-58 Site are VOCs which have relatively low bioaccumulation potential. Further, the existing and foreseeable future land use at the LO-58 Site does not include hunting, fishing, gardening, or the collection of any biota for human consumption. Thus, current or reasonably foreseeable uses of the LO-58 Site do not suggest that biotic exposure is a complete exposure pathway.

6.2 RECOMMENDATIONS

WESTON has the following recommendations for additional activities at the LO-58 Site in response to the conclusions of this CSM Report. The proposed sample locations are included on Figure 6-1.

6.2.1 Additional Soil Investigation

In order for the LO-58 Site to comply with MEDEP regulations, the current nature and extent of MEDEP cleanup level exceedances DRO should be determined. WESTON recommends the collection of replicate soil samples from previous sample locations SB-13and SB-55, for laboratory analysis for EPH by MassDEP Method for the Determination of EPH. The proposed locations and depth intervals for these samples are depicted in Figure 6-1. If the soil analytical results indicate that the soil meets MEDEP cleanup levels, the results can be used to support a conclusion that natural attenuation has reduced concentrations of COPCs in soil, and that no further soil remedial investigations are necessary at the LO-58 Site. If one or more of the samples indicate that the soil still exceeds MEDEP cleanup levels, additional soil samples should be collected to determine the extent of soil impacts greater than their MEDEP cleanup levels. The soil samples should be collected in an iterative fashion, utilizing field headspace screening to initially delineate the extent of impacts, reserving laboratory analysis for confirmatory results. The number of samples required will be determined by the availability of pre-existing results and the relationship between sample locations where soil still exceeds MEDEP cleanup levels. As noted in Subsection 5.1.1, this is considered a relatively important data gap, and further investigation would require relatively inexpensive, targeted soil sampling. For these reasons, this additional soil investigation is considered to have a relatively high cost-benefit and should be considered to be a high priority.

In order to address the lack of soil PCB data in the vicinity of the AMAC Building, WESTON proposes that five shallow (0 to 2 ft) soil samples (SS-01 through SS-05) be collected and analyzed for PCBs. The proposed locations for these samples are depicted in Figure 6-1. As noted in Subsection 5.1.1, this is considered a relatively unimportant data gap, but further investigation would require relatively inexpensive, targeted soil sampling. For these reasons, this additional soil investigation is considered to have a moderate cost-benefit and should be considered to be a medium priority.

6.2.2 Additional Groundwater Investigation

In order to determine whether potentially-contaminated groundwater from Site LO-58 have impacted the nearest off-site drinking water well, WESTON recommends that a drinking water sample be collected from this well, and analyzed for VOCs (TCE and its breakdown products) and EPH. As noted in Subsection 5.1.2, this data gap is considered of limited importance, but further investigation would require relatively inexpensive, drinking water sampling. For these reasons, this additional groundwater investigation is considered to have a relatively high cost-benefit and should be considered to be a high priority.

In order to determine whether nitric acid or dimethylhydrazine may have been released at Site LO-58, WESTON recommends adding nitrate/nitrite and dimethylhydrazine analyses to future long-term groundwater monitoring rounds. The Site LO-58 wells to be sampled would include monitoring wells MW-03 and MW-05, and drinking water wells DW-1 and DW-2, prior to their POC treatment.

6.2.3 Additional Sediment/Surface Water Investigation

In order to determine whether potentially-contaminated groundwater may discharge to surface water between the LO-58 Site and Hardwood Brook, WESTON recommends the installation of an overburden monitoring well (MW-08) located within the valley northeast of the VFW Building. The natural valley between the VFW Building and the AMAC Building is the most likely place for this discharge at the LO-58 Site. The proposed location for this well is depicted in Figure 6-1.

In order to assess potential surface water and sediment impacts related to the LO-58 Site, WESTON recommends the collection of a limited number of surface water and sediment samples. An estimated six surface water and/or sediment samples (SW-01 through SW-03 and SD-01 through SD-03, respectively), collected in the late summer when regional precipitation is at its annual low and groundwater discharge to surface water is greatest, from the nearest identified surface water and wetland soil locations northwest of the LO-58 Site. Figure 6-2 depicts the proposed locations of these samples. Note that the actual sample locations will be selected based on field reconnaissance, and the locations depicted on Figure 6-2 are subject to change. As noted in Subsection 5.3.1, this is considered a relatively important data gap, and further investigation would require a relatively inexpensive overburden monitoring well installation. For these reasons, this additional groundwater investigation is considered to have a relatively high cost-benefit and should be considered to be a high priority.

6.2.4 Additional Air Investigation

In order to determine whether potentially-contaminated groundwater may result in air impacts in the vicinity of the AMAC Building, WESTON recommends the collection of two sub slab soil vapor samples and one indoor air sample from the AMAC Building. As noted in

Subsection 5.4.1, this is considered a relatively important data gap, and further investigation would require a relatively inexpensive soil vapor sample collection. For these reasons, this additional soil vapor investigation is considered to have a relatively high cost-benefit and should be considered to be a high priority.

6.2.5 Further Actions

The additional data proposed for collection above will be combined with the available data to create a more complete dataset. These data should be applied to update the CSM which will include recommendations regarding the need for further actions at the LO-58 Site.

In order to determine the need for further remedial actions at the LO-58 Site, the available soil data will be compared to applicable MEDEP cleanup levels which typically results in a conservative evaluation. If the soil data fail the MEDEP cleanup level screening, WESTON recommends that a risk assessor evaluate the data regarding the likelihood that a less conservative human health risk assessment (HHRA) and an ecological risk assessment (ERA) would come to a different conclusion. Upon a favorable evaluation from the risk assessor, an HHRA and/or ERA should be performed in order to accurately assess the potential risk associated with the LO-58 Site.

SECTION 7

REFERENCES

7. REFERENCES

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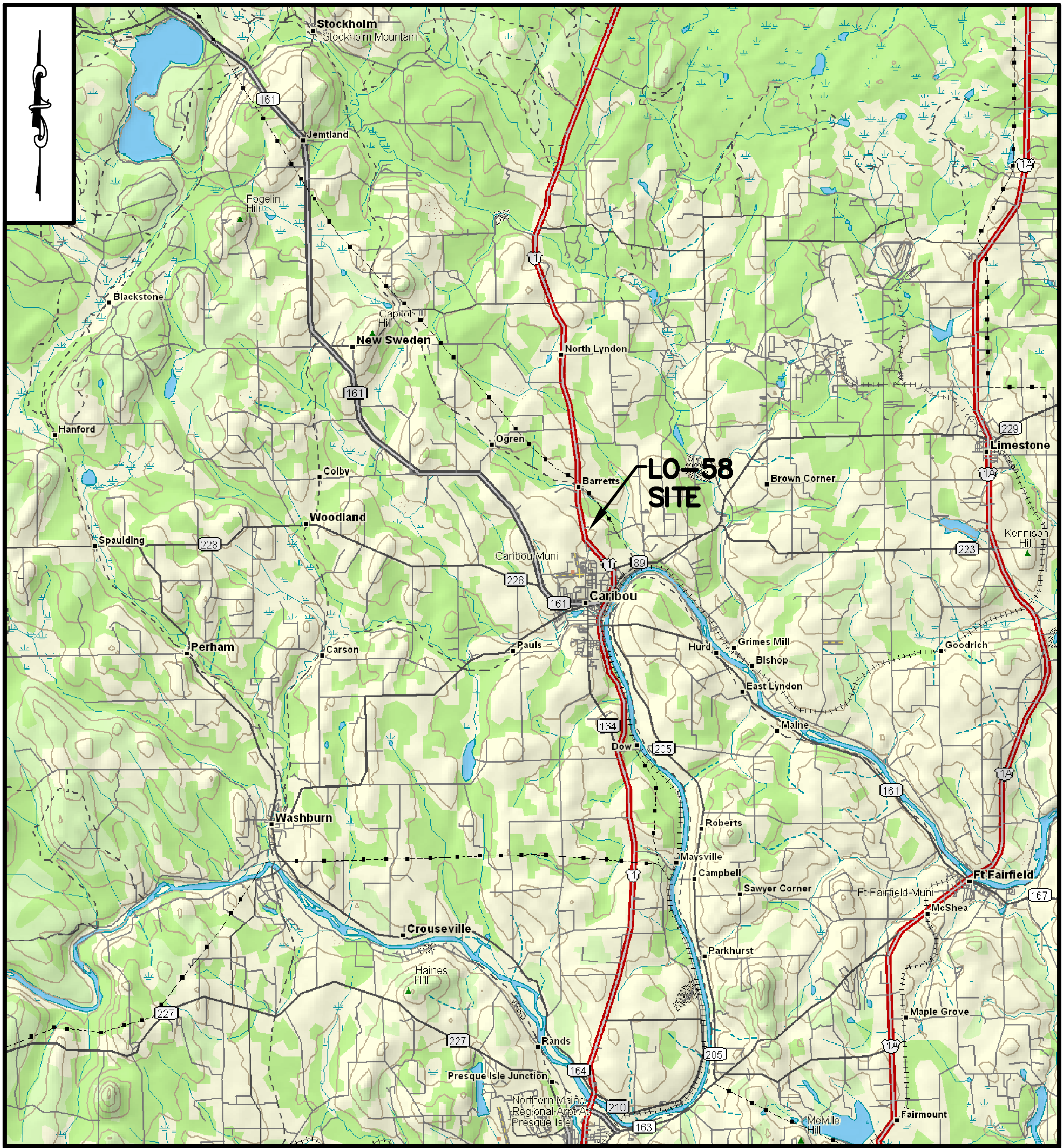
FIGURES



SOURCE
US DEPT. OF THE INTERIOR, GEOLOGICAL SURVEY
7.5x7.5 MINUTE SERIES (TOPOGRAPHIC)
1:24,000 CARIBOU, MAINE (1984)

GRAPHIC SCALE
3 1.5 0 1.5 3
APPROXIMATE SCALE IN MILES

CONCEPTUAL SITE
MODEL REPORT
LO–58 SITE
CARIBOU, MAINE

WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

SITE LOCATION MAP

DRAWN AJM	DATE MAY 2009	DES. ENG.	DATE	W.O. NO. 03886.184.001
CHECKED JS	DATE MAY 2009	SCALE AS SHOWN	REVISION	FIGURE NO. 1–1

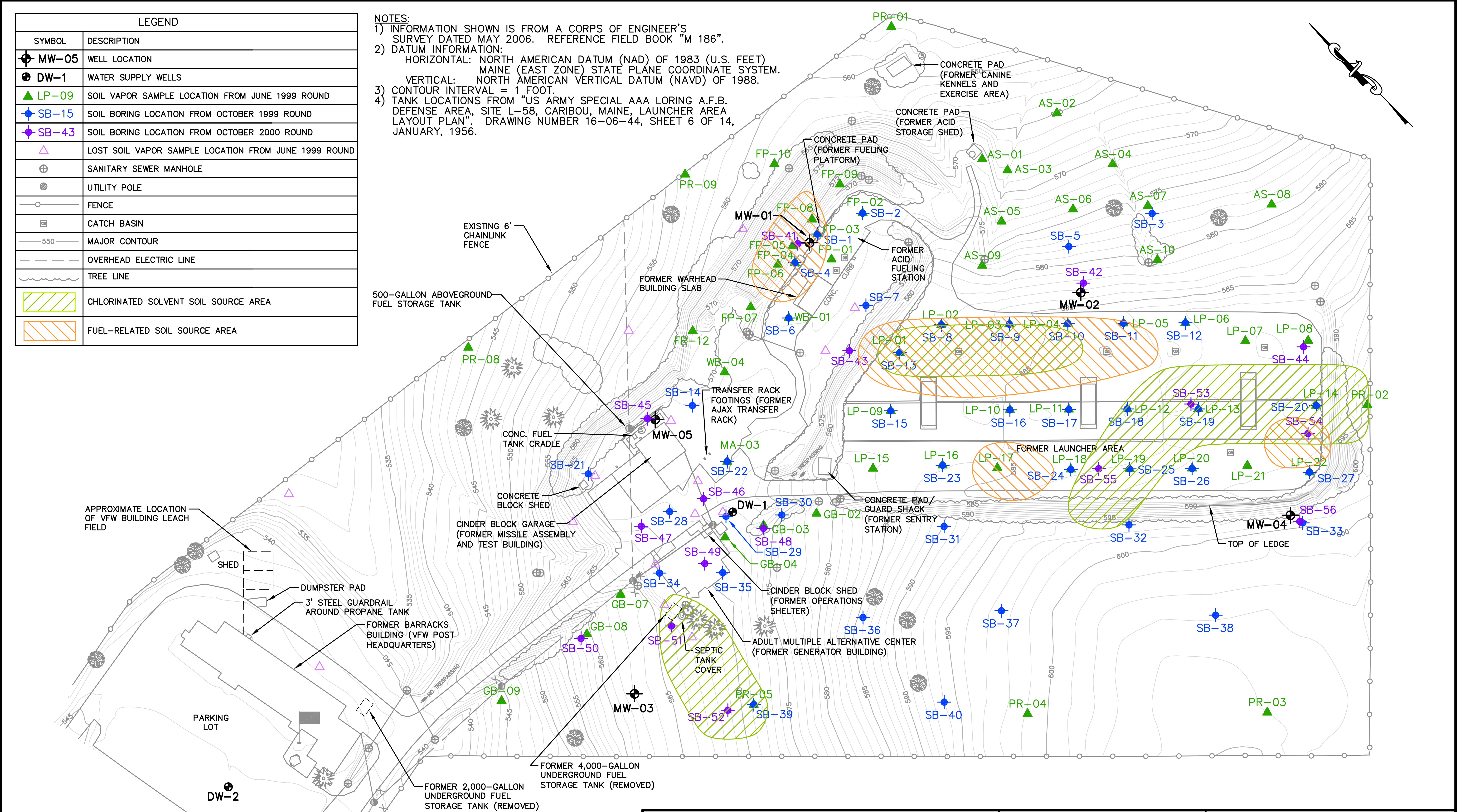
M:\Design\DWG\ACOE\MEFUDS\5FUDS\LO–58 2009\CSM 2009\FIG 1–1.dwg, Layout1, 5/5/2009 1:31:06 PM, GIRARDEB, 1:1

M:\Design\DWG\ACOE\MEFUDS\5FUDS\2009\LO-58 2009\CSM 2009\FIG 2-1.dwg, Layout1, 2/24/2011 3:10:40 PM, GIRARDEB, 1:1

LEGEND

SYMBOL	DESCRIPTION
⌖ MW-05	WELL LOCATION
● DW-1	WATER SUPPLY WELLS
▲ LP-09	SOIL VAPOR SAMPLE LOCATION FROM JUNE 1999 ROUND
✦ SB-15	SOIL BORING LOCATION FROM OCTOBER 1999 ROUND
✦ SB-43	SOIL BORING LOCATION FROM OCTOBER 2000 ROUND
△	LOST SOIL VAPOR SAMPLE LOCATION FROM JUNE 1999 ROUND
⊕	SANITARY SEWER MANHOLE
●	UTILITY POLE
—○—	FENCE
▣	CATCH BASIN
550	MAJOR CONTOUR
— — —	OVERHEAD ELECTRIC LINE
︵︵︵	TREE LINE
🟩	CHLORINATED SOLVENT SOIL SOURCE AREA
🟧	FUEL-RELATED SOIL SOURCE AREA

NOTES:
1) INFORMATION SHOWN IS FROM A CORPS OF ENGINEER'S SURVEY DATED MAY 2006. REFERENCE FIELD BOOK "M 186".
2) DATUM INFORMATION:
HORIZONTAL: NORTH AMERICAN DATUM (NAD) OF 1983 (U.S. FEET) MAINE (EAST ZONE) STATE PLANE COORDINATE SYSTEM.
VERTICAL: NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988.
3) CONTOUR INTERVAL = 1 FOOT.
4) TANK LOCATIONS FROM "US ARMY SPECIAL AAA LORING A.F.B. DEFENSE AREA, SITE L-58, CARIBOU, MAINE, LAUNCHER AREA LAYOUT PLAN". DRAWING NUMBER 16-06-44, SHEET 6 OF 14, JANUARY, 1956.



GRAPHIC SCALE
100 50 0 50 100
APPROXIMATE SCALE IN FEET

CONCEPTUAL SITE MODEL REPORT
LO-58 SITE
CARIBOU, MAINE

WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
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CONCORD, MASSACHUSETTS

SITE PLAN WITH HISTORIC SAMPLE LOCATIONS

DRAWN	DATE	DES. ENG.	DATE	W.O. NO.
BEG	MAY 2009	JS	MAY 2009	03886.184.001
CHECKED	DATE	SCALE	REVISION	FIGURE NO.
JS	MAY 2009	AS SHOWN		2-1

LEGEND

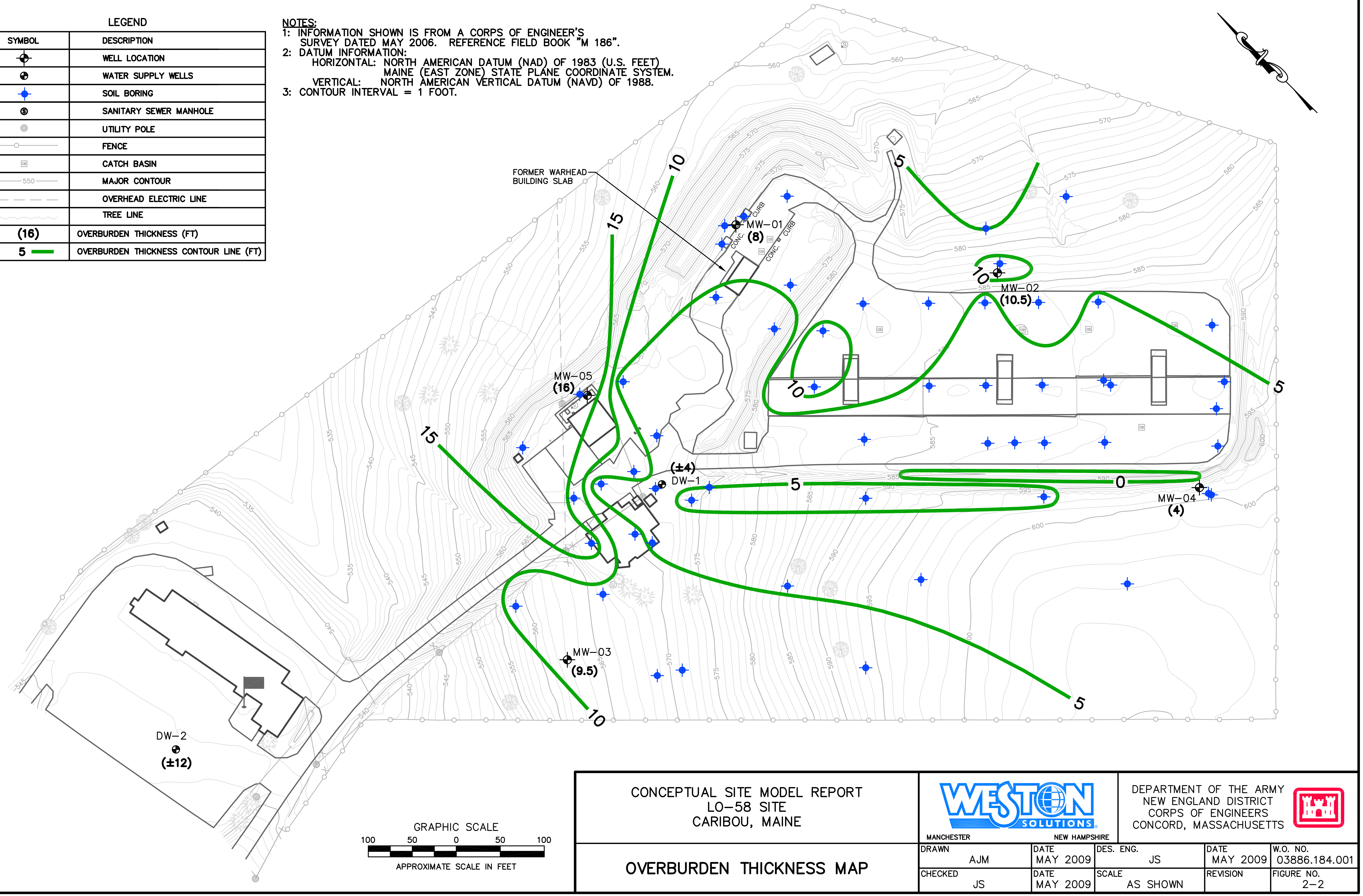
SYMBOL	DESCRIPTION
⌖	WELL LOCATION
●	WATER SUPPLY WELLS
✦	SOIL BORING
Ⓢ	SANITARY SEWER MANHOLE
◎	UTILITY POLE
——o——	FENCE
▣	CATCH BASIN
——550——	MAJOR CONTOUR
— — — —	OVERHEAD ELECTRIC LINE
～～～	TREE LINE
(16)	OVERBURDEN THICKNESS (FT)
5 ▬	OVERBURDEN THICKNESS CONTOUR LINE (FT)

NOTES:

1: INFORMATION SHOWN IS FROM A CORPS OF ENGINEER'S SURVEY DATED MAY 2006. REFERENCE FIELD BOOK "M 186".

2: DATUM INFORMATION:
HORIZONTAL: NORTH AMERICAN DATUM (NAD) OF 1983 (U.S. FEET) MAINE (EAST ZONE) STATE PLANE COORDINATE SYSTEM.
VERTICAL: NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988.

3: CONTOUR INTERVAL = 1 FOOT.



CONCEPTUAL SITE MODEL REPORT
LO-58 SITE
CARIBOU, MAINE

OVERBURDEN THICKNESS MAP

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DRAWN	DATE	DES. ENG.	DATE	W.O. NO.
AJM	MAY 2009	JS	MAY 2009	03886.184.001
CHECKED	DATE	SCALE	REVISION	FIGURE NO.
JS	MAY 2009	AS SHOWN		2-2

SYMBOL	DESCRIPTION
⊕	WELL LOCATION
◕	WATER SUPPLY WELLS
✚	SOIL BORING
Ⓢ	SANITARY SEWER MANHOLE
●	UTILITY POLE
—○—	FENCE
▣	CATCH BASIN
—550—	MAJOR CONTOUR
— — — —	OVERHEAD ELECTRIC LINE
〰	TREE LINE
(560.9)	BEDROCK ELEVATION (FT AMSL)
560 ▬	BEDROCK ELEVATION CONTOUR LINE (FT AMSL)

NOTES:
1: INFORMATION SHOWN IS FROM A CORPS OF ENGINEER'S SURVEY DATED MAY 2006. REFERENCE FIELD BOOK "M 186".
2: DATUM INFORMATION:
HORIZONTAL: NORTH AMERICAN DATUM (NAD) OF 1983 (U.S. FEET) MAINE (EAST ZONE) STATE PLANE COORDINATE SYSTEM.
VERTICAL: NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988.
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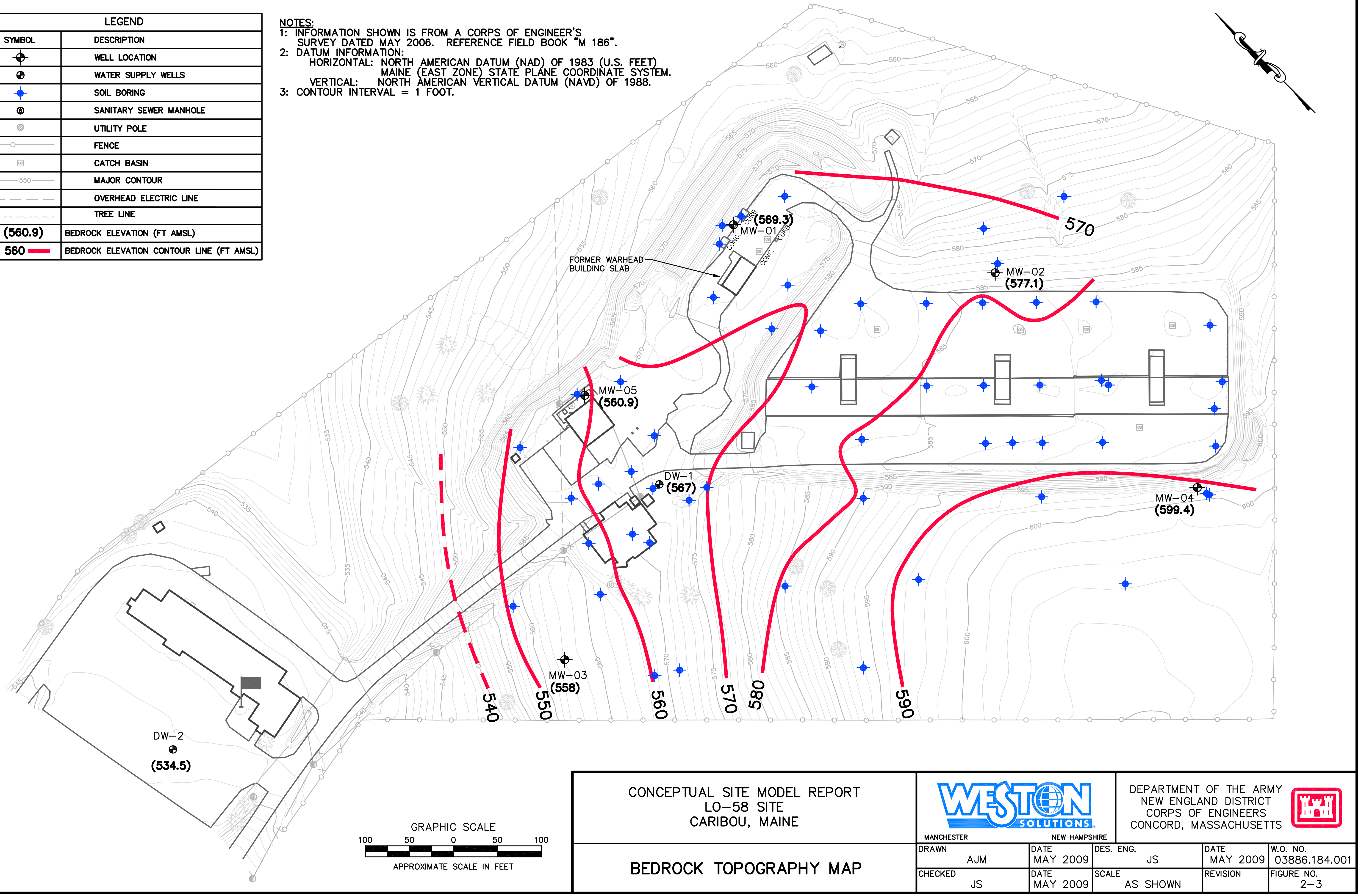

CONCEPTUAL SITE MODEL REPORT
LO-58 SITE
CARIBOU, MAINE

MANCHESTER NEW HAMPSHIRE

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

BEDROCK TOPOGRAPHY MAP

DRAWN	DATE	DES. ENG.	DATE	W.O. NO.
AJM	MAY 2009	JS	MAY 2009	03886.184.001
CHECKED	DATE	SCALE	REVISION	FIGURE NO.
JS	MAY 2009	AS SHOWN		2-3

LEGEND

- Ss SPRAGUEVILLE FORMATION
- SOcmu CARYS MILLS FORMATION (UPPER MEMBER)
- SOcml CARYS MILLS FORMATION (LOWER MEMBER)

SOURCE
GEOLOGIC MAP OF THE CARIBOU AND NORTHERN PRESQUE ISLE QUADRANGLES, MAINE. MAINE GEOLOGIC SURVEY, DEPARTMENT OF CONSERVATION, OPEN–FILE NUMBER 87–2. 1985.

GRAPHIC SCALE
5000 2500 0 2500 5000
APPROXIMATE SCALE IN FEET

CONCEPTUAL SITE
MODEL REPORT
LO–58 SITE
CARIBOU, MAINE

WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
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CONCORD, MASSACHUSETTS

BEDROCK GEOLOGIC MAP	DRAWN AJM	DATE MAY 2009	DES. ENG.	DATE	W.O. NO. 03886.184.001
	CHECKED JS	DATE MAY 2009	SCALE AS SHOWN	REVISION	FIGURE NO. 2-4

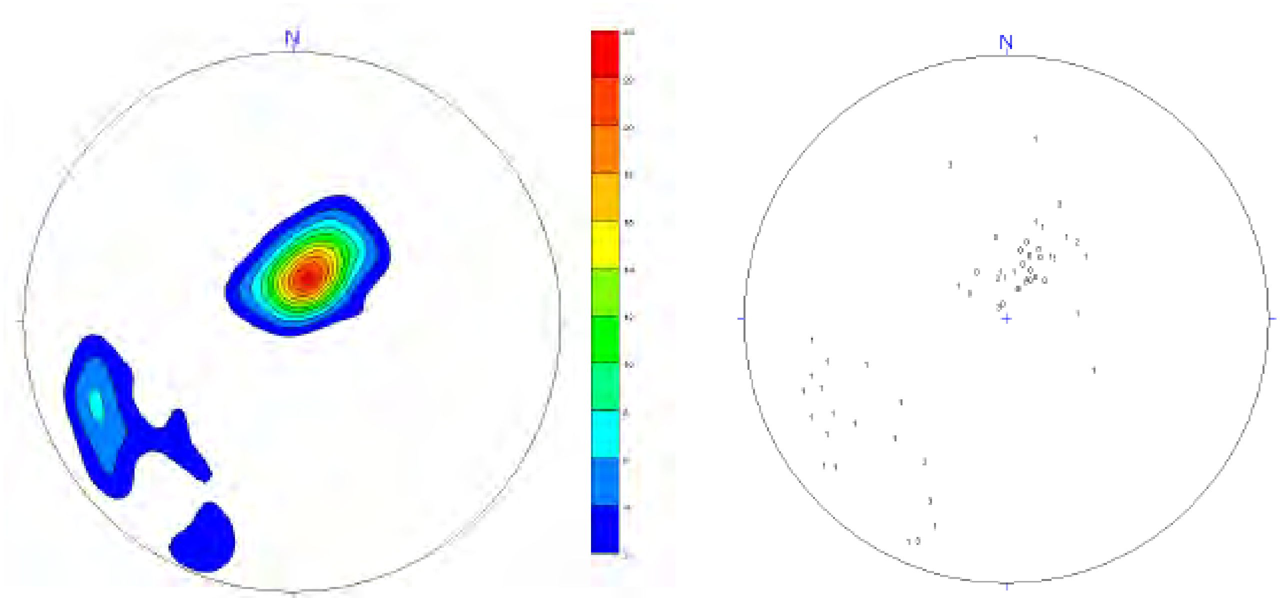
M:\Design\DWG\ACOE\MEFUDS\5FUDS\2009\LO–58 2009\CSM 2009\FIG 2–5.dwg, Layout1, 5/14/2009 10:40:03 AM, GIRARDEB, 1:1

Figure 2-5
LO-58 Site Stereonets of Bedding and Joints/Faults
Conceptual Site Model Report

Drinking Water Well DW-1

Schmidt Projection with Contours

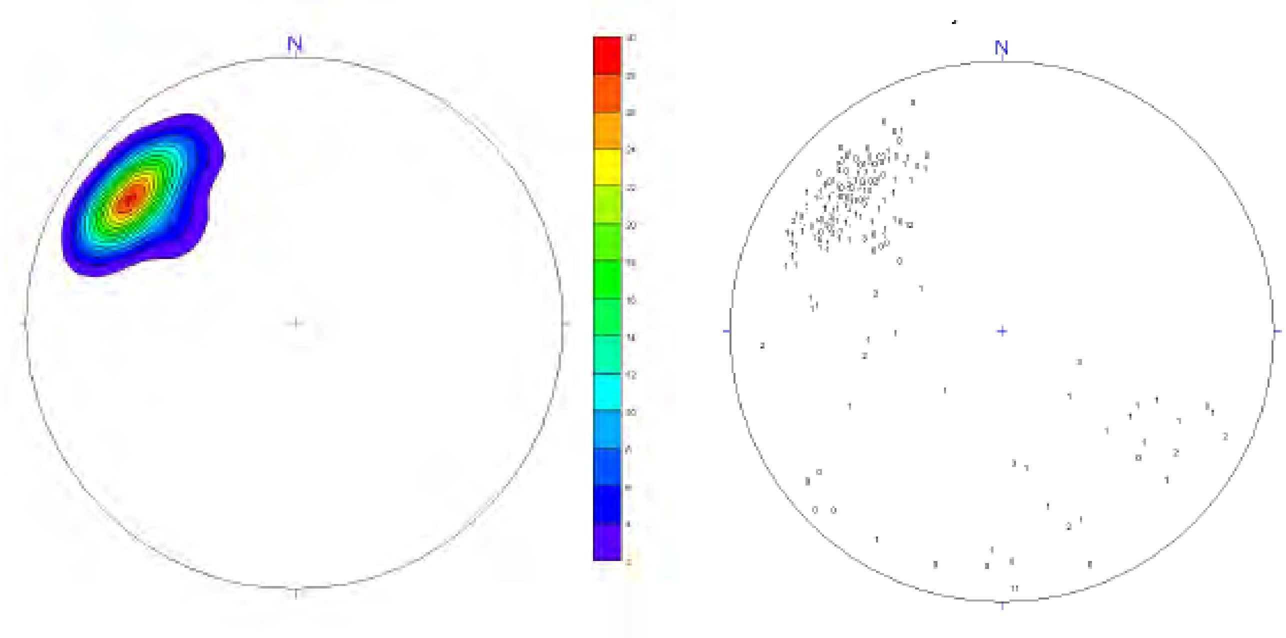
Schmidt Projection with Feature Ranks



Drinking Water Well DW-2

Schmidt Projection with Contours

Schmidt Projection with Feature Ranks



From *HydroPhysics*^{TM} *and Geophysical Logging Results*, 2009.

LEGEND

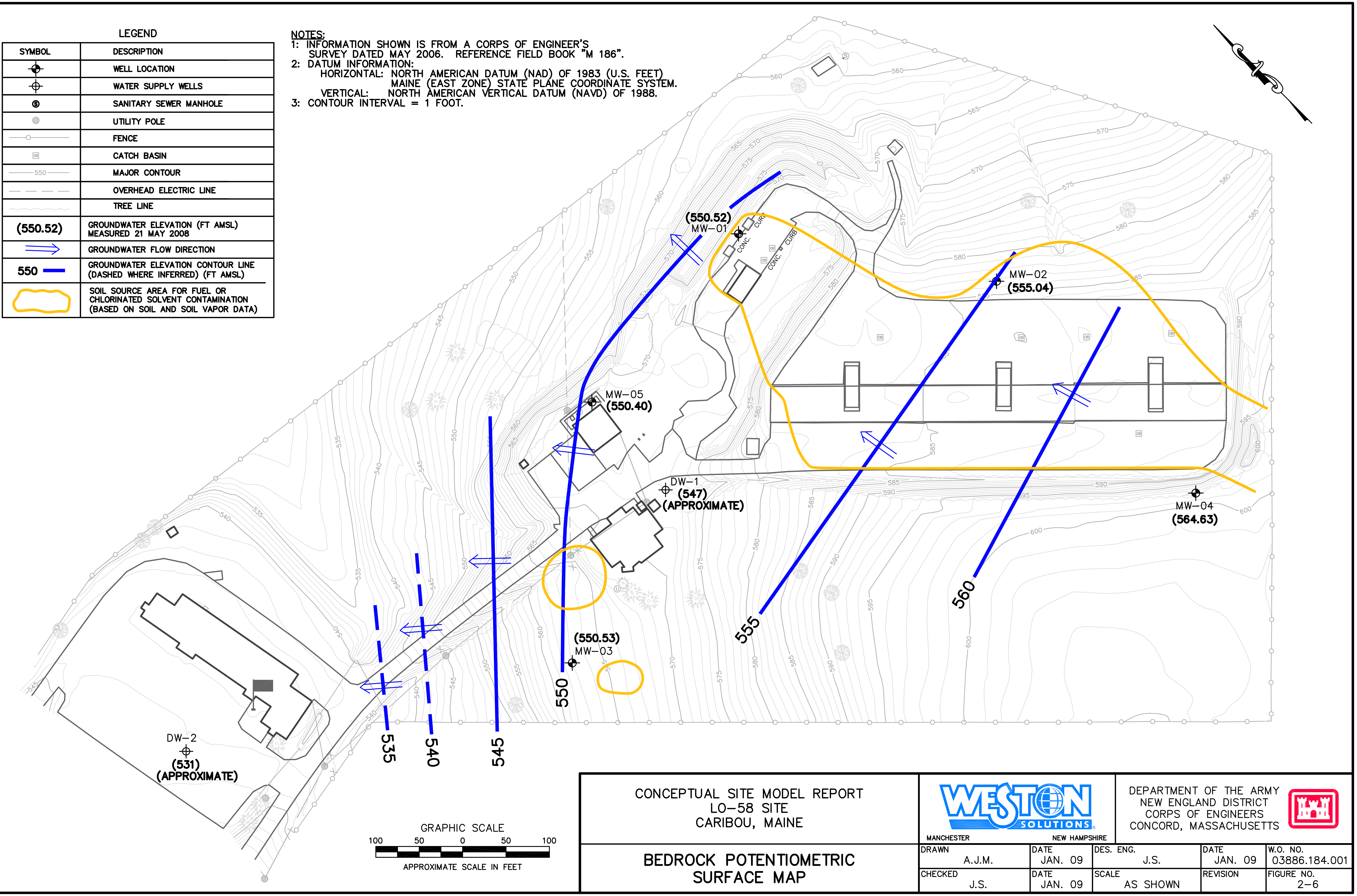
SYMBOL	DESCRIPTION
⊕	WELL LOCATION
⌖	WATER SUPPLY WELLS
Ⓢ	SANITARY SEWER MANHOLE
●	UTILITY POLE
—○—	FENCE
▫	CATCH BASIN
—550—	MAJOR CONTOUR
— — — —	OVERHEAD ELECTRIC LINE
～～～	TREE LINE
(550.52)	GROUNDWATER ELEVATION (FT AMSL) MEASURED 21 MAY 2008
⇒	GROUNDWATER FLOW DIRECTION
550 ━	GROUNDWATER ELEVATION CONTOUR LINE (DASHED WHERE INFERRED) (FT AMSL)
◯	SOIL SOURCE AREA FOR FUEL OR CHLORINATED SOLVENT CONTAMINATION (BASED ON SOIL AND SOIL VAPOR DATA)

NOTES:

1: INFORMATION SHOWN IS FROM A CORPS OF ENGINEER'S SURVEY DATED MAY 2006. REFERENCE FIELD BOOK "M 186".

2: DATUM INFORMATION:
HORIZONTAL: NORTH AMERICAN DATUM (NAD) OF 1983 (U.S. FEET) MAINE (EAST ZONE) STATE PLANE COORDINATE SYSTEM.
VERTICAL: NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988.

3: CONTOUR INTERVAL = 1 FOOT.



CONCEPTUAL SITE MODEL REPORT
LO-58 SITE
CARIBOU, MAINE

BEDROCK POTENTIOMETRIC
SURFACE MAP

WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

DRAWN A.J.M.	DATE JAN. 09	DES. ENG. J.S.	DATE JAN. 09	W.O. NO. 03886.184.001
CHECKED J.S.	DATE JAN. 09	SCALE AS SHOWN	REVISION	FIGURE NO. 2-6

M:\Design\DWG\ACOE\MEFUDS\FUDS\2009\LO-58 2009\CSM 2009\FIG 2-6.dwg, Layout1, 7/1/2010 3:06:21 PM, GIRARDEB, 1:1

Figure 2-7

Concentration Trends in Analytical Results for Well DW-1
Maine Formerly Used Defense Site LO-58
Conceptual Site Model Report

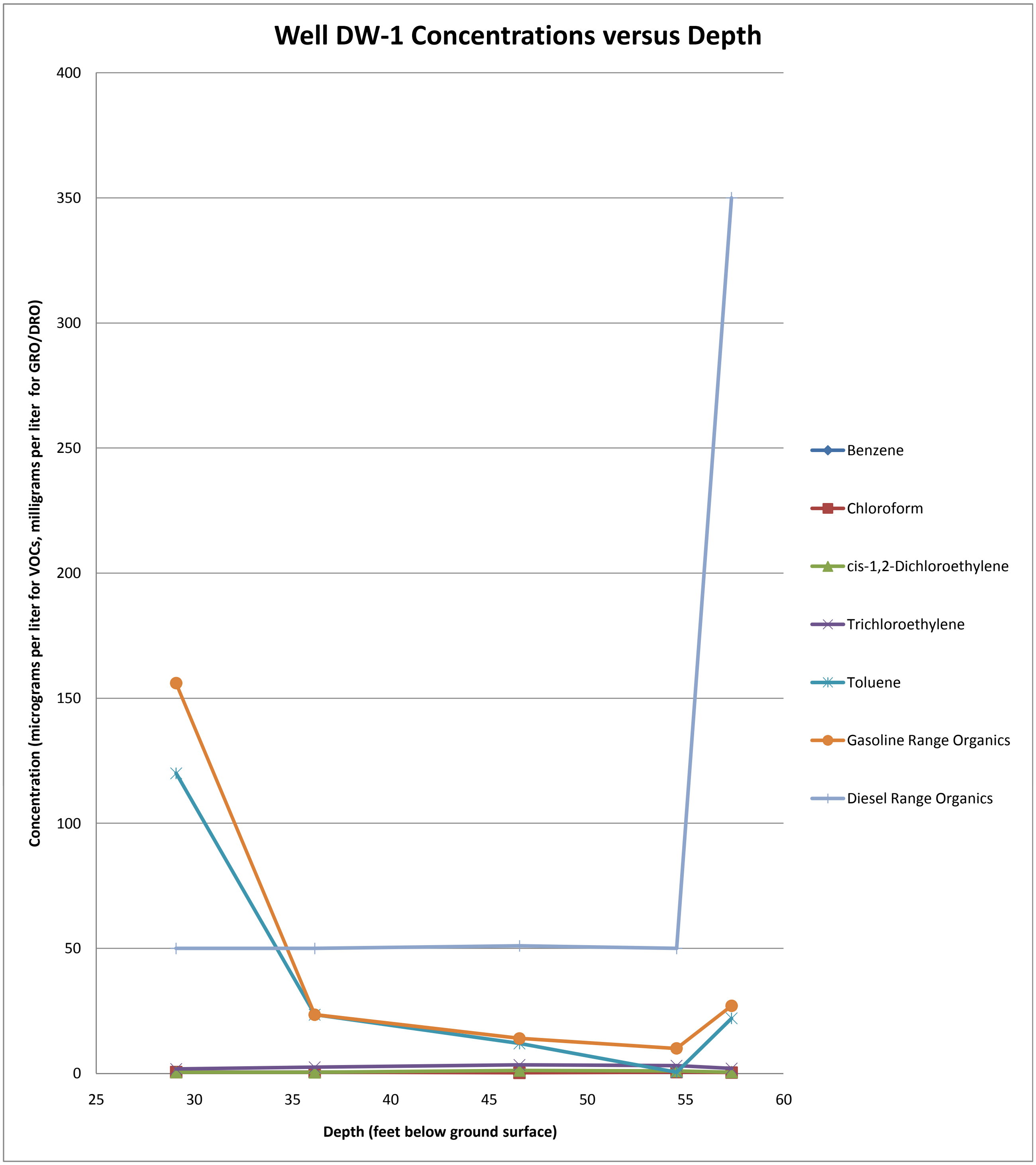


Figure 2-8

Degradation Rate for Chlorinated Solvents for Well DW-1
Maine Formerly Used Defense Site LO-58
Conceptual Site Model Report

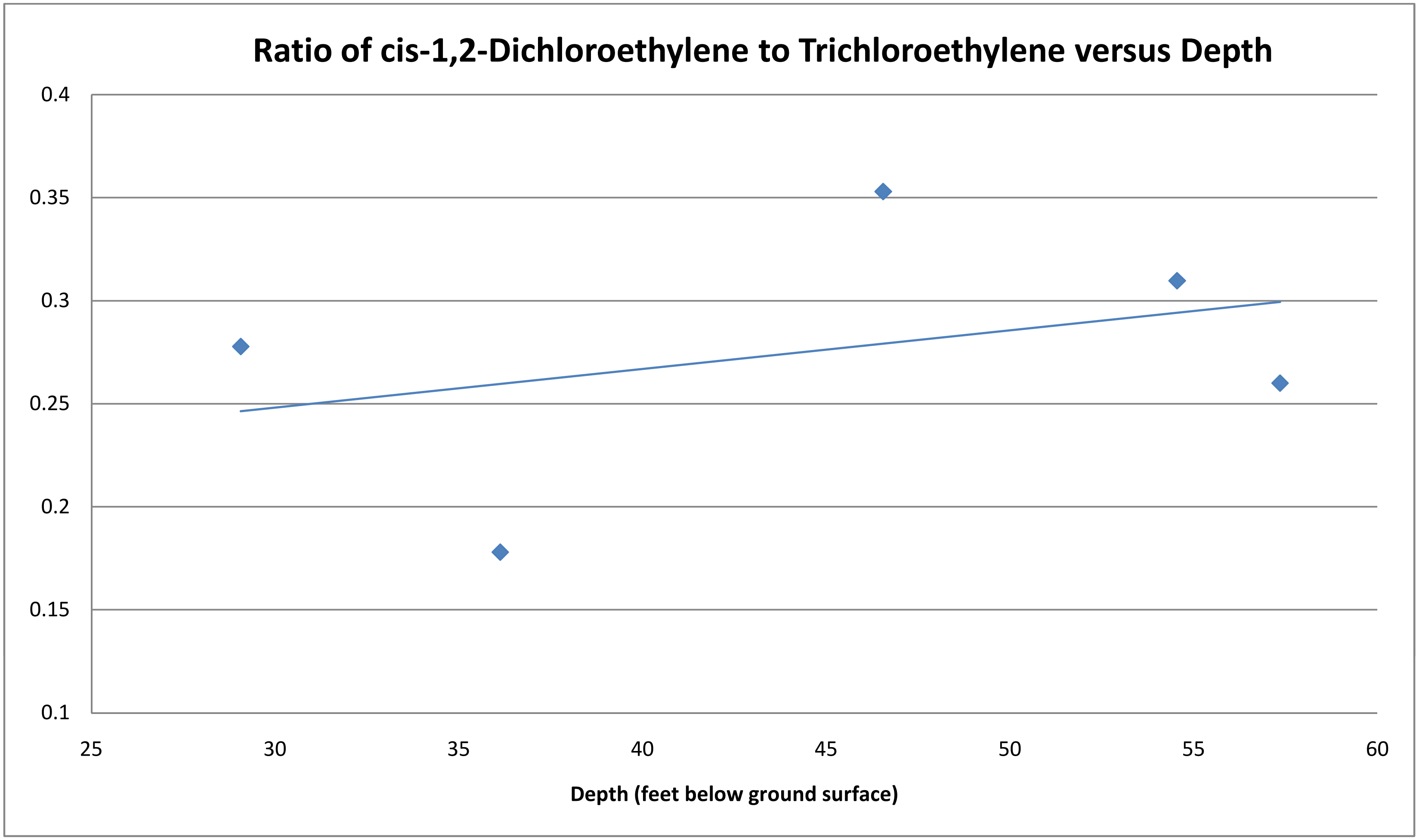
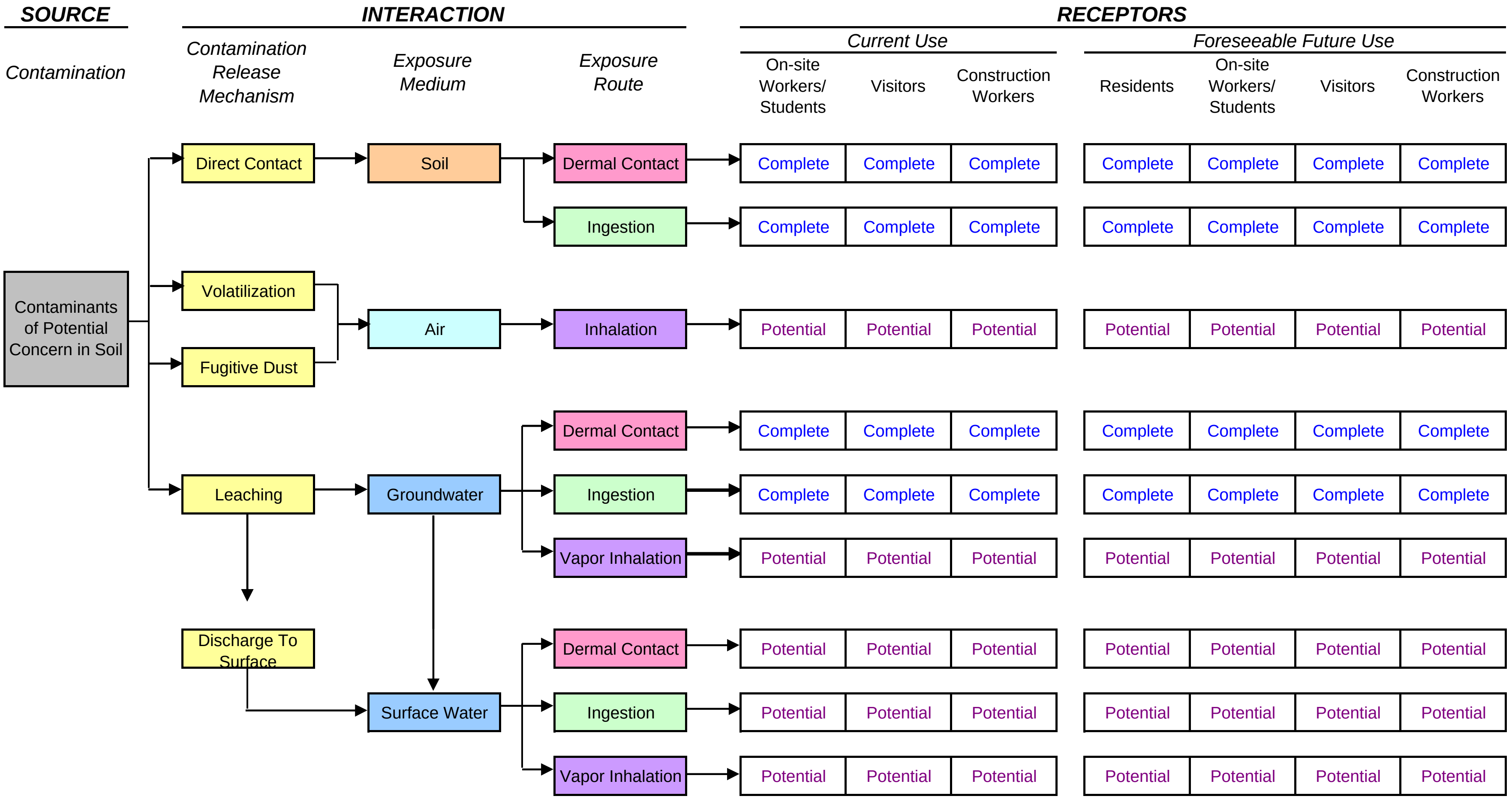


Figure 4-1

Graphic Representation of Conceptual Site Model

LO-58 Site, Caribou, Maine



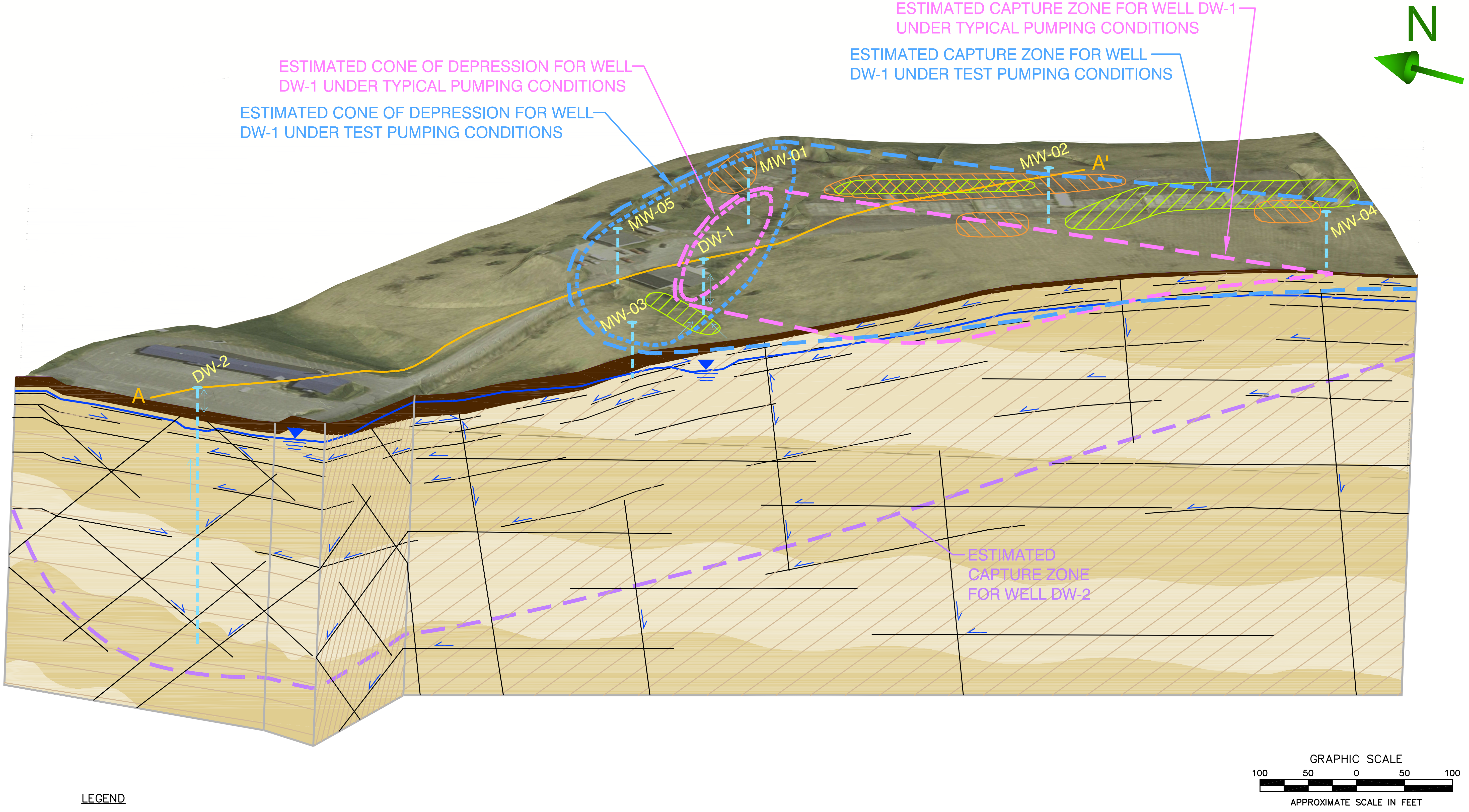
				Current Use			Foreseeable Future Use			
Contamination	Contamination Release Mechanism	Exposure Medium	Exposure Route	On-site Workers/ Students	Visitors	Construction Workers	Residents	On-site Workers/ Students	Visitors	Construction Workers
Contaminants of Potential Concern in Soil	Direct Contact	Soil	Dermal Contact	Complete	Complete	Complete	Complete	Complete	Complete	Complete
			Ingestion	Complete	Complete	Complete	Complete	Complete	Complete	Complete
	Volatilization Fugitive Dust	Air	Inhalation	Potential	Potential	Potential	Potential	Potential	Potential	Potential
	Leaching	Groundwater	Dermal Contact	Complete	Complete	Complete	Complete	Complete	Complete	Complete
			Ingestion	Complete	Complete	Complete	Complete	Complete	Complete	Complete
			Vapor Inhalation	Potential	Potential	Potential	Potential	Potential	Potential	Potential
	Discharge To Surface	Surface Water	Dermal Contact	Potential	Potential	Potential	Potential	Potential	Potential	Potential
			Ingestion	Potential	Potential	Potential	Potential	Potential	Potential	Potential
			Vapor Inhalation	Potential	Potential	Potential	Potential	Potential	Potential	Potential

Pathway Status

Complete: Source and/or medium contain contaminants at concentrations greater than Maine Remedial Action Guidelines or Maximum Exposure Guidelines, an actual exposure route, and available receptors.

Potential: Data regarding one or more of the items required for a complete pathway is uncertain or lacking, and data for all remaining items support a complete pathway. Pathway requires additional data collection.

Incomplete: Data regarding one or more of the items required for a complete pathway indicate that the pathway is not complete.



LEGEND

- FRACTURE WITH GROUNDWATER FLOW DIRECTION
- ▨ CHLORINATED SOLVENT SOIL SOURCE AREA
- ▨ FUEL–RELATED SOIL SOURCE AREA
- ▨ FOLIATION

NOTE:
THE FRACURES DEPICTED DO NOT RELATE TO ACTUAL FRACTURES AND ARE INTENDED TO SHOW GENERAL FRACTURE ORIENTATION.

CONCEPTUAL SITE MODEL REPORT
LO–58 SITE
CARIBOU, MAINE

WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

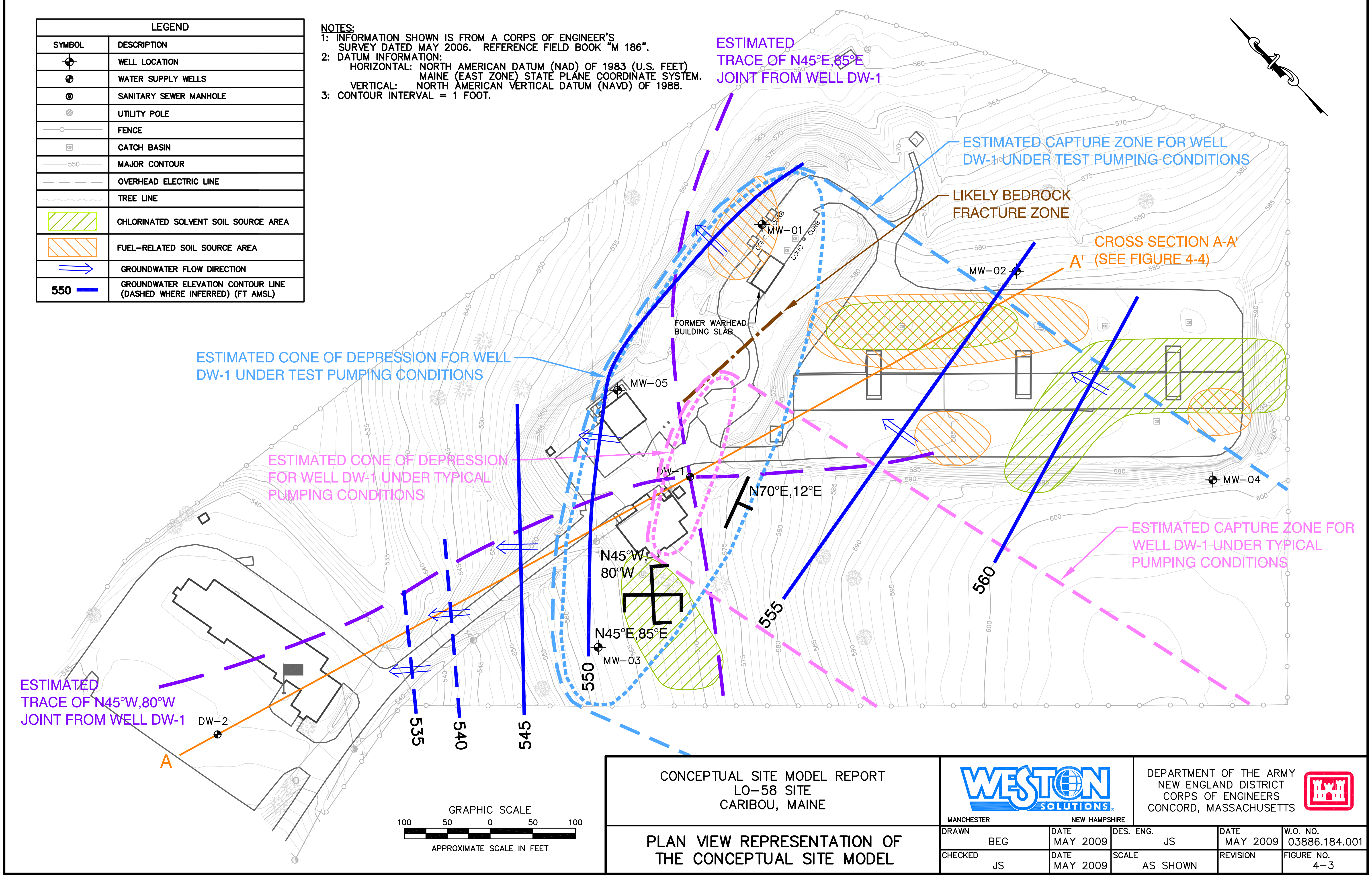
BLOCK DIAGRAM REPRESENTATION OF THE CONCEPTUAL SITE MODEL

DRAWN BEG	DATE MAY 2009	DES. ENG. JS	DATE MAY 2009	W.O. NO. 03886.184.001
CHECKED JS	DATE MAY 2009	SCALE AS SHOWN	REVISION	FIGURE NO. 4–2

M:\Design\DWG\ACOE\MEFUDS\5FUDS\2009\LO–58 2009\CSM 2009\FIG 4–2.dwg, Layout1, 2/28/2011 3:04:01 PM, GIRARDEB, 1:1

LEGEND	
SYMBOL	DESCRIPTION
⌖	WELL LOCATION
◕	WATER SUPPLY WELLS
Ⓢ	SANITARY SEWER MANHOLE
◎	UTILITY POLE
—o—	FENCE
▣	CATCH BASIN
—550—	MAJOR CONTOUR
— — —	OVERHEAD ELECTRIC LINE
﹏	TREE LINE
🟩	CHLORINATED SOLVENT SOIL SOURCE AREA
🟧	FUEL-RELATED SOIL SOURCE AREA
⇒	GROUNDWATER FLOW DIRECTION
550 —	GROUNDWATER ELEVATION CONTOUR LINE (DASHED WHERE INFERRED) (FT AMSL)

NOTES:
1: INFORMATION SHOWN IS FROM A CORPS OF ENGINEER'S SURVEY DATED MAY 2006. REFERENCE FIELD BOOK "M 186".
2: DATUM INFORMATION:
HORIZONTAL: NORTH AMERICAN DATUM (NAD) OF 1983 (U.S. FEET) MAINE (EAST ZONE) STATE PLANE COORDINATE SYSTEM.
VERTICAL: NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988.
3: CONTOUR INTERVAL = 1 FOOT.



CONCEPTUAL SITE MODEL REPORT
LO-58 SITE
CARIBOU, MAINE

WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
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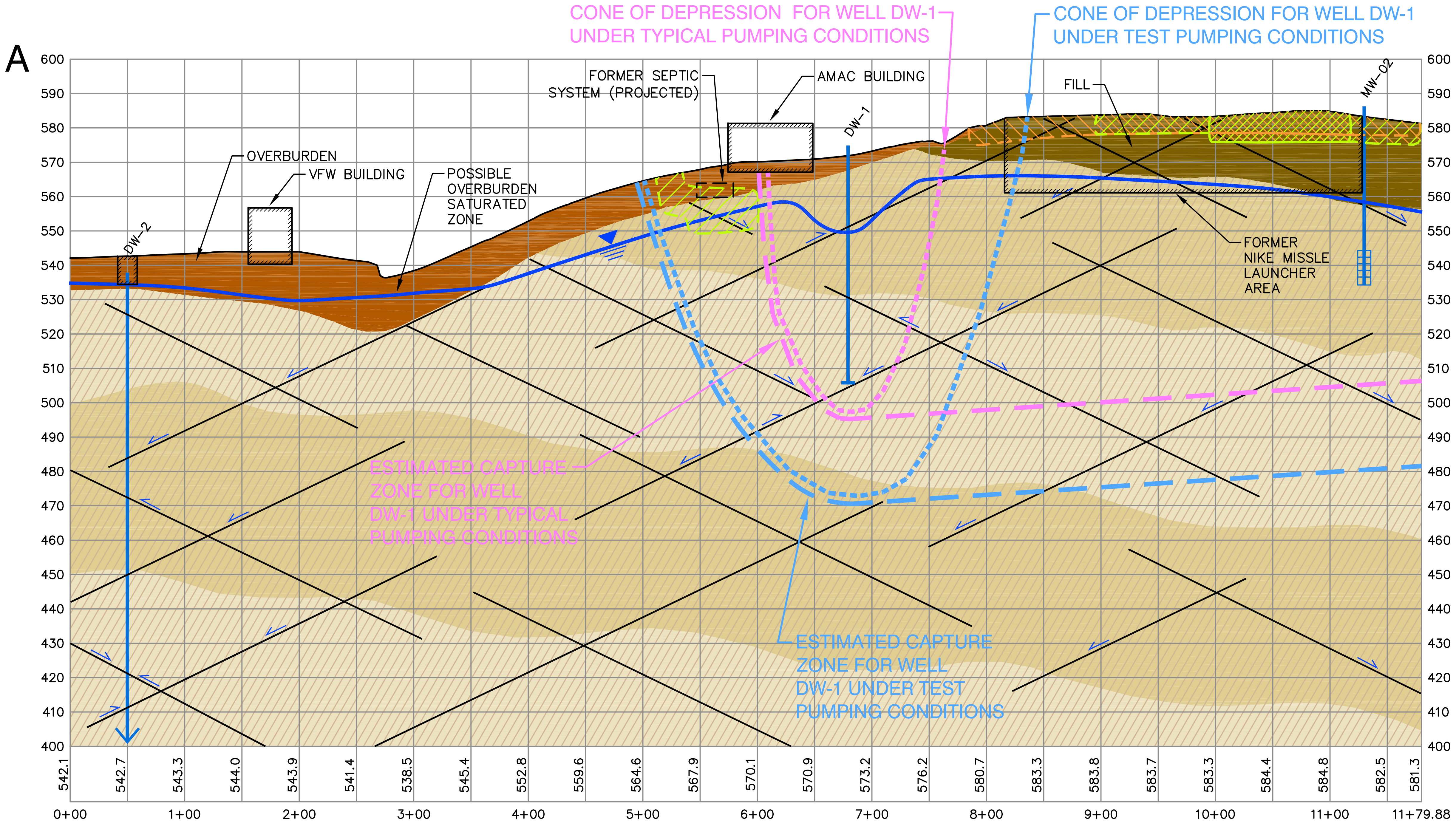
PLAN VIEW REPRESENTATION OF THE CONCEPTUAL SITE MODEL

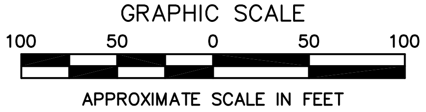
DRAWN BEG	DATE MAY 2009	DES. ENG. JS	DATE MAY 2009	W.O. NO. 03886.184.001
CHECKED JS	DATE MAY 2009	SCALE AS SHOWN	REVISION	FIGURE NO. 4-3

M:\Design\DWG\ACOE\MEFUDS\5FUDS\2009\LO-58 2009\CSM 2009\FIG 4-3.dwg, Layout1, 2/28/2011 2:56:35 PM, GIRARDEB, 1:1



LEGEND

←	FRACTURE WITH GROUNDWATER FLOW DIRECTION
🟩	CHLORINATED SOLVENT SOIL SOURCE AREA
▨	CHLORINATED SOLVENT SOIL SOURCE AREA (PROJECTED)
🟧	FUEL-RELATED SOIL SOURCE AREA
▨	FUEL-RELATED SOIL SOURCE AREA (PROJECTED)
▨	FOLIATION



CONCEPTUAL SITE MODEL REPORT
LO-58 SITE
CARIBOU, MAINE

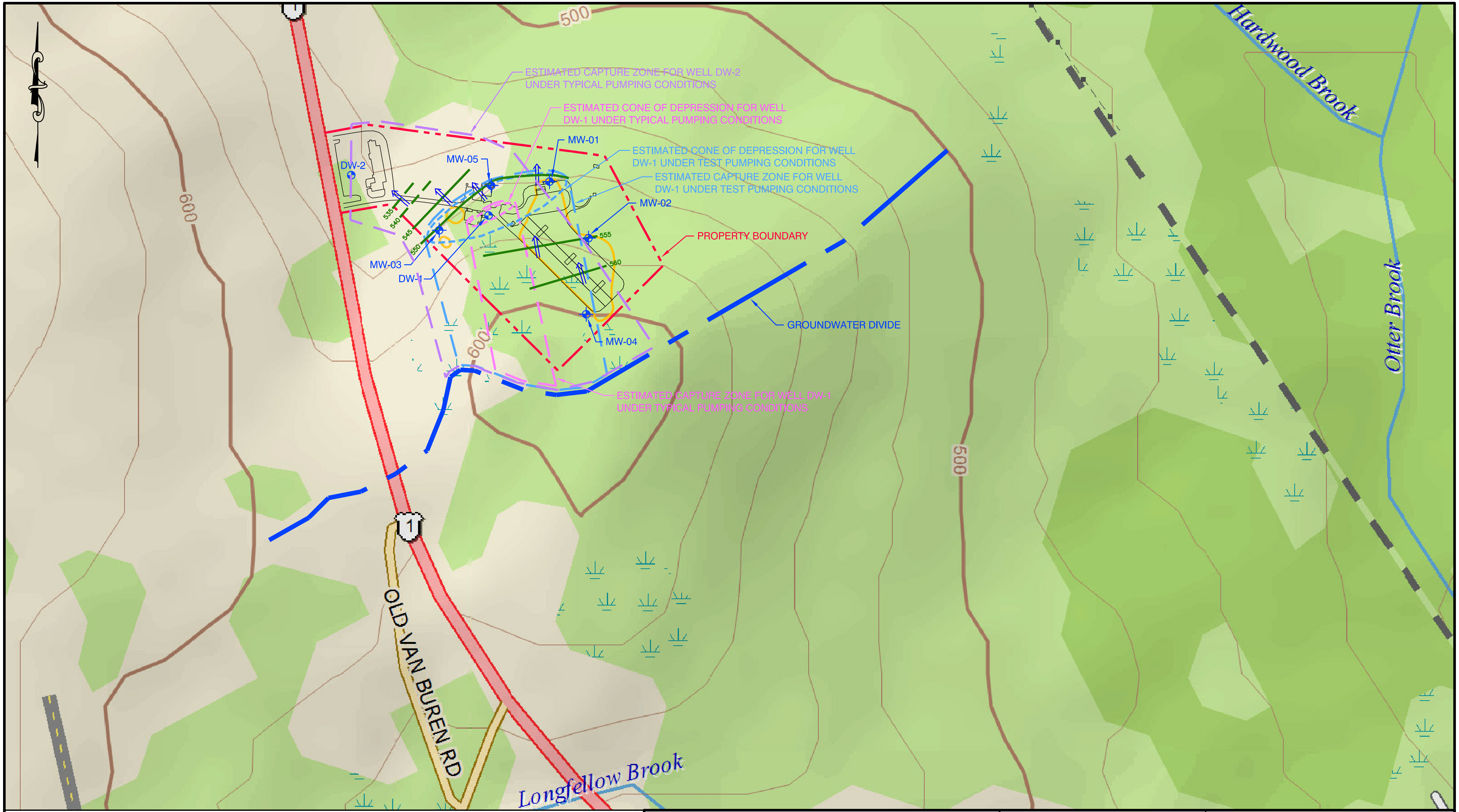
MANCHESTER NEW HAMPSHIRE

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

CROSS-SECTIONAL REPRESENTATION OF THE CONCEPTUAL SITE MODEL

DRAWN BEG	DATE MAY 2009	DES. ENG. JS	DATE MAY 2009	W.O. NO. 03886.184.001
CHECKED JS	DATE MAY 2009	SCALE AS SHOWN	REVISION	FIGURE NO. 4-4

M:\Design\DWG\ACOE\MEFUDS\5FUDS\2009\LO-58 2009\CSM 2009\FIG 4-4.dwg, Layout1, 2/28/2011 11:48:21 AM, GIRARDEB, 1:1



LEGEND

⟸ GROUNDWATER FLOW DIRECTION

535 — — GROUNDWATER ELEVATION CONTOUR LINE (DASHED WHERE INFERRED) (FT AMSL)

⬭ SOIL SOURCE AREA FOR FUEL OR CHLORINATED SOLVENT CONTAMINATION (BASED ON SOIL AND SOIL VAPOR DATA)

GRAPHIC SCALE
400 200 0 200 400
APPROXIMATE SCALE IN FEET

CONCEPTUAL SITE MODEL REPORT
LO–58 SITE
CARIBOU, MAINE

WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

DEPARTMENT OF THE ARMY
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CONCORD, MASSACHUSETTS

REGIONAL CONTEXT OF THE
SITE CONCEPTUAL MODEL

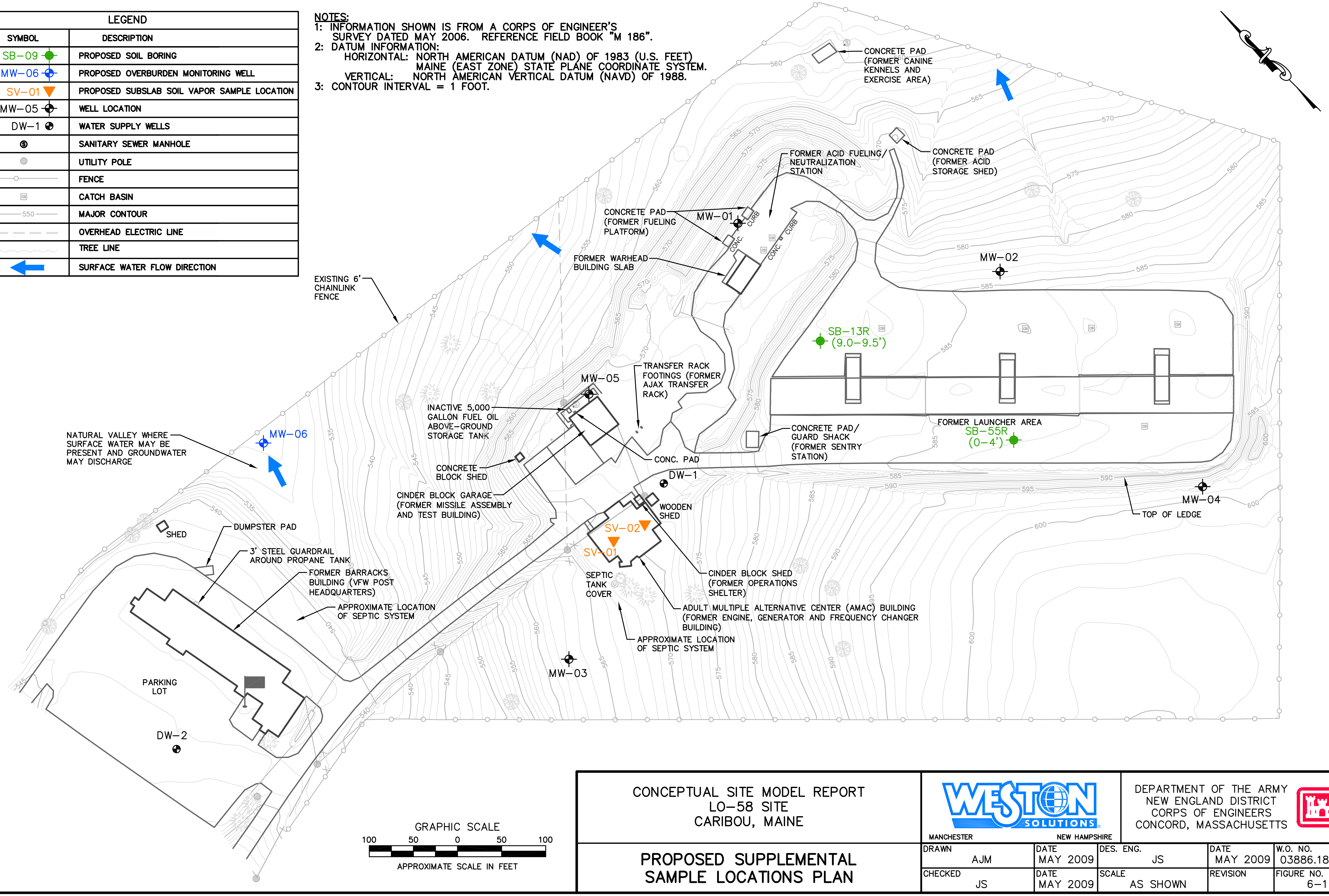
DRAWN BEG	DATE FEB 2011	DES. ENG. JS	DATE FEB 2011	W.O. NO. 03886.184.001
CHECKED JS	DATE FEB 2011	SCALE AS SHOWN	REVISION	FIGURE NO. 4–5

M:\Design\DWG\ACOE\MEFUDS\5FUDS\2009\LO–58 2009\CSM 2009\FIG 4–5.dwg, Layout1, 2/28/2011 3:48:59 PM, GIRARDEB, 1:1

LEGEND

SYMBOL	DESCRIPTION
SB−09 ●	PROPOSED SOIL BORING
MW−06 ⊕	PROPOSED OVERBURDEN MONITORING WELL
SV−01 ▼	PROPOSED SUBSLAB SOIL VAPOR SAMPLE LOCATION
MW−05 ⊕	WELL LOCATION
DW−1 ●	WATER SUPPLY WELLS
Ⓢ	SANITARY SEWER MANHOLE
●	UTILITY POLE
—o—	FENCE
▫	CATCH BASIN
——550——	MAJOR CONTOUR
— — — —	OVERHEAD ELECTRIC LINE
∿∿∿	TREE LINE
⬅	SURFACE WATER FLOW DIRECTION

NOTES:
1: INFORMATION SHOWN IS FROM A CORPS OF ENGINEER'S SURVEY DATED MAY 2006. REFERENCE FIELD BOOK "M 186".
2: DATUM INFORMATION:
HORIZONTAL: NORTH AMERICAN DATUM (NAD) OF 1983 (U.S. FEET) MAINE (EAST ZONE) STATE PLANE COORDINATE SYSTEM.
VERTICAL: NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988.
3: CONTOUR INTERVAL = 1 FOOT.



CONCEPTUAL SITE MODEL REPORT
LO−58 SITE
CARIBOU, MAINE

WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
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CONCORD, MASSACHUSETTS

PROPOSED SUPPLEMENTAL SAMPLE LOCATIONS PLAN

DRAWN AJM	DATE MAY 2009	DES. ENG. JS	DATE MAY 2009	W.O. NO. 03886.184.001
CHECKED JS	DATE MAY 2009	SCALE AS SHOWN	REVISION	FIGURE NO. 6−1

M:\Design\DWG\ACOE\MEFUDS\5FUDS\2009\LO−58 2009\CSM 2009\FIG 6−1.dwg, Layout1, 8/5/2011 12:56:50 PM, girardeb, 1:1

LEGEND

SW–01 ▲ PROPOSED SURFACE WATER SAMPLE LOCATION

SD–01 ■ PROPOSED SEDIMENT SAMPLE LOCATION

GRAPHIC SCALE

400 200 0 200 400

APPROXIMATE SCALE IN FEET

CONCEPTUAL SITE MODEL REPORT
LO–58 SITE
CARIBOU, MAINE

PROPOSED SUPPLEMENTAL SAMPLE LOCATION MAP

WESTON SOLUTIONS
MANCHESTER NEW HAMPSHIRE

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

DRAWN BEG	DATE MAY 2009	DES. ENG. JS	DATE MAY 2009	W.O. NO. 03886.184.001
CHECKED JS	DATE MAY 2009	SCALE AS SHOWN	REVISION	FIGURE NO. 6–2

M:\Design\DWG\ACOE\MEFUDS\5FUDS\LO–58 2009\CSM 2009\FIG 6–2.dwg, Layout1, 5/5/2009 1:54:19 PM, GIRARDEB, 1:1

TABLES

Table 2-1

Well Construction Summary
Maine Formerly Used Defense Site LO-58
Conceptual Site Model Report

Well ID	MW-01	MW-02	MW-03	MW-04	MW-05	DW-1	DW-2
Ground Elevation (ft amsl)	577.3	587.6	567.5	603.4	575.9	571	546.5
Protective/Steel Casing Elevation (ft amsl)	578.96	590.13	571.07	605.84	575.88	573	539.5
Top of Inner Casing Elevation (ft amsl)	578.79	589.36	570.63	605.45	575.72	na	na
Casing Stickup, construction log (ft)	1.66	2.53	3.57	2.44	-0.02	na	na
Casing Stickup, measured (ft)	1.66	2.53	3.57	2.44	-0.02	2.4	-6*
Well Total Depth, construction log (ft bmp)	142	62	47	82	82	na	na
Well Total Depth, measured (ft bmp)	143.1	61.6	47.85	82.7	77.8	58.1	284
Casing Diameter (inches)	2	2	2	2	2	6	6
Screened Interval Elevation (ft amsl)	435.69 to 445.69	527.76 to 537.76	521.78 to 531.78	522.75 to 532.75	497.92 to 507.92	514.9 to 563	524.5 to 255.5
Casing Bottom Elevation (ft amsl)	435.69	527.76	521.78	522.75	497.92	514.9	255.5
Depth to Water (ft bmp)	28.27	34.32	20.10	40.82	25.32	25.92	8.86
Groundwater Elevation (ft amsl)	550.52	555.04	550.53	564.63	550.4	547.08	530.64

Notes:

na = not available

Elevations for well DW-1 and DW-2 are approximate, and not the result of a precise survey.

ft bmp = feet below measuring point

ft amsl = feet above mean sea level

Groundwater depth measurements were made on 21 May 2008.

* = Following fieldwork, well casing was raised 4 ft to meet current construction guidelines; current stickup is -2 ft below ground surface.

Table 2-2

Summary of Caribou, Maine Precipitation Records
Maine Formerly Used Defense Site LO-58
Conceptual Site Model Report

Date	Rainfall Amount (inches)
4/30/2008	Trace
5/1/2008	0
5/2/2008	0
5/3/2008	0
5/4/2008	0.17
5/5/2008	0
5/6/2008	0
5/7/2008	0
5/8/2008	0.55
5/9/2008	0
5/10/2008	0
5/11/2008	0
5/12/2008	0
5/13/2008	0
5/14/2008	0
5/15/2008	Trace
5/16/2008	Trace
5/17/2008	0
5/18/2008	0
5/19/2008	0.81
5/20/2008	Trace
5/21/2008	0.04

Data from National Oceaninc and Atmospheric Agency.

Table 2-3

Summary of Monitoring Well Drawdown Measurements
Maine Formerly Used Defense Site LO-58
Conceptual Site Model Report

Well ID	**Date**	**14-May-08**	**19-May-08**	**19-May-08**	**20-May-08**
	Time	13:37	10:39	19:27	13:33
	Pumping Rate (gpm)	unknown	7.0	6.3	2.7
MW-01	**Drawdown (feet)**	0.469	0.319	0.24	0.165
MW-03		0.479	0.346	0.204	0.154
MW-05		0.637	0.482	0.314	0.200

Notes:
gpm = gallons per minute

Estimation of Drawdown at Typical Pumping Rate

Test Pumping Rate (gpm)	7.0	**Typical Pumping Rate (gpm)**	**Drawdown at Test Pumping Rate (feet)**
Drawdown at Test Pumping Rate (feet)	0.319	0.1	0.0046
	0.346	0.1	0.0049
	0.482	0.1	0.0069

Test Pumping Rate (gpm)	6.3	**Typical Pumping Rate (gpm)**	**Drawdown at Test Pumping Rate (feet)**
Drawdown at Test Pumping Rate (feet)	0.24	0.1	0.0038
	0.204	0.1	0.0032
	0.314	0.1	0.0050

Test Pumping Rate (gpm)	2.7	**Typical Pumping Rate (gpm)**	**Drawdown at Test Pumping Rate (feet)**
Drawdown at Test Pumping Rate (feet)	0.165	0.1	0.0061
	0.154	0.1	0.0057
	0.2	0.1	0.0074

APPENDIX A

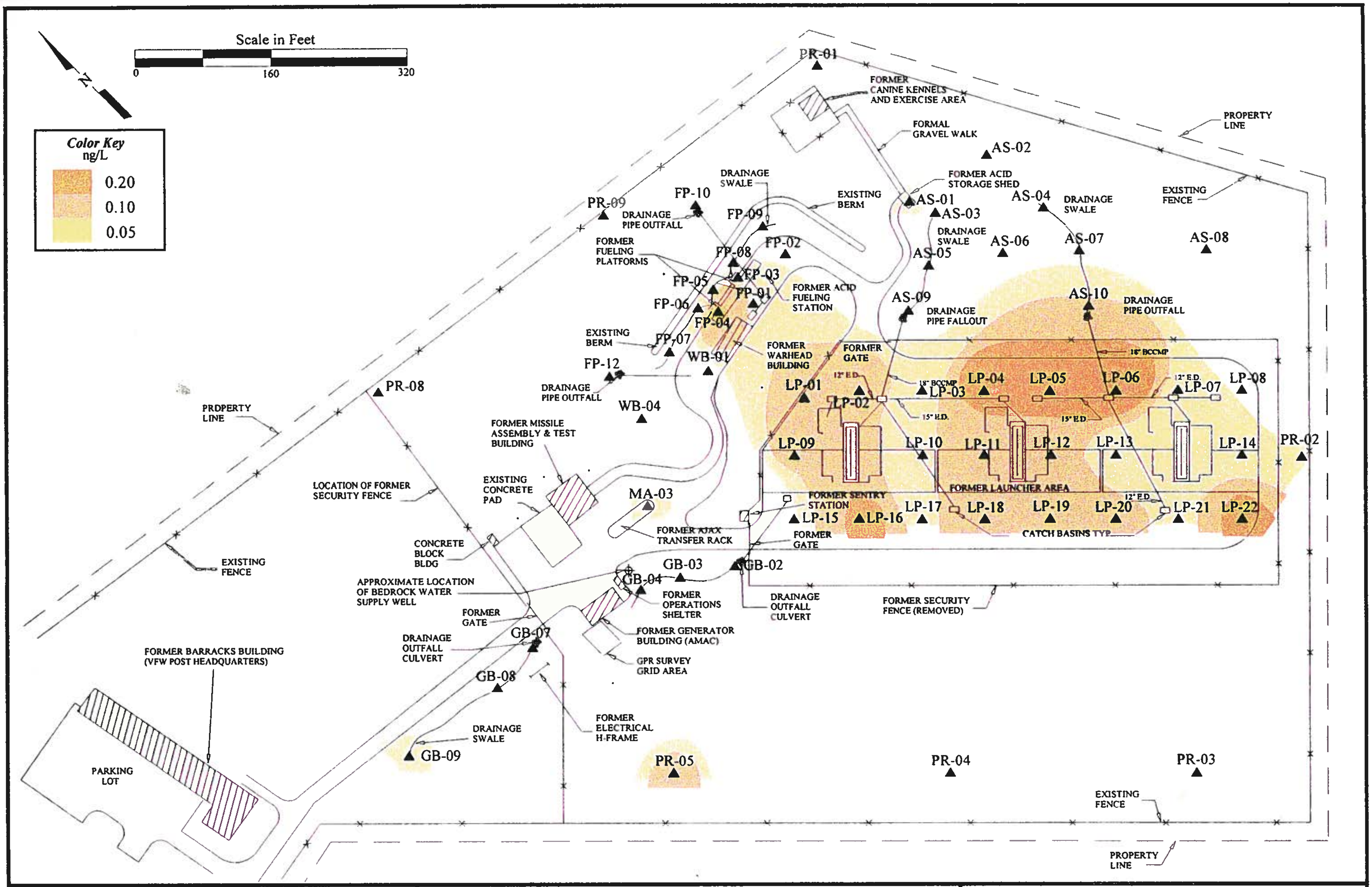
HISTORIC ENVIRONMENTAL SAMPLE ANALYTICAL RESULTS

Table 4-1

Number of VOC Detections by Compound in Soil-Gas Samples

Compound	Number of Detections	Maximum (ng/L, or parts per trillion)	Minimum (ng/L, or parts per trillion)
Toluene	39	0.15	0.02
Xylenes (total)	18	0.15	0.01
Benzene	15	0.03	0.02
Tetrachloroethene	6	0.04	0.01 J
1,2,4-Trimethylbenzene	6	0.06	0.03
Chloromethane	3	0.15	0.09
1,3,5-Trimethylbenzene	2	0.02	0.02
Ethylbenzene	2	0.02	0.02
Trichloroethene	2	0.02	0.01 J
Naphthalene	1	0.05	N/A

The most commonly occurring compounds in the soil-gas sample analyses were those of the BTEX group. BTEX compounds were detected at 43 of the 45 locations where VOCs were reported above laboratory quantitation limits (BEACON, 1999). The distribution and total BTEX concentrations of this VOC group are presented graphically on Figure 4-2. The next two most commonly occurring compounds at the Nike LO-58 site were PCE and 1,2,4-Trimethylbenzene, each detected in a total of six soil-gas probe locations (BEACON, 1999). Five of the six probes where PCE was detected were located at the former Launcher Pad area, and the sixth was installed in the grassy area located to the west of the pad. Four of the six probes where 1,2,4-Trimethylbenzene was detected were also located at the former Launcher Pad area. The remaining two probes were installed in the drainage swale leading away from the concrete pad at the former AFN area. The distribution and concentrations of the PCE and 1,2,4-Trimethylbenzene compounds detected at the Site are presented graphically on Figures 4-3 and 4-4, respectively. Trichloroethene, the compound detected in the AMAC bedrock water supply well, was detected at only two locations (FP-02 and FP-06) and therefore is not presented graphically on the figures. A summary of compounds detected during the soil-gas investigation is presented in Table 4-1.



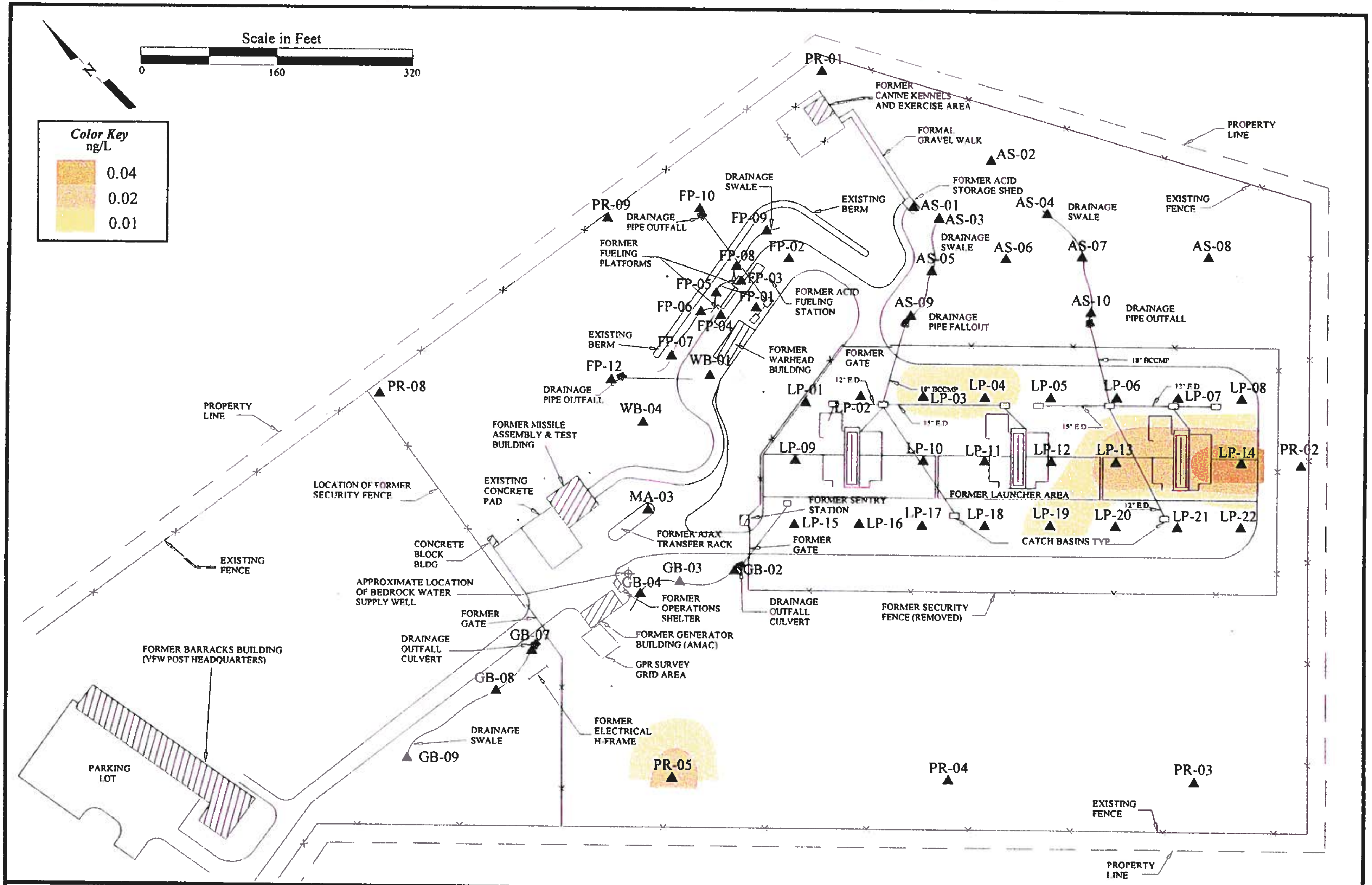
BEACON
ENVIRONMENTAL SERVICES

PR-05 ▲ EMFLUX Sample Point Location

Notes: Sixteen sample locations were omitted (see Section 3).
The reported quantitation level for Total BTEX is 0.01 ng/L.

Figure 4-2
Total BTEX

Nike Missile Site
Caribou, ME



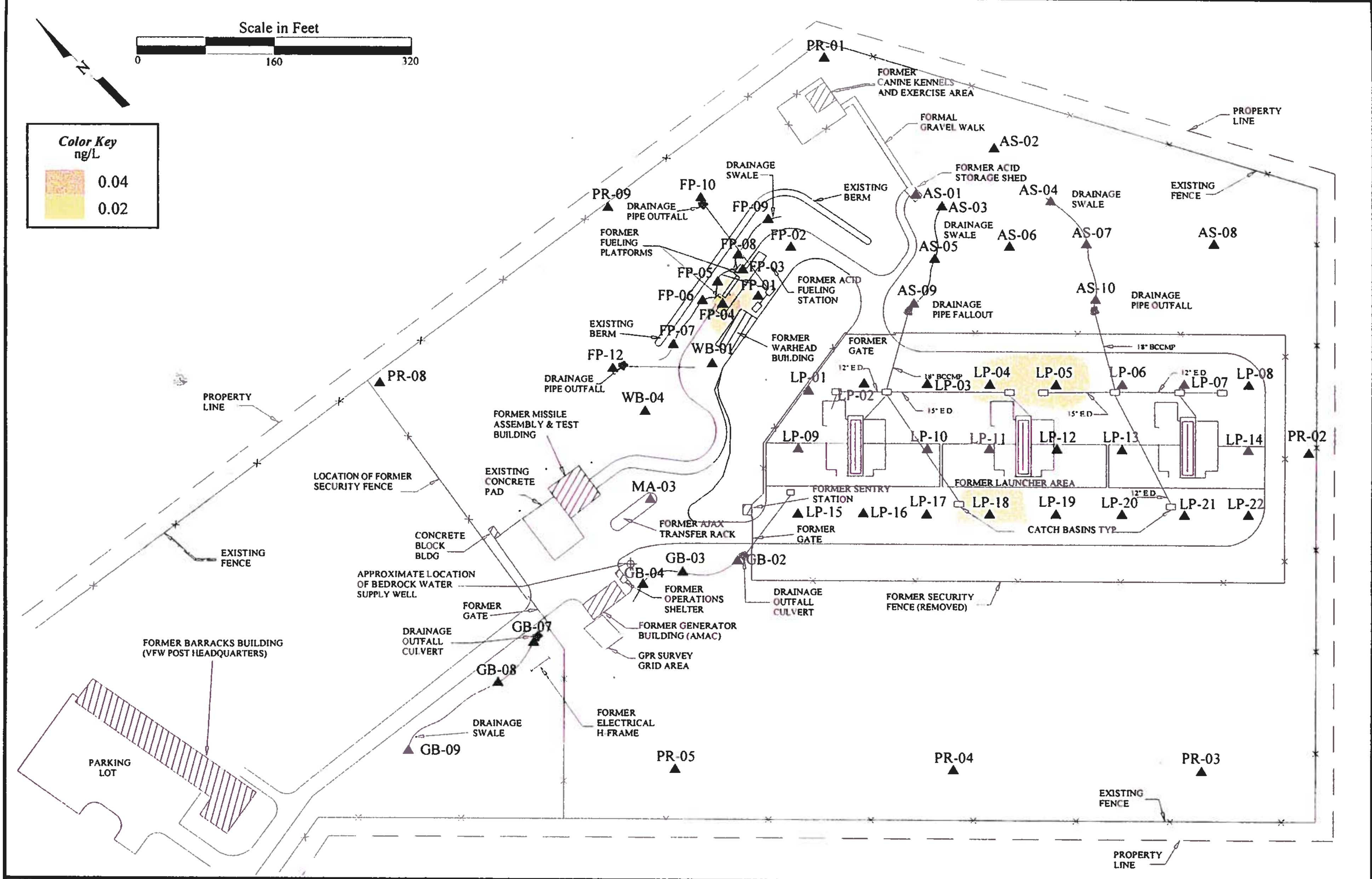
BEACON
ENVIRONMENTAL SERVICES

PR-05 ▲ EMFLUX Sample Point Location

Note: Sixteen sample locations were omitted (see Section 3).

Figure 4-3
Tetrachloroethene

Nike Missile Site
Caribou, ME



BEACON
ENVIRONMENTAL SERVICES

PR-05 ▲ EMFLUX Sample Point Location

Note: Sixteen sample locations were omitted (see Section 3).

Figure 4-4
1,2,4-Trimethylbenzene

Nike Missile Site
Caribou, ME

TABLE 4-2
SOIL SAMPLE ANALYTICAL RESULTS
VOLATILE ORGANIC COMPOUNDS (VOCs)
FORMER NIKE LO-58 LAUNCH AREA
CARIBOU, MAINE

Compound (µg/kg)	MEDEP Remedial Action Guideline	SB-01	SB-04	QC-02	SB-09	SB-10
1,1,1,2-Tetrachloroethane	660,000	5 U	5.7 U	4.4 U	3.6 U	3.5 U
1,1,1-Trichloroethane	260,000	5 U	5.7 U	4.4 U	3.6 U	3.5 U
1,1,2,2-Tetrachloroethane	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
1,1,2-Trichloroethane	3,000	5 U	5.7 U	4.4 U	3.6 U	3.5 U
1,1-Dichloroethane	645,000	5 U	5.7 U	4.4 U	3.6 U	3.5 U
1,1-Dichloroethene	200	5 U	5.7 U	4.4 U	3.6 U	3.5 U
1,1-Dichloropropene	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
1,2,3-Trichlorobenzene	--	10 U	11.4 U	8.9 U	7.2 U	7 U
1,2,3-Trichloropropane	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
1,2,4-Trichlorobenzene	540,000	5 U	5.7 U	4.4 U	3.6 U	3.5 U
1,2,4-Trimethylbenzene	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
1,2-Dibromo-3-Chloropropane	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
1,2-Dibromoethane	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
1,2-Dichlorobenzene	2,670,000	5 U	5.7 U	4.4 U	3.6 U	3.5 U
1,2-Dichloroethane	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
1,2-Dichloropropane	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
1,3,5-Trimethylbenzene	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
1,3-Dichlorobenzene	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
1,3-Dichloropropane	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
1,4-Dichlorobenzene	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
2,2-Dichloropropane	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
2-Butanone	10,000,000	40 U	45.4 U	35.6 U	28.7 U	27.9 U
2-Chlorotoluene	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
2-Hexanone	--	25 U	28.4 U	22.2 U	17.9 U	17.4 U
4-Chlorotoluene	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
4-Methyl-2-Pentanone	--	25 U	28.4 U	22.2 U	17.9 U	17.4 U
Acetone	475,000	55.1	26.7 J	24.7 J	6.8 J	23 J
Benzene	5,000	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Bromobenzene	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Bromochloromethane	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Bromodichloromethane	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Bromoform	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U

Please see notes page at end of Table 4-2.

TABLE 4-2
SOIL SAMPLE ANALYTICAL RESULTS
VOLATILE ORGANIC COMPOUNDS (VOCs)
FORMER NIKE LO-58 LAUNCH AREA
CARIBOU, MAINE

Compound (µg/kg)	MEDEP Remedial Action Guideline	SB-01	SB-04	QC-02	SB-09	SB-10
Bromomethane	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Carbon Tetrachloride	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Chlorobenzene	310,000	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Chloroethane	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Chloroform	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Chloromethane	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
cis-1,2-Dichloroethene	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
cis-1,3-Dichloropropene	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Dibromochloromethane	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Dibromomethane	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Dichlorodifluoromethane	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Ethylbenzene	1,670,000	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Hexachlorobutadiene	--	10 U	11.4 U	8.9 U	7.2 U	7 U
Isopropylbenzene	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Methyl tert-Butyl Ether (MTBE)	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Methylene Chloride	13,000	5 U	4.3 JTB	1.1 JTB	1.5 JTB	2.1 JTB
n-Butylbenzene	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
n-Propylbenzene	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Naphthalene	245,000	5 U	5.7 U	4.4 U	3.6 U	3.5 U
sec-Butylbenzene	--	10 U	11.4 U	8.9 U	7.2 U	7 U
Styrene	--	10 U	11.4 U	8.9 U	7.2 U	7 U
tert-Butylbenzene	--	10 U	11.4 U	8.9 U	7.2 U	7 U
Tetrachloroethene	3,000	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Tetrahydrofuran	--	10 U	11.4 U	8.9 U	7.2 U	7 U
Toluene	2,390,000	5 U	5.7 U	4.4 U	3.6 U	3.5 U
trans-1,2-Dichloroethene	135,000	5 U	5.7 U	4.4 U	3.6 U	3.5 U
trans-1,3-Dichloropropene	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Trichloroethene	19,000	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Trichlorofluoromethane	--	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Vinyl Acetate	--	10 U	11.4 U	8.9 U	7.2 U	7 U
Vinyl Chloride	40	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Xylene O	10,000,000 (total)	5 U	5.7 U	4.4 U	3.6 U	3.5 U
Xylene P,M	10,000,000 (total)	10 U	11.4 U	8.9 U	7.2 U	7 U

Please see notes page at end of Table 4-2.

TABLE 4-2
SOIL SAMPLE ANALYTICAL RESULTS
VOLATILE ORGANIC COMPOUNDS (VOCs)
FORMER NIKE LO-58 LAUNCH AREA
CARIBOU, MAINE

Compound (µg/kg)	MEDEP Remedial Action Guideline	SB-11	SB-13	SB-16	SB-20	SB-21
1,1,1,2-Tetrachloroethane	660,000	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
1,1,1-Trichloroethane	260,000	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
1,1,2,2-Tetrachloroethane	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
1,1,2-Trichloroethane	3,000	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
1,1-Dichloroethane	645,000	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
1,1-Dichloroethene	200	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
1,1-Dichloropropene	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
1,2,3-Trichlorobenzene	--	9.8 U	7.8 U	7 U	7.5 U	6.5 U
1,2,3-Trichloropropane	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
1,2,4-Trichlorobenzene	540,000	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
1,2,4-Trimethylbenzene	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
1,2-Dibromo-3-Chloropropane	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
1,2-Dibromoethane	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
1,2-Dichlorobenzene	2,670,000	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
1,2-Dichloroethane	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
1,2-Dichloropropane	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
1,3,5-Trimethylbenzene	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
1,3-Dichlorobenzene	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
1,3-Dichloropropane	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
1,4-Dichlorobenzene	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
2,2-Dichloropropane	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
2-Butanone	10,000,000	39.4 U	31.1 U	28.1 U	29.9 U	25.9 U
2-Chlorotoluene	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
2-Hexanone	--	24.6 U	19.5 U	17.5 U	18.7 U	16.2 U
4-Chlorotoluene	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
4-Methyl-2-Pentanone	--	24.6 U	19.5 U	17.5 U	18.7 U	16.2 U
Acetone	475,000	18.3 J	8.3 J	9.7 J	19.3 J	25.9 U
Benzene	5,000	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Bromobenzene	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Bromochloromethane	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Bromodichloromethane	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Bromoform	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U

Please see notes page at end of Table 4-2.

TABLE 4-2
SOIL SAMPLE ANALYTICAL RESULTS
VOLATILE ORGANIC COMPOUNDS (VOCs)
FORMER NIKE LO-58 LAUNCH AREA
CARIBOU, MAINE

Compound (µg/kg)	MEDEP Remedial Action Guideline	SB-11	SB-13	SB-16	SB-20	SB-21
Bromomethane	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Carbon Tetrachloride	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Chlorobenzene	310,000	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Chloroethane	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Chloroform	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Chloromethane	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
cis-1,2-Dichloroethene	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
cis-1,3-Dichloropropene	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Dibromochloromethane	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Dibromomethane	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Dichlorodifluoromethane	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Ethylbenzene	1,670,000	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Hexachlorobutadiene	--	9.8 U	7.8 U	7 U	7.5 U	6.5 U
Isopropylbenzene	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Methyl tert-Butyl Ether (MTBE)	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Methylene Chloride	13,000	3.7 JTB	1.6 JTB	1.5 JTB	2.8 JTB	1.6 JTB
n-Butylbenzene	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
n-Propylbenzene	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Naphthalene	245,000	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
sec-Butylbenzene	--	9.8 U	7.8 U	7 U	7.5 U	6.5 U
Styrene	--	9.8 U	7.8 U	7 U	7.5 U	6.5 U
tert-Butylbenzene	--	9.8 U	7.8 U	7 U	7.5 U	6.5 U
Tetrachloroethene	3,000	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Tetrahydrofuran	--	9.8 U	7.8 U	7 U	7.5 U	6.5 U
Toluene	2,390,000	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
trans-1,2-Dichloroethene	135,000	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
trans-1,3-Dichloropropene	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Trichloroethene	19,000	4.9 U	1.1 J	3.5 U	3.7 U	3.2 U
Trichlorofluoromethane	--	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Vinyl Acetate	--	9.8 U	7.8 U	7 U	7.5 U	6.5 U
Vinyl Chloride	40	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Xylene O	10,000,000 (total)	4.9 U	3.9 U	3.5 U	3.7 U	3.2 U
Xylene P,M	10,000,000 (total)	9.8 U	7.8 U	7 U	7.5 U	6.5 U

Please see notes page at end of Table 4-2.

TABLE 4-2
SOIL SAMPLE ANALYTICAL RESULTS
VOLATILE ORGANIC COMPOUNDS (VOCs)
FORMER NIKE LO-58 LAUNCH AREA
CARIBOU, MAINE

Compound (µg/kg)	MEDEP Remedial Action Guideline	SB-22	SB-27	SB-29	QC-01	SB-34
1,1,1,2-Tetrachloroethane	660,000	4.6 U	4.1 U	4 U	4.5 U	4.1 U
1,1,1-Trichloroethane	260,000	4.6 U	4.1 U	4 U	4.5 U	4.1 U
1,1,2,2-Tetrachloroethane	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
1,1,2-Trichloroethane	3,000	4.6 U	4.1 U	4 U	4.5 U	4.1 U
1,1-Dichloroethane	645,000	4.6 U	4.1 U	4 U	4.5 U	4.1 U
1,1-Dichloroethene	200	4.6 U	4.1 U	4 U	4.5 U	4.1 U
1,1-Dichloropropene	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
1,2,3-Trichlorobenzene	--	9.2 U	8.3 U	8.1 U	9 U	8.1 U
1,2,3-Trichloropropane	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
1,2,4-Trichlorobenzene	540,000	4.6 U	4.1 U	4 U	4.5 U	4.1 U
1,2,4-Trimethylbenzene	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
1,2-Dibromo-3-Chloropropane	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
1,2-Dibromoethane	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
1,2-Dichlorobenzene	2,670,000	4.6 U	4.1 U	4 U	4.5 U	4.1 U
1,2-Dichloroethane	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
1,2-Dichloropropane	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
1,3,5-Trimethylbenzene	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
1,3-Dichlorobenzene	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
1,3-Dichloropropane	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
1,4-Dichlorobenzene	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
2,2-Dichloropropane	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
2-Butanone	10,000,000	36.9 U	33.1 U	32.2 U	36.1 U	32.5 U
2-Chlorotoluene	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
2-Hexanone	--	23 U	20.7 U	20.1 U	22.6 U	20.3 U
4-Chlorotoluene	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
4-Methyl-2-Pentanone	--	23 U	20.7 U	20.1 U	22.6 U	20.3 U
Acetone	475,000	31.6 J	24 J	30	40	47.6
Benzene	5,000	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Bromobenzene	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Bromochloromethane	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Bromodichloromethane	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Bromoform	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U

Please see notes page at end of Table 4-2.

TABLE 4-2
SOIL SAMPLE ANALYTICAL RESULTS
VOLATILE ORGANIC COMPOUNDS (VOCs)
FORMER NIKE LO-58 LAUNCH AREA
CARIBOU, MAINE

Compound (µg/kg)	MEDEP Remedial Action Guideline	SB-22	SB-27	SB-29	QC-01	SB-34
Bromomethane	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Carbon Tetrachloride	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Chlorobenzene	310,000	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Chloroethane	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Chloroform	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Chloromethane	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
cis-1,2-Dichloroethene	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
cis-1,3-Dichloropropene	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Dibromochloromethane	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Dibromomethane	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Dichlorodifluoromethane	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Ethylbenzene	1,670,000	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Hexachlorobutadiene	--	9.2 U	8.3 U	8.1 U	9 U	8.1 U
Isopropylbenzene	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Methyl tert-Butyl Ether (MTBE)	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Methylene Chloride	13,000	2.2 JTB	2.8 JTB	2 JTB	2.5 JTB	1.9 JTB
n-Butylbenzene	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
n-Propylbenzene	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Naphthalene	245,000	4.6 U	4.1 U	4 U	4.5 U	4.1 U
sec-Butylbenzene	--	9.2 U	8.3 U	8.1 U	9 U	8.1 U
Styrene	--	9.2 U	8.3 U	8.1 U	9 U	8.1 U
tert-Butylbenzene	--	9.2 U	8.3 U	8.1 U	9 U	8.1 U
Tetrachloroethene	3,000	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Tetrahydrofuran	--	9.2 U	8.3 U	8.1 U	9 U	8.1 U
Toluene	2,390,000	4.6 U	4.1 U	4 U	4.5 U	4.1 U
trans-1,2-Dichloroethene	135,000	4.6 U	4.1 U	4 U	4.5 U	4.1 U
trans-1,3-Dichloropropene	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Trichloroethene	19,000	4.6 U	4.1 U	4 U	4.5 U	9
Trichlorofluoromethane	--	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Vinyl Acetate	--	9.2 U	8.3 U	8.1 U	9 U	8.1 U
Vinyl Chloride	40	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Xylene O	10,000,000 (total)	4.6 U	4.1 U	4 U	4.5 U	4.1 U
Xylene P,M	10,000,000 (total)	9.2 U	8.3 U	8.1 U	9 U	8.1 U

Please see notes page at end of Table 4-2.

TABLE 4-2
SOIL SAMPLE ANALYTICAL RESULTS
VOLATILE ORGANIC COMPOUNDS (VOCs)
FORMER NIKE LO-58 LAUNCH AREA
CARIBOU, MAINE

Compound (µg/kg)	MEDEP Remedial Action Guideline	SB-37	SB-39	TB-01	TB-02
1,1,1,2-Tetrachloroethane	660,000	4.6 U	4.2 U	5 U	5 U
1,1,1-Trichloroethane	260,000	4.6 U	4.2 U	5 U	5 U
1,1,2,2-Tetrachloroethane	--	4.6 U	4.2 U	5 U	5 U
1,1,2-Trichloroethane	3,000	4.6 U	4.2 U	5 U	5 U
1,1-Dichloroethane	645,000	4.6 U	4.2 U	5 U	5 U
1,1-Dichloroethene	200	4.6 U	4.2 U	5 U	5 U
1,1-Dichloropropene	--	4.6 U	4.2 U	5 U	5 U
1,2,3-Trichlorobenzene	--	9.3 U	8.5 U	10 U	10 U
1,2,3-Trichloropropane	--	4.6 U	4.2 U	5 U	5 U
1,2,4-Trichlorobenzene	540,000	4.6 U	4.2 U	5 U	5 U
1,2,4-Trimethylbenzene	--	4.6 U	4.2 U	5 U	5 U
1,2-Dibromo-3-Chloropropane	--	4.6 U	4.2 U	5 U	5 U
1,2-Dibromoethane	--	4.6 U	4.2 U	5 U	5 U
1,2-Dichlorobenzene	2,670,000	4.6 U	4.2 U	5 U	5 U
1,2-Dichloroethane	--	4.6 U	4.2 U	5 U	5 U
1,2-Dichloropropane	--	4.6 U	4.2 U	5 U	5 U
1,3,5-Trimethylbenzene	--	4.6 U	4.2 U	5 U	5 U
1,3-Dichlorobenzene	--	4.6 U	4.2 U	5 U	5 U
1,3-Dichloropropane	--	4.6 U	4.2 U	5 U	5 U
1,4-Dichlorobenzene	--	4.6 U	4.2 U	5 U	5 U
2,2-Dichloropropane	--	4.6 U	4.2 U	5 U	5 U
2-Butanone	10,000,000	37.1 U	33.9 U	40 U	40 U
2-Chlorotoluene	--	4.6 U	4.2 U	5 U	5 U
2-Hexanone	--	23.2 U	21.2 U	25 U	25 U
4-Chlorotoluene	--	4.6 U	4.2 U	5 U	5 U
4-Methyl-2-Pentanone	--	23.2 U	21.2 U	25 U	25 U
Acetone	475,000	19.4 J	30	40 U	40 U
Benzene	5,000	4.6 U	4.2 U	5 U	5 U
Bromobenzene	--	4.6 U	4.2 U	5 U	5 U
Bromochloromethane	--	4.6 U	4.2 U	5 U	5 U
Bromodichloromethane	--	4.6 U	4.2 U	5 U	5 U
Bromoform	--	4.6 U	4.2 U	5 U	5 U

Please see notes page at end of Table 4-2.

TABLE 4-2
SOIL SAMPLE ANALYTICAL RESULTS
VOLATILE ORGANIC COMPOUNDS (VOCs)
FORMER NIKE LO-58 LAUNCH AREA
CARIBOU, MAINE

Compound (µg/kg)	MEDEP Remedial Action Guideline	SB-37	SB-39	TB-01	TB-02
Bromomethane	--	4.6 U	4.2 U	5 U	5 U
Carbon Tetrachloride	--	4.6 U	4.2 U	5 U	5 U
Chlorobenzene	310,000	4.6 U	4.2 U	5 U	5 U
Chloroethane	--	4.6 U	4.2 U	5 U	5 U
Chloroform	--	4.6 U	4.2 U	5 U	5 U
Chloromethane	--	4.6 U	4.2 U	5 U	5 U
cis-1,2-Dichloroethene	--	4.6 U	4.2 U	5 U	5 U
cis-1,3-Dichloropropene	--	4.6 U	4.2 U	5 U	5 U
Dibromochloromethane	--	4.6 U	4.2 U	5 U	5 U
Dibromomethane	--	4.6 U	4.2 U	5 U	5 U
Dichlorodifluoromethane	--	4.6 U	4.2 U	5 U	5 U
Ethylbenzene	1,670,000	4.6 U	4.2 U	5 U	5 U
Hexachlorobutadiene	--	9.3 U	8.5 U	10 U	10 U
Isopropylbenzene	--	4.6 U	4.2 U	5 U	5 U
Methyl tert-Butyl Ether (MTBE)	--	4.6 U	4.2 U	5 U	5 U
Methylene Chloride	13,000	2.4 JTB	2.4 JTB	4.8 J	1.7 J
n-Butylbenzene	--	4.6 U	4.2 U	5 U	5 U
n-Propylbenzene	--	4.6 U	4.2 U	5 U	5 U
Naphthalene	245,000	4.6 U	4.2 U	5 U	5 U
sec-Butylbenzene	--	9.3 U	8.5 U	10 U	10 U
Styrene	--	9.3 U	8.5 U	10 U	10 U
tert-Butylbenzene	--	9.3 U	8.5 U	10 U	10 U
Tetrachloroethene	3,000	4.6 U	4.2 U	5 U	5 U
Tetrahydrofuran	--	9.3 U	8.5 U	10 U	10 U
Toluene	2,390,000	4.6 U	4.2 U	5 U	5 U
trans-1,2-Dichloroethene	135,000	4.6 U	4.2 U	5 U	5 U
trans-1,3-Dichloropropene	--	4.6 U	4.2 U	5 U	5 U
Trichloroethene	19,000	4.6 U	4.2 U	5 U	5 U
Trichlorofluoromethane	--	4.6 U	4.2 U	5 U	5 U
Vinyl Acetate	--	9.3 U	8.5 U	10 U	10 U
Vinyl Chloride	40	4.6 U	4.2 U	5 U	5 U
Xylene O	10,000,000 (total)	4.6 U	4.2 U	5 U	5 U
Xylene P,M	10,000,000 (total)	9.3 U	8.5 U	10 U	10 U

Please see notes page at end of Table 4-2.

SUMMARY OF NOTES AND DATA QUALIFIERS
SOIL SAMPLE ANALYTICAL RESULTS
VOLATILE ORGANIC COMPOUNDS (VOCs)
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Notes:
U = Not detected above associated Method Reporting Limit (MRL)
J = Reported below MRL; Estimated value.
TB = Methylene Chloride was detected in the trip blank; therefore, all results in the samples for $MeCl_2$ which are below the action level (4.8 x 5 = 24.0) have been qualified as "TB".
-- = Value not listed in MEDEP Remedial Action Guidelines, Revised 6/1/98
QC-01 = Duplicate sample of SB-29
QC-02 = Duplicate sample of SB-04
All values shown are in units of µg/kg (ppb)

TABLE 4-3
SOIL SAMPLE ANALYTICAL RESULTS
TOTAL PETROLEUM HYDROCARBONS - GRO AND DRO
FORMER NIKE LO-58 LAUNCH AREA
CARIBOU, MAINE

Compound (mg/kg)	MEDEP Remedial Action Guideline	SB-01	SB-04	QC-02	SB-09	SB-10	SB-11	SB-13
TPH - Gasoline Range Organics (GRO)	5	1.9 U	2.2 U	2.5 U	1.7 U	1.4 U	2.2 U	1.4 U
TPH - Diesel Range Organics (DRO)	10	8 UJ	8 J	8 UJ	10 J	10 U	8 UJ	**36**

Notes:

TPH = Total Petroleum Hydrocarbons

GRO = Gasoline Range Organics

DRO = Diesel Range Organics

U = Not detected above associated Method Reporting Limit (MRL).

J = Estimated due to result below MRL.

UJ = Non-detect qualified as estimated due to result below MRL.

BOLD value indicates that the concentration is above MEDEP Remedial Action Guideline (6/1/98).

-- = Trip Blanks were not submitted for analysis of TPH-DRO.

All values shown are in units of mg/kg (ppm).

TABLE 4-3
SOIL SAMPLE ANALYTICAL RESULTS
TOTAL PETROLEUM HYDROCARBONS - GRO AND DRO
FORMER NIKE LO-58 LAUNCH AREA
CARIBOU, MAINE

Compound (mg/kg)	MEDEP Remedial Action Guideline	SB-16	SB-20	SB-21	SB-22	SB-27	SB-29
TPH - Gasoline Range Organics (GRO)	5	1.4 U	1.3 U	1.5 U	2.1 U	1.2 U	1.6 U
TPH - Diesel Range Organics (DRO)	10	9 U	10 U	7 UJ	7 UJ	6 UJ	7 UJ

Notes:

TPH = Total Petroleum Hydrocarbons

GRO = Gasoline Range Organics

DRO = Diesel Range Organics

U = Not detected above associated Method Reporting Limit (MRL).

J = Estimated due to result below MRL.

UJ = Non-detect qualified as estimated due to result below MRL.

BOLD value indicates that the concentration is above MEDEP Remedial Action Guideline (6/1/98).

-- = Trip Blanks were not submitted for analysis of TPH-DRO.

All values shown are in units of mg/kg (ppm).

TABLE 4-3
SOIL SAMPLE ANALYTICAL RESULTS
TOTAL PETROLEUM HYDROCARBONS - GRO AND DRO
FORMER NIKE LO-58 LAUNCH AREA
CARIBOU, MAINE

Compound (mg/kg)	MEDEP Remedial Action Guideline	QC-01	SB-34	SB-37	SB-39	TB-01	TB-02
TPH - Gasoline Range Organics (GRO)	5	1.9 U	1.7 U	1.9 U	1.8 U	2 U	2 U
TPH - Diesel Range Organics (DRO)	10	8 UJ	8 UJ	8 UJ	7 UJ	--	--

Notes:

TPH = Total Petroleum Hydrocarbons

GRO = Gasoline Range Organics

DRO = Diesel Range Organics

U = Not detected above associated Method Reporting Limit (MRL).

J = Estimated due to result below MRL.

UJ = Non-detect qualified as estimated due to result below MRL.

BOLD value indicates that the concentration is above MEDEP Remedial Action Guideline (6/1/98).

-- = Trip Blanks were not submitted for analysis of TPH-DRO.

All values shown are in units of mg/kg (ppm).

TABLE 3-1
SUMMARY OF VOLATILE ORGANIC COMPOUNDS AND TPH IN SOIL
FORMER MIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP RAG[1] (µg/kg)[2]	SB-41 (0-4 ft)	SB-42 (0-4 ft)	SB-43 (0-4 ft)	SB-44 (0-4 ft)	SB-44 (0-4 ft) (Duplicate)	SB-45 (0-4 ft)	SB-46 (0-4 ft)	SB-47 (0-4 ft)	SB-48 (0-4 ft)
Volatile Organic Compounds (VOCs)										
1,1,1-Trichloroethane	2,000	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,1,2-Trichloroethane	20	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,1,1,2-Tetrachlorothane	660,000	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,1,2,2-Tetrachloroethane	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,1-Dichloroethane	23,000	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,1-Dichloroethene	60	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,2-Dichloroethane	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
cis-1,2-Dichloroethene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
trans-1,2-Dichloroethene	700	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,2-Dichloropropane	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,3-Dichloropropane	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
2,2-Dichloropropane	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,1-Dichloropropene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
cis-1,3-Dichloropropene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
trans-1,3-Dichloropropene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
2-Butanone	10,000,000	*12*	8 U	*13*	12 U	8 U	*15*	10 U	8 U	11 U
2-Hexanone	--	2 U	8 U	9 U	12 U	8 U	8 U	10 U	8 U	11 U
Acetone	16,000	*146*	8 U	*113*	*72 TB*	*26 TB*	*238*	*60 TB*	*66 TB*	*53 TB*
Benzene	30	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Bromochloromethane	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Bromodichloromethane	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Bromobenzene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Bromoform	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U

TABLE 3-1
SUMMARY OF VOLATILE ORGANIC COMPOUNDS AND TPH IN SOIL
FORMER MIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP RAG[1] (µg/kg)[2]	SB-41 (0-4 ft)	SB-42 (0-4 ft)	SB-43 (0-4 ft)	SB-44 (0-4 ft)	SB-44 (0-4 ft) (Duplicate)	SB-45 (0-4 ft)	SB-46 (0-4 ft)	SB-47 (0-4 ft)	SB-48 (0-4 ft)
Bromomethane	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
n-Butylbenzene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
sec-Butylbenzene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
tert-Butylbenzene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Carbon Disulfide	--	*1 J*	2 U	3	2 U	2 U	2 U	2 U	*3*	2 U
Carbon Tetrachloride	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Chlorobenzene	1,000	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Chloroethane	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Chloroform	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Chloromethane	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
2-Chlorotoluene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
4-Chlorotoluene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Dibromochloromethane	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,2-Dibromo-3-chloropropane	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,2-Dibromoethane(EDB)	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Dibromomethane	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,2-Dichlorobenzene	17,000	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,3-Dichlorobenzene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,4-Dichlorobenzene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Dichlorodifluoromethane	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Ethylbenzene	13,000	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U

TABLE 3-1
SUMMARY OF VOLATILE ORGANIC COMPOUNDS AND TPH IN SOIL
FORMER MIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP RAG[1] (µg/kg)[2]	SB-41 (0-4 ft)	SB-42 (0-4 ft)	SB-43 (0-4 ft)	SB-44 (0-4 ft)	SB-44 (0-4 ft) (Duplicate)	SB-45 (0-4 ft)	SB-46 (0-4 ft)	SB-47 (0-4 ft)	SB-48 (0-4 ft)
Hexachlorobutadiene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Isopropylbenzene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
p-Isopropyltoluene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Methylene Chloride	20	6 U	4 U	4 U	6 U	4 U	4 U	5 U	4 U	5 U
4-Methyl-2-pentanone	--	11 U	8 U	9 U	12 U	8 U	8 U	10 U	8 U	11 U
MTBE	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Naphthalene	84,000	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
n-Propylbenzene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Styrene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Tetrachloroethene	60	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Tetrahydrofuran	--	11 U	8 U	9 U	12 U	8 U	8 U	10 U	8 U	11 U
Toluene	12,000	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,3,5-Trichlorobenzene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,2,4-Trichlorobenzene	5,000	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Trichloroethene	60	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Trichlorofluoromethane	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,2,3-Trichloropropane	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,2,4-Trimethylbenzene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
1,3,5-Trimethylbenzene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Vinyl Acetate	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Vinyl Chloride	10	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
o-Xylene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
m,p-Xylene	--	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Total Petroleum Hydrocarbons (TPH)										
TPH-DRO (mg/kg)	10	6 U	6 U	6 U	6 U	6 U	***11***	7 U	6 U	6 U
TPH-GRO (mg/kg)	5	1.3 U	1.1 U	1 U	1.2 U	1.5 U	1.1 U	1.5 U	1.3 U	1.1 U

TABLE 3-1
SUMMARY OF VOLATILE ORGANIC COMPOUNDS AND TPH IN SOIL
FORMER MIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP RAG[1] (µg/kg)[2]	SB-49 (0-4 ft)	SB-49 (0-4 ft) (Duplicate)	SB-50 (0-4 ft)	SB-51 (0-4 ft)	SB-52 (0-4 ft)	SB-53 (0-4 ft)	SB-54 (0-4 ft)	SB-55 (0-4 ft)	SB-56 (0-4 ft)
Volatile Organic Compounds (VOCs)		**Volatile Organic Compounds (VOCs)**								
1,1,1-Trichloroethane	2,000	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
1,1,2-Trichloroethane	20	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
1,1,1,2-Tetrachlorothane	660,000	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
1,1,2,2-Tetrachloroethane	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
1,1-Dichloroethane	23,000	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
1,1-Dichloroethene	60	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
1,2-Dichloroethane	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
cis-1,2-Dichloroethene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
trans-1,2-Dichloroethene	700	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
1,2-Dichloropropane	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
1,3-Dichloropropane	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
2,2-Dichloropropane	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
1,1-Dichloropropene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
cis-1,3-Dichloropropene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
trans-1,3-Dichloropropene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
2-Butanone	10,000,000	*26 J*	14 UJ	7 U	9 U	9 U	9 U	*14*	7 U	10 U
2-Hexanone	--	13 U	14 U	7 U	9 U	9 U	9 U	8 U	7 U	10 U
Acetone	16,000	*210 J*	*87 JTB*	7 U	*21*	*26 TB*	*30 TB*	*71 TB*	*36 TB*	10 U
Benzene	30	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Bromochloromethane	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Bromodichloromethane	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Bromobenzene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Bromoform	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U

TABLE 3-1
SUMMARY OF VOLATILE ORGANIC COMPOUNDS AND TPH IN SOIL
FORMER MIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP RAG^1 (µg/kg)^2	SB-49 (0-4 ft)	SB-49 (0-4 ft) (Duplicate)	SB-50 (0-4 ft)	SB-51 (0-4 ft)	SB-52 (0-4 ft)	SB-53 (0-4 ft)	SB-54 (0-4 ft)	SB-55 (0-4 ft)	SB-56 (0-4 ft)
Bromomethane	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
n-Butylbenzene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
sec-Butylbenzene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
tert-Butylbenzene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Carbon Disulfide	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	*1*	*13*
Carbon Tetrachloride	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Chlorobenzene	1,000	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Chloroethane	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Chloroform	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Chloromethane	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
2-Chlorotoluene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
4-Chlorotoluene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Dibromochloromethane	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
1,2-Dibromo-3-chloropropane	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
1,2-Dibromoethane(EDB)	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Dibromomethane	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
1,2-Dichlorobenzene	17,000	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
1,3-Dichlorobenzene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
1,4-Dichlorobenzene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Dichlorodifluoromethane	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Ethylbenzene	13,000	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U

TABLE 3-1
SUMMARY OF VOLATILE ORGANIC COMPOUNDS AND TPH IN SOIL
FORMER MIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP RAG[1] (µg/kg)[2]	SB-49 (0-4 ft)	SB-49 (0-4 ft) (Duplicate)	SB-50 (0-4 ft)	SB-51 (0-4 ft)	SB-52 (0-4 ft)	SB-53 (0-4 ft)	SB-54 (0-4 ft)	SB-55 (0-4 ft)	SB-56 (0-4 ft)
Hexachlorobutadiene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Isopropylbenzene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
p-Isopropyltoluene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Methylene Chloride	20	6 U	7 U	4 U	4 U	5 U	5 U	4 U	4 U	5 U
4-Methyl-2-pentanone	--	13 U	14 U	7 U	9 U	9 U	9 U	8 U	7 U	10 U
MTBE	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Naphthalene	84,000	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
n-Propylbenzene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Styrene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Tetrachloroethene	60	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Tetrahydrofuran	--	13 U	14 U	7 U	9 U	9 U	9 U	8 U	7 U	10 U
Toluene	12,000	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
1,3,5-Trichlorobenzene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
1,2,4-Trichlorobenzene	5,000	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Trichloroethene	60	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Trichlorofluoromethane	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
1,2,3-Trichloropropane	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
1,2,4-Trimethylbenzene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
1,3,5-Trimethylbenzene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Vinyl Acetate	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Vinyl Chloride	10	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
o-Xylene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
m,p-Xylene	--	3 U	3 U	1 U	2 U	2 U	2 U	2 U	1 U	2 U
Total Petroleum Hydrocarbons (TPH)		**Total Petroleum Hydrocarbons (TPH)**								
TPH-DRO (mg/kg)	10	6 U	6 U	6 U	6 U	6 U	6 U	***24***	***133***	6 U
TPH-GRO (mg/kg)	5	1 U	1.3 U	1.1 U	1 U	0.9 U	1.2 U	1.1 U	0.8 U	1.4 U

[1] For soil VOCs, Regulatory Criteria values are "Remedial Action Guidelines (RAGs) - Groundwater Guideline" (MEDEP May 20, 1997). For those compounds where a Groundwater Guideline value was not applicable (1,1,1,2-Tetrachloroethane and 2-Butanone), then the "Direct Contact Guideline" was substituted.

[2] Units for VOCs are in micrograms per kilogram (µg/kg); Units for TPH are in milligrams per kilogram (mg/kg).

-- = No published "Direct Contact Guideline" or RAG exists for this compound.

U = Not detected at associated reporting limit.

J/UJ = Estimated due to field duplicate criteria not being met.

Values shown in *Italics* indicate that the compound was detected, but at a concentration below its respective MEDEP RAG.

Values shown in **BOLD** indicate that the compound was detected at a concentration that exceeds its MEDEP RAG.

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	MW-01					
		10/26/2000	5/16/2001	12/5/2002	4/23/2003	9/19/2003	5/11/2004
Volatile Organic Compounds (VOCs)							
1,1,1-Trichloroethane	200	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2-Trichloroethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,1,2-Tetrachloroethane	13	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	1.8	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethene	0.6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloroethane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,2-Dichloroethene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,2-Dichloroethene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloropropane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2,2-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,3-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,3-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Butanone	1,440	5 U	NA	NA	5 U	5 U	NA
2-Hexanone	--	5 U	NA	NA	5 U	5 U	5 U
Acetone	700	5 U	NA	NA	5 U	5 U	5 U
Benzene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromochloromethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromodichloromethane	6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromoform	44	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromomethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
sec-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
tert-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG^1 (µg/L)	MW-01					
		10/26/2000	5/16/2001	12/5/2002	4/23/2003	9/19/2003	5/11/2004
Volatile Organic Compounds (VOCs)							
Carbon Disulfide	--	0.5 U	NA	NA	0.5 U	0.5 U	0.5 U
Carbon Tetrachloride	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chlorobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	57	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloromethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Chlorotoluene	100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dibromochloromethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dibromo-3-chloropropane	0.2	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
1,2-Dibromoethane (EDB)	0.004	0.5 U	0.02 U	0.005 U	0.005 U	0.005 U	0.005 U
Dibromomethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichlorobenzene	63	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichlorobenzene	60	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,4-Dichlorobenzene	21	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dichlorodifluoromethane	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Ethylbenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Hexachlorobutadiene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Isopropylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
p-Isopropyltoluene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Methylene Chloride	47	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Methyl-2-pentanone	--	5 U	NA	NA	NA	NA	NA
MTBE	35	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Naphthalene	14	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Propylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Styrene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrachloroethene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	MW-01					
		10/26/2000	5/16/2001	12/5/2002	4/23/2003	9/19/2003	5/11/2004
Volatile Organic Compounds (VOCs)							
Tetrahydrofuran	70	5 U	NA	NA	2.5 U	2.5 U	2.5 U
Toloune	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3,5-Trichlorobenzene	40	0.5 U	NA	NA	0.5 U	0.5 U	NA
1,2,4-Trichlorobenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichloroethene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichlorofluoromethane	2,100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,3-Trichloropropane	0.05	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
1,2,4-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3,5-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl Acetate	--	0.5 U	NA	NA	NA	NA	NA
o-Xylene	10,000 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
m,p-Xylene	10,000 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl Chloride	0.15	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Total Petroleum Hydrocarbons (TPH)							
TPH-DRO	0.05 mg/L	0.05 U	0.05 U	0.05 UJ	0.05 U	0.05 U	0.05 U
TPH-GRO	0.05 mg/L	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	MW-02					
		10/26/2000	5/15/2001	12/5/2002	4/22/2003	9/19/2003	5/11/2004
Volatile Organic Compounds (VOCs)							
1,1,1-Trichloroethane	200	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2-Trichloroethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,1,2-Tetrachloroethane	13	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	1.8	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethene	0.6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloroethane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,2-Dichloroethene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,2-Dichloroethene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloropropane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2,2-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,3-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,3-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Butanone	1,440	5 U	NA	NA	5 U	5 U	NA
2-Hexanone	--	5 U	NA	NA	5 U	5 U	5 U
Acetone	700	5 U	NA	NA	5 U	5 U	5 U
Benzene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromochloromethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromodichloromethane	6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromoform	44	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromomethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
sec-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
tert-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	MW-02 10/26/2000	MW-02 5/15/2001	MW-02 12/5/2002	MW-02 4/22/2003	MW-02 9/19/2003	MW-02 5/11/2004
Volatile Organic Compounds (VOCs)							
Carbon Disulfide	--	0.5 U	NA	NA	0.5 U	0.5 U	0.5 U
Carbon Tetrachloride	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chlorobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	57	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloromethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Chlorotoluene	100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dibromochloromethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dibromo-3-chloropropane	0.2	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
1,2-Dibromoethane (EDB)	0.004	0.5 U	0.02 U	0.005 U	0.005 U	0.005 U	0.005 U
Dibromomethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichlorobenzene	63	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichlorobenzene	60	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,4-Dichlorobenzene	21	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dichlorodifluoromethane	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Ethylbenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Hexachlorobutadiene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Isopropylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
p-Isopropyltoluene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Methylene Chloride	47	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Methyl-2-pentanone	--	5 U	NA	NA	NA	NA	NA
MTBE	35	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Naphthalene	14	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Propylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Styrene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrachloroethene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	MW-02					
		10/26/2000	5/15/2001	12/5/2002	4/22/2003	9/19/2003	5/11/2004
Volatile Organic Compounds (VOCs)							
Tetrahydrofuran	70	5 U	NA	NA	2.5 U	2.5 U	2.5 U
Toloune	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3,5-Trichlorobenzene	40	0.5 U	NA	NA	0.5 U	0.5 U	NA
1,2,4-Trichlorobenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichloroethene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichlorofluoromethane	2,100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,3-Trichloropropane	0.05	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
1,2,4-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3,5-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl Acetate	--	0.5 U	NA	NA	NA	NA	NA
o-Xylene	10,000 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
m,p-Xylene	10,000 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl Chloride	0.15	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Total Petroleum Hydrocarbons (TPH)							
TPH-DRO	0.05 mg/L	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
TPH-GRO	0.05 mg/L	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

	MEDEP MEG[1]	**MW-03**					
Analyte of Concern	**(µg/L)**	**10/26/2000**	**5/15/2001**	**12/5/2002**	**4/23/2003**	**9/18/2003**	**5/11/2004**
Volatile Organic Compounds (VOCs)							
1,1,1-Trichloroethane	200	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2-Trichloroethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,1,2-Tetrachloroethane	13	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	1.8	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethene	0.6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloroethane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,2-Dichloroethene	70	0.5 U	0.5 U	0.5 U	*0.79*	0.5 U	0.5 U
trans-1,2-Dichloroethene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloropropane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2,2-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,3-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,3-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Butanone	1,440	5 U	NA	NA	5 U	5 U	NA
2-Hexanone	--	5 U	NA	NA	5 U	5 U	5 U
Acetone	700	5 U	NA	NA	5 U	5 U	5 U
Benzene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromochloromethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromodichloromethane	6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromoform	44	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromomethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
sec-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
tert-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	MW-03					
		10/26/2000	**5/15/2001**	**12/5/2002**	**4/23/2003**	**9/18/2003**	**5/11/2004**
Volatile Organic Compounds (VOCs)							
Carbon Disulfide	--	0.5 U	NA	NA	0.5 U	0.5 U	0.5 U
Carbon Tetrachloride	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chlorobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	57	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloromethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Chlorotoluene	100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dibromochloromethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dibromo-3-chloropropane	0.2	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
1,2-Dibromoethane (EDB)	0.004	0.5 U	0.02 U	0.005 U	0.005 U	0.005 U	0.005 U
Dibromomethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichlorobenzene	63	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichlorobenzene	60	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,4-Dichlorobenzene	21	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dichlorodifluoromethane	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Ethylbenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Hexachlorobutadiene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Isopropylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
p-Isopropyltoluene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Methylene Chloride	47	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Methyl-2-pentanone	--	5 U	NA	NA	NA	NA	NA
MTBE	35	0.5 U	*0.46 J*	0.5 U	0.5 U	0.5 U	0.5 U
Naphthalene	14	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Propylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Styrene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrachloroethene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	**MEDEP MEG^1 (µg/L)**	**MW-03**					
		10/26/2000	**5/15/2001**	**12/5/2002**	**4/23/2003**	**9/18/2003**	**5/11/2004**
Volatile Organic Compounds (VOCs)							
Tetrahydrofuran	70	5 U	NA	NA	2.5 U	2.5 U	2.5 U
Toloune	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3,5-Trichlorobenzene	40	0.5 U	NA	NA	0.5 U	0.5 U	NA
1,2,4-Trichlorobenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichloroethene	5	0.5 U	0.5 U	0.5 U	*0.76*	0.5 U	0.5 U
Trichlorofluoromethane	2,100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,3-Trichloropropane	0.05	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
1,2,4-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3,5-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl Acetate	--	0.5 U	NA	NA	NA	NA	NA
o-Xylene	10,000 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
m,p-Xylene	10,000 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl Chloride	0.15	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Total Petroleum Hydrocarbons (TPH)							
TPH-DRO	0.05 mg/L	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
TPH-GRO	0.05 mg/L	0.01 U	***0.068***	0.01 U	0.01 U	0.01 U	0.01 U

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	MW-04					
		10/26/2000	5/15/2001	12/5/2002	4/22/2003	9/19/2003	5/11/2004
Volatile Organic Compounds (VOCs)							
1,1,1-Trichloroethane	200	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2-Trichloroethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,1,2-Tetrachloroethane	13	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	1.8	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethene	0.6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloroethane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,2-Dichloroethene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,2-Dichloroethene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloropropane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2,2-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,3-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,3-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Butanone	1,440	5 U	NA	NA	5 U	5 U	NA
2-Hexanone	--	5 U	NA	NA	5 U	5 U	5 U
Acetone	700	5 U	NA	NA	5 U	5 U	5 U
Benzene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromochloromethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromodichloromethane	6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromoform	44	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromomethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
sec-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
tert-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	MW-04					
		10/26/2000	5/15/2001	12/5/2002	4/22/2003	9/19/2003	5/11/2004
Volatile Organic Compounds (VOCs)							
Carbon Disulfide	--	0.5 U	NA	NA	0.5 U	0.5 U	0.5 U
Carbon Tetrachloride	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chlorobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	57	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloromethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Chlorotoluene	100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dibromochloromethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dibromo-3-chloropropane	0.2	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
1,2-Dibromoethane (EDB)	0.004	0.5 U	0.02 U	0.005 U	0.005 U	0.005 U	0.005 U
Dibromomethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichlorobenzene	63	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichlorobenzene	60	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,4-Dichlorobenzene	21	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dichlorodifluoromethane	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Ethylbenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Hexachlorobutadiene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Isopropylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
p-Isopropyltoluene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Methylene Chloride	47	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Methyl-2-pentanone	--	5 U	NA	NA	NA	NA	NA
MTBE	35	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Naphthalene	14	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Propylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Styrene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrachloroethene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	MW-04					
		10/26/2000	5/15/2001	12/5/2002	4/22/2003	9/19/2003	5/11/2004
Volatile Organic Compounds (VOCs)							
Tetrahydrofuran	70	5 U	NA	NA	2.5 U	2.5 U	2.5 U
Toloune	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3,5-Trichlorobenzene	40	0.5 U	NA	NA	0.5 U	0.5 U	NA
1,2,4-Trichlorobenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichloroethene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichlorofluoromethane	2,100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,3-Trichloropropane	0.05	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
1,2,4-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3,5-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl Acetate	--	0.5 U	NA	NA	NA	NA	NA
o-Xylene	10,000 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
m,p-Xylene	10,000 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl Chloride	0.15	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Total Petroleum Hydrocarbons (TPH)							
TPH-DRO	0.05 mg/L	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
TPH-GRO	0.05 mg/L	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	MW-05					
		10/26/2000	5/16/2001	12/5/2002	4/22/2003	9/18/2003	5/11/2004
Volatile Organic Compounds (VOCs)							
1,1,1-Trichloroethane	200	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2-Trichloroethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,1,2-Tetrachloroethane	13	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	1.8	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethene	0.6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloroethane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,2-Dichloroethene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,2-Dichloroethene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloropropane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2,2-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,3-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,3-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Butanone	1,440	5 U	NA	NA	5 U	5 U	NA
2-Hexanone	--	5 U	NA	NA	5 U	5 U	5 U
Acetone	700	5 U	NA	NA	5 U	5 U	5 U
Benzene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromochloromethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromodichloromethane	6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromoform	44	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromomethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
sec-Butylbenzene	--	*3.7*	*2.5*	*3.6*	*1.7*	*3*	*2.5*
tert-Butylbenzene	--	*1.9*	*1.2*	*1.9*	*1.0*	*1.5*	*1.3*

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	MW-05					
		10/26/2000	5/16/2001	12/5/2002	4/22/2003	9/18/2003	5/11/2004
Volatile Organic Compounds (VOCs)							
Carbon Disulfide	--	0.5 U	NA	NA	*0.44 J*	*0.44 J*	0.5 U
Carbon Tetrachloride	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chlorobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	57	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloromethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Chlorotoluene	100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dibromochloromethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dibromo-3-chloropropane	0.2	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
1,2-Dibromoethane (EDB)	0.004	0.5 U	0.02 U	0.005 U	0.005 U	0.005 U	0.005 U
Dibromomethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichlorobenzene	63	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichlorobenzene	60	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,4-Dichlorobenzene	21	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dichlorodifluoromethane	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Ethylbenzene	70	*0.82*	0.5 U	*0.36 J*	*0.29 J*	0.5 U	0.5 U
Hexachlorobutadiene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Isopropylbenzene	--	*2.1*	*0.65*	*1.3*	*0.63*	*0.88*	*0.79*
p-Isopropyltoluene	70	*2.4*	*1.0*	*1.4*	*0.3 J*	*1.2*	*0.9*
Methylene Chloride	47	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Methyl-2-pentanone	--	5 U	NA	NA	NA	NA	NA
MTBE	35	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Naphthalene	14	*6.1*	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Propylbenzene	--	*1.8*	*0.81*	*1.3*	*0.56*	*1*	*0.87*
Styrene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrachloroethene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	MW-05					
		10/26/2000	**5/16/2001**	**12/5/2002**	**4/22/2003**	**9/18/2003**	**5/11/2004**
Volatile Organic Compounds (VOCs)							
Tetrahydrofuran	70	5 U	NA	NA	2.5 U	2.5 U	2.5 U
Toloune	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3,5-Trichlorobenzene	40	0.5 U	NA	NA	0.5 U	0.5 U	NA
1,2,4-Trichlorobenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichloroethene	5	0.5 U	*0.36 J*	*0.48 J*	*0.38 J*	*0.47 J*	*0.41 J*
Trichlorofluoromethane	2,100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,3-Trichloropropane	0.05	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
1,2,4-Trimethylbenzene	--	*8.5*	*0.6*	*2.7*	*0.67*	*0.93* J[2]	*0.58*
1,3,5-Trimethylbenzene	--	*1.3*	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl Acetate	--	0.5 U	NA	NA	NA	NA	NA
o-Xylene	10,000 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
m,p-Xylene	10,000 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl Chloride	0.15	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Total Petroleum Hydrocarbons (TPH)							
TPH-DRO	0.05 mg/L	***0.570***	***0.301***	***0.409***	***0.197***	***0.169***	***0.146***
TPH-GRO	0.05 mg/L	***0.324***	***0.152***	***0.246***	***0.095***	***0.274***	***0.169***

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	MW-05 (Duplicate)					
		10/26/2000	5/16/2001	12/5/2002	4/22/2003	9/18/2003	5/11/2004
Volatile Organic Compounds (VOCs)							
1,1,1-Trichloroethane	200	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2-Trichloroethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,1,2-Tetrachloroethane	13	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	1.8	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethene	0.6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloroethane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,2-Dichloroethene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,2-Dichloroethene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloropropane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2,2-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,3-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,3-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Butanone	1,440	5 U	NA	NA	5 U	5 U	NA
2-Hexanone	--	5 U	NA	NA	5 U	5 U	5 U
Acetone	700	5 U	NA	NA	5 U	5 U	5 U
Benzene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromochloromethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromodichloromethane	6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromoform	44	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromomethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
sec-Butylbenzene	--	*3.9*	*2.5*	*3.6*	*1.7*	*2.9*	*2.4*
tert-Butylbenzene	--	*2.1*	*1.2*	*1.8*	*1.1*	*1.4*	*1.3*

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

	MEDEP MEG^1	MW-05 (Duplicate)					
Analyte of Concern	**(µg/L)**	**10/26/2000**	**5/16/2001**	**12/5/2002**	**4/22/2003**	**9/18/2003**	**5/11/2004**
Volatile Organic Compounds (VOCs)							
Carbon Disulfide	--	0.5 U	NA	NA	*0.44 J*	0.5 U	0.5 U
Carbon Tetrachloride	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chlorobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	57	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloromethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Chlorotoluene	100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dibromochloromethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dibromo-3-chloropropane	0.2	0.5 U	0.02 U	0.5 U	0.02 U	NA	0.5 U
1,2-Dibromoethane (EDB)	0.004	0.5 U	0.02 U	0.5 U	0.005 U	NA	0.5 U
Dibromomethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichlorobenzene	63	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichlorobenzene	60	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,4-Dichlorobenzene	21	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dichlorodifluoromethane	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Ethylbenzene	70	*0.73*	0.5 U	*0.36 J*	*0.30 J*	0.50 U	0.5 U
Hexachlorobutadiene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Isopropylbenzene	--	*2.1*	*0.69*	*1.3*	*0.68*	*0.86*	*0.79*
p-Isopropyltoluene	70	*2.6*	*1.1*	*1.4*	*0.32 J*	*1.2*	*0.82*
Methylene Chloride	47	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Methyl-2-pentanone	--	5 U	NA	NA	NA	NA	NA
MTBE	35	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Naphthalene	14	*5.8*	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Propylbenzene	--	*2.0*	*0.86*	*1.3*	*0.57*	*0.99*	*0.82*
Styrene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrachloroethene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	MW-05 (Duplicate)					
		10/26/2000	**5/16/2001**	**12/5/2002**	**4/22/2003**	**9/18/2003**	**5/11/2004**
Volatile Organic Compounds (VOCs)							
Tetrahydrofuran	70	5 U	NA	NA	2.5 U	2.5 U	2.5 U
Toloune	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3,5-Trichlorobenzene	40	0.5 U	NA	NA	0.5 U	0.5 U	NA
1,2,4-Trichlorobenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichloroethene	5	0.5 U	*0.38 J*	*0.5*	*0.39 J*	*0.47 J*	*0.38 J*
Trichlorofluoromethane	2,100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,3-Trichloropropane	0.05	0.5 U	0.02 U	0.5 U	0.02 U	NA	0.5 U
1,2,4-Trimethylbenzene	--	*8.4*	*0.64*	*2.6*	*0.70*	*0.62* J[2]	*0.44 J*
1,3,5-Trimethylbenzene	--	*1.2*	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl Acetate	--	0.5 U	NA	NA	NA	NA	NA
o-Xylene	10,000 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
m,p-Xylene	10,000 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl Chloride	0.15	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Total Petroleum Hydrocarbons (TPH)							
TPH-DRO	0.05 mg/L	***0.572***	***0.294***	***0.391***	***0.185***	***0.227***	***0.161***
TPH-GRO	0.05 mg/L	***0.308***	***0.171***	***0.258***	***0.097***	***0.253***	***0.146***

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	DW-01 (AMAC)					
		10/26/2000	5/15/2001	12/5/2002	4/22/2003	9/18/2003	5/11/2004
Volatile Organic Compounds (VOCs)							
1,1,1-Trichloroethane	200	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2-Trichloroethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,1,2-Tetrachloroethane	13	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	1.8	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethene	0.6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloroethane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,2-Dichloroethene	70	*2.8*	*2.0*	*1.2*	0.5 U	0.5 U	*1.4*
trans-1,2-Dichloroethene	70	0.5 U	0.5 U	0.5 U	0.5 U	*2.9*	0.5 U
1,2-Dichloropropane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2,2-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,3-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,3-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Butanone	1,440	5 U	NA	NA	5 U	5 U	NA
2-Hexanone	--	5 U	NA	NA	5 U	5 U	5 U
Acetone	700	5 U	NA	NA	5 U	5 U	5 U
Benzene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromochloromethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromodichloromethane	6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromoform	44	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromomethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
sec-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
tert-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	DW-01 (AMAC)					
		10/26/2000	5/15/2001	12/5/2002	4/22/2003	9/18/2003	5/11/2004
Volatile Organic Compounds (VOCs)							
Carbon Disulfide	--	0.5 U	NA	NA	NA	NA	0.5 U
Carbon Tetrachloride	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chlorobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	57	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloromethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Chlorotoluene	100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dibromochloromethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dibromo-3-chloropropane	0.2	0.5 U	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U
1,2-Dibromoethane (EDB)	0.004	0.5 U	0.5 U	0.005 U	0.005 U	0.005 U	0.005 U
Dibromomethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichlorobenzene	63	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichlorobenzene	60	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,4-Dichlorobenzene	21	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dichlorodifluoromethane	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Ethylbenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Hexachlorobutadiene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Isopropylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
p-Isopropyltoluene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Methylene Chloride	47	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Methyl-2-pentanone	--	5 U	NA	NA	NA	NA	NA
MTBE	35	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Naphthalene	14	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Propylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Styrene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrachloroethene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	DW-01 (AMAC)					
		10/26/2000	5/15/2001	12/5/2002	4/22/2003	9/18/2003	5/11/2004
Volatile Organic Compounds (VOCs)							
Tetrahydrofuran	70	5 U	NA	NA	NA	NA	2.5 U
Toloune	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3,5-Trichlorobenzene	40	0.5 U	NA	NA	NA	NA	NA
1,2,4-Trichlorobenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichloroethene	5	***5.7***	*4.5*	***6.0***	*1.2*	***5.8***	***5.8***
Trichlorofluoromethane	2,100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,3-Trichloropropane	0.05	0.5 U	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U
1,2,4-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3,5-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl Acetate	--	0.5 U	NA	NA	NA	NA	NA
o-Xylene	10,000 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
m,p-Xylene	10,000 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl Chloride	0.15	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Total Petroleum Hydrocarbons (TPH)							
TPH-DRO	0.05 mg/L	0.05 U	0.05 U	0.05 UJ	0.05 U	0.05 U	0.05 U
TPH-GRO	0.05 mg/L	NS	NS	0.01 U	0.01 U	0.01 U	0.01 U

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	DW-02 (VFW) 10/26/2000	5/15/2001	12/5/2002	4/23/2003	9/18/2003	5/11/2004
Volatile Organic Compounds (VOCs)							
1,1,1-Trichloroethane	200	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2-Trichloroethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,1,2-Tetrachloroethane	13	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	1.8	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethene	0.6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloroethane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,2-Dichloroethene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,2-Dichloroethene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloropropane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2,2-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,3-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,3-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Butanone	1,440	5 U	NA	NA	5 U	5 U	NA
2-Hexanone	--	5 U	NA	NA	5 U	5 U	5 U
Acetone	700	5 U	NA	NA	5 U	5 U	5 U
Benzene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromochloromethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromodichloromethane	6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromoform	44	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromomethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
sec-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
tert-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Carbon Disulfide	--	0.5 U	NA	NA	NA	NA	0.5 U
Carbon Tetrachloride	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chlorobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	57	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloromethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	DW-02 (VFW)					
		10/26/2000	5/15/2001	12/5/2002	4/23/2003	9/18/2003	5/11/2004
Volatile Organic Compounds (VOCs)							
4-Chlorotoluene	100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dibromochloromethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dibromo-3-chloropropane	0.2	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
1,2-Dibromoethane (EDB)	0.004	0.5 U	0.02 U	0.005 U	0.005 U	0.005 U	0.005 U
Dibromomethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichlorobenzene	63	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichlorobenzene	60	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,4-Dichlorobenzene	21	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	*0.26 J*
Dichlorodifluoromethane	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Ethylbenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Hexachlorobutadiene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Isopropylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
p-Isopropyltoluene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Methylene Chloride	47	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Methyl-2-pentanone	--	5 U	NA	NA	NA	NA	NA
MTBE	35	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Naphthalene	14	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Propylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Styrene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrachloroethene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrahydrofuran	70	5 U	NA	NA	NA	NA	2.5 U
Toloune	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3,5-Trichlorobenzene	40	0.5 U	NA	NA	NA	NA	NA
1,2,4-Trichlorobenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichloroethene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichlorofluoromethane	2,100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,3-Trichloropropane	0.05	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
1,2,4-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3,5-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl Acetate	--	0.5 U	NA	NA	NA	NA	NA
o-Xylene	10,000 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
m,p-Xylene	10,000 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl Chloride	0.15	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U
Total Petroleum Hydrocarbons (TPH)							

TABLE 3-4
GROUNDWATER AND DRINKING WATER ANALYTICAL RESULTS
FORMER NIKE LO-58 LAUNCH SITE
CARIBOU, MAINE

Analyte of Concern	MEDEP MEG[1] (µg/L)	DW-02 (VFW) 10/26/2000	5/15/2001	12/5/2002	4/23/2003	9/18/2003	5/11/2004
Volatile Organic Compounds (VOCs)							
TPH-DRO	0.05 mg/L	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
TPH-GRO	0.05 mg/L	NS	NS	0.01 U	0.01 U	0.01 U	0.01 U

[1] For groundwater volatile organic compounds, Regulatory Criteria values are "Maximum Exposure Guidelines (MEGs) for Drinking Water" (MEDEP, 1992), or EPA Maximum Contaminant Level (MCL), whichever is less.

Values shown are in units of µg/L unless noted [diesel range organics (DRO) and gasoline range organics (GRO)].

Values shown in *Italics* indicate that the compound was detected, but at a concentration below its MEG.

Values shown in ***BOLD*** indicate that the compound was detected above its respective MEG.

U = Not detected at associated reporting limit.

J = Concentration is estimated.

UJ = DRO non-detect results are estimated due to low surrogate recovery.

(µg/L)= Microgram per Liter

NS = Not Sampled.

NA = Not Analyzed.

Table 2-6

Summary of Drinking Water Well Wire-Line Straddle Packer Sampling Analytical Results
Maine Formerly Used Defense Site LO-58
Borehole Hydrophysics and Geophysics Report

Well	Maine Maximum Exposure Guideline (µg/L)	EPA Maximum Contaminant Limit (µg/L)	DW-1					
Field Sample ID			LS58DW1-0508-29	LS58DW1-0508-34	LS58DW1-0508-34E	LS58DW1-0508-41	LS58DW1-0508-51	LS58DW1-0508-56
Sample Date			5/20/2008	5/20/2008	5/20/2008	5/19/2008	5/19/2008	5/18/2008
Depth Interval (ft bgs)			(water) 24.98 to 33.15	33.75 to 38.5		41.2 to 51.9	51.0 to 58.1 (bottom)	56.6 to 58.1 (bottom)
Volatile Organic Compounds by EPA Method 524.2 (µg/L)								
Benzene	6	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	70	NE	**0.52**	0.5 U	0.5 U	**0.24 J**	0.5 U	**0.34 J**
cis-1,2-Dichloroethylene	70	70	0.5 U	**0.44 J**	**0.45 J**	**1.2**	**0.96**	**0.52**
Trichloroethylene	32*	5	**1.8**	**2.5**	**2.5**	**3.4**	**3.1**	**2**
Toluene	1,400	1,000	**120 D**	**25**	**22**	**12**	0.5 U	**22**
1,2-Ethylene Dibromide, 1,2-Dibromo-3-Chloropropane, and 1,2,3-Trichloropronane by EPA Method 504.1 (µg/L)								
No analytes detected								
Gasoline Range Organics by the Maine Health and Environmental Testing Laboratory Method 4.1.17 (µg/L)								
Gasoline Range Organics	50	NE	**156**	**24**	**23**	**14**	10 U	**27**
Diesel Range Organics by the Maine Health and Environmental Testing Laboratory Method 4.1.25 (µg/L)								
Diesel Range Organics	50	NE	50 U	50 U	50 U	**51 J^1**	50 U	**350 J^1**

Well	Maine Maximum Exposure Guideline (µg/L)	EPA Maximum Contaminant Limit (µg/L)	DW-2					
Field Sample ID			LS58DW2-0508-16	LS58DW2-0508-28.5	LS58DW2-0508-37	LS58DW2-0508-94.5	LS58DW2-0508-189	LS58DW2-0508-265
Sample Date			5/16/2008	5/16/2008	5/17/2008	5/17/2008	5/17/2008	5/17/2008
Depth Interval (ft bgs)			16.0 to 20.0	28.5 to 32.5	37.0 to 41.7	94.5 to 98.5	187.9 to 192.2	265 to 284.0 (bottom)
Volatile Organic Compounds by EPA Method 524.2 (µg/L)								
Benzene	6	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	70	NE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U U
cis-1,2-Dichloroethylene	70	70	0.5 U	0.5 U	0.5 U	0.5 U	**0.23 J**	0.5 U
Trichloroethylene	32*	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Toluene	1,400	1,000	**2.4**	0.5 U	0.5 U	**5.5**	2.3 U^1	0.79 U^1
1,2-Ethylene Dibromide, 1,2-Dibromo-3-Chloropropane, and 1,2,3-Trichloropronane by EPA Method 504.1 (µg/L)								
No analytes detected								
Gasoline Range Organics by the Maine Health and Environmental Testing Laboratory Method 4.1.17 (µg/L)								
Gasoline Range Organics	50	NE	10 U	10 U	10 U	10 U	10 U	10 U
Diesel Range Organics by the Maine Health and Environmental Testing Laboratory Method 4.1.25 (µg/L)								
Diesel Range Organics	50	NE	**1,050**	50 U	50 U	50 U	50 U	**80 J^1**

Notes:

NE = Standard not established.

µg/L = Micrograms per liter (parts per billion).

ft bgs = Feet below ground surface.

Bold = Substance Detected.

Blue Highlight = Exceeds Maine Maximum Exposure Guideline.

EPA = United States Environmental Protection Agency

D = Result from dilution analysis.

J = Quantitation approximate.

J^1 = Diesel range organics quantitation approximate due to detection in rinsate blank.

U = substance not detected at the listed detection limit.

U^1 = Toluene qualifiued as not detected due to detection in rinsate blank.

* = Although the Maine Maximum Exposure Guideline is 32 µg/L, the action level used by the State of Maine is one-half the EPA Maximum Contaminant Level, 2.5 µg/L.

Table 4-3
Groundwater Analytical Results - Volatile Organic Compounds, DRO/GRO
Former Nike LO-58 Launch Site
Caribou, *Maine*

Analyte of Concern	MEDEP MEG/ EPA MCL^1 (µg/L) except where noted	Monitoring Well MW-03																
		10/26/2000	5/15/2001	12/5/2002	4/23/2003	9/18/2003	5/11/2004	9/30/2004	4/25/2005	9/14/2005	5/23/2006	5/23/2007	10/25/2007	4/30/2008	10/29/2008	5/1/2009	10/31/2009	5/26/2010
Volatile Organic Compounds (VOC)																		
1,1,1-Trichloroethane	200	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2-Trichloroethane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,1,2-Tetrachloroethane	13	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	1.8	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloroethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,2-Dichloroethene	70	0.5 U	0.5 U	0.5 U	*0.79*	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,2-Dichloroethene	100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloropropane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2,2-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,3-Dichloropropene	4 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,3-Dichloropropene	4 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Benzene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromochloromethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromodichloromethane	6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromoform	44	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromomethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
sec-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
tert-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Carbon Disulfide	--	0.5 U	NA	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Carbon Tetrachloride	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chlorobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

Table 4-3
Groundwater Analytical Results - Volatile Organic Compounds, DRO/GRO
Former Nike LO-58 Launch Site
Caribou, *Maine*

Analyte of Concern	MEDEP MEG/ EPA MCL^1 (µg/L) except where noted	Monitoring Well MW-03																
		10/26/2000	5/15/2001	12/5/2002	4/23/2003	9/18/2003	5/11/2004	9/30/2004	4/25/2005	9/14/2005	5/23/2006	5/23/2007	10/25/2007	4/30/2008	10/29/2008	5/1/2009	10/31/2009	5/26/2010
Volatile Organic Compounds (VOC)																		
Chloroethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloromethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dibromochloromethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dibromo-3-chloropropane	0.2	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
1,2-Dibromoethane (EDB)	0.05	0.5 U	0.02 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.006 U	0.005 U	0.005 U	0.005 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Dibromomethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichlorobenzene	63	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichlorobenzene	60	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,4-Dichlorobenzene	21	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dichlorodifluoromethane	1,400	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Ethylbenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Hexachlorobutadiene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Isopropylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
p-Isopropyltoluene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ
Methylene Chloride	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
MTBE	35	0.5 U	*0.46 J*	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Naphthalene	14	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Propylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Styrene	100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrachloroethene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrahydrofuran	70	5 U	NA	NA	2.5 U	2.5 U	2.5 U	2.5 U	*10*	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Toluene	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	*0.3 J*	0.5 U	0.5 U	0.5 U
1,2,4-Trichlorobenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichloroethene	5	0.5 U	0.5 U	0.5 U	*0.76*	0.5 U	0.5 U	*0.29 J*	*1.1*	0.5 U	*0.45 J*	0.5 U	0.5 U	0.5 U	0.8	0.5 U	0.4 J	0.5 U
Trichlorofluoromethane	2,100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,3-Trichloropropane	0.05	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,4-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3,5-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
o-Xylene	1,400 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
m,p-Xylene	1,400 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	*0.3 J*	0.5 U	0.5 U	0.5 U
Vinyl Chloride	0.2	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.5 U	0.5 U	0.5 U	0.1 U

Table 4-3
Groundwater Analytical Results - Volatile Organic Compounds, DRO/GRO
Former Nike LO-58 Launch Site
Caribou, *Maine*

Analyte of Concern	MEDEP MEG/ EPA MCL^1 (µg/L) except where noted	Monitoring Well MW-03																
		10/26/2000	5/15/2001	12/5/2002	4/23/2003	9/18/2003	5/11/2004	9/30/2004	4/25/2005	9/14/2005	5/23/2006	5/23/2007	10/25/2007	4/30/2008	10/29/2008	5/1/2009	10/31/2009	5/26/2010
Total Petroleum Hydrocarbons (TPH)																		
TPH-DRO	0.05 mg/L	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
TPH-GRO	0.05 mg/L	0.01 U	***0.068***	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 UJ	0.01 UJ

Notes: [1] For groundwater volatile organic compounds, Regulatory Criteria values are "Maximum Exposure Guidelines (MEG) for Drinking Water" (MEDEP, revised 2008), or U.S. Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL), whichever is less.

Values shown are in units of micrograms per liter (µg/L) unless noted [diesel range organics (DRO) and gasoline range organics (GRO)].

Values shown in ***BOLD*** indicate that the compound was detected, but at a concentration below its MEG/MCL.

Values shown in ***BOLD*** and SHADED indicate that the compound was detected at or above its respective MEG/MCL.

U = Not detected at associated reporting limit.

J = Concentration is estimated.

J^1/UJ^1 = Concentration is estimated because field duplicate criteria was not met.

J^2 = Diesel range organics (DRO) results are qualified as estimated due to DRO detection in the rinsate/equipment blank sample (10/24/06 only). Sample results may be biased high.

MEDEP = Maine Department of Environmental Protection

mg/L = Milligrams per liter

NA = Not analyzed

AMAC = Adult Multiple Alternative Center

VFW = Veterans of Foreign Wars

NS = Not sampled

Table 4-3
Groundwater Analytical Results - Volatile Organic Compounds, DRO/GRO
Former Nike LO-58 Launch Site
Caribou, *Maine*

Analyte of Concern	MEDEP MEG/ EPA MCL[1] (µg/L) except where noted	Monitoring Well MW-05																	
		10/26/2000	5/16/2001	12/5/2002	4/22/2003	9/18/2003	5/11/2004	9/30/2004	4/25/2005	9/14/2005	5/23/2006	10/24/2006	5/24/2007	10/25/2007	4/30/2008	10/29/2008	5/1/2009	10/31/2009	5/26/2010
Volatile Organic Compounds (VOC)																			
1,1,1-Trichloroethane	200	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2-Trichloroethane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,1,2-Tetrachloroethane	13	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	1.8	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloroethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,2-Dichloroethene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,2-Dichloroethene	100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloropropane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichloropropane	–	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2,2-Dichloropropane	–	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloropropene	–	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,3-Dichloropropene	4 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,3-Dichloropropene	4 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Benzene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromochloromethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromodichloromethane	6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromobenzene	–	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromoform	44	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromomethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Butylbenzene	–	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
sec-Butylbenzene	–	*3.7*	*2.5*	*3.6*	*1.7*	*3*	*2.5*	*3*	*1.2*	*2.9*	*1.3*	*2.5*	*1.2*	*3.0*	0.5 U	*0.3 J*	*0.4 J*	*1.2*	*0.3 J*
tert-Butylbenzene	–	*1.9*	*1.2*	*1.9*	*1.0*	*1.5*	*1.3*	*1.4*	*0.62*	*1.5*	*0.71*	*1.6*	*0.7*	*1.7*	0.5 U	0.5 U	0.5 U	0.8	0.5 U
Carbon Disulfide	–	0.5 U	NA	NA	*0.44 J*	*0.44 J*	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Carbon Tetrachloride	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chlorobenzene	–	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

Table 4-3
Groundwater Analytical Results - Volatile Organic Compounds, DRO/GRO
Former Nike LO-58 Launch Site
Caribou, *Maine*

Analyte of Concern	MEDEP MEG/ EPA MCL^1 (µg/L) except where noted	Monitoring Well MW-05																	
		10/26/2000	5/16/2001	12/5/2002	4/22/2003	9/18/2003	5/11/2004	9/30/2004	4/25/2005	9/14/2005	5/23/2006	10/24/2006	5/24/2007	10/25/2007	4/30/2008	10/29/2008	5/1/2009	10/31/2009	5/26/2010
Volatile Organic Compounds (VOC)																			
Chloroethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloromethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dibromochloromethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dibromo-3-chloropropane	0.2	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
1,2-Dibromoethane (EDB)	0.05	0.5 U	0.02 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.006 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.01 U	0.01 U	0.01 U	0.01 U
Dibromomethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichlorobenzene	63	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichlorobenzene	60	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,4-Dichlorobenzene	21	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dichlorodifluoromethane	1,400	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Ethylbenzene	70	***0.82***	0.5 U	***0.36 J***	***0.29 J***	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	***0.5***	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Hexachlorobutadiene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Isopropylbenzene	--	***2.1***	***0.65***	***1.3***	***0.63***	***0.88***	***0.79***	***0.77***	***0.50***	***0.69***	***0.5 J***	***0.7***	***0.5***	***1.7***	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
p-Isopropyltoluene	70	***2.4***	***1.0***	***1.4***	***0.3 J***	***1.2***	***0.9***	***1.4***	***0.28 J***	***1.4***	***0.33 J***	***0.3 J***	***0.4 J***	***1.2***	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Methylene Chloride	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ
MTBE	35	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Naphthalene	14	***6.1***	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	***1.0***	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Propylbenzene	--	***1.8***	***0.81***	***1.3***	***0.56***	***1***	***0.87***	***0.92***	***0.47 J***	***0.79***	***0.51***	***0.5***	***0.5***	***1.4***	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Styrene	100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrachloroethene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrahydrofuran	70	5 U	NA	NA	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U
Toluene	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	***0.4 J***	0.5 U	0.5 U	0.5 U
1,2,4-Trichlorobenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichloroethene	5	0.5 U	***0.36 J***	***0.48 J***	***0.38 J***	***0.47 J***	***0.41 J***	***0.44 J***	***0.27 J***	***0.38 J***	***0.34 J***	***0.3 J***	***0.3 J***	***0.4 J***	***0.4 J***	***0.4 J***	***0.4 J***	***0.3 J***	***0.3 J***
Trichlorofluoromethane	2,100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,3-Trichloropropane	0.05	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,4-Trimethylbenzene	--	***8.5***	***0.6***	***2.7***	***0.67***	***0.93 J***	***0.58***	***1.1***	***1.1***	***0.98***	***0.66***	***1.4***	***0.4 J***	***5.6***	0.5 U	***0.3 J***	0.5 U	***0.3 J***	0.5 U
1,3,5-Trimethylbenzene	--	***1.3***	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	***0.6***	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
o-Xylene	1,400 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
m,p-Xylene	1,400 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	***0.4 J***	0.5 U	0.5 U	0.5 U
Vinyl Chloride	0.2	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.5 U	0.5 U	0.5 U	0.5 U

Table 4-3
Groundwater Analytical Results - Volatile Organic Compounds, DRO/GRO
Former Nike LO-58 Launch Site
Caribou, *Maine*

Analyte of Concern	MEDEP MEG/ EPA MCL[1] (µg/L) except where noted	Monitoring Well MW-05																	
		10/26/2000	5/16/2001	12/5/2002	4/22/2003	9/18/2003	5/11/2004	9/30/2004	4/25/2005	9/14/2005	5/23/2006	10/24/2006	5/24/2007	10/25/2007	4/30/2008	10/29/2008	5/1/2009	10/31/2009	5/26/2010
Total Petroleum Hydrocarbons (TPH)																			
TPH-DRO	0.05 mg/L	***0.570***	***0.301***	***0.409***	***0.197***	***0.169***	***0.146***	0.05 U	***0.455***	***0.328***	***0.16***	***0.280 J^2***	***0.152***	***0.312***	0.05 U	0.05 U	0.05 U	***0.063***	0.05 U
TPH-GRO	0.05 mg/L	***0.324***	***0.152***	***0.246***	***0.095***	***0.274***	***0.169***	***0.262***	***0.062***	***0.174 J^1***	***0.09***	***0.134***	***0.112***	***0.276***	0.01 U	***0.026***	***0.032***	***0.027 J***	0.01 UJ

Notes: [1] For groundwater volatile organic compounds, Regulatory Criteria values are "Maximum Exposure Guidelines (MEG) for Drinking Water" (MEDEP, revised 2008), or U.S. Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL), whichever is less.

Values shown are in units of micrograms per liter (µg/L) unless noted [diesel range organics (DRO) and gasoline range organics (GRO)].
Values shown in ***BOLD*** indicate that the compound was detected, but at a concentration below its MEG/MCL.
Values shown in ***BOLD*** and SHADED indicate that the compound was detected at or above its respective MEG/MCL.
U = Not detected at associated reporting limit.
J = Concentration is estimated.
J^1/UJ^1 = Concentration is estimated because field duplicate criteria was not met.
J^2 = Diesel range organics (DRO) results are qualified as estimated due to DRO detection in the rinsate/equipment blank sample (10/24/06 only). Sample results may be biased high.
MEDEP = Maine Department of Environmental Protection
mg/L = Milligrams per liter
NA = Not analyzed
AMAC = Adult Multiple Alternative Center
VFW = Veterans of Foreign Wars
NS = Not sampled

Table 4-3
Groundwater Analytical Results - Volatile Organic Compounds, DRO/GRO
Former Nike LO-58 Launch Site
Caribou, *Maine*

Analyte of Concern	MEDEP MEG/ EPA MCL^1 (µg/L) except where noted	Monitoring Well MW-05 (Duplicate)																	
		10/26/2000	5/16/2001	12/5/2002	4/22/2003	9/18/2003	5/11/2004	9/30/2004	4/25/2005	9/14/2005	5/23/2006	10/24/2006	5/24/2007	10/25/2007	4/30/2008	10/29/2008	5/1/2009	10/31/2009	5/26/2010
Volatile Organic Compounds (VOC)																			
1,1,1-Trichloroethane	200	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2-Trichloroethane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,1,2-Tetrachloroethane	13	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	1.8	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloroethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,2-Dichloroethene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,2-Dichloroethene	100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloropropane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2,2-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,3-Dichloropropene	4 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,3-Dichloropropene	4 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Benzene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromochloromethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromodichloromethane	6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromoform	44	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromomethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
sec-Butylbenzene	--	***3.9***	***2.5***	***3.6***	***1.7***	***2.9***	***2.4***	***3***	***1.3***	***2.9***	***1.3***	***2.5***	***1.3***	***3.1***	0.5 U	***0.4 J***	***0.4 J***	***1.2***	***0.3 J***
tert-Butylbenzene	--	***2.1***	***1.2***	***1.8***	***1.1***	***1.4***	***1.3***	***1.4***	***0.68***	***1.5***	***0.76***	***1.6***	***0.7***	***1.7***	0.5 U	0.5 U	0.5 U	0.8	0.5 U
Carbon Disulfide	--	0.5 U	NA	NA	***0.44 J***	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Carbon Tetrachloride	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chlorobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

Table 4-3
Groundwater Analytical Results - Volatile Organic Compounds, DRO/GRO
Former Nike LO-58 Launch Site
Caribou, *Maine*

Analyte of Concern	MEDEP MEG/ EPA MCL¹ (µg/L) except where noted	Monitoring Well MW-05 (Duplicate)																	
		10/26/2000	5/16/2001	12/5/2002	4/22/2003	9/18/2003	5/11/2004	9/30/2004	4/25/2005	9/14/2005	5/23/2006	10/24/2006	5/24/2007	10/25/2007	4/30/2008	10/29/2008	5/1/2009	10/31/2009	5/26/2010
Volatile Organic Compounds (VOC)																			
Chloroethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloromethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dibromochloromethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dibromo-3-chloropropane	0.2	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.1 U	0.1 U	0.1 U	0.01 U
1,2-Dibromoethane (EDB)	0.05	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.1 U	0.1 U	0.1 U	0.01 U
Dibromomethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichlorobenzene	63	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichlorobenzene	60	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,4-Dichlorobenzene	21	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dichlorodifluoromethane	1,400	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Ethylbenzene	70	*0.73*	0.5 U	*0.36 J*	*0.30 J*	0.50 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	*0.6*	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Hexachlorobutadiene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Isopropylbenzene	--	*2.1*	*0.69*	*1.3*	*0.68*	*0.86*	*0.79*	*0.76*	*0.56*	*0.72*	*0.53*	*0.7*	*0.5*	*1.7*	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
p-Isopropyltoluene	70	*2.6*	*1.1*	*1.4*	*0.32 J*	*1.2*	*0.82*	*1.4*	*0.32 J*	*1.4*	*0.34 J*	*0.3 J*	*0.4 J*	*1.2*	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ
Methylene Chloride	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
MTBE	35	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Naphthalene	14	*5.8*	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	*0.9*	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Propylbenzene	--	*2.0*	*0.86*	*1.3*	*0.57*	*0.99*	*0.82*	*0.90*	*0.52*	*0.82*	*0.52*	*0.5*	*0.5*	*1.4*	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Styrene	100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrachloroethene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrahydrofuran	70	5 U	NA	NA	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U
Toluene	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	*0.3 J*	0.5 U	0.5 U	0.5 U
1,2,4-Trichlorobenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichloroethene	5	0.5 U	*0.38 J*	*0.5*	*0.39 J*	*0.47 J*	*0.38 J*	*0.42 J*	*0.28 J*	*0.37 J*	*0.33 J*	*0.3 J*	*0.3 J*	*0.3 J*	*0.4 J*	*0.3 J*	*0.4 J*	*0.3 J*	*0.3 J*
Trichlorofluoromethane	2,100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,3-Trichloropropane	0.05	0.5 U	0.5 U	0.5 U	0.5 U	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,4-Trimethylbenzene	--	*8.4*	*0.64*	*2.6*	*0.70*	*0.62* J[1]	*0.44 J*	*1.1*	*1.1*	*1.0*	*0.67*	*1.3*	*0.4 J*	*5.4*	0.5 U	*0.3 J*	0.5 U	*0.3 J*	0.5 U
1,3,5-Trimethylbenzene	--	*1.2*	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	*0.6*	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
o-Xylene	1,400 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
m,p-Xylene	1,400 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	*0.4 J*	0.5 U	0.5 U	0.5 U
Vinyl Chloride	0.2	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.5 U	0.5 U	0.5 U	0.5 U

Table 4-3
Groundwater Analytical Results - Volatile Organic Compounds, DRO/GRO
Former Nike LO-58 Launch Site
Caribou, *Maine*

Analyte of Concern	MEDEP MEG/ EPA MCL[1] (µg/L) except where noted	Monitoring Well MW-05 (Duplicate)																	
		10/26/2000	5/16/2001	12/5/2002	4/22/2003	9/18/2003	6/11/2004	9/30/2004	4/25/2005	9/14/2005	5/23/2006	10/24/2006	5/24/2007	10/25/2007	4/30/2008	10/29/2008	5/1/2009	10/31/2009	5/26/2010
Total Petroleum Hydrocarbons (TPH)																			
TPH-DRO	0.05 mg/L	***0.67***	***0.29***	***0.39***	***0.19***	***0.23***	***0.16***	***0.237***	***0.389***	***0.320***	***0.164***	***0.298 J[2]***	***0.156***	***0.344***	0.05 U	0.05 U	0.05 U	***0.07***	0.05 U
TPH-GRO	0.05 mg/L	***0.31***	***0.17***	***0.26***	***0.1***	***0.25***	***0.15***	***0.238***	***0.064***	***0.251 J[1]***	***0.100***	***0.119***	***0.112***	***0.273***	0.01 U	***0.031***	***0.029***	***0.032 J***	0.01 UJ

Notes: [1] For groundwater volatile organic compounds, Regulatory Criteria values are "Maximum Exposure Guidelines (MEG) for Drinking Water" (MEDEP, revised 2008), or U.S. Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL), whichever is less.

Values shown are in units of micrograms per liter (µg/L) unless noted [diesel range organics (DRO) and gasoline range organics (GRO)].

Values shown in ***BOLD*** indicate that the compound was detected, but at a concentration below its MEG/MCL.

Values shown in ***BOLD*** and SHADED indicate that the compound was detected at or above its respective MEG/MCL.

U = Not detected at associated reporting limit.

J = Concentration is estimated.

J[1]/UJ[1] = Concentration is estimated because field duplicate criteria was not met.

J[2] = Diesel range organics (DRO) results are qualified as estimated due to DRO detection in the rinsate/equipment blank sample (10/24/06 only). Sample results may be biased high.

MEDEP = Maine Department of Environmental Protection

mg/L = Milligrams per liter

NA = Not analyzed

AMAC = Adult Multiple Alternative Center

VFW = Veterans of Foreign Wars

NS = Not sampled

Table 4-3

Groundwater Analytical Results - Water Supply Samples
Former Nike LO-58 Launch Site
Caribou, Maine

Analyte of Concern	MEDEP MEG/ EPA MCL[1] (µg/L) except where noted	Drinking Water Supply Well DW-01 (AMAC)													
		10/26/2000	5/15/2001	12/5/2002	4/22/2003	9/18/2003	5/11/2004	9/30/2004	4/25/2005	9/14/2005	5/23/2006	10/24/2006	5/23/2007	10/24/2007	4/30/2008
Volatile Organic Compounds (VOC)															
1,1,1-Trichloroethane	200	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2-Trichloroethane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,1,2-Tetrachloroethane	13	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	1.8	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloroethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,2-Dichloroethene	70	***2.8***	***2.0***	***1.2***	0.5 U	0.5 U	***1.4***	***1.8***	***0.43 J***	***2.5***	***0.65***	***0.5***	***0.8***	***3.2***	0.5 U
trans-1,2-Dichloroethene	100	0.5 U	0.5 U	0.5 U	0.5 U	***2.9***	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloropropane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2,2-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,3-Dichloropropene	4 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,3-Dichloropropene	4 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Benzene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromochloromethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromodichloromethane	6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	***1.2***	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromoform	44	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromomethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
sec-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
tert-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Carbon Disulfide	--	0.5 U	NA	NA	NA	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Carbon Tetrachloride	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chlorobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

Table 4-3

Groundwater Analytical Results - Water Supply Samples
Former Nike LO-58 Launch Site
Caribou, Maine

Analyte of Concern	MEDEP MEG/ EPA MCL[1] (µg/L) except where noted	Drinking Water Supply Well DW-01 (AMAC)													
		10/26/2000	5/15/2001	12/5/2002	4/22/2003	9/18/2003	5/11/2004	9/30/2004	4/25/2005	9/14/2005	5/23/2006	10/24/2006	5/23/2007	10/24/2007	4/30/2008
Volatile Organic Compounds (VOC)															
Chloroethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	***24***	***0.99***	***3.2***	***0.7***	0.5 U	***0.3 J***	0.5 U
Chloromethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dibromochloromethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dibromo-3-chloropropane	0.2	0.5 U	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
1,2-Dibromoethane (EDB)	0.05	0.5 U	0.5 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.006 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Dibromomethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichlorobenzene	63	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichlorobenzene	60	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,4-Dichlorobenzene	21	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dichlorodifluoromethane	1,400	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Ethylbenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Hexachlorobutadiene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Isopropylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
p-Isopropyltoluene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Methylene Chloride	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
MTBE	35	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Naphthalene	14	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Propylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Styrene	100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrachloroethene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrahydrofuran	70	5 U	NA	NA	NA	NA	2.5 U	2.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Toluene	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,4-Trichlorobenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichloroethene	5	***5.7***	***4.5***	***6.0***	***1.2***	***5.8***	***5.8***	***5.5***	***3.5***	***7.1***	***4.3***	***4.0***	***4.5***	***8.4***	***1.2***
Trichlorofluoromethane	2,100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,3-Trichloropropane	0.05	0.5 U	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,4-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3,5-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
o-Xylene	1,400 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.7
m,p-Xylene	1,400 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl Chloride	0.2	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U

Table 4-3

Groundwater Analytical Results - Water Supply Samples
Former Nike LO-58 Launch Site
Caribou, Maine

Analyte of Concern	MEDEP MEG/ EPA MCL[1] (µg/L) except where noted	Drinking Water Supply Well DW-01 (AMAC)													
		10/26/2000	5/15/2001	12/5/2002	4/22/2003	9/18/2003	5/11/2004	9/30/2004	4/25/2005	9/14/2005	5/23/2006	10/24/2006	5/23/2007	10/24/2007	4/30/2008
Total Petroleum Hydrocarbons (TPH)															
TPH-DRO	0.05 mg/L	0.05 U	0.05 U	0.05 UJ[1]	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
TPH-GRO	0.05 mg/L	NS	NS	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U

Notes: [1] For groundwater volatile organic compounds, Regulatory Criteria values are "Maximum Exposure Guidelines (MEG) for Drinking Water" (MEDEP, revised 2008), or U.S. Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL), whichever is less.

Values shown are in units of micrograms per liter (µg/L) unless noted [diesel range organics (DRO) and gasoline range organics (GRO)].

Values shown in ***BOLD*** indicate that the compound was detected, but at a concentration below its MEG/MCL.

Values shown in ***BOLD*** and SHADED indicate that the compound was detected at or above its respective MEG/MCL.

U = Not detected at associated reporting limit.

J = Concentration is estimated.

J^1/UJ^1 = Concentration is estimated because field duplicate criteria was not met.

J^2 = Diesel range organics (DRO) results are qualified as estimated due to DRO detection in the rinsate/equipment blank sample (10/24/06 only). Sample results may be biased high.

MEDEP = Maine Department of Environmental Protection

mg/L = Milligrams per liter

NA = Not analyzed

AMAC = Adult Multiple Alternative Center

VFW = Veterans of Foreign Wars

NS = Not sampled

Table 4-3

Groundwater Analytical Results - Water Supply Samples
Former Nike LO-58 Launch Site
Caribou, Maine

Analyte of Concern	MEDEP MEG/ EPA MCL^1 (µg/L) except where noted	Drinking Water Supply Well DW-01 (AMAC) cont.													
		Pre-filter	Pre-filter	Pre-filter	Between-filters	Post-filter	Pre-filter	Between-filters	Post-filter	Pre-filter	Between-filters	Post-filter	Pre-filter	Between-filters	Post-filter
		10/29/2008	5/1/2009	10/30/2009	10/30/2009	10/30/2009	1/12/2010	1/12/2010	1/12/2010	5/26/2010	5/26/2010	5/26/2010	7/26/2010	7/26/2010	7/26/2010
Volatile Organic Compounds (VOC)															
1,1,1-Trichloroethane	200	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2-Trichloroethane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,1,2-Tetrachloroethane	13	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	1.8	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloroethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,2-Dichloroethene	70	0.5 U	***1.0***	***0.6***	0.5 U	0.5 U	***1.7***	0.5 U	0.5 U	***1.2 J***	0.5 U	0.5 U	***1.3***	0.5 U	0.5 U
trans-1,2-Dichloroethene	100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloropropane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2,2-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,3-Dichloropropene	4 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,3-Dichloropropene	4 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Benzene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromochloromethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromodichloromethane	6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromoform	44	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromomethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
sec-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
tert-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Carbon Disulfide	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Carbon Tetrachloride	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chlorobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

Table 4-3

Groundwater Analytical Results - Water Supply Samples
Former Nike LO-58 Launch Site
Caribou, Maine

Analyte of Concern	MEDEP MEG/ EPA MCL[1] (µg/L) except where noted	Drinking Water Supply Well DW-01 (AMAC) cont.													
		Pre-filter	Pre-filter	Pre-filter	Between-filters	Post-filter	Pre-filter	Between-filters	Post-filter	Pre-filter	Between-filters	Post-filter	Pre-filter	Between-filters	Post-filter
		10/29/2008	5/1/2009	10/30/2009	10/30/2009	10/30/2009	1/12/2010	1/12/2010	1/12/2010	5/26/2010	5/26/2010	5/26/2010	7/26/2010	7/26/2010	7/26/2010
Volatile Organic Compounds (VOC)															
Chloroethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloromethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dibromochloromethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dibromo-3-chloropropane	0.2	0.01 U	0.01 U	0.01 U	NS	NS	NS	NS	NS	0.01 U	NS	NS	NS	NS	NS
1,2-Dibromoethane (EDB)	0.05	0.01 U	0.01 U	0.01 U	NS	NS	NS	NS	NS	0.01 U	NS	NS	NS	NS	NS
Dibromomethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichlorobenzene	63	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichlorobenzene	60	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,4-Dichlorobenzene	21	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dichlorodifluoromethane	1,400	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Ethylbenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Hexachlorobutadiene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Isopropylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
p-Isopropyltoluene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Methylene Chloride	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ	0.5 UJ	0.5 UJ	0.5 U	0.5 U	0.5 U
MTBE	35	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Naphthalene	14	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Propylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Styrene	100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrachloroethene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrahydrofuran	70	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U
Toluene	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,4-Trichlorobenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichloroethene	5	***2.0***	***4.4***	***4.4 J***	0.5 U	0.5 U	***4.6***	0.5 U	0.5 U	***3.8 J***	0.5 U	0.5 U	***6.6***	0.5 U	0.5 U
Trichlorofluoromethane	2,100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,3-Trichloropropane	0.05	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,4-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3,5-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
o-Xylene	1,400 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
m,p-Xylene	1,400 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl Chloride	0.2	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

Table 4-3

Groundwater Analytical Results - Water Supply Samples
Former Nike LO-58 Launch Site
Caribou, Maine

Analyte of Concern	MEDEP MEG/ EPA MCL^1 (µg/L) except where noted	Drinking Water Supply Well DW-01 (AMAC) cont.													
		Pre-filter	Pre-filter	Pre-filter	Between-filters	Post-filter	Pre-filter	Between-filters	Post-filter	Pre-filter	Between-filters	Post-filter	Pre-filter	Between-filters	Post-filter
		10/29/2008	5/1/2009	10/30/2009	10/30/2009	10/30/2009	1/12/2010	1/12/2010	1/12/2010	5/26/2010	5/26/2010	5/26/2010	7/26/2010	7/26/2010	7/26/2010
Total Petroleum Hydrocarbons (TPH)															
TPH-DRO	0.05 mg/L	0.05 U	0.05 U	0.05 U	NS	NS	NS	NS	NS	0.05 U	NS	NS	NS	NS	NS
TPH-GRO	0.05 mg/L	0.01 U	0.01 U	0.01 UJ	NS	NS	NS	NS	NS	0.01 UJ	NS	NS	NS	NS	NS

Table 4-3

Groundwater Analytical Results - Water Supply Samples
Former Nike LO-58 Launch Site
Caribou, Maine

Analyte of Concern	MEDEP MEG/ EPA MCL^1 (µg/L) except where noted	Drinking Water Supply Well DW-02 (VFW)																	
		10/26/2000	5/15/2001	12/5/2002	4/23/2003	9/18/2003	5/11/2004	9/30/2004	4/25/2005	9/14/2005	5/23/2006	10/24/2006	5/24/2007	10/24/2007	4/30/2008	10/29/2008	5/1/2009	10/30/2009	5/26/2010
Volatile Organic Compounds (VOC)																			
1,1,1-Trichloroethane	200	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2-Trichloroethane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,1,2-Tetrachloroethane	13	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	1.8	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethane	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloroethene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloroethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,2-Dichloroethene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,2-Dichloroethene	100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichloropropane	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2,2-Dichloropropane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1-Dichloropropene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
cis-1,3-Dichloropropene	4 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
trans-1,3-Dichloropropene	4 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Benzene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromochloromethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromodichloromethane	6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromoform	44	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Bromomethane	10	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
sec-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
tert-Butylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Carbon Disulfide	--	0.5 U	NA	NA	NA	NA	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Carbon Tetrachloride	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chlorobenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

Table 4-3

Groundwater Analytical Results - Water Supply Samples
Former Nike LO-58 Launch Site
Caribou, Maine

Analyte of Concern	MEDEP MEG/ EPA MCL[1] (µg/L) except where noted	Drinking Water Supply Well DW-02 (VFW)																	
		10/26/2000	5/15/2001	12/5/2002	4/23/2003	9/18/2003	5/11/2004	9/30/2004	4/25/2005	9/14/2005	5/23/2006	10/24/2006	5/24/2007	10/24/2007	4/30/2008	10/29/2008	5/1/2009	10/30/2009	5/26/2010
Volatile Organic Compounds (VOC)																			
Chloroethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloromethane	3	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
2-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
4-Chlorotoluene	140	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dibromochloromethane	4	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dibromo-3-chloropropane	0.2	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
1,2-Dibromoethane (EDB)	0.05	0.5 U	0.02 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	***0.014***	0.006 U	0.005 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U
Dibromomethane	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dichlorobenzene	63	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3-Dichlorobenzene	60	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,4-Dichlorobenzene	21	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	***0.26 J***	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Dichlorodifluoromethane	1,400	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Ethylbenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Hexachlorobutadiene	1	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	***0.3 J***	0.5 U	0.5 U	0.5 U
Isopropylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
p-Isopropyltoluene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 UJ
Methylene Chloride	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
MTBE	35	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Naphthalene	14	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
n-Propylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Styrene	100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrachloroethene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Tetrahydrofuran	70	5 U	NA	NA	NA	NA	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U
Toluene	1,000	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,4-Trichlorobenzene	70	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichloroethene	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichlorofluoromethane	2,100	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,3-Trichloropropane	0.05	0.5 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2,4-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,3,5-Trimethylbenzene	--	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
o-Xylene	1,400 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
m,p-Xylene	1,400 (total)	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl Chloride	0.2	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.5 U	0.5 U	0.5 U	0.5 U

Table 4-3

Groundwater Analytical Results - Water Supply Samples
Former Nike LO-58 Launch Site
Caribou, Maine

Analyte of Concern	MEDEP MEG/ EPA MCL[1] (µg/L) except where noted	Drinking Water Supply Well DW-02 (VFW)																	
		10/26/2000	5/15/2001	12/5/2002	4/23/2003	9/18/2003	5/11/2004	9/30/2004	4/25/2005	9/14/2005	5/23/2006	10/24/2006	5/24/2007	10/24/2007	4/30/2008	10/29/2008	5/1/2009	10/30/2009	5/26/2010
Total Petroleum Hydrocarbons (TPH)																			
TPH-DRO	0.05 mg/L	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
TPH-GRO	0.05 mg/L	NS	NS	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 UJ	0.01 UJ

Notes: [1] For groundwater volatile organic compounds, Regulatory Criteria values are "Maximum Exposure Guidelines (MEG) for Drinking Water" (MEDEP, revised 2008), or U.S. Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL), whichever is less.

Values shown are in units of micrograms per liter (µg/L) unless noted [diesel range organics (DRO) and gasoline range organics (GRO)].

Values shown in ***BOLD*** indicate that the compound was detected, but at a concentration below its MEG/MCL.

Values shown in ***BOLD*** and SHADED indicate that the compound was detected at or above its respective MEG/MCL.

U = Not detected at associated reporting limit.

J = Concentration is estimated.

J^1/UJ^1 = Concentration is estimated because field duplicate criteria was not met.

J^2 = Diesel range organics (DRO) results are qualified as estimated due to DRO detection in the rinsate/equipment blank sample (10/24/06 only). Sample results may be biased high.

MEDEP = Maine Department of Environmental Protection

mg/L = Milligrams per liter

NA = Not analyzed

AMAC = Adult Multiple Alternative Center

VFW = Veterans of Foreign Wars

NS = Not sampled

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August 10, 2010

Mr. Bob Osborne
The Johnson Company, Inc.
100 State Street
Montpelier VT 05602

RE: Analytical Results Case Narrative
UASCE-ME FUDS Project # 1-2128-13
Analytics # 67355

Dear Mr. Donovan:

Enclosed please find the analytical results for samples collected from the above-mentioned project. The attached Cover Page lists the sample IDs, Lab tracking numbers and collection dates for the samples included in this deliverable.

Samples were analyzed for the target volatile organic compounds by EPA Method 524.2.

Unless otherwise noted in the Non-conformance Summary listed below, all of the quality control (QC) criteria including initial calibration, calibration verification, surrogate recovery, holding time and method accuracy/precision for these analyses were within acceptable limits.

This Level II package has been assembled in the following order:

- Case Narrative/Non-Conformance Summary
- Sample Log Sheet - Cover Page
- VOA Form 1 Sample Data Results
  - Chromatograms
- VOA Form 3 MS/MSD and LCS Recoveries
- Chain of Custody (COC) Forms

QC NON-CONFORMANCE SUMMARY

Sample Receipt:
No exceptions.

EPA Method 524.2 Volatile Organics:
This narrative is specific to target analytes reported on the Form 1 data pages. Non-target (NT) analyte deviations were not addressed. The following analytes were not 'J" flagged in this report: Vinyl Chloride, Methylene choride, Diethyl ether, Acetone, Hexachlorobutadiene, and Naphthalene.

Bromomethane used quadratic fit for quantitation for the calibration curve analyzed 08/05/2010.

Methylene Chloride had high RPD in the laboratory control pair (L508050B/L508050B2). The MS/MSD analyzed 67335-1 had high recovery for Bromomethane. These analytes were not detected in any samples for this SDG and results were reported without qualification.

If you have any questions on this data submittal, please do not hesitate to contact me.

Sincerely,
ANALYTICS Environmental Laboratory, LLC

Stephen Knollmeyer
Laboratory Director

analytics environmental laboratory LLC

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800-929-9906
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Mr. Bob Osborne
The Johnson Company, Inc.
100 State Street
Montpelier, VT 05602

Report Number: 67355

Revision: Rev. 0

Re: USACE- Northern MEFUDS (Project No: 1-2128-13)

Enclosed are the results of the analyses on your sample(s). Samples were received on 27 July 2010 and analyzed for the tests listed. Samples were received in acceptable condition, with the exceptions noted below or on the chain of custody. These results pertain to samples as received by the laboratory and for the analytical tests requested on the chain of custody. The results reported herein conform to the most current NELAC standards, where applicable, unless otherwise narrated in the body of the report. Please see individual reports for specific methodologies and references.

Lab Number	Sample Date	Station Location	Analysis	Comments
67355-1	07/26/10	LS58DW1-0710	EPA 524.2 Volatile Organics	
67355-2	07/26/10	LS58DW1-0710BTF	EPA 524.2 Volatile Organics	
67355-3	07/26/10	LS58DW1-0710AF	EPA 524.2 Volatile Organics	
67355-4	07/26/10	LS58QC1-0710	Electronic Data Deliverable	
	07/26/10	LS58QC1-0710	EPA 524.2 Volatile Organics	

Sample Receipt Exceptions: None

Analytics Environmental Laboratory is certified by the states of New Hampshire, Maine, Massachusetts, Connecticut, Rhode Island, Virginia, Maryland, and is accredited by the Deparment of Defense (DOD) ELAP program. A list of actual certified parameters is available upon request.

If you have any questions on these results, please do not hesitate to contact us.

Authorized signature ______________
Stephen L. Knollmeyer Lab. Director

Date 8/10/2010

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Surrogate Compound Limits

Matrix:	Aqueous	Solid	
Units:	% Recovery	% Recovery	Method
Volatile Organic Compounds - Drinking Water			
1,4-Difluorobenzene	70-130		EPA 524.2
Bromofluorobenzene	70-130		
1,2-Dichlorobenzene-d4	70-130		
Volatile Organic Compounds			
1,2-Dichloroethane-d4	70-120	70-120	EPA 624/8260B
Toluene-d8	85-120	85-120	
Bromofluorobenzene	75-120	75-120	
Semi-Volatile Organic Compounds			
2-Fluorophenol	20-110	35-105	EPA 625/8270C
d5-Phenol	15-110	40-100	
d5-nitrobenzene	40-110	35-100	
2-Fluorobiphenyl	50-110	45-105	
2,4,6-Tribromophenol	40-110	40-125	
d14-p-terphenyl	50-130	30-125	
PAH's by SIM			
d5-nitrobenzene	21-110	35-110	EPA 8270C
2-Fluorobiphenyl	36-121	45-105	
d14-p-terphenyl	33-141	30-125	
Pesticides and PCBs			
2,4,5,6-Tetrachloro-m-xylene (TCX)	46-122	40-130	EPA 608/8082
Decachlorobiphenyl (DCB)	40-135	40-130	
Herbicides			
Dichloroacetic acid (DCAA)	30-150	30-150	
Gasoline Range Organics/TPH Gasoline			
Trifluorotoluene TFT (FID)	60-140	60-140	MEDEP 4217/EPA 8015
Bromofluorobenzene (BFB) (FID)	60-140	60-140	
Trifluorotoluene TFT (PID)	60-140	60-140	
Bromofluorobenzene (BFB) (PID)	60-140	60-140	
Diesel Range Organics/TPH Diesel			
m-terphenyl	60-140	60-140	MEDEP 4125/EPA 8015/CT ETPH
Volatile Petroleum Hydrocarbons			
2,5-Dibromotoluene (PID)	70-130	70-130	MADEP VPH May 2004 Rev1.1
2,5-Dibromotoluene (FID)	70-130	70-130	
Extracatable Petroleum Hydrocarbons			
1-chloro-octadecane (aliphatic)	40-140	40-140	MADEP EPH May 2004 Rev1.1
o-Terphenyl (aromatic)	40-140	40-140	
2-Fluorobiphenyl (Fractionation)	40-140	40-140	
2-Bromonaphthalene (fractionation)	40-140	40-140	

VOLATILE
DATA SUMMARIES

AnalvticsLLC:AEL Documents LLC:Pkg Dividers:VOC.doc

analytics environmental laboratory LLC

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800-929-9906

Mr. Bob Osborne
The Johnson Company, Inc.
100 State Street
Montpelier, VT 05602

August 10, 2010

SAMPLE DATA

Lab Sample ID: B508050B
Matrix: Aqueous
Percent Solid: N/A
Dilution Factor: 1
Collection Date: N/A
Lab Receipt Date: N/A
Analysis Date: 08/05/10

CLIENT SAMPLE ID

Project Name: USACE- Northern MEFUDS

Project Number: 1-2128-13
Field Sample ID: LAB QC

ANALYTICAL RESULTS VOLATILE ORGANICS

COMPOUND	Quantitation Limit µg/L	Result µg/L	COMPOUND	Quantitation Limit µg/L	Result µg/L
Benzene	0.5	U	1,3-Dichloropropane	0.5	U
Bromobenzene	0.5	U	cis-1,3-Dichloropropene	0.5	U
Bromochloromethane	0.5	U	trans-1,3-Dichloropropene	0.5	U
Bromodichloromethane	0.5	U	2,2-Dichloropropane	0.5	U
Bromoform	0.5	U	1,1-Dichloropropene	0.5	U
Bromomethane	0.5	U	Ethylbenzene	0.5	U
n-butylbenzene	0.5	U	Hexachlorobutadiene	0.5	U
sec-butylbenzene	0.5	U	Isopropylbenzene	0.5	U
tert-butylbenzene	0.5	U	p-isopropyltoluene	0.5	U
Carbon Tetrachloride	0.5	U	Methylene Chloride	0.5	U
Chlorobenzene	0.5	U	Methyl-tert-butyl ether (MTBE)	0.5	U
Chloroethane	0.5	U	Naphthalene	0.5	U
Chloroform	0.5	U	n-Propylbenzene	0.5	U
Chloromethane	0.5	U	Styrene	0.5	U
2-Chlorotoluene	0.5	U	1,1,1,2-Tetrachloroethane	0.5	U
4-Chlorotoluene	0.5	U	1,1,2,2-Tetrachloroethane	0.5	U
Dibromochloromethane	0.5	U	Tetrachloroethene	0.5	U
Dibromomethane	0.5	U	Toluene	0.5	U
1,2-Dichlorobenzene	0.5	U	1,2,3-Trichlorobenzene	0.5	U
1,3-Dichlorobenzene	0.5	U	1,2,4-Trichlorobenzene	0.5	U
1,4-Dichlorobenzene	0.5	U	1,1,1-Trichloroethane	0.5	U
Dichlorodifluoromethane	0.5	U	1,1,2-Trichloroethane	0.5	U
1,1-Dichloroethane	0.5	U	Trichloroethene	0.5	U
1,2-Dichloroethane	0.5	U	Trichlorofluoromethane	0.5	U
1,1-Dichloroethene	0.5	U	1,2,3-Trichloropropane	0.5	U
cis-1,2-Dichloroethene	0.5	U	1,2,4-Trimethylbenzene	0.5	U
trans-1,2-Dichloroethene	0.5	U	1,3,5-Trimethylbenzene	0.5	U
1,2-Dichloropropane	0.5	U	Vinyl Chloride	0.1	U
			o-Xylene	0.5	U
			m,p-Xylene	0.5	U

Surrogate Standard Recovery

1,4-Difluorobenzene	102 %	Bromofluorobenzene	99 %	1,2-Dichlorobenzene-d4	99 %

U=Undetected J=Estimated E=Exceeds Calibration Range B=Detected in Blank

METHODOLOGY: Sample analysis was conducted according to EPA 600, Method 524.2

COMMENTS:

NH 524MEFUD
(57))

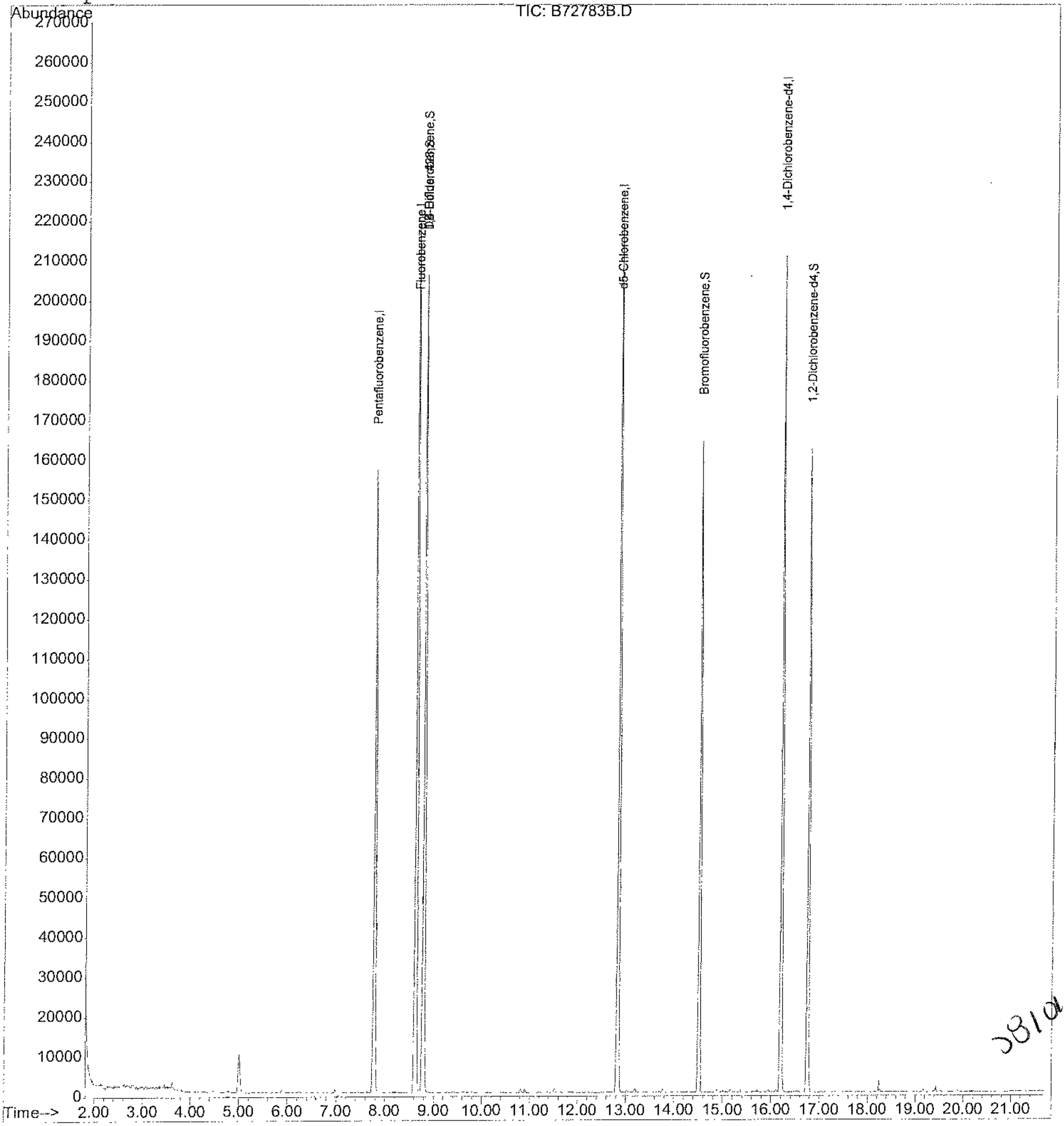
Authorized signature

Quantitation Report

```
Data File : C:\HPCHEM\1\DATA\080510-B\B72783B.D          Vial: 20
Acq On    :  5 Aug 2010   8:06 pm                    Operator: MT
Sample    : B508050B                                 Inst    : Instrumen
Misc      : 25000                                    Multiplr: 1.00
MS Integration Params: rteint.p
Quant Time: Aug  9  7:37 2010              Quant Results File: V508050B.RES

Method        : C:\HPCHEM\1\METHODS\V508050B.M (RTE Integrator)
Title         : 524.2 Purgable Organics
Last Update   : Thu Aug 05 17:33:56 2010
Response via  : Initial Calibration
```

MT 8/9/10



J8/9/10

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Mr. Bob Osborne
The Johnson Company, Inc.
100 State Street
Montpelier, VT 05602

August 10, 2010

SAMPLE DATA

Lab Sample ID: 67355-1
Matrix: Aqueous
Percent Solid: N/A
Dilution Factor: 1
Collection Date: 07/26/10
Lab Receipt Date: 07/27/10
Analysis Date: 08/06/10

CLIENT SAMPLE ID

Project Name: USACE- Northern MEFUDS

Project Number: 1-2128-13
Field Sample ID: LS58DW1-0710

ANALYTICAL RESULTS VOLATILE ORGANICS

COMPOUND	Quantitation Limit µg/L	Result µg/L	COMPOUND	Quantitation Limit µg/L	Result µg/L
Benzene	0.5	U	1,3-Dichloropropane	0.5	U
Bromobenzene	0.5	U	cis-1,3-Dichloropropene	0.5	U
Bromochloromethane	0.5	U	trans-1,3-Dichloropropene	0.5	U
Bromodichloromethane	0.5	U	2,2-Dichloropropane	0.5	U
Bromoform	0.5	U	1,1-Dichloropropene	0.5	U
Bromomethane	0.5	U	Ethylbenzene	0.5	U
n-butylbenzene	0.5	U	Hexachlorobutadiene	0.5	U
sec-butylbenzene	0.5	U	Isopropylbenzene	0.5	U
tert-butylbenzene	0.5	U	p-isopropyltoluene	0.5	U
Carbon Tetrachloride	0.5	U	Methylene Chloride	0.5	U
Chlorobenzene	0.5	U	Methyl-tert-butyl ether (MTBE)	0.5	U
Chloroethane	0.5	U	Naphthalene	0.5	U
Chloroform	0.5	U	n-Propylbenzene	0.5	U
Chloromethane	0.5	U	Styrene	0.5	U
2-Chlorotoluene	0.5	U	1,1,1,2-Tetrachloroethane	0.5	U
4-Chlorotoluene	0.5	U	1,1,2,2-Tetrachloroethane	0.5	U
Dibromochloromethane	0.5	U	Tetrachloroethene	0.5	U
Dibromomethane	0.5	U	Toluene	0.5	U
1,2-Dichlorobenzene	0.5	U	1,2,3-Trichlorobenzene	0.5	U
1,3-Dichlorobenzene	0.5	U	1,2,4-Trichlorobenzene	0.5	U
1,4-Dichlorobenzene	0.5	U	1,1,1-Trichloroethane	0.5	U
Dichlorodifluoromethane	0.5	U	1,1,2-Trichloroethane	0.5	U
1,1-Dichloroethane	0.5	U	Trichloroethene	0.5	**6.6**
1,2-Dichloroethane	0.5	U	Trichlorofluoromethane	0.5	U
1,1-Dichloroethene	0.5	U	1,2,3-Trichloropropane	0.5	U
cis-1,2-Dichloroethene	0.5	**1.3**	1,2,4-Trimethylbenzene	0.5	U
trans-1,2-Dichloroethene	0.5	U	1,3,5-Trimethylbenzene	0.5	U
1,2-Dichloropropane	0.5	U	Vinyl Chloride	0.1	U
			o-Xylene	0.5	U
			m,p-Xylene	0.5	U

Surrogate Standard Recovery

1,4-Difluorobenzene	99 %	Bromofluorobenzene	93 %	1,2-Dichlorobenzene-d4	97 %

U=Undetected J=Estimated E=Exceeds Calibration Range B=Detected in Blank

METHODOLOGY: Sample analysis was conducted according to EPA 600, Method 524.2

COMMENTS:

NH 524MEFUD
(57))

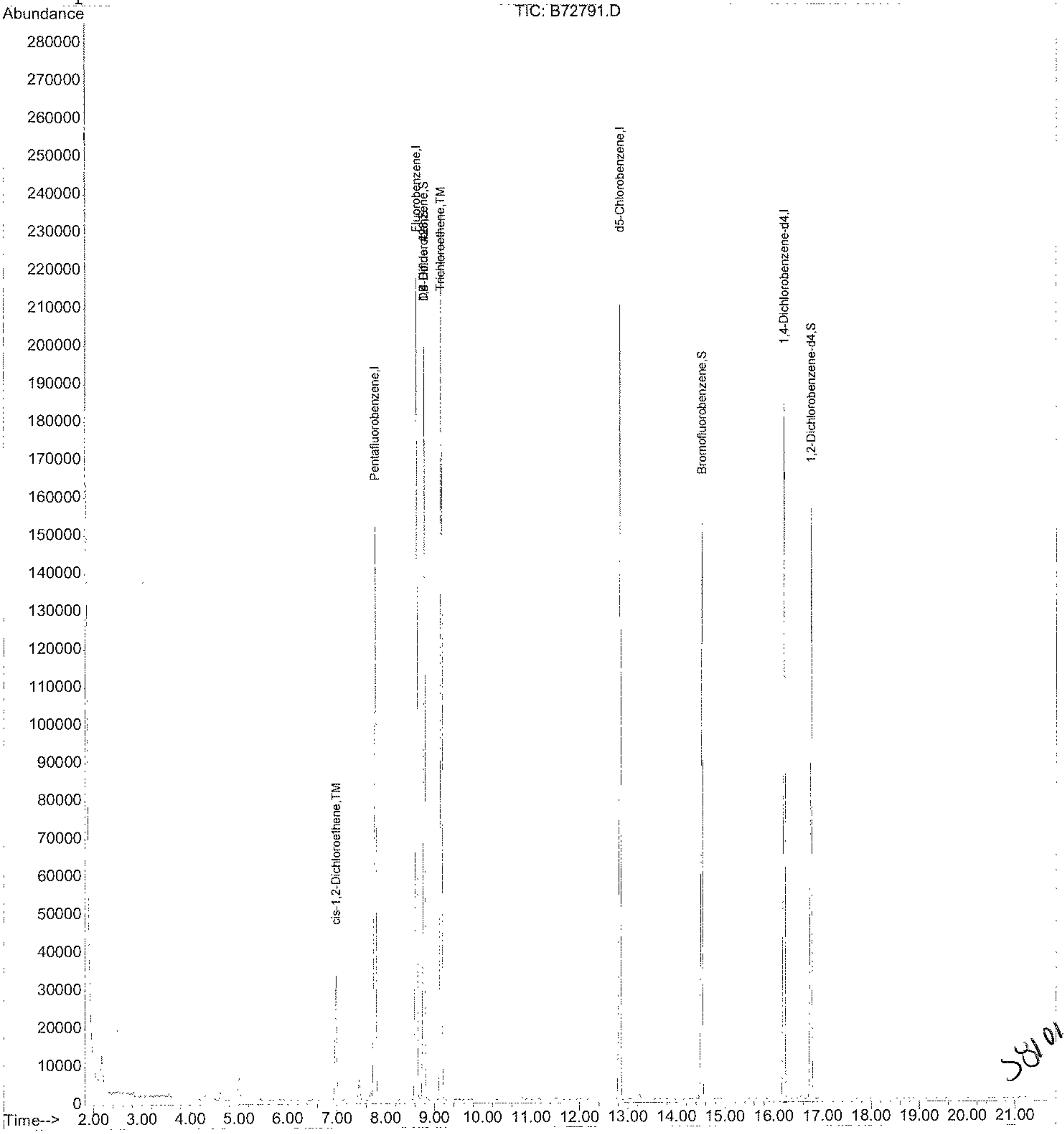
Authorized signature

Quantitation Report

```
Data File : C:\HPCHEM\1\DATA\080510-B\B72791.D          Vial: 28
Acq On    :  6 Aug 2010  12:44 am                   Operator: MT
Sample    : 67355-1                                 Inst    : Instrumen
Misc      : 25000                                   Multiplr: 1.00
MS Integration Params: rteint.p
Quant Time: Aug  9  7:45 2010              Quant Results File: V508050B.RES

Method         : C:\HPCHEM\1\METHODS\V508050B.M (RTE Integrator)
Title          : 524.2 Purgable Organics
Last Update    : Thu Aug 05 17:33:56 2010
Response via   : Initial Calibration
```

MT 8/9/10



58010

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Mr. Bob Osborne
The Johnson Company, Inc.
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August 10, 2010

SAMPLE DATA

Lab Sample ID: 67355-2
Matrix: Aqueous
Percent Solid: N/A
Dilution Factor: 1
Collection Date: 07/26/10
Lab Receipt Date: 07/27/10
Analysis Date: 08/06/10

CLIENT SAMPLE ID

Project Name: USACE- Northern MEFUDS

Project Number: 1-2128-13
Field Sample ID: LS58DW1-0710BTF

ANALYTICAL RESULTS VOLATILE ORGANICS

COMPOUND	Quantitation Limit μg/L	Result μg/L	COMPOUND	Quantitation Limit μg/L	Result μg/L
Benzene	0.5	U	1,3-Dichloropropane	0.5	U
Bromobenzene	0.5	U	cis-1,3-Dichloropropene	0.5	U
Bromochloromethane	0.5	U	trans-1,3-Dichloropropene	0.5	U
Bromodichloromethane	0.5	U	2,2-Dichloropropane	0.5	U
Bromoform	0.5	U	1,1-Dichloropropene	0.5	U
Bromomethane	0.5	U	Ethylbenzene	0.5	U
n-butylbenzene	0.5	U	Hexachlorobutadiene	0.5	U
sec-butylbenzene	0.5	U	Isopropylbenzene	0.5	U
tert-butylbenzene	0.5	U	p-isopropyltoluene	0.5	U
Carbon Tetrachloride	0.5	U	Methylene Chloride	0.5	U
Chlorobenzene	0.5	U	Methyl-tert-butyl ether (MTBE)	0.5	U
Chloroethane	0.5	U	Naphthalene	0.5	U
Chloroform	0.5	U	n-Propylbenzene	0.5	U
Chloromethane	0.5	U	Styrene	0.5	U
2-Chlorotoluene	0.5	U	1,1,1,2-Tetrachloroethane	0.5	U
4-Chlorotoluene	0.5	U	1,1,2,2-Tetrachloroethane	0.5	U
Dibromochloromethane	0.5	U	Tetrachloroethene	0.5	U
Dibromomethane	0.5	U	Toluene	0.5	U
1,2-Dichlorobenzene	0.5	U	1,2,3-Trichlorobenzene	0.5	U
1,3-Dichlorobenzene	0.5	U	1,2,4-Trichlorobenzene	0.5	U
1,4-Dichlorobenzene	0.5	U	1,1,1-Trichloroethane	0.5	U
Dichlorodifluoromethane	0.5	U	1,1,2-Trichloroethane	0.5	U
1,1-Dichloroethane	0.5	U	Trichloroethene	0.5	U
1,2-Dichloroethane	0.5	U	Trichlorofluoromethane	0.5	U
1,1-Dichloroethene	0.5	U	1,2,3-Trichloropropane	0.5	U
cis-1,2-Dichloroethene	0.5	U	1,2,4-Trimethylbenzene	0.5	U
trans-1,2-Dichloroethene	0.5	U	1,3,5-Trimethylbenzene	0.5	U
1,2-Dichloropropane	0.5	U	Vinyl Chloride	0.1	U
			o-Xylene	0.5	U
			m,p-Xylene	0.5	U

Surrogate Standard Recovery

1,4-Difluorobenzene	100 %	Bromofluorobenzene	93 %	1,2-Dichlorobenzene-d4	95 %

U=Undetected J=Estimated E=Exceeds Calibration Range B=Detected in Blank

METHODOLOGY: Sample analysis was conducted according to EPA 600, Method 524.2

COMMENTS:

NH 524MEFUD
(57))

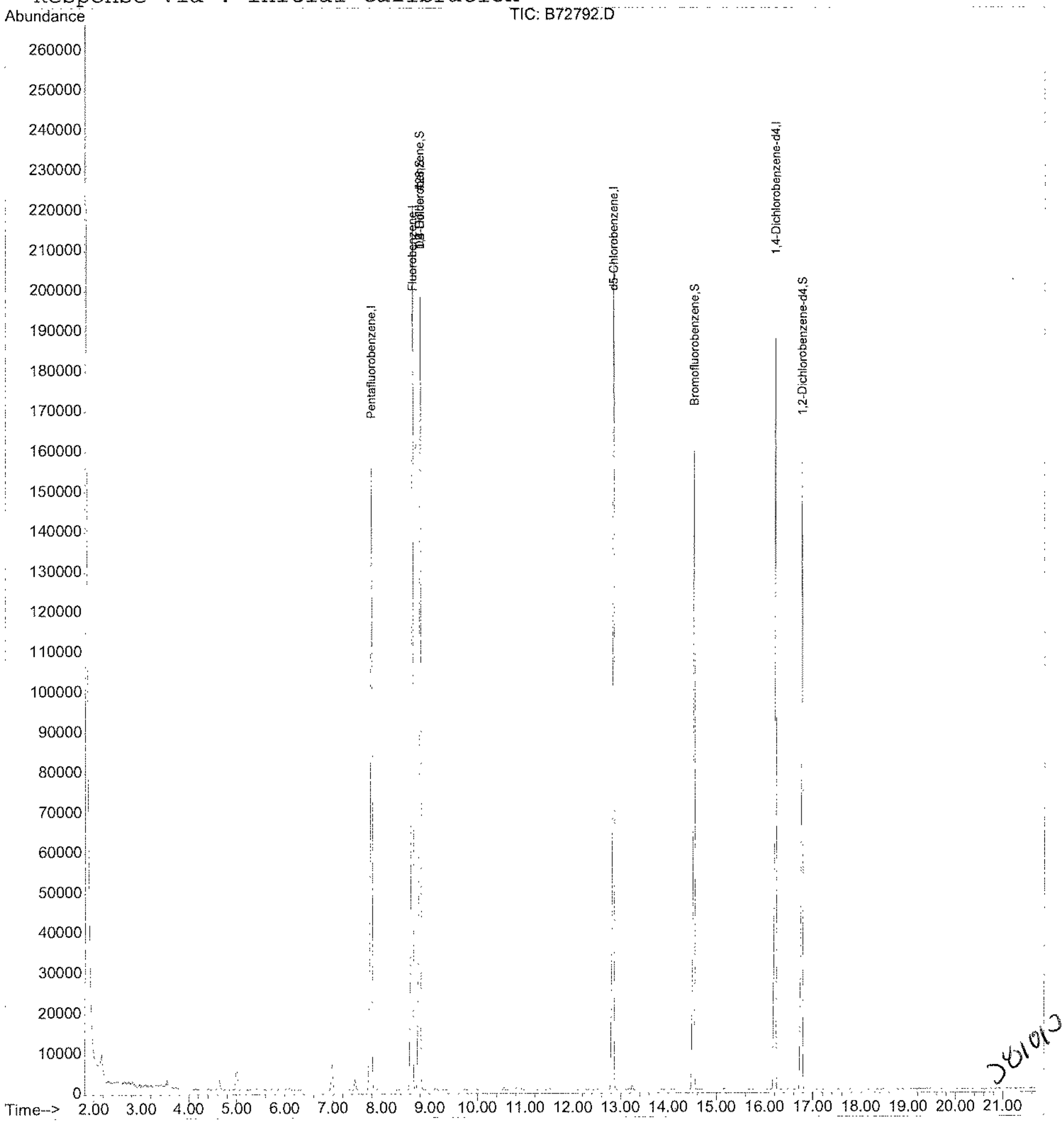
Authorized signature

Quantitation Report

```
Data File : C:\HPCHEM\1\DATA\080510-B\B72792.D          Vial: 29
Acq On    :  6 Aug 2010   1:14 am                   Operator: MT
Sample    : 67355-2                                 Inst    : Instrumen
Misc      : 25000                                   Multiplr: 1.00
MS Integration Params: rteint.p
Quant Time: Aug  9  7:38 2010             Quant Results File: V508050B.RES

Method          : C:\HPCHEM\1\METHODS\V508050B.M (RTE Integrator)
Title           : 524.2 Purgable Organics
Last Update     : Thu Aug 05 17:33:56 2010
Response via    : Initial Calibration
```

MT 8/9/10



080910

analytics environmental laboratory LLC

195 Commerce Way
Portsmouth, New Hampshire 03801
603-436-5111 Fax 603-430-2161
800-929-9906

Mr. Bob Osborne
The Johnson Company, Inc.
100 State Street
Montpelier, VT 05602

August 10, 2010

SAMPLE DATA

Lab Sample ID: 67355-3
Matrix: Aqueous
Percent Solid: N/A
Dilution Factor: 1
Collection Date: 07/26/10
Lab Receipt Date: 07/27/10
Analysis Date: 08/06/10

CLIENT SAMPLE ID

Project Name: USACE- Northern MEFUDS

Project Number: 1-2128-13
Field Sample ID: LS58DW1-0710AF

ANALYTICAL RESULTS VOLATILE ORGANICS

COMPOUND	Quantitation Limit μg/L	Result μg/L	COMPOUND	Quantitation Limit μg/L	Result μg/L
Benzene	0.5	U	1,3-Dichloropropane	0.5	U
Bromobenzene	0.5	U	cis-1,3-Dichloropropene	0.5	U
Bromochloromethane	0.5	U	trans-1,3-Dichloropropene	0.5	U
Bromodichloromethane	0.5	U	2,2-Dichloropropane	0.5	U
Bromoform	0.5	U	1,1-Dichloropropene	0.5	U
Bromomethane	0.5	U	Ethylbenzene	0.5	U
n-butylbenzene	0.5	U	Hexachlorobutadiene	0.5	U
sec-butylbenzene	0.5	U	Isopropylbenzene	0.5	U
tert-butylbenzene	0.5	U	p-isopropyltoluene	0.5	U
Carbon Tetrachloride	0.5	U	Methylene Chloride	0.5	U
Chlorobenzene	0.5	U	Methyl-tert-butyl ether (MTBE)	0.5	U
Chloroethane	0.5	U	Naphthalene	0.5	U
Chloroform	0.5	U	n-Propylbenzene	0.5	U
Chloromethane	0.5	U	Styrene	0.5	U
2-Chlorotoluene	0.5	U	1,1,1,2-Tetrachloroethane	0.5	U
4-Chlorotoluene	0.5	U	1,1,2,2-Tetrachloroethane	0.5	U
Dibromochloromethane	0.5	U	Tetrachloroethene	0.5	U
Dibromomethane	0.5	U	Toluene	0.5	U
1,2-Dichlorobenzene	0.5	U	1,2,3-Trichlorobenzene	0.5	U
1,3-Dichlorobenzene	0.5	U	1,2,4-Trichlorobenzene	0.5	U
1,4-Dichlorobenzene	0.5	U	1,1,1-Trichloroethane	0.5	U
Dichlorodifluoromethane	0.5	U	1,1,2-Trichloroethane	0.5	U
1,1-Dichloroethane	0.5	U	Trichloroethene	0.5	U
1,2-Dichloroethane	0.5	U	Trichlorofluoromethane	0.5	U
1,1-Dichloroethene	0.5	U	1,2,3-Trichloropropane	0.5	U
cis-1,2-Dichloroethene	0.5	U	1,2,4-Trimethylbenzene	0.5	U
trans-1,2-Dichloroethene	0.5	U	1,3,5-Trimethylbenzene	0.5	U
1,2-Dichloropropane	0.5	U	Vinyl Chloride	0.1	U
			o-Xylene	0.5	U
			m,p-Xylene	0.5	U

Surrogate Standard Recovery

1,4-Difluorobenzene	102 %	Bromofluorobenzene	96 %	1,2-Dichlorobenzene-d4	97 %

U=Undetected J=Estimated E=Exceeds Calibration Range B=Detected in Blank

METHODOLOGY: Sample analysis was conducted according to EPA 600, Method 524.2

COMMENTS:

NH 524MEFUD
(57))

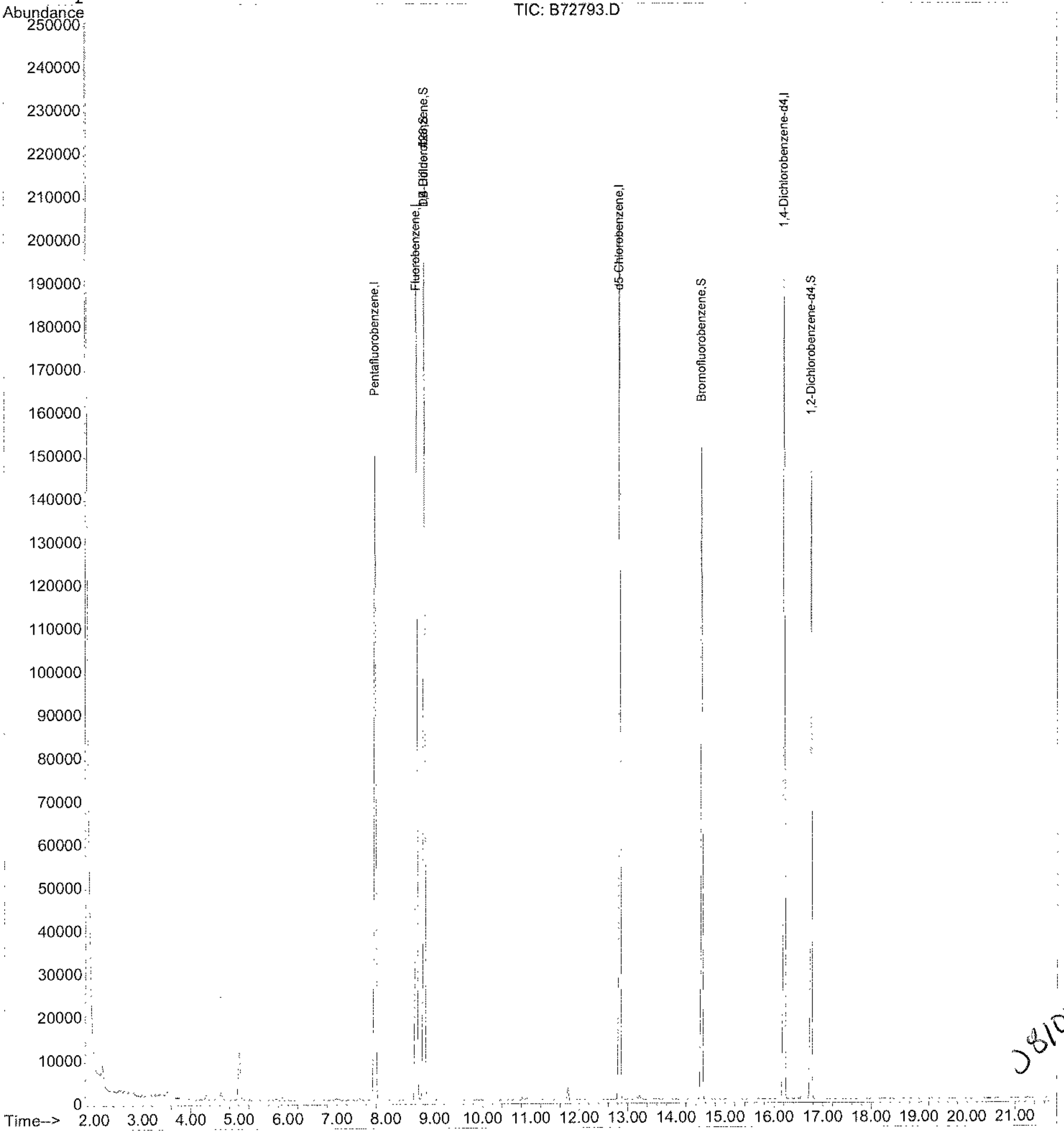
Authorized signature

Quantitation Report

Data File : C:\HPCHEM\1\DATA\080510-B\B72793.D Vial: 30
Acq On : 6 Aug 2010 1:58 am Operator: MT
Sample : 67355-3 Inst : Instrumen
Misc : 25000 Multiplr: 1.00
MS Integration Params: rteint.p
Quant Time: Aug 9 7:38 2010 Quant Results File: V508050B.RES

Method : C:\HPCHEM\1\METHODS\V508050B.M (RTE Integrator)
Title : 524.2 Purgable Organics
Last Update : Thu Aug 05 17:33:56 2010
Response via : Initial Calibration

MT 8/9/10



08/010

analytics environmental laboratory LLC

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603-436-5111 Fax 603-430-2151
800-929-9906

Mr. Bob Osborne
The Johnson Company, Inc.
100 State Street
Montpelier, VT 05602

August 10, 2010

SAMPLE DATA

Lab Sample ID: 67355-4
Matrix: Aqueous
Percent Solid: N/A
Dilution Factor: 1
Collection Date: 07/26/10
Lab Receipt Date: 07/27/10
Analysis Date: 08/05/10

CLIENT SAMPLE ID

Project Name: USACE- Northern MEFUDS

Project Number: 1-2128-13
Field Sample ID: LS58QC1-0710

ANALYTICAL RESULTS VOLATILE ORGANICS

COMPOUND	Quantitation Limit µg/L	Result µg/L	COMPOUND	Quantitation Limit µg/L	Result µg/L
Benzene	0.5	U	1,3-Dichloropropane	0.5	U
Bromobenzene	0.5	U	cis-1,3-Dichloropropene	0.5	U
Bromochloromethane	0.5	U	trans-1,3-Dichloropropene	0.5	U
Bromodichloromethane	0.5	U	2,2-Dichloropropane	0.5	U
Bromoform	0.5	U	1,1-Dichloropropene	0.5	U
Bromomethane	0.5	U	Ethylbenzene	0.5	U
n-butylbenzene	0.5	U	Hexachlorobutadiene	0.5	U
sec-butylbenzene	0.5	U	Isopropylbenzene	0.5	U
tert-butylbenzene	0.5	U	p-isopropyltoluene	0.5	U
Carbon Tetrachloride	0.5	U	Methylene Chloride	0.5	U
Chlorobenzene	0.5	U	Methyl-tert-butyl ether (MTBE)	0.5	U
Chloroethane	0.5	U	Naphthalene	0.5	U
Chloroform	0.5	U	n-Propylbenzene	0.5	U
Chloromethane	0.5	U	Styrene	0.5	U
2-Chlorotoluene	0.5	U	1,1,1,2-Tetrachloroethane	0.5	U
4-Chlorotoluene	0.5	U	1,1,2,2-Tetrachloroethane	0.5	U
Dibromochloromethane	0.5	U	Tetrachloroethene	0.5	U
Dibromomethane	0.5	U	Toluene	0.5	U
1,2-Dichlorobenzene	0.5	U	1,2,3-Trichlorobenzene	0.5	U
1,3-Dichlorobenzene	0.5	U	1,2,4-Trichlorobenzene	0.5	U
1,4-Dichlorobenzene	0.5	U	1,1,1-Trichloroethane	0.5	U
Dichlorodifluoromethane	0.5	U	1,1,2-Trichloroethane	0.5	U
1,1-Dichloroethane	0.5	U	Trichloroethene	0.5	U
1,2-Dichloroethane	0.5	U	Trichlorofluoromethane	0.5	U
1,1-Dichloroethene	0.5	U	1,2,3-Trichloropropane	0.5	U
cis-1,2-Dichloroethene	0.5	U	1,2,4-Trimethylbenzene	0.5	U
trans-1,2-Dichloroethene	0.5	U	1,3,5-Trimethylbenzene	0.5	U
1,2-Dichloropropane	0.5	U	Vinyl Chloride	0.1	U
			o-Xylene	0.5	U
			m,p-Xylene	0.5	U

Surrogate Standard Recovery

1,4-Difluorobenzene	102 %	Bromofluorobenzene	98 %	1,2-Dichlorobenzene-d4	99 %

U=Undetected J=Estimated E=Exceeds Calibration Range B=Detected in Blank

METHODOLOGY: Sample analysis was conducted according to EPA 600, Method 524.2

COMMENTS:

NH 524MEFUD
(57))

Authorized signature

Quantitation Report

```
Data File : C:\HPCHEM\1\DATA\080510-B\B72784.D          Vial: 21
Acq On    :  5 Aug 2010   8:50 pm                    Operator: MT
Sample    : 67355-4                                  Inst    : Instrumen
Misc      : 25000                                    Multiplr: 1.00
MS Integration Params: rteint.p
Quant Time: Aug  9  7:38 2010             Quant Results File: V508050B.RES

Method          : C:\HPCHEM\1\METHODS\V508050B.M (RTE Integrator)
Title           : 524.2 Purgable Organics
Last Update     : Thu Aug 05 17:33:56 2010
Response via    : Initial Calibration
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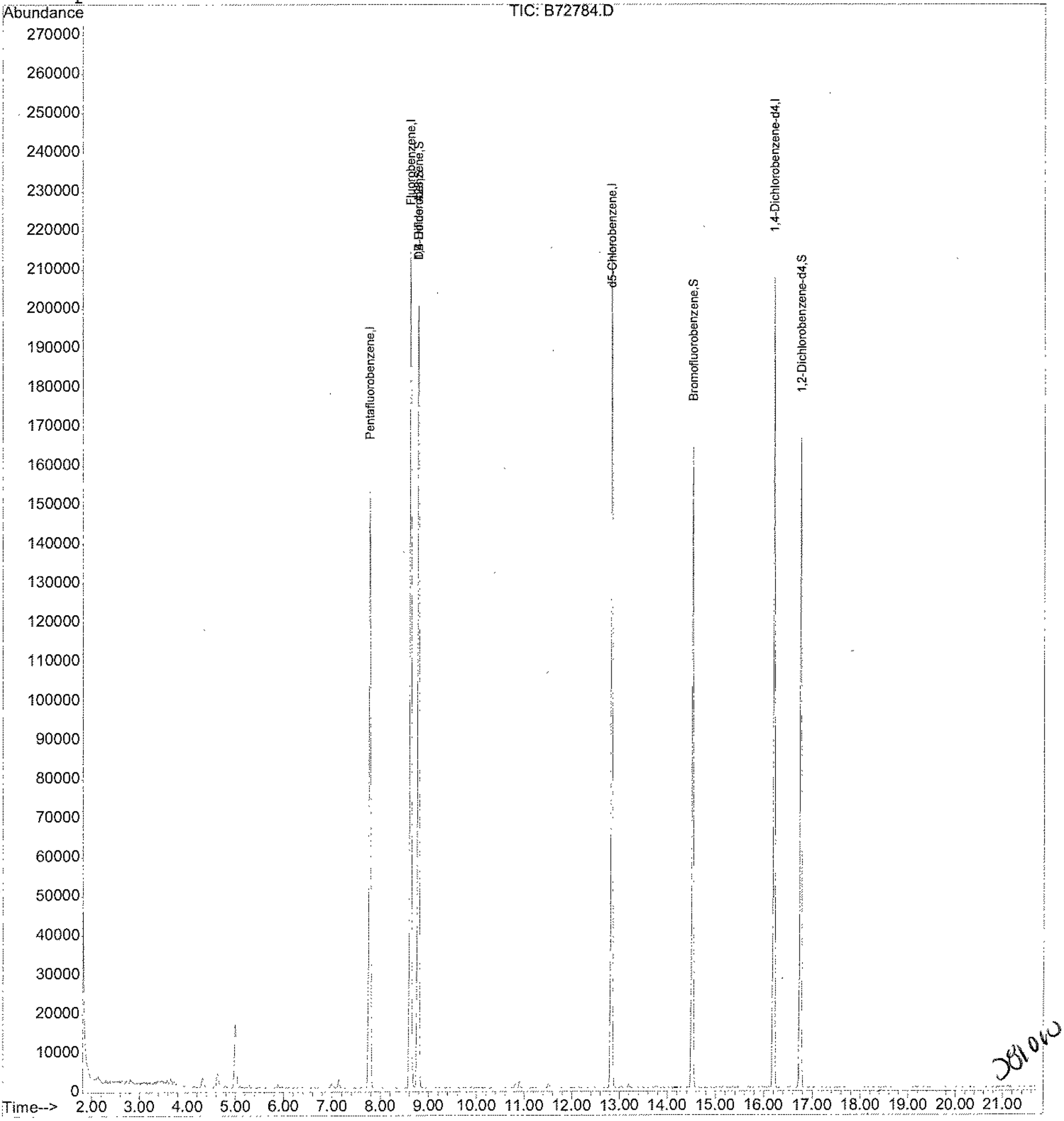
MT 8/9/10



VOLATILE
QC FORMS

AnalyticsLLC:AEL Documents LLC:Pkg Dividers:VOCQC.doc

VOLATILE ORGANIC AQUEOUS
LABORATORY CONTROL SAMPLE
LABORATORY CONTROL SAMPLE DUPLICATE
PERCENT RECOVERY

Instrument ID: I
GC Column: RTX-502.2
Column ID: 0.25 mm

SDG: 67355
Non-spiked sample: B508050B
Spike: L508050B
Spike Duplicate L508050B2

COMPOUND	SPIKE ADDED	LOWER LIMIT	UPPER LIMIT	RPD LIMIT	NON-SPIKE RESULT (ug/L)	SPIKE RESULT (ug/L)	SPIKE % REC	#	SPIKE DUP RESULT (ug/L)	SPIKE DUP % REC	#	RPD	#
Dichlorodifluoromethane	1	70	130	15	0.00	0.92	92		0.87	87		5	
Chloromethane	1	70	130	15	0.00	1.03	103		0.98	98		5	
Vinyl Chloride	1	70	130	15	0.00	0.98	98		0.95	95		3	
Bromomethane	1	70	130	15	0.00	1.30	130		1.14	114		13	
Chloroethane	1	70	130	15	0.00	1.01	101		1.00	100		1	
t-Butyl alcohol (TBA)	5	70	130	15	0.00	5.54	111		5.56	111		0	
Trichlorofluoromethane	1	70	130	15	0.00	0.86	86		0.82	82		5	
Diethyl ether	1	70	130	15	0.00	1.01	101		1.00	100		0	
1,1,2-Trichlorotrifluoroethane	1	70	130	15	0.00	0.93	93		0.90	90		4	
Acetone	5	70	130	15	0.00	5.14	103		4.55	91		12	
1,1-Dichloroethene	1	70	130	15	0.00	0.99	99		0.93	93		6	
Di-isopropyl ether (DIPE)	1	70	130	15	0.00	1.07	107		1.03	103		4	
Methylene Chloride	1	70	130	15	0.00	0.94	94		1.11	111		17	*
Carbon Disulfide	1	70	130	15	0.00	1.06	106		0.99	99		7	
Acrylonitrile	1	70	130	15	0.00	1.22	122		1.15	115		6	
Methyl-tert-butyl ether (MTBE)	2	70	130	15	0.00	2.16	108		2.09	105		3	
trans-1,2-Dichloroethene	1	70	130	15	0.00	1.05	105		1.00	100		5	
1,1-Dichloroethane	1	70	130	15	0.00	1.05	105		0.99	99		6	
Methyl ethyl ketone	5	70	130	15	0.00	5.45	109		5.14	103		6	
Ethyl t-butyl ether (ETBE)	1	70	130	15	0.00	1.06	106		1.03	103		3	
2,2-Dichloropropane	1	70	130	15	0.00	0.93	93		0.88	88		5	
cis-1,2-Dichloroethene	1	70	130	15	0.00	1.10	110		1.06	106		4	
t-Amyl methyl ether (TAME)	1	70	130	15	0.00	1.06	106		1.05	105		2	
Chloroform	1	70	130	15	0.00	1.04	104		1.00	100		4	
Bromochloromethane	1	70	130	15	0.00	1.07	107		1.07	107		0	
Tetrahydroforan	1	70	130	15	0.00	1.13	113		0.87	87		26	*
1,1,1-Trichloroethane	1	70	130	15	0.00	1.01	101		0.95	95		6	
1,1-Dichloropropene	1	70	130	15	0.00	1.04	104		0.99	99		5	
Carbon Tetrachloride	1	70	130	15	0.00	0.99	99		0.94	94		5	
1,2-Dichloroethane	1	70	130	15	0.00	1.04	104		0.99	99		4	
Benzene	1	70	130	15	0.00	1.10	110		1.04	104		5	
Trichloroethene	1	70	130	15	0.00	1.09	109		1.03	103		5	
1,2-Dichloropropane	1	70	130	15	0.00	1.03	103		1.01	101		2	
Bromodichloromethane	1	70	130	15	0.00	1.01	101		0.97	97		4	
Dibromomethane	1	70	130	15	0.00	1.02	102		1.00	100		2	
2-Hexanone	5	70	130	15	0.00	5.37	107		5.66	113		5	
Methyl isobutyl ketone	5	70	130	15	0.00	5.29	106		5.59	112		5	
cis-1,3-Dichloropropene	1	70	130	15	0.00	1.04	104		0.99	99		5	
Toluene	1	70	130	15	0.00	1.10	110		1.09	109		1	
trans-1,3-Dichloropropene	1	70	130	15	0.00	0.90	90		0.90	90		0	
1,1,2-Trichloroethane	1	70	130	15	0.00	1.05	105		1.08	108		3	
1,3-Dichloropropane	1	70	130	15	0.00	1.07	107		1.04	104		3	
Tetrachloroethene	1	70	130	15	0.00	1.07	107		1.02	102		4	
Dibromochloromethane	1	70	130	15	0.00	0.99	99		0.97	97		3	
1,2-Dibromoethane	1	70	130	15	0.00	1.08	108		0.99	99		9	
Chlorobenzene	1	70	130	15	0.00	1.06	106		1.04	104		2	

VOA FORM 3

VOLATILE ORGANIC AQUEOUS
LABORATORY CONTROL SAMPLE
LABORATORY CONTROL SAMPLE DUPLICATE
PERCENT RECOVERY

Instrument ID: 1
GC Column: RTX-502.2
Column ID: 0.25 mm

SDG: 67355
Non-spiked sample: B508050B
Spike: L508050B
Spike Duplicate L508050B2

COMPOUND	SPIKE ADDED	LOWER LIMIT	UPPER LIMIT	RPD LIMIT	NON-SPIKE RESULT (ug/L)	SPIKE RESULT (ug/L)	SPIKE % REC	#	SPIKE DUP RESULT (ug/L)	SPIKE DUP % REC	#	RPD	#
1,1,1,2-Tetrachloroethane	1	70	130	15	0.00	1.03	103		0.97	97		6	
Ethylbenzene	1	70	130	15	0.00	1.08	108		1.03	103		4	
m,p-Xylene	2	70	130	15	0.00	2.21	110		2.10	105		5	
o-Xylene	1	70	130	15	0.00	1.09	109		1.02	102		6	
Styrene	1	70	130	15	0.00	1.09	109		1.06	106		4	
Bromoform	1	70	130	15	0.00	0.99	99		0.92	92		7	
Isopropylbenzene	1	70	130	15	0.00	0.94	94		0.88	88		7	
1,1,2,2-Tetrachloroethane	1	70	130	15	0.00	1.09	109		1.03	103		6	
1,2,3-Trichloropropane	1	70	130	15	0.00	0.98	98		0.98	98		1	
trans-1,4-Dichloro-2-butene	1	70	130	15	0.00	0.75	75		0.60	60	*	22	*
n-Propylbenzene	1	70	130	15	0.00	1.05	105		0.97	97		8	
Bromobenzene	1	70	130	15	0.00	1.08	108		1.03	103		5	
1,3,5-Trimethylbenzene	1	70	130	15	0.00	1.08	108		1.01	101		7	
2-Chlorotoluene	1	70	130	15	0.00	1.08	108		1.03	103		5	
4-Chlorotoluene	1	70	130	15	0.00	1.08	108		1.03	103		5	
tert-butylbenzene	1	70	130	15	0.00	1.03	103		1.00	100		3	
1,2,4-Trimethylbenzene	1	70	130	15	0.00	1.02	102		0.98	98		4	
sec-butylbenzene	1	70	130	15	0.00	1.03	103		0.98	98		5	
p-isopropyltoluene	1	70	130	15	0.00	0.99	99		0.97	97		2	
1,3-Dichlorobenzene	1	70	130	15	0.00	1.04	104		1.02	102		3	
1,4-Dichlorobenzene	1	70	130	15	0.00	1.06	106		1.01	101		5	
n-butylbenzene	1	70	130	15	0.00	1.05	105		1.00	100		5	
1,2-Dichlorobenzene	1	70	130	15	0.00	1.06	106		1.02	102		3	
1,2-Dibromo-3-chloropropane	1	70	130	15	0.00	1.08	108		1.07	107		1	
1,2,4-Trichlorobenzene	1	70	130	15	0.00	0.99	99		0.94	94		5	
Hexachlorobutadiene	1	70	130	15	0.00	1.00	100		0.99	99		1	
Naphthalene	1	70	130	15	0.00	0.95	95		0.96	96		1	
1,2,3-Trichlorobenzene	1	70	130	15	0.00	1.01	101		1.00	100		2	
1,3,5-Trichlorobenzene	1	70	130	15	0.00	0.99	99		0.95	95		3	

\# Column to be used to flag recovery and RPD values outside of QC limits
* Values outside QC limits

Non-spike result of "0" used in place of "U" to allow calculation of spike recovery

Comments: ______________________________

VOLATILE ORGANIC AQUEOUS
MATRIX SPIKE/DUPLICATE
PERCENT RECOVERY

Instrument ID: 1
GC Column: RTX-502.2
Column ID: 0.25 mm

SDG: 67355
Non-spiked sample: 67355-1
Spike: 67355-1,MS
Spike Duplicate 67355-1,MSD

COMPOUND	SPIKE ADDED	LOWER LIMIT	UPPER LIMIT	RPD LIMIT	NON-SPIKE RESULT (ug/L)	SPIKE RESULT (ug/L)	SPIKE % REC	#	SPIKE DUP RESULT (ug/L)	SPIKE DUP % REC	#	RPD	#
Dichlorodifluoromethane	5	70	130	15	0.00	5	105		5	104		1	
Chloromethane	5	70	130	15	0.00	6	111		6	111		1	
Vinyl Chloride	5	70	130	15	0.00	6	117		6	118		1	
Bromomethane	5	70	130	15	0.00	7	132	*	7	141	*	7	
Chloroethane	5	70	130	15	0.00	6	111		6	110		1	
t-Butyl alcohol (TBA)	25	70	130	15	0.00	21	82		20	80		3	
Trichlorofluoromethane	5	70	130	15	0.00	5	101		5	99		2	
Diethyl ether	5	70	130	15	0.00	4	86		4	81		6	
1,1,2-Trichlorotrifluoroethane	5	70	130	15	0.00	5	102		5	100		1	
Acetone	25	70	130	15	0.00	23	93		22	87		7	
1,1-Dichloroethene	5	70	130	15	0.00	5	105		5	105		0	
Di-isopropyl ether (DIPE)	5	70	130	15	0.00	5	101		5	99		1	
Methylene Chloride	5	70	130	15	0.00	4	87		4	83		5	
Carbon Disulfide	5	70	130	15	0.00	6	114		6	112		2	
Acrylonitrile	5	70	130	15	0.00	5	102		5	104		2	
Methyl-tert-butyl ether (MTBE)	10	70	130	15	0.00	10	95		9	94		2	
trans-1,2-Dichloroethene	5	70	130	15	0.00	5	107		5	105		2	
1,1-Dichloroethane	5	70	130	15	0.00	5	104		5	105		1	
Methyl ethyl ketone	25	70	130	15	0.00	23	93		22	88		6	
Ethyl t-butyl ether (ETBE)	5	70	130	15	0.00	5	96		5	94		2	
2,2-Dichloropropane	5	70	130	15	0.00	5	90		4	88		2	
cis-1,2-Dichloroethene	5	70	130	15	1.29	7	107		7	107		1	
t-Amyl methyl ether (TAME)	5	70	130	15	0.00	5	94		5	91		3	
Chloroform	5	70	130	15	0.00	5	105		5	103		2	
Bromochloromethane	5	70	130	15	0.00	5	102		5	99		3	
Tetrahydrofuran	5	70	130	15	0.00	5	96		4	87		10	
1,1,1-Trichloroethane	5	70	130	15	0.00	6	112		5	110		1	
1,1-Dichloropropene	5	70	130	15	0.00	5	110		5	109		1	
Carbon Tetrachloride	5	70	130	15	0.00	5	109		5	108		0	
1,2-Dichloroethane	5	70	130	15	0.00	5	97		5	93		4	
Benzene	5	70	130	15	0.00	5	106		5	103		2	
Trichloroethene	5	70	130	15	6.59	12	112		12	109		1	
1,2-Dichloropropane	5	70	130	15	0.00	5	98		5	96		2	
Bromodichloromethane	5	70	130	15	0.00	5	97		5	95		2	
Dibromomethane	5	70	130	15	0.00	4	90		5	91		1	
2-Hexanone	25	70	130	15	0.00	24	96		23	92		5	
Methyl isobutyl ketone	25	70	130	15	0.00	23	91		23	91		0	
cis-1,3-Dichloropropene	5	70	130	15	0.00	5	99		5	98		0	
Toluene	5	70	130	15	0.00	5	106		5	106		0	
trans-1,3-Dichloropropene	5	70	130	15	0.00	4	86		4	84		3	
1,1,2-Trichloroethane	5	70	130	15	0.00	5	97		5	91		6	
1,3-Dichloropropane	5	70	130	15	0.00	5	96		5	91		5	
Tetrachloroethene	5	70	130	15	0.00	6	111		6	110		0	
Dibromochloromethane	5	70	130	15	0.00	5	96		5	94		2	
1,2-Dibromoethane	5	70	130	15	0.00	5	92		5	92		1	
Chlorobenzene	5	70	130	15	0.00	5	108		5	105		3	

VOA FORM 3

VOLATILE ORGANIC AQUEOUS
MATRIX SPIKE/DUPLICATE
PERCENT RECOVERY

Instrument ID: 1
GC Column: RTX-502.2
Column ID: 0.25 mm

SDG: 67355
Non-spiked sample: 67355-1
Spike: 67355-1,MS
Spike Duplicate 67355-1,MSD

COMPOUND	SPIKE ADDED	LOWER LIMIT	UPPER LIMIT	RPD LIMIT	NON-SPIKE RESULT (ug/L)	SPIKE RESULT (ug/L)	SPIKE % REC	#	SPIKE DUP RESULT (ug/L)	SPIKE DUP % REC	#	RPD	#
1,1,1,2-Tetrachloroethane	5	70	130	15	0.00	5	106		5	104		2	
Ethylbenzene	5	70	130	15	0.00	6	116		6	114		2	
m,p-Xylene	10	70	130	15	0.00	11	114		11	113		1	
o-Xylene	5	70	130	15	0.00	6	112		6	111		1	
Styrene	5	70	130	15	0.00	6	113		6	110		2	
Bromoform	5	70	130	15	0.00	5	96		5	96		1	
Isopropylbenzene	5	70	130	15	0.00	5	103		5	101		2	
1,1,2,2-Tetrachloroethane	5	70	130	15	0.00	5	98		5	92		7	
1,2,3-Trichloropropane	5	70	130	15	0.00	4	89		4	90		1	
trans-1,4-Dichloro-2-butene	5	70	130	15	0.00	4	83		4	78		7	
n-Propylbenzene	5	70	130	15	0.00	6	111		6	112		0	
Bromobenzene	5	70	130	15	0.00	5	105		5	102		3	
1,3,5-Trimethylbenzene	5	70	130	15	0.00	6	114		6	112		2	
2-Chlorotoluene	5	70	130	15	0.00	6	113		5	110		3	
4-Chlorotoluene	5	70	130	15	0.00	5	108		5	106		2	
tert-butylbenzene	5	70	130	15	0.00	6	112		6	112		0	
1,2,4-Trimethylbenzene	5	70	130	15	0.00	5	108		5	108		0	
sec-butylbenzene	5	70	130	15	0.00	6	117		6	115		2	
p-isopropyltoluene	5	70	130	15	0.00	6	111		6	111		1	
1,3-Dichlorobenzene	5	70	130	15	0.00	5	104		5	103		1	
1,4-Dichlorobenzene	5	70	130	15	0.00	5	101		5	103		2	
n-butylbenzene	5	70	130	15	0.00	6	112		6	113		1	
1,2-Dichlorobenzene	5	70	130	15	0.00	5	100		5	99		1	
1,2-Dibromo-3-chloropropane	5	70	130	15	0.00	5	91		4	87		5	
1,2,4-Trichlorobenzene	5	70	130	15	0.00	5	95		5	97		2	
Hexachlorobutadiene	5	70	130	15	0.00	5	108		6	117		8	
Naphthalene	5	70	130	15	0.00	5	93		5	95		2	
1,2,3-Trichlorobenzene	5	70	130	15	0.00	5	98		5	96		1	
1,3,5-Trichlorobenzene	5	70	130	15	0.00	5	103		5	106		3	

\# Column to be used to flag recovery and RPD values outside of QC limits
* Values outside QC limits

Non-spike result of "0" used in place of "U" to allow calculation of spike recovery

Comments: ______________________________

CHAIN OF CUSTODIES

AnalyticsLLC:AEL Documents LLC:Pkg Dividers:COC.doc

CHAIN OF CUSTODY RECORD

7240

Client / Project Name: USACE – NorthernMEFUDS

Project Location: Aroostook County, ME

Project No.: 1-2128-13

Field Logbook No.: —

Sampler: (*Signature*)

Chain of Custody Tape No.: 7240

ANALYZES

Sample No. / Identification	Date	Time	Lab Sample Number	Type of Sample	VOCs-524.2	(40ml VOA w/HCl)	VOCs 524.2, 2				REMARKS Trip Blank on ice in cooler 2.3°
S58QC1-0710	7-26-10	—	-4	Lab DI	2						
58DW1-0710	↓	14:47	67355 -1	grab/Drinking water	3		③				Extra VOAs for Lab QC
58DW1-0710 BTF		14:42	-2	↓	3						Any questions call
58DW1-0710 AF		14:37	-3		3						Warren 802-223-4502
											Results to Bob
											Osborne
											802-229-4600
						Labels ✓'d by JB 7/27/10					

Relinquished by: (*Signature*)	Date	Time	Received by: (*Signature*)	Date	Time
	7-26-10	15:30	FEDEX	7/26/10	1530

Relinquished by: (*Signature*)	Date	Time	Received for Laboratory: (*Signature*)	Date	Time
FEDEX	7/27/10	1030		7/27/10	1030

Sample Disposal Method:	Disposed of by: (*Signature*)	Date	Time

SAMPLE COLLECTOR

100 State Street, Suite 600
Montpelier, VT 05602
(802) 229-4600
Fax (802) 229-5876

THE JOHNSON COMPANY, INC.
Environmental Sciences and Engineering

ANALYTICAL LABORATORY

Analytics Env. Lab
195 Commerce Way, STE. E
Portsmouth, NH 03801

Shipper ID #: Fed Exp.

WHITE - To accompany sample to the lab and returned to the Johnson Co.   YELLOW - Lab copy   PINK - Transporter copy   GOLD - Sampler copy

ANALYTICS SAMPLE RECEIPT CHECKLIST

analytics environmental laboratory LLC

AEL LAB#: 67355
CLIENT: JOHNSON CO
PROJECT: USACE NORTHERN METHODS

COOLER NUMBER: N/A
NUMBER OF COOLERS: 1
DATE RECEIVED: 07/27/10

A: PRELIMINARY EXAMINATION:

DATE COOLER OPENED: 07/27/10

1. Cooler received by(initials):

Date Received: 07/27/10

2. Circle one: Hand delivered (If so, skip 3) [✓ Shipped]

3. Did cooler come with a shipping slip? [✓ Y] N

3a. Enter carrier name and airbill number here: FEDEX 8450 4373 2976

4. Were custody seals on the outside of cooler? [✓ Y] N
How many & where: 1 FRONT LID Seal Date: N/A Seal Name: N/A

5. Did the custody seals arrive unbroken and intact upon arrival? [✓ Y] N

6. COC#: 7240

7. Were Custody papers filled out properly (ink,signed, etc)? [✓ Y] N

8. Were custody papers sealed in a plastic bag? [✓ Y] N

9. Did you sign the COC in the appropriate place? [✓ Y] N

10. Was the project identifiable from the COC papers? [✓ Y] N

11. Was enough ice used to chill the cooler? [✓ Y] N Temp. of cooler: 2.3°

B. Log-In: Date samples were logged in: 07/27/10 By:

12. Type of packing in cooler([✓ bubble wrap], popcorn) [✓ Y] N

13. Were all bottles sealed in separate plastic bags? [✓ Y] N

14. Did all bottles arrive unbroken and were labels in good condition? [✓ Y] N

15. Were all bottle labels complete(ID,Date,time,etc.) [✓ Y] N

16. Did all bottle labels agree with custody papers? [✓ Y] N

17. Were the correct containers used for the tests indicated: [✓ Y] N

18. Were samples received at the correct pH? Y [✓ NA]

19. Was sufficient amount of sample sent for the tests indicated? [✓ Y] N

20. Were bubbles absent in VOA samples? Y [✓ N]

If NO, List Sample ID's and Lab #s: 2 OF 2 SAMPLES LS58QC1.0710 CONTAINED BUBBLES SMALLER THAN PEA-SIZE (Trip Blanks)

21. Laboratory labeling verified by (initials): Date: 7/27/10

C:ANLYTICS LLC\AEL DOCUMENTS\FORMS\SMPL CHKLST\Edit 4908

Rev. 2, 4/13/10

FedEx Express **USA Airbill** 845043732976

0200

FedEx Retrieval Copy

1A
2005

1B
2005

1C
2005

1 From

Date 7-26-10 Sender's FedEx Account Number 107573364

Sender's Name Warren Davey Phone 802 223-4502

Company The Johnson Co

Address 100 State St, Suite 600 Dept./Floor/Suite/Room

City Montpelier State VT ZIP 05602

2 Your Internal Billing Reference 1-2128-13

3 To

Recipient's Name Sample Receiving Phone 603 436-5111

Company Analytics Environ. Lab

Address 195 Commerce Way Suite E

To "HOLD" at FedEx location, print FedEx address. We cannot deliver to P.O. boxes or P.O. ZIP codes.

Address

Dept./Floor/Suite/Room

City Portsmouth State NH ZIP 03801

8450 4373 2976

L

4a Express Package Service ***Packages up to 150 lbs.***
Delivery commitment may be later in some areas.

1 ☒ FedEx Priority Overnight Next business morning
5 ☐ FedEx Standard Overnight Next business afternoon
6 ☐ FedEx First Overnight Earliest next business morning delivery to select locations.
23 ☐ FedEx 2Day Second business day
20 ☐ FedEx Express Saver Third business day

FedEx Envelope rate not available. Minimum charge: One-pound rate.

4b Express Freight Service ***Packages over 150 lbs.***
Delivery commitment may be later in some areas.

7 ☐ FedEx 1Day Freight* Next business day
8 ☐ FedEx 2Day Freight Second business day
83 ☐ FedEx 3Day Freight Third business day

* Call for Confirmation:

5 Packaging * Declared value limit $500.

6 ☐ FedEx Envelope*
2 ☐ FedEx Pak* Includes FedEx Small Pak, FedEx Large Pak, and FedEx Sturdy Pak.
1 ☒ Other

6 Special Handling Include FedEx address in Section 3.

3 ☐ **SATURDAY Delivery** Available only for FedEx Priority Overnight and FedEx 2Day to select ZIP codes
1 ☐ **HOLD Weekday** at FedEx Location Not available for FedEx First Overnight
31 ☐ **HOLD Saturday** at FedEx Location Available only for FedEx Priority Overnight and FedEx 2Day to select locations

Does this shipment contain dangerous goods?
One box must be checked.

☒ No 4 ☐ Yes As per attached Shipper's Declaration ☐ Yes Shipper's Declaration not required 6 ☐ Dry Ice Dry Ice, 9, UN 1845 ____ x ____ kg

Dangerous Goods (including Dry Ice) cannot be shipped in FedEx packaging. ☐ Cargo Aircraft Only

7 Payment ***Bill to:*** Enter FedEx Acct. No. or Credit Card No. below. ☐ Obtain Recip. Acct. No.

1 ☒ Sender Acct. No. in Section 1 will be billed.
2 ☐ Recipient
3 ☐ Third Party
4 ☐ Credit Card
5 ☐ Cash/Check

FedEx Acct. No. Credit Card No.

Total Packages	Total Weight		Total Charges
1	13	[redacted]	Credit Card Auth.

†Our liability is limited to $100 unless you declare a higher value. See the *FedEx Service Guide* for details.

8 Release Signature *Sign to authorize delivery without obtaining signature.*

By signing you authorize us to deliver this shipment without obtaining a signature and agree to indemnify and hold us harmless from any resulting claims.

446

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APPENDIX B

HYDROPHYSICS^{TM} AND GEOPHYSICAL LOGGING RESULTS INCLUDING HYDROPHYSICS^{TM} AND GEOPHYSICAL LOG MONTAGE PLOTS

HydroPhysical™ and Geophysical Logging Results
Former LO-58 Nike Battery Launch Site,
Maine Formerly Used Defense Sites (FUDS)
Caribou, ME

Prepared for
Weston Solutions, Inc.
January 13, 2009

Prepared by
COLOG Division of Layne Christensen Company
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Prepared By:	Reviewed By:
Summer Montgomery	Greg Bauer
Geophysical Engineer	Asst. Gen. Manager/Senior Hydrogeologist

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HydroPhysical™ and Geophysical Logging Results;
Former LO-58 Nike Battery Launch Site,
Maine Formerly Used Defense Sites (FUDS);
Caribou, ME

Figures and Tables – DW-1

DW-2 Logging Results

Figures and Tables – DW-2

IV. Appendices

List of Acronyms

Weston Solutions – Weston Solutions, Inc.
gpm – gallons per minute
FEC – Fluid Electrical Conductivity
OBI – Optical Borehole Imager (optical televiewer)
ABI – Acoustic Borehole Imager (acoustic televiewer)
WSP – Wireline Straddle Packer
VSP – Vertical Seismic Profile
ft – feet
min. – minute
cm – centimeters
s – second
μS – micro Siemons
HpL™ - HydroPhysical™ Logging
DI – De-ionized, e.g., DI water
ftbtoc – feet below top of casing
GS – Ground Surface

HydroPhysical™ and Geophysical Logging Results
Former LO-58 Nike Battery Launch Site,
Maine Formerly Used Defense Sites (FUDS)
Caribou, ME

I. Executive Summary

The results of the HydroPhysical™ and geophysical logging performed in two open boreholes and five 2-inch PVC wells at the Former LO-58 Nike Battery Launch Site, Maine Formerly Used Defense Sites (FUDS) in Caribou, Maine identified water-bearing fractures ranging in flow rates from 0.005 to 5.69 gpm. High-angle fractures with aperture were identified in each of the two open boreholes and wireline straddle packer testing indicated the high-angle fractures are likely providing a vertical conduit for hydraulic communication outside the influence of the borehole. Fracture-specific transmissivities calculated using the hydrophysical data in the two open boreholes range from 0.20 to 220 feet^2/day. Fracture-specific FEC did not vary significantly between the boreholes, with FEC ranging from 321 to 597 µS/cm.

Ambient testing identified horizontal flow in DW-1 and downward vertical flow within the fluid column in DW-2. The difference is likely due to the highly fractured borehole in DW-1 with some of those water-bearing fractures high-angle, resulting in an interconnected network of fractures that have pressure-equilibrated outside the influence of the borehole. In DW-2, a significantly deeper borehole, though there are still high-angle fractures identified, their aperture and water-bearing potential are not as significant and likely lack the vertical hydraulic potential in the middle portion of DW-2.

Please refer to Table Summary:1 for a complete summary of the HydroPhysical™ logging results. All depths reported herein are referenced to the top of steel or PVC casings.

Table Summary 1: Summary of Hydrophysical Logging Results; Weston Solutions; LO-58; Caribou, ME.

Well ID	Water Bearing Interval #	Interval of Flow (feet)	Interval Specific Flow Rate During Ambient Testing (gpm)	Interval Specific Flow Rate During Pumping (gpm)	Transmissivity (ft2/day)	Interval-Specific Fluid Electrical Conductivity (uS/cm)
DW-1	**1**	27.3 - 31.7	0.085	0.207	8.51E+00	376
	2	34.6 - 35.0	0.011	0.195	1.28E+01	376
	3	37.4 - 38.4	0.000	0.745	5.18E+01	428
	4	40.4 - 48.6	0.140	2.00	1.29E+02	357
	5	49.0 - 50.2	0.018	0.416	2.76E+01	375
	6	52.7 - 53.6	0.058	1.65	1.11E+02	375
	7	54.4 - 58.1	0.000	0.838	5.82E+01	375
DW-2	**1**	19.5 - 19.6	0.026	0.01	2.95E+00	321
	2	30.4 - 31.6	0.297	5.69	2.20E+02	378
	3	38.2 - 41.8	0.016	0.374	1.43E+01	528
	4	44.9 - 51.4	0.074	0.081	2.82E-01	512
	5	96.4 - 97.0	-0.370	0.000	1.48E+01	432
	6	143.3 - 144.3	0.000	0.008	3.20E-01	432
	7	179.2 - 183.0	0.000	0.015	6.00E-01	431
	8	189.5 - 191.0	-0.185	0.051	9.45E+00	429
	9	191.4 - 218.3	0.000	0.008	3.20E-01	429
	10	227.4 - 228.2	0.000	0.005	2.00E-01	597
	11	243.7 - 279.2	0.000	0.024	9.61E-01	597

Summary of Drinking Water Well Wire-Line Straddle Packer Sampling Analytical Results
Maine Formerly Used Defense Site LO-58
Borehole Hydrophysics and Geophysics Report

Well	Maine Maximum Exposure Guideline (µg/L)	EPA Maximum Contaminant Limit (µg/L)	DW-1					
Field Sample ID			LS58DW1-0508-29	LS58DW1-0508-34	LS58DW1-0508-34E	LS58DW1-0508-41	LS58DW1-0508-51	LS58DW1-0508-56
Sample Date			5/20/2008	5/20/2008	5/20/2008	5/19/2008	5/19/2008	5/18/2008
Depth Interval (ft bgs)			(water) 24.98 to 33.15	33.75 to 38.5		41.2 to 51.9	51.0 to 58.1 (bottom)	56.6 to 58.1 (bottom)
Volatile Organic Compunds by the United States Environmetal Protection Agency Method 524.2 (µg/L)								
Benzene	6	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	70	NE	**0.52**	0.5 U	0.5 U	**0.24 J**	0.5 U	**0.34 J**
cis-1,2-Dichloroethylene	70	70	0.5 U	**0.44 J**	**0.45 J**	**1.2**	**0.96**	**0.52**
Trichloroethylene	32*	5	**1.8**	**2.5**	**2.5**	**3.4**	**3.1**	**2**
Toluene	1,400	1,000	**120 D**	**25**	**22**	**12**	0.5 U	**22**
1,2-Ethylene Dibromide, 1,2-Dibromo-3-Chloropropane, and 1,2,3-Trichloropronane by the United States Environmetal Protection Agency Method 504.1 (µg/L)								
No analytes detected								
Gasoline Range Organics by the Maine Health and Environmental Testing Laboratory Method 4.1.17 (µg/L)								
Gasoline Range Organics	50	NE	**156**	**24**	**23**	**14**	10 U	**27**
Diesel Range Organics by the Maine Health and Environmental Testing Laboratory Method 4.1.25 (µg/L)								
Diesel Range Organics	50	NE	50 U	50 U	50 U	**51 J^1**	50 U	**350 J^1**

Well	Maine Maximum Exposure Guideline (µg/L)	EPA Maximum Contaminant Limit (µg/L)	DW-2					
Field Sample ID			LS58DW2-0508-16	LS58DW2-0508-28.5	LS58DW2-0508-37	LS58DW2-0508-94.5	LS58DW2-0508-189	LS58DW2-0508-265
Sample Date			5/16/2008	5/16/2008	5/17/2008	5/17/2008	5/17/2008	5/17/2008
Depth Interval (ft bgs)			16.0 to 20.0	28.5 to 32.5	37.0 to 41.7	94.5 to 98.5	187.9 to 192.2	265 to 284.0 (bottom)
Volatile Organic Compunds by the United States Environmetal Protection Agency Method Method 524.2 (µg/L)								
Benzene	6	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	70	NE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U U
cis-1,2-Dichloroethylene	70	70	0.5 U	0.5 U	0.5 U	0.5 U	**0.23 J**	0.5 U
Trichloroethylene	32*	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Toluene	1,400	1,000	**2.4**	0.5 U	0.5 U	**5.5**	2.3 U^1	0.79 U^1
1,2-Ethylene Dibromide, 1,2-Dibromo-3-Chloropropane, and 1,2,3-Trichloropronane by the United States Environmetal Protection Agency Method 504.1 (µg/L)								
No analytes detected								
Gasoline Range Organics by the Maine Health and Environmental Testing Laboratory Method 4.1.17 (µg/L)								
Gasoline Range Organics	50	NE	10 U	10 U	10 U	10 U	10 U	10 U
Diesel Range Organics by the Maine Health and Environmental Testing Laboratory Method 4.1.25 (µg/L)								
Diesel Range Organics	50	NE	**1,050**	50 U	50 U	50 U	50 U	**80 J^1**

Notes:

NE = Standard not established.

µg/L = Micrograms per liter (parts per billion).

ft bgs = Feet below ground surface.

Bold = Substance Detected.

Blue Highlight = Exceeds Maine Maximum Exposure Guideline.

EPA = United States Environmental Protection Agency

D = Result from dilution analysis.

J = Quantitation approximate.

J^1 = Diesel range organics quantitation approximate due to detection in rinsate blank.

U = substance not detected at the listed detection limit.

U^1 = Toluene qualifiued as not detected due to detection in rinsate blank.

* = Although the Maine Maximum Exposure Guideline is 32 µg/L, the action level used by the State of Maine is one-half the EPA Maximum Contaminant Level, 2.5 µg/L .

II. Introduction

In accordance with COLOG's proposal dated February 23, 2007, COLOG has applied HydroPhysical™ (HpL™) and geophysical logging methods and wireline straddle packer methods to characterize the formation waters and orientation of identified fractures and features intersecting two open boreholes and five PVC wells at the Former LO-58 Nike Battery Launch Site, Maine Formerly Used Defense Sites (FUDS) in Caribou, Maine. The objectives of the investigation were to:

1) Evaluate temperature and fluid electrical conductivity under pre-testing conditions.
2) Identify fractures and features intersecting the borehole and evaluate their orientation.
3) Characterize and quantify flow in the borehole under both non-stressed (ambient) and stressed (pumping) conditions.
4) Evaluate the vertical distribution of flow and interval-specific permeability for all identified water-producing fractures or intervals.
5) Sample and stress test water-bearing intervals using the WSP to acquire depth-specific groundwater samples.
6) Apply surface geophysical methods and downhole methods to estimate subsurface velocities.

The two open boreholes logged with the hydrophysical and geophysical logging methods at the LO-58 site are: DW-1 (AMAC well) and DW-2 (VFW well). The five PVC wells tested are: MW-1, MW-2, MW-3, MW-4 and MW-5. The geophysical and hydrophysical logging methods used to achieve the objectives were HydroPhysical™ logging, optical televiewer, acoustic televiewer, 3-arm caliper, natural gamma, water quality (pH, ORP, DO), EM induction conductivity, electric resistivity, VSP, wireline straddle packer, downhole video and full waveform sonic. The two open boreholes were tested under both non-stressed, or ambient, conditions and stressed, or pumping, conditions to fully evaluate the water-bearing horizons intersecting the boreholes. The PVC wells were not hydrophysically tested. All depths reported herein are referenced to the top of steel casings in the case of the open boreholes and PVC casings in the case of the wells.

COLOG's logging of the three subject wellbores was performed over the period of May 5th through May 20th, 2008.

Well Construction Summary

Former Nike Battery Launch Site LO-58, Maine Formerly Used Defense Sites

Well ID	MW-01	MW-02	MW-03	MW-04	MW-05	DW-1	DW-2
Ground Elevation (ft amsl)	577.3	587.6	567.5	603.4	575.9	571	546.5
Protective Casing Elevation (ft amsl)	578.96	590.13	571.07	605.84	575.88	573	539.5
Top of Inner Casing Elevation (ft amsl)	578.79	589.36	570.63	605.45	575.72	na	na
Casing Stickup (ft)	1.66	2.53	3.57	2.44	-0.02	2.4	-6
Well Total Depth (ft bmp)	142	62	47	82	82	58.1	284
Casing Diameter (inches)	2	2	2	2	2	6	6
Screened Interval Elevation (ft amsl)	435.69 to 445.69	527.76 to 537.76	521.78 to 531.78	522.75 to 532.75	497.92 to 507.92	514.9 to 563	524.5 to 255.5
Casing Bottom Elevation (ft amsl)	435.69	527.76	521.78	522.75	497.92	514.9	255.5
Depth to Water (ft bmp)	28.27	34.32	20.10	40.82	25.32	25.92	8.86
Groundwater Elevation (ft amsl)	550.52	555.04	550.53	564.63	550.4	547.08	530.64

Notes:

Elevations for well DW-1 and DW-2 are approximate, and not the result of a precise survey.

ft bmp = feet below measuring point.

ft amsl = feet above mean sea level.

Groundwater depth measurements were made on 21 May 2008.

III. Methodology

A. HydroPhysical™ Logging (HpL™)

The HydroPhysical™ logging technique involves pumping the wellbore and then pumping while injecting into the Wellbore with deionized water (DI). During this process, profiles of the changes in fluid electrical conductivity of the fluid column are recorded. These changes occur when electrically contrasting formation water is drawn back into the borehole by pumping or by native formation pressures (for ambient flow characterization). A downhole wireline HydroPhysical™ tool, which simultaneously measures fluid electrical conductivity (FEC) and temperature is employed to log the physical/chemical changes of the emplaced fluid.

The computer programs FLOWCALC and/or BOREII (Hale and Tsang, 1988 and (Daughtery and Tsang, 2000) can be utilized to evaluate the inflow quantities of the formation water for each specific inflow location. FLOWCALC is used to estimate the interval-specific flow rates for the production test results based on "hand-picked" values of FEC and depth. The values are determined from the "Pumping" and "Pumping During DI Injection logs". Numerical modeling of the reported data is performed using code BORE/BOREII. These methods accurately reflect the flow quantities for the identified water bearing intervals.

In addition to conducting HydroPhysical™ logging for identification of the hydraulically conductive intervals and quantification of the interval specific flow rates, additional logging runs are also typically performed. Prior to emplacement of DI, ambient fluid electrical conductivity and temperature (FEC/T) logs are acquired to assess the ambient fluid conditions within the borehole. During these runs, no pumping or DI emplacement is performed, and precautions are taken to preserve the existing ambient geohydrological and geochemical regime. These ambient water quality logs are performed to provide baseline values for the undisturbed borehole fluid conditions prior to testing.

For interval-specific permeability estimations, COLOG utilizes Hvorslev's 1951 porosity equation in conjunction with the HpL™ results. Several assumptions are made for estimating the permeability of secondary porosity. First, the type of production test COLOG performs in the field may significantly affect the accuracy of the transmissivity estimation. The permeability equation is relatively sensitive to overall observed drawdown. For a high yield wellbore, drawdown will usually stabilize and an accurate observed drawdown can be estimated. However, for a low yield wellbore, drawdown usually does not stabilize but instead, water level continues to drop until it reaches the pump inlet and the test is complete. In this case COLOG utilizes the maximum observed drawdown. The inaccuracy arises in the fact that overall observed drawdown does not stabilize and therefore is more an arbitrary value dependent on the placement of the pump downhole. Secondly, in an environment where flow originates from secondary porosity the length of the interval is derived from the either the thickness of the fracture down to 0.1 feet or the thickness of the fracture network producing water. This assumption of a fracture network producing water versus a porous media is not how the permeability equation was designed to be used. In lieu of a more appropriate equation unknown to COLOG at this time, COLOG utilizes Hvorslev's 1951 porosity equation based on its sensitivity to interval-specific flow which can be measured accurately, drawdown which can be measured accurately in the case of a high yield wellbore and its insensitivity to effective radius. The insensitivity to effective radius is critical when an observation well is not available to measure drawdown at a known distance from the subject wellbore.

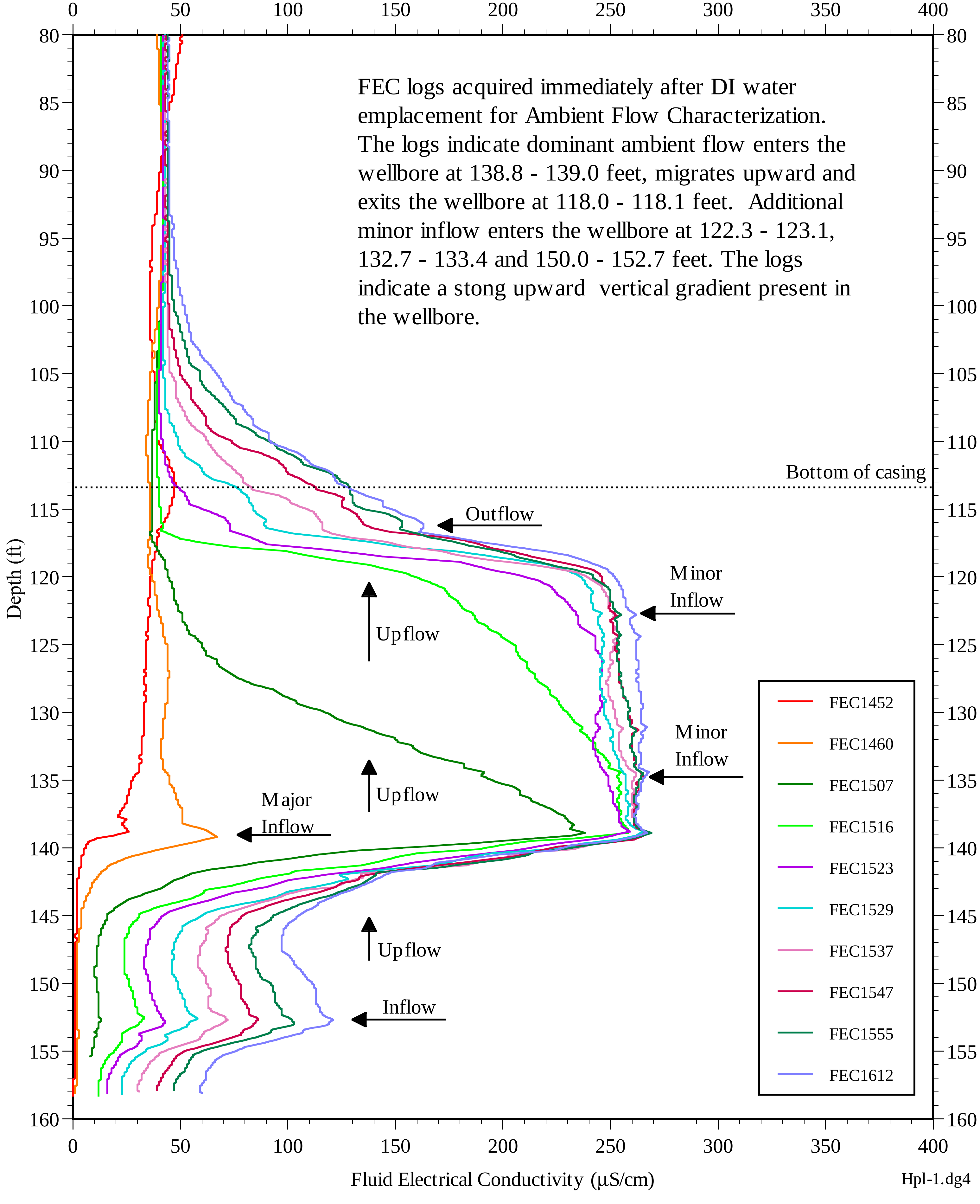
How to Interpret HydroPhysical™ Logs

Figure HpL:1 below is an example data set for an ambient flow evaluation. The data represents HpL™ logs acquired immediately after deionized (DI) water emplacement for ambient flow evaluation. For ambient flow evaluation the wellbore fluids are first replaced with DI water (termed "emplacement"), then a series of fluid electrical conductivity (FEC) logs are acquired over a period of a time to monitor ground water entering the wellbore under natural pressures and migrating either vertically or horizontally through the wellbore. The wellbore fluids are replaced with DI water without disturbing the ambient free-water level by injecting DI water at the bottom of the wellbore and extracting wellbore water at exactly the same rate at the free-water surface. However, at the beginning of the DI water emplacement, a slightly depressed free-water level (approximately one tenth of a foot below ambient free water-level) is achieved and maintained throughout the test. This procedure is implemented to ensure that little to no DI water is able to enter the surrounding formation during DI water emplacement. By acquiring FEC logs during the emplacement of DI water and by continuously measuring water level with a downhole pressure transducer the emplacement can be properly monitored and controlled to minimize the disturbance of the recorded ambient water. After the wellbore fluids are replaced with DI water, the injection and extraction pumps are turned off and in most cases the downhole plumbing is removed from the wellbore. A check valve is installed in the pump standpipe to ensure water in the standpipe does not drain back into the wellbore. While the plumbing is removed from the wellbore DI water is injected from the top of the wellbore to maintain ambient water level. Often a baseline FEC log is acquired during the final stages of the emplacement of DI water to provide baseline conditions just before the ceasing of pumping. Figure HpL:1 illustrates ambient flow entering the wellbore at depths of 150.0 to 152.7, 138.8 to 139.0, 132.7 to 133.4, 122.3 to 123.1 and 118.0 to 118.1 feet. The location of these intervals is illustrated by the sharp increases or "spikes" in FEC. The increase in FEC over time at these four intervals is characteristic of ambient inflow. The upward vertical trend in this inflow is also apparent from the FEC logs. For example, the dominant inflowing zone at 138.8 to 139.0 feet illustrates a major growth in FEC above the inflow "spike", and little growth below the "spike." The zone at 118.0 to 118.1 feet is the termination of all inflow into the well. The sum of the four inflow zones make up the outflow of this zone, and this value, along with the value of the four inflow zones is computed using code BOREII.

COLOG uses three types of tests to identify the water-bearing intervals in a wellbore under stressed conditions. In the lowest yield environment (less than 0.5-0.7 gpm) a slug test approach is utilized. In a relatively low-yield wellbore environment a pump after emplacement (PAE) test is conducted, and in a relatively medium to high-yield wellbore environment a pump and inject (PNI) test is conducted. The decision on the type of test to perform on a specific wellbore is made in the field based on the ability of the wellbore to recover to ambient free-water level when a disturbance in water level is introduced into the well, i.e. inserting tools and/or pluming into the well.

In a low-yield wellbore environment a slug or PAE test is utilized to identify the water-bearing intervals under stressed conditions. These tests are similar in protocol and involve first a replacement of wellbore fluids with DI water in a manner identical to that of the emplacement during an ambient flow evaluation. Often a baseline FEC log is acquired during the final stages of the emplacement of DI water to provide baseline conditions just before the ceasing of injection pumping. Following the cessation of injection pumping, the extraction pump is left used to either pull an instantaneous slug (slug test) or is used to pump at a relatively steady low rate of flow in the wellbore (approximately 1-2 gpm). During this time numerous FEC logs are acquired over time. The location of water-bearing intervals is apparent by the sharp increases or "spikes" in FEC over time. The rate at which these intervals inflow is calculated using BOREII and is based on the rate of increase of mass (area under the curve using the FEC log as the curve). Flow direction is easily determined by tracking the center of mass of the area under the curve. In

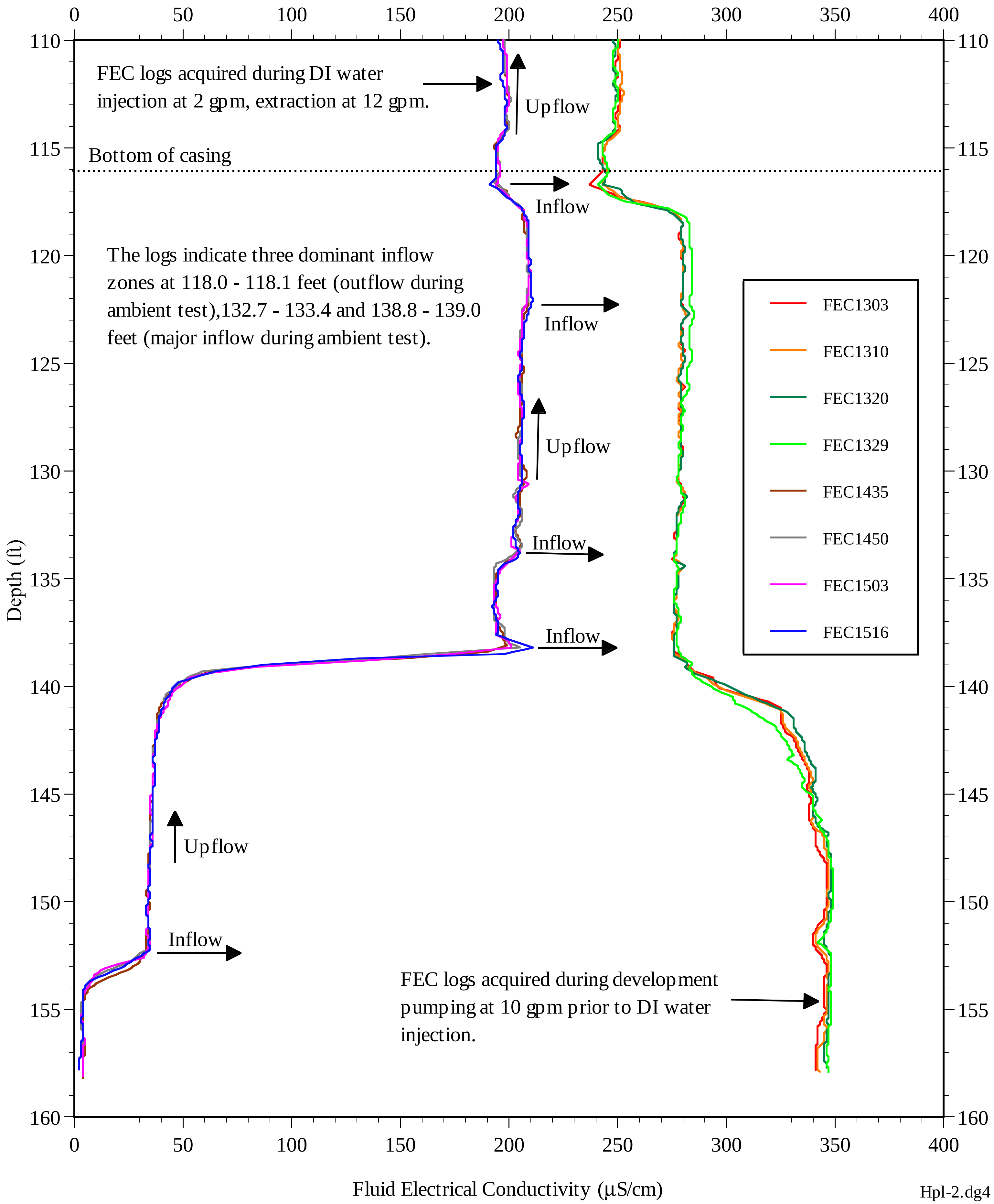
FIGURE HpL:1. EXAMPLE OF HYDROPHYSICAL LOGS DURING AMBIENT FLOW CHARACTERIZATION WITH EXAMPLE INTERPRETATION.



most cases, if pumping is being conducted flow is traveling up the wellbore towards the pump which is situated inside casing.

Figure HpL:2 is an example data set from a production test (stress test) from the same wellbore as above. The data represents HpL^{TM} logs acquired during a PNI test. The set of FEC logs on the right of this figure (FEC1303, FEC1310, FEC1320, and FEC1329) illustrate the condition of the wellbore during development pumping. In the case of this example, the wellbore was stressed at a rate of approximately 10 gpm until a relatively steady-state condition was achieved in the wellbore. A steady-state condition is apparent when the FEC logs begin to repeat as they do in figure HpL:2. Repeatable FEC logs indicate that the hydrochemistry of the water inflowing to the wellbore is not changing over time (steady-state) and that the flow rates of all inflow zones is also not changing over time. Additionally, the drawdown is monitored continuously to observe a “slowing down” in the rate of increase of drawdown. When drawdown (water level) is stable, the inflow rates of the various inflow zones are assumed to be steady. By contrast, if DI water injection is begun in the early stages of pumping when drawdown is still increasing, i.e. water level is dropping rapidly, the inflow rates of the various inflow zones would increase with time as less wellbore storage is used to maintain a particular pumping rate. The remaining FEC logs (FEC1435, FEC1450, FEC1503, and FEC1516) illustrate the conditions in the wellbore during pumping and injection procedures. Fluid was extracted from the wellbore at a rate of approximately twelve gpm while DI water was simultaneously injected at the bottom of the wellbore at a rate of approximately two gpm, until a relatively steady-state condition existed in the well. Water-bearing intervals in the wellbore are identified by changes or “steps” in FEC throughout the FEC logs. The flow rate of these intervals is computed using BOREII and/or Flowcalc software. Every location that the FEC increases in these logs is a zone of inflow. Similarly, where the logs decrease in FEC indicates a zone of inflow with water lower in FEC than the water in the wellbore. A zone exhibiting a decrease in FEC on the injection logs should also decrease at the same depth on the development (pre-DI water injection) logs. Please see Appendix B for a detailed discussion of code BOREII used to numerically model the reported field FEC logs.

FIGURE HpL:2. EXAMPLE OF HYDROPHYSICAL LOGS DURING A 10 GPM PRODUCTION TEST WITH EXAMPLE INTERPRETATION.



Hpl-2.dg4

Sensitivity of Transmissivity to Effective Radius

An estimation of transmissivity (T) has be made for all identified water-bearing intervals using an equation after Hvorslev (1951) assuming steady-state radial flow in an unconfined aquifer:

$$T = KL = \frac{q_i}{2\pi\Delta h_w}\ln\left(\frac{r_e}{r_w}\right)$$

where K is the hydraulic conductivity, q_i is the interval specific inflow rate calculated using HpL™ results (or "Delta Flow" from the table which equals "Interval-Specific Flow Rate During Pumping Conditions" minus "Ambient Flow Rate" if any), r_w is the borehole radius, r_e is the effective pumping radius, Δh_w is the observed maximum drawdown and L is the thickness of the zone through which flow occurs. The thickness, or length of the interval is calculated using a combination of both the HpL™ data and other geophysical data such as optical televiewer data. L can usually be estimated with a high degree of confidence based on both of those data sets. Q_i, or Delta Flow, can also be estimated accurately using code BOREII (see appendix B) for the HpL™ data sets. Δh_w is estimated with a high degree of confidence using Cologs' downhole pressure transducer and a laptop to record water-level data every second. Additionally, the borehole radius is confirmed quite readily from caliper data or core data. For this example, r_w equals 0.20 feet, r_e has been assumed to be approximately 100 feet and the observed maximum drawdown was estimated at 9.98 feet (the drawdown plot). By applying L and q_i from the HpL™ results under the two pressure conditions, the interval specific transmissivity can be calculated for each identified water-producing interval.

Colog utilizes Hvorslevs' 1951 equation when an observation well a known distance away with measurable drawdown is not available. Essentially, Hvorslevs' 1951 equation is similar to the prevalent Theis equation minus the observation well drawdown information. In replace of the observation well drawdown data Hvorslevs' equation uses an assumed "effective radius" divided by the borehole radius. One benefit to using Hvorslevs' 1951 equation when observation well data is unavailable is the insensitivity of the equation to the assumed effective radius as this is the only "unknown" variable in the equation. All other variables are known or calculated with a high degree of confidence. Only the effective radius is unproven, or unsupported, but its value can be estimated with some degree of accuracy.

The following example will illustrate the insensitivity of Hvorslevs' 1951 equation to the assumed effective radius of an aquifer. The greatest magnitude of change in this example between r_e of 50 feet and r_e of 300 feet is 2.22 feet^2/day transmissivity.

Interval (feet)	**Length of Interval (feet)**	**Q_i - Delta Flow (gpm)**	**Borehole Radius (feet)**	**Transmissivity Using r_e of 50 Feet**	**Transmissivity Using r_e of 100 Feet**	**Transmissivity Using r_e of 300 Feet**
118.0 – 118.1	0.1	3.997	0.20	6.78 x E^{01}	7.63 x E^{01}	8.98 x E^{01}
122.3 – 123.1	0.8	0.335	0.20	5.68 x E^{00}	6.39 x E^{00}	7.53 x E^{00}
132.7 – 133.4	0.7	1.217	0.20	2.06 x E^{01}	2.32 x E^{01}	2.73 x E^{01}
138.8 – 139.0	0.2	3.961	0.20	6.72 x E^{01}	7.56 x E^{01}	8.90 x E^{01}
150.0 – 152.7	2.7	0.197	0.20	3.34 x E^{00}	3.76 x E^{00}	4.43 x E^{00}

B. Optical Televiewer (OBI)

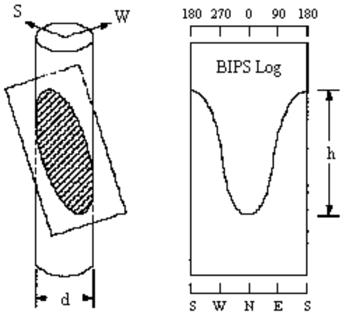
The optical televiewer provides the highest resolution available for fracture and feature analysis in boreholes. This technology is based on direct optical observation of the borehole wall face. Precise measurements of dip angle and direction of bedding and joint planes, along with other geological analyses, are possible in both air and clear fluid filled boreholes.

Theory of Operation

A small light ring illuminates the borehole wall allowing a camera to directly image the borehole wall face. A conical mirror housed in a clear cylindrical window focuses a 360° optical "slice" of the borehole wall into the camera's lens. As the optical televiewer tool is lowered down the hole, the video signal from this camera is transmitted uphole via the wireline to the optical televiewer surface instrumentation.

The signal is digitized in real time by capturing 360 pixels around a 0.5 mm ring from the conical image. The rings are stacked and unwrapped to a 2-D image of the borehole wall. A digital fluxgate magnetometer is used to determine the orientation of the digital image. A secondary mechanical compass is imaged along with the analog signal to insure proper orientation of the digital image.

The optical televiewer image is an oriented, 2-D picture of the borehole wall unwrapped from south to south or north to north depending on the software used (Figure 1). Planar features that intersect the borehole appear to be sinusoids on the unwrapped image. To calculate the dip angle of a fracture or bedding feature the amplitude of the sinusoid (h) and the borehole diameter (d) are required. The angle of dip is equal to the arc tangent of h/d, and the dip direction is picked at the trough of the sinusoid (Figure 1).



Dip Direction = Orientation of Sinusoid Minimum
Dip Angle = ArcTan h/d
where: h = height of sinusoid
d = borehole diameter

Figure 1: Geometric representation of a north dipping fracture plane and corresponding log.

Sinusoidal features were picked throughout wells by visual inspection of the digital optical televiewer images using interactive software. The software performed the orientation calculations and assigned depths to the fractures or bedding features at the inflection points (middles) of the sinusoids. Features were subjectively ranked for flow potential using COLOG's Ranking System for optical televiewer features included in this report. The features picked along with their assigned ranks, orientations and depths are presented in tables for each well. Orientations are based on magnetic north and are corrected for declination. The Stereonet plots and Rose Diagrams provide useful information concerning the statistical distribution and possible patterns or trends that may exist from the optical televiewer feature orientations.

Interpreting Optical Televiewer Data

Data acquired from the optical televiewer is typically in the form of dip direction/dip angle, i.e. 230/45. When plotted in 2-D color, the fractures and features intersecting the borehole appear as sinusoids as discussed above. Using the software program WellCAD version 3.2, the user identifies the features/fractures and has the software assign and record a dip angle and direction based on the above algorithm as described in the "Theory" section. The data can easily be converted into table format for display in Excel or any tabular editing program. From the data table, rose diagrams and/or stereonets can be generated if requested.

Rose Diagrams

A rose diagram is a polar diagram in which radial length of the petals indicates the relative frequency (percentage) of observation of a particular angle or fracture dip direction or range of angles or dip directions. Rose diagrams are used to identify patterns (if any) in the frequency of dip angles or directions for a particular data set. Figures 3 and 4 are example rose diagrams from an optical televiewer data set of fractures and features.

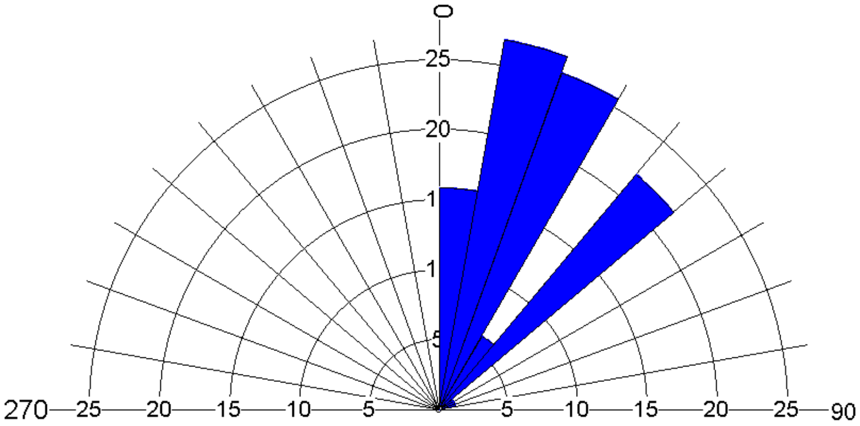


Figure 3: Example rose diagram from an optical televiewer data set illustrating the frequency (%) of dip angles.

Figure 3 above indicates, from an example data set, that approximately 16 percent of the fractures/features have a dip angle between 0 and 10 degrees, approximately 27 percent of the fractures/features have a dip angle between 11 and 20 degrees, approximately 25.5 percent between 21 and 30 degrees, approximately 6 percent between 31 and 40 degrees and 22 percent between 41 and 50 degrees. A quick glance at Figure 3 identifies a pattern of dip angle where greater than 50 percent of the fracture/features identified have a dip angle between 11 and 30 degrees. Additionally, no high-angle (greater than 50 degrees) fractures/features were identified from this data set.

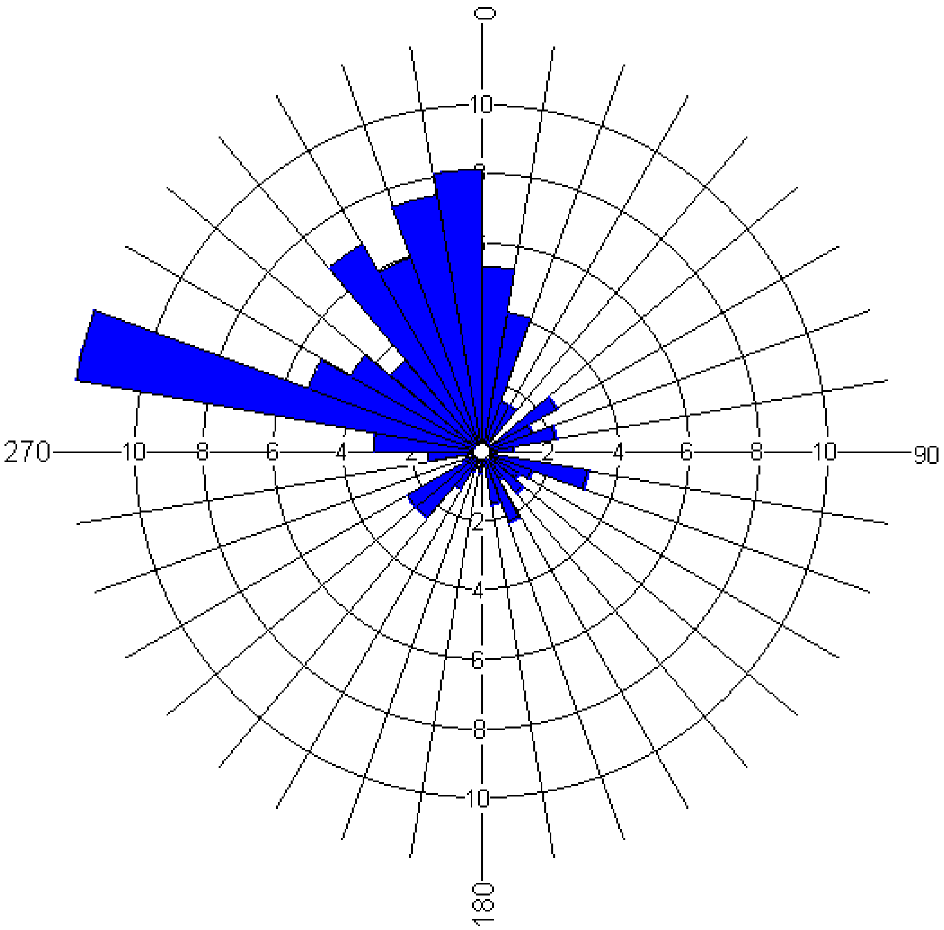


Figure 4: Example rose diagram from an optical televiewer data set illustrating the frequency (%) of dip direction.

Figure 4 (example data set) above indicates, with a quick glance, that the majority of the fractures/features dip in the direction of northwest. Specifically, approximately 62 percent of the identified fractures/features have a dip direction of 280 degrees (west) to 20 degrees (north).

Stereonets

For stereonets, COLOG utilizes a Schmidt net, an equal-area plot of longitude and latitude used in plotting geologic data such as the direction of structural features. Here, the angle indicates dip direction and the distance from the center indicates the dip magnitude. The further from the center the shallower the dip angle. Figure 5 below is an example stereonet diagram from an acoustic televiewer data set of fractures and features.

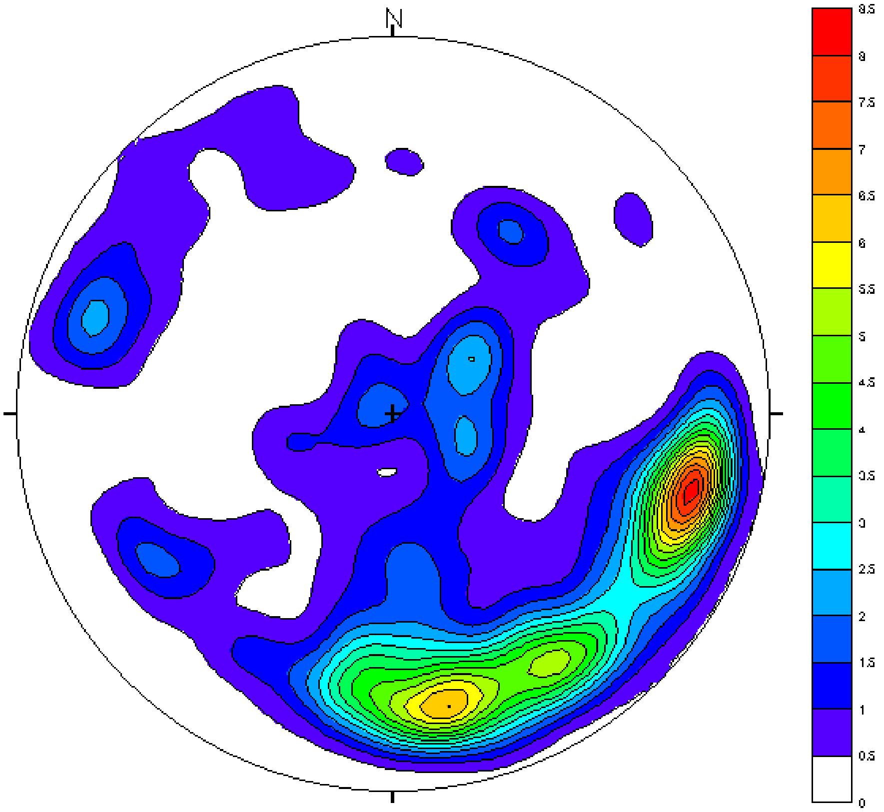


Figure 5: Example stereonet from an optical televiewer data set illustrating the frequency (%) of dip direction and dip angle in 2-D space.

Figure 5 above indicates, with a quick glance, that two distinct patterns exist in the example data set. A cluster of fractures/features with similar dip direction of approximately 110 degrees and similar steep dip angles is apparent. A second cluster, slightly less dense, is apparent with similar dip directions of approximately 170 degrees (almost due south) and similarly steep dip angles.

Please refer to the following Ranking System for Optical Televiewer Features for an explanation of the qualitative ranks assigned each optical televiewer feature identified.

C. Facsimile 40 - Acoustic Televiewer (FAC-40 ATV or ABI-40)

The FAC-40 ATV, from Advanced Logic Technologies (ALT), provides a detailed, oriented image of acoustic reflections from the borehole wall. A unique focusing system resolves bedding features as small as 2 mm and is capable of detecting fractures with apertures as small as 0.1 mm. The acoustic image is precisely oriented using a 3-axis magnetometer with dual accelerometers, which also combine to measure deviation (or drift) of the borehole trajectory.

Theory

The FAC-40 transmits ultrasonic pulses from a rotating sensor and records the signals reflected from the interface between the borehole fluid and the borehole wall (Figure 1). The amplitude of these reflections is representative of the hardness of the formation surrounding the borehole, while the travel time represents the borehole shape and diameter. As many as 288 reflections may be recorded per revolution at up to 12 revolutions per second. The digital amplitude or travel time data are presented using a variety of color schemes that represent the borehole wall.

This ATV image is an oriented, 2-D picture of the borehole wall unwrapped from north to north (Figure 2). Planar features that intersect the borehole appear to be sinusoids on the unwrapped image· To calculate the dip angle of a fracture or bedding feature the amplitude of the sinusoid (h) and the borehole diameter (d) are required. The angle of dip is equal to the arc tangent of h/d, and the dip direction is picked at the trough of the sinusoid (Figure 2).

Sinusoidal features are picked by visual inspection of the amplitude and travel time images using interactive software called WellCAD, version 4.1. The software performs the orientation calculations and assigns a depth to the fracture or bedding feature at the inflection point (middle) of the sinusoid. Features may be subjectively ranked for flow potential using the ranking system developed by the USGS presented in Table 1. Statistical analysis of the fracture/feature data such as stereonet plots and rose diagrams provide useful information concerning the statistical distribution and possible patterns or trends that may exist in the set of fracture/feature orientations.

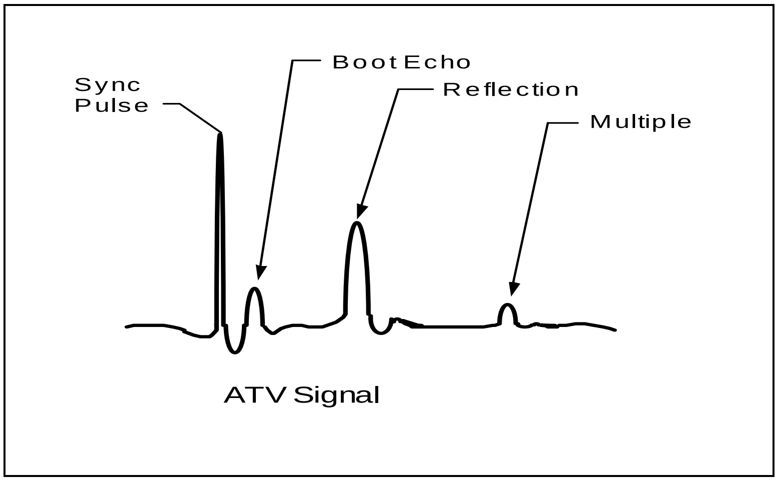


Figure 1: Returned signal.

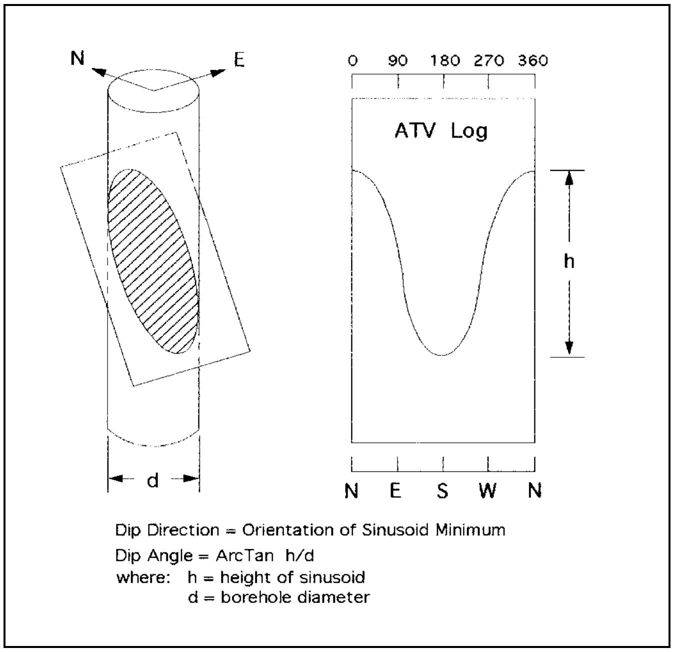


Figure 2: Geometric representation of a fracture plane and corresponding ATV log.

Acoustic Televiewer Caliper Log

An unconventional caliper log may be generated from the travel time data acquired by the Fac-40 acoustic televiewer. Using WellCAD version 3.2, an estimation of the distance from the probe to the borehole wall can be made by incorporating the travel time of the acoustic signal with an estimation of the velocity of the wellbore fluid. The time it takes the acoustic signal to travel through a known viscous medium and back to the probe is directly related to the distance between the signal generator and the borehole wall provided the borehole fluid viscosity remains constant and the probe is properly centralized. The distance from the probe to the borehole wall is then corrected for the radius of the probe producing a borehole diameter in inches.

Applications

The high resolution reflection images and the precise travel time measurements make the FAC-40 ATV a versatile tool. Possible applications include:

- Fracture detection and evaluation
- Detection of thin beds
- Determination of bedding dip
- Lithological characterization
- Casing inspection
- High resolution caliper measurements

D. 3-Arm Caliper

The caliper log represents the average borehole diameter determined by the extension of 1 or 3 spring-loaded arms. The measurement of the borehole diameter is determined by the change in the variable pot resistors in the probe, which are internally connected to the caliper arms.

Caliper logs may show diameter increases in cavities and, depending on drilling techniques used, in weathered zones. An apparent decrease in borehole diameter may result from mud or drill-cutting accumulation along the sides of the borehole (mudcake), a swelled clay horizon or a planned change in drill bit size. The bottom of the boring can also induce a small diameter reading from the caliper due to the caliper leaning up against on side of the borehole. The caliper log is often a useful indicator of fracturing. The log anomalies do not directly represent the true in-situ fracture size or geometry. Rather, they represent areas of borehole wall breakage associated with the mechanical weakening at the borehole-fracture intersection. Caliper anomalies may represent fractures, bedding planes, lithologic changes or solution openings. Generally, in solid bedrock caliper log anomalies indicate the intervals where fractures intersect boreholes.

COLOG records the caliper log with either a single-arm caliper measurement using the decentralization arm of the density probe or a separate stand-alone three-arm caliper. Calibrations of the probe are done routinely on the bench and in the field directly before the tool is placed into the borehole. Calibration standards consist of rings of known diameters that are placed over the extended arms as the tool response at these diameters is recorded. Additionally, as with other geophysical measurements, a repeat section may be collected and compared with original logs for consistency and accuracy.

Fundamental assumptions and limitations inherent in these procedures are as follows:

- Excessive borehole diameters (greater than 36 inches) may limit the range of borehole caliper measurements. Holes greater than 12 inches must be logged with extended arms for hole diameters up to 36 inches.

- Since the caliper probe is an electro-mechanical device, a certain amount of error is inherent in the measurement. These errors are due to: 1) averaging hole diameter using three arms, 2) non-linearity of the measurement resistor, 3) tolerance in the mechanical movement of the caliper arms (mechanical hysteresis).

E. Natural Gamma

The natural gamma log (also known as gamma or gamma ray log) provides a measurement recorded in counts per second (CPS), that is proportional to the natural radioactivity of the formation. Actual counts depend upon the detector size and efficiency but are often normalized in API units. 200 API units equal the detector response in a specially constructed physical model designed to simulate the typical shale. For most of COLOG's gamma probes, 1 API unit is approximately equal to 1.25 CPS. The depth of investigation for the gamma log is typically 10 to 12 inches. Gamma logs provide formation clay and shale content and general stratigraphic correlation in sedimentary formations. In general, the natural gamma ray activity of clay-bearing sediments is much higher than that of quartz sands and carbonates. Gamma logs are also used in hard rock environments to differentiate between different rock types and in mining applications for assessment of radioactive mineralization such as uranium, potash, etc.

Gamma radiation is measured with scintillation NaI detectors. The gamma-emitting radioisotopes that naturally occur in geologic materials are Potassium40 and nuclides in the Uranium238 and Thorium232 decay series. Potassium40 occurs with all potassium minerals, including potassium feldspars. Uranium238 is typically associated with dark shales and uranium mineralization. Thorium232 is typically associated with biotite, sphene, zircon and other heavy minerals.

The usual interpretation of the gamma log, for hydrogeology applications, is that measured counts are proportional to the quantity of clay minerals present. This assumes that the natural radioisotopes of potassium, uranium, and thorium occur in exchange ions, which are attached to the clay particles. Thus, the correlation is between gamma counts and the cation exchange capacity (CEC). Usually gamma logs show an inverse linear correlation between gamma counts and the average grain size (higher counts indicate smaller grain size, lower counts indicate larger grain size). This relation can become invalid if there are radioisotopes in the mineral grains themselves (immature sandstones or arkose), and if there are differences in the CEC of clay minerals in the different parts of the formation. Both of these situations are possible in many environments. The former situation would most likely occur in basal conglomerates composed of granitic debris, and the latter where clay occurs as a primary sediment in shale and another as an authigenic mineral deposited in pore spaces during diagenesis.

The assumption of a linear relationship between clay mineral fraction in measured gamma activity can be used to produce a shale fraction calibration for a gamma log in the form:

$$Csh = (G-Gss) / (Gsh - Gss)$$

Where Csh is the shale volume fraction, G is the measured gamma activity; Gss is the gamma activity in clean sandstone or limestone; Gsh is the gamma activity measured in shale.

Calibration of the gamma logging tool is usually performed in large physical models such as the API test pits in Houston, or the DOE uranium calibration test pits. In hydrogeology, the gamma measurement is usually a relative log and quantitative calibrations are not routinely performed. However, the stability and repeatability of the natural gamma measurement is routinely checked with a sleeve of known radioactivity. It is also common to routinely check the gamma log by repeat logging a section of a well. Natural radioactive decay follows a Gaussian distribution; that is, approximately 67% of the radioactive response occurs within ± the square root of the count rate. For instance, if a background radiation of 100 CPS is being measured, there is approximately ± 10 CPS variability.

Fundamental assumptions and limitations inherent in these procedures are as follows:

- The natural gamma ray log, as with all nuclear or radiation logs, have a fundamental advantage over most other logs in that they may be recorded in either cased or open holes that are fluid or air filled. Borehole fluid and casing may attenuate the gamma values.

- Excessive borehole rugosity, often caused by air drilling, may degrade natural gamma ray log results.

F. Electrical Measurements

All electrical logs require the presence of the borehole fluid to carry the current from the probe to the formation, and therefore these devices do not work above fluid level. Quantitative formation electrical resistivity, spontaneous potential and qualitative single point resistance can be measured with a combination tool. The operational features of each measurement is discussed under the measurement heading.

16-inch and 64-inch Normal Resistivities

Formation resistivity is dependent on the fluid salinity, permeability, and connected fracture paths within the depth of investigation of the measurement. Measured resistivity is also controlled by particle surface conduction in clastic environments. The resistivity measurement decreases in larger diameter boreholes and areas in which the borehole has been broken out, and/or highly fractured. The above responses allow interpretation of lithologic types, correlation of beds, estimation of fluid quality and possible fractured zones.

A constant current is supplied to the downhole current electrode and the resulting voltage drop is measured on the return electrodes 16" and 64" away from the current electrode. The resistivity of the surrounding media (which includes the borehole fluid) is derived from Ohm's Law and the geometry of the electrode arrangement. The static electric field which results from the geometric arrangement of electrodes is ideally a sphere 16" or 64" in radius (for the short and long normal functions respectively). The presence of the borehole diameter and mudcake affects the measurement sphere by decreasing the lateral extent, and increasing the vertical extent. Borehole corrections based on the borehole fluid resistivity can be made, but these corrections do not address the effects of vertical averaging. Accurate interpretation of the logs minimizes this averaging effect. The influence of the borehole size becomes less with smaller diameter boreholes. Calibration of the 16" and 64" normals is performed in the field with a resistance box which tests a range of known resistivities from 0.0 ohm-m to 10,000 ohm-m.

Single Point Resistance (SPR)

The SPR measurement is controlled by rock and fluid parameters in much the same way as resistivity logs. SPR is a simple system of two electrodes (the resistivity current electrode) and a surface electrode. Current is passed through the formation and voltage differences are measured between the two electrodes. The measured resistance includes the resistance of the cable, borehole fluid, and the formation around the borehole. The current density is higher near the borehole electrode and surface electrode. Since the current density at the surface electrode is constant, formation variations close to the probe produce the resistance changes visible on the logs. Since there is a single downhole electrode, not an array, the log effectively shows a point measurement. This gives a very "responsive", high vertical resolution measurement. Though the single point resistance cannot be calibrated quantitatively, its instantaneous response is a good boundary indicator, and does show a more well defined response than the 16" or 64" normals.

Spontaneous Potential (SP)

The SP is a measurement of the naturally occurring potential in the borehole. This naturally occurring potential is most often caused by a concentration gradient between the borehole fluid and formation fluid (electro-chemical), and requires the presence of a clay rich/porous media interface to occur. Reduction/oxidation (redox) interfaces and streaming potentials (electro-kenetic) caused by the flow of fluid in or out of the borehole are also causes for the occurrence of spontaneous potential. In fresh water environments where the drilling fluid is natural or the salinity is near the formation pore fluid salinity the electro-chemical potential is minimized. The absence of sulfide mineralization or fluid movement into or out of the formation may minimize the redox and streaming potentials.

Fundamental assumptions and limitations inherent in these procedures are as follows:

- The range within which a given device is accurate is different for the different measurement techniques. This range shall be specified for each device, and the appropriate device shall be selected for the borehole under investigation.

- The properties of the borehole and borehole fluid influence the response of normal resistivity logs in what is commonly known as "Borehole Effects". As the hole diameter increases, these effects become more pronounced. These effects have been quantified, and log data may be corrected based on standard techniques.

- The geometry of the logging probe such as the positions of the source and measurement electrodes of resistivity type probes affects the measurement values.

- The ability of a given measurement to accurately measure resistivity across a thin bed is a function of the geometry and of the resistivity contrast and bed thickness.

- The distance away from the borehole which influences a given measurement is a function of the geometry and the radial distribution of electrical properties.

- The log should be recorded with the tool moving **up** the borehole, but measurements can be made while logging downward also. In fact, in deep wells, it is suggested that data be recorded while running in the well, just in case hole conditions or tool problems prevent getting a good log in the up direction.
- The electric resistivity measurement is adversely affected by metalic or ferrous material in the vicinity of the probe.

- Electric resistivity measurements can not be performed through PVC, fiberglass or steel casing.

G. Fluid Temperature/Resistivity (Conductivity)

Geothermal gradients in the near surface earth are usually dominated by conduction, and are generally linear increasing with depth due to the relative constancy of the thermal conductivity of earth materials. Convective heat flow within the borehole fluid is caused by formation fluid entering or leaving the borehole at some permeable interval. Therefore, deviations from the linear thermal gradient can be attributed to fluid movement. Both the thermal gradient and fluid resistivity profile of the borehole fluid can be obtained with the same probe. The temperature is measured with a thermistor and the fluid resistivity is measured with a closely spaced Wenner electrical array.

Slope changes in both the temperature and fluid resistivity logs may be indicative of fluid flow between the formation and the borehole. Both responses are affected by drilling method, time since circulation, mud type or additives and well development procedures.

A differential temperature log is a calculated curve that amplifies slight slope changes in the temperature gradient and can assistance in the interpretation of the fluid temperature log. As the probe is lowered downhole, small changes in the slope of the temperature curve are identified by a differential curve that is plotted from a center zero line. The differential temperature is constructed by using a temperature point at one depth and subtracting a point at a lower depth throughout the entire logged interval.

(temperature value Depth 1) **-** (temperature value Depth 2) = differential value

In real time the differential values are calculated across the acquisition digitizing interval (e.g. 0.1 to 0.5 ft). Because of the small digitizing interval the calculated real time differential curve may only identify larger temperature gradient deviations. Another differential temperature can be constructed in post processing over a larger sample interval (sometimes up to 2 ft). This log commonly provides a more diagnostic differential curve and is used frequently in the temperature profile interpretation.

The fluid resistivity in the borehole is controlled primarily by the salinity. Therefore, salinity stratification, or the introduction of a fluid of different water quality into the borehole, can be observed by changes in the fluid resistivity log. Often, the exchange of fluid between the formation and the borehole, influences both the temperature and the fluid resistivity so that the response is evident in both logs.

Temperature corrected resistivity can be converted to equivalent NaCl salinity in parts per million (Bateman and Konen, 1977). A salinity profile can then be plotted which indicates the general water quality trend of the borehole fluid. If the assumption is made that the borehole fluid is in equilibrium with the formation fluid, then the borehole salinity profile can be interpreted as a formation fluid salinity profile. Differences between these profiles from well to well, may contain information concerning the extent of hydraulic connectivity in the area.

Fundamental assumptions and limitations inherent in these procedures are as follows:

- The borehole temperature log is usually the first log run in a borehole and, unlike virtually all other logs, is run while the probe is moving down the hole. The exception to running this probe first, however, would be if any optical measurement is to be acquired. The idea is that the logging of the temperature/resistivity probe may stir up the wellbore fluids inhibiting the optical device.

- The recorded borehole temperature is only that of the fluid surrounding the probe, which may or may not be representative of the temperature in the surrounding rocks.

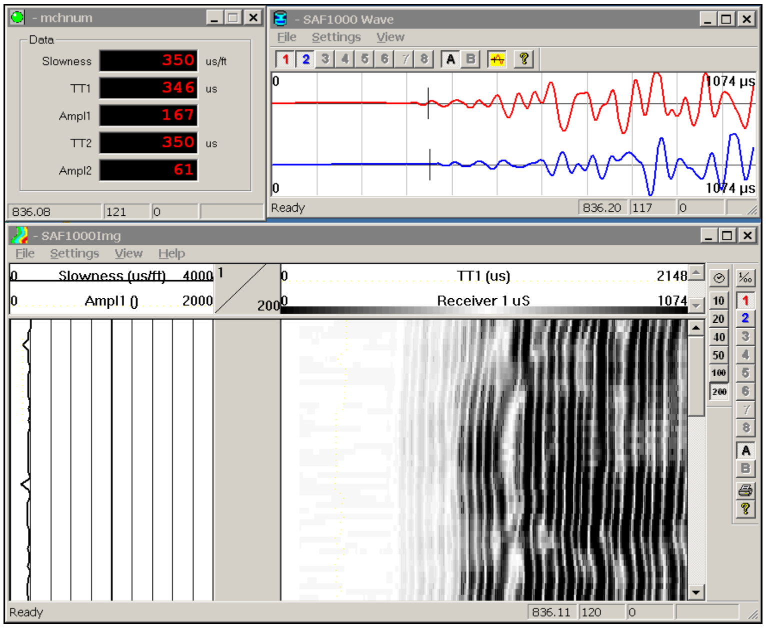
- In most wells the geothermal gradient is considerably modified by fluid movement in the borehole and adjacent rocks.

- Temperature logs are generally recommended for uncased fluid-filled boreholes, but may be used in fluid-filled cased wells for some applications.

H. Full Waveform Sonic

Full Waveform Sonic Methodology

Digital full-waveform sonic (FWS) data is acquired with a Mount Sopris Instruments 2SAF probe, that can be configured with two or three receivers at fixed separations from the sonic transmitter. The acquisition software allows the real-time viewing of the waveforms as they are written directly to hard disk. The waveforms can also subsequently be viewed and processed for amplitude, frequency, and velocity information. Functionality and repeatability of the probe is monitored by logging in an ungrouted, fluid-filled, steel pipe, and by repeat logging of boreholes at each project.



Slowness 350 us/ft
TT1 346 us
Ampl1 167
TT2 350 us
Ampl2 61

Figure: Real-time presentation from the sonic acquisition software, illustrating the output of a 2SAF configured with two receivers.

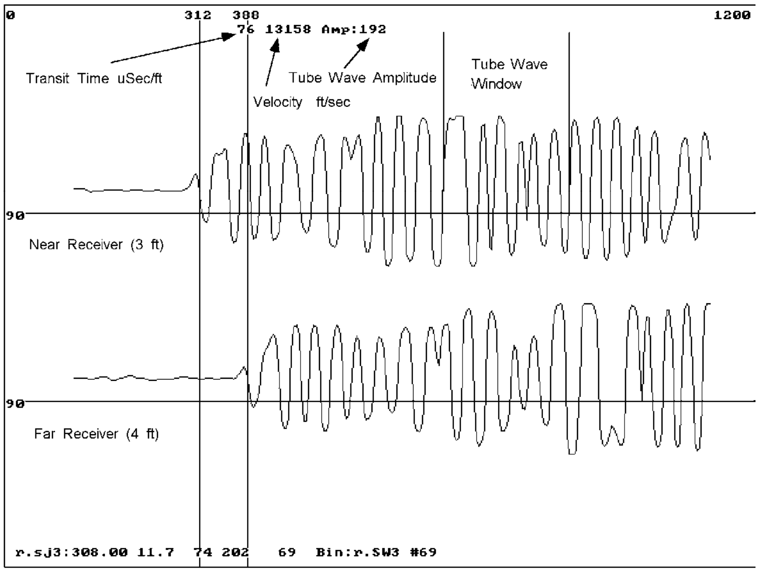


Figure: Example of a typical waveform pair with the tube wave annotated.

The FWS log, recorded in the time domain at two or three downhole receivers, consists of interacting sonic waves generated by a 30 kHz acoustic energy pulse from the downhole transmitter. Sonic logs can only be obtained in the fluid filled portion of the borehole, and the propagation of these waves is controlled by the borehole wall/fluid interface, at which head waves are critically refracted and complicated reflections occur.

Sonic transit time is the compression-wave travel time, per foot of rock, and represents the inverse of velocity (i.e., greater transit time equals slower velocity). Often referred to as "delta-T" because it is the difference in arrival times between two receivers spaced one foot apart, transit time can be used to characterize rock lithology, consolidation, and presence of discontinuities. These characterizations, however, usually require calibration from core data unless regional relationships are available. Transit times are also used to help in the processing of seismic reflection and refraction data.

The tube wave is a guided fluid wave that travels along the borehole wall/fluid boundary at a velocity slightly slower than the speed of sound in water.

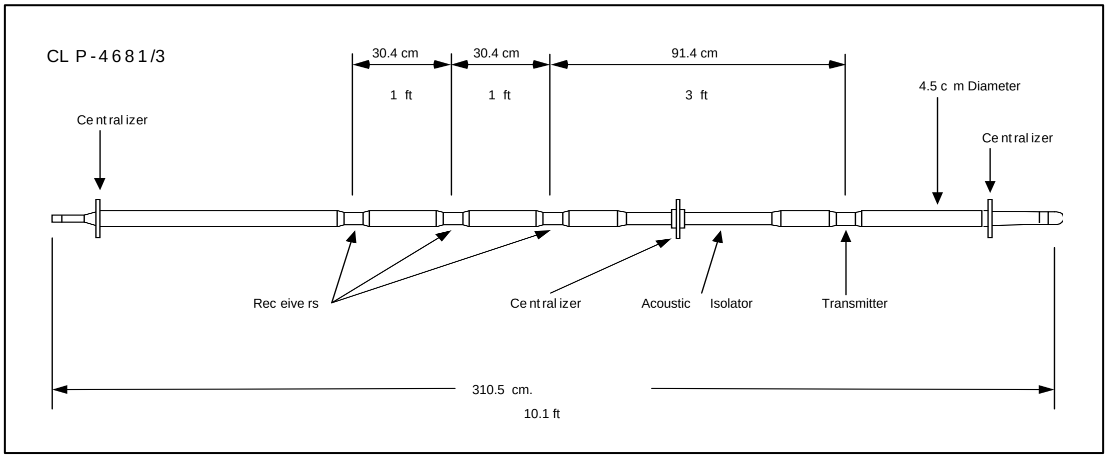


Figure: Probe schematic for the 2SAF sonic probe.

Vertical stacking of the individual waveforms creates the full waveform display, which uses a banded presentation to represent the sinusoidal nature of sonic waves. By convention, black bands represent high amplitude waves above the centerline, dark gray is the low amplitude portion of the positive wave, while light grey is the low amplitude portion of the negative wave below the centerline, and white is the high amplitude portion of the negative wave. The degree of discontinuity of the rock is reflected by the deviation from parallel banding in the FWS VDL display. The velocities and other information obtained from sonic logs are used to determine the lithology, formation porosity, cement bonding, formation weathering, rock strength, and to identify fractures.

I. Formation Conductivity (Induction)

The induction measurement is made by using a magnetic field to induce electric currents in the material being surveyed. Because the magnitude of these electric currents is proportional to the conductivity of the media being measured, the magnetic field generated by the induced electric current is measured.

The tool is designed to measure formation conductivity in millisiemens per meter (mS/m) which is converted to resistivity in software. This probe also measures the rate of change of the magnetic susceptibility as a percent of primary magnetic field, however the tool has been optimized for conductivity readings and the magnetic susceptibility measurements are qualitative. For the purposes of this investigation, the magnetic susceptibility measurements provided no additional information and were not plotted.

Fundamental assumptions and limitations inherent in these procedures are as follows:

- The EM induction measurement is adversely affected by metallic or ferrous material in the vicinity of the probe.

- The EM induction measurement can be effected, though not adversely, but the conductivity of the wellbore fluid present and the fluid in the formation.

- Because the EM induction measurement is spherical, major borehole washouts may effect the measurement of formation conductivity at that depth.

- The EM induction measurement can be performed through PVC casing if need be.

MW-1 Geophysical Report

1.0 Geophysical Logging

On May 5th and May 8th, 2008, downhole geophysical investigations were performed in boring MW-1. The geophysical logs performed were: ambient fluid temperature and fluid conductivity, natural gamma, EM conductivity and vertical seismic profiling (VSP). The data for these logs are presented in the MW-1 Geophysical Summary Plot at the end of this well report.

1.1 Ambient Fluid Temperature/Fluid Conductivity

On May 5th, 2008, an ambient fluid temperature and electrical fluid conductivity (FEC) profile was acquired in MW-1 to a depth of 142.5 feet. The ambient temperature log is relatively featureless with the exception of an anomaly at approximately 48.9 feet. As this anomaly is at a depth corresponding to blank PVC casing, this anomaly is likely not the result of flow. At the screened interval of interest of 133.0 to 143.0 feet the ambient fluid temperature and FEC profiles are relatively featureless. The ambient FEC profile registers a nominal 294 to 296 µS/cm at the screened interval. The ambient temperature profile registers a nominal 6.70 degrees C at the top of the fluid column and 5.11 degrees C at the interval of interest.

1.2 Natural Gamma

On May 5th, 2008, a natural gamma profile was acquired in MW-1 to a depth of 141.7 feet. The natural gamma profile is relatively featureless ranging in gamma counts of 22 to 91 counts per second (CPS).

1.3 EM Induction Conductivity

On May 5th, 2008, an EM conductivity profile was acquired in MW-1 to a depth of 140.5 feet. The EM conductivity profile registers an anomaly at 133 feet indicating the top of the screened interval and at 21.7 feet indicating water level. The EM conductivity log registers a nominal 175 mSeimans/meter above 133 feet and 183.6 mSeimans/meter below 133 feet.

1.4 Vertical Seismic Profile (VSP)

On May 8th, 2008, a vertical seismic profile (VSP) investigation was conducted in MW-1 to a depth of 140 feet. Four distinct intervals of specific velocity were observed in MW-1 at 15 to 47.5, 47.5 to 77.5, 77.5 to 130 and 130 to 140 feet, registering 5,706, 8,200, 12,400 and 3,338 feet per second (fps). The deepest calculated velocity is derived from low P-wave energy data. As such, the calculated value of 3,338 fps is suspect. The higher velocity value is consistent with limestone bedrock.

Project: LO-58	**Well ID:** MW-1	**Date Logged:** 5 May 2008
Location: Aroostook County, Caribou, ME	**Log Ref.:** Top PVC Casing	**Hole Diameter:** 8" nom. to TD
Depth Logger: 143.1 ft	**Log Ref. Elev.:** 578.79 ft above MSL	**Csg Size/Type:** 2" PVC
Depth Driller: 142 ft bgs	**Recorded by:** G. Bauer	**Witnessed by:** A. Fuller

LOGS & TOOLS

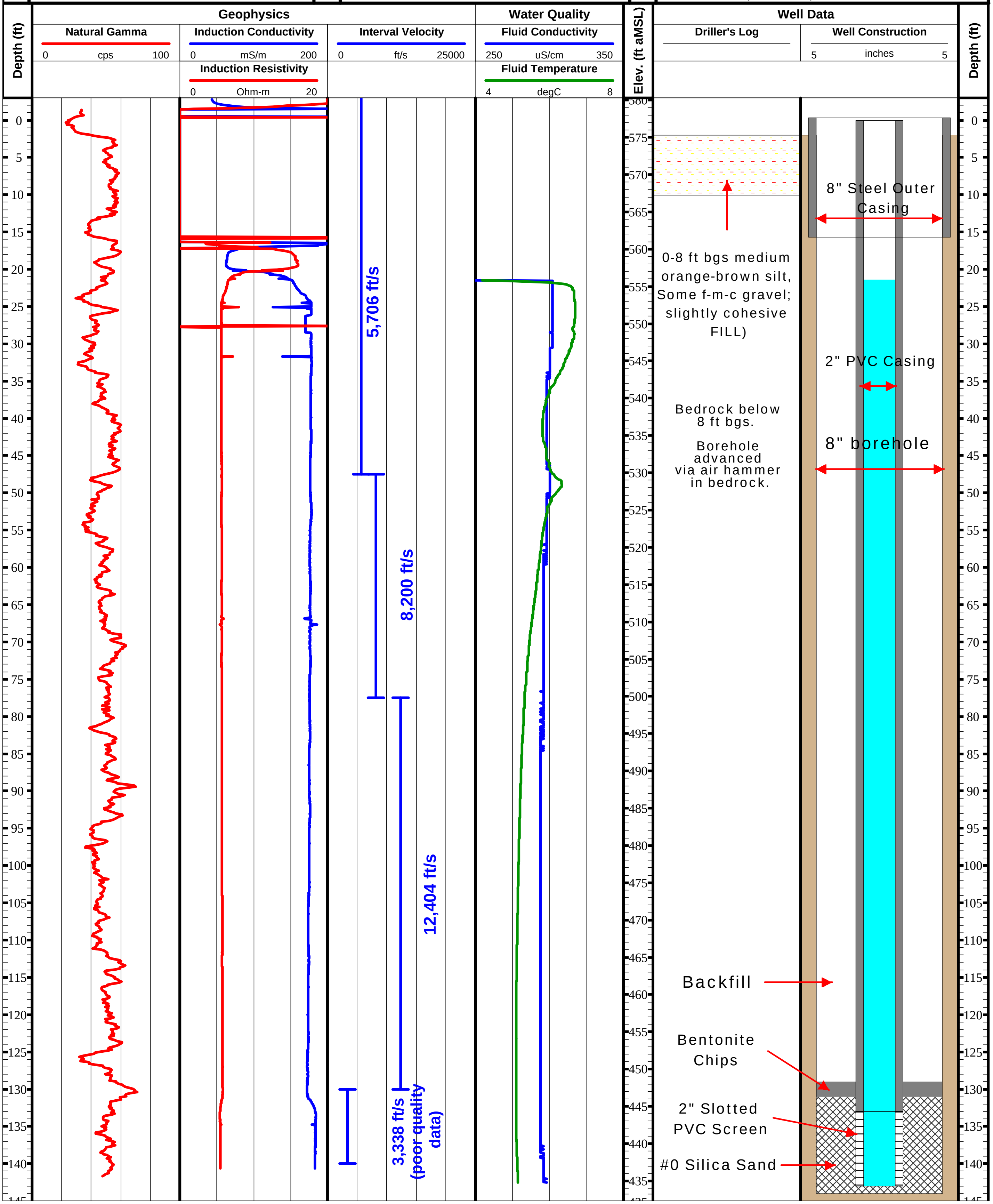
Gamma: Gamma SN# 311, depth err. -0.04 ft, speed 10 ft/min
Ind. Cond./Res.: 2PIA SN# 2041, depth err. -0.18 ft, speed 10 ft/min
Fluid Temp./Cond.: HpL SN# A, depth err. 0.1 ft, speed 5 ft/min

COMMENTS

Ground Elevation: 577.3 ft. aMSL.
Natural Gamma log includes K, U, and Th.
Water Quality logs performed under ambient conditions.
Ambient Water Level about 21.4 ft (19.7 ft bgs).
Borehole was not logged while drilling.

COMMENTS

All depths here referenced to top PVC casing unless noted otherwise.
Measured casing stick up above ground surface: PVC 1.75 ft, Steel 2.0 ft.
Steel outer casing total depth 15.7 ft, estimated from induced cond. log.
Other well Consturction info taken directly from drilling report.
Measured and drill report PVC stickup differ.



0-8 ft bgs medium orange-brown silt, Some f-m-c gravel; slightly cohesive FILL)

Bedrock below 8 ft bgs.

Borehole advanced via air hammer in bedrock.

MW-2 Geophysical Report

1.0 Geophysical Logging

On May 7th and May 8th, 2008, downhole geophysical investigations were performed in boring MW-2. The geophysical logs performed were: ambient fluid temperature and fluid conductivity, natural gamma, EM conductivity, vertical seismic profiling (VSP) and water chemistry (pH, ORP, DO). The data for these logs are presented in the MW-2 Geophysical Summary Plot at the end of this well report.

1.1 Ambient Fluid Temperature/Fluid Conductivity

On May 7th, 2008, an ambient fluid temperature and electrical fluid conductivity (FEC) profile was acquired in MW-2 to a depth of 61.7 feet. The ambient temperature log indicates an anomaly at the top of the screened interval at 52 feet. Above 52 the temperature log registers a nominal 6.01 degrees C. Below 52 feet the temperature log registers a nominal 5.15 degrees C. The temperature profile is featureless within the screened interval. The ambient FEC profile registers a nominal 368 µS/cm at the top of the screened interval at 52 feet and is observed to increase with depth to 377 µS/cm at 61.7 feet (TD).

1.2 Natural Gamma

On May 7th, 2008, a natural gamma profile was acquired in MW-2 to a depth of 57.6 feet. The natural gamma profile indicates a high-gamma count anomaly at 46 to 50 feet. The natural gamma profile ranges from 16 to 92 CPS.

1.3 EM Induction Conductivity

On May 7th, 2008, an EM conductivity profile was acquired in MW-2 to a depth of 59.4 feet. The EM conductivity profile does not register usable data, for unknown reasons, though the anomalies have the character of registering metal nearby. It is possible there is rebar or other metal under the asphalt in the immediate vicinity of the well. Two different EM conductivity probes were utilized on MW-2 and both registered the same result, along with repeat logs.

1.4 Vertical Seismic Profile (VSP)

On May 8th, 2008, a vertical seismic profile (VSP) investigation was conducted in MW-2 to a depth of 57.5 feet. Three distinct intervals of specific velocity were observed in MW-2 at 5 to 15, 15 to 30 and 30 to 57.5 feet, registering 5,936, 1,921 and 7,178 fps.

1.5 Water Chemistry (pH, ORP, DO)

On May 7th, 2008, an ambient pH, oxidation-reduction potential (ORP) and dissolved oxygen (DO) profile was acquired in MW-2 to a depth of 61.8 feet. The pH profile registers a high-pH anomaly at water level, which is typical of this type of log. Below water level the pH measurement decreases with depth until the top of screened interval at 52 feet. Below 52 feet the pH registers a nominal 7.45 through the screened interval. The DO measurement registers regular low-DO anomalies every 4 feet approximately, perhaps the result of casing joints. Within the screened interval the DO measurement increases with depth, registering 2.36 to 2.47 percent.

Project: LO-58	Well ID: MW-2	Date Logged: 7 May 2008
Location: Aroostook County, Caribou, ME	Log Ref.: Top PVC Casing	Hole Diameter: 8" Nom. to TD
Depth Logger: 61.6 ft	Log Ref. Elev.: 589.36 ft above MSL	Csg Size/Type: 2" PVC
Depth Driller: 62 ft bgs	Recorded by: G. Bauer	Witnessed by: A. Fuller

LOGS & TOOLS

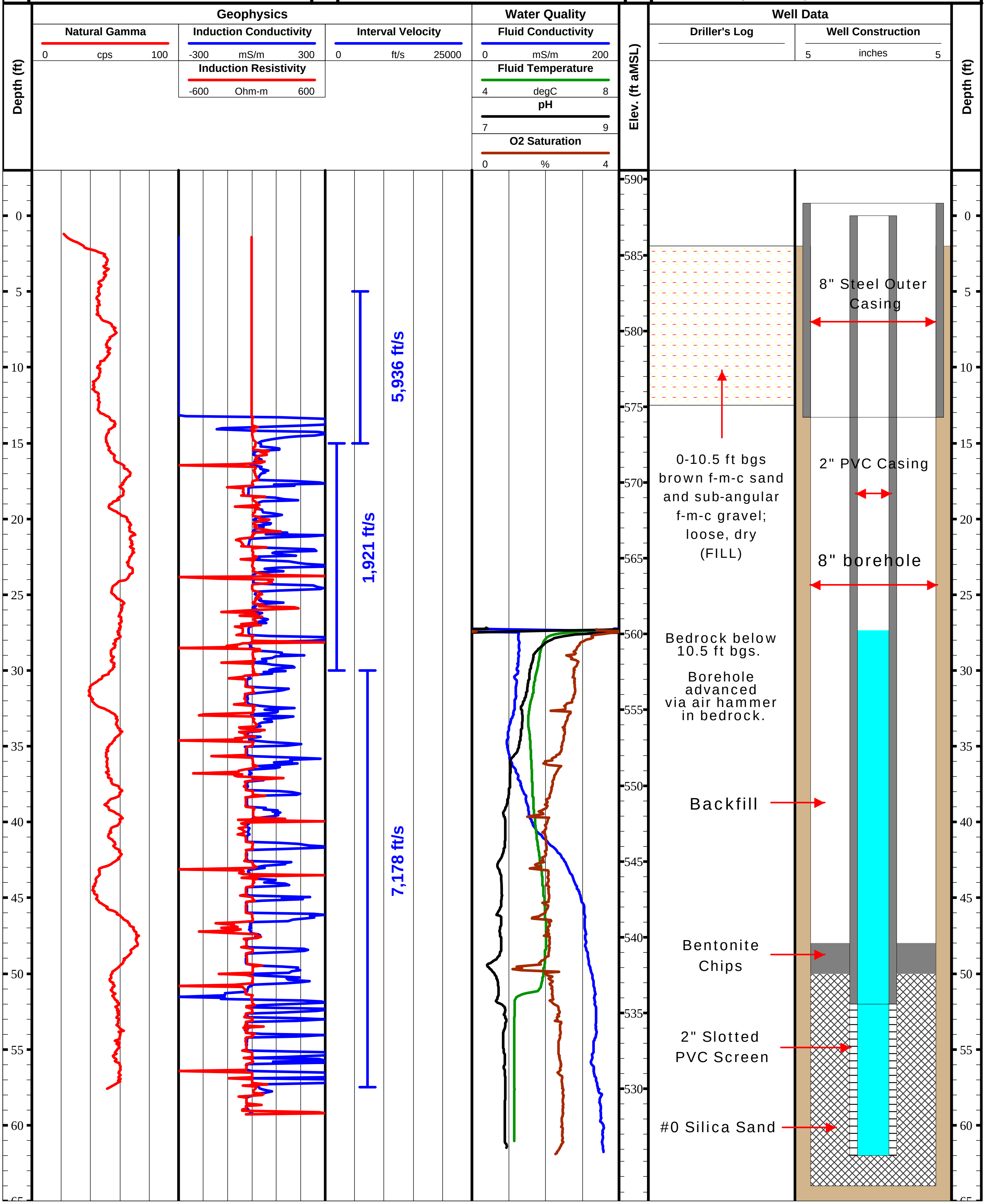
Gamma: Gamma SN# 311, depth err. 0.10 ft, speed 10 ft/min
Cond./Res.: 2PIA SN# 2041, depth err. 0.10 ft, speed 10 ft/min
Fluid Temp: HpL SN# A, depth err. 0.08 ft, speed 5 ft/min
Fluid Cond/pH/O2: WQ SN# 3048, depth err. 0.08 ft, speed 4.5 ft/min

COMMENTS

Ground Elevation: 587.6 ft aMSL.
Natural Gamma log includes K, U, and Th.
Water Quality logs performed under ambient conditions.
Ambient Water Level about 27.4 ft (25.7 ft bgs).
Suspected metel underground affecting logs. Missile pad area.

COMMENTS

All depths here referenced to top PVC casing unless noted otherwise.
Measured casing stick up above ground surface: PVC 1.75 ft, Steel 2.54 ft.
Steel outer casing total depth 13.3 ft bgs, estimated from induced cond. log.
Other well consturction info taken directly from drilling report.
Measured and drill report PVC stickup differ.



0-10.5 ft bgs
brown f-m-c sand
and sub-angular
f-m-c gravel;
loose, dry
(FILL)

Bedrock below
10.5 ft bgs.

Borehole
advanced
via air hammer
in bedrock.

MW-3 Geophysical Report

1.0 Geophysical Logging

On May 6th and May 8th, 2008, downhole geophysical investigations were performed in boring MW-3. The geophysical logs performed were: ambient fluid temperature and fluid conductivity, natural gamma, EM conductivity, vertical seismic profiling (VSP) and water chemistry (pH, DO). The data for these logs are presented in the MW-3 Geophysical Summary Plot at the end of this well report.

1.1 Ambient Fluid Temperature/Fluid Conductivity

On May 6th, 2008, an ambient fluid temperature and electrical fluid conductivity (FEC) profile was acquired in MW-3 to a depth of 48.4 feet. The ambient temperature log indicates an anomaly at the top of the screened interval at 39 feet. Below 39 feet the temperature log registers a nominal 6.38 to 6.63 degrees C. The temperature profile is featureless within the screened interval. The ambient FEC profile registers approximately 663 µS/cm at the top of the screened interval at 39 feet and 643 µS/cm at near TD. The FEC observed in MW-3 is notably higher than other wells on site.

1.2 Natural Gamma

On May 6th, 2008, a natural gamma profile was acquired in MW-3 to a depth of 47.5 feet. The natural gamma profile is relatively featureless with gamma counts ranging from 50 to 69 CPS, with the exception of the low gamma counts that are likely the result of near-surface effect.

1.3 EM Induction Conductivity

On May 6th, 2008, an EM conductivity profile was acquired in MW-3 to a depth of 46.5 feet. The EM conductivity profile is rather erratic below 31.5 feet registering approximately 100 to 150 mSeimans/meter. Below 43.1 feet the conductivity log registers -1,400 mSeimans/meter – possibly the effect of metal near the well.

1.4 Vertical Seismic Profile (VSP)

On May 8th, 2008, a vertical seismic profile (VSP) investigation was conducted in MW-3 to a depth of 45 feet. Three distinct intervals of specific velocity were observed in MW-3 at 5 to 20, 20 to 30 and 30 to 45 feet, registering 2,031, 3,435 and 11,492 fps. The deepest interval was calculated using a two-point calculation between 30 and 45 feet due to high scatter in the data set.

1.5 Water Chemistry (pH, DO)

On May 6th, 2008, an ambient pH, oxidation-reduction potential (ORP) and dissolved oxygen (DO) profile was acquired in MW-3 to a depth of 48.4 feet. The pH profile registers a low-pH anomaly at 39 feet. Below 39 feet the pH registers a nominal 7.57 with a minor high-pH anomaly at 42.3 feet. The DO measurement registers a low-DO anomaly at 39 feet, the top of the screened interval. Below 39 feet the DO registers 10.67 to 10.8 percent.

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Project:	LO-58	Well ID:	MW-3	Date Logged:	6 May 2008
Location:	Aroostook County, Caribou, ME	Log Ref.:	Top PVC Casing	Hole Diameter:	8" Nom. to TD
Depth Logger:	48.85 ft	Log Ref. Elev.:	570.63 ft above MSL	Csg Size/Type:	2" PVC
Depth Driller:	47 ft bgs	Recorded by:	G. Bauer	Witnessed by:	A. Fuller

LOGS & TOOLS

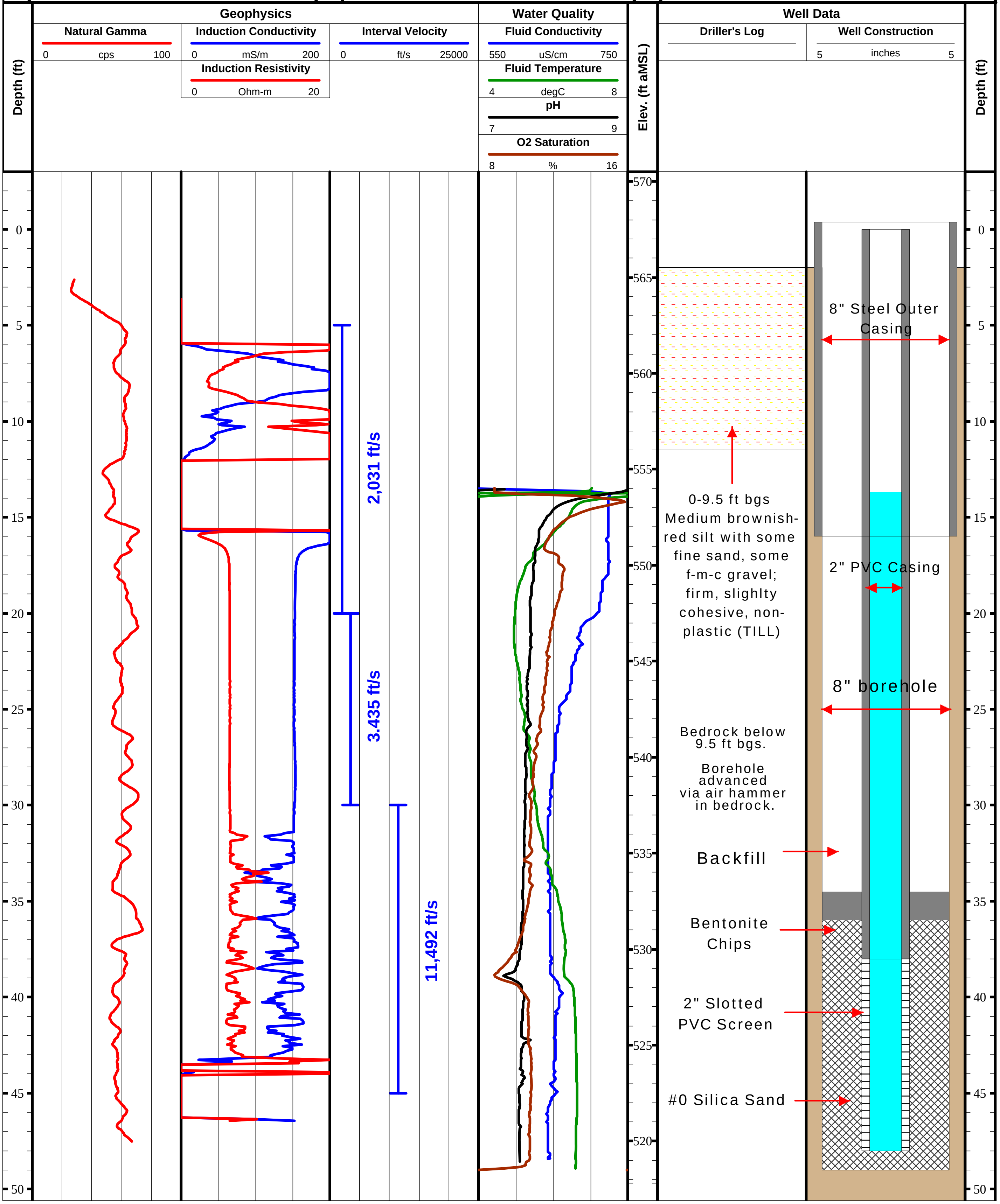
Gamma: Gamma SN# 311, depth err. 0.10 ft, speed 10 ft/min
Cond./Res.: 2PIA SN# 2041, depth err. 0.10 ft, speed 10 ft/min
Fluid Cond: HpL SN# A, depth err. 0.10 ft, speed 5 ft/min
Fluid Temp/pH/O2: WQ SN# 3048, depth err. 0.08 ft, speed 4.0 ft/min

COMMENTS

Ground Elevation: 567.5 ft aMSL.
Natural Gamma log includes K, U, and Th.
Water Quality logs performed under ambient conditions.
Ambient Water Level about 13.7 ft (10.32 ft bgs).

COMMENTS

All depths here referenced to top PVC casing unless noted otherwise.
Measured casing stick up above ground surface: PVC 3.38 ft, Steel 3.79 ft.
Steel outer casing total depth 16.0 ft bgs, estimated from induced cond. log.
Other well construction info taken directly from drilling report.
Measured and drill report PVC stickup differ.



MW-4 Geophysical Report

1.0 Geophysical Logging

On May 6th and May 8th, 2008, downhole geophysical investigations were performed in boring MW-4. The geophysical logs performed were: ambient fluid temperature and fluid conductivity, natural gamma, EM conductivity and vertical seismic profiling (VSP). The data for these logs are presented in the MW-4 Geophysical Summary Plot at the end of this well report.

1.1 Ambient Fluid Temperature/Fluid Conductivity

On May 6th, 2008, an ambient fluid temperature and electrical fluid conductivity (FEC) profile was acquired in MW-4 to a depth of 82.3 feet. The ambient temperature log is relatively featureless in the interval of interest, ranging in temperature from 4.16 to 4.13 degrees C. The ambient FEC profile indicates some stratification of wellbore fluids inside the blank casing at 58 feet. Below 58 feet the ambient FEC profile registers a nominal 416 to 421 µS/cm within the screened interval. A minor high-FEC anomaly is observed at 79 feet within the screened interval.

1.2 Natural Gamma

On May 6th, 2008, a natural gamma profile was acquired in MW-4 to a depth of 81.2 feet. The natural gamma profile is relatively featureless ranging in gamma counts of 29 to 75 counts per second (CPS).

1.3 EM Induction Conductivity

On May 6th, 2008, an EM conductivity profile was acquired in MW-4 to a depth of 80.1 feet. The EM conductivity profile registers an anomaly at 72 feet indicating the top of the screened interval and 31.2 feet indicating water level. The EM conductivity log registers a nominal 176 mSeimans/meter above 72 feet and 186 mSeimans/meter below 72 feet.

1.4 Vertical Seismic Profile (VSP)

On May 8th, 2008, a vertical seismic profile (VSP) investigation was conducted in MW-4 to a depth of 80 feet. Three distinct intervals of specific velocity were observed in MW-3 at 5 to 30, 30 to 47.5 and 47.5 to 80 feet, registering 4,529, 6,548 and 6,678 fps. The deepest interval was calculated using a two-point calculation between 47.5 and 80 feet due to high scatter in the data set.

Project: LO-58	Well ID: MW-4	Date Logged: 6 May 2008
Location: Aroostook County, Caribou, ME	Log Ref.: Top PVC Casing	Hole Diameter: 8" Nom. to TD
Depth Logger: 82.7 ft	Log Ref. Elev.: 605.45 ft above MSL	Csg Size/Type: 2" PVC
Depth Driller: 82 ft bgs	Recorded by: G. Bauer	Witnessed by: A. Fuller

LOGS & TOOLS

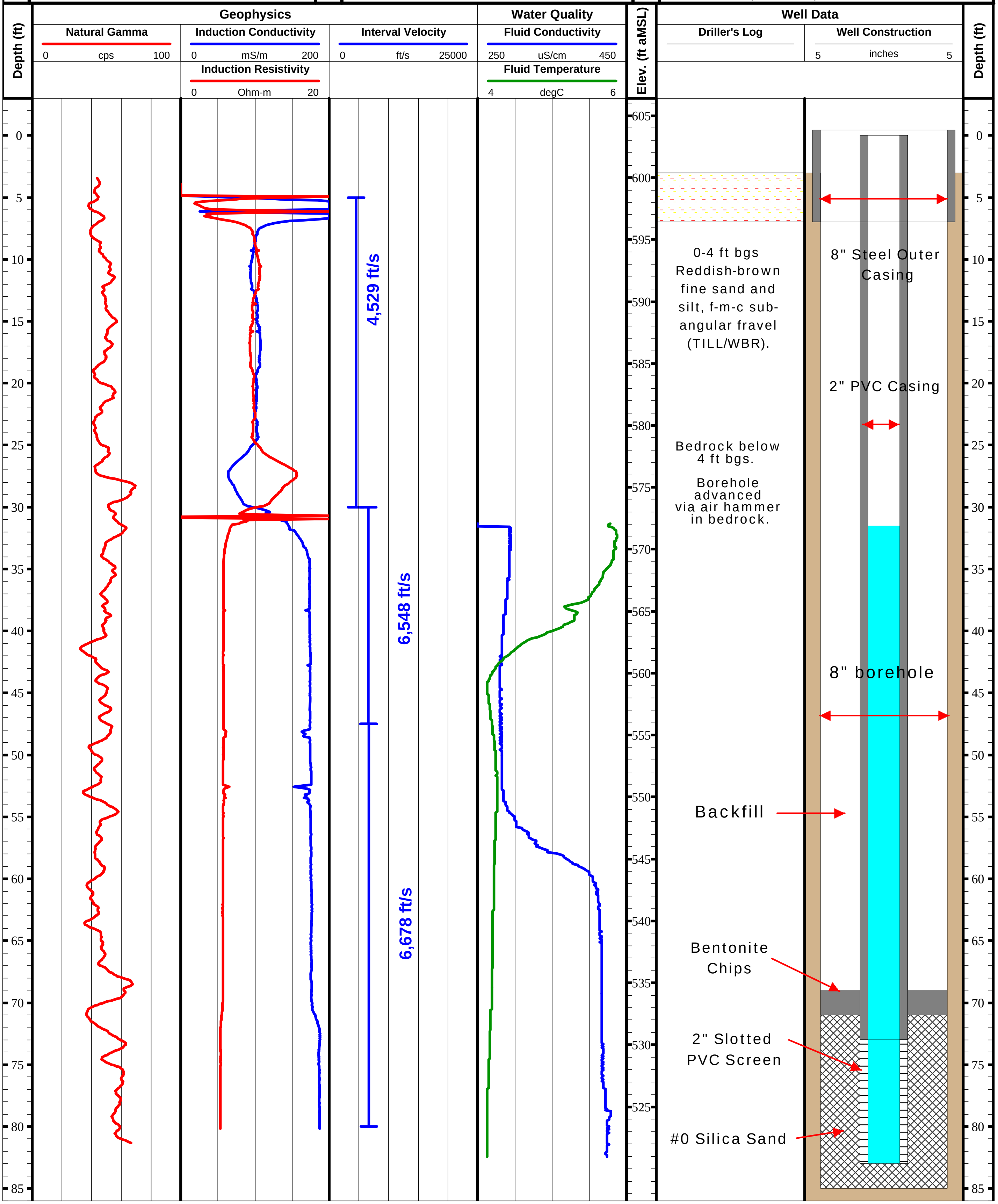
Gamma: Gamma SN# 311, depth err. -0.08 ft, speed 10 ft/min
Cond./Res.: 2PIA SN# 2041, depth err. 0.16 ft, speed 10 ft/min
Fluid Temp./Cond.: HLP SN# A, depth err. 0.1 ft, speed 5 ft/min

COMMENTS

Ground Elevation: 603.4 ft. aMSL.
Natural Gamma log includes K, U, and Th.
Water Quality logs performed under ambient conditions.
Ambient Water Level about 31.5 ft (29.5 ft bgs).

COMMENTS

All depths here referenced to top PVC casing unless noted otherwise.
Measured casing stick up above ground surface: PVC 2.0 ft, Steel 2.42 ft.
Steel outer casing total depth 7.0 ft, est from induced conductivity log.
Other well construction data taken directly from drilling report.
Measured and drill report PVC stickup differ.



MW-5 Geophysical Report

1.0 Geophysical Logging

On May 8th and May 9th, 2008, downhole geophysical investigations were performed in boring MW-5. The geophysical logs performed were: ambient fluid temperature and fluid conductivity, natural gamma, EM conductivity, vertical seismic profiling (VSP) and water chemistry (pH, DO). The data for these logs are presented in the MW-5 Geophysical Summary Plot at the end of this well report.

1.1 Ambient Fluid Temperature/Fluid Conductivity

On May 8th, 2008, an ambient fluid temperature and electrical fluid conductivity (FEC) profile was acquired in MW-5 to a depth of 77.7 feet. The ambient temperature log decreases with depth below 42 feet. In the screened interval the temperature log is relatively featureless decreasing from 4.6 to 4.55 degrees C. The ambient FEC profile registers approximately 454 µS/cm at the top of the screened interval at 70 feet and 461 µS/cm at TD.

1.2 Natural Gamma

On May 8th, 2008, a natural gamma profile was acquired in MW-5 to a depth of 73.8 feet. The natural gamma profile is relatively featureless with the exception of a high-gamma anomaly at 62 to 67 feet. The natural gamma profile ranges in gamma counts from 50 to 90 CPS.

1.3 EM Induction Conductivity

On May 8th, 2008, an EM conductivity profile was acquired in MW-5 to a depth of 75.7 feet. The EM conductivity profile is somewhat erratic below water level at 20 feet, registering approximately 142 mSeimens/meter and increasing with depth. The conductivity profile registers approximately 158 mSeimens/meter near TD with a high-induction conductivity anomaly at 70.6 feet, within the screened interval.

1.4 Vertical Seismic Profile (VSP)

On May 9th, 2008, a vertical seismic profile (VSP) investigation was conducted in MW-5 to a depth of 75 feet. Five distinct intervals of specific velocity were observed in MW-5 at 2.5 to 5, 5 to 17.5, 17.5 to 27.5, 32.5 to 57.5 and 60 to 70 feet, registering 984, 3,385, 5,244, 15,936 and 20,307 fps. A low-velocity anomaly is observed at 57.5 to 60 feet with poor P-wave energy returned.

1.5 Water Chemistry (pH, DO)

On May 8th, 2008, an ambient pH and dissolved oxygen (DO) profile was acquired in MW-5 to a depth of 77.6 feet. The pH profile registers low-pH anomalies at 61.7, 64.8 and 67.9 feet. The pH profile registers a nominal 7.09 pH above the screened interval and 7.27 near TD. The DO measurement indicates an erratic profile with regular anomalies that may be related to casing joints. The DO registers approximately 0.16 percent within the screened interval.

Project: LO-58	Well ID: MW-5	Date Logged: 7-8 May 08
Location: Aroostook County, Caribou, ME	Log Ref.: Top PVC Casing	Hole Diameter: 8" nom. to TD
Depth Logger: 77.8 ft	Log Ref. Elev.: 575.72 ft above MSL	Csg Size/Type: 2" PVC
Depth Driller: 82 ft bgs	Recorded by: G. Bauer	Witnessed by: A. Fuller

LOGS & TOOLS

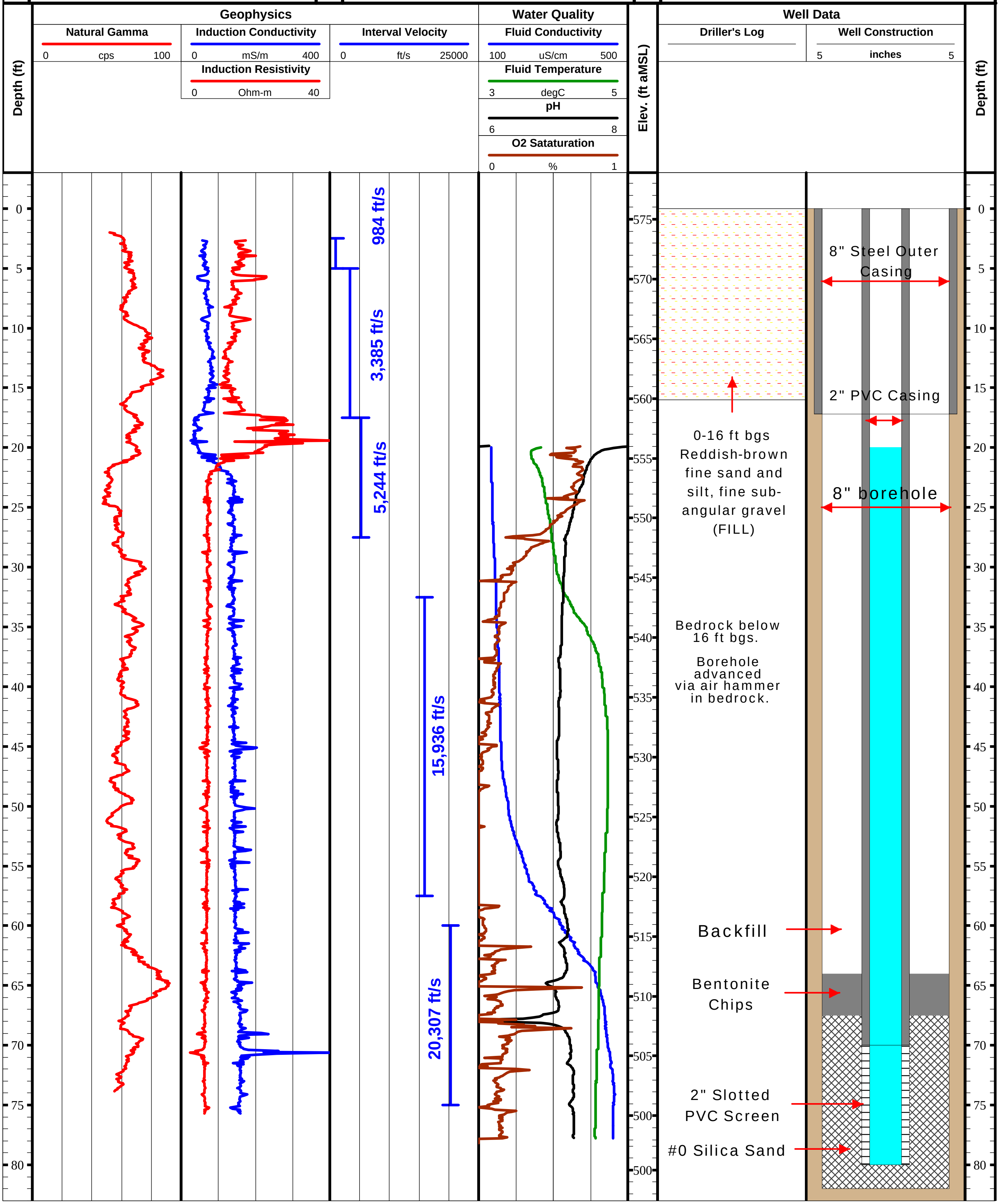
Gamma: 2PEA SN# 2955, depth err. 0.10 ft, speed 10 ft/min
Cond./Res.: 2PIA SN# 2041, depth err. 0.10 ft, speed 10 ft/min
Fluid Cond/Temp: HLP SN# A, depth err. 0.10 ft, speed 5 ft/min
Fluid pH/O2: WQ SN# 3048, depth err. 0.10 ft, speed 4 ft/min

COMMENTS

Ground Elevation: 575.9 ft aMSL.
Natural Gamma log includes K, U, and Th.
Water Quality logs performed under ambient conditions.
Ambient Water Level about 20 ft (20 ft bgs).

COMMENTS

All depths here referenced to top PVC casing unless noted otherwise.
Measured casing stick up above ground surface: PVC 0.0 ft, Steel 0.0 ft.
Steel outer casing total depth is undetermined from data. Guess is shown.



DW-1 Logging Results

1.0 HydroPhysical™ Logging

1.1 Ambient Fluid Electrical Conductivity and Temperature Log: DW-1

At 1202 hours on May 13th, 2008, after a calibration check of the fluid electrical conductivity (FEC) and temperature logging tool, the fluid column was logged for FEC and temperature profiles with COLOG's 1.5-inch diameter HpL™ probe. These logs were performed prior to the installation of any pumping equipment. Please refer to Figure DW-1:1. The ambient FEC profile indicates a relatively featureless profile with a notable increase at approximately 38.7 feet. The ambient FEC profile registers a nominal FEC of approximately 303 µS/cm above 38.7 feet and approximately 343 µS/cm below 42 feet. The anomaly observed in the ambient FEC profile correlates well with a water-bearing interval identified during hydrophysical testing. The ambient temperature profile is relatively rugose exhibiting a temperature range of 4.73 to 5.21 degrees C. Anomalies observed in the ambient temperature profile at approximately 27.3, 35.0, 37.2, 53.2 and 55.2 feet correlate well with identified water-bearing intervals. In vertically flowing conditions, where water enters the borehole, termed inflow, a change in either FEC is typically seen

.

1.2 Ambient Flow Characterization: DW-1

On May 13th, 2008, an ambient flow characterization was conducted in the boring DW-1. For ambient flow assessment, the formation water in the borehole was diluted with deionized water (DI) and the boring left in an undisturbed state to allow any natural flow to occur. After DI water emplacement the pump was removed from the boring to insure that water in the pump standpipe would not drain back into the boring. Prior to this period and throughout all HpL™ testing, water levels were monitored and recorded. Ambient flow evaluation is reported for the period after the water surface returned to near pre-emplacement levels. A series of FEC and temperature logs were then conducted to identify changes in the fluid column associated with ambient flow. Ambient flow characterization is conducted to evaluate the presence of both vertical and horizontal ambient flow.

On May 13th, 2008, at 1318 hours (t = 0 minutes, elapsed time of test), dilution of the fluid column was complete. Minimal to no DI water was lost to the formation due to the slightly depressed head maintained during emplacement procedures. During the 18.5 hours following the emplacement of DI water, multiple logs were conducted. Of these logs, 9 are presented in Figure DW-1:2. The designation of each logging with the FEC tool is indicated in the figure legend by the time of logging (e.g., FEC1318 versus a subsequent logging at FEC1334), thus the progressing of curves to the right in this figure represents changes in FEC over the total logging period. The last four digits of each log ID correspond to the time at which that particular log was started. Only logs acquired during logging in the downward direction are presented as the design of the FEC/Temperature probe allows the most accurate data to be collected in the downward direction. The logs acquired in the upward logging direction are not representative of downhole conditions and are therefore omitted. These logs illustrate significant change at several intervals throughout the length of the borehole. These dramatic changes in the FEC profiles with respect to time are associated with ambient horizontal flow occurring within the borehole.

Formation water migration by horizontal flow through the fluid column is indicated by the increase in FEC over time in the data presented in Figure DW-1:2 for the intervals 27.3 to 31.7, 34.6 to 35.0, 40.4 to 48.6, 49.0 to 50.2, and 52.7 to 53.6 feet. Numerical modeling of the reported field data using code BOREII of the horizontal flow intervals suggests the volumetric flow rate observed in the wellbore for these intervals are 0.085, 0.011, 0.14, 0.018, and 0.058 gpm, respectively. Correcting for convergence of flow at the wellbore and factoring the length of the interval, this flow rate equates to a Darcy velocity, or specific discharge of groundwater in the aquifer of 2.84, 3.91, 2.53, 2.28, and 9.56 feet/day, respectively. Please refer to Figure DW-1:2 and Table DW-1:1 for a complete summary of the HydroPhysical™ logging results. Please refer to Appendix B for a discussion of the methodology and code used to calculate these values. The ambient depth to water at the time of testing was 22.39 ftbtoc.

1.3 Flow Characterization During 6 GPM Production Test: DW-1

Pumping of borehole fluids and simultaneous DI injection was conducted at one pumping rate to establish the inflow locations and evaluate the interval specific inflow rates. Pumping at a given rate was conducted until reasonably constant drawdown was observed. When constant drawdown was observed, DI injection was initiated at about 20-30% of the pumping rate and the extraction pumping rate was increased to maintain a constant total formation production rate (i.e. pumping rate prior to DI injection). These procedures were conducted at a differential rate of 6.04 gpm.

On May 14th, 2008, at 1000 hours (t = 0 minutes elapsed time of testing), development pumping was initiated at approximately 6.6 gpm. Prior to initiating pumping, the ambient depth to water was recorded at 22.79 ftbtoc. All drawdown values are referenced to this ambient water level. Time dependent depth to water, totals and flow rate information were recorded digitally every second and are presented in Figure DW-1:3. Pumping was maintained at a time-averaged rate of 6.64 gpm until 1215 hours (t = 135 minutes, elapsed time of testing). During development pumping numerous FEC logs were acquired to monitor the development process and assist in identifying the depths of flow zones. Of these FEC logs, six (FEC1041 through FEC1150) are presented in Figure DW-1:4. The FEC logs acquired during development pumping illustrate a reasonably stable, repeatable condition of the fluid column with local inflow locations identified by spikes or incremental step increases or decreases in FEC. DI water injection from the bottom of the wellbore was initiated at 1215 hours at a time-averaged rate of 1.39 gpm while the total extraction rate was increased to a time-averaged rate of 7.43 gpm, resulting in a total borehole formation time-averaged production rate of 6.04 gpm. These flow conditions were maintained until 1323 hours (t = 203 minutes) during which time a reasonably constant drawdown of approximately 3.02 feet was observed. COLOG defines reasonably constant drawdown as drawdown that fluctuates less than 10 percent of the total drawdown. The FEC logs acquired during dilution procedures illustrate a reasonably stable condition of the fluid column with local inflow locations identified by spikes or incremental step increases in FEC. Seven inflow zones were identified from these logs at 27.3 to 31.7, 34.6 to 35.0, 37.4 to 38.4, 40.4 to 48.6, 49.0 to 50.2, 52.7 to 53.6, and 54.4 to 58.1 feet with flow rates ranging of 0.207, 0.195, 0.745, 2.00, 0.416, 1.65, and 0.838 gpm, respectively. The logs indicate the interval 40.4 to 48.6 and 52.7 to 53.6 feet dominated flow during pumping, producing 3.65 gpm or 60 percent of the total flow. Please refer to Table DW-1:1 for a summary of HydroPhysical™ flow results and the depths of individual inflow zones.

1.4 Estimation of Interval Specific Transmissivity: DW-1

An estimation of transmissivity (T) can be made using an equation after Hvorslev (1951) assuming steady-state radial flow in an unconfined aquifer:

$$T = KL = \frac{q_i}{2\pi \Delta h_w} \ln\left(\frac{r_e}{r_w}\right)$$

where K is the hydraulic conductivity, q_i is the interval specific inflow rate calculated using HpL™ results, r_w is the borehole radius (0.26 ft), r_e is the effective pumping radius, Δh_w is the observed maximum drawdown (22.79 feet) and L is the thickness of the zone through which flow occurs. For our calculations, COLOG used r_e of 300 feet (assumed). By applying L and q_i from the HpL™ results under the two pressure conditions, the interval specific transmissivity can be calculated for each identified water producing interval. These calculations were made at each identified interval and are presented in Table DW-1:1. In summary, the intervals 40.4 to 48.6 and 52.7 to 53.6 feet exhibited the highest transmissivities of approximately 129 and 111 ft^2/day, respectively.

2.0 Geophysical Logging

On May 11th, 2008 through May 20th, 2008, downhole geophysical and hydrogeologic investigations were performed in boring DW-1. The geophysical and hydrogeologic logs performed were: optical televiewer (OBI), acoustic televiewer (ATV), 3-arm caliper, natural gamma, electric resistivity, EM induction conductivity, water chemistry (pH, ORP, DO), full waveform sonic, vertical seismic profile (VSP), wireline straddle packer (WSP) and downhole video. The data for these logs are presented in the DW-1 Geophysical/HydroPhysical™ Summary Plot and Figures DW-1:5, 6, 7 and 8 and Table DW-1:2 for the statistical analysis of all fractures/features, Table DW-1:3 for a summary of the VSP velocities and Figures DW-1:9A through E and Table DW-1:4 for the WSP pressure data and results at the end of this well report. The downhole video was provided to the client in the field at the time of logging.

2.1 Optical Televiewer (OBI)/Acoustic Televiewer (ABI)

On May 11th, 2008 optical and acoustic televiewer logging was performed in DW-1 to a depth of 58.1 feet. The televiewers identified features at depths correlating well with the HpL™ and caliper data. The features observed by the OBI at water-bearing intervals identified from the HpL™ data had apparent aperture and in some cases evidence of staining. Two hundred twenty high-angle fractures or features (dip angles greater than 45 degrees) were identified in DW-1. Seventeen of these high-angle features are qualitatively ranked 2 or greater suggesting the potential for vertical hydraulic communication outside the influence of the borehole. Data acquired during WSP testing confirms the presence of vertical hydraulic communication between several water-bearing zones in the immediate vicinity of the borehole.

2.2 Three-Arm Caliper

On May 11th, 2008 three-arm caliper logging was performed in DW-1 to a depth of 57.7 feet. The caliper log indicates a relatively rugose borehole with nine major inflections observed at approximately 10.4 to 12.6, 18.5, 23.0, 26.9, 34.7, 37.9, 40.4 to 45.1, 46.8 to 48.2 and 52.4 to 53.5 feet. The inflections, or borehole enlargements, observed in the caliper log correlate well with water-bearing zones and fractures identified by the hydrophysical and optical televiewer data. The caliper log registers an approximately nominal 6.25-inch diameter borehole below casing at 10.4 feet.

2.3 Natural Gamma

On May 11th, 2008 natural gamma logging was performed, in conjunction with the electric resistivity logging, in DW-1. The natural gamma measurement reached to a depth of 54.1 feet. The natural gamma is relatively featureless with minor fluctuations in gamma counts, expected in limestone. The natural gamma log registers an approximately nominal 44 to 70 counts per second.

2.4 Electric Resistivities (8, 16, 32, 64-inch Normal Resistivities, SP, SPR)

On May 11th, 2008 electric resistivity logging was performed, in conjunction with the natural gamma log, in DW-1 to a depth of 57.8 feet. The electric measurements consist of 8, 16, 32 and 64-inch “normal” resistivities, spontaneous potential (SP) and single-point resistance (SPR). The normal resistivities registered approximately 850 Ohm-meters (8-inch resistivity) to 3,690 Ohm-meters (64-inch resistivity). A notable anomaly in the electric resistivity is observed at approximately 47 to 48 feet. The higher spaced resistivities (32 and 64-inch) register lower resistivities below this depth. Above 47 to 48 feet, the higher spaced resistivities register a marked increase in resistivity, typical of more massive limestone. However, the limestone above this depth is marked with large, occasionally high-angle, fractures. The SP is also relatively featureless registering a nominal 125 to 246 milivolts below water level. The SPR measurement registers low-resistivity anomalies at 37.8, 40.4 to 48.2 and 52.8 feet, correlating well with identified major fractures. The SPR registers 432 to 791 Ohms.

2.5 EM Induction Conductivity

On May 11th, 2008 EM induction conductivity logging was performed in DW-1 to a depth of 55.8 feet. The induction conductivity log is featureless with the exception of anomalies at the bottom of casing at 10.5 feet and water level at approximately 21.4 feet. The induction conductivity registers a nominal 43 miliS/meter above water level and 154 miliS/meter below water level.

2.6 Water Chemistry (pH, ORP, DO)

On May 11th, 2008, pH, oxidation-reduction potential (ORP) and dissolved oxygen (DO) measurements were acquired under ambient conditions in DW-1 to a depth of 57.6 feet. The pH measurement is relatively featureless with the exception of a high-pH anomaly at waters surface. The pH measurement registers a nominal pH ranging from 7.41 to 7.50. The ORP measurement indicates a gradual increase in oxidation potential with depth. The ORP measurement registers approximately 137 mV at waters surface and 195 mV near total depth. The dissolved oxygen measurement is relatively variable with significant fluctuations in DO. The DO measurement registers an increase in dissolved oxygen with depth, registering zero from waters surface to approximately 37.6 feet where the data indicates an increase in DO. Near total depth the DO is observed to be approximately 1.57 percent.

2.7 Full Waveform Sonic

On May 11th, 2008 full waveform sonic logging was performed in DW-1 to a depth of 58.1 feet. The sonic registered slower velocity anomalies at 37.4 to 46.4, 48.4 and 53.1 feet, correlating well with identified fractures and water-bearing zones observed in the optical televiewer, caliper and hydrophysical data. The sonic registered p-wave velocities ranging from 9,340 to 19,550 feet/second. The lower value of p-wave velocity correlates well with velocities identified using vertical seismic profiling (VSP).

2.8 Vertical Seismic Profile (VSP)

On May 8th, 2008 a vertical seismic profile (VSP) was conducted in DW-1 to a depth of 55 feet. The VSP investigation in DW-1 identified 3 specific intervals of specific velocity at 5 to 10, 10 to 25 and 25 to 55 feet, registering 1,670, 7,135 and 8,493 feet/second (fps), respectively. All of the DW-1 velocity calculations are effectively two-point calculations, using arrival times at the beginning & end of the indicated depth ranges. Late arrivals indicate possible low-velocity zones near 20 & 50 feet deep. The 1,670 fps value is consistent with dry overburden. The higher values are relatively low for bedrock velocities, but consistent with highly fractured bedrock.

2.9 Wireline Straddle Packer (WSP)

On May 18th through 20th, 2008 wireline straddle packer (WSP) testing was conducted in DW-1 at five intervals:

33.15 to 24.98 feet (the top of water table)
33.75 to 38.5 feet
41.2 to 51.9 feet
51.0 to 58.1 feet (total depth)
54.0 to 58.1 feet (total depth)

WSP testing was conducted to acquire a fracture-specific groundwater sample from each major water-bearing fracture identified during hydrophysical production testing. In addition to collecting a representative groundwater sample from each interval, development pumping was conducted at each interval and pressures above, below and in the interval of interest recorded to estimate fracture-specific permeability for each interval tested. Please see Tables WSP Summary and DW-1:4 for a complete summary of wireline straddle packer testing results.

Several different configurations of the WSP were utilized to properly characterize the numerous fracture zones in this borehole. Due to either a long length of fracture zone that is intended to be tested, or the fracture of interest being close to water level of the bottom of the borehole, the WSP was configured several different ways:

Interval 33.15 to 24.98 feet (water level) – the top of the upper packer was situated at 33.15 feet and only the upper packer was inflated. The middle zone of the packer assembly was sealed from the upper interval and pumping was conducted from a 2-inch pump lowered to the interval of interest, 33.15 feet up to water level (24.98 ftbtoc). In this configuration, both the middle and lower pressure transducers are recording the same interval of interest – the entire interval below the upper packer to TD. Notice there is no evidence of vertical hydraulic communication outside the influence of the borehole between water-bearing fractures in the test interval of 33.15 feet up to water level and water-bearing fractures below the upper packer (bottom of the upper packer seal approximately 35 feet) based on the non-response to pumping registered by the middle and lower pressure transducers. However, the pumping rate of 0.25 gpm is very low with respect to the yields of the identified water-bearing fractures below this interval of interest. As such, any vertical hydraulic communication at this testing flow rate would likely not be measured in the pressure transducers below this interval of interest. Please see Figure DW-1:9A and Table DW-1:4 for a complete summary of the data acquired and results for this interval.

Interval 33.75 to 38.5 feet – The WSP was utilized in its standard configuration, with a 4.8-foot interval, both packers inflated, and all pressure transducers measuring pressure in their respective zones of interest. The data clearly indicates vertical hydraulic communication outside the influence of the borehole between water-bearing fractures in the interval of interest at 33.75 to 38.5 feet and the lower interval below the lower packer based on the correlating responses observed in the middle and lower pressure transducers. The data indicates a small correlating response in the upper pressure transducer, likely observed during this test due to the higher pumping rate of 2.73 gpm during stress testing compared to the pumping rate of 0.25 gpm during stress testing of the upper interval 33.15 feet to water level. Please see Figure DW-1:9B and Table DW-1:4 for a complete summary of the data acquired and results for this interval.

Interval 41.2 to 51.9 feet – For this interval of interest, the WSP was reconfigured for a longer length between packers. For this test the interval was lengthened to 10.7 feet due to the highly fractured interval and lack of pertinent, solid borehole to place a packer for a good seal. The data clearly indicates vertical hydraulic communication outside the influence of the borehole between water-bearing fractures in the interval of interest at 41.2 to 51.9 feet and the upper and lower intervals surrounding the interval of interest based on the correlating responses observed in the upper and lower pressure transducers. This is not unexpected based on the high-angle fractures with aperture identified in the optical and acoustic televiewer data in this interval. Please see Figure DW-1:9C and Table DW-1:4 for a complete summary of the data acquired and results for this interval.

Interval 51.0 feet to TD – For this interval of interest, the WSP was reconfigured by removing the lower packer in order to enable the sample port of the WSP to reach this interval of interest near the bottom of the borehole. For this test the middle and lower pressure transducers are both in the interval of interest and register the same changes in pressure. The interval of interest is considered to be from the base of the upper packer to total depth of the borehole – 58.2 feet. The data clearly indicates vertical hydraulic communication outside the influence of the borehole between water-bearing fractures in the interval of interest at 51.0 to TD and the upper interval above this interval of interest based on the correlating response observed in the upper pressure transducers. This is not unexpected based on the high-angle fractures with aperture identified in the optical and acoustic televiewer data. Please see Figure DW-1:9D and Table DW-1:4 for a complete summary of the data acquired and results for this interval.

Interval 54.0 feet to TD – For this interval of interest, the WSP was reconfigured by removing the lower packer in order to enable the sample port of the WSP to reach this interval of interest near the bottom of the borehole. For this test the middle and lower pressure transducers are both in the interval of interest and register the same changes in pressure. The interval of interest is considered to be from the base of the upper packer to total depth of the borehole – 58.2 feet. The data clearly indicates vertical hydraulic communication outside the influence of the borehole between water-bearing fractures in the interval of interest at 54.0 to TD and the upper interval above this interval of interest based on the correlating response observed in the upper pressure transducers. Please see Figure DW-1:9E and Table DW-1:4 for a complete summary of the data acquired and results for this interval.

3.0 Data Summary

Processing and interpretation of the geophysical and HydroPhysical™ logs in DW-1 suggest the presence of seven producing intervals for this borehole. Numerical modeling of the reported HydroPhysical™ field data was performed using computer programs FLOWCALC and/or BOREII. These analyses were performed to estimate the rate of inflow for each identified hydraulically conductive borehole interval during DI injection procedures. The results of these analyses are presented in Table DW-1:1. . In summary, the intervals at 40.4 to 48.6 and 52.7 to 53.6 feet dominated flow during pumping, producing 3.65 gpm or 60 percent of the total flow. Five of the seven identified producing intervals correlate well with water-bearing zones identified during ambient testing. The remaining two intervals were not actively flowing water during ambient testing.

During ambient testing, boring DW-1 exhibited a complex network of horizontal flow zones. Five ambient inflow intervals are identified at 27.3 to 31.7, 34.6 to 35.0, 40.4 to 48.6, 49.0 to 50.2, and 52.7 to 53.6 feet, with observed flow rates of 0.085, 0.011, 0.14, 0.018, and 0.058 gpm respectively. Ambient flow from these inflow intervals is observed to migrate horizontally across the borehole. Correcting for convergence to the wellbore and factoring the length of the interval, this flow rate equates to Darcy velocities of 2.84, 3.91, 2.53, 2.28, and 9.56 ft/day, respectively.

The optical and acoustic televiewers identified features at depths correlating well with the HpL™ and caliper data. The features observed by the OBI at water-bearing intervals identified from the HpL™ data had apparent aperture and in some cases evidence of staining. Two hundred twenty high-angle fractures or features (dip angles greater than 45 degrees) were identified in DW-1. Seventeen of these high-angle features are qualitatively ranked 2 or greater suggesting the potential for vertical hydraulic communication outside the influence of the borehole. Data acquired during WSP testing confirms the presence of vertical hydraulic communication between several water-bearing zones in the immediate vicinity of the borehole.

The seven interval-specific transmissivity estimates calculated using the hydrophysical data in DW-1 ranged from 8.51 to 129 ft^2/day, with the interval at 40.4 to 48.6 feet registering the highest transmissivity. The ranges of transmissivities suggest that flow originates from secondary porosity consisting of large discrete fractures at the major inflow zones and minor fractures or features with less inter-connectiveness at the minor inflow zones. Interval-specific FEC ranged from 357 to 428 µS/cm.

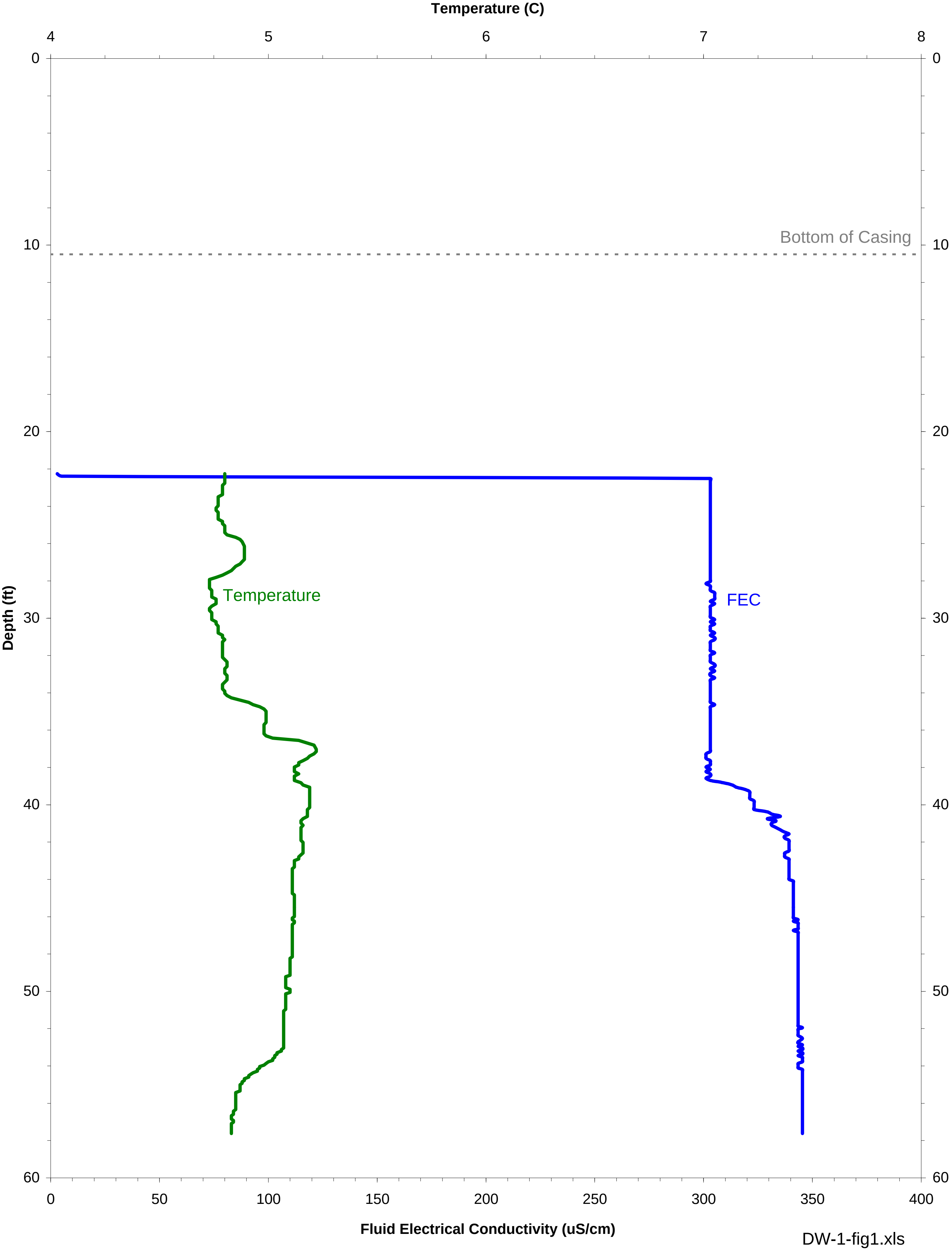
The WSP sampling results identified contaminant concentrations in each of the five sampled intervals. Of particular note is a high toluene anomaly of 120 µg/L in the uppermost sample interval of 33.2 to water level (24.86 ftbtoc). Each of the five sampled intervals at 33.2 to water level, 33.8 to 38.5, 41.2 to 51.9, 51.0 to 58.2 (TD) and 54.0 to 58.2 feet registered concentrations of TCE of 1.8, 2.5, 3.4, 3.1 and 2 µg/L, respectively. Please see Table WSP Summary in the Executive Summary for a complete summary of the sample results.

Fracture inter-connectiveness in the immediate vicinity of a wellbore can be inferred by the similarity, or lack there of, of parameters such as interval-specific transmissivity estimates and interval-specific FEC, along with the presence of high-angle fractures and pressure differentials within the borehole. Similar transmissivity and FEC estimates would suggest an inter-connected

network of fractures or aquifers in the immediate vicinity of the wellbore. High-angle fractures with aperture may provide a conduit for vertical communication. Moreover, although a pressure differential would seem to suggest the driving force for vertical communication is present, typically substantially vertically interconnected fractures or aquifers tend to pressure-equilibrate in the immediate vicinity of the wellbore. Thus, the presence of a pressure differential in a wellbore may suggest a lack of vertical communication between fractures or aquifers in the immediate vicinity of the borehole.

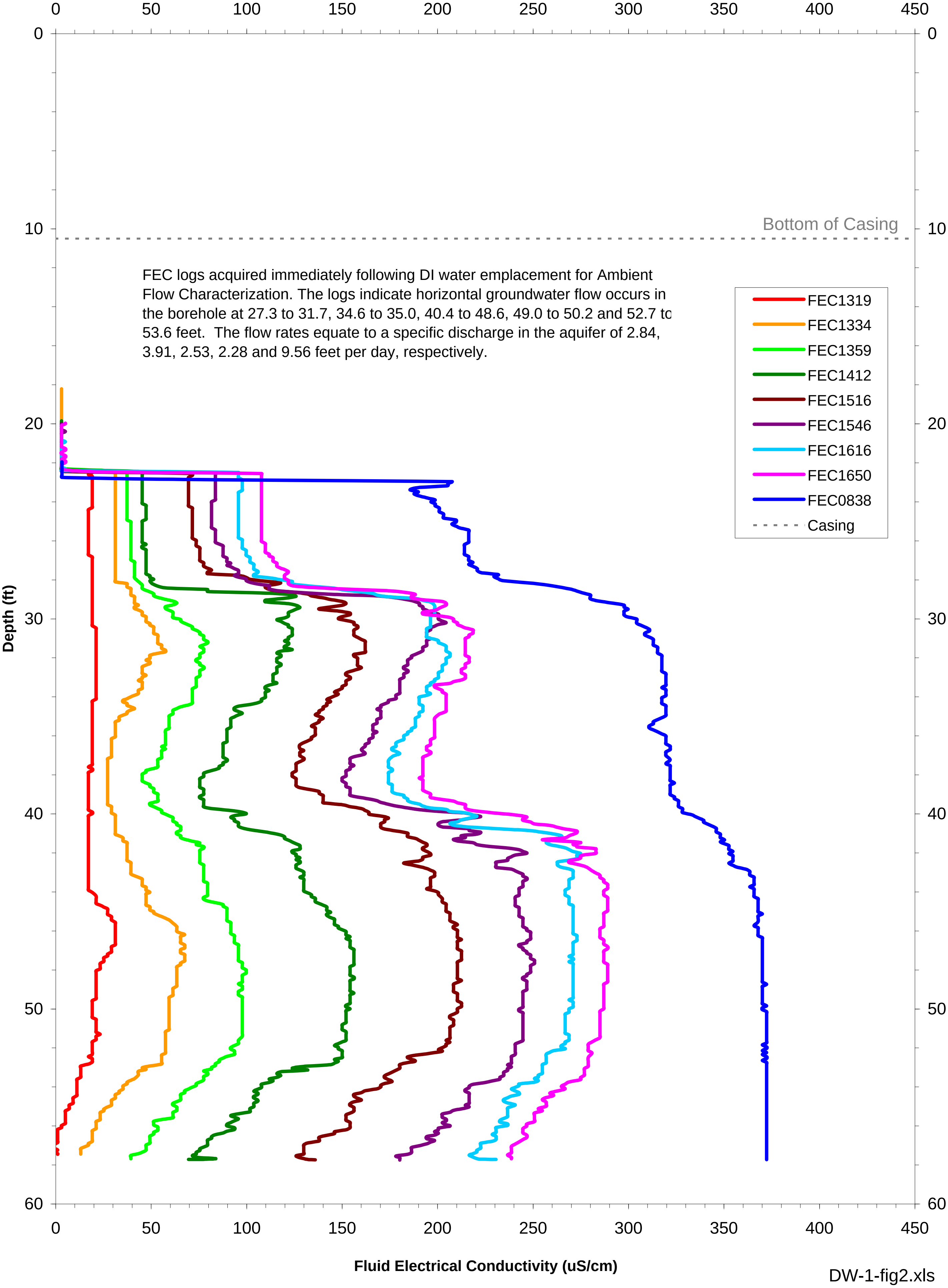
The data acquired in DW-1 exhibited dissimilar interval-specific transmissivity but similar FEC estimates. The televiewers identified high-angle fractures with aperture and the WSP registered pressure correlations above and below several tested intervals. The data strongly suggest the fractures are vertically inter-connected in the immediate vicinity of the wellbore. Please see Table DW-1:1 for a summary of the HydroPhysical™ and geophysical logging results which includes the locations, flow rates and transmissivity and hydraulic conductivity estimates assessed by COLOG.

FIGURE DW-1:1. Ambient Temperature And Fluid Electrical Conductivity; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-1



DW-1-fig1.xls

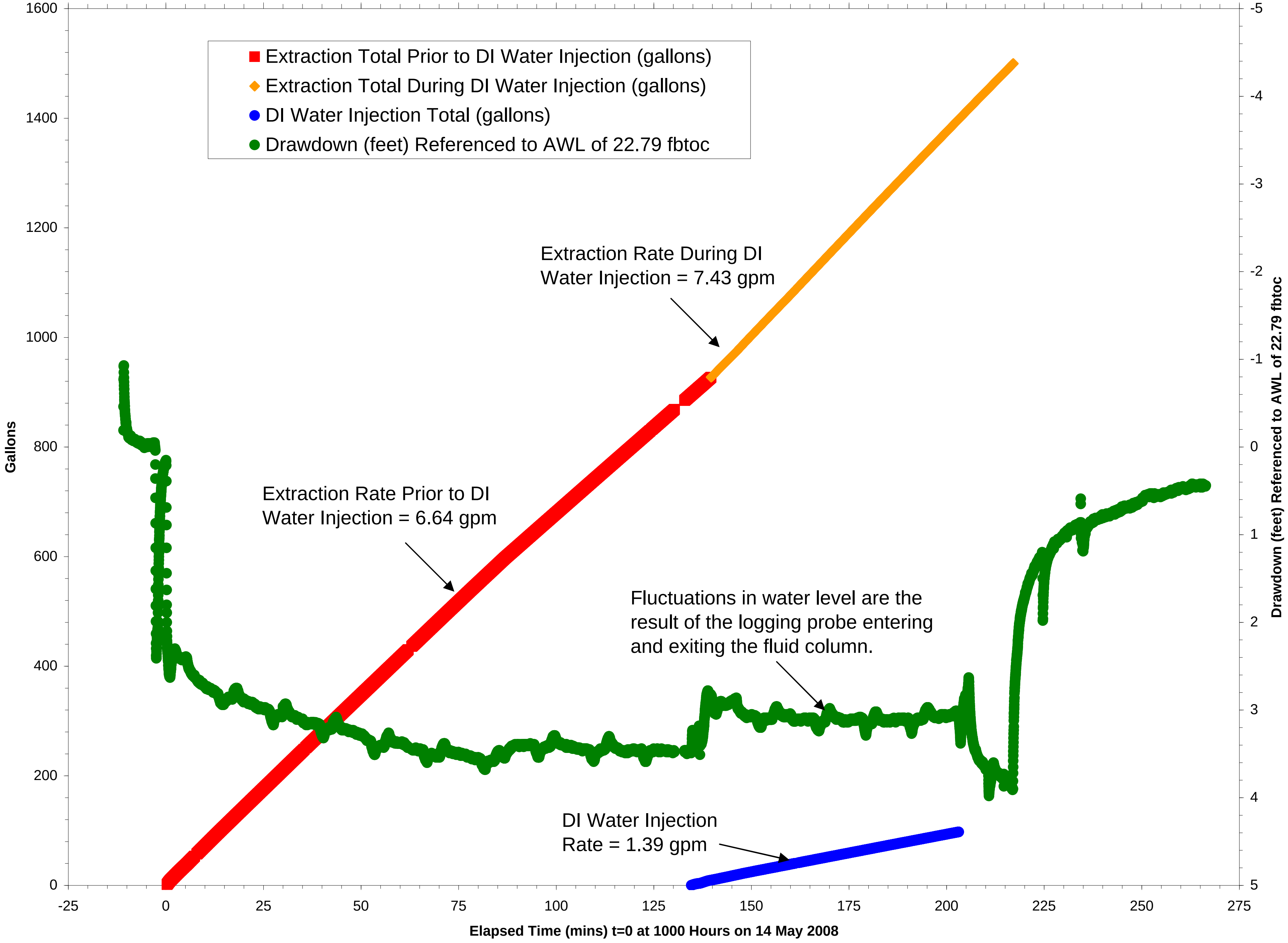
FIGURE DW-1:2. Summary of Hydrophysical Logs During Ambient Flow Characterization; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-1



FEC logs acquired immediately following DI water emplacement for Ambient Flow Characterization. The logs indicate horizontal groundwater flow occurs in the borehole at 27.3 to 31.7, 34.6 to 35.0, 40.4 to 48.6, 49.0 to 50.2 and 52.7 to 53.6 feet. The flow rates equate to a specific discharge in the aquifer of 2.84, 3.91, 2.53, 2.28 and 9.56 feet per day, respectively.

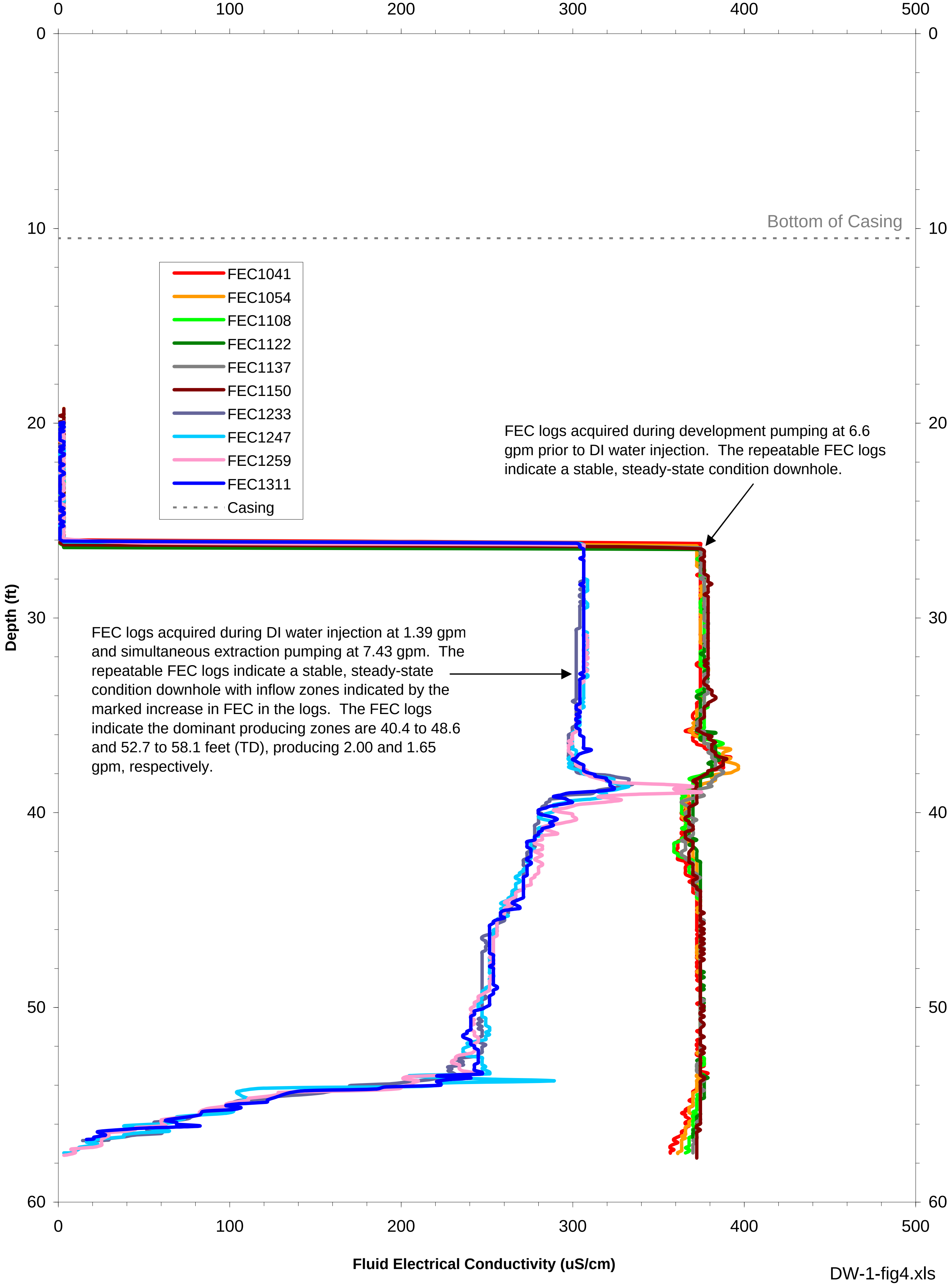
DW-1-fig2.xls

FIGURE DW-1:3. Pumping And Drawdown Data During 6 GPM Production Test; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-1



DW-1-fig3.xls

FIGURE DW-1:4. Summary of Hydrophysical Logs 6 GPM Hydrophysical Production Test; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-1



FEC logs acquired during development pumping at 6.6 gpm prior to DI water injection. The repeatable FEC logs indicate a stable, steady-state condition downhole.

FEC logs acquired during DI water injection at 1.39 gpm and simultaneous extraction pumping at 7.43 gpm. The repeatable FEC logs indicate a stable, steady-state condition downhole with inflow zones indicated by the marked increase in FEC in the logs. The FEC logs indicate the dominant producing zones are 40.4 to 48.6 and 52.7 to 58.1 feet (TD), producing 2.00 and 1.65 gpm, respectively.

DW-1-fig4.xls

Table DW-1:1. Summary Of HydroPhysical^{TM} Logging Results With Hydraulic Conductivity And Transmissivity Estimations; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-1

Well Name	DW-1
Ambient Depth to Water (ftbtoc)	22.79
Diameter of Borehole (ft)	0.52
Maximum Drawdown (ft)	3.11
Effective Radius (ft)	300

Interval No.	Top of Interval (ft)	Bottom of Interval (ft)	Length of Interval (ft)	Ambient Flow[1] (gpm)	Darcy Velocity in Aquifer[2] (Specific Discharge) (ft/day)	Interval Specific Flow Rate During Pumping (gpm)	Delta Flow[3] (gpm)	Delta Flow (ft^3/min.)	Interval Specific Hydraulic Conductivity[4] (ft/day)	Transmissivity (ft2/day)	Interval Specific Fluid Electrical Conductivity (microS/cm)
1	27.3	31.7	4.4	0.085	2.84	0.207	0.123	0.016	1.93E+00	8.51E+00	376
2	34.6	35.0	0.4	0.011	3.91	0.195	0.184	0.025	3.20E+01	1.28E+01	376
3	37.4	38.4	1.0	0.000	0.00	0.745	0.745	0.100	5.18E+01	5.18E+01	428
4	40.4	48.6	8.2	0.140	2.53	2.00	1.860	0.249	1.58E+01	1.29E+02	357
5	49.0	50.2	1.2	0.018	2.28	0.416	0.398	0.053	2.30E+01	2.76E+01	375
6	52.7	53.6	0.9	0.058	9.56	1.65	1.592	0.213	1.23E+02	1.11E+02	375
7	54.4	58.1	3.7	0.000	0.00	0.838	0.838	0.112	1.57E+01	5.82E+01	375

[1] Horizontal flow is identified in this borehole under ambient conditions.

[2] Darcy Velocity is calculated using the observed volumetric flow rate, the cross-sectional area of the flow interval in the wellbore and a wellbore convergence factor of 2.5 (Drost, 1968). The Darcy Velocity is only applicable to ambient horizontal flow

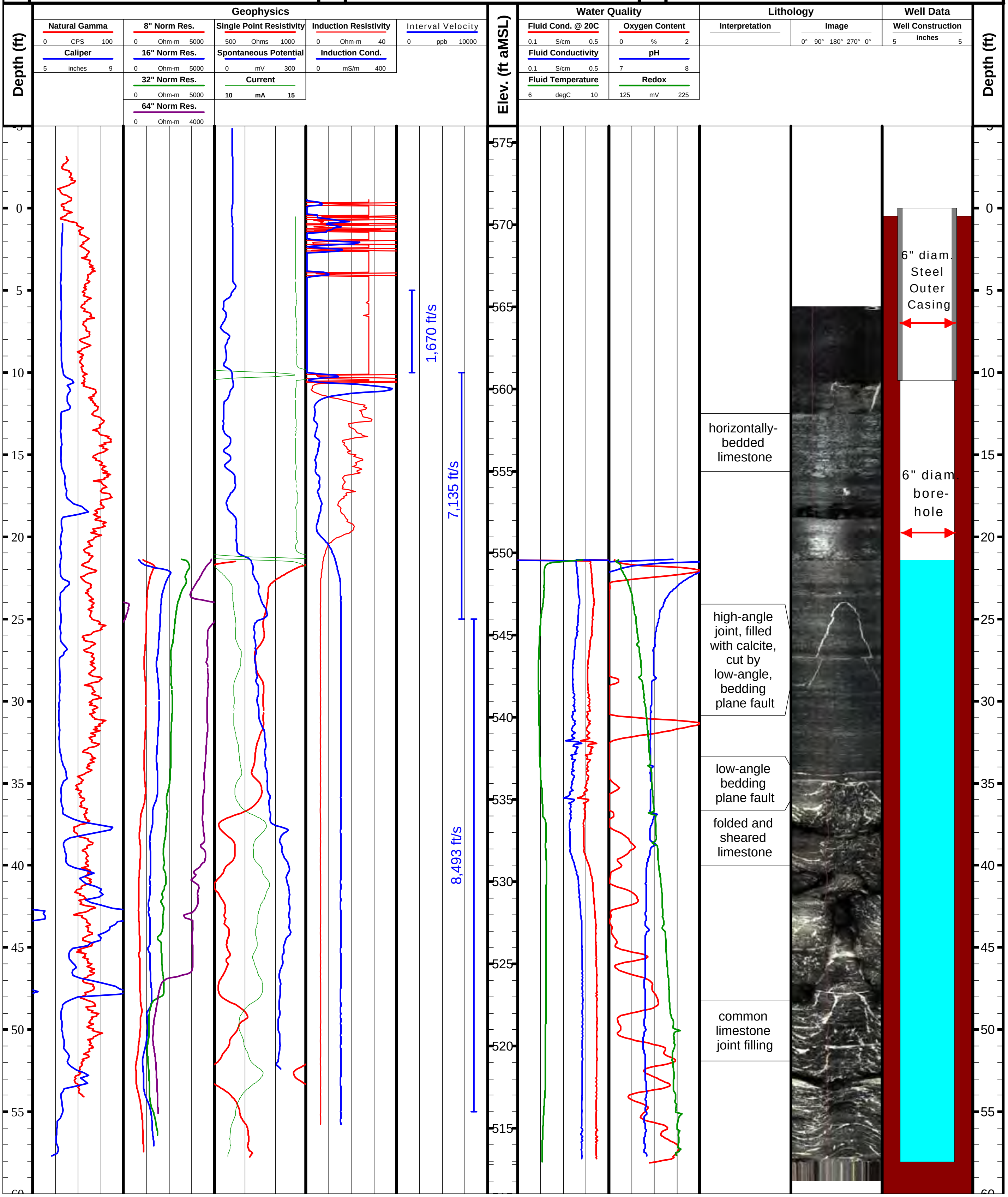
[3] Delta Flow is the difference between Interval-Specific Flow Rate (during pumping) and Ambient Flow Rate.

[4] Hydraulic conductivity and transmissivity estimates are based on single well drawdown data, a porus-medium equivilent model and Hvorslev's 1951 porosity equatior

NA - Not Applicable

Project: LO-58	Well ID: DW-01 (AMAC Well)	Date Logged: 11-20 May 08
Location: Aroostook County, Caribou, ME	Log Ref.: Top Steel Casing	Hole Diameter: 6" nom. to TD
Depth Logger: 58.1 ft	Log Ref. Elev.: ~573 ft above MSL	Csg Size/Type: 6" Steel
Depth Driller: No Data	Recorded by: G. Bauer	Witnessed by: J. Schmidl

LOGS & TOOLS		COMMENTS		COMMENTS	
	See Individual Logs		Ground Elevation: ~571ft. aMSL. Natural Gamma log includes K, U, and Th. Water Quality logs performed under ambient conditions. Ambient Water Level about 21.4 ft (20.9 ft bgs). Logs relative to Truth North (mag dec = 20W)		All depths here referenced to top steel casing unless noted otherwise. Measured casing stick up above ground surface: 0.5 ft. Steel outer casing total depth 10.5 ft, estimated from image log.



Project: LO-58	Well ID: DW-01 (AMAC Well)	Date Logged: 11-20 May 08	
Location: Aroostook County, Caribou, ME	Log Ref.: Top Steel Casing	Hole Diameter: 6" nom. to TD	
Depth Logger: 58.1 ft	Log Ref. Elev.: ~573 ft above MSL	Csg Size/Type: 6" Steel	
Depth Driller: No Data	Recorded by: G. Bauer	Witnessed by: J. Schmidl	

LEGEND

Tadpoles at depth of planar structure, pointing towards strike, and centered on dip. Projections corresponding to each tadpole shown in adjacent column.

Structure Tadpoles

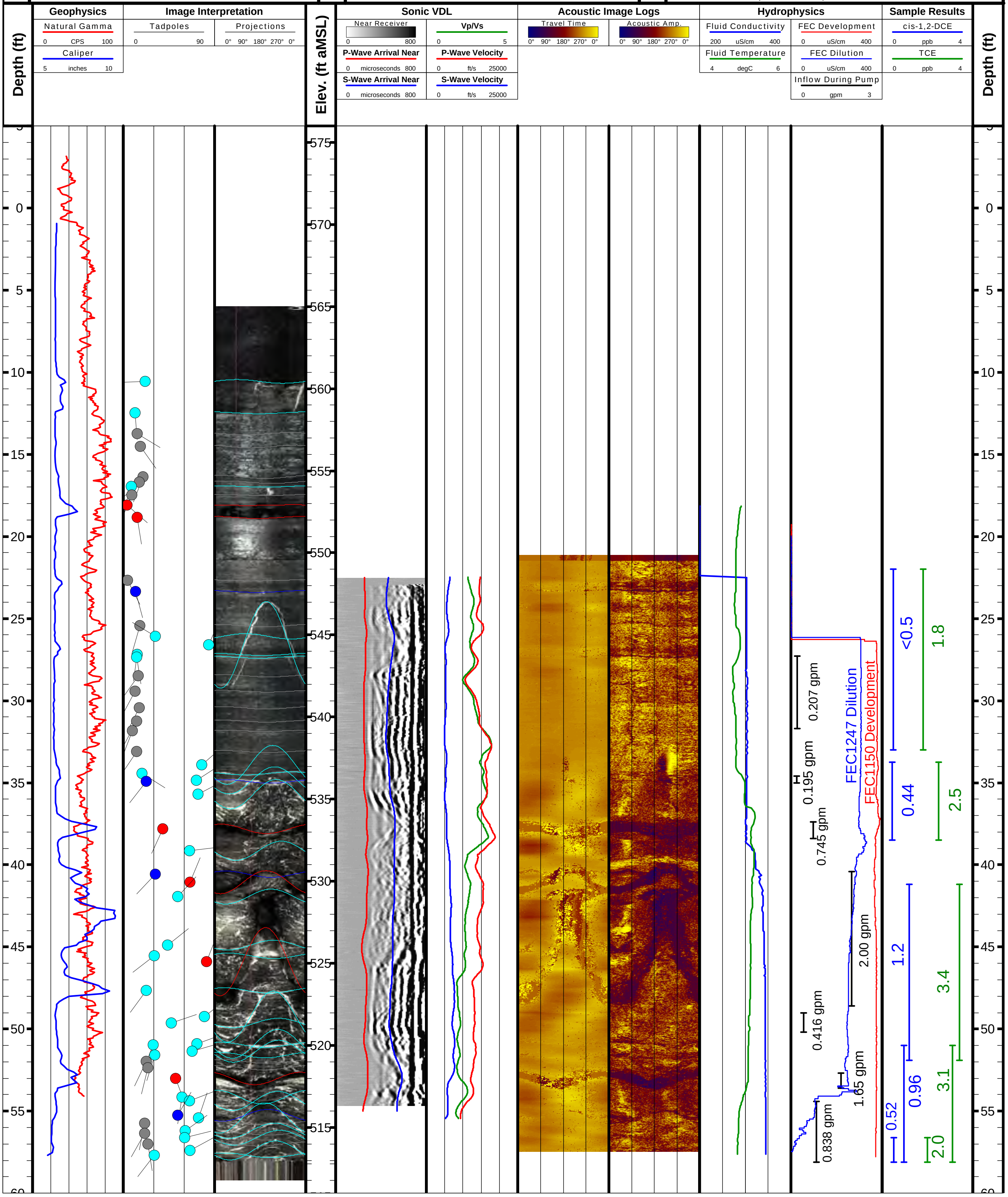
● Partial Fracture	● Healed Fracture/Bedding Plane
● Complete Fracture	● Open Fracture
● Wide Fracture/Multiple Fractures	● Washout/Wide Fracture Zone

COMMENTS

Ground Elevation: ~571 ft. aMSL.
Natural Gamma log includes K, U, and Th.
Water Quality logs performed under ambient conditions.
Ambient Water Level about 21.4 ft (20.9 ft bgs).
Logs relative to Truth North (mag dec = 20W)

COMMENTS

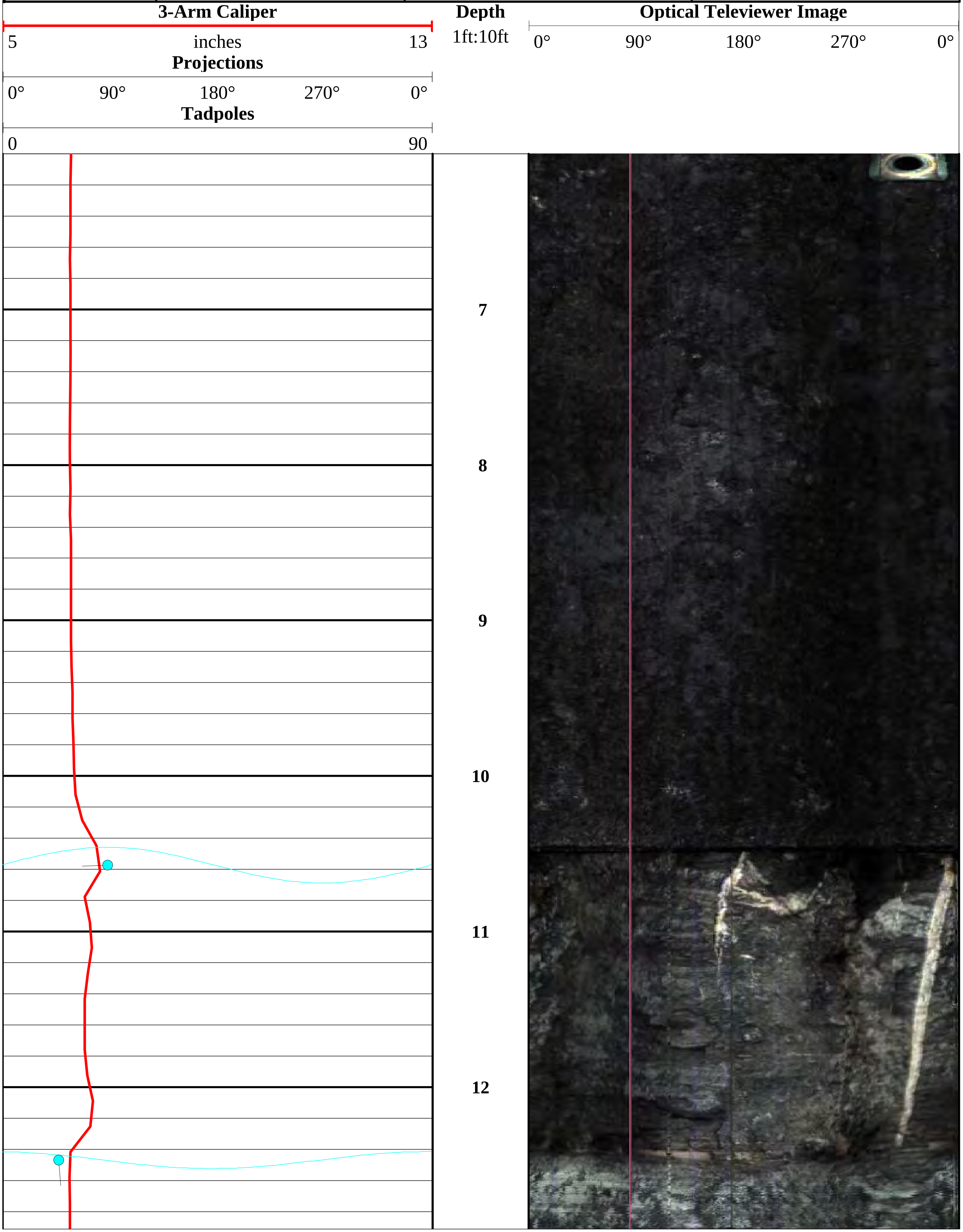
All depths here referenced to top steel casing unless noted otherwise.
Measured casing stick up above ground surface: 0.5 ft.
Steel outer casing total depth 10.5 ft, estimated from image log.
Other well Consturction info taken directly from drilling report.
Measured and drill report PVC stickup differ.

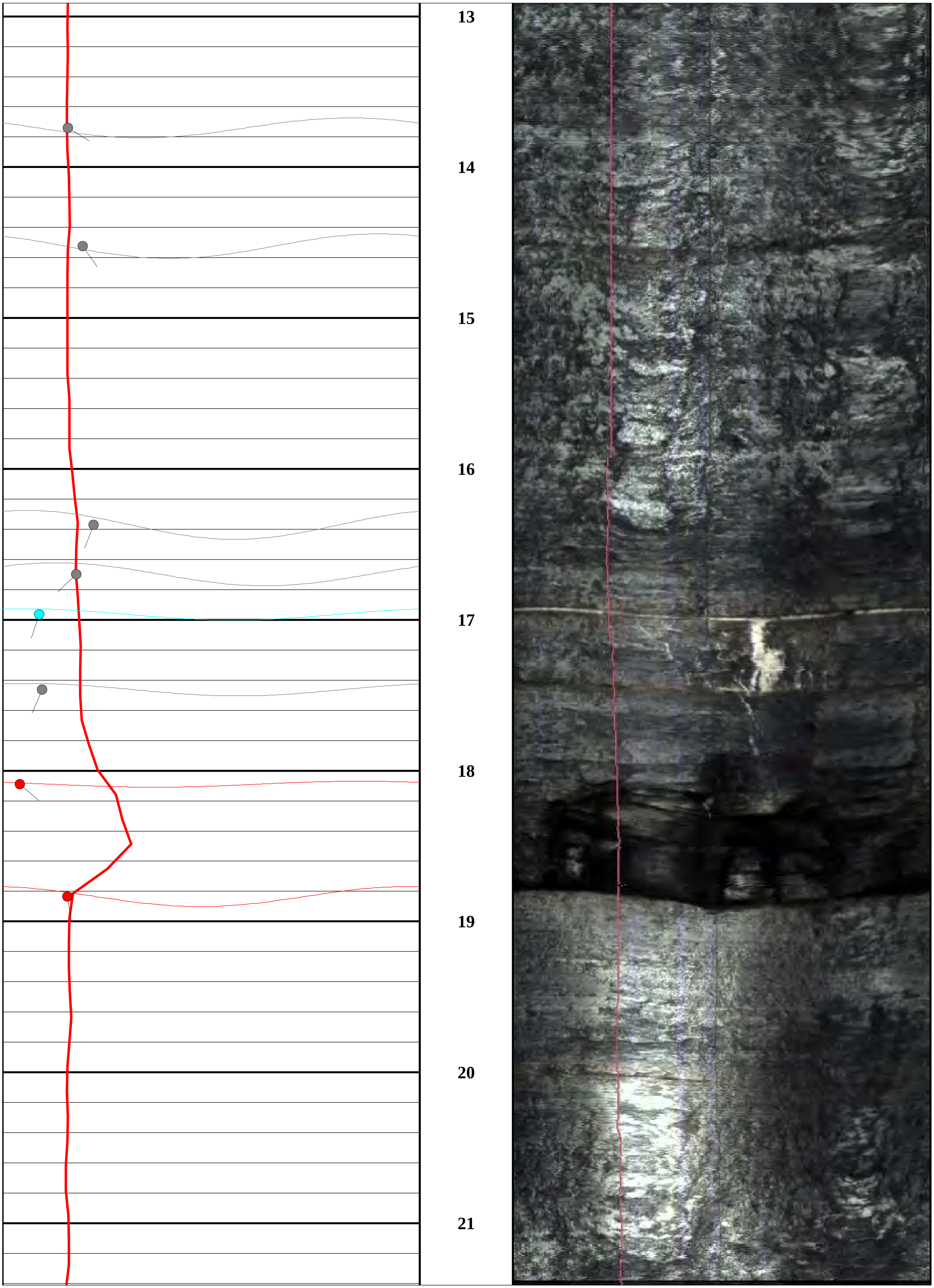


Optical Televiewer Image Plot - True North

COMPANY: Weston Solutions
PROJECT: LO-58
DATE LOGGED: 12 May 2008
WELL: DW-01 (AMAC Well)

COLOG Main Office
810 Quail Street, Suite E, Lakewood, CO 80215
Phone: (303) 279-0171, Fax: (303) 278-0135
www.colog.com

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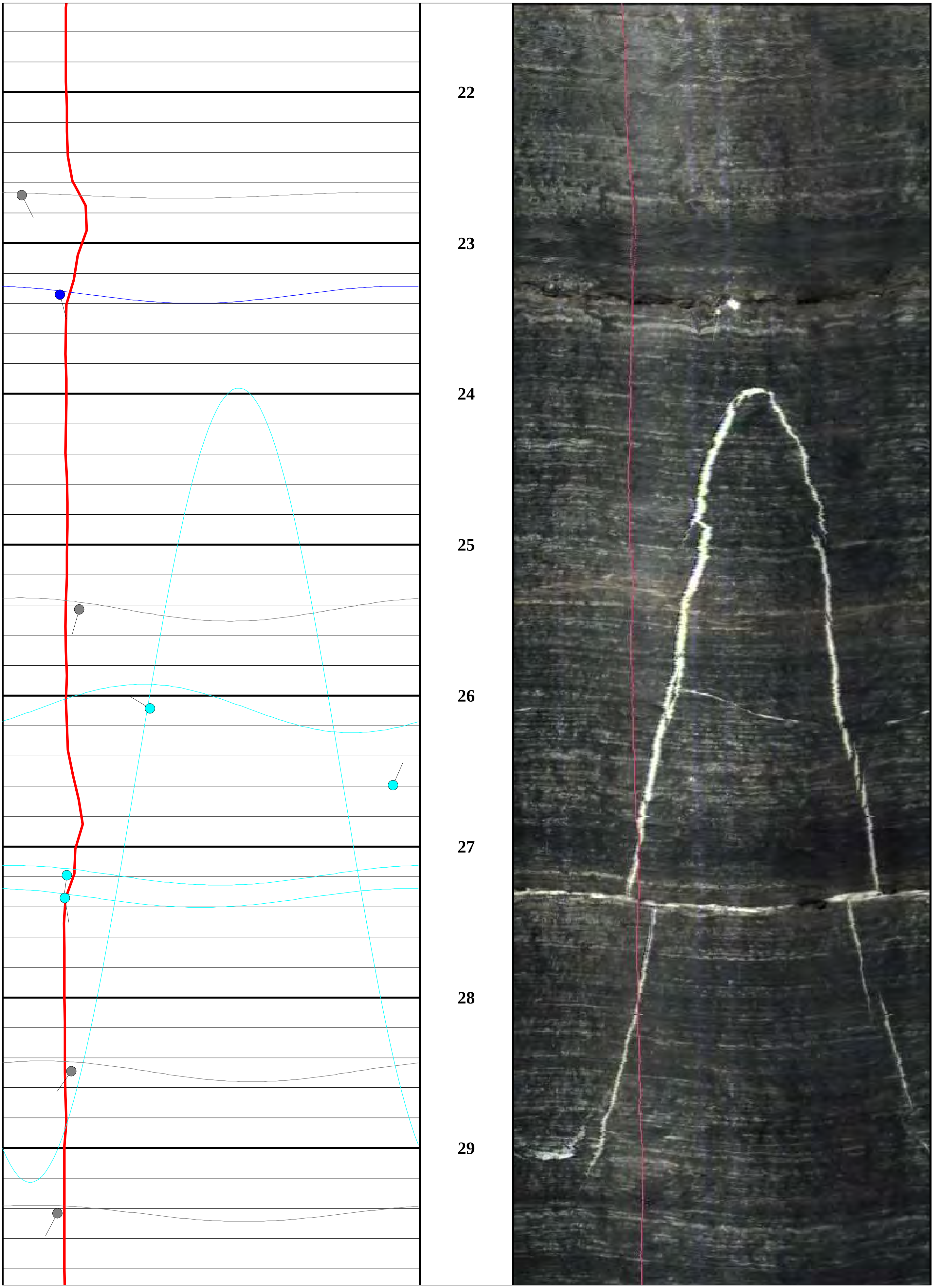
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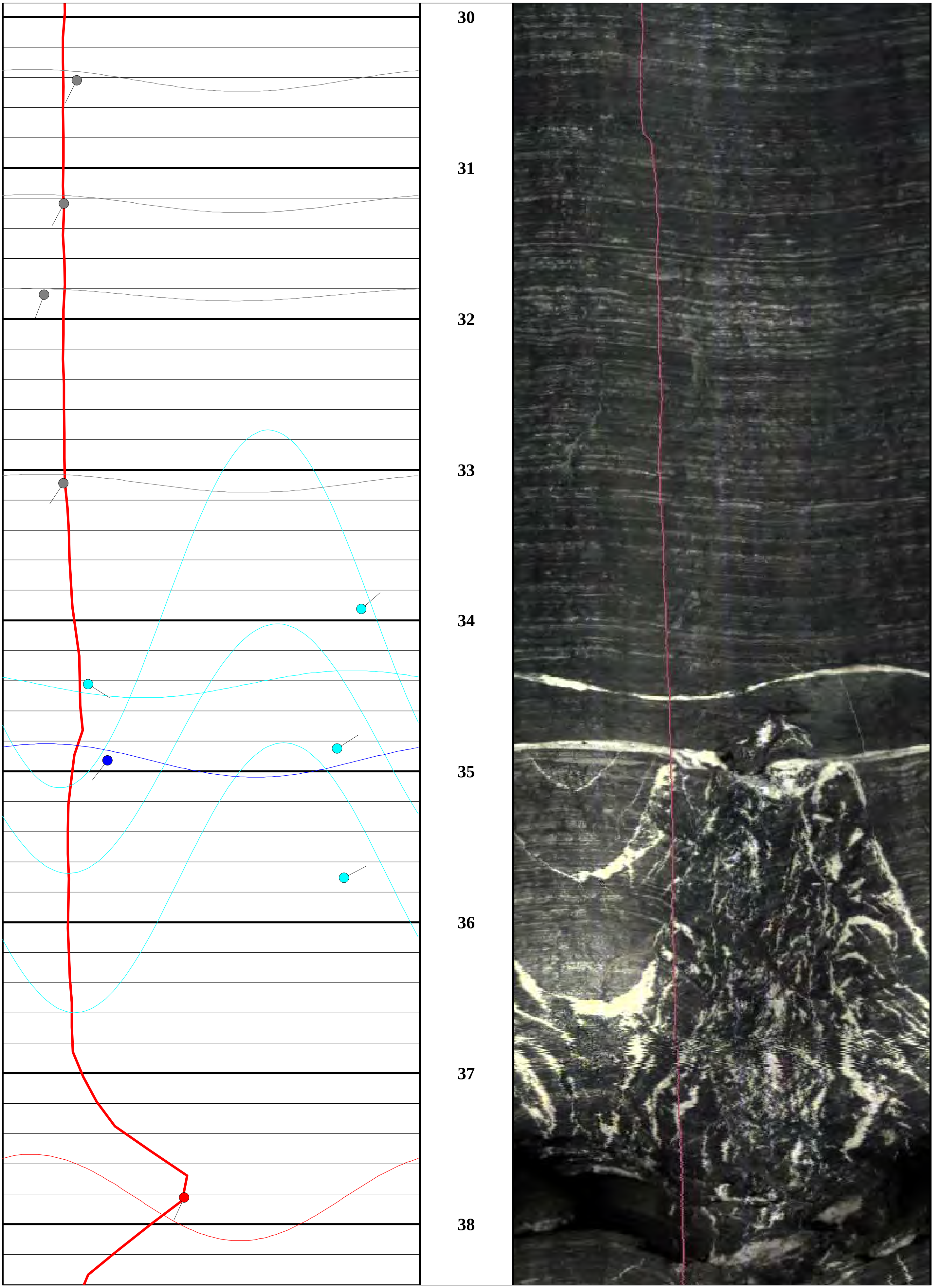
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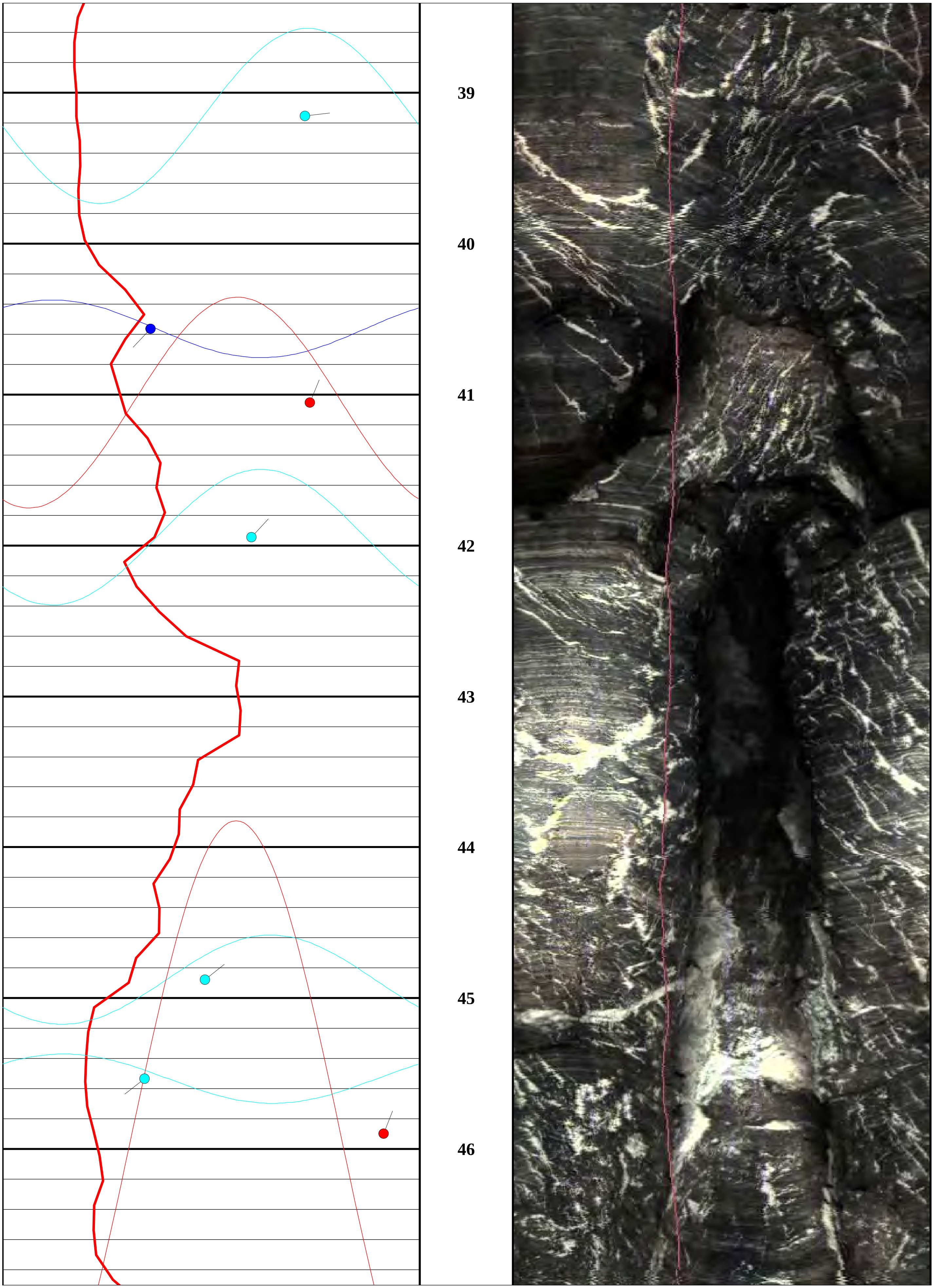
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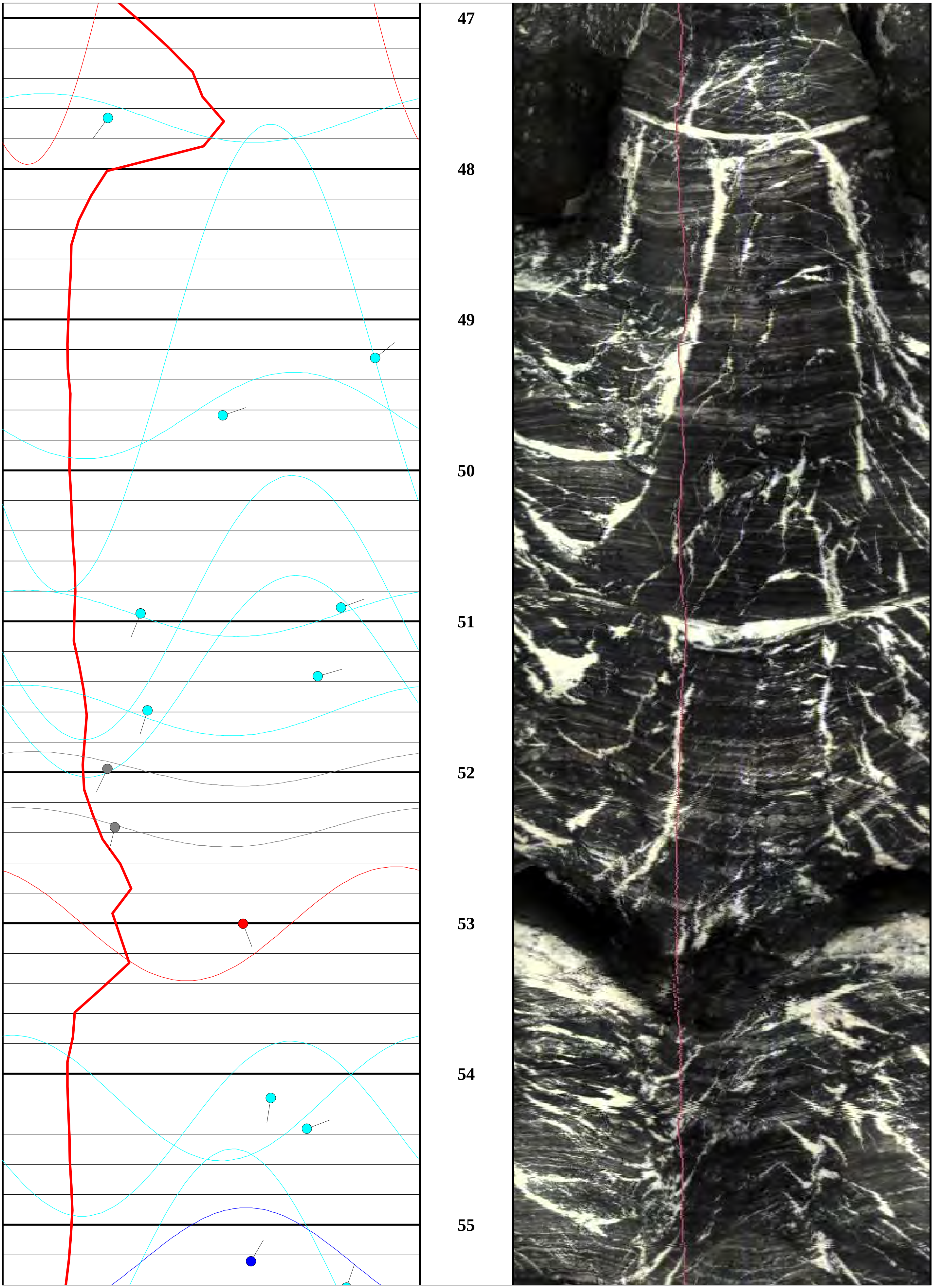
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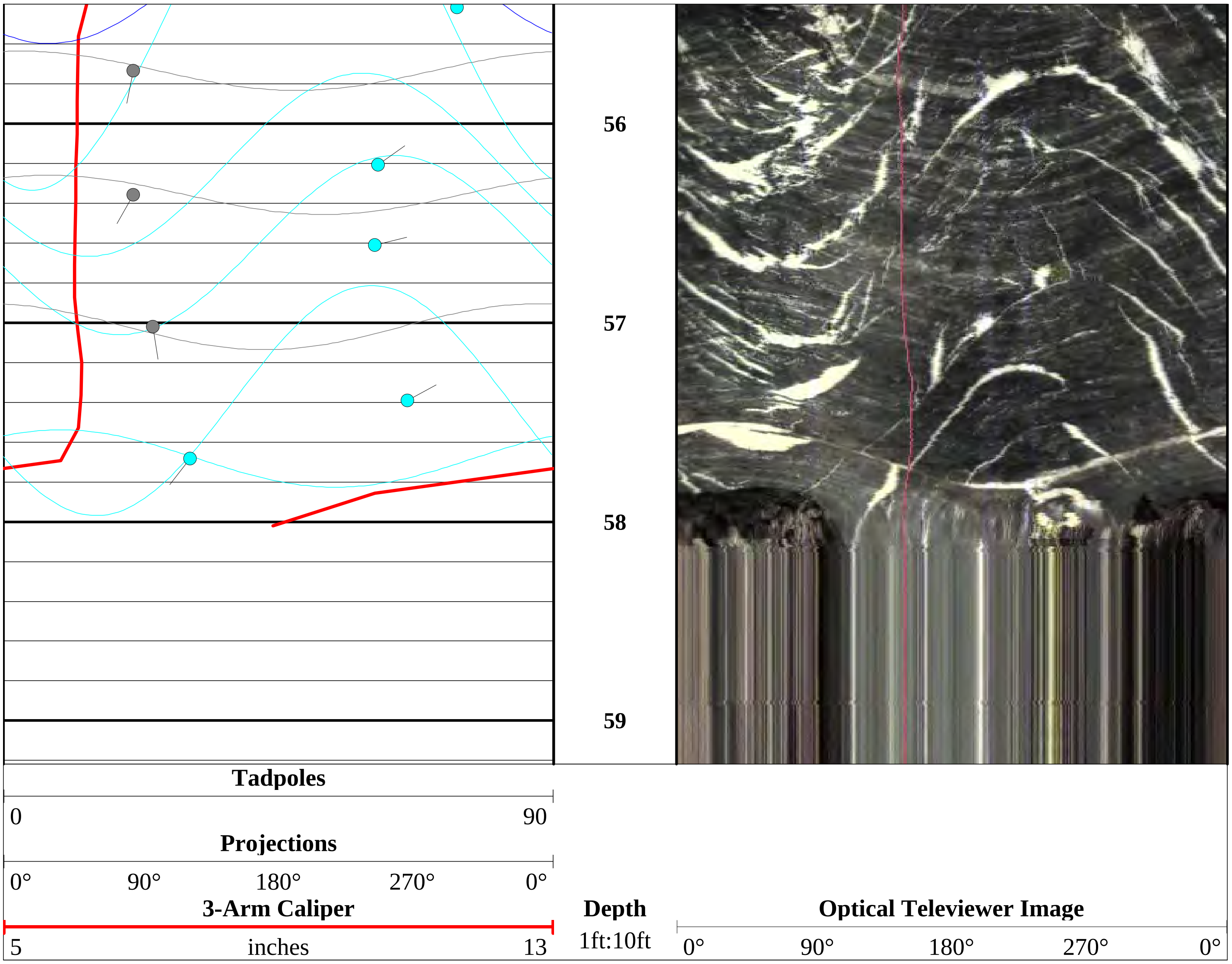
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57
58
59
Tadpoles
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90
Projections
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180°
270°
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3-Arm Caliper
5
inches
13
Depth
1ft:10ft
Optical Televiewer Image
0°
90°
180°
270°
0°

Acoustic Televiewer Image Plot

COMPANY: Weston Solutions
PROJECT: LO-58
DATE LOGGED: 11 May 2008
WELL: DW-1

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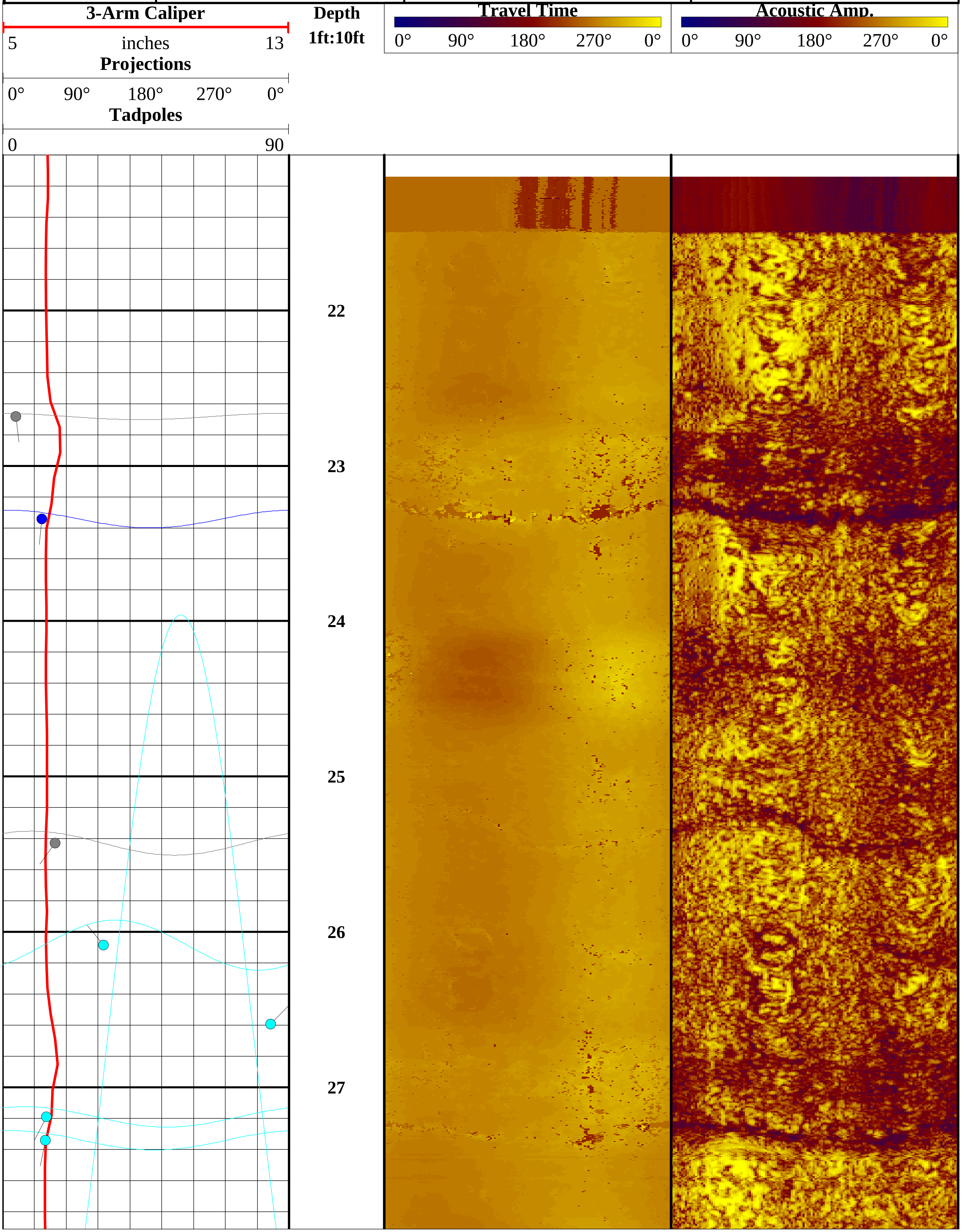

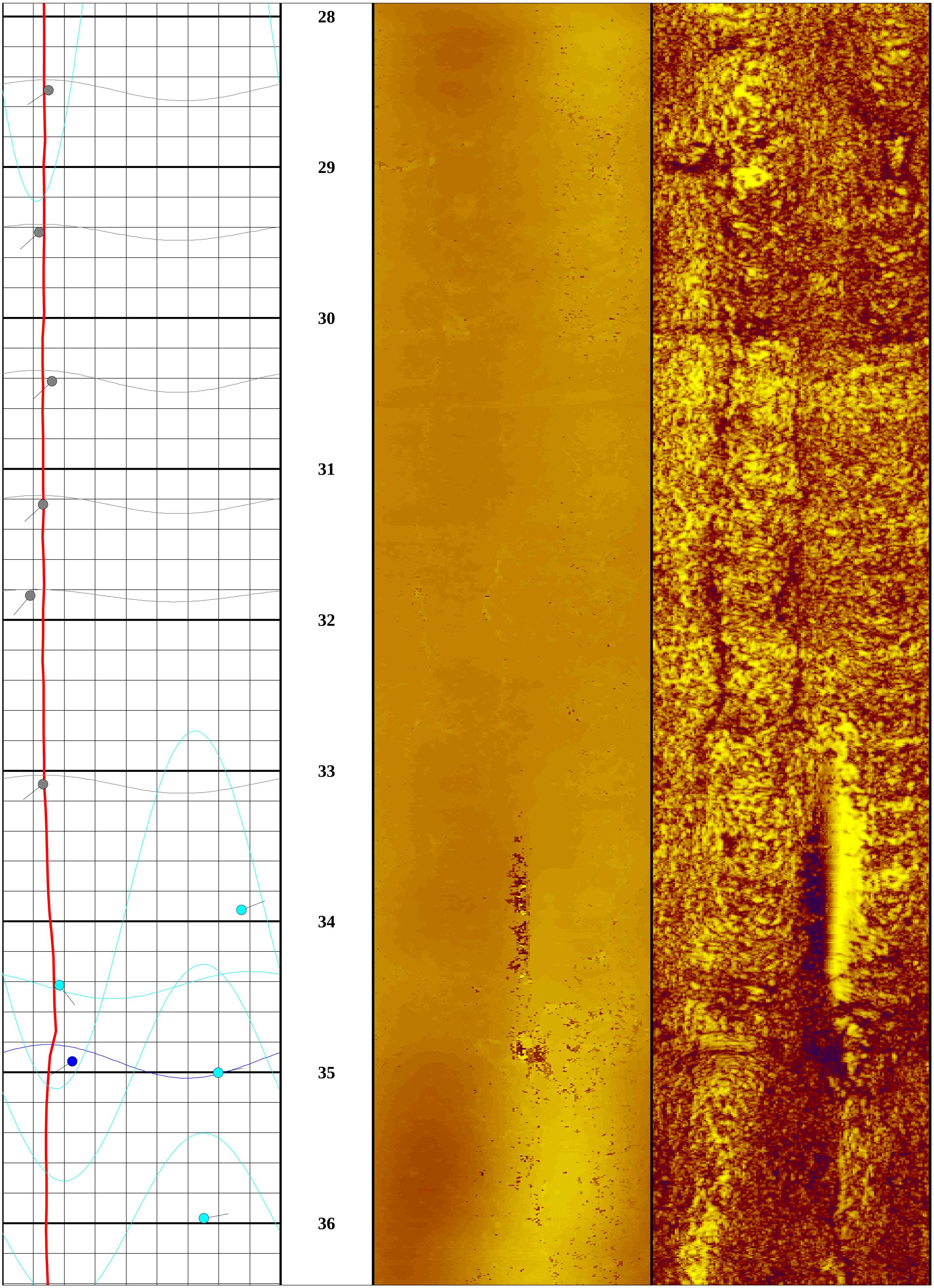
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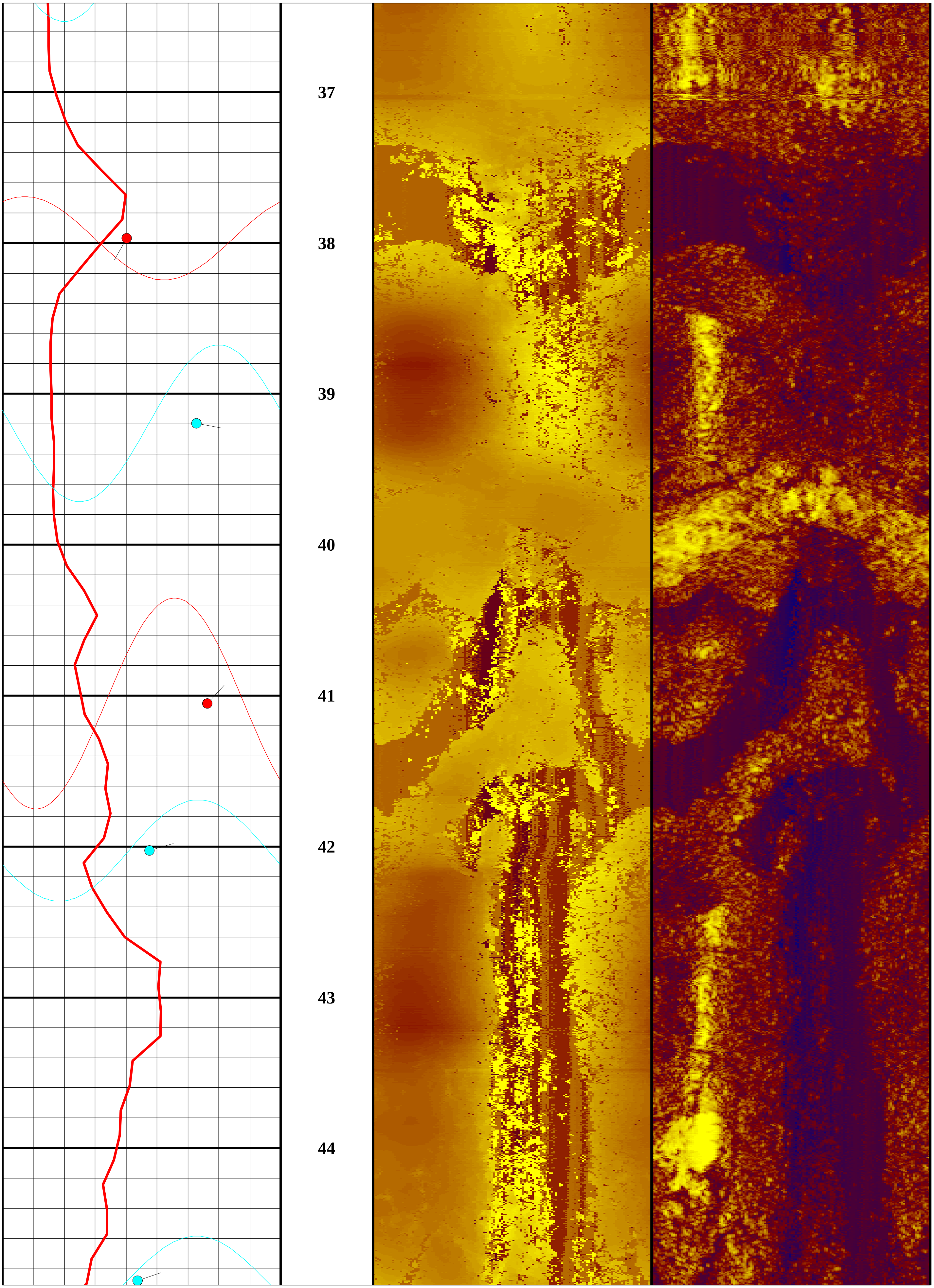
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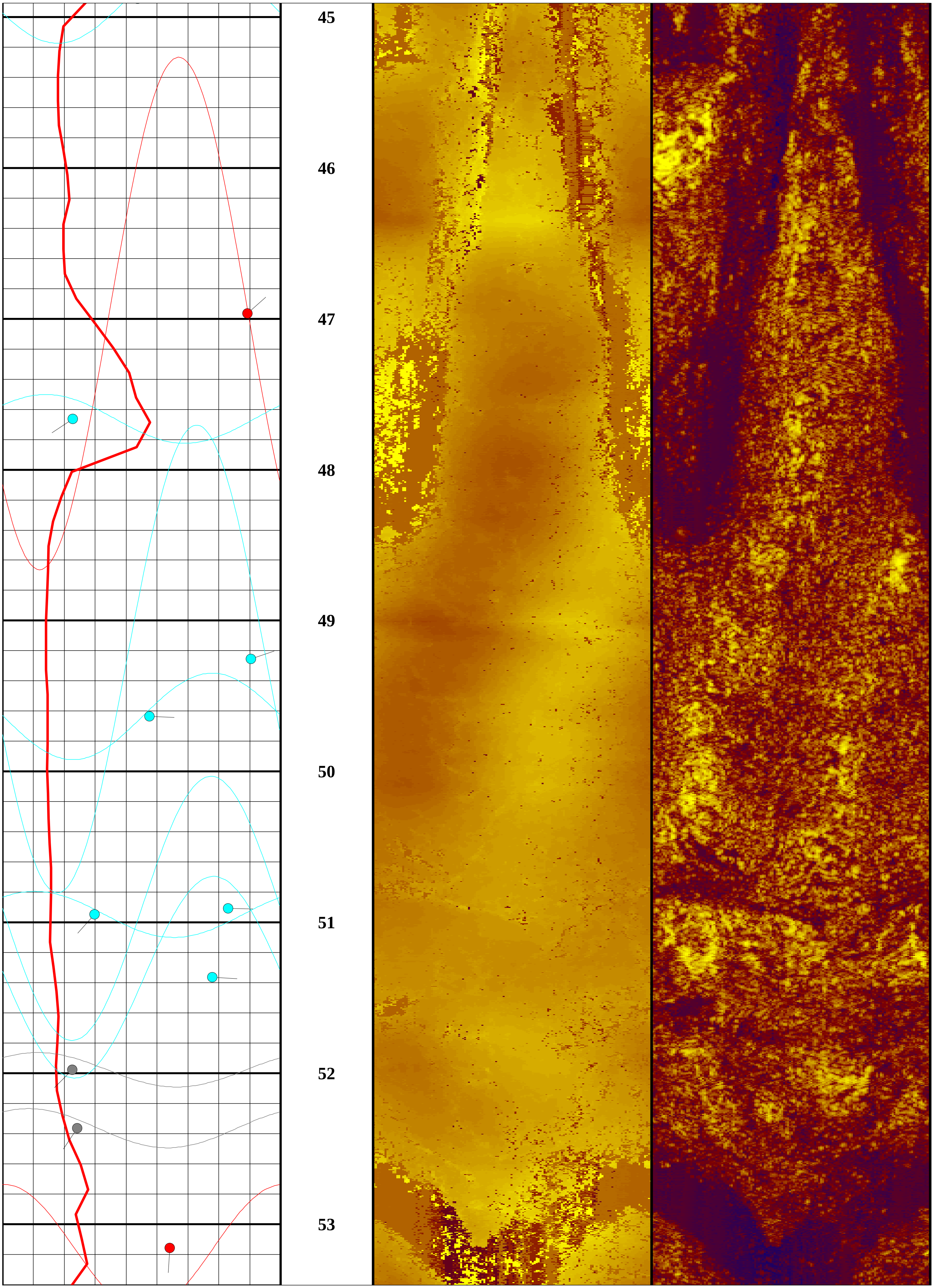
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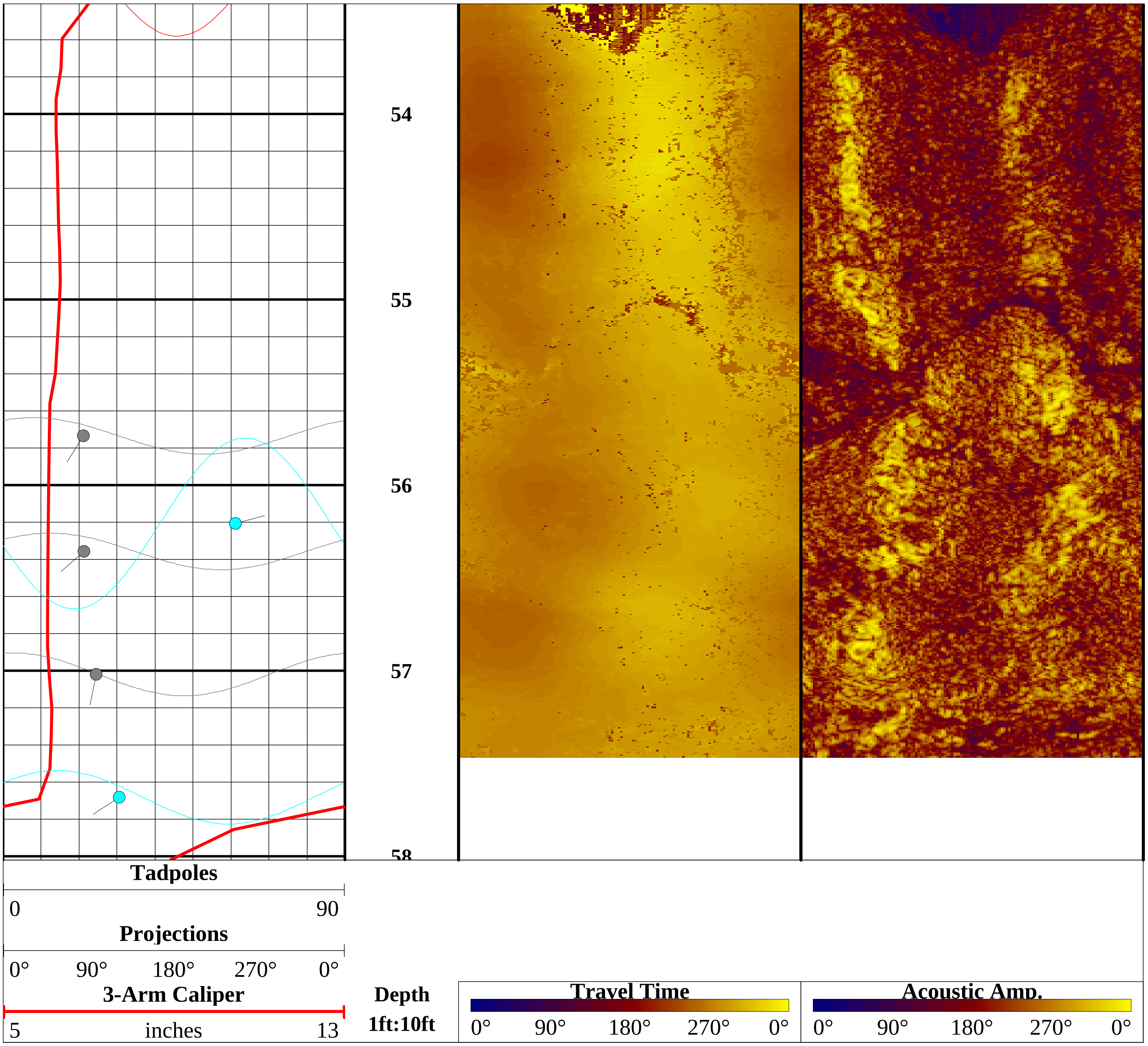
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Tadpoles
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Projections
0°
90°
180°
270°
0°
3-Arm Caliper
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inches
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Depth
1ft:10ft
Travel Time
0°
90°
180°
270°
0°
Acoustic Amp.
0°
90°
180°
270°
0°

Figure DW-1:5. Rose Diagram of Optical Televiewer Features
Weston Solutions
MEFUDS; LO-58
Wellbore: DW-1
May 11, 2008

Dip Direction

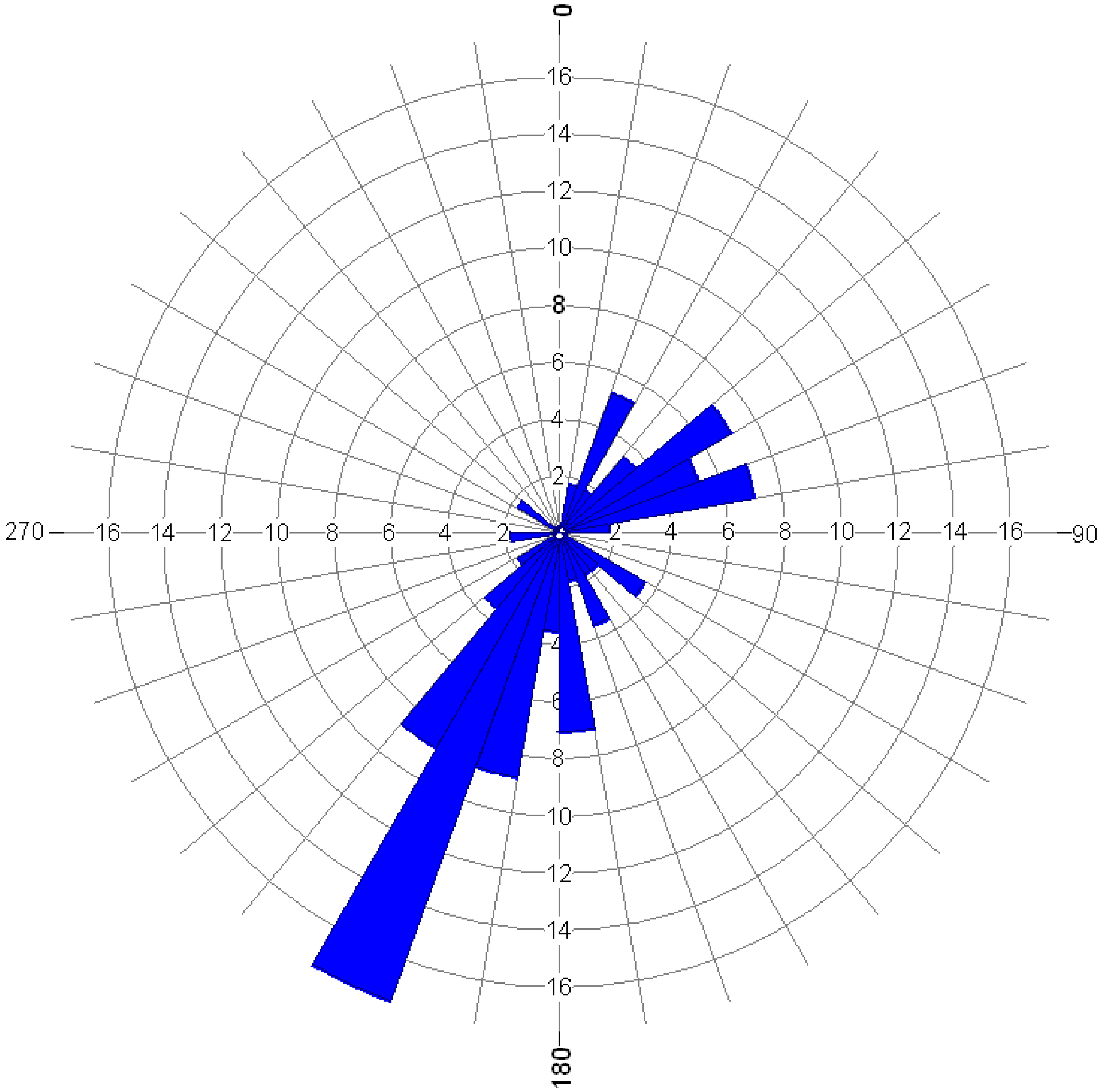


Figure DW-1:6. Rose Diagram of Optical Televiewer Features
Weston Solutions
MEFUDS; LO-58
Wellbore: DW-1
May 11, 2008

Dip Angles

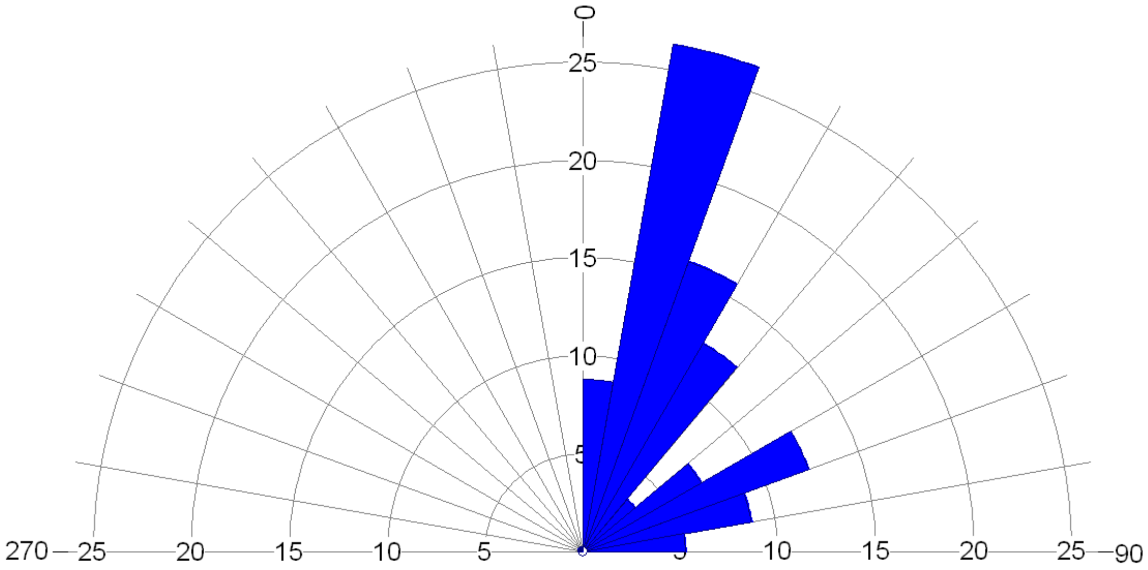


Figure DW-1:7. Stereonet of Optical Televiewer Features
Weston Solutions
MEFUDS; LO-58
Wellbore: DW-1
May 11, 2008

Schmidt Projection with Contours

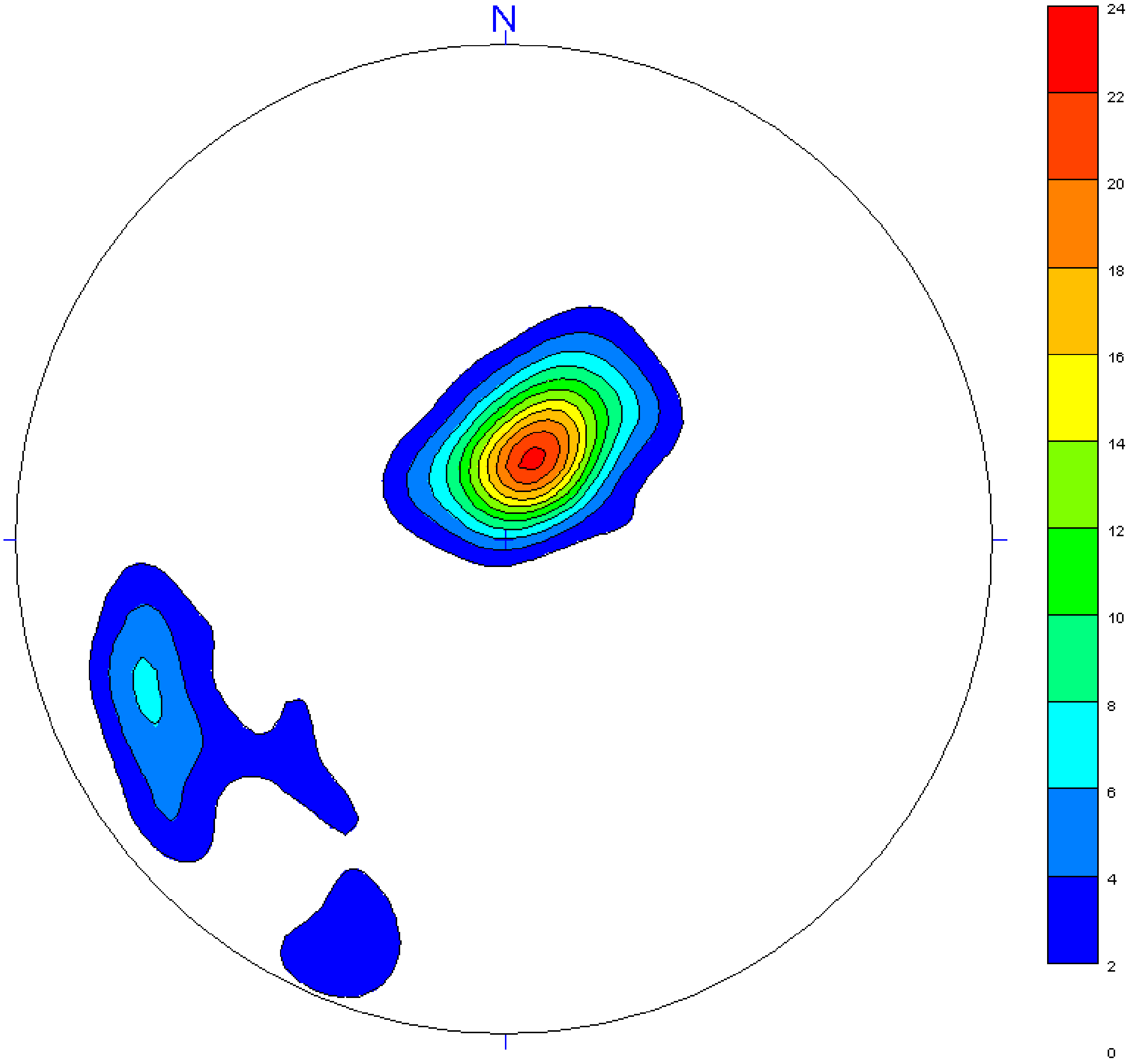


Figure DW-1:8. Stereonet of Optical Televiewer Features
Weston Solutions
MEFUDS; LO-58
Wellbore: DW-1
May 11, 2008

Schmidt Projection with Feature Ranks

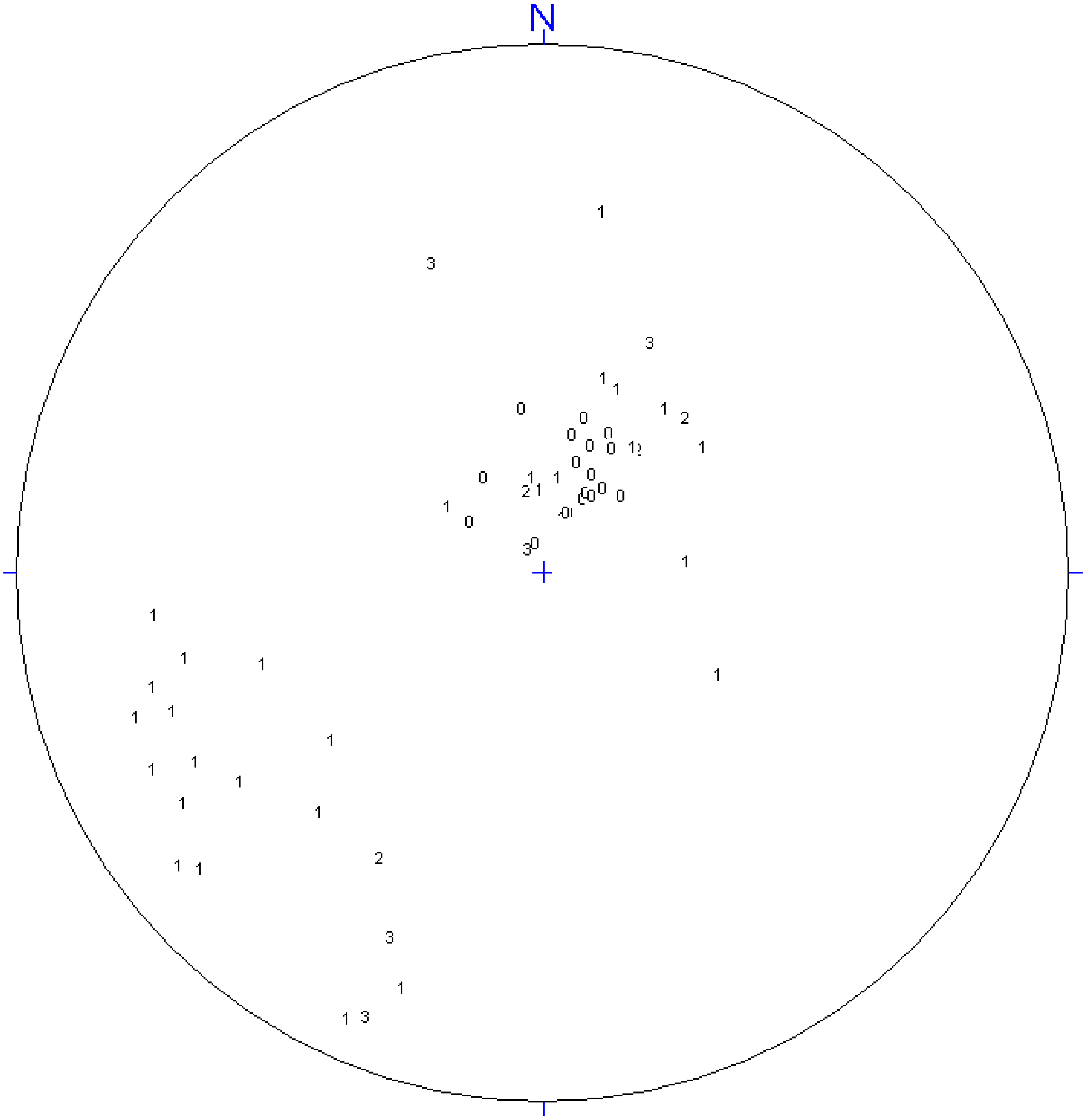


Table DW-1:2. Orientation Summary Table
Image Features
Weston Solutions
LO-58;
Wellbore: DW-1
May 11, 2008

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
1	3.22	10.6	268	22	1
2	3.80	12.5	175	12	1
3	4.19	13.7	120	14	0
4	4.43	14.5	144	17	0
5	4.99	16.4	200	20	0
6	5.09	16.7	227	16	0
7	5.17	17.0	199	8	1
8	5.32	17.5	203	9	0
9	5.51	18.1	130	4	3
10	5.74	18.8	171	14	3
11	6.91	22.7	153	4	0
12	7.11	23.3	165	12	2
13	7.75	25.4	196	17	0
14	7.95	26.1	302	32	1
15	8.11	26.6	24	84	1
16	8.29	27.2	187	14	1
17	8.33	27.3	171	14	1
18	8.68	28.5	215	15	0
19	8.97	29.4	208	12	0
20	9.27	30.4	206	16	0
21	9.52	31.2	208	13	0
22	9.70	31.8	200	9	0
23	10.09	33.1	213	13	0
24	10.34	33.9	49	77	1
25	10.49	34.4	121	18	1
26	10.62	34.9	57	72	1
27	10.65	34.9	218	23	2
28	10.88	35.7	63	74	1
29	11.53	37.8	205	39	3
30	11.93	39.2	83	65	1
31	12.36	40.6	223	32	2
32	12.51	41.1	23	66	3
33	12.79	42.0	43	54	1
34	13.68	44.9	51	44	1
35	13.88	45.5	233	31	1
36	13.99	45.9	22	82	3
37	14.53	47.7	216	23	1
38	15.01	49.3	51	80	1
39	15.13	49.6	71	48	1
40	15.52	50.9	70	73	1
41	15.53	51.0	202	30	1
42	15.65	51.4	73	68	1
43	15.72	51.6	197	31	1
44	15.84	52.0	205	23	0

All directions are with respect to true north (magnatic declination 20W).

Table DW-1:2. Orientation Summary Table
Image Features
Weston Solutions
LO-58;
Wellbore: DW-1
May 11, 2008

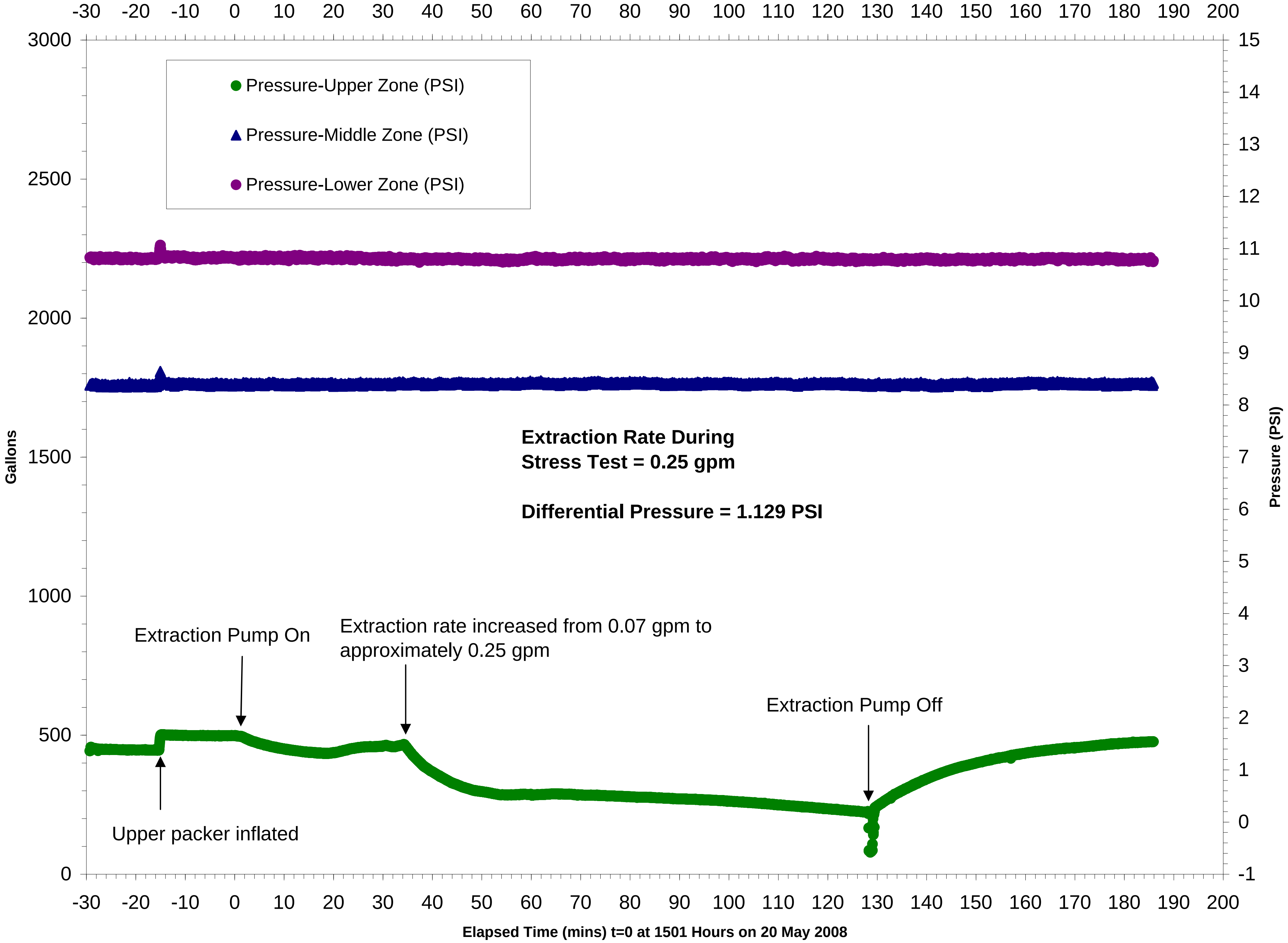
Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
45	15.96	52.4	194	24	0
46	16.16	53.0	159	52	3
47	16.51	54.2	189	58	1
48	16.57	54.4	69	66	1
49	16.84	55.2	30	54	2
50	16.89	55.4	19	74	1
51	16.99	55.7	191	21	0
52	17.13	56.2	55	61	1
53	17.18	56.4	209	21	0
54	17.25	56.6	76	61	1
55	17.38	57.0	171	25	0
56	17.49	57.4	61	66	1
57	17.58	57.7	217	31	1

All directions are with respect to true north (magnatic declination 20W).

Table DW-1:3. Summary of Vertical Seismic Profile Results; Weston Solutions; LO-58, Caribou, ME; Wellbore: DW-1

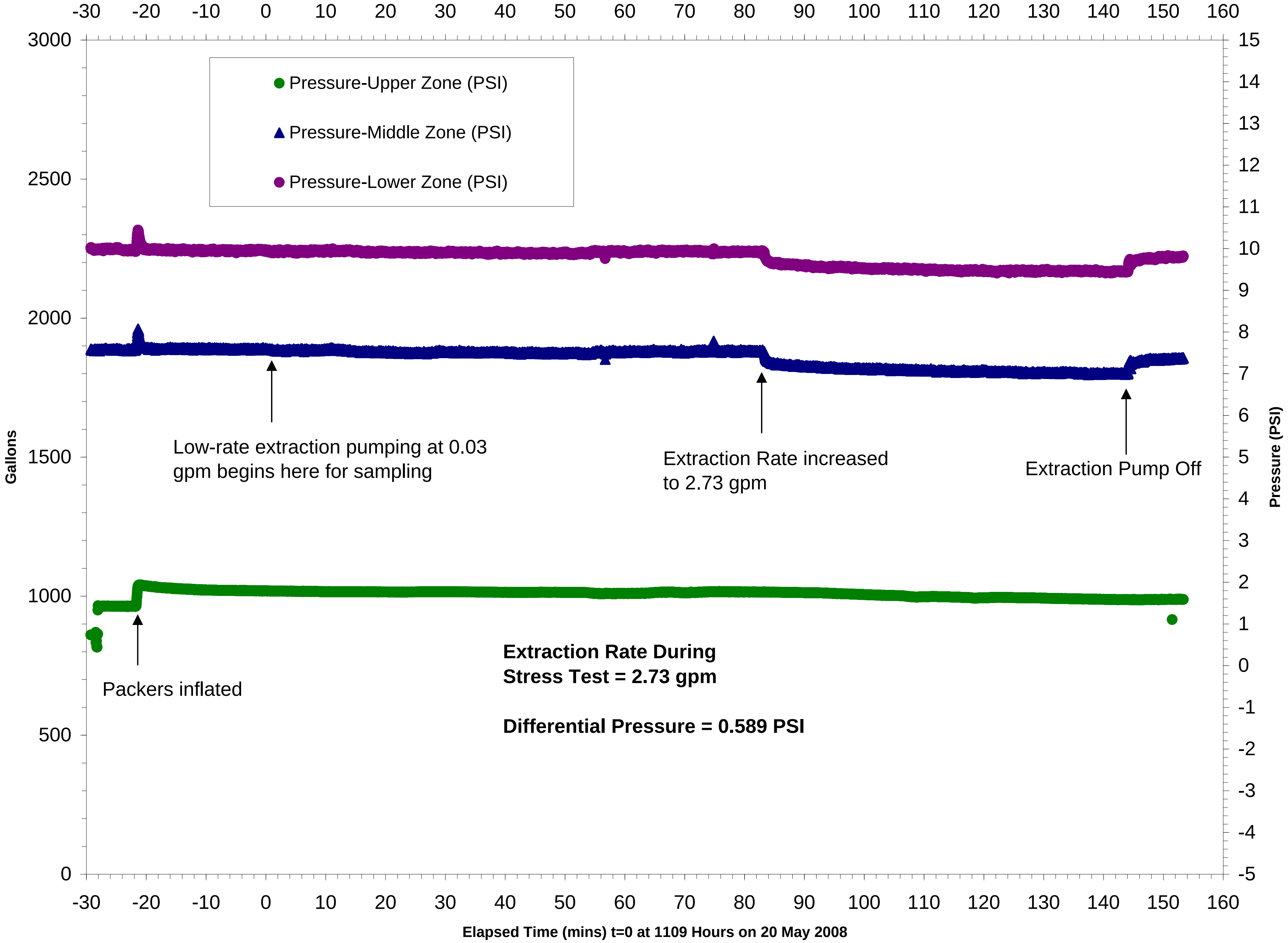
Well	Depth Interval (ftbtoc)	Interval-Specific Velocity (feet/second)	Comments
DW-01	5 - 10	1,670	Consistent with overburden
	10 - 25	7,135	Consistent with highly fractured bedrock
	25 - 55	8,493	Consistent with highly fractured bedrock

FIGURE DW-1:9A. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 33.15 feet and Up; Weston Solutions; LO-58; Aroostook County; Caribou, ME; Wellbore: DW-1



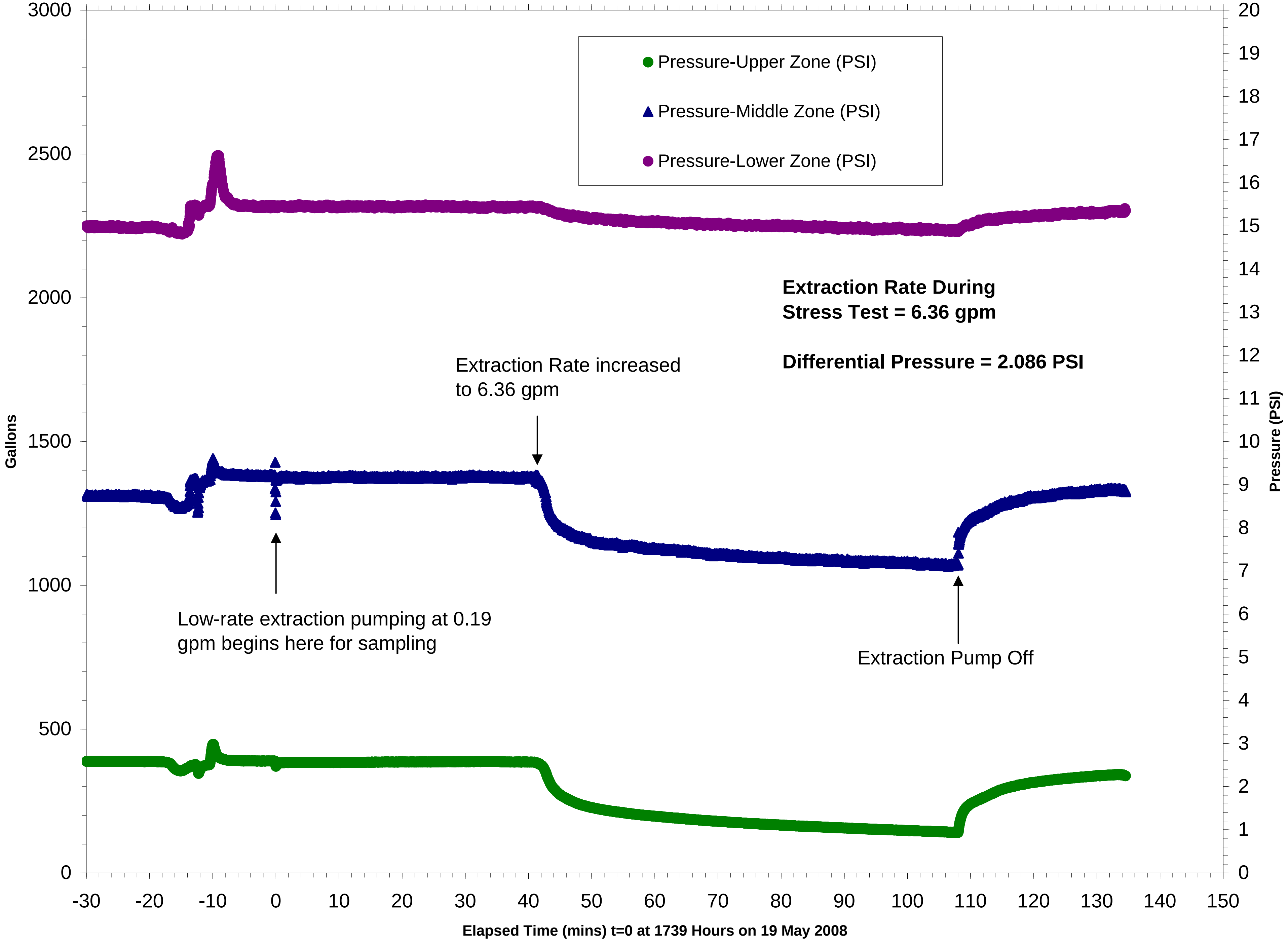
RS-1522-fig3.xls

FIGURE DW-1:9B. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 33.75 to 38.5 Feet; Weston Solutions; LO-58; Aroostook County; Caribou, ME; Wellbore: DW-1



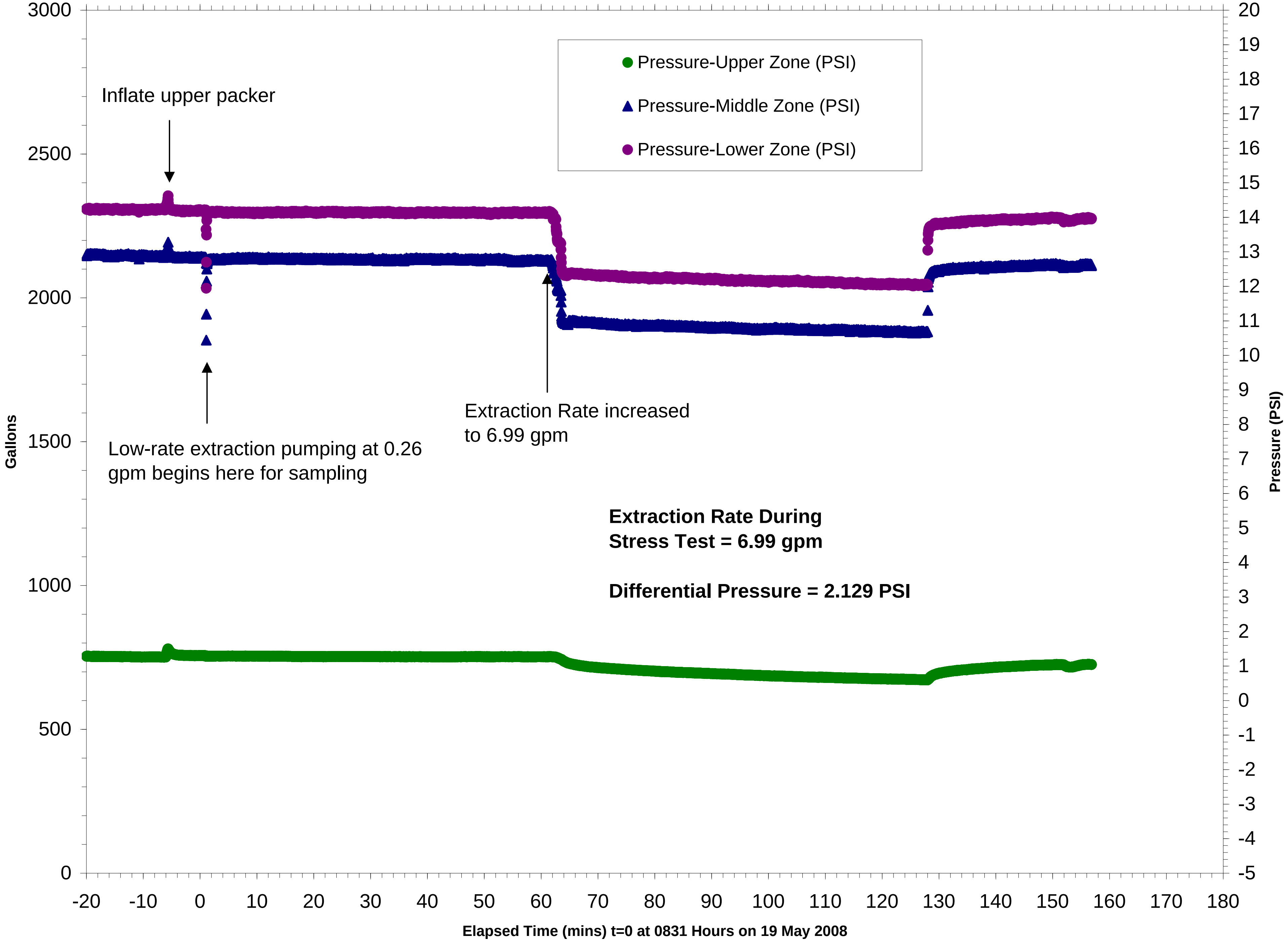
RS-1522-fig3.xls

FIGURE DW-1:9C. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 41.2 to 51.9 Feet; Weston Solutions; LO-58; Aroostook County; Caribou, ME; Wellbore: DW-1



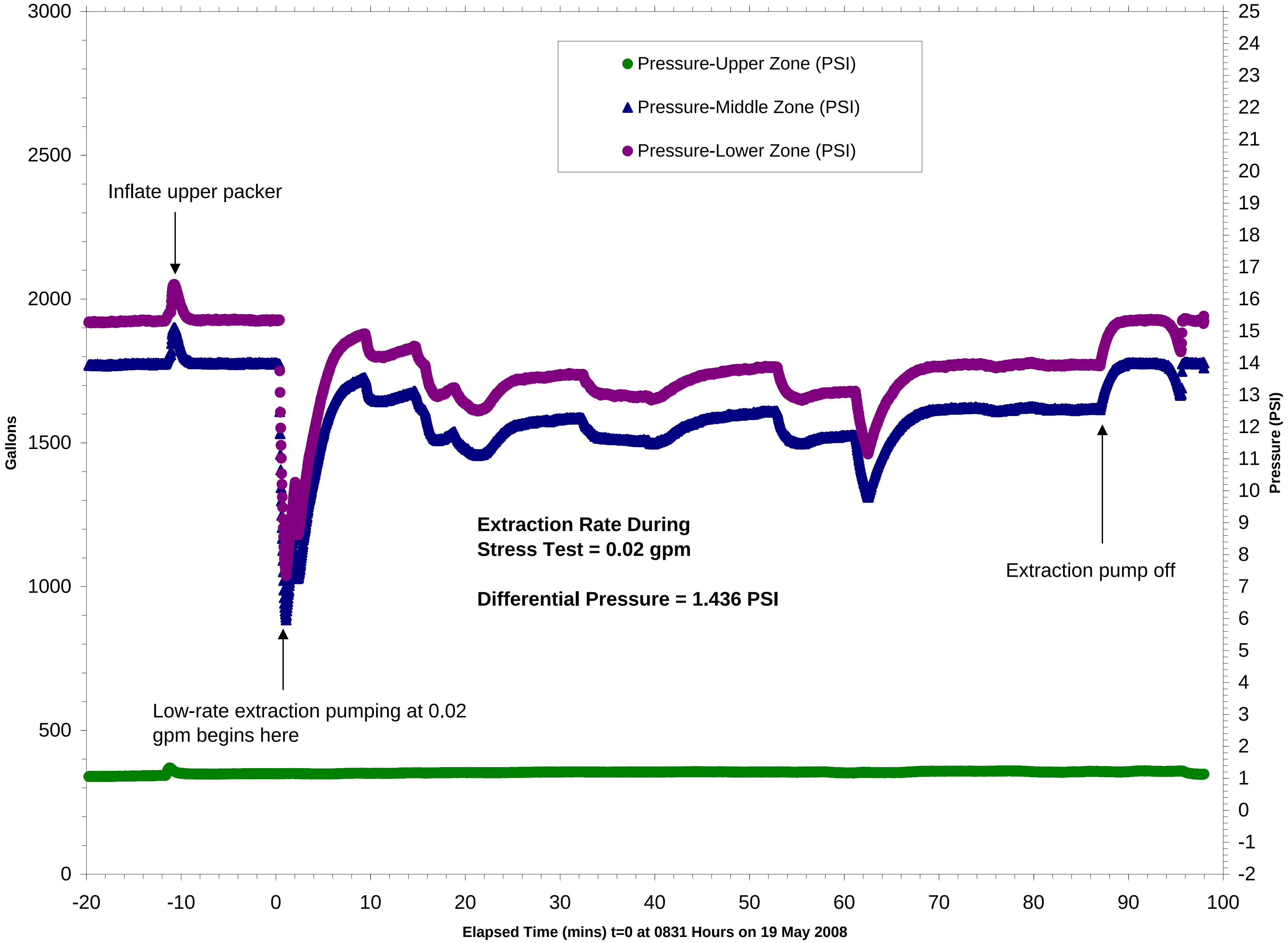
RS-1522-fig3.xls

FIGURE DW-1:9D. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 51.0 to 58.2 Feet (TD); Weston Solutions; LO-58; Aroostook County; Caribou, ME; Wellbore: DW-1



RS-1522-fig3.xls

FIGURE DW-1:9E. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 54.0 to 58.2 Feet (TD); Weston Solutions; LO-58; Aroostook County; Caribou, ME; Wellbore: DW-1



RS-1522-fig3.xls

Table DW-1:4. Summary Of Wireline Straddle Packer Testing With With Hydraulic Conductivity And Transmissivity Estimations; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-1

Well Name	DW-01
Ambient Depth to Water (ftbtoc)	24.86
Diameter of Borehole (ft)	0.52
Effective Radius (ft)	300

Interval No.	Top of Interval (ft)	Bottom of Interval (ft)	Length of Interval (ft)	Differential Pressure (PSI)	Differential Head (feet)[1]	Interval Specific Flow Rate: WSP Stress Test (gpm)	Interval Specific Hydraulic Conductivity[4] (ft/day)	Transmissivity (ft2/day)	Interval Specific Fluid Electrical Conductivity (microS/cm)
1*	24.9	33.2	8.3	1.129	2.607	0.25	1.86E+01	1.55E+02	439
2	33.8	38.5	4.7	0.589	1.360	2.73	6.90E+02	3.24E+03	461
3	41.2	51.9	10.7	2.086	4.818	6.36	1.99E+02	2.13E+03	433
4**	51.0	58.2	7.2	2.129	4.917	6.99	3.19E+02	2.30E+03	459
5**	54.0	58.2	4.2	1.436	3.316	0.02	2.32E+00	9.75E+00	424

* The reported top depth is ambient water level.

** The reported bottom depth of these intervals is the total depth (TD) of the borehole.

[1] Differential Head is the difference between ambient pressure and pumping pressure, converted to feet.

DW-2 Logging Results

1.0 HydroPhysical™ Logging

1.1 Ambient Fluid Electrical Conductivity and Temperature Log: DW-2

At 0933 hours on May 9th, 2008, after a calibration check of the fluid electrical conductivity (FEC) and temperature logging tool, the fluid column was logged for FEC and temperature profiles with COLOG's 1.5-inch diameter HpL™ probe. These logs were performed prior to the installation of any pumping equipment. Please refer to Figure DW-2:1. The ambient FEC profile indicates a relatively featureless profile with the exception of FEC anomalies at 32, 52 and a notable increase at approximately 191.1 feet. The nominal FEC above 191.1 feet is approximately 392 µS/cm while the nominal FEC below 191.1 feet is approximately 596 µS/cm. The ambient temperature profile indicates a gradual increase in temperature with depth with an inflection at approximately 191.1 feet. The anomaly observed in the ambient FEC profile at 191.1 feet indicates a strong correlation with the identified water-bearing feature observed during hydrophysical ambient and stressed testing. In vertically flowing conditions, where water enters the borehole, termed inflow, a change in either FEC is typically seen.

1.2 Ambient Flow Characterization: DW-2

On May 14th, 2008, ambient flow characterization was conducted in the boring DW-2. For ambient flow assessment, the formation water in the borehole was diluted with deionized water (DI) and the boring left in an undisturbed state to allow any natural flow to occur. After DI water emplacement the pump was removed from the boring to insure that water in the pump standpipe would not drain back into the boring. Prior to this period and throughout all HpL™ testing, water levels were monitored and recorded digitally every second. Ambient flow evaluation is reported for the period after the water surface returned to near pre-emplacement levels. A series of FEC and temperature logs were then conducted to identify changes in the fluid column associated with ambient flow. Ambient flow characterization is conducted to evaluate the presence of both vertical and horizontal ambient flow.

On May 14th, 2008, at 1818 hours (t = 0 minutes, elapsed time of test), dilution of the fluid column was complete. Minimal to no DI water was lost to the formation due to the slightly depressed head maintained during emplacement procedures. During the 15.5 hours following the emplacement of DI water, multiple logs were conducted. Of these logs, 8 are presented in Figure DW-2:2. The designation of each logging with the FEC tool is indicated in the figure legend by the time of logging (e.g., FEC1818 versus a subsequent logging at FEC1840), thus the progressing of curves to the right in this figure represents changes in FEC over the total logging period. The last four digits of each log ID correspond to the time at which that particular log was started. Only logs acquired during logging in the downward direction are presented as the design of the FEC/Temperature probe allows the most accurate data to be collected in the downward direction. The logs acquired in the upward logging direction are not representative of downhole conditions and are therefore omitted. These logs illustrate significant change at several intervals throughout the length of the borehole. These dramatic changes in the FEC profiles with respect to time are associated with ambient vertical flow occurring within the borehole.

Formation water migration as a result of downward vertical flow within the fluid column is indicated by the increase in FEC over time in Figure DW-2:2 beginning near the base of casing and at 31 feet. Numeric modeling of the reported field data suggests groundwater enters the wellbore at 19.5 to 19.6, 30.4 to 31.6, 38.2 to 41.8, and 44.9 to 51.4 feet at rates of 0.026, 0.297, 0.016 and 0.074 gpm, respectively. The combined inflow of 0.413 gpm of these four intervals is observed to migrate vertically downward through the borehole based on the migration of the center of mass of the area under the curve. The modeling suggests groundwater exits the borehole at depths of 96.4 to 97.0 and 189.5 to 191.0 feet, at rates of 0.370 and 0.185 gpm, respectively. Evidence for these outflow zones is observed in the logs presented in Figure DW-2:2. Where the velocity of the water slows within the borehole ("downstream" of an outflow zone) a change in slope, or truncation, of the FEC logs is observed. All flow rates are based on the rate of increase of mass at their respective intervals. Of particular note is the FEC anomaly observed at the base of the borehole at 280 feet. This early increase in mass is not the result of ambient flow. Notice the mass at this depth, or area under the curve, does not increase with time, but instead disperses. During removal of the plumbing at the conclusion of the emplacement groundwater was momentarily allowed to enter the borehole at this depth near the bottom of the borehole. Over the course of the Ambient Flow Characterization however, no additional groundwater entered the borehole at this depth. As such, this water-bearing interval is not considered to produce groundwater to the borehole under ambient conditions. Please refer to Table DW-2:1 and Summary:1 for a complete summary of the HydroPhysical™ logging results. Please refer to Appendix B for a discussion of the methodology and code used to calculate these values. The ambient depth to water at the time of testing was 4.31 ftbtoc.

1.3 Flow Characterization During 6 GPM Production Test: DW-2

Pumping of borehole fluids and simultaneous DI injection was conducted at one pumping rate to establish the inflow locations and evaluate the interval specific inflow rates. Pumping at a given rate was conducted until reasonably constant drawdown was observed. When constant drawdown was observed, DI injection was initiated at about 20% of the pumping rate and the extraction pumping rate was increased to maintain a constant total formation production rate (i.e. pumping rate prior to DI injection). These procedures were conducted at a differential rate of 6.35 gpm.

On May 15th, 2008, at 1148 hours (t = 0 minutes elapsed time of testing), development pumping was initiated at approximately 6 gpm. Prior to initiating pumping, the ambient depth to water was recorded at 4.54 ftbgs. All drawdown values are referenced to this ambient water level. Time dependent depth to water, totals and flow rate information were recorded digitally every second and are presented in Figure DW-2:3. Pumping was maintained at a time-averaged rate of 6.25 gpm until 1740 hours (t = 352 minutes, elapsed time of testing). During development pumping numerous FEC logs were acquired to monitor the development process and assist in identifying the depths of flow zones. Of these FEC logs, nine are presented in Figure DW-2:4A. The FEC logs acquired during development pumping illustrate the development process of the borehole fluids, with local inflow locations indicated by the depths at which FEC is observed to increase over time. DI water injection from the bottom of the wellbore was initiated at 1740 hours at a time-averaged rate of 1.3 gpm while the total extraction rate was increased to a time-averaged rate of 7.65 gpm, resulting in a total borehole formation time-averaged production rate of 6.35 gpm. These flow conditions were maintained until 2332 hours (t = 704 minutes) during which time a reasonably constant drawdown of approximately 5.40 feet was observed. The FEC logs acquired during dilution procedures are presented in Figure DW-2:4B, along with the last four development logs for comparison, and illustrate a reasonably stable condition of the fluid column with local inflow locations identified by spikes or incremental step increases in FEC. Eleven inflow zones were identified from these logs ranging in flow from 0.005 to 5.69 gpm with the dominant inflow zone at 30.4 to 31.6 feet, producing 5.69 gpm, or 90 percent of the total formation production rate. Please refer to Table DW-2:1 for a summary of HydroPhysical™ flow results and the depths of individual inflow zones.

1.4 Estimation of Interval Specific Transmissivity: DW-2

An estimation of transmissivity (T) can be made using an equation after Hvorslev (1951) assuming steady-state radial flow in an unconfined aquifer:

$$T = KL = \frac{q_i}{2\pi\Delta h_w}\ln\left(\frac{r_e}{r_w}\right)$$

where K is the hydraulic conductivity, q_i is the interval specific inflow rate calculated using HpL™ results, r_w is the borehole radius (0.26 ft), r_e is the effective pumping radius, Δh_w is the observed maximum drawdown (5.40 feet) and L is the thickness of the zone through which flow occurs. For our calculations, COLOG used r_e of 300 feet (assumed). By applying L and q_i from the HpL™ results under the two pressure conditions, the interval specific transmissivity can be calculated for each identified water producing interval. These calculations were made at each identified interval and are presented in Table DW-2:1. In summary, the interval 30.4 to 31.6 feet exhibited the highest transmissivity of approximately 216 ft^2/day.

2.0 Geophysical Logging

On May 8th through May 17th, 2008, downhole geophysical and hydrogeologic investigations were performed in boring DW-1. The geophysical and hydrogeologic logs performed were: optical televiewer (OBI), acoustic televiewer (ATV), 3-arm caliper, natural gamma, electric resistivity, EM induction conductivity, water chemistry (pH, ORP, DO), full waveform sonic, vertical seismic profile (VSP) and wireline straddle packer (WSP). The data for these logs are presented in the DW-2 Geophysical/HydroPhysical™ Summary Plots and Figures DW-2:5, 6, 7 and 8 and Table DW-2:2 for the statistical analysis of all fractures/features, Table DW-2:3 for a summary of the VSP velocities and Figures DW-2:9A through E and Table DW-2:4 for the WSP pressure data and permeability results at the end of this well report.

2.1 Optical Televiewer (OBI)/Acoustic Televiewer (ABI)

On May 8th, 2008 optical and acoustic televiewer logging was performed in DW-1 to a depth of 280.6 feet. The televiewers identified features at depths correlating well with the HpL™ and caliper data. The features observed by the OBI at water-bearing intervals identified from the HpL™ data had apparent aperture and in some cases evidence of staining. Twenty high-angle fractures or features (dip angles greater than 45 degrees) were identified in DW-2. Four of these high-angle features are qualitatively ranked 2 or greater suggesting the potential for vertical hydraulic communication outside the influence of the borehole. However, none of these high-angle fracture or features are found deeper than 55 feet – all are shallow features. Data acquired during WSP testing confirms the presence of vertical hydraulic communication between several water-bearing zones in the immediate vicinity of the borehole.

2.2 Three-Arm Caliper

On May 9th, 2008 three-arm caliper logging was performed in DW-2 to a depth of 284.2 feet. The caliper log indicates a relatively rugose borehole with eight notable inflections observed at approximately 31.3, 45.4, 96.5, 158.6, 170.7, 179.7, 190.9 and 244.0 feet. All but two of the inflections, or borehole enlargements, at 158.6 and 170.7 feet, observed in the caliper log correlate well with water-bearing zones and fractures identified by the hydrophysical and optical televiewer data. The caliper log registers an approximately nominal 6.4-inch diameter borehole below casing at 14.6 feet.

2.3 Natural Gamma

On May 10th, 2008 natural gamma logging was performed, in conjunction with the electric resistivity logging, in DW-1. The natural gamma measurement reached to a depth of 279.1 feet. The natural gamma is relatively featureless with minor fluctuations in gamma counts, expected in limestone. The natural gamma log registers an approximately nominal 27 to 62 counts per second.

2.4 Electric Resistivities (8, 16, 32, 64-inch Normal Resistivities, SP, SPR)

On May 11th, 2008 electric resistivity logging was performed, in conjunction with the natural gamma log, in DW-1 to a depth of 280.2 feet. The electric measurements consist of 8, 16, 32 and 64-inch "normal" resistivities, spontaneous potential (SP) and single-point resistance (SPR). The normal resistivities registered approximately 923 Ohm-meters (8-inch resistivity) to 2,480 Ohm-meters (64-inch resistivity). A notable anomaly in the electric resistivity is observed at approximately 31.6 to 161.3 feet where the electric resistivities uniformly register higher resistivities, indicative of pertinent limestone. Low resistivity anomalies are observed at 30 to 33 and 161 to 191 feet, indicative of a fractured environment under these conditions. The SP is relatively featureless registering a gradual increase in potential with depth, registering 44 to 358 milivolts below water level. The SPR measurement correlates well with the normal resistivities and also registers low-resistivity anomalies at 30 to 33 and 161 to 191 feet. The SPR registers 427 to 2,119 Ohms.

2.5 EM Induction Conductivity

On May 10th, 2008 EM induction conductivity logging was performed in DW-2 to a depth of 279.5 feet. The induction conductivity log is featureless with the exception of a minor anomaly at 255 feet. The induction conductivity registers a nominal 196 mS/meter above 255 feet and 149 mS/meter below 255 feet.

2.6 Water Chemistry (pH, ORP, DO)

On May 9th, 2008, pH, oxidation-reduction potential (ORP) and dissolved oxygen (DO) measurements were acquired under ambient conditions in DW-2 to a depth of 280.4 feet. The pH measurement is relatively featureless with the exception of an anomaly at 191 feet where the pH registers approximately 7.53 above 191 feet. Below 191 feet the pH log registers an approximately uniform 7.69. The ORP measurement indicates a gradual increase in oxidation potential with depth until 191 feet. The ORP measurement indicates approximately 135 mV near water surface and 247 mV at 191 feet. Below 191 feet the ORP log gradually decreases to TD, registering 185 mV at TD. The dissolved oxygen measurement registers a nominal 0.35 percent from water surface to 191 feet. Below 191 feet the DO measurement registers zero. It should be noted that no ambient flow is identified below 191 feet – a stagnant zone.

2.7 Full Waveform Sonic

On May 9th, 2008 full waveform sonic logging was performed in DW-2 to a depth of 277.2 feet. The sonic registered slower velocity anomalies at 29, 45, 67, 188 and 274 feet, correlating well with identified fractures and water-bearing zones observed in the optical televiewer, caliper and hydrophysical data. The sonic registered P-wave velocities ranged from 12,060 to 24,900 feet/second, correlating well with the velocities identified using vertical seismic profiling (VSP).

2.8 Vertical Seismic Profile (VSP)

On May 7th, 2008 a vertical seismic profile (VSP) was conducted in DW-2 to a depth of 200 feet. The VSP investigation in DW-2 identified three specific intervals of specific velocity at 25 to 30, 35 to 115 and 115 to 185 feet, registering 1,789, 10,255 and 17,274 feet/second (fps), respectively. However, due to the cement vault and backfill encasing the well casing and the presence of asphalt at the surface, the velocity reported here at 25 to 30 feet is suspect. Below 185 feet the P-wave energy was too little to report usable data.

2.9 Wireline Straddle Packer (WSP)

On May 16th and 17th, 2008 wireline straddle packer (WSP) testing was conducted in DW-2 at six intervals:

16.0 to 20.0 feet
28.5 to 32.5 feet
37.0 to 41.7 feet
94.5 to 98.5 feet
187.9 to 192.2 feet
265.4 to 284.0 feet (bottom of the borehole)

WSP testing was conducted to acquire a fracture-specific groundwater sample from each major water-bearing fracture identified during hydrophysical production testing. In addition to collecting a representative groundwater sample from each interval, development pumping was conducted at each interval and pressures above, below and in the interval of interest recorded to estimate fracture-specific permeability for each interval tested. Please see Tables WSP Summary and DW-1:4 for a complete summary of wireline straddle packer testing results.

Interval 16.0 to 20.0 feet – The WSP was utilized in its standard configuration, both packers inflated, and all pressure transducers measuring pressure in their respective zones of interest. During low-rate pumping for sampling the pump cavitated several times indicating the lack of significant yield from this interval. It is apparent from the WSP pumping that this interval cannot yield more than approximately 0.01 gpm. During pumping on this interval, no correlating response from either the upper or lower pressure transducer was observed, suggesting no vertical hydraulic communication exits outside the influence of the borehole between this interval and fracture/features in close proximity above and below this interval. The pumping rate of approximately 0.01 gpm during sampling was also used as the “stress test” pumping rate. Please see Figure DW-2:9A and Table DW-1:4 for a complete summary of the data acquired and results for this interval.

Interval 28.5 to 32.5 feet – The WSP was utilized in its standard configuration, both packers inflated, and all pressure transducers measuring pressure in their respective zones of interest. The data clearly indicates vertical hydraulic communication outside the influence of the borehole between water-bearing fractures in the interval of interest at 28.5 to 32.5 feet and the upper and lower intervals surrounding the interval of interest based on the correlating responses observed in the upper and lower pressure transducers. This is not unexpected based on the numerous fractures of approximately 30 to 50 degrees dip in and in the immediate vicinity of the interval of interest. Please see Figure DW-2:9B and Table DW-2:4 for a complete summary of the data acquired and results for this interval.

Interval 37.0 to 41.7 feet – The WSP was utilized in its standard configuration, both packers inflated, and all pressure transducers measuring pressure in their respective zones of interest. The data clearly indicates vertical hydraulic communication outside the influence of the borehole between water-bearing fractures in the interval of interest at 37.0 to 41.7 feet and the upper and lower intervals surrounding the interval of interest based on the correlating responses observed in the upper and lower pressure transducers. This is not unexpected based on the numerous fractures of approximately 30 to 50 degrees dip in and in the immediate vicinity of the interval of interest. Please see Figure DW-2:9C and Table DW-2:4 for a complete summary of the data acquired and results for this interval.

Interval 94.5 to 98.5 – The WSP was utilized in its standard configuration, both packers inflated, and all pressure transducers measuring pressure in their respective zones of interest. The data clearly indicates vertical hydraulic communication outside the influence of the borehole between water-bearing fractures in the interval of interest at 94.5 to 98.5 feet and the lower interval below this interval of interest based on the correlating response observed in the lower pressure transducers. No response is observed in the upper interval pressure transducer. This is not unexpected based on the identification of a downward pressure gradient and the fact this interval was identified as a thief zone (water exited the borehole at approximately 97 feet) during ambient testing. The presence of a pressure differential between this interval and the upper interval suggests little to no significant vertical hydraulic communication outside the influence of the borehole. The data does indicate a vertical hydraulic connection between the interval of interest and the lower zone however. During ambient testing the lower flow interval of 189.5 to 191.0 feet was also identified as an outflow zone (less significant pressure differential between 189.5 to 191.0 and this flow interval of 96.4 to 97.0 feet) and is likely the flow interval hydraulically interconnected with this WSP sample interval. Please see Figure DW-2:9D and Table DW-2:4 for a complete summary of the data acquired and results for this interval.

Interval 187.9 to 192.2 feet – The WSP was utilized in its standard configuration, both packers inflated, and all pressure transducers measuring pressure in their respective zones of interest. The data clearly indicates vertical hydraulic communication outside the influence of the borehole between water-bearing fractures in the interval of interest at 187.9 to 192.2 feet and the lower interval below this interval of interest based on the correlating response observed in the lower pressure transducers. No response is observed in the upper interval pressure transducer. This is not unexpected based on the identification of a downward pressure gradient and the fact this interval was identified as a thief zone (water was observed to exit the borehole at approximately 189.5 to 191.0 feet) during ambient testing. The presence of a pressure differential between this interval and the upper interval suggests little to no significant vertical hydraulic communication outside the influence of the borehole. The data does indicate a vertical hydraulic connection between the interval of interest and the lower zone however. Please see Figure DW-2:9E and Table DW-2:4 for a complete summary of the data acquired and results for this interval.

3.0 Data Summary

Processing and interpretation of the geophysical and HydroPhysical™ logs in DW-2 suggest the presence of eleven producing intervals for this borehole. Numerical modeling of the reported HydroPhysical™ field data was performed using computer programs FLOWCALC and/or BOREII. These analyses were performed to estimate the rate of inflow for each identified hydraulically conductive borehole interval during DI injection procedures. The results of these analyses are presented in Table DW-2:1. In summary, the interval at 30.4 to 31.6 feet dominated flow during pumping, producing 5.69 gpm or 90 percent of the total flow. Six of the eleven identified producing intervals correlate well with water-bearing zones identified during ambient testing. The remaining five intervals were not actively flowing water during ambient testing.

During ambient testing, boring DW-2 exhibited a straight-forward downward flow regime. Four water-bearing intervals were identified to contribute groundwater to the wellbore during ambient testing, the dominant interval being 30.4 to 31.6 feet, contributing 0.297 gpm, or 72 percent of the aggregate 0.413 ambient inflow. Two water-bearing intervals are identified under ambient conditions to thieve water from the wellbore at 96.4 to 97.0 and 189.5 to 191.0 feet, taking 0.370 and 0.185 gpm, respectively, from the wellbore.

The optical and acoustic televiewers identified features at depths correlating well with the HpL™ and caliper data. The features observed by the OBI at water-bearing intervals identified from the HpL™ data had apparent aperture and in some cases evidence of staining. Twenty high-angle fractures or features (dip angles greater than 45 degrees) were identified in DW-2. Four of these high-angle features are qualitatively ranked 2 or greater suggesting the potential for vertical hydraulic communication outside the influence of the borehole. However, none of these high-angle fracture or features are found deeper than 55 feet – all are shallow features. Data acquired during WSP testing confirms the presence of vertical hydraulic communication between several water-bearing zones in the immediate vicinity of the borehole.

The eleven interval-specific transmissivity estimates calculated using the hydrophysical data in DW-2 ranged from 0.20 to 216 ft^2/day, with the interval at 30.4 to 31.6 feet registering the highest transmissivity. The ranges of transmissivities suggest that flow originates from secondary porosity consisting of large discrete fractures at the major inflow zones and minor fractures or features with less inter-connectiveness at the minor inflow zones.

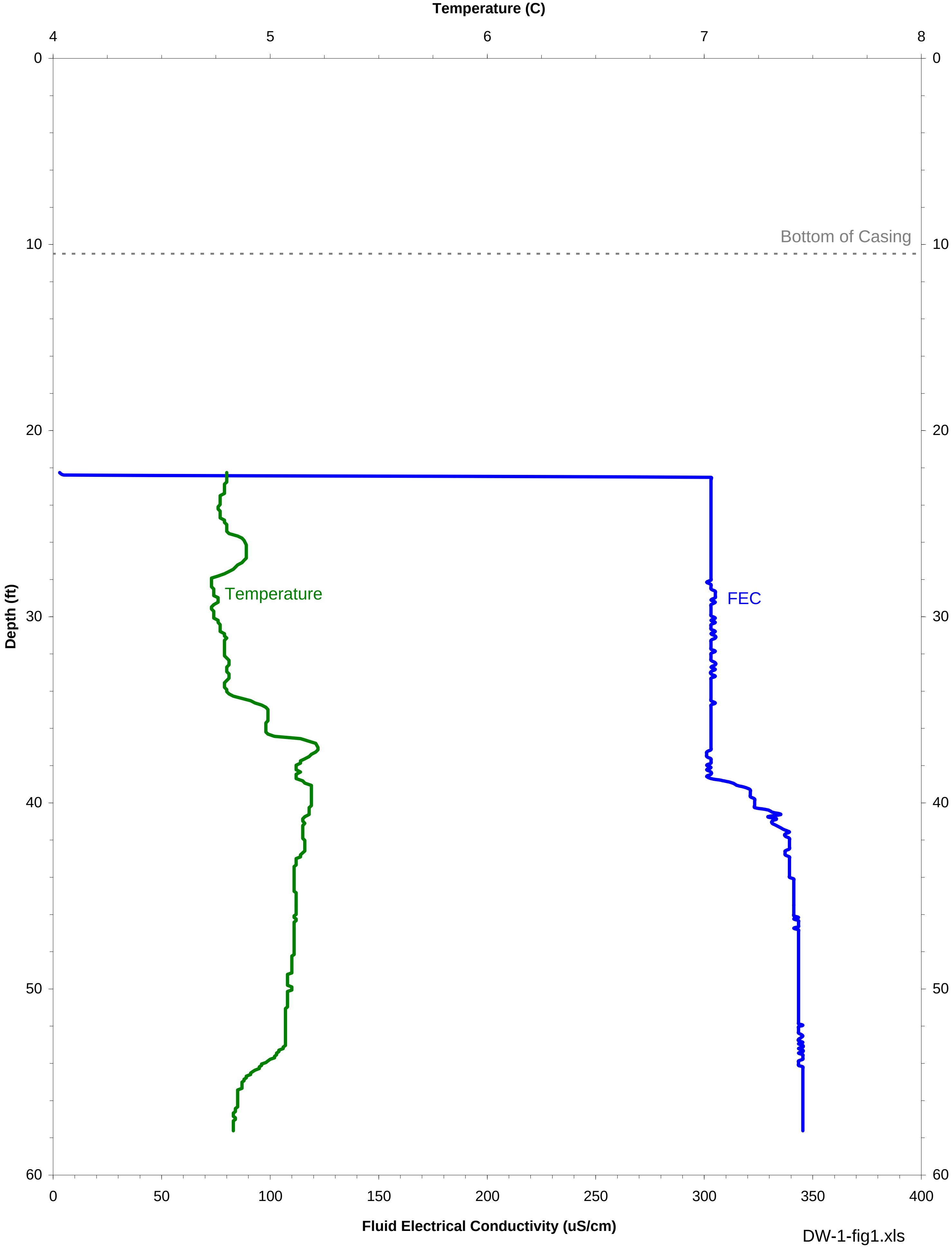
The WSP sampling results identified contaminant concentrations in four of the six sampled intervals. The two contaminants that registered identifiable concentrations are cis-1,2-DCE and toluene. The sample interval 187.9 to 192.2 feet registered only cis-1,2-DCE at 0.23 µg/L. The sample intervals 16.0 to 20.0, 37.0 to 41.7 and 94.5 to 98.5 feet registered only toluene at 2.4, 4 and 5.5 µg/L, respectively. Please see Table WSP Summary in the Executive Summary for a complete summary of the sample results.

Fracture inter-connectiveness in the immediate vicinity of a wellbore can be inferred by the similarity, or lack there of, of parameters such as interval-specific transmissivity estimates and interval-specific FEC, along with the presence of high-angle fractures and pressure differentials within the borehole. Similar transmissivity and FEC estimates would suggest an inter-connected

network of fractures or aquifers in the immediate vicinity of the wellbore. High-angle fractures with aperture may provide a conduit for vertical communication. Moreover, although a pressure differential would seem to suggest the driving force for vertical communication is present, typically substantially vertically interconnected fractures or aquifers tend to pressure-equilibrate in the immediate vicinity of the wellbore. Thus, the presence of a pressure differential in a wellbore may suggest a lack of vertical communication between fractures or aquifers in the immediate vicinity of the borehole.

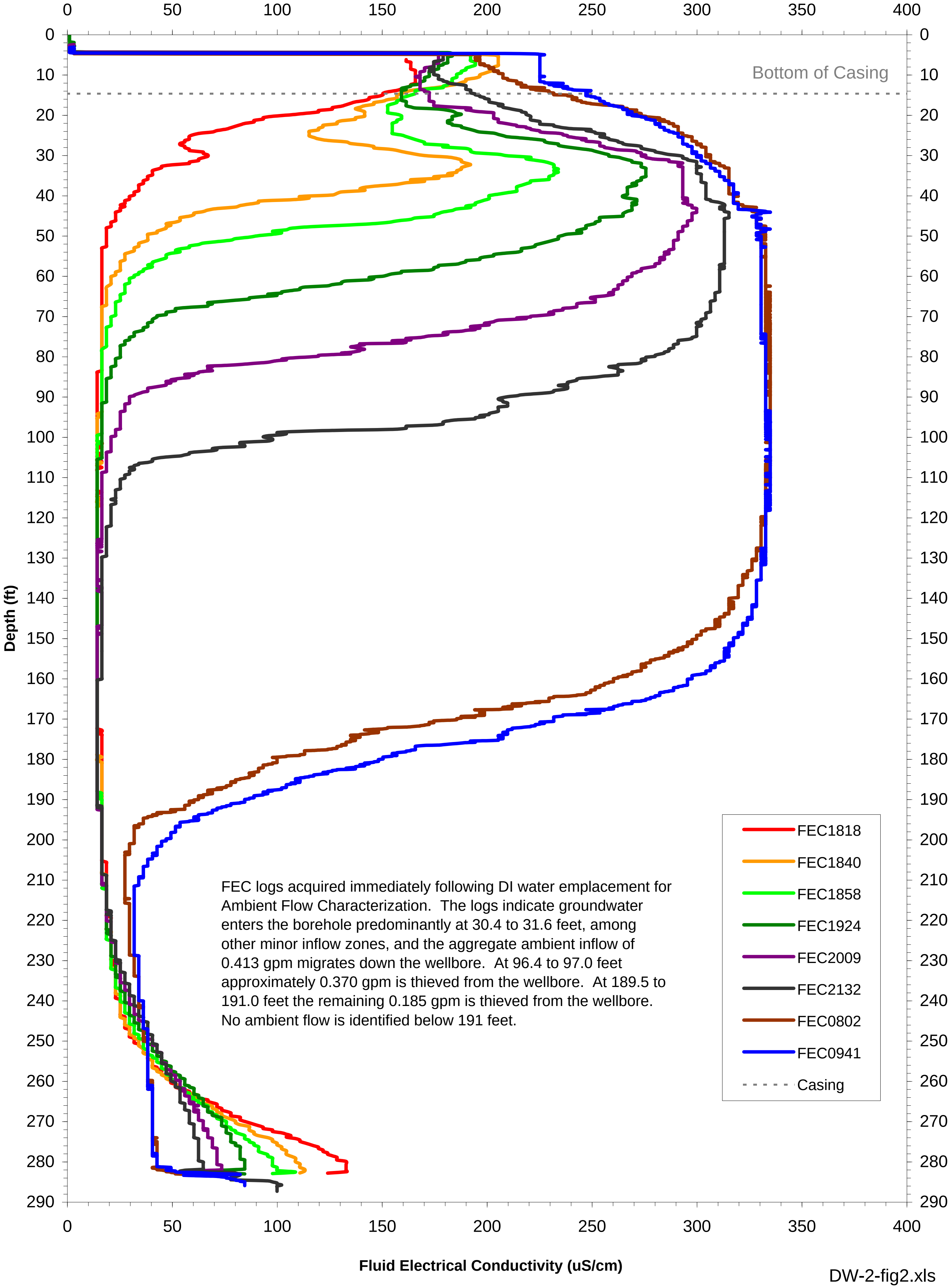
The data acquired in DW-2 exhibited dissimilar interval-specific transmissivity but similar FEC estimates. The televiewers identified high-angle fractures with aperture and the WSP registered pressure correlations above and below several tested intervals. Though a pressure differential was identified under ambient conditions, the WSP data support the suggestion that certain intervals are not hydraulically connected over the intervals in which the pressure differential under ambient conditions was observed in the borehole. The data suggest the fractures are moderately vertically inter-connected in the immediate vicinity of the wellbore, primarily in the upper intervals. Please see Table DW-2:1 for a summary of the HydroPhysical™ and geophysical logging results which includes the locations, flow rates and transmissivity and hydraulic conductivity estimates assessed by COLOG.

FIGURE DW-1:1. Ambient Temperature And Fluid Electrical Conductivity; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-1



DW-1-fig1.xls

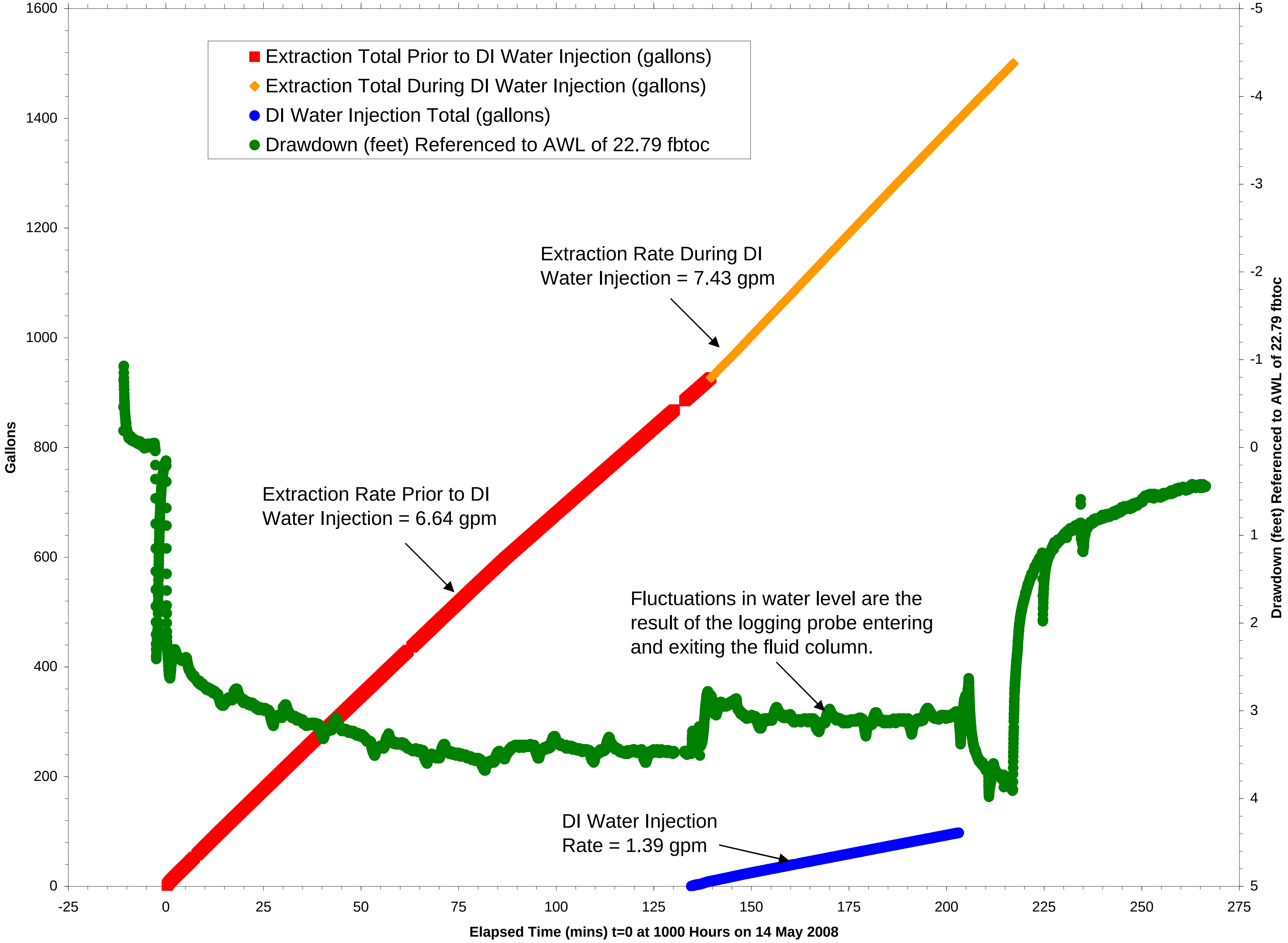
FIGURE DW-2:2. Summary of Hydrophysical Logs During Ambient Flow Characterization; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2



FEC logs acquired immediately following DI water emplacement for Ambient Flow Characterization. The logs indicate groundwater enters the borehole predominantly at 30.4 to 31.6 feet, among other minor inflow zones, and the aggregate ambient inflow of 0.413 gpm migrates down the wellbore. At 96.4 to 97.0 feet approximately 0.370 gpm is thieved from the wellbore. At 189.5 to 191.0 feet the remaining 0.185 gpm is thieved from the wellbore. No ambient flow is identified below 191 feet.

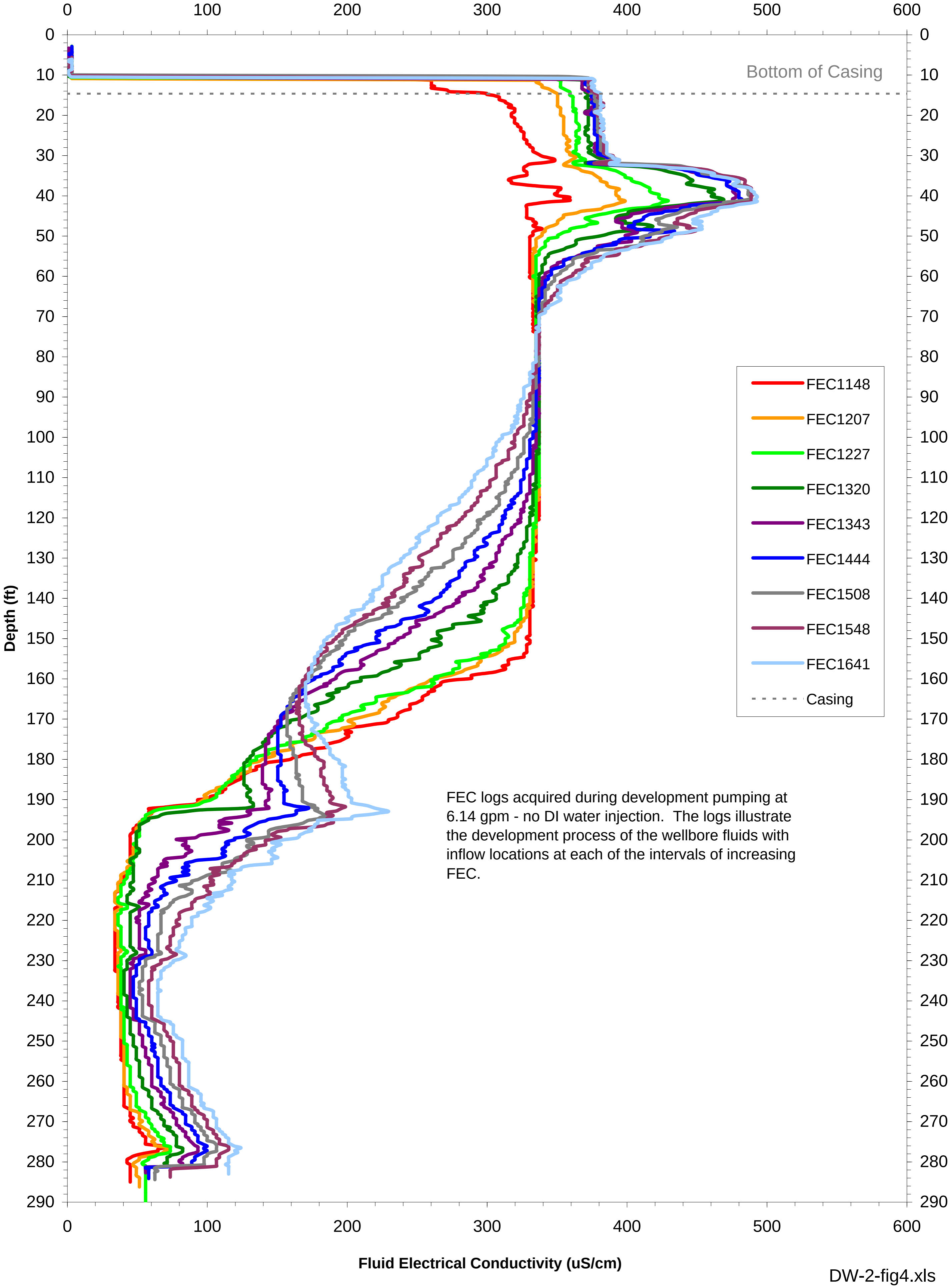
DW-2-fig2.xls

FIGURE DW-1:3. Pumping And Drawdown Data During 6 GPM Production Test; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-1



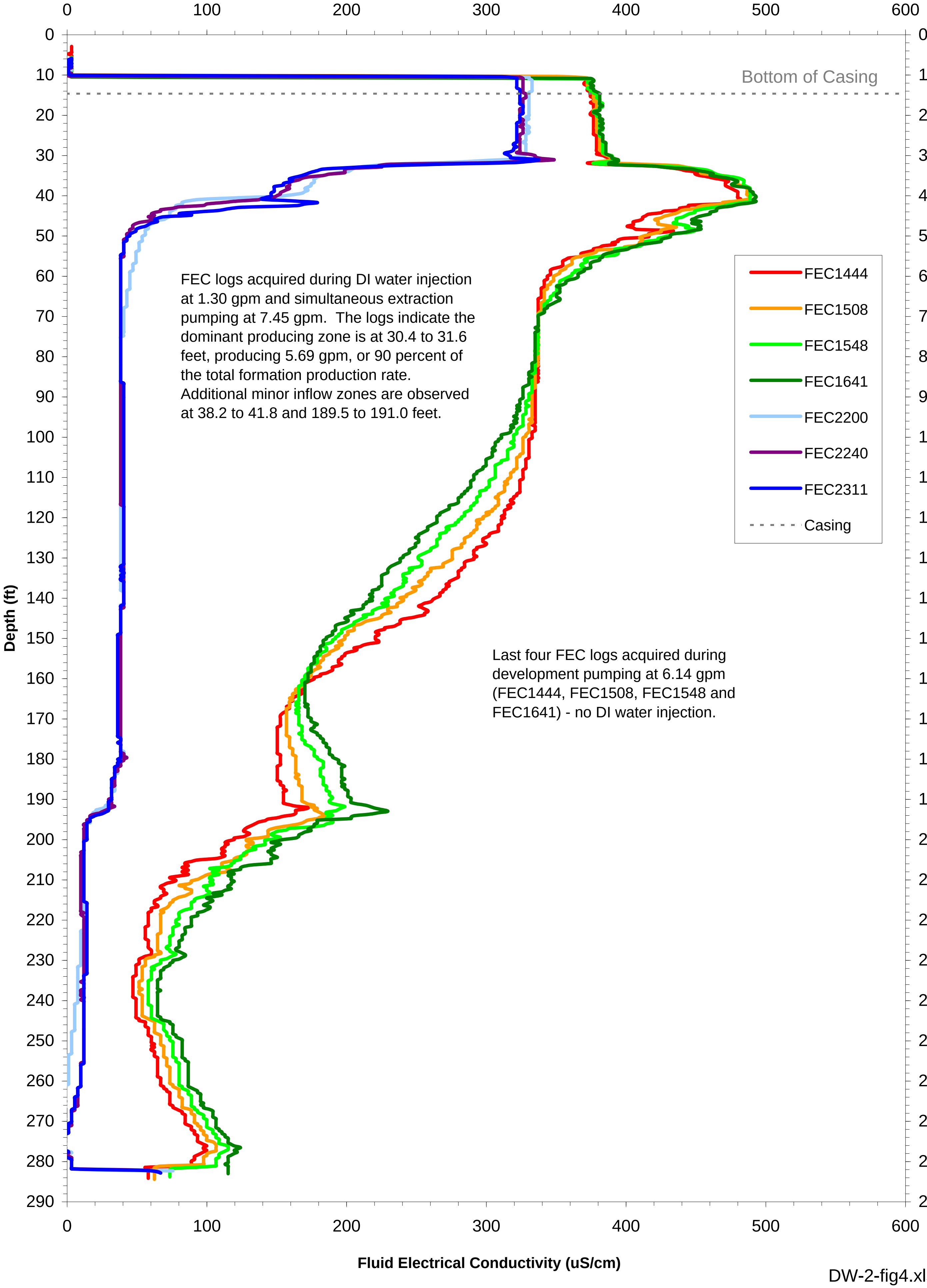
DW-1-fig3.xls

FIGURE DW-2:4A. Summary of Hydrophysical Logs During Development Pumping at 6 GPM; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2



FEC logs acquired during development pumping at 6.14 gpm - no DI water injection. The logs illustrate the development process of the wellbore fluids with inflow locations at each of the intervals of increasing FEC.

FIGURE DW-2:4B. Summary of Hydrophysical Logs During 6 GPM Hydrophysical Production Test; Weston Solution; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2



FEC logs acquired during DI water injection at 1.30 gpm and simultaneous extraction pumping at 7.45 gpm. The logs indicate the dominant producing zone is at 30.4 to 31.6 feet, producing 5.69 gpm, or 90 percent of the total formation production rate. Additional minor inflow zones are observed at 38.2 to 41.8 and 189.5 to 191.0 feet.

Last four FEC logs acquired during development pumping at 6.14 gpm (FEC1444, FEC1508, FEC1548 and FEC1641) - no DI water injection.

DW-2-fig4.xls

Table DW-2:1. Summary Of HydroPhysical^{TM} Logging Results With Hydraulic Conductivity And Transmissivity Estimations; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2

Well Name	DW-2
Ambient Depth to Water (ftbtoc)	4.54
Diameter of Borehole (ft)	0.52
Maximum Drawdown (ft)	5.40
Effective Radius (ft)	300

Interval No.	Top of Interval (ft)	Bottom of Interval (ft)	Length of Interval (ft)	Ambient Flow[1] (gpm)	Darcy Velocity in Aquifer[2] (Specific Discharge) (ft/day)	Interval Specific Flow Rate During Pumping (gpm)	Delta Flow[3] (gpm)	Delta Flow (ft^3/min.)	Interval Specific Hydraulic Conductivity[4] (ft/day)	Transmissivity (ft2/day)	Interval Specific Fluid Electrical Conductivity (microS/cm)
1	19.5	19.6	0.1	0.026	NA	0.10	0.074	0.010	3.68E+01	2.95E+00	321
2	30.4	31.6	1.2	0.297	NA	5.69	5.393	0.721	1.80E+02	2.16E+02	378
3	38.2	41.8	3.6	0.016	NA	0.374	0.358	0.048	3.98E+00	1.43E+01	528
4	44.9	51.4	6.5	0.074	NA	0.081	0.007	0.001	4.33E-02	2.82E-01	512
5	96.4	97.0	0.6	-0.370	NA	0.000	0.370	0.049	2.47E+01	1.48E+01	NA
6	143.3	144.3	1.0	0.000	NA	0.008	0.008	0.001	3.20E-01	3.20E-01	432
7	179.2	183.0	3.8	0.000	NA	0.015	0.015	0.002	1.58E-01	6.00E-01	431
8	189.5	191.0	1.5	-0.185	NA	0.051	0.236	0.032	6.30E+00	9.45E+00	429
9	191.4	218.3	26.9	0.000	NA	0.008	0.008	0.001	1.19E-02	3.20E-01	429
10	227.4	228.2	0.8	0.000	NA	0.005	0.005	0.001	2.50E-01	2.00E-01	597
11	243.7	279.2	35.5	0.000	NA	0.024	0.024	0.003	2.71E-02	9.61E-01	597

[1] Downward vertical flow is identified in this borehole under ambient conditions.

[2] Darcy Velocity is calculated using the observed volumetric flow rate, the cross-sectional area of the flow interval in the wellbore and a wellbore convergence factor of 2.5 (Drost, 1968). The Darcy Velocity is only applicable to ambient horizontal flow

[3] Delta Flow is the difference between Interval-Specific Flow Rate (during pumping) and Ambient Flow Rate.

[4] Hydraulic conductivity and transmissivity estimates are based on single well drawdown data, a porus-medium equivilent model and Hvorslev's 1951 porosity equatior

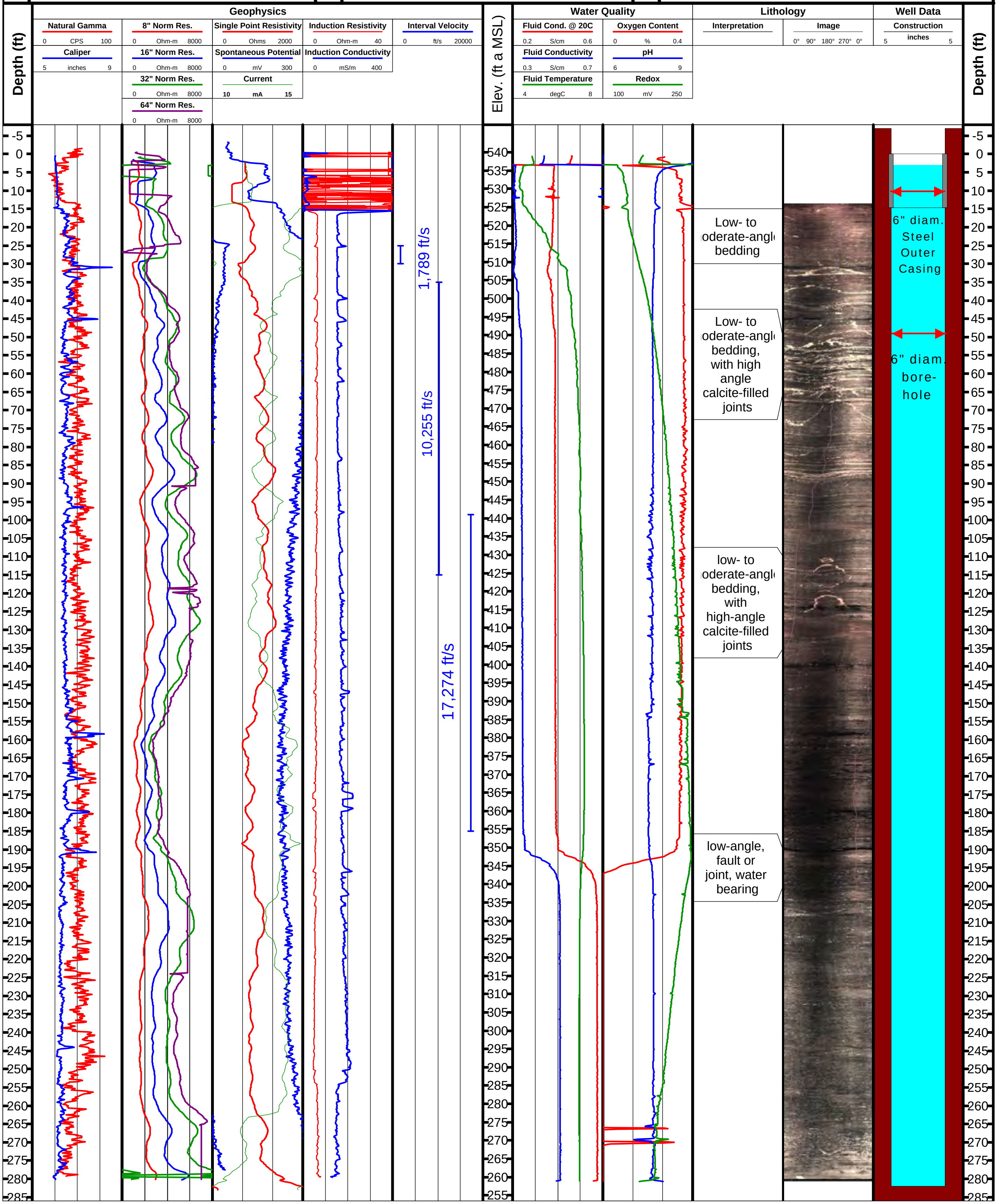
NA - Not Applicable

Project: LO-58	Well ID: DW-02 (VFW Well)	Date Logged: 8-15 May 08
Location: Aroostook County, Caribou, ME	Log Ref.: Top Steel Casing	Hole Diameter: 6" nom. to TD
Depth Logger: 283 ft	Log Ref. Elev.: ~539.5 ft above MSL	Csg Size/Type: 6" Steel
Depth Driller: No Data	Recorded by: G. Bauer	Witnessed by: J. Schmidl

LOGS & TOOLS: See Individual Logs

COMMENTS:
Ground Elevation: ~546.5 ft. aMSL.
Natural Gamma log includes K, U, and Th.
Water Quality logs performed under ambient conditions.
Ambient Water Level about 2.9 ft (9.9 ft bgs).
Logs relative to Truth North (mag dec = 20W)

COMMENTS:
All depths here referenced to top steel casing unless noted otherwise.
Measured casing stick down below ground surface: 7.0 ft.
Steel outer casing total depth 14.6 ft, estimated from image log.



BOREHOLE GEOPHYSICS & HYDROPHYSICS COLOG A DIVISION OF LAYNE CHRISTENSEN COMPANY

WESTON SOLUTIONS

Project: LO-58	Well ID: DW-02 (VFW Well)	Date Logged: 8-15 May 08
Location: Aroostook County, Caribou, ME	Log Ref.: Top Steel Casing	Hole Diameter: 6" nom. to TD
Depth Logger: 283 ft	Log Ref. Elev.: ~539.5 ft above MSL	Csg Size/Type: 6" Steel
Depth Driller: No Data	Recorded by: G. Bauer	Witnessed by: J. Schmidl

LEGEND

Tadpoles at depth of planar structure, pointing towards strike, and centered on dip. Projections corresponding to each tadpole shown in adjacent column.

Structure Tadpoles

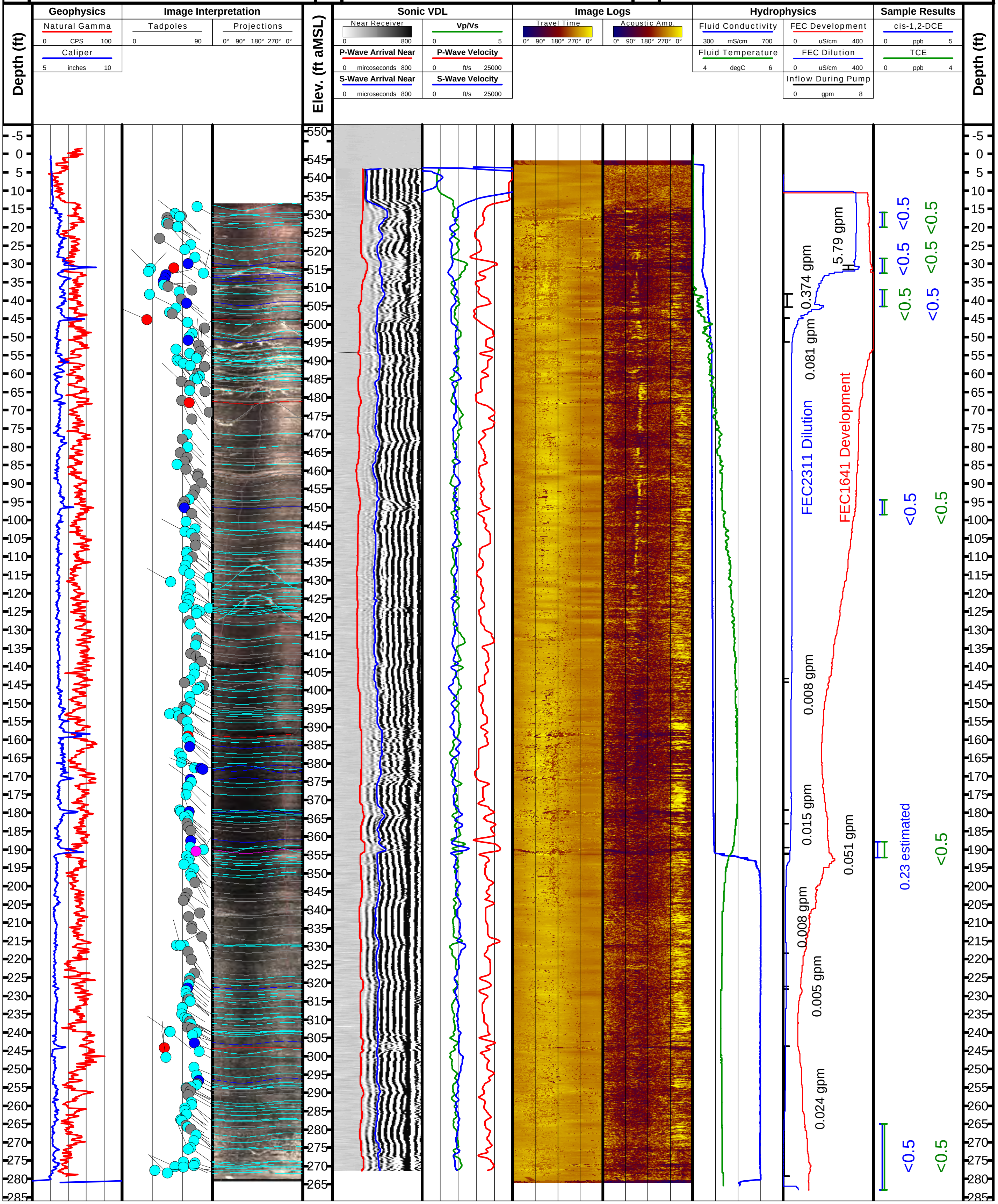
- Washout/Wide Fracture Zone
- Wide Fracture/Multiple Fractures
- Open Fracture
- Complete Fracture
- Healed Fracture/Bedding Plane
- Partial Fracture

COMMENTS

Ground Elevation: ~546.5 ft. aMSL.
Natural Gamma log includes K, U, and Th.
Water Quality logs performed under ambient conditions.
Ambient Water Level about 2.9 ft (9.9 ft bgs).
Logs relative to Truth North (mag dec = 20W)

COMMENTS

All depths here referenced to top steel casing unless noted otherwise.
Measured casing stick down below ground surface: 7.0 ft.
Steel outer casing total depth 14.6 ft, estimated from image log.



Optical Televiewer Image Plot - True North

BOREHOLE GEOPHYSICS & HYDROPHYSICS
COLOG
A DIVISION OF LAYNE CHRISTENSEN COMPANY

COMPANY: Weston Solutions
PROJECT: LO-58
DATE LOGGED: 8 May 2008
WELL: DW-2

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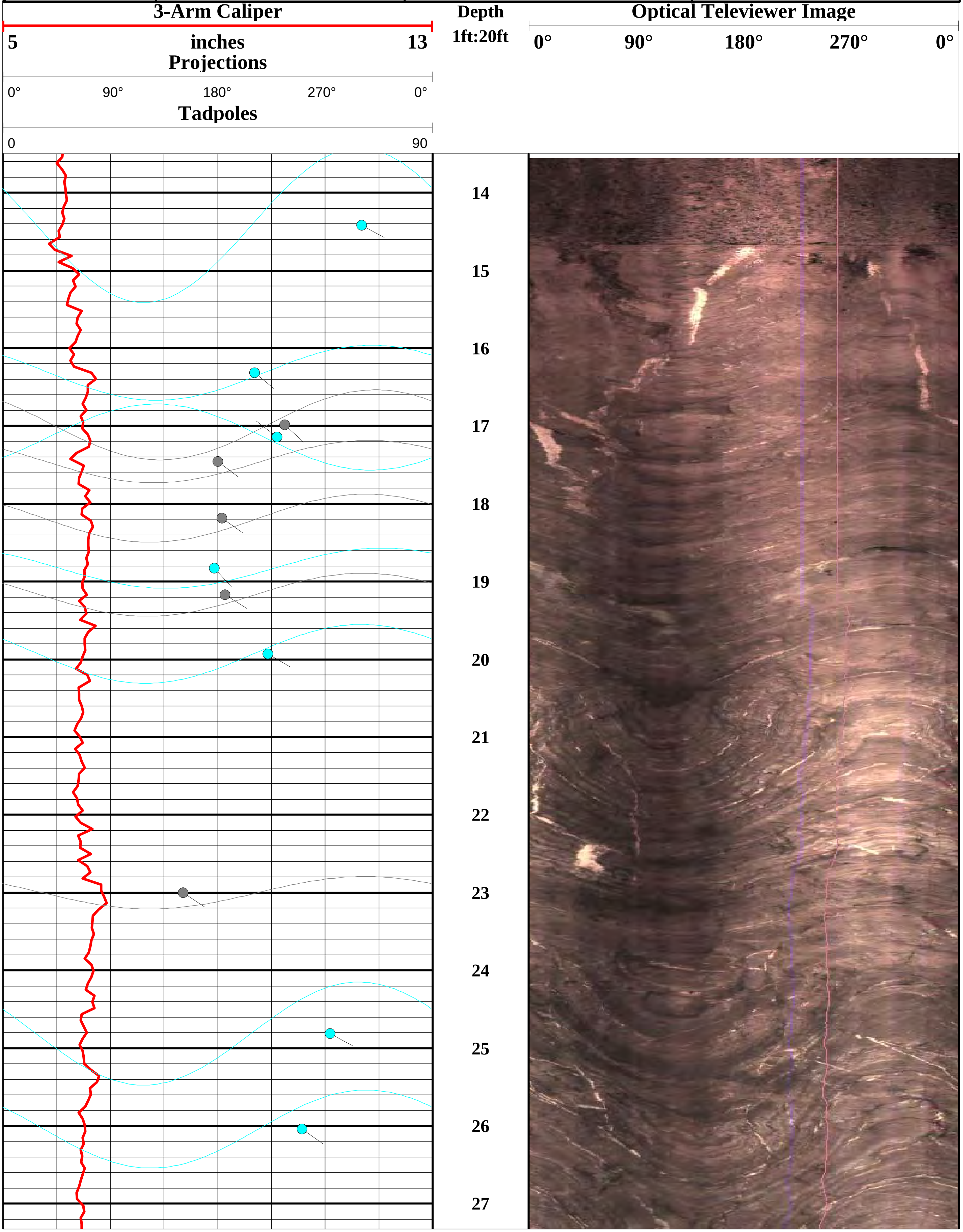

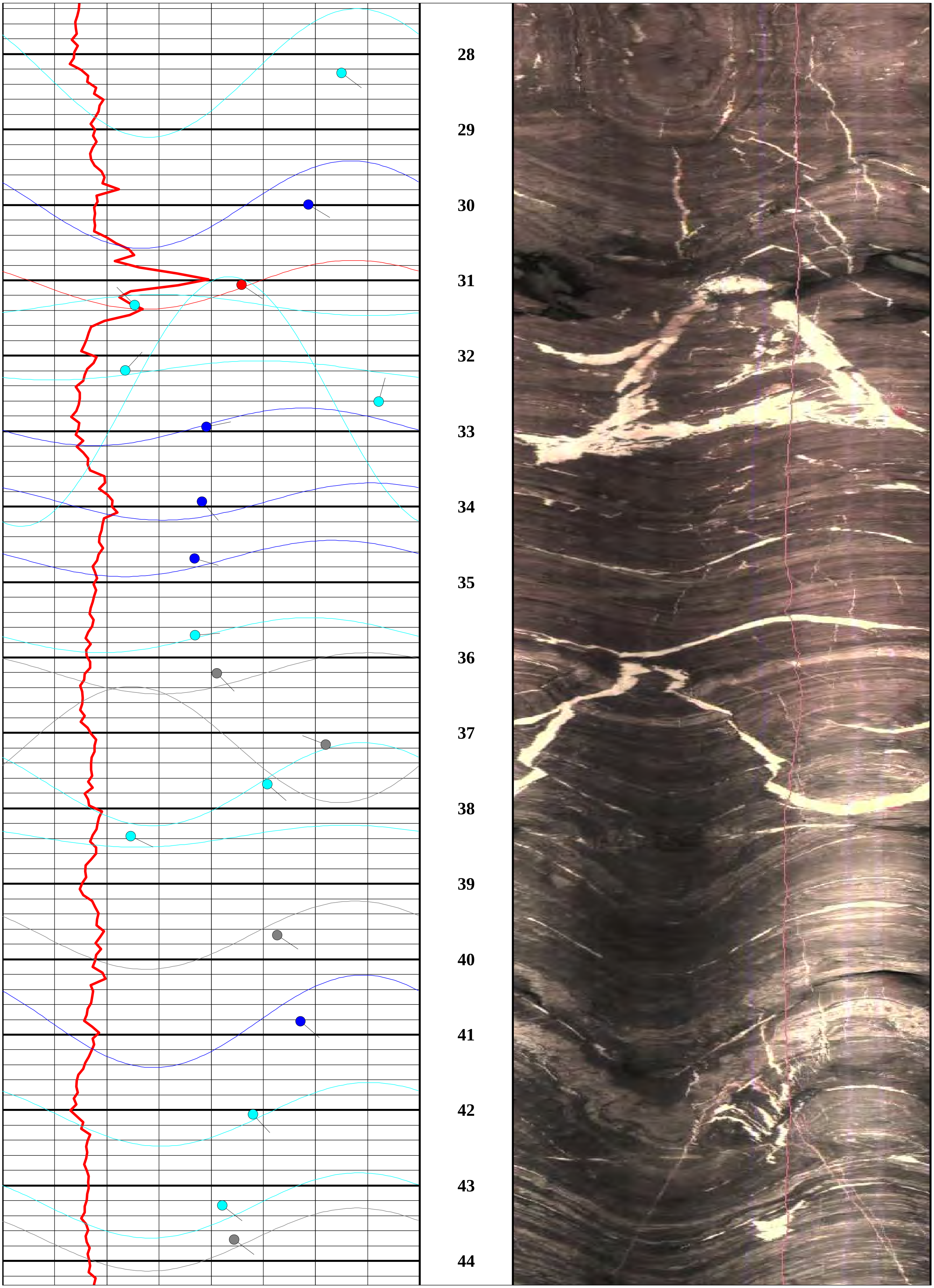
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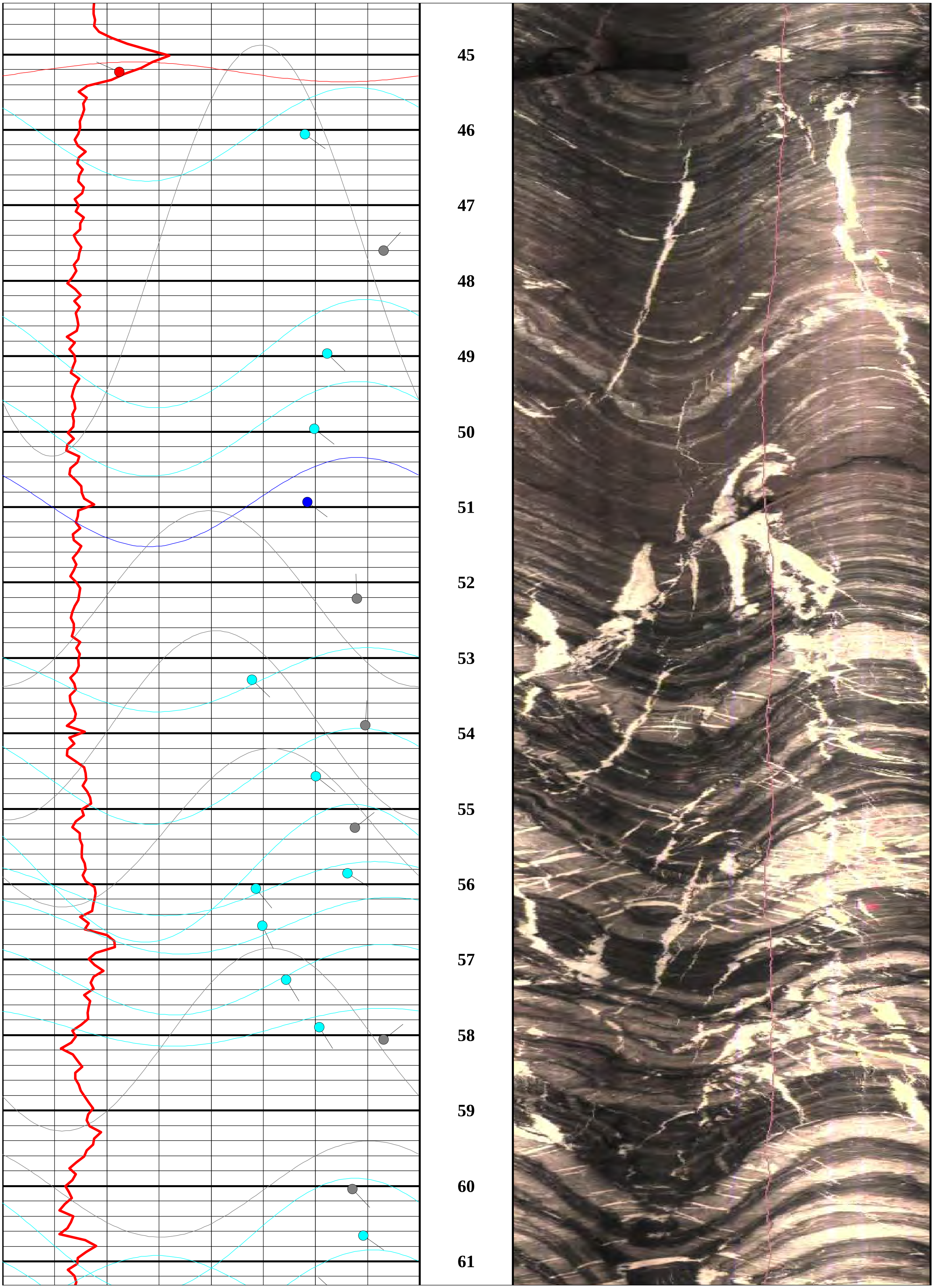
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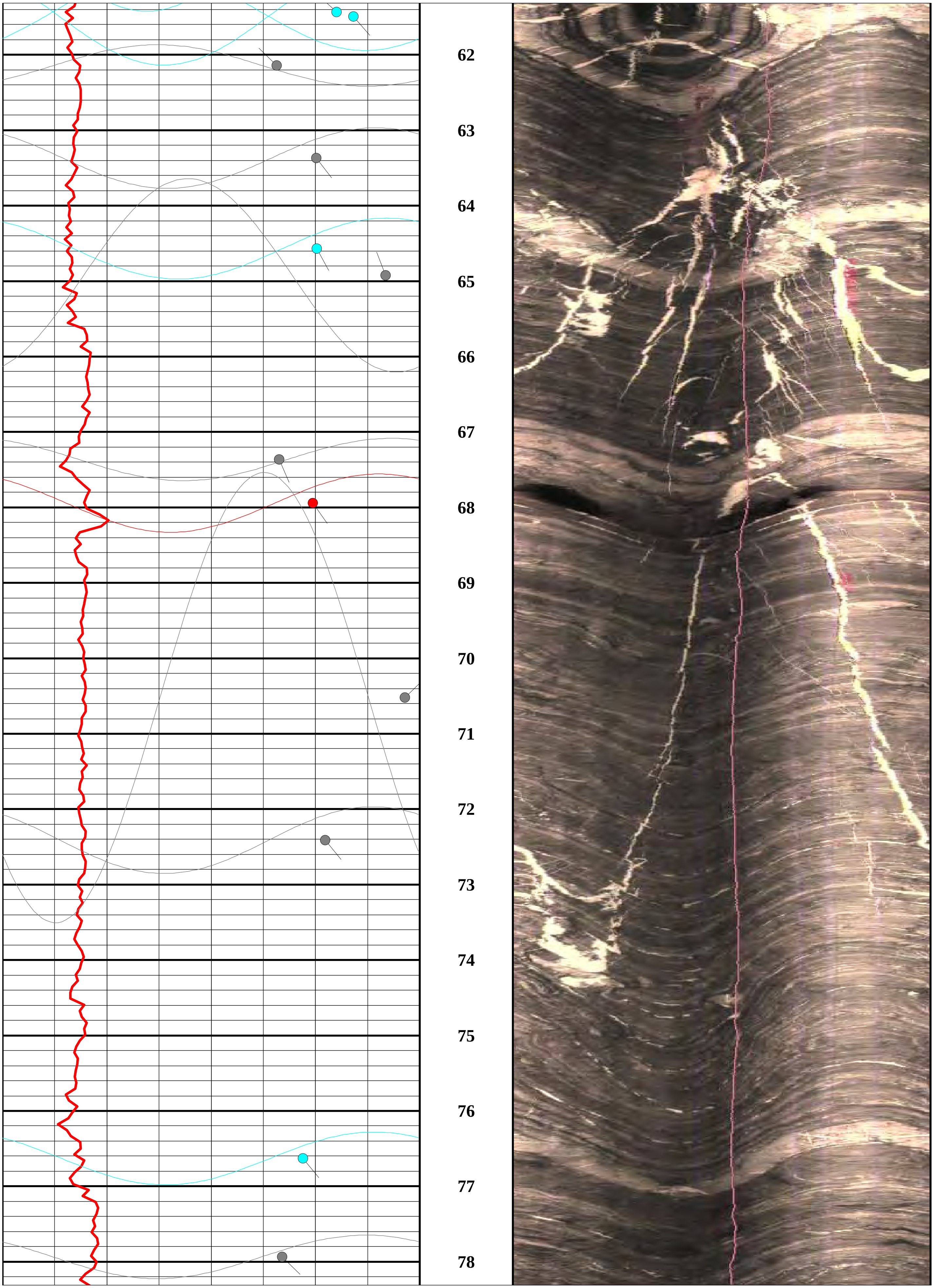
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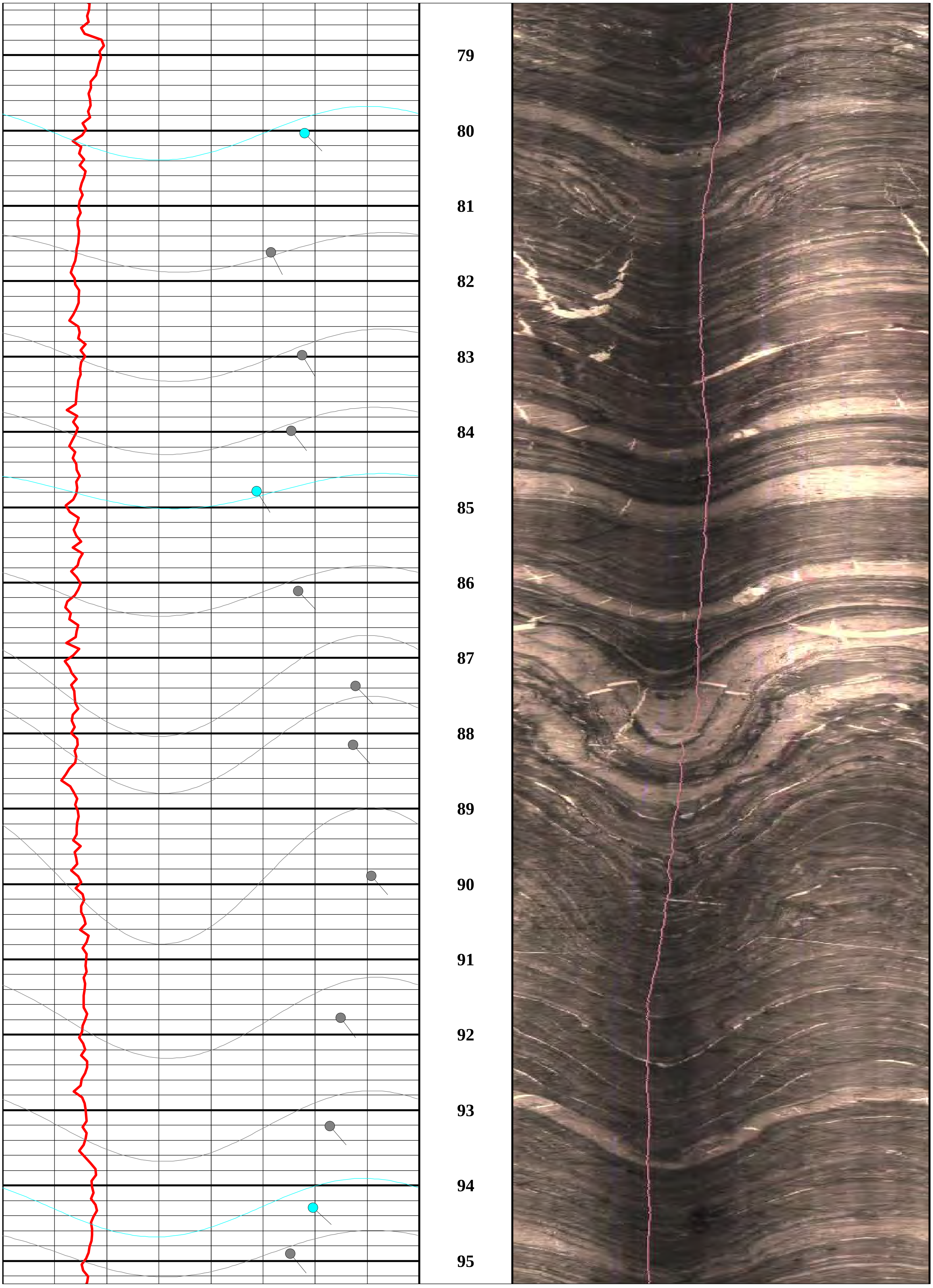
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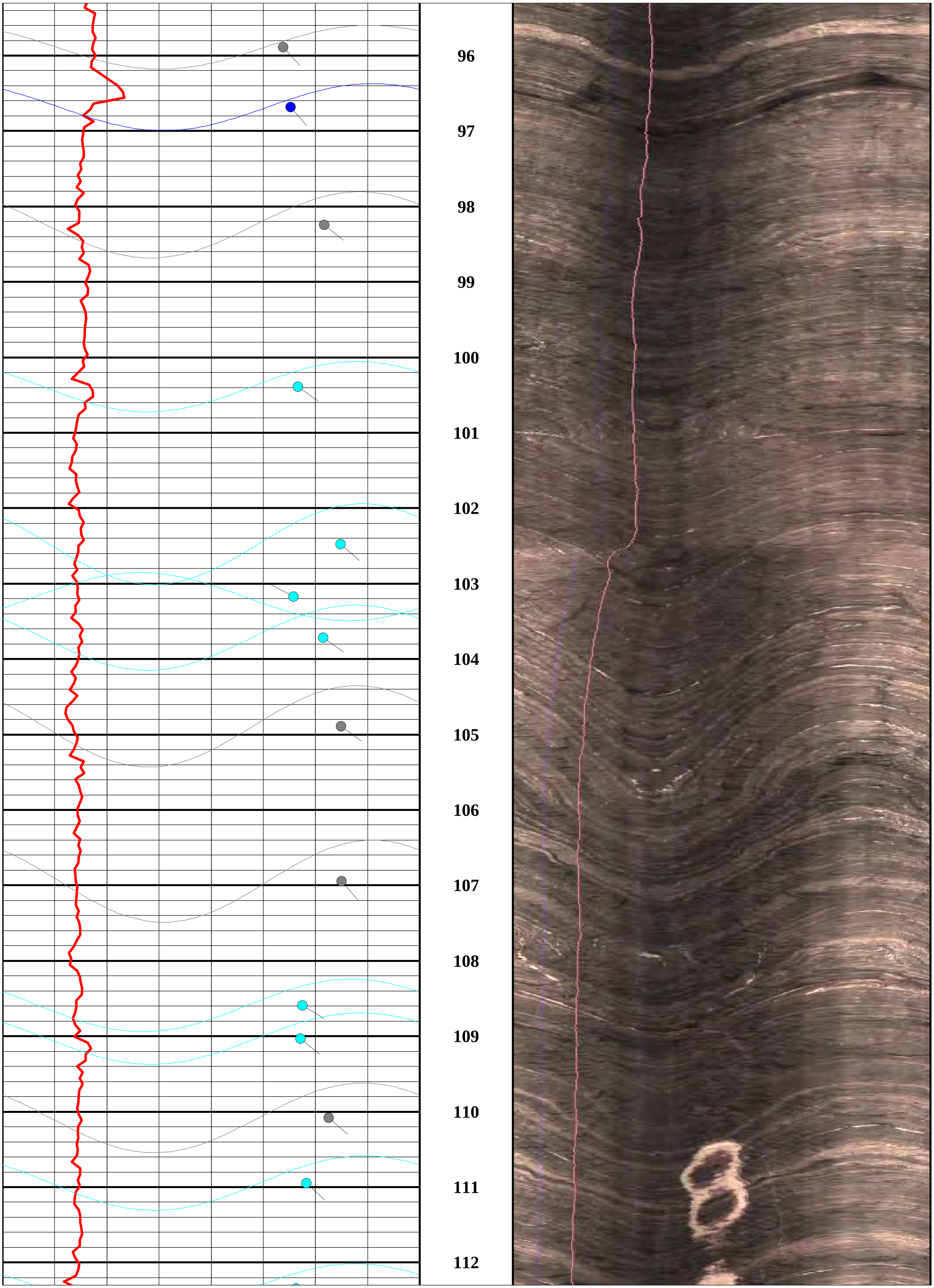
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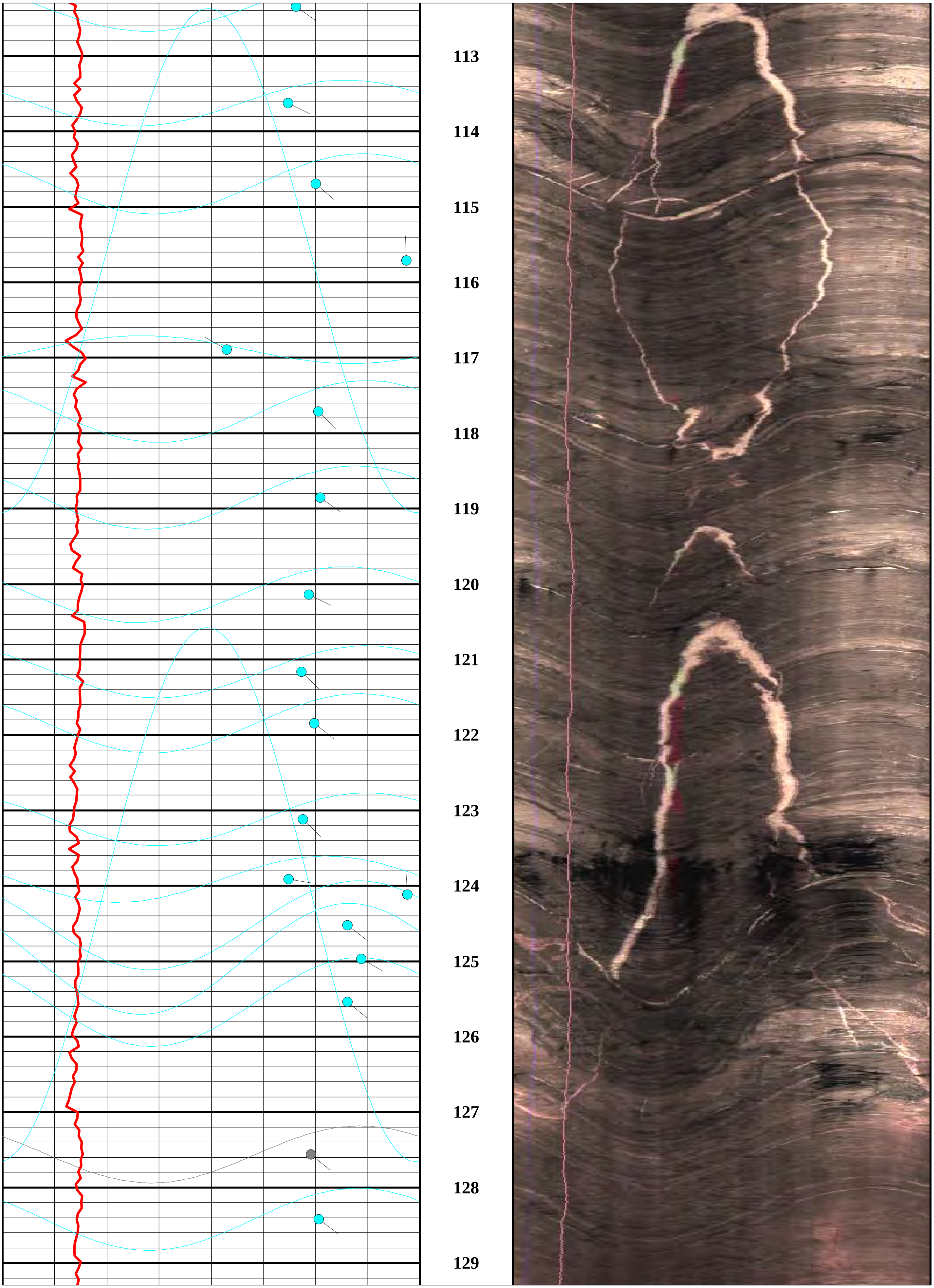
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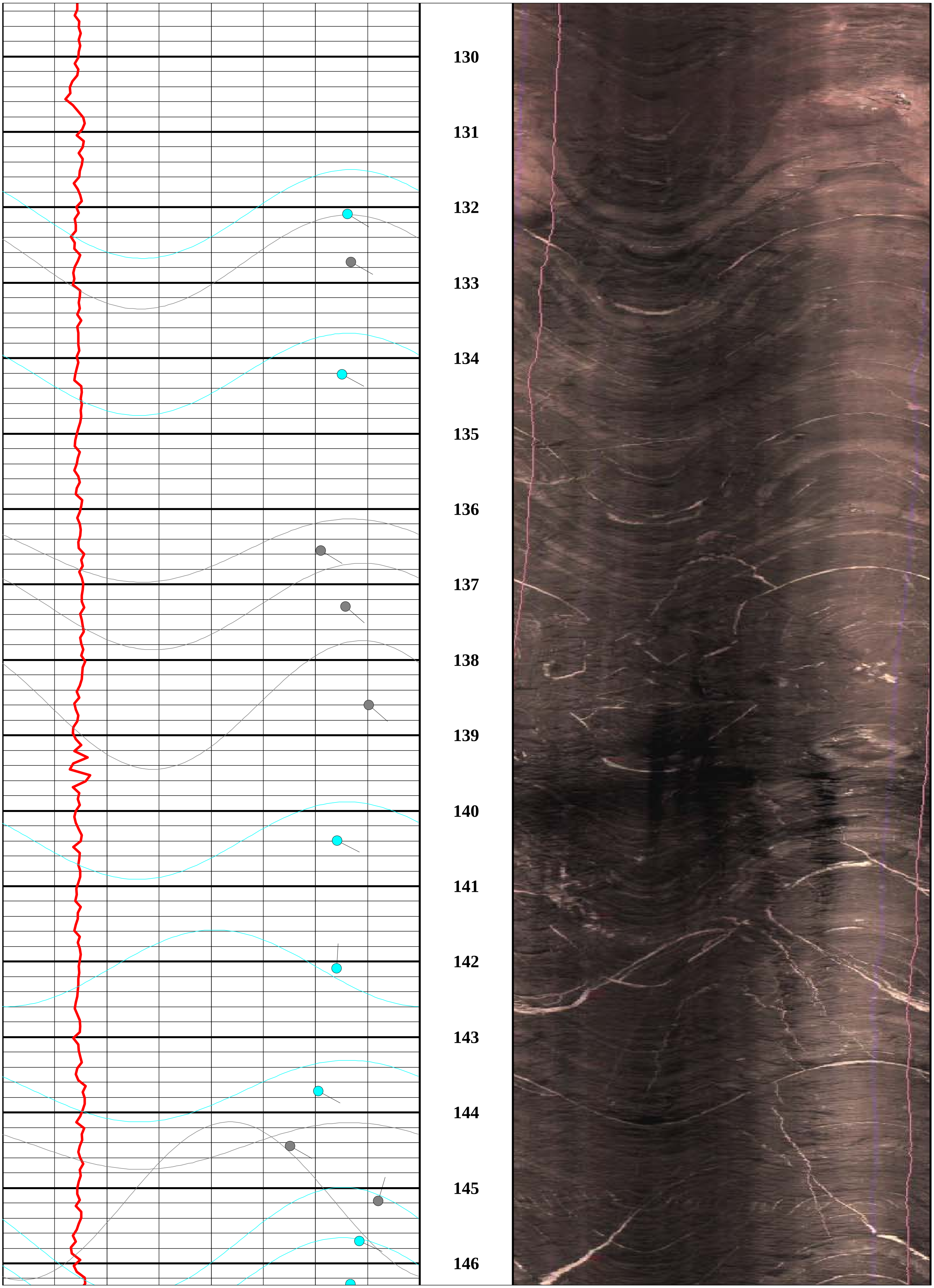
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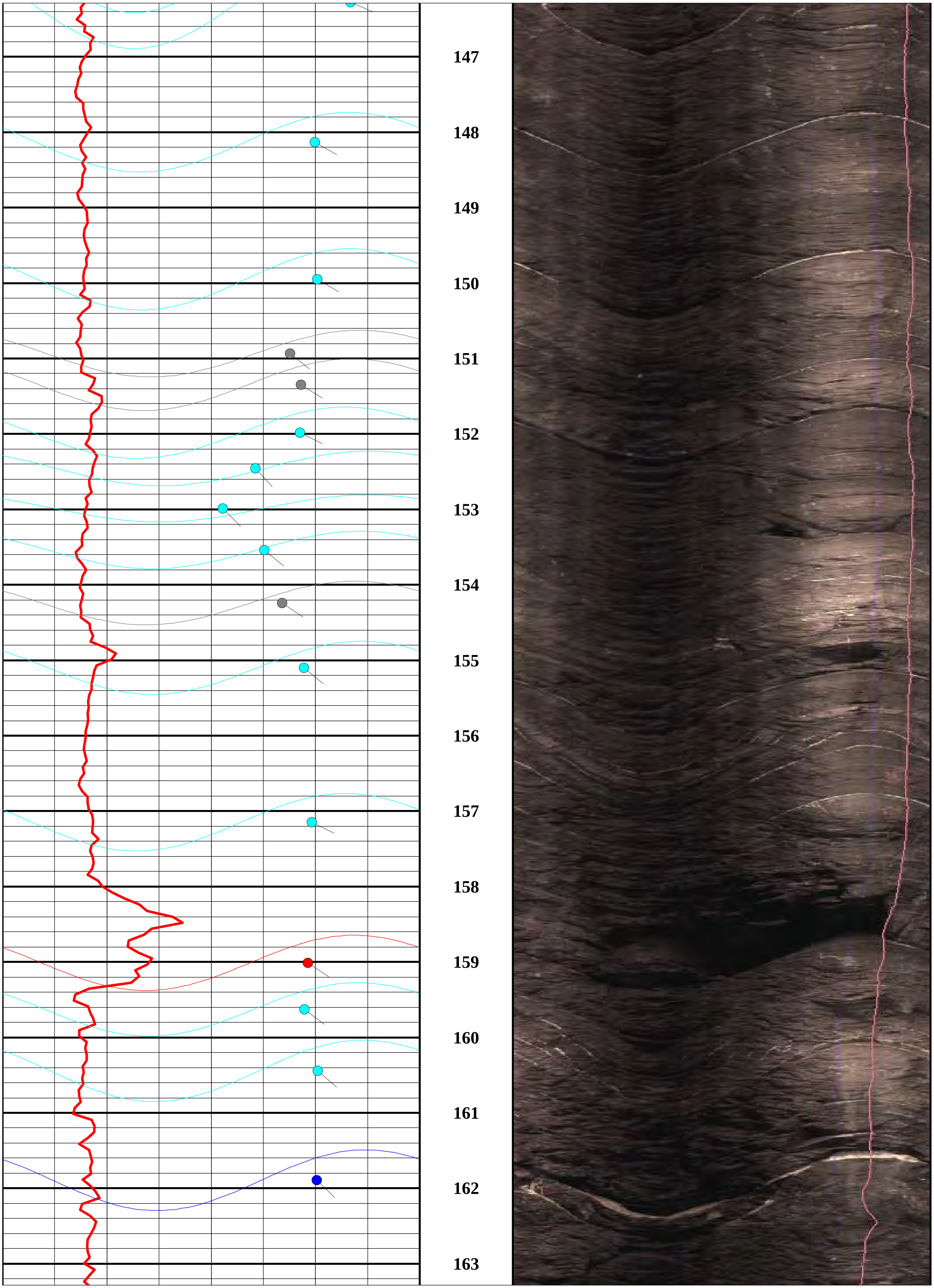
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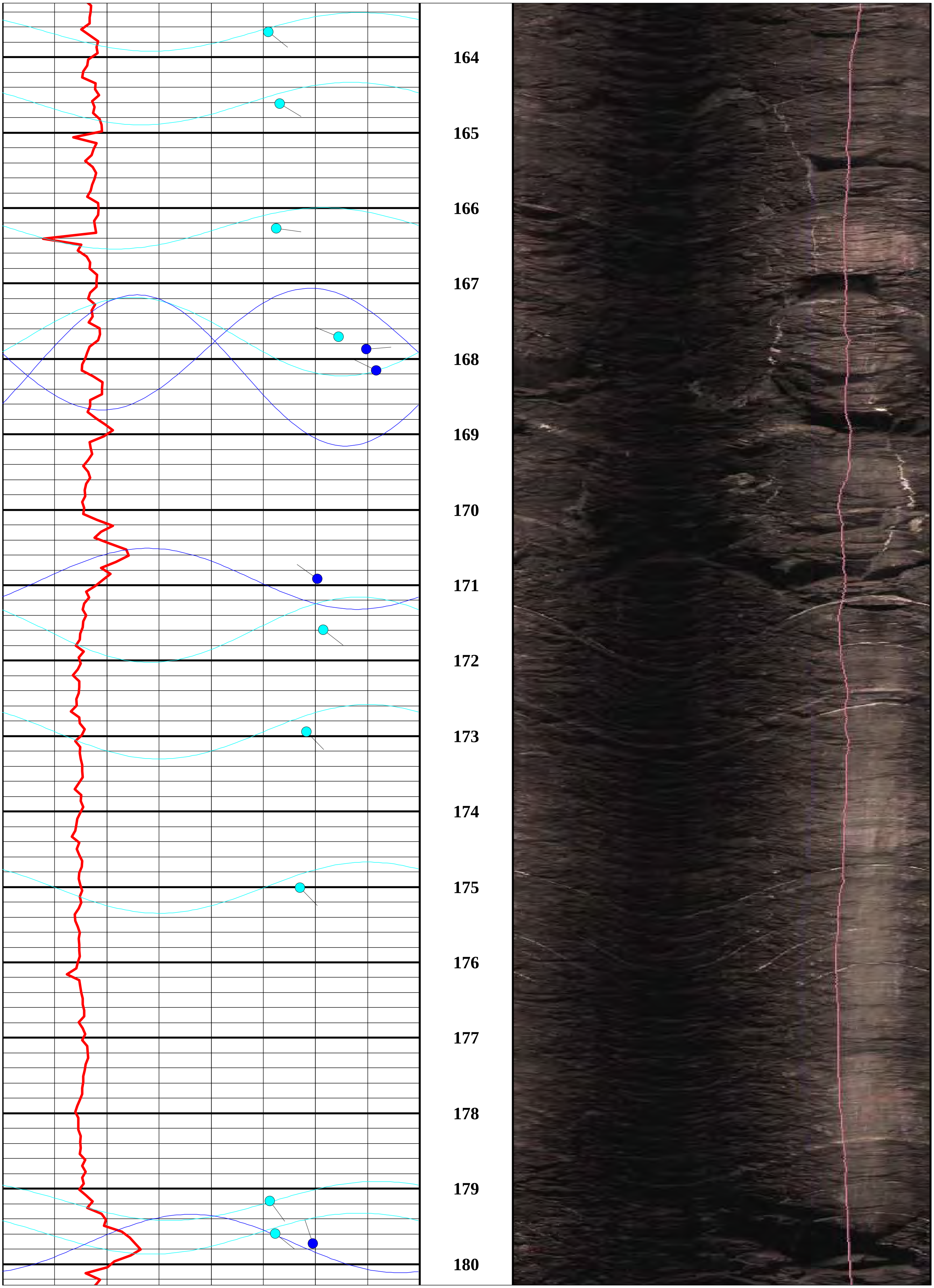
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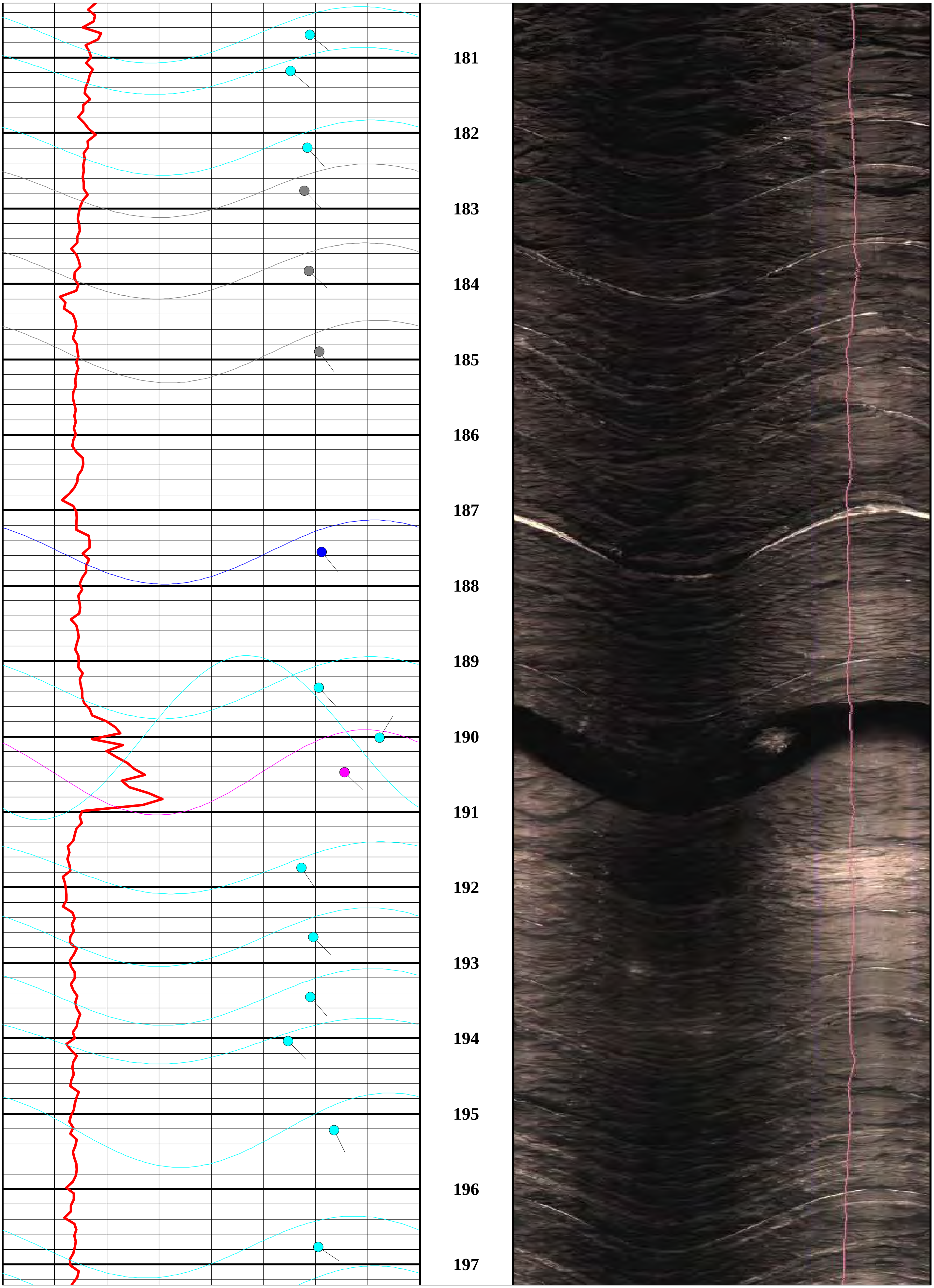
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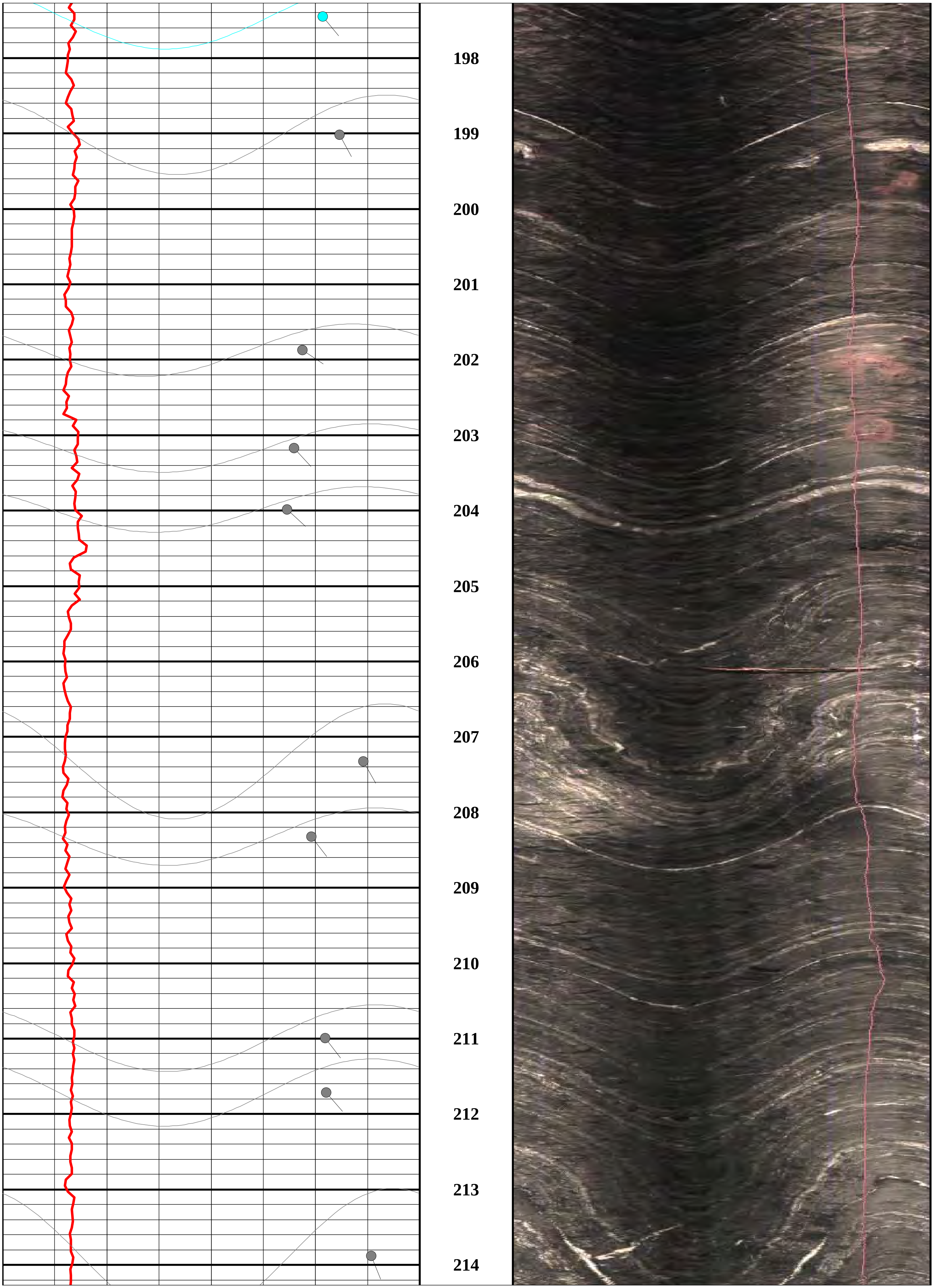
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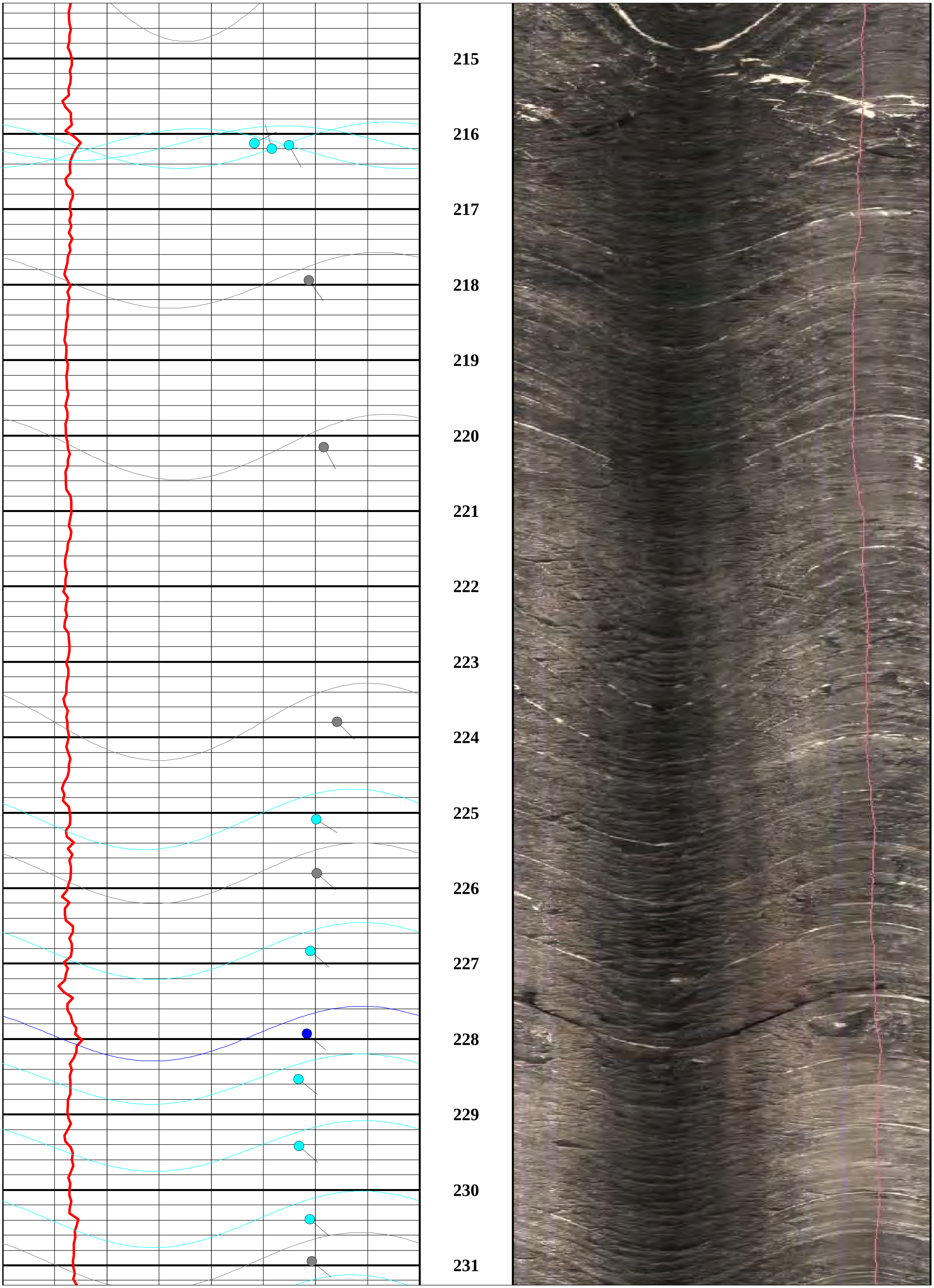
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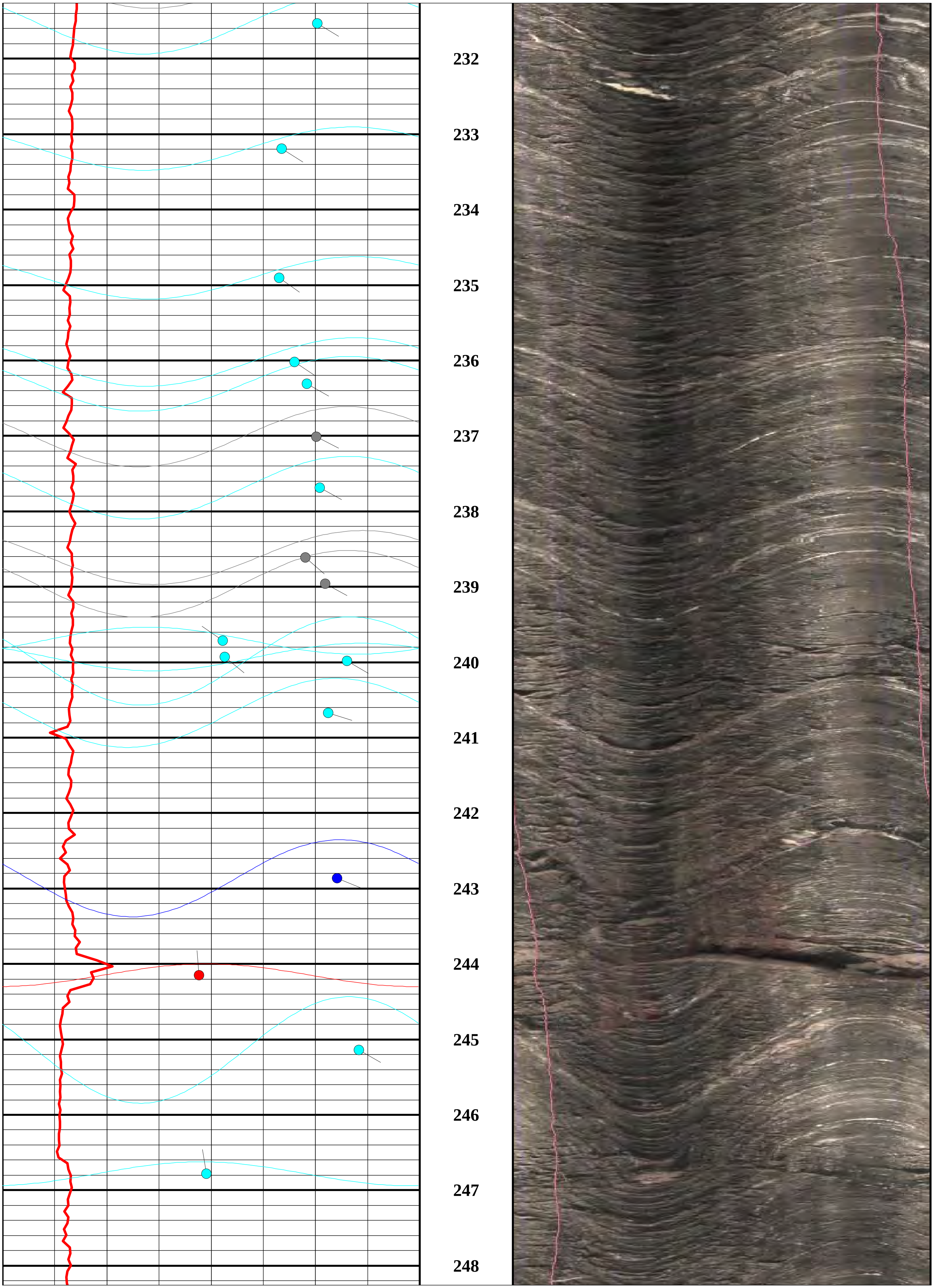
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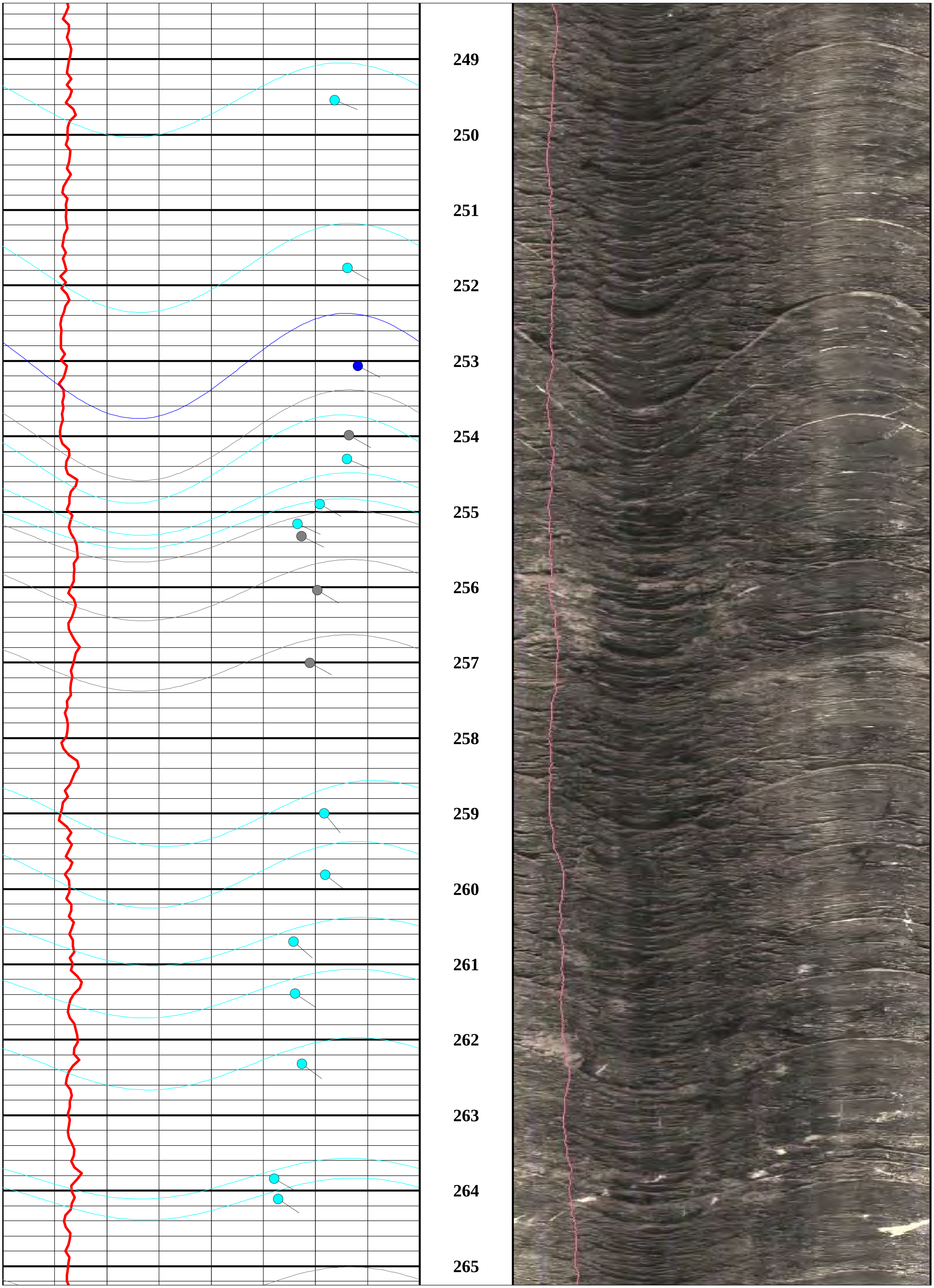
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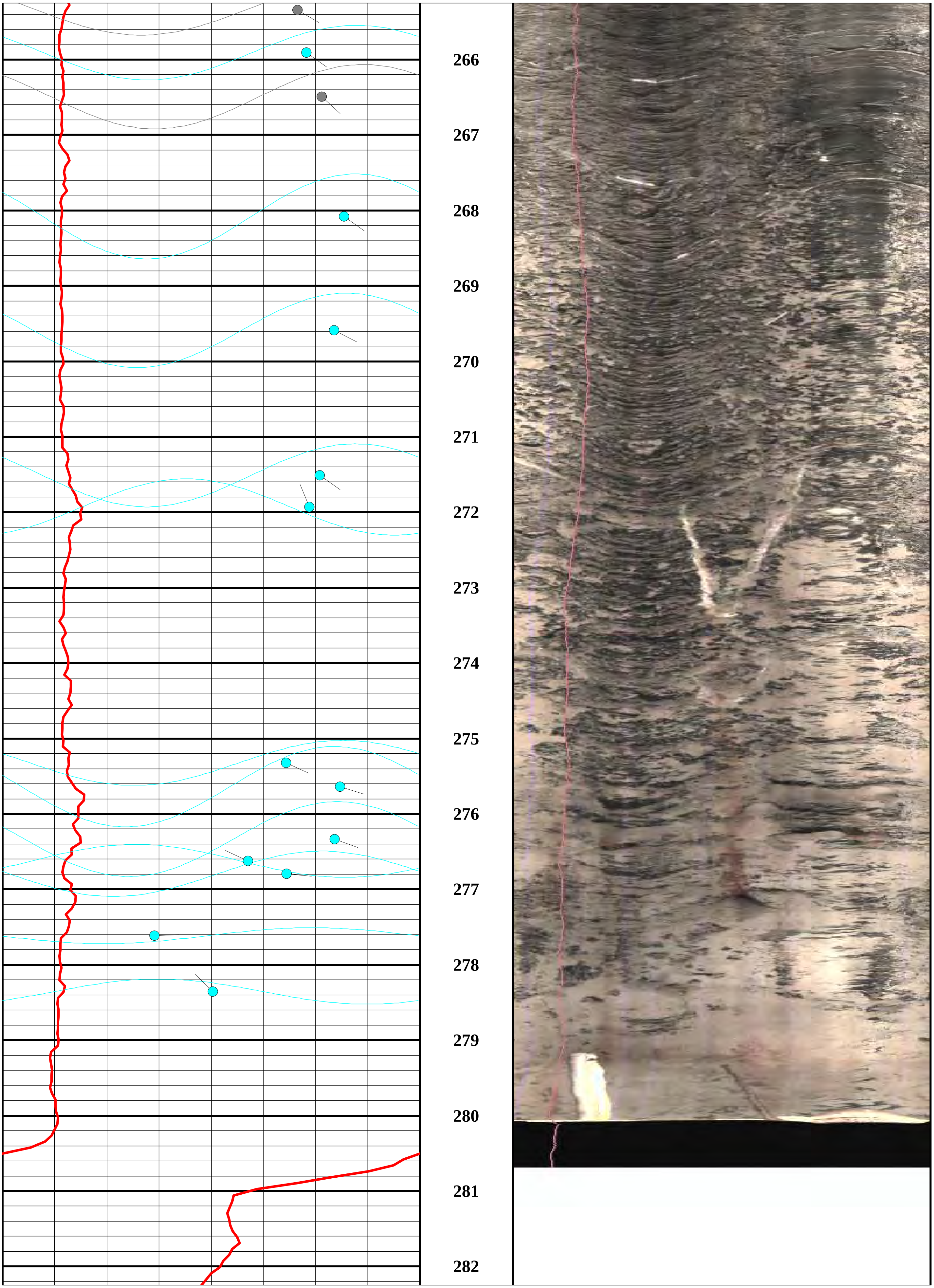
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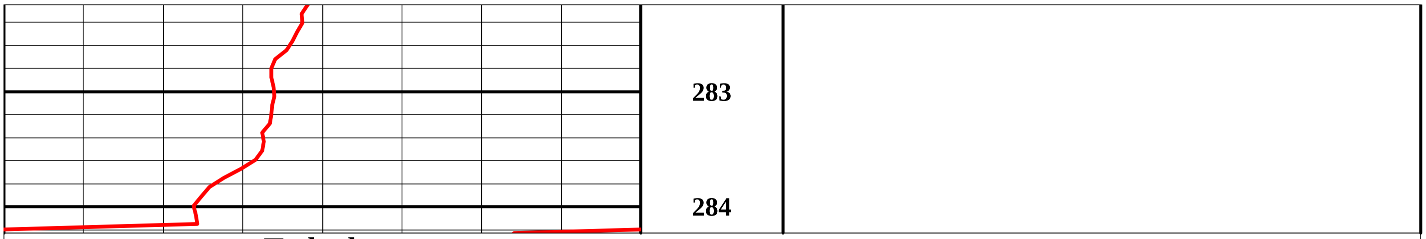


Tadpoles

0 90

Projections

0° 90° 180° 270° 0°

3-Arm Caliper

5 inches 13

Depth

1ft:20ft

Optical Televiewer Image

0° 90° 180° 270° 0°

Acoustic Televiewer Image Plot-True North

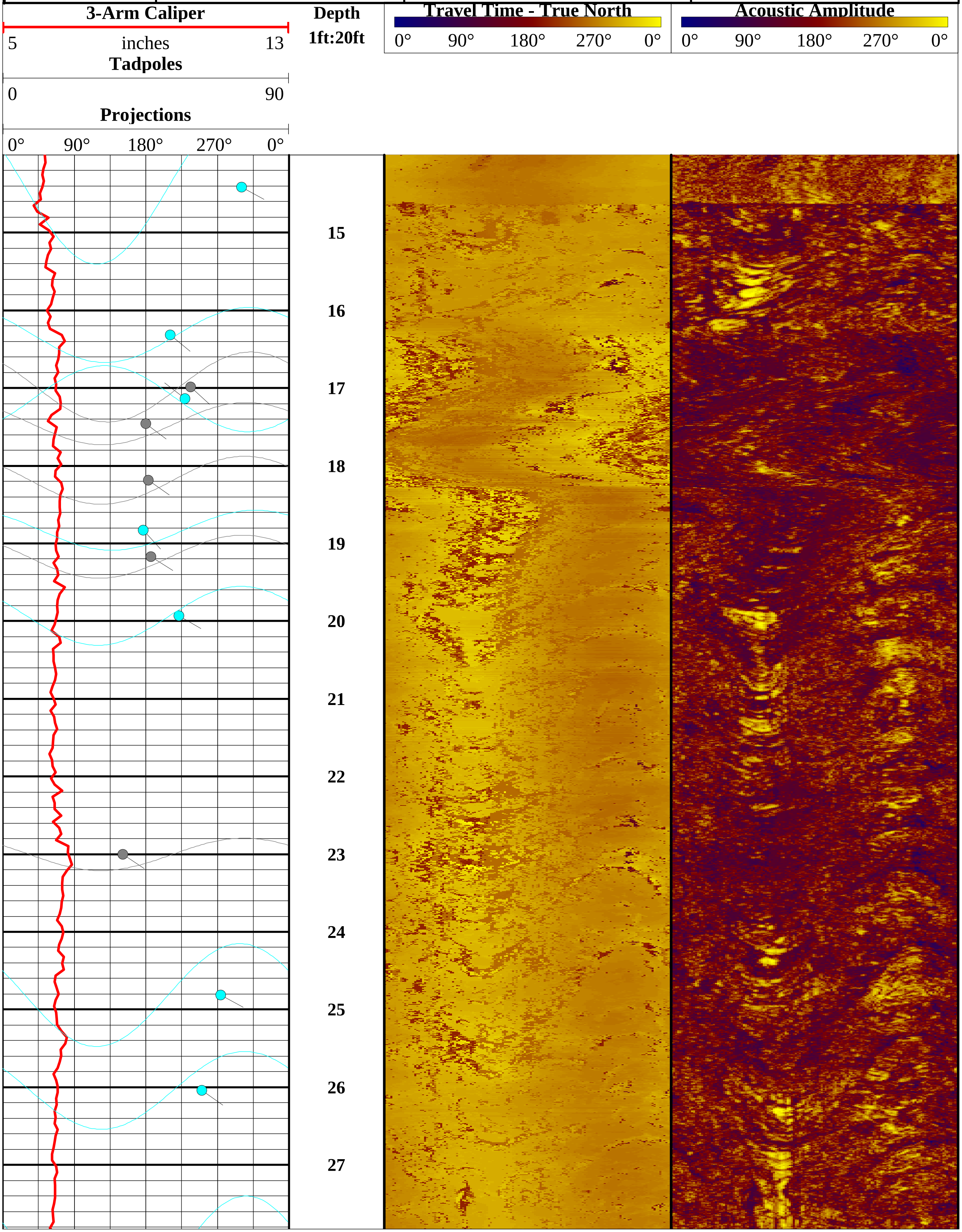
COMPANY: Weston Solutions

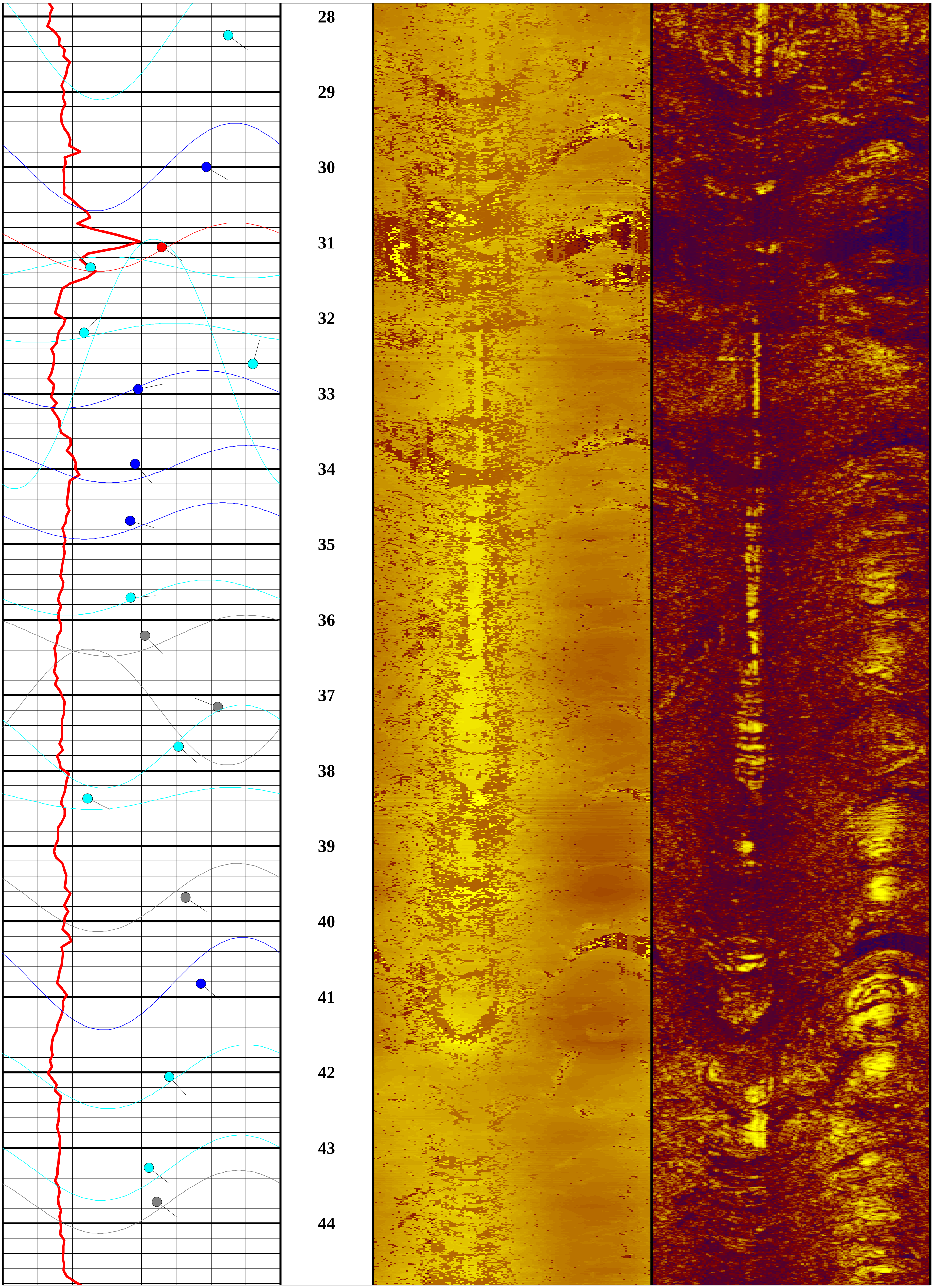
PROJECT: LO-58

DATE LOGGED: 10 May 2008

WELL: DW-2 (Adj. to True North)

COLOG Main Office
810 Quail Street, Suite E, Lakewood, CO 80215
Phone: (303) 279-0171, Fax: (303) 278-0135
www.colog.com

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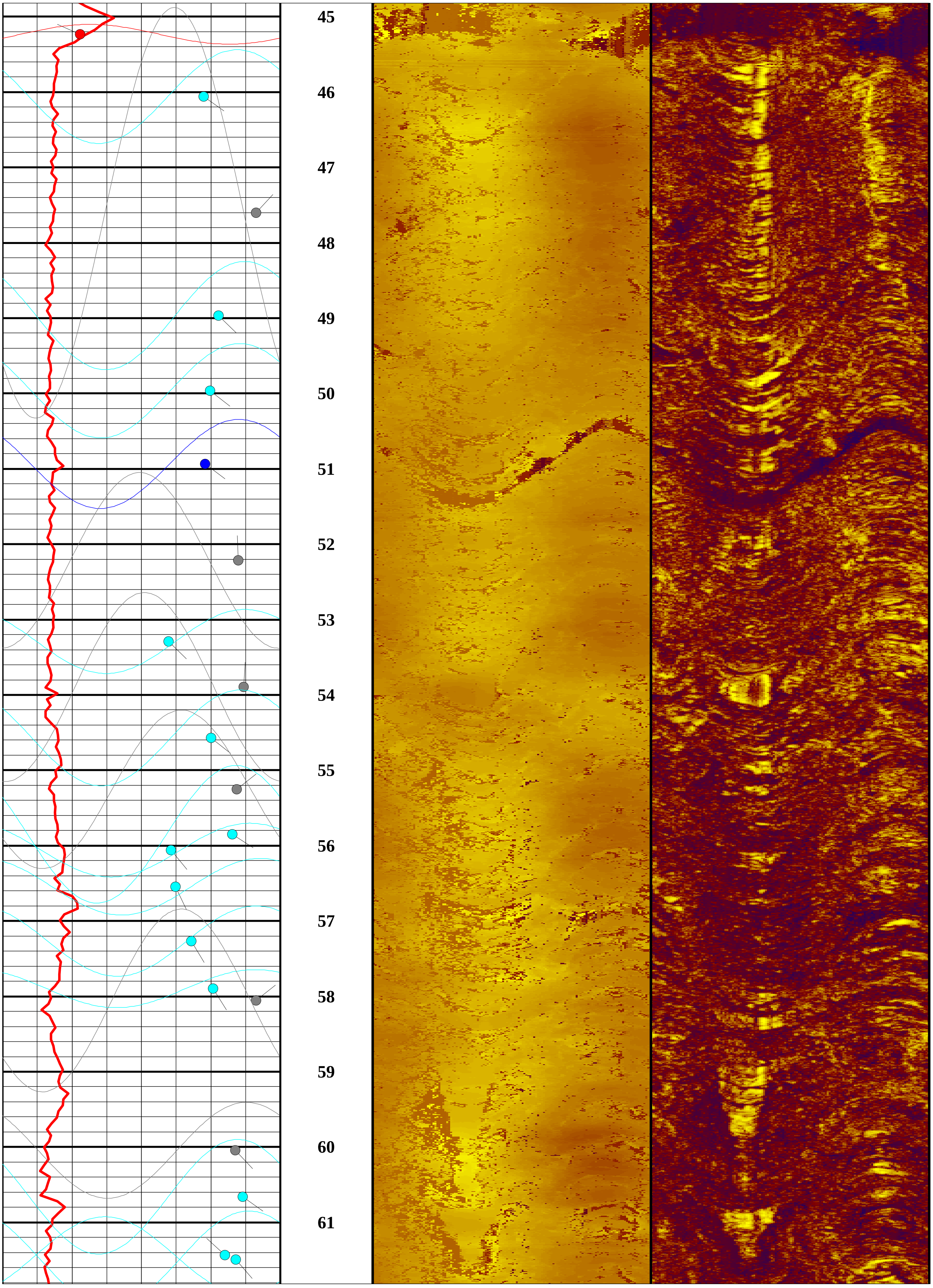
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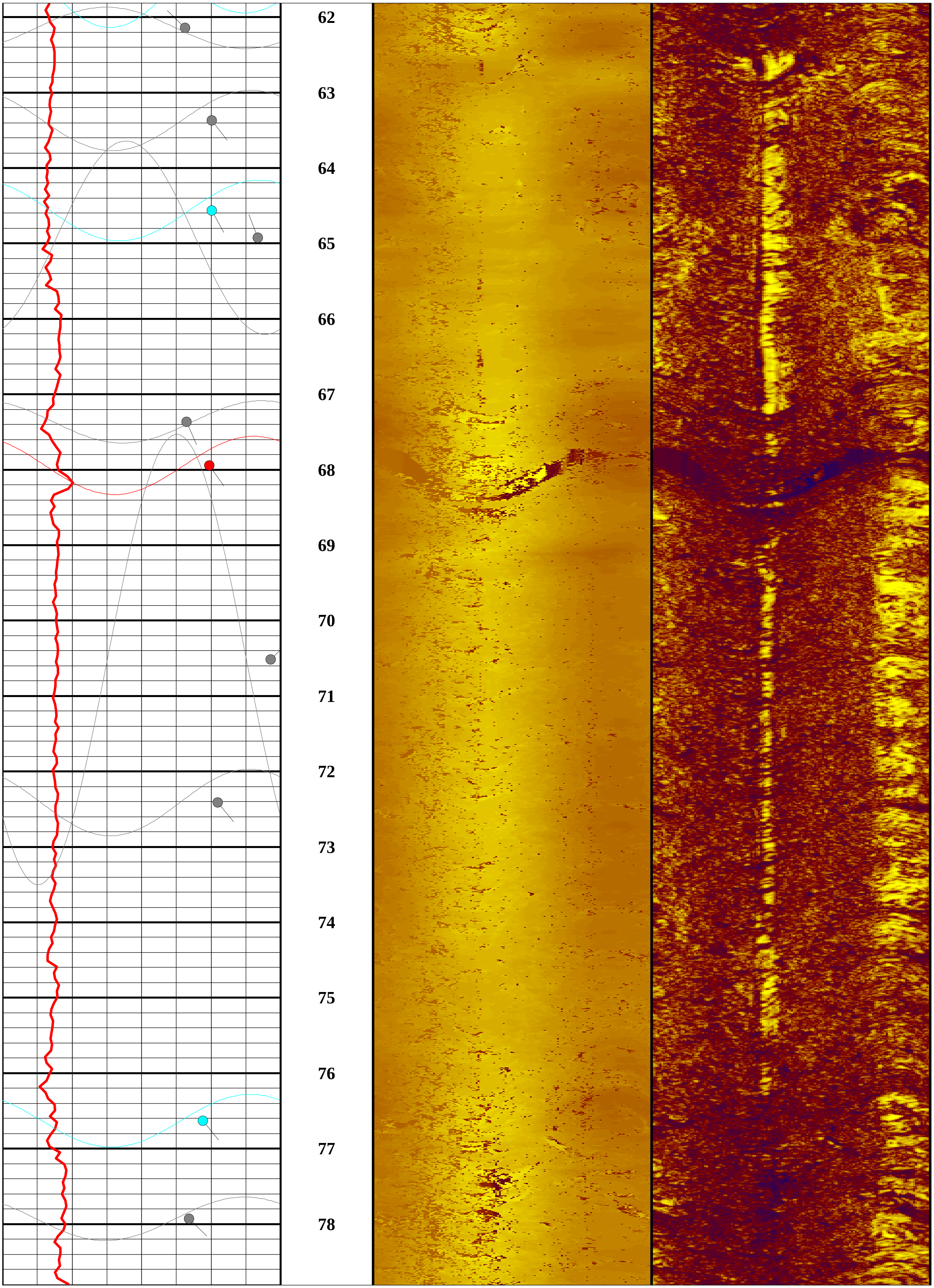
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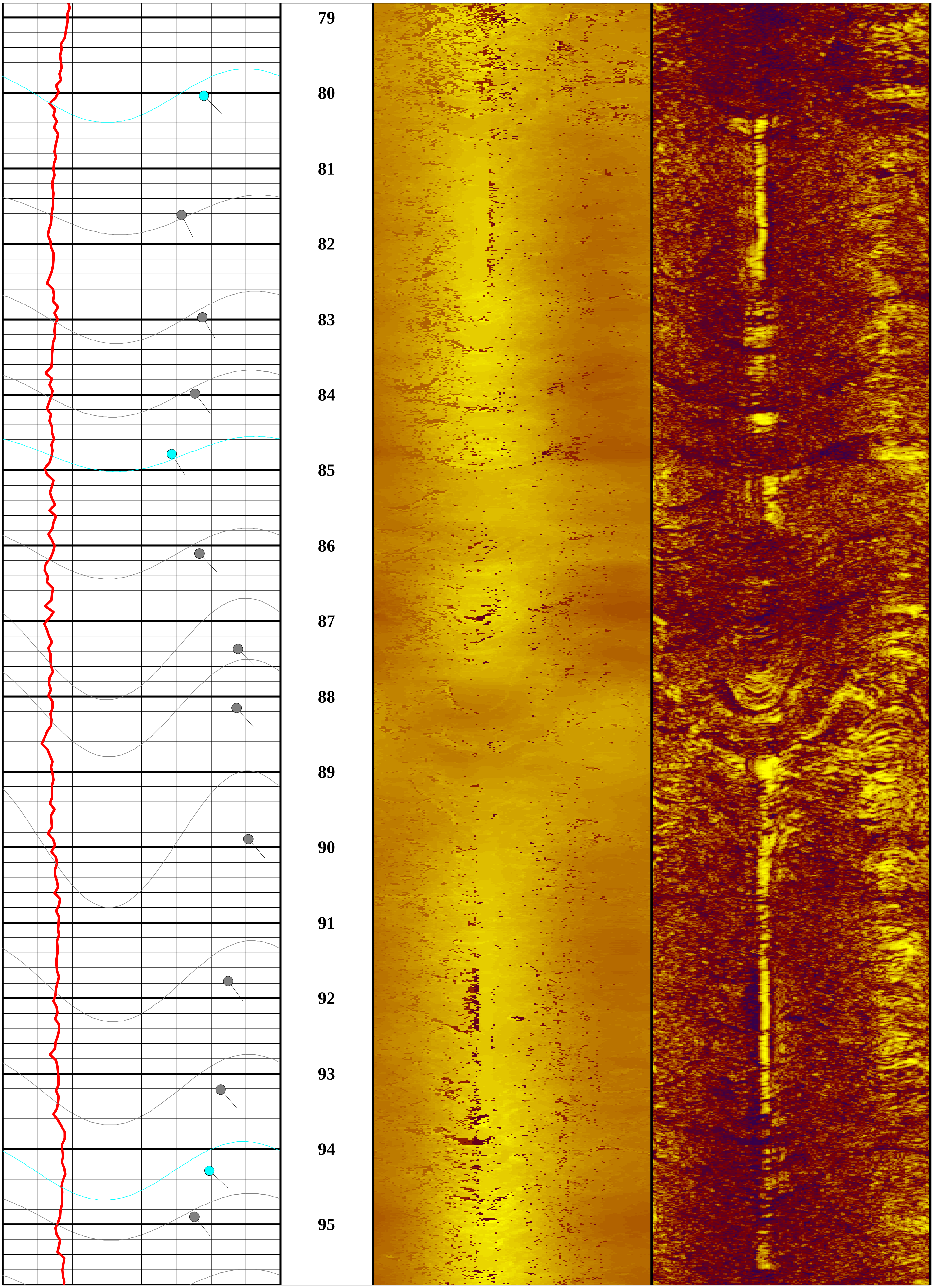
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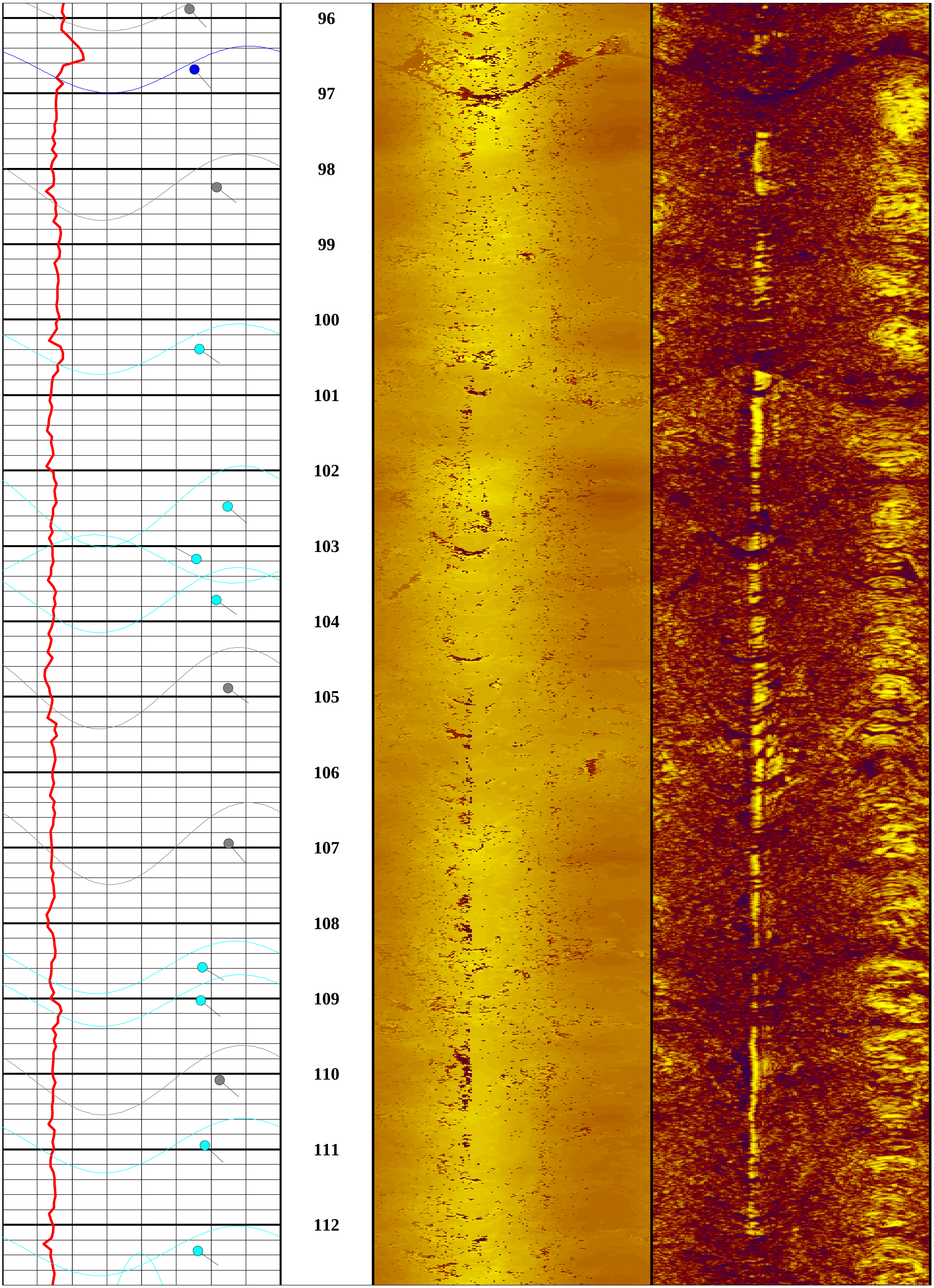
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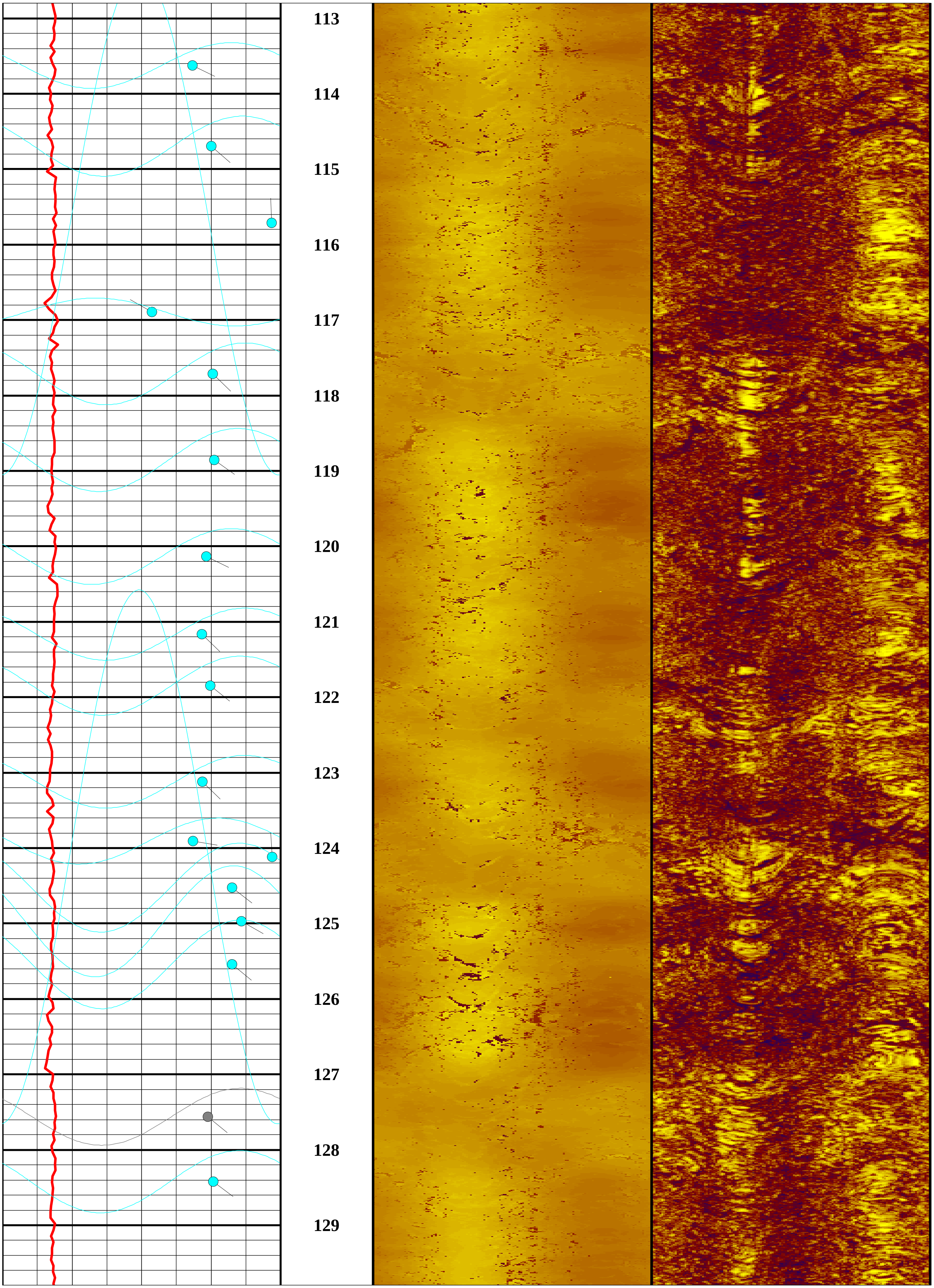
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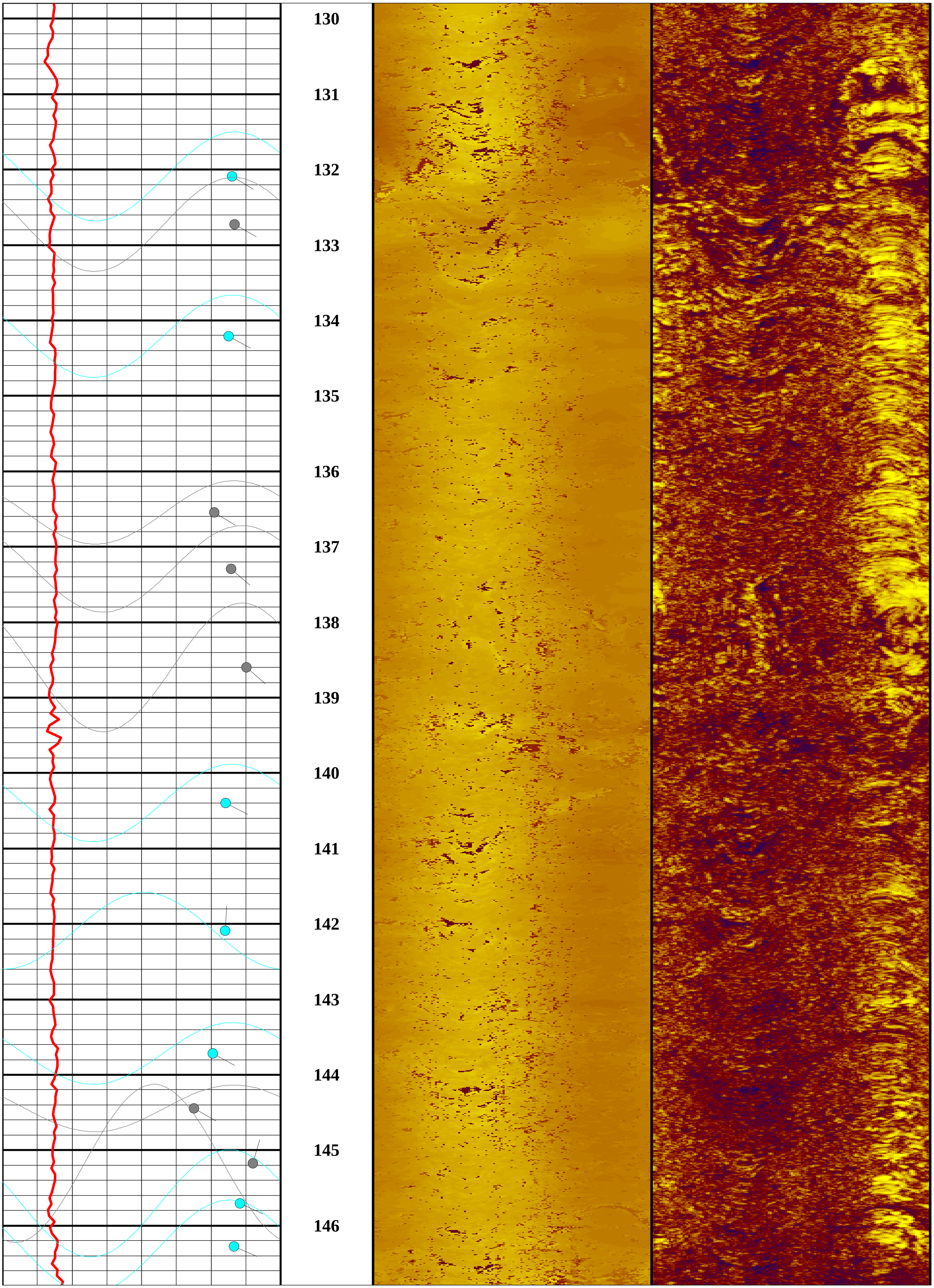
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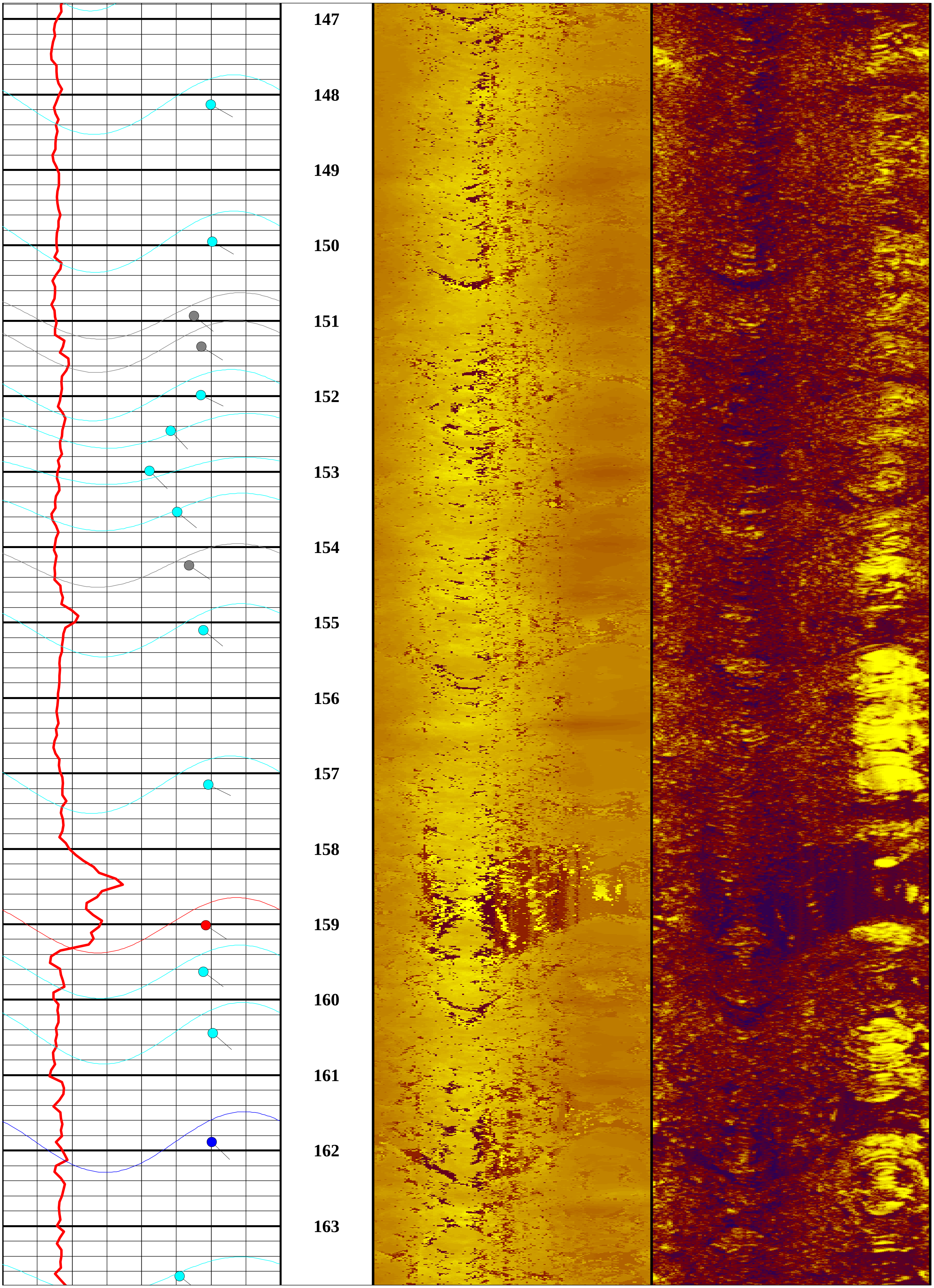
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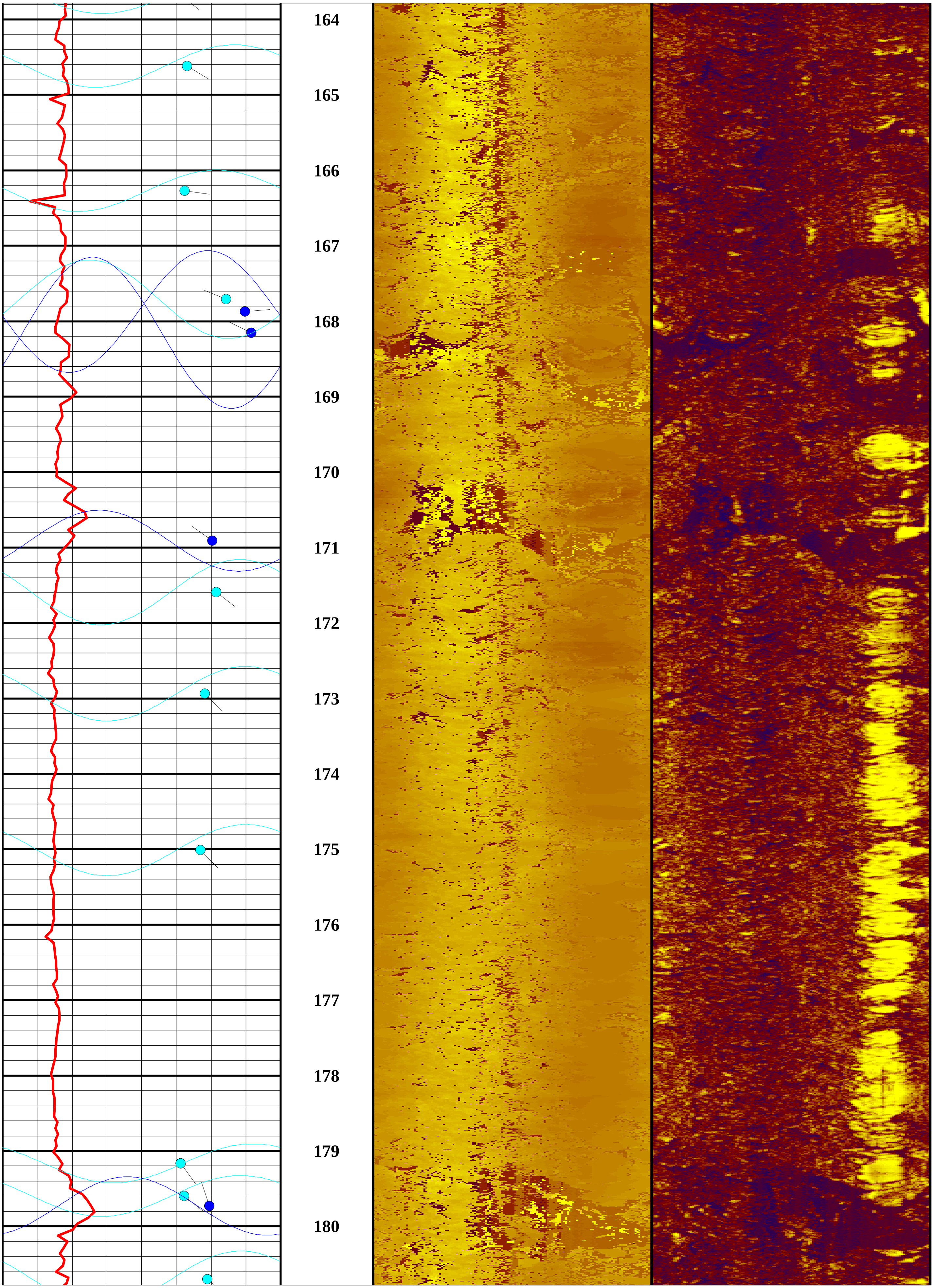
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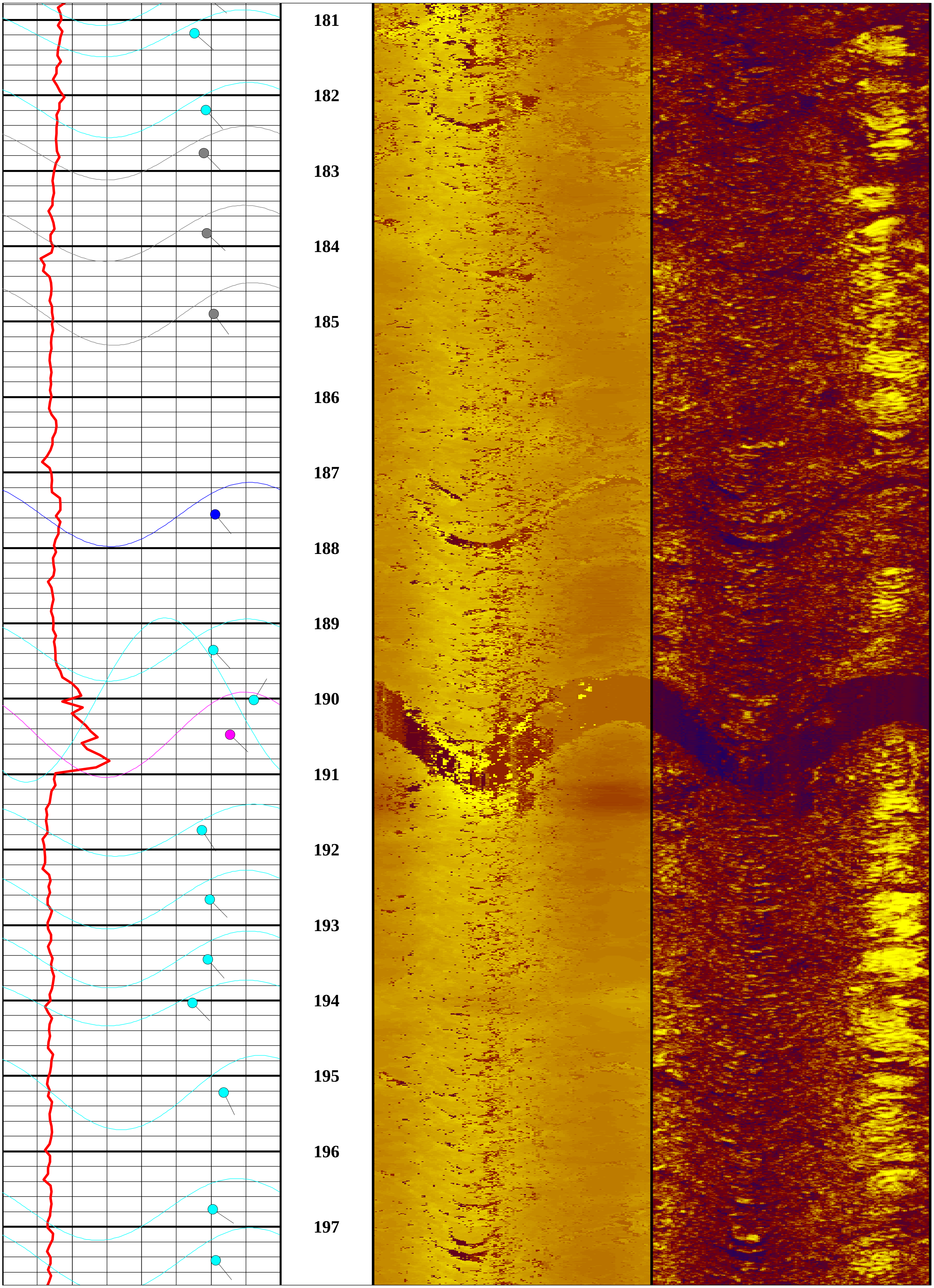
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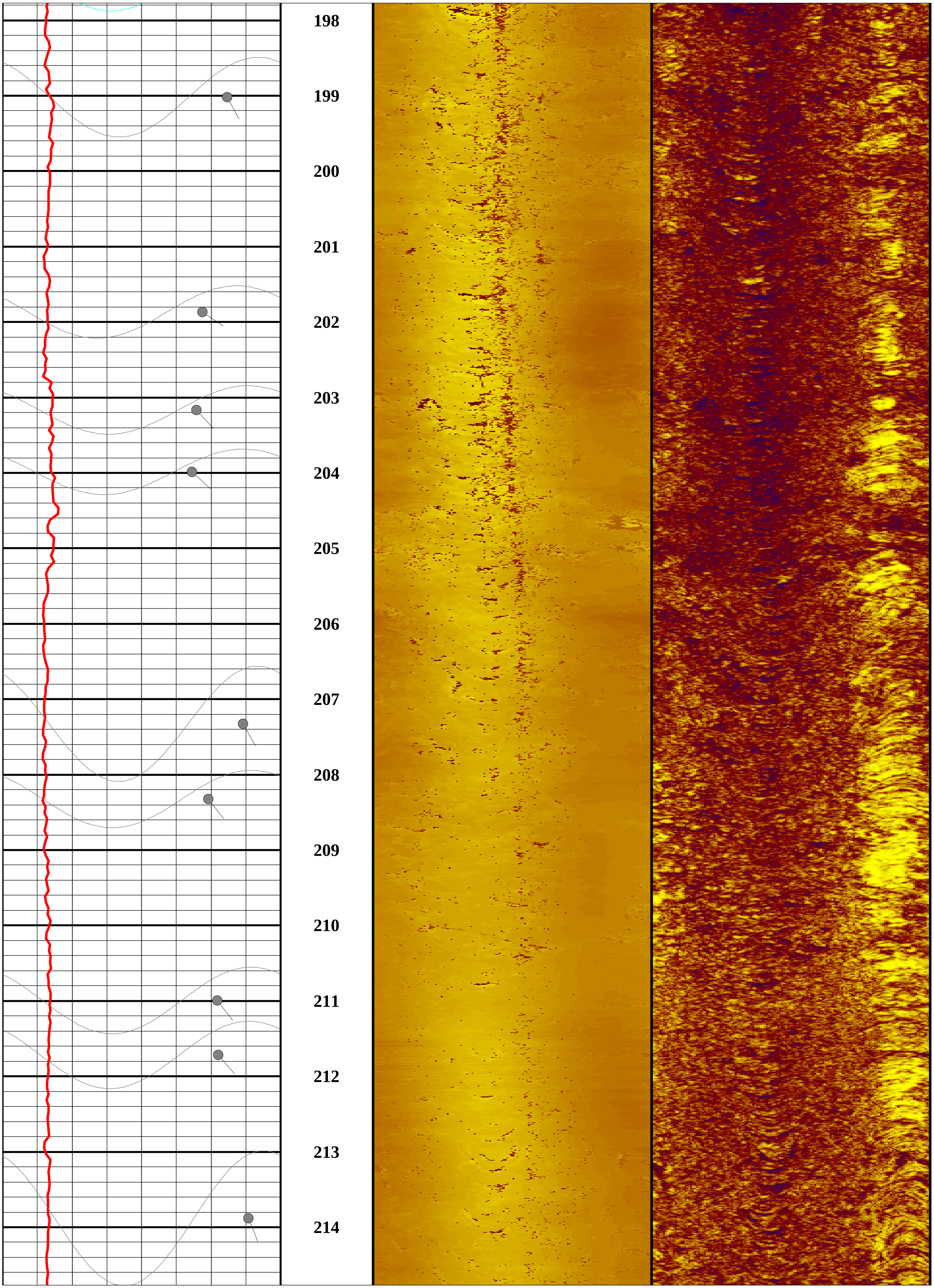
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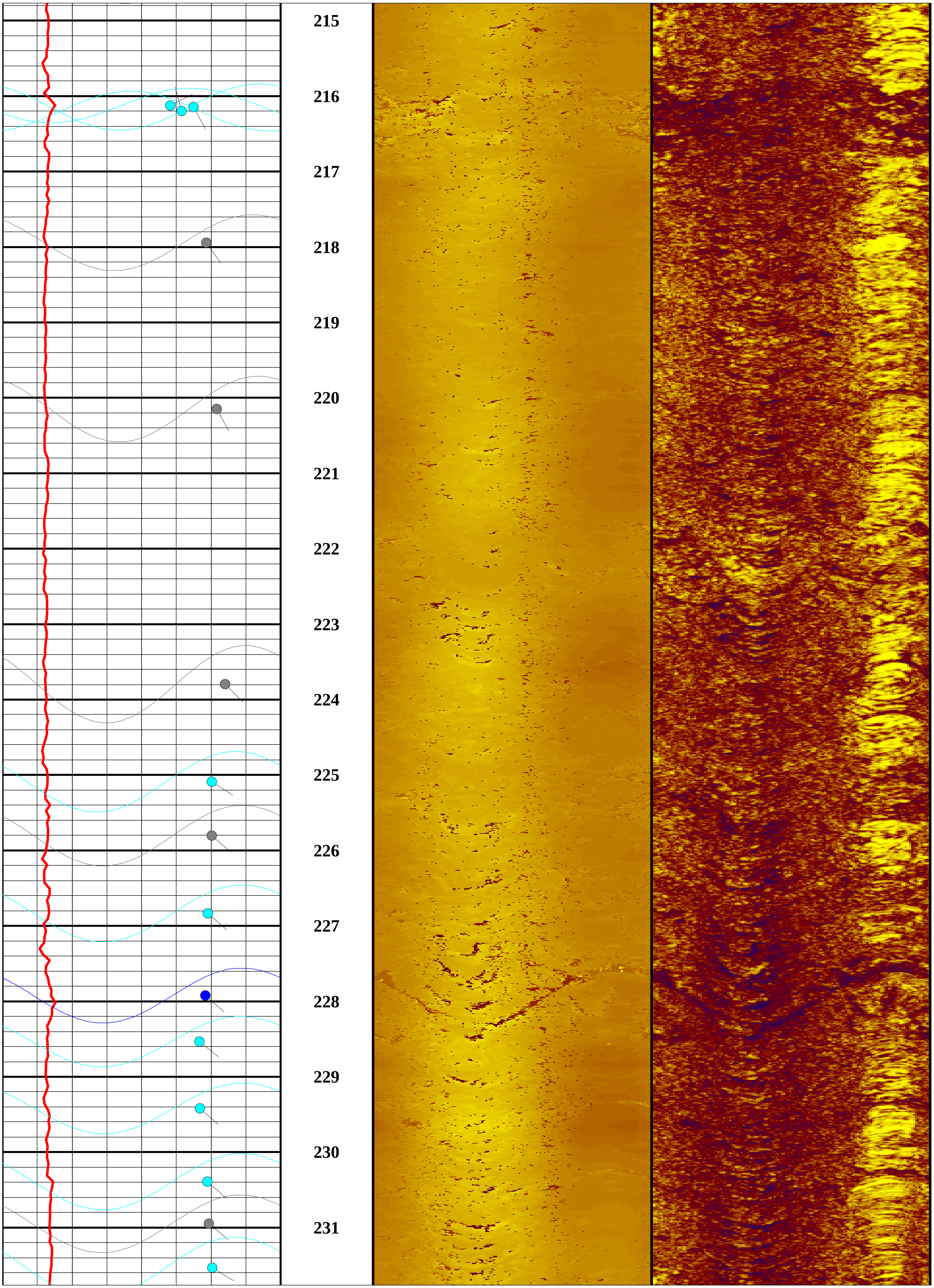
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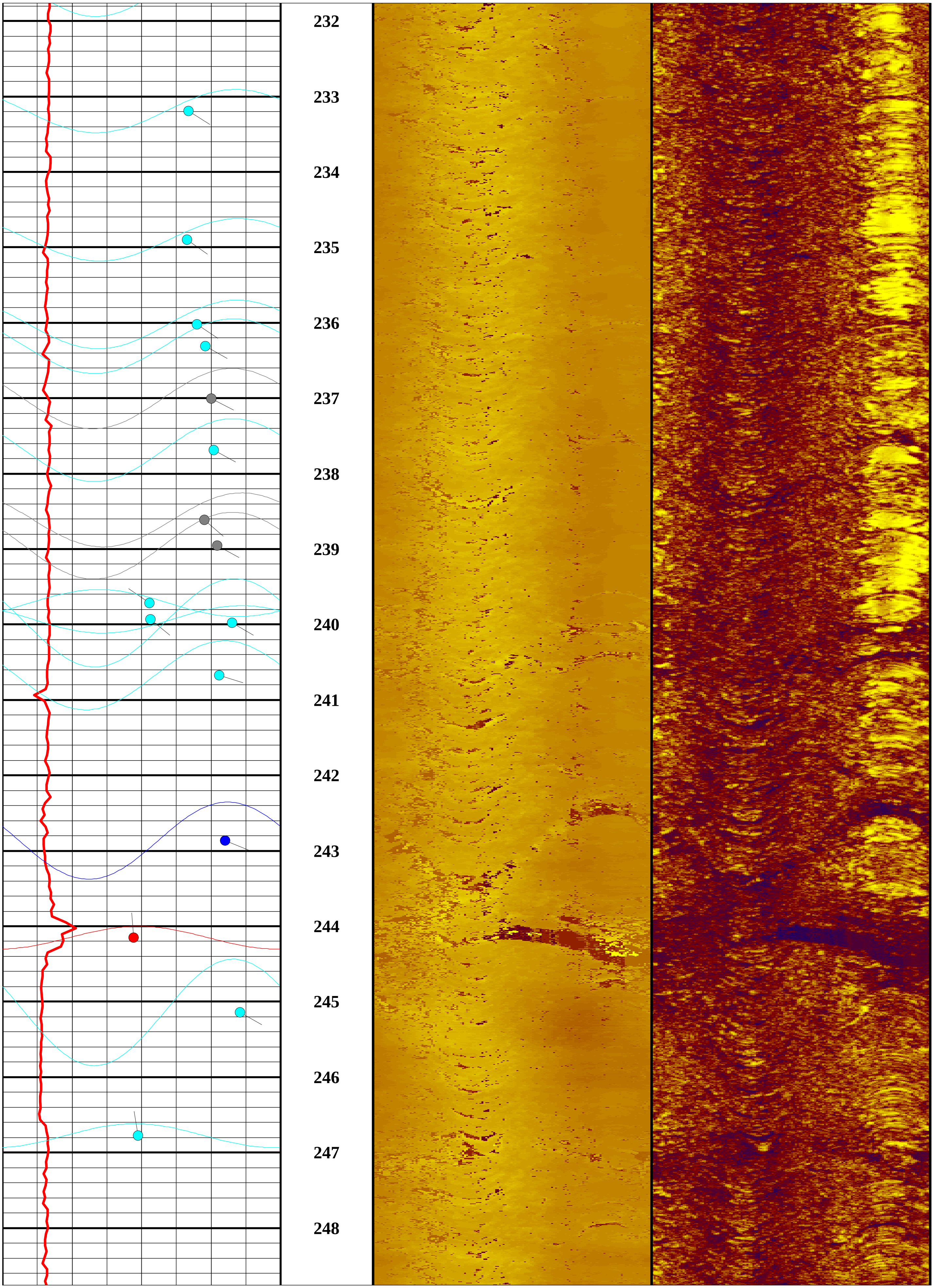
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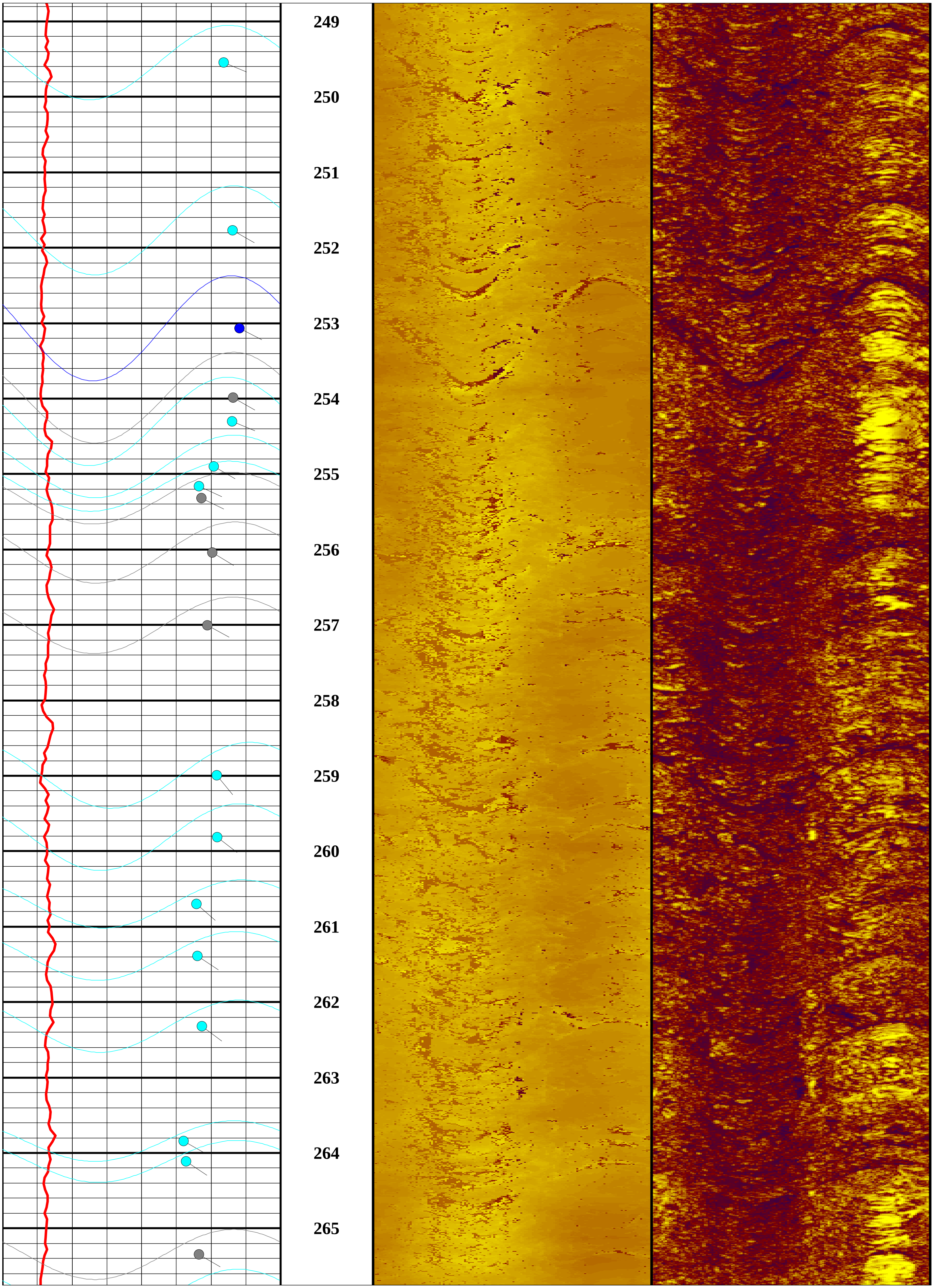

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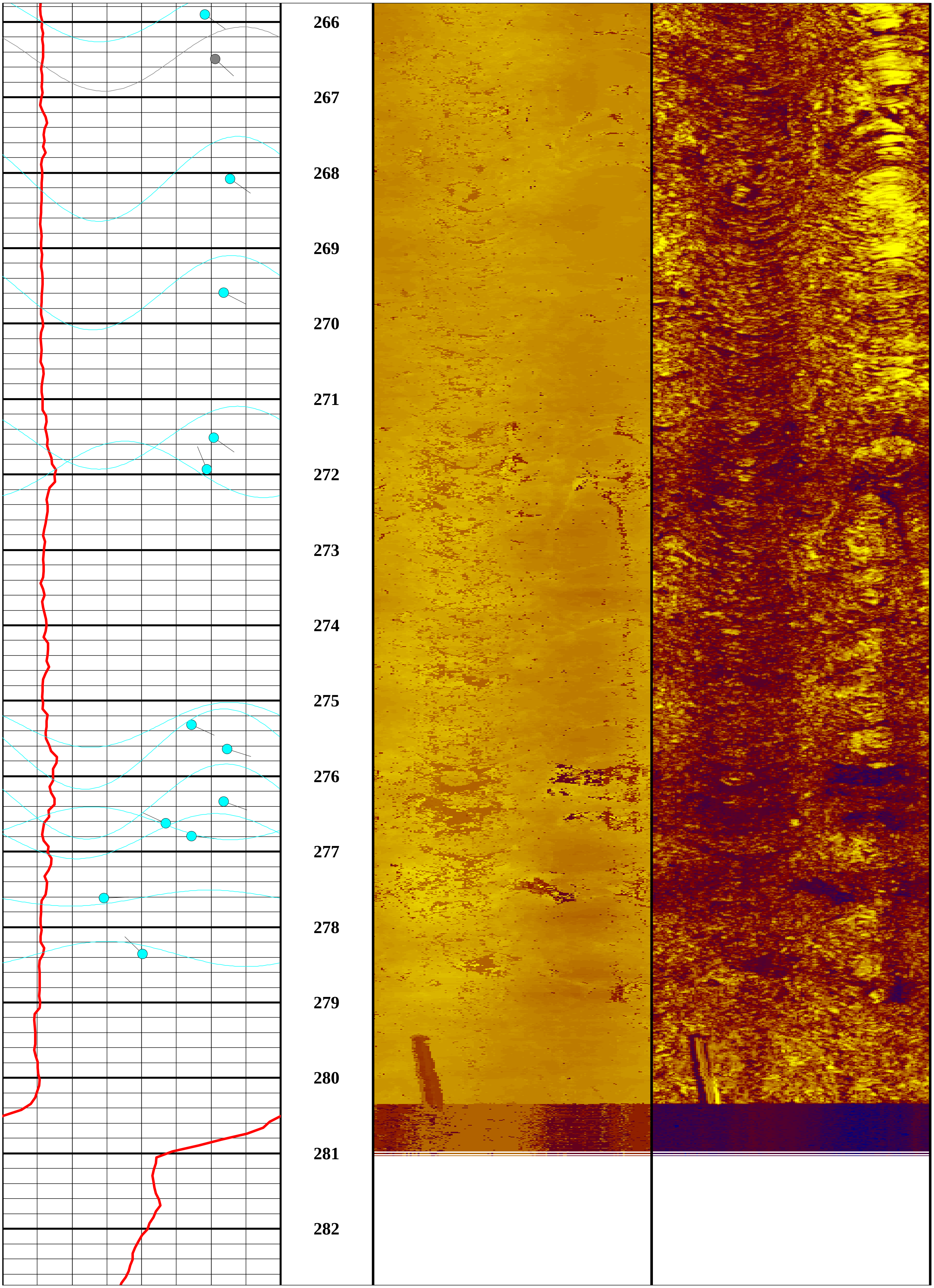
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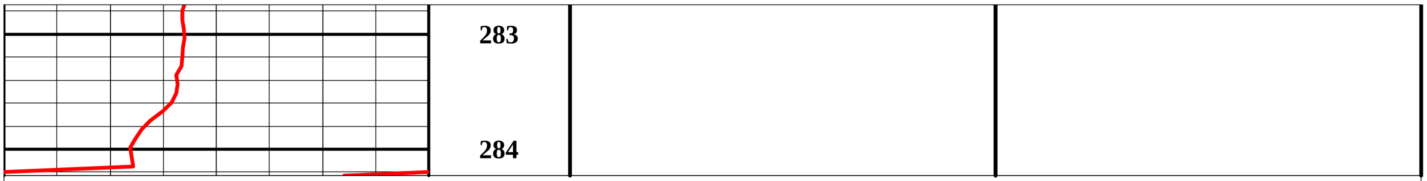

Projections

0° 90° 180° 270° 0°

Tadpoles

0 90

3-Arm Caliper

5 inches 13

Depth

1ft:20ft

Travel Time - True North

0° 90° 180° 270° 0°

Acoustic Amplitude

0° 90° 180° 270° 0°

Figure DW-2:5. Rose Diagram of Optical Televiewer Features
Weston Solutions
MEFUDS; LO-58
Wellbore: DW-2
May 8, 2008

Dip Direction

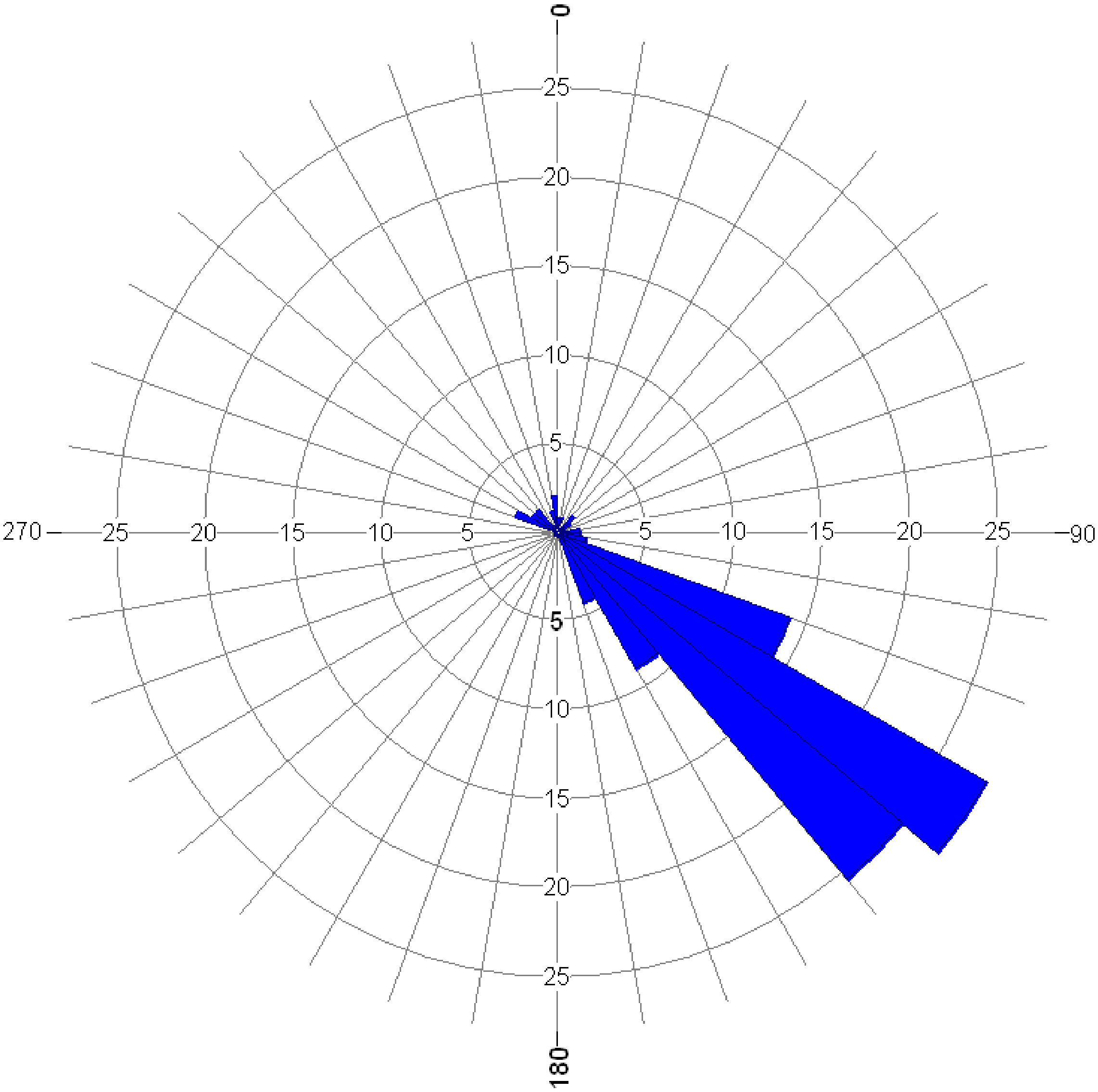

Figure DW-2:6. Rose Diagram of Optical Televiewer Features
Weston Solutions
MEFUDS; LO-58
Wellbore: DW-2
May 8, 2008

Dip Angles

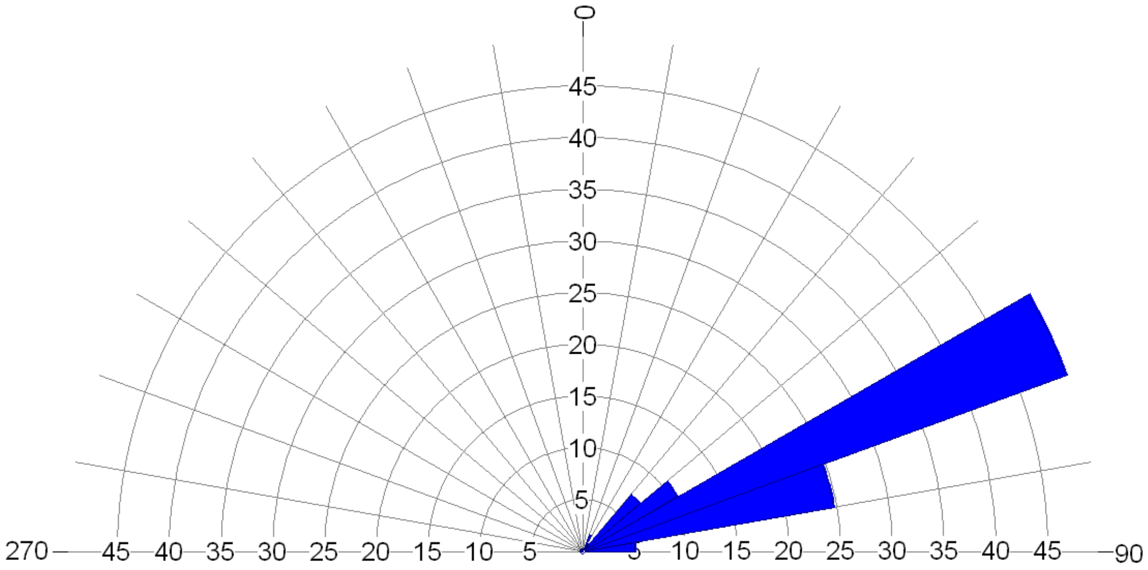

Figure DW-2:7. Stereonet of Optical Televiewer Features
Weston Solutions
MEFUDS; LO-58
Wellbore: DW-2
May 8, 2008

Schmidt Projection with Contours

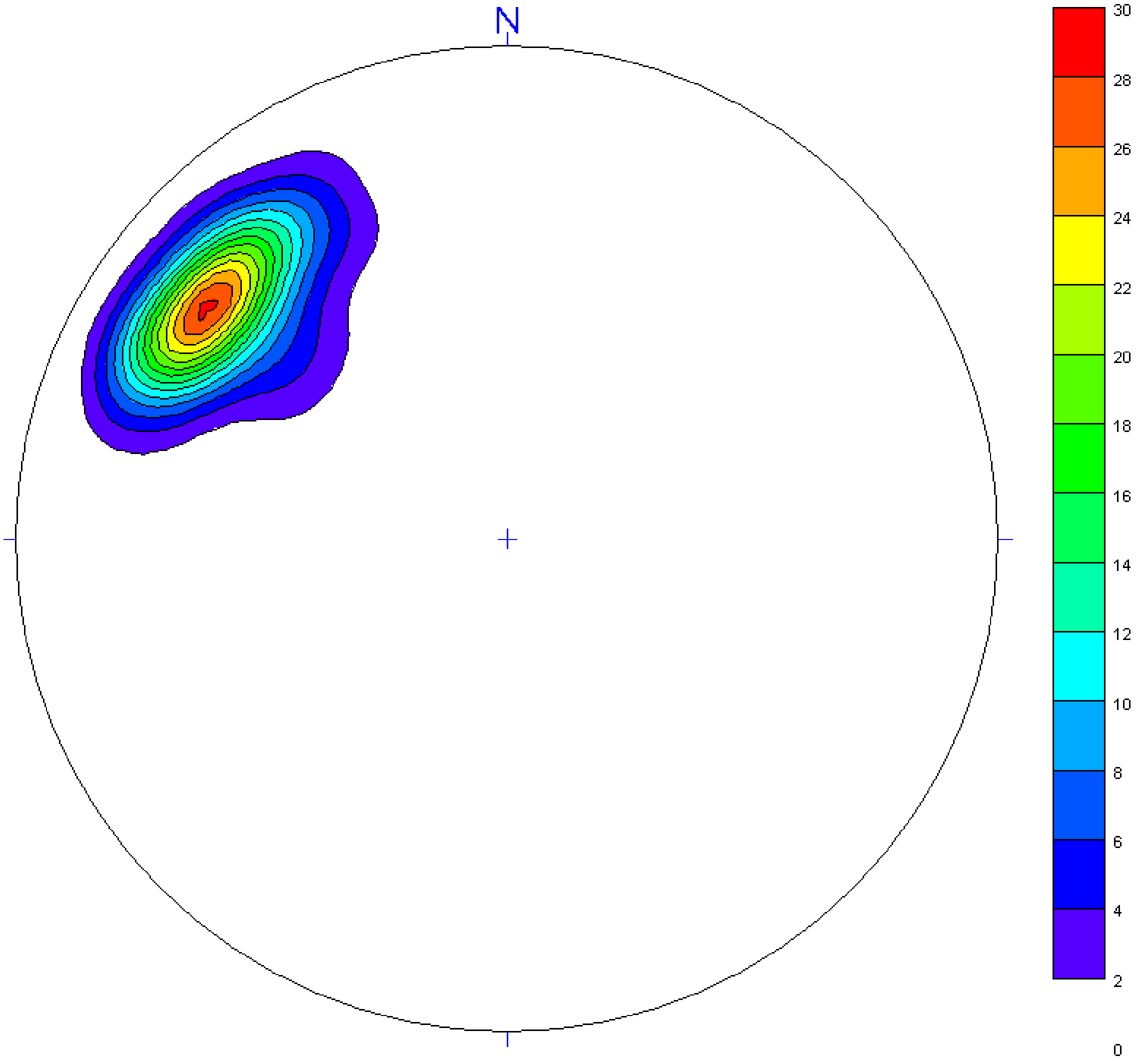

Figure DW-2:8. Stereonet of Optical Televiewer Features
Weston Solutions
MEFUDS; LO-58
Wellbore: DW-2
May 8, 2008

Schmidt Projection with Feature Ranks

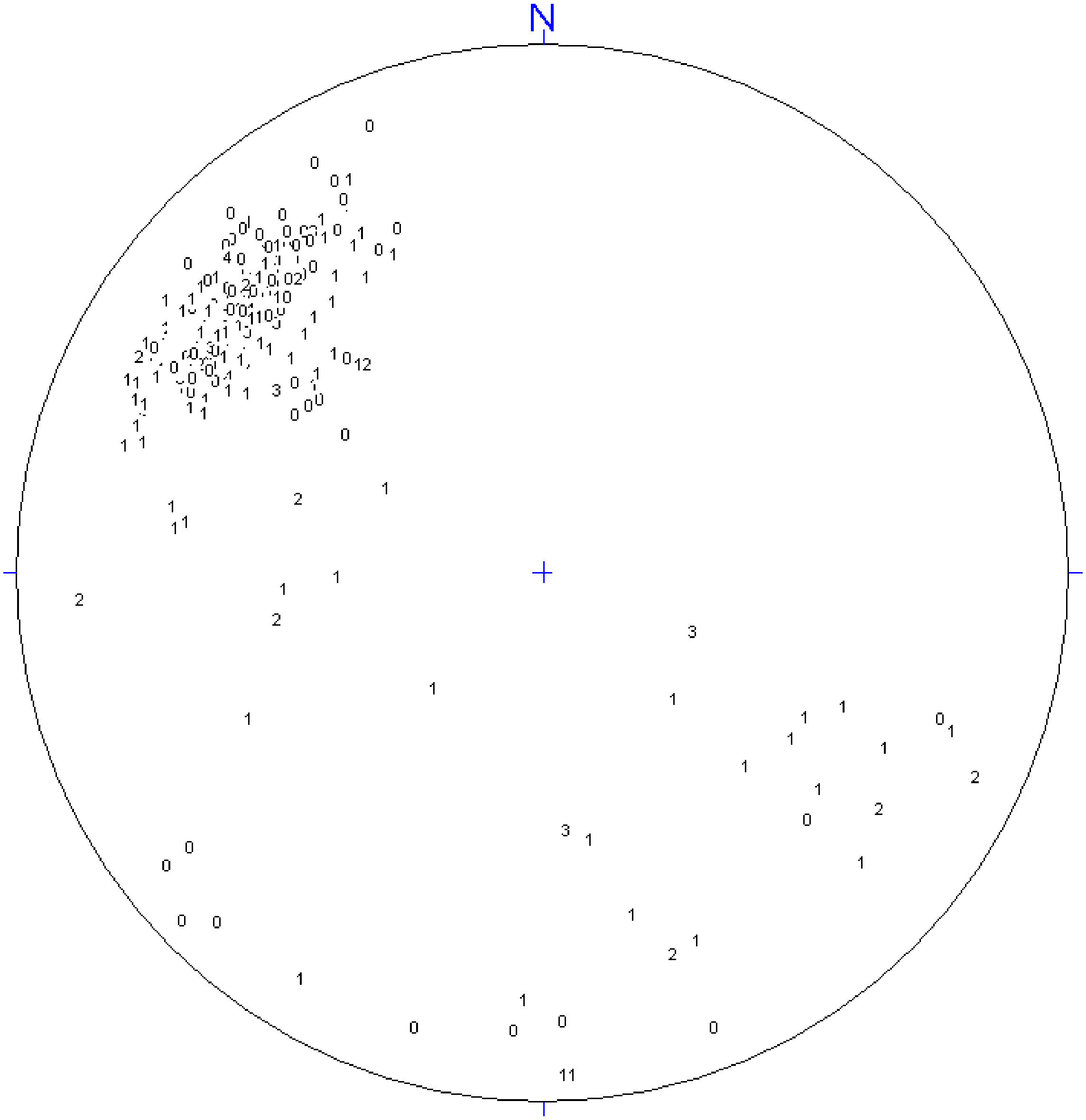

Table DW-2:2. Orientation Summary Table
Image Features
Weston Solutions
LO-58;
Wellbore: DW-2
May 8, 2008

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
1	4.40	14.4	118	75	1
2	4.97	16.3	129	53	1
3	5.18	17.0	132	59	0
4	5.22	17.1	309	57	1
5	5.32	17.5	126	45	0
6	5.54	18.2	124	46	0
7	5.74	18.8	137	44	1
8	5.84	19.2	121	47	0
9	6.07	19.9	120	56	1
10	7.01	23.0	123	38	0
11	7.56	24.8	118	69	1
12	7.94	26.0	124	63	1
13	8.61	28.3	126	73	1
14	9.14	30.0	120	66	2
15	9.47	31.1	123	52	3
16	9.55	31.3	316	29	1
17	9.81	32.2	43	26	1
18	9.94	32.6	16	81	1
19	10.04	33.0	79	44	2
20	10.34	33.9	138	43	2
21	10.57	34.7	105	41	2
22	10.88	35.7	85	42	1
23	11.04	36.2	136	46	0
24	11.32	37.2	291	70	0
25	11.48	37.7	130	57	1
26	11.70	38.4	116	28	1
27	12.09	39.7	124	59	0
28	12.44	40.8	131	64	2
29	12.82	42.1	137	54	1
30	13.19	43.3	128	47	1
31	13.33	43.7	126	50	0
32	13.79	45.2	294	25	3
33	14.04	46.1	124	65	1
34	14.51	47.6	43	82	0
35	14.93	49.0	134	70	1
36	15.23	50.0	127	67	1
37	15.53	50.9	127	66	2
38	15.91	52.2	358	76	0
39	16.24	53.3	134	54	1
40	16.43	53.9	4	78	0
41	16.63	54.6	128	68	1
42	16.84	55.3	52	76	0
43	17.02	55.9	122	75	1
44	17.09	56.1	141	55	1

All directions are with respect to true north (magnatic declination 20W).

Table DW-2:2. Orientation Summary Table
Image Features
Weston Solutions
LO-58;
Wellbore: DW-2
May 8, 2008

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
45	17.24	56.6	154	56	1
46	17.46	57.3	149	61	1
47	17.65	57.9	147	68	1
48	17.70	58.1	52	82	0
49	18.30	60.1	136	76	0
50	18.49	60.7	125	78	1
51	18.72	61.4	313	72	1
52	18.74	61.5	139	76	1
53	18.94	62.1	314	59	0
54	19.32	63.4	142	68	0
55	19.68	64.6	151	68	1
56	19.79	64.9	340	83	0
57	20.53	67.4	156	60	0
58	20.71	67.9	145	67	3
59	21.49	70.5	46	87	0
60	22.07	72.4	140	70	0
61	23.36	76.6	141	65	1
62	23.75	77.9	134	60	0
63	24.40	80.0	135	65	1
64	24.88	81.6	152	58	0
65	25.29	83.0	148	65	0
66	25.60	84.0	142	62	0
67	25.84	84.8	148	55	1
68	26.25	86.1	136	64	0
69	26.63	87.4	135	76	0
70	26.87	88.2	138	76	0
71	27.40	89.9	138	80	0
72	27.97	91.8	143	73	0
73	28.41	93.2	139	71	0
74	28.74	94.3	132	67	1
75	28.93	94.9	140	62	0
76	29.23	95.9	136	61	0
77	29.47	96.7	139	62	2
78	29.94	98.2	128	70	0
79	30.60	100.4	125	64	1
80	31.24	102.5	131	73	1
81	31.45	103.2	298	63	1
82	31.61	103.7	125	69	1
83	31.97	104.9	126	73	0
84	32.60	107.0	139	73	0
85	33.10	108.6	121	65	1
86	33.23	109.0	129	64	1
87	33.55	110.1	131	70	0
88	33.82	111.0	132	66	1

All directions are with respect to true north (magnatic declination 20W).

Table DW-2:2. Orientation Summary Table
Image Features
Weston Solutions
LO-58;
Wellbore: DW-2
May 8, 2008

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
89	34.24	112.3	124	63	1
90	34.63	113.6	116	62	1
91	34.96	114.7	131	68	1
92	35.27	115.7	358	87	1
93	35.63	116.9	300	48	1
94	35.88	117.7	134	68	1
95	36.23	118.9	125	69	1
96	36.62	120.1	116	66	1
97	36.93	121.2	134	65	1
98	37.14	121.9	128	67	1
99	37.53	123.1	134	65	1
100	37.77	123.9	99	62	1
101	37.83	124.1	357	87	1
102	37.95	124.5	127	74	1
103	38.09	125.0	119	77	1
104	38.26	125.5	129	74	1
105	38.88	127.6	128	67	0
106	39.14	128.4	127	68	1
107	40.26	132.1	121	74	1
108	40.46	132.7	119	75	0
109	40.91	134.2	118	73	1
110	41.62	136.6	120	69	0
111	41.85	137.3	130	74	0
112	42.25	138.6	130	79	0
113	42.79	140.4	117	72	1
114	43.31	142.1	3	72	1
115	43.81	143.7	118	68	1
116	44.03	144.4	119	62	0
117	44.25	145.2	16	81	0
118	44.41	145.7	114	77	1
119	44.59	146.3	114	75	1
120	45.15	148.1	119	67	1
121	45.70	150.0	120	68	1
122	46.01	150.9	128	62	0
123	46.13	151.4	121	64	0
124	46.32	152.0	116	64	1
125	46.47	152.5	137	55	1
126	46.63	153.0	135	48	1
127	46.80	153.5	129	57	1
128	47.01	154.2	124	60	0
129	47.27	155.1	130	65	1
130	47.90	157.2	116	67	1
131	48.47	159.0	123	66	3
132	48.66	159.6	127	65	1

All directions are with respect to true north (magnatic declination 20W).

Table DW-2:2. Orientation Summary Table
Image Features
Weston Solutions
LO-58;
Wellbore: DW-2
May 8, 2008

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
133	48.90	160.4	131	68	1
134	49.34	161.9	133	68	2
135	49.89	163.7	128	57	1
136	50.18	164.6	120	60	1
137	50.68	166.3	97	59	1
138	51.12	167.7	292	73	1
139	51.17	167.9	86	79	2
140	51.25	168.2	296	81	2
141	52.09	170.9	306	68	2
142	52.30	171.6	127	69	1
143	52.71	172.9	135	66	1
144	53.34	175.0	135	64	1
145	54.61	179.2	144	58	1
146	54.74	179.6	128	59	1
147	54.78	179.7	342	67	2
148	55.08	180.7	129	66	1
149	55.22	181.2	131	62	1
150	55.53	182.2	138	66	1
151	55.71	182.8	136	65	0
152	56.03	183.8	133	66	0
153	56.36	184.9	144	68	0
154	57.17	187.6	140	69	2
155	57.71	189.4	137	68	1
156	57.92	190.0	31	81	1
157	58.06	190.5	134	74	4
158	58.44	191.7	146	65	1
159	58.72	192.7	135	67	1
160	58.96	193.5	139	67	1
161	59.14	194.0	135	62	1
162	59.50	195.2	153	72	1
163	59.98	196.8	123	68	1
164	60.18	197.5	141	69	1
165	60.66	199.0	151	73	0
166	61.53	201.9	123	65	0
167	61.93	203.2	138	63	0
168	62.18	204.0	132	61	0
169	63.19	207.3	150	78	0
170	63.50	208.3	142	67	0
171	64.31	211.0	142	70	0
172	64.53	211.7	139	70	0
173	65.19	213.9	158	80	0
174	65.87	216.1	63	54	1
175	65.88	216.2	151	62	1
176	65.90	216.2	346	58	1

All directions are with respect to true north (magnatic declination 20W).

Table DW-2:2. Orientation Summary Table
Image Features
Weston Solutions
LO-58;
Wellbore: DW-2
May 8, 2008

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
177	66.43	217.9	144	66	0
178	67.10	220.2	151	69	0
179	68.21	223.8	135	72	0
180	68.61	225.1	122	68	1
181	68.83	225.8	130	68	0
182	69.14	226.8	130	67	1
183	69.47	227.9	130	66	2
184	69.66	228.5	128	64	1
185	69.93	229.4	131	64	1
186	70.22	230.4	130	66	1
187	70.39	231.0	129	67	0
188	70.57	231.5	121	68	1
189	71.08	233.2	121	60	1
190	71.60	234.9	125	60	1
191	71.94	236.0	124	63	1
192	72.03	236.3	119	66	1
193	72.24	237.0	117	68	0
194	72.45	237.7	118	69	1
195	72.73	238.6	130	65	0
196	72.84	239.0	118	70	0
197	73.07	239.7	305	48	1
198	73.13	239.9	130	48	1
199	73.15	240.0	120	74	1
200	73.36	240.7	107	70	1
201	74.02	242.9	111	72	2
202	74.42	244.2	356	42	3
203	74.72	245.1	119	77	1
204	75.22	246.8	351	44	1
205	76.06	249.5	112	72	1
206	76.74	251.8	119	74	1
207	77.14	253.1	117	77	2
208	77.42	254.0	119	75	0
209	77.51	254.3	112	74	1
210	77.69	254.9	120	68	1
211	77.77	255.2	114	64	1
212	77.82	255.3	116	65	0
213	78.04	256.0	121	68	0
214	78.34	257.0	118	66	0
215	78.94	259.0	140	69	1
216	79.19	259.8	127	70	1
217	79.46	260.7	130	63	1
218	79.67	261.4	123	63	1
219	79.96	262.3	126	65	1
220	80.42	263.8	119	59	1

All directions are with respect to true north (magnatic declination 20W).

Table DW-2:2. Orientation Summary Table
Image Features
Weston Solutions
LO-58;
Wellbore: DW-2
May 8, 2008

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
221	80.50	264.1	124	60	1
222	80.88	265.3	120	64	0
223	81.05	265.9	125	66	1
224	81.23	266.5	131	69	0
225	81.71	268.1	125	74	1
226	82.17	269.6	116	72	1
227	82.76	271.5	124	69	1
228	82.88	271.9	338	66	1
229	83.92	275.3	114	61	1
230	84.02	275.6	106	73	1
231	84.23	276.3	109	72	1
232	84.32	276.6	295	53	1
233	84.37	276.8	96	61	1
234	84.62	277.6	87	33	1
235	84.84	278.4	315	45	1

All directions are with respect to true north (magnatic declination 20W).

Table DW-2:3. Summary of Vertical Seismic Profile Results; Weston Solutions; LO-58, Caribou, ME; Wellbore: DW-2

Well	Depth Interval (ftbtoc)	Interval-Specific Velocity (feet/second)	Comments
DW-02	20 - 30	1,789	Signal degraded due to cement vault, asphalt
	35 - 115	10,255	Consistent with highly fractured bedrock
	115 - 185	17,274	Consistent with highly fractured bedrock

Note: P-wave signal degradation is observed in all test stations likely due to the cement vault and backfill arround the steel casing and the asphalt surface. Moreover, seismograms at 195 and 200 feet had too little P-wave seismic energy to estimate velocities.

FIGURE DW-1:9A. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 16.0 to 20.0 Feet; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2

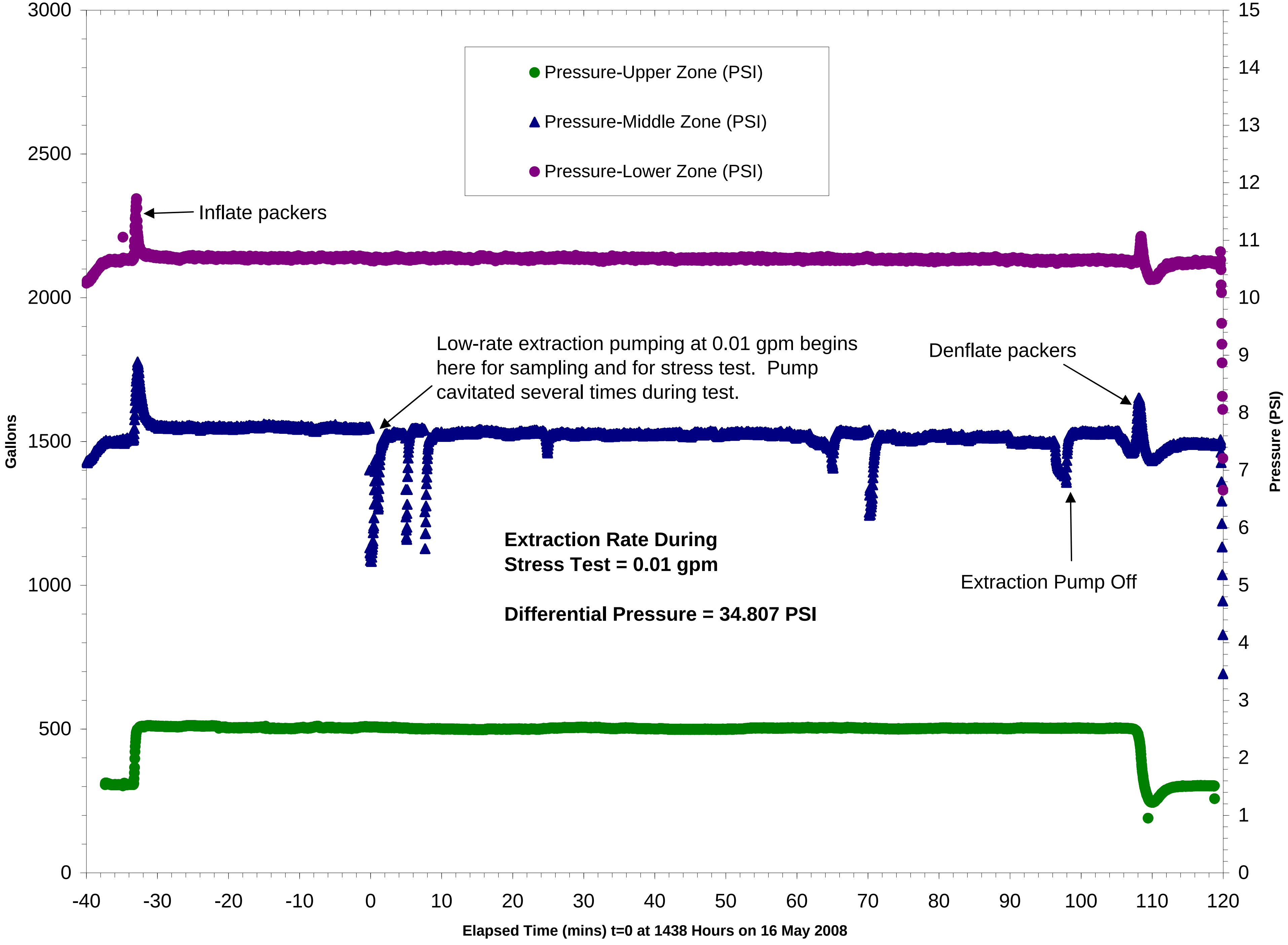

FIGURE DW-1:9B. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 28.5 to 32.5 Feet; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2

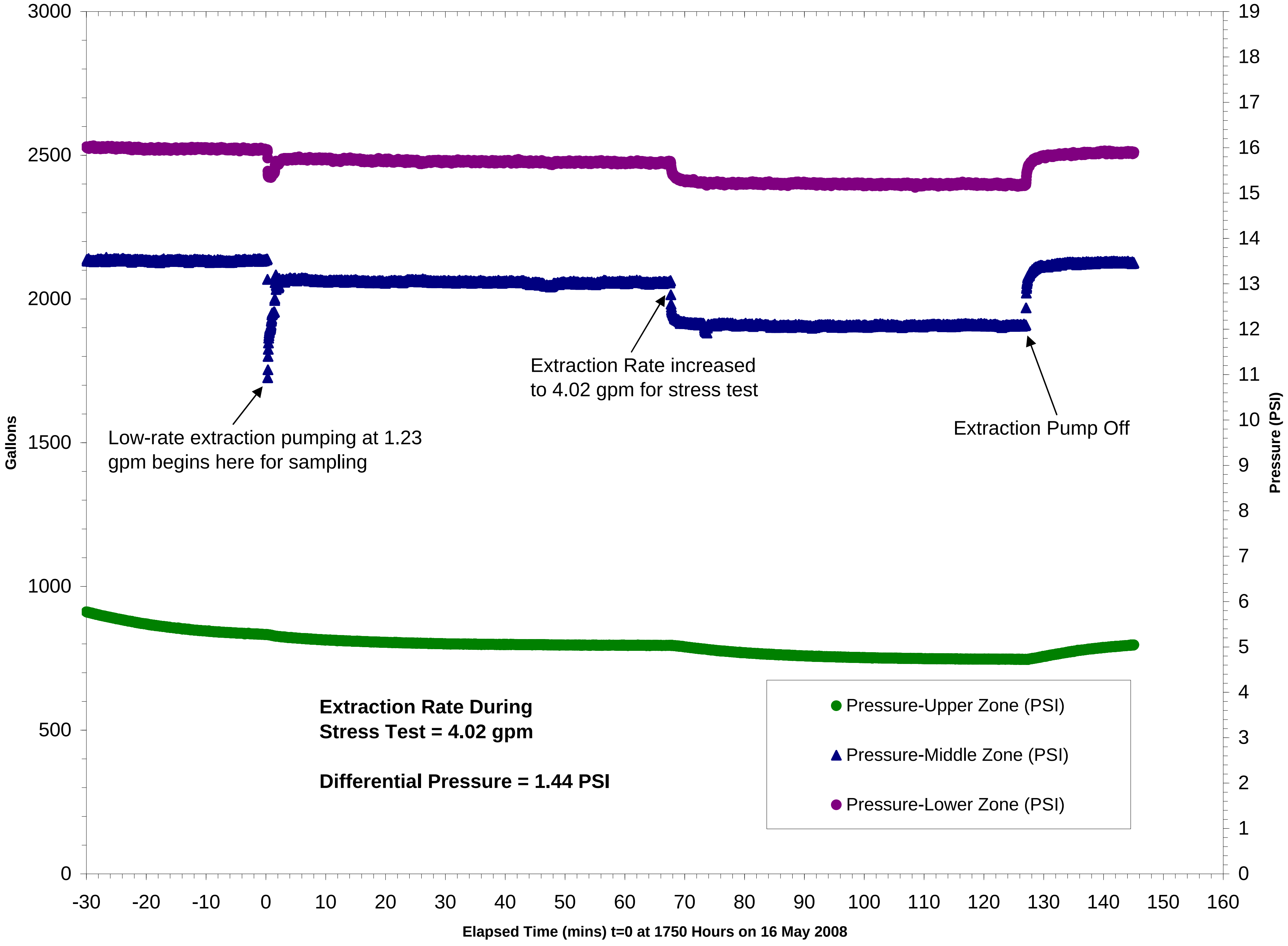

FIGURE DW-1:9C. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 37.0 to 41.7 Feet; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2

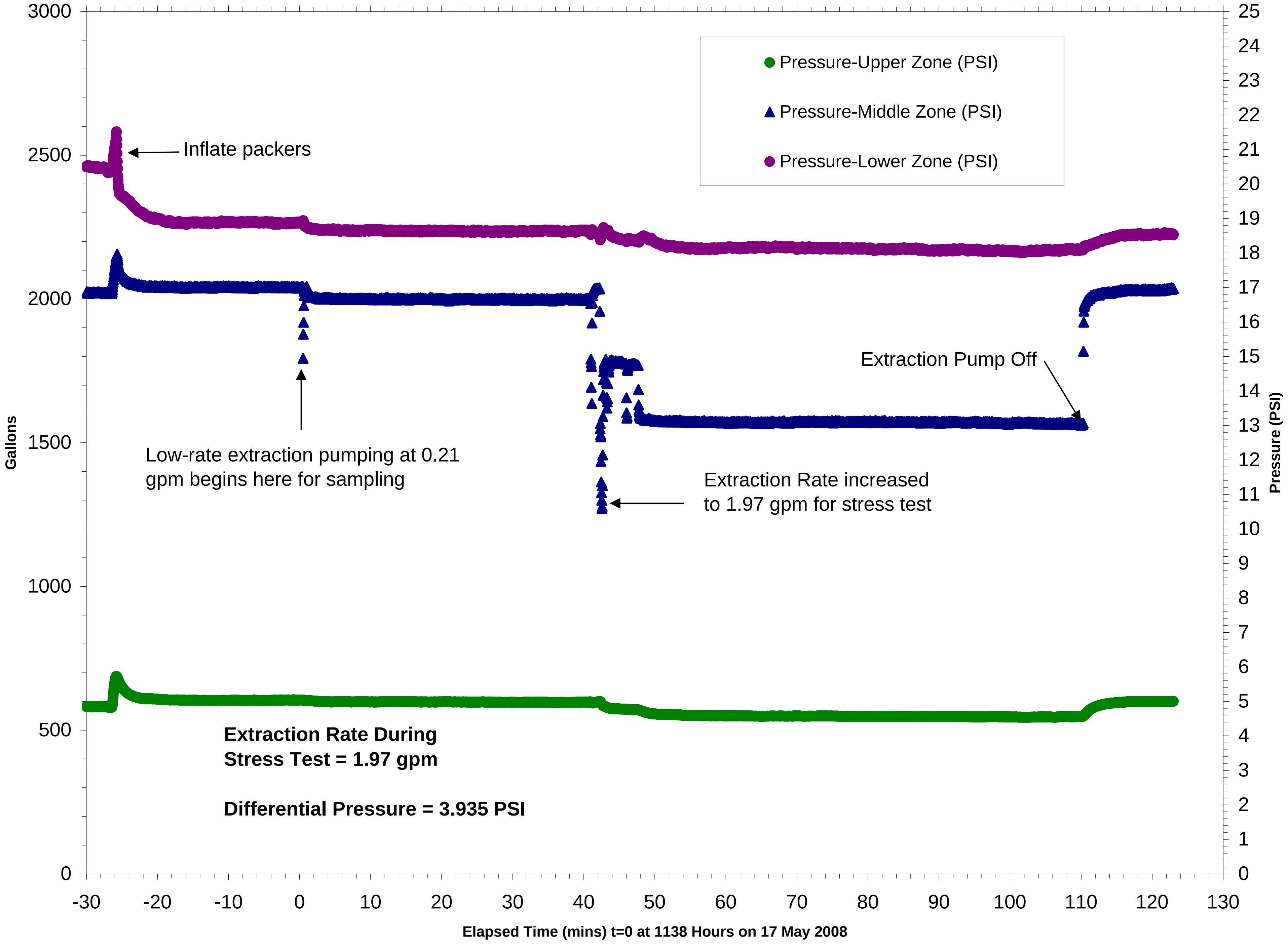

FIGURE DW-1:9D. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 94.5 to 98.5 Feet; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2

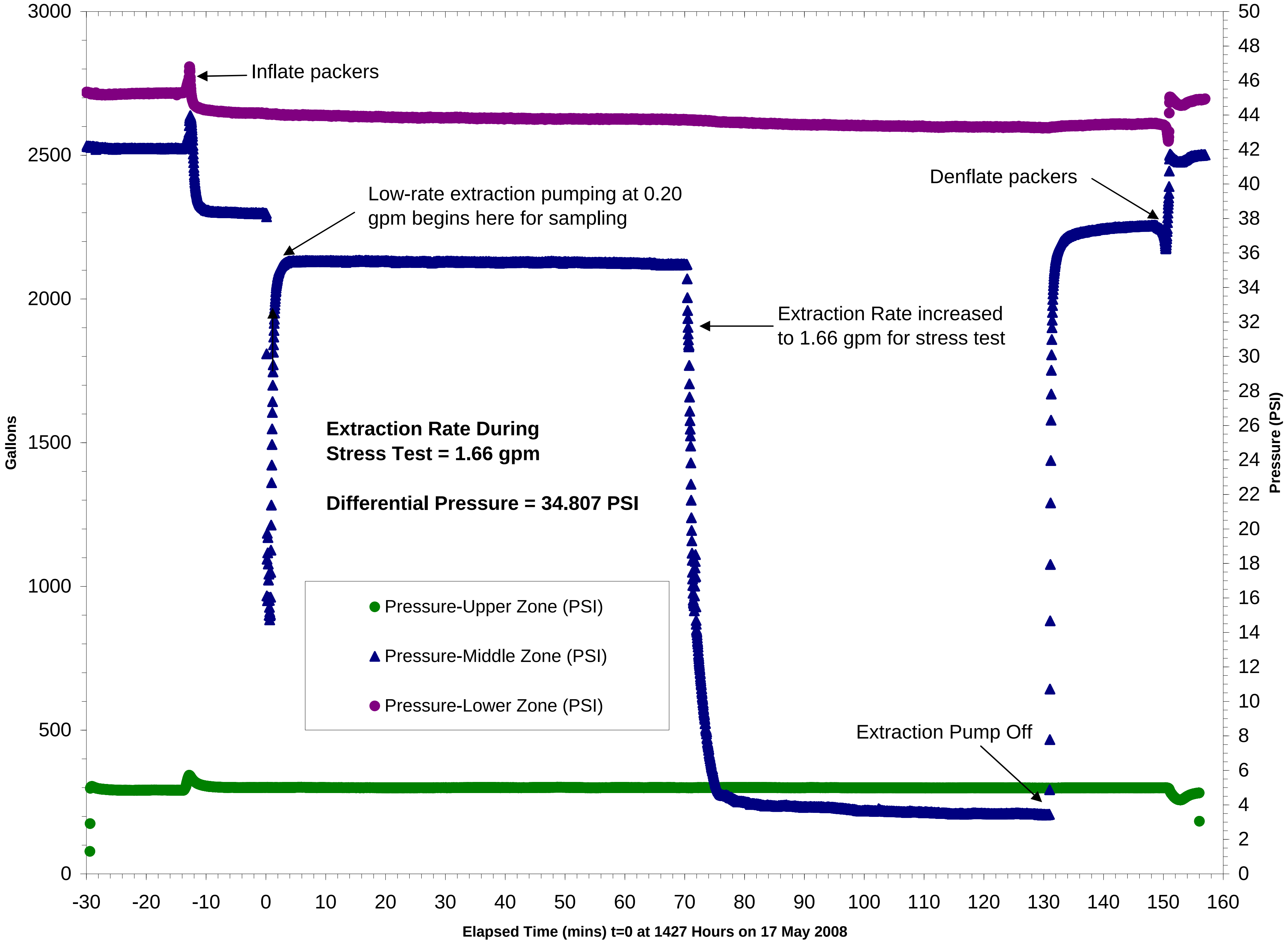

FIGURE DW-1:9E. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 187.9 to 192.2 Feet; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2

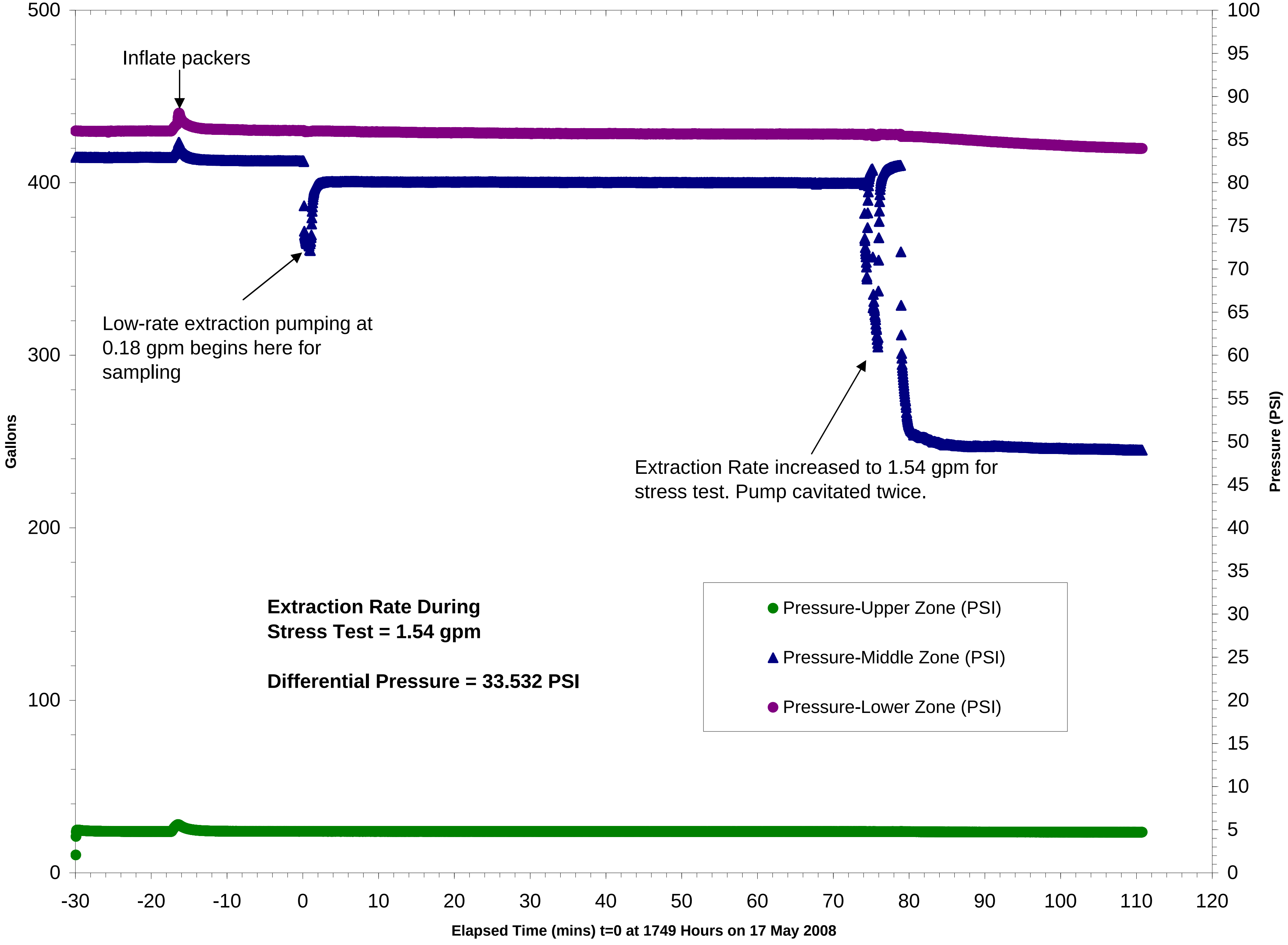

Table DW-2:4. Summary Of Wireline Straddle Packer Testing With Hydraulic Conductivity And Transmissivity Estimations; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2

Well Name	DW-02
Ambient Depth to Water (ftbtoc)	4.94
Diameter of Borehole (ft)	0.52
Effective Radius (ft)	300

Interval No.	Top of Interval (ft)	Bottom of Interval (ft)	Length of Interval (ft)	Differential Pressure (PSI)	Differential Head (feet)[1]	Interval Specific Flow Rate: WSP Stress Test (gpm)	Interval Specific Hydraulic Conductivity[4] (ft/day)	Transmissivity (ft2/day)	Interval Specific Fluid Electrical Conductivity (microS/cm)
1	16.0	20.0	4.0	0.120	0.277	0.01	1.46E+01	5.83E+01	430
2	28.5	32.5	4.0	1.440	3.326	4.02	4.89E+02	1.95E+03	450
3	37.0	41.7	4.7	3.935	9.088	1.97	7.46E+01	3.50E+02	451
4	94.5	98.5	4.0	34.807	80.386	1.66	8.35E+00	3.34E+01	435
5	187.9	192.2	4.3	33.532	77.441	1.54	7.48E+00	3.22E+01	438
6*	265.0	284.0	19.0	56.592	130.697	0.41	2.67E-01	5.07E+00	225

* The reported bottom depth of this interval is the total depth (TD) of the borehole.

[1] Differential Head is the difference between ambient pressure and pumping pressure, converted to feet.

APPENDIX A

STANDARD OPERATING PROCEDURES FOR HYDROPHYSICAL™ LOGGING

Standard Operating Procedures
HydroPhysical™ Logging for Aquifer Characterization

1. Purpose

Application of the HydroPhysical™ (HpL™) logging method to analyze and determine:

- The location of hydraulically conductive intervals within a wellbore
- The interval specific rate of inflow during well production, in conjunction with the drawdown data, can be used to estimate interval specific hydraulic conductivity or transmissivity
- Ambient (non-pumping) flow conditions (inflow and outflow rates, and locations)
- The hydrochemistry (fluid electrical conductivity (FEC) and temperature) of the associated formation waters

In addition, when downhole, discrete point fluid sampling is coupled with the HydroPhysical™ Logging technique, analysis of the actual contaminant concentrations associated with each identified conductive interval is accomplished for any aqueous phase contaminant.

2. Equipment and Materials

This SOP specifically applies to application of the technique using COLOG's HydroPhysical™ Logging Truck 16, which has been specially configured to handle those field conditions associated with small diameter, low-moderate yield wells The maximum capability of the van is to a total depth of 700 ft and 350 ft total drawdown (maximum depth to water) . In the event of high yield wells, the wireline capability of any COLOG truck can be used to accompany fluid management equipment.

- HydroPhysical™ logging truck field equipment includes:

- Fluid management system
  - Back Pressure Regulator or orifices
  - Rubber hose (0.75-inch i.d.) for injection
  - Submersible Pump
  - Evacuation Line
  - Storage tanks (as required) with inlet/outlet valves
  - Surface Pump
  - Fluid management manifold/Monitoring Panel
  - Data Acquisition System (for recording volumes, flow rates, time)
  - Wireline System
  - Wireline winch unit
  - Depth encoder
  - Water level indicator
  - Computer System

    - HydroPhysical™ Logging tool
    - Downhole Fluid Sampler
- Deionizing Units
- Deionized water (prepared with wellbore fluids or transported on-site)
- Standard Reference Solutions - Electrical conductivity reference solutions (set of 3 solutions).

3. Procedures

1.) Review well construction details and complete general well information sheet. The HydroPhysical™ logging technique involves dilution of the wellbore fluids with DI water and profiling of the wellbore dynamics using a HydroPhysical™ logging tool. Significant aberrations or reductions in the borehole diameter should be identified as the downhole equipment can become lodged in the borehole. Additionally, application of the technique requires certain wellbore conditions:

- In open bedrock boreholes, casing must be installed through the overburden and grouted at the rock/alluvium interface to inhibit water leakage into the borehole from the saturated alluvium. For cased boreholes, the well should be fully cased and gravel packed with single or multiple screened intervals;
- The diameter of the borehole must be approximately 4 inches or greater for application with the slim-tool (1.5-inch o.d.). Two inch i.d. boreholes may be tested using the slug test approach described in Section 5.
- For newly drilled wells, cuttings and drill fluids must be removed from the affected fractures by standard well development procedures.

2.) Review and record additional wellbore construction/site details and fill out the general well information form which includes the following information:

- Ambient depth-to-water
- Depth of casing
- Total depth of well
- Lithology (if available)
- Estimated well yield and any available drawdown data
- Type and concentration of contamination

3.) Prepare the deionized (DI) water. Consult with DI water tank firm for assistance if necessary. If DI water has not been transported to the site, surface or groundwater may be used if it is of suitable quality Generally source water containing less than 1000 micro Siemens per centimeter (µS/cm) and less then 200 ppb VOCs will not significantly affect the deionizing units, but this should be confirmed with DI water firm. If the groundwater from the well under construction cannot be used for DI water generation, then DI water must be transported to the site and containerized at the wellhead.

Depending on the amount of HydroPhysical™ testing to be performed (ambient and/or during production) the typical volume of DI water required for each borehole is approximately three times the volume of the standing column of formation water in the wellbore per type of HydroPhysical™ characterization.

If preparation takes place on site, pump the source water through a pre-filter, to the deionizing units, and into the storage tanks.

Monitor the FEC of the DI water in-line to verify homogeneity; the target value is 5 to 25 µS/cm.

4.) Calibrate the HydroPhysical™ logging tool using standard solutions prepared and certified by a qualified chemical supply manufacturer. Fill out tool calibration form following the steps defined in the software program, "tools" under the directory, calibration. Also use a separate field temperature / FEC / pH meter to support calibration data. Record the results of the tool calibrations, specifically noting any problems on the tool calibration form. Also record the certification number of the standard solutions.

5.) Set datum on the depth encoder with the FEC sensor on the tool as 0 depth at the top of casing. If inadequate space is available at the wellhead, measure 10 feet from the FEC sensor up the cable (using measuring tape) and reference with a wrap of electrical tape. Lower the tool down the hole to the point where the tape equals the elevation at the top of the casing and reference that as 10 feet depth on the depth encoder.

6.) Place the top of the tool approximately 3 feet below the free-water surface to allow it to achieve thermal equilibrium. Monitor the temperature output until thermal stabilization is observed at approximately ± .02 °C.

7.) After thermal stabilization of the logging tool is observed, log the ambient conditions of the wellbore (temperature and FEC). Fill out the water quality log form. During the logging run, the data are plotted in real time in log format on the computer screen and, the data string is simultaneously recorded on the hard drive.

Log the ambient fluid conditions in both directions (i.e. record down and up). The ideal logging speed is 5 feet per minute (fpm). For deeper wells the logging speed can be adjusted higher, but the fpm should not exceed 20.

At completion of the ambient log, place the tool approximately 10 feet below the free water surface. The tool will remain there during equipment set up as long as borehole conditions permit. Establish and record ambient depth to water using top of protective casing as datum.

8.) Attach back pressure regulator or orifice, if used, and weighted boot, to end of emplacement line and secure. Insure that the injection line is of adequate length to reach the bottom of the wellbore.

9.) Lower the flexible emplacement line to the bottom of the well allowing one foot of clearance from the well bottom to the outlet of the injection line.

10.) Lower tool about 10 feet below the water surface. The tool will be stationed beneath the submersible pump during non-logging times.

11.) Lower submersible pump in the well to a depth just above the logging tool. Record approximate depth of the pump location.

12.) Record all initial readings of gauges at elapsed time 0.0 minutes. Fill out well testing data form.

13.) Mark hoses with a round of electrical tape for reference. In addition, establish datum for tool depth to the nearest foot and mark on wire with wrap of tape. Reset datum on optical encoder for this depth.

14.) When ambient flow characterization is to be conducted, it should be done now, before disturbing the aquifer (i.e. by pumping). Fill out ambient flow characterization (AFC) form. Skip to Section 17 for procedures.

15.) After AFC, if performed, conduct a controlled, short term well production test (pump test) to characterize the overall hydraulics of the wellbore (drawdown at given pumping rate provides total well transmissivity or yield) and to make an initial assessment of formation water hydrochemistry. Begin pumping at a total extraction flow rate appropriate for wellbore under investigation (see Section 4 Special Notes). During this period, record elapsed time of pumping, depth to water, total gallons extracted, and extraction flow rate at approximately one minute intervals.

During extraction, log the fluid column continuously until at least three wellbore volumes have been extracted from the wellbore, or a stabilized water level elevation is obtained.

Review fluid logging results to verify that true formation water is present within the affected borehole interval and that the vertical distribution of water quality parameters within this interval is stable.

16.) Review data obtained during the pumping test to determine DI water emplacement and pumping/logging procedures. Extraction procedures for detection and characterization of hydraulically conductive intervals and the formation water hydrochemistry are determined based on the pumping test information. The emplacement, testing and pumping procedures will differ depending upon well yield and determined lengths of intervals of interest. In wellbore situations where intervals of interest are small (less than 30 feet) and hydraulic characteristics observed during borehole advancement and preliminary hydraulic testing indicate hydraulically conductive intervals with extremely low flow rates (i.e. <0.10 gpm/foot of drawdown), a slug testing procedure can be employed. In wellbore cases where the preliminary hydraulic testing indicates low to moderate total yield (i.e. 0.10 < Q < 4 gpm/foot of drawdown), constant low flow rate pumping after DI water emplacement procedures can be employed. In wellbore situations where intervals of interest are large, and high total yield (i.e. > 4 gpm/foot of drawdown) is observed, constant pumping during DI water injection procedures will be employed.

17.) When the fluid column is to be replaced with DI water, (vertical flow characterization, slug testing, logging during pumping after DI water emplacement) the following emplacement procedures apply:

Pump the DI water to the bottom of the wellbore using the surface pump and the injection riser. Simultaneously use the submersible pump to maintain a stable, elevated total head by extracting groundwater from near the free-water surface. When groundwater from the subject well is used for DI water generation, generate DI water from the extracted formation water and re-circulated to the well bottom via the solid riser.

Use the water level meter to observe the elevated total head during emplacement. If borehole conditions permit (i.e. the absence of constricted borehole intervals), the logging tool is used to monitor the advancement of the fluid up the borehole as it displaces the standing formation water. Draw the logging tool up the wellbore in successive increments as the DI water is emplaced. Monitor the electrical conductivity of the fluid expelled from the evacuation pump during emplacement procedures. When FEC values are representative of the DI water, or sufficiently diluted formation water, terminate emplacement procedures.

Emplacement is complete when DI water, or sufficiently diluted formation water, is observed from the evacuation pump or when logging tool stationed near the pump indicates DI water or sufficiently diluted formation water.

Upon completion, turn off the evacuation pump. Then turn off the injection line.

18.) Record volumes of extracted and injected fluids on the well testing data form. Calculate the volume of DI water lost to the formation.

19.) Take initial background HydroPhysical™ log, or begin continuous logging depending upon extraction method (i.e. slug vs. continuous).

20.) Pumping and testing procedures vary depending upon wellbore hydraulics and construction detail.

21.) Continuous logging is conducted until stabilized and consistent diluted FEC logs are observed. If inflow characterization at a second pumping rate is desired, increase extraction rate and assure the proper DI water injection rate. Perform continuous logging until stabilized and consistent FEC logs are observed and all diluted formation water is re-saturated with formation water.

22.) After stabilized and consistent FEC traces are observed, terminate DI water injection. Reduce the total extraction flow rate to the net formation rate and conduct continuous logging. Conduct logging until stable and consistent FEC values are observed.

23.) Conduct depth specific sampling at this time.

24.) At the conclusion of the above procedures, assess the wellbore fluid conditions and compare them with those observed during the original pumping (Step 14).

25.) Turn all pumps off. First remove the extraction pump from the borehole. During removal, thoroughly clean the evacuation line (2-inch o.d.) with a brush and alconox and rinse DI water. Also clean the outside of the pump. Place the pump in a drum of DI water and flush DI water through the system.

Remove the tool. Clean the wireline for the tool in a similar manner during its withdrawal from the borehole.

Remove the injection line from the well. Follow the same procedures when cleaning the injection line as for the evacuation line.

Store the pumps and logging tools properly for transport.

Place cover on well and lock (if available).

4. Special Notes

On-site pre-treatment of groundwater using activated carbon, can be conducted prior to DI water generation, if there is a contaminated groundwater source. In addition, on-site treatment can also be considered to handle extracted fluids that would require containerization and treatment prior to disposal.

The rate(s) of pumping are determined by drawdown information previously obtained or at rate(s) appropriate for the wellbore diameter and saturated interval thickness. The appropriate extraction rate is a function of length of saturated interval, borehole diameter, and previous well yield knowledge. The appropriate pumping procedures to be employed are also dictated by the length of the exposed rock interval. In general, the extraction flow rate should be sufficient to induce adequate inflow from the producing intervals. The concern is that the extraction flow rate does not cause extreme drawdown within the well i.e. lowering the free water surface to within the interval of investigation.

5. Discussion

LOW YIELD: Extraction Slug Test After DI water Emplacement

In wells with very low total flow capability (i.e. < 0.10 gpm/foot of drawdown), perform a slug test in accordance with procedures developed by Hvorslev (1951). Rapidly extract a small volume of water from near the free water surface using the extraction riser and pump. A drop in piezometric head of about 2 feet should be adequate for the initial test. Record the rise in the free water surface with time and develop a conventional time-lag plot.

When the free water surface has recovered to a satisfactory elevation, log the wellbore fluid conditions. Repeat the procedures described above with successive increases in the drop of piezometric head (or volume extracted). Let the wellbore recover and record the rise in the free water surface. Repeat logging of the wellbore fluid after the free water surface has recovered to a satisfactory elevation. The number of slug tests performed is determined in the field after review of previous logging results.

MODERATE YIELD: Time Series HydroPhysical™ Logging During Continuous Pumping After DI water Emplacement

In the case of moderate yield wells (i.e. 0.10 < Y < 4 gpm/foot of drawdown), maintain a constant flow rate from the evacuation pump and record the total volume of groundwater evacuated from the wellbore. Employ a continuous reading pressure transducer (or equivalent device) to monitor the depressed total head during pumping, along with the associated pumping rate.

Hold the flow rate from the evacuation pump constant at a rate determined for the specific borehole. Drawdown of the free water surface produced during pumping should not overlap any identified water producing interval. Conduct hydrophysical logging continuously. The time interval is a function of flow rate and is specific to each well. The number of logging runs and the length of time required to conduct all loggings is a function of the particular hydraulic conditions. Logging and pumping is continued until the fluid column is re-saturated with formation water (i.e. all DI water is removed from the borehole).

HIGH YIELD: Time Series Wellbore Fluid Logging During Continuous Pumping and Simultaneous DI Water Injection

When wells exhibit high yield (> 4 gpm/foot of drawdown), as determined by a review of the interval of interest, the borehole diameter and the results obtained from previous information and preliminary hydraulic testing, the appropriateness of time series fluid logging during continuous pumping and simultaneous DI water injection is determined.

In this case, maintain a constant flow rate from the evacuation pump and record this rate and the associated drawdown. During this period, conduct hydrophysical logging until reasonably similar HydroPhysical™ logs are observed and stabilized drawdown is achieved. After reasonably similar downhole fluid conditions are observed and simultaneous with extraction pumping, inject DI water at the bottom of the well at a constant rate of 10 to 20% of that employed for extraction. Increase the total rate of extraction to maintain total formation production reasonably similar to that prior to DI water injection (i.e. increase the total extraction by amount equal to the DI water injection rate).

Periodically record the total volume and flow rate of well fluids evacuated and the total volume and flow rate of DI water injected. Use a continuous reading pressure transducer or similar device to monitor the depressed total head during pumping. Record the depressed total head (piezometric surface) periodically, with the associated pumping and injection data.

The evacuation and DI water injection flow rates are held constant at a rate determined for the specific wellbore. Drawdown of the free water surface during pumping must not overlap any identified water producing intervals. HydroPhysical™ Logging is conducted continuously. The number of logging runs and the length of time required to conduct all loggings is a function of the particular hydraulic conditions exhibited by the well under investigation.

APPENDIX B

BORE II MODELING SOFTWARE

LBNL-46833

BORE II – A Code to Compute Dynamic Wellbore Electrical Conductivity Logs with Multiple Inflow/Outflow Points Including the Effects of Horizontal Flow across the Well

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Abstract

Dynamic wellbore electrical conductivity logs provide a valuable means to determine the flow characteristics of fractures intersecting a wellbore, in order to study the hydrologic behavior of fractured rocks. To expedite the analysis of log data, a computer program called BORE II has been developed that considers multiple inflow or outflow points along the wellbore, including the case of horizontal flow across the wellbore. BORE II calculates the evolution of fluid electrical conductivity (FEC) profiles in a wellbore or wellbore section, which may be pumped at a low rate, and compares model results to log data in a variety of ways. FEC variations may arise from inflow under natural-state conditions or due to tracer injected in a neighboring well (interference tests). BORE II has an interactive, graphical user interface and runs on a personal computer under the Windows operating system. BORE II is a modification and extension of an older code called BORE, which considered inflow points only and did not provide an interactive comparison to field data. In this report, we describe BORE II capabilities, provide a detailed user's guide, and show a series of example applications.

1. Introduction

The variation of formation permeability surrounding a wellbore is useful information not only for identifying hydraulically conducting fractures or other high-conductivity features intercepted by the well, but also for quantifying the heterogeneity of the medium. These are essential data in the evaluation of in-situ flow and transport characteristics at a given site.

Methods to evaluate permeability values along the depth of a well include the packer method, in which constant pressure, constant flow, or pulse tests are conducted in packed-off intervals in a wellbore, and various downhole flow meters. The packer method has the disadvantage that it is very time consuming and costly, and the vertical resolution is limited by the interval between the two packers that can be set in the well. Flow meter methods such as spinners and heat pulse flow meters generally allow better vertical resolution than the packer method, but they are not as accurate in determining permeability, because they mostly measure the wellbore fluid velocity, which is very sensitive to variations in the wellbore radius.

In 1990, Tsang et al. (1990) proposed a method using logs of fluid electric conductivity (FEC) at successive times under constant-pumping conditions to obtain inflow from the formation into the well as a function of depth in the well. In this method, the wellbore is first filled by de-ionized water or water of a constant salinity (i.e., ion concentration) distinct from that of the formation water. This is usually done by passing the de-ionized water down a tube to the bottom of the wellbore at a given rate while simultaneously pumping at the top of the well at the same rate. After this is done, the well is pumped at a constant flow rate, which can be adjusted to optimize wellbore flow conditions. An electric resistivity probe is lowered into the wellbore to scan FEC as a function of depth along the wellbore. This is what is called fluid conductivity logging. A series of five or six such logs are obtained at time intervals over a one- or two-day period. At the depth levels where water enters the wellbore, the conductivity log displays peaks, which grow with time and become skewed in the direction of water flow. By analyzing these logs, it is possible to obtain the permeability and salinity of each hydrologic layer transmitting water. The method has been very successful, being much more accurate than flow meters and much more efficient (much cheaper) than packer tests (Tsang et al. 1990), particularly in low permeability formations. A typical 1000-m section in a deep hole can be tested in two or three days at a spatial resolution of ~0.10 m all along the length of the wellbore section. The method is now being widely used in Europe and the U.S. (Marschall and Vomvoris, 1995; Pedler et al., 1992; Bauer and LoCoco, 1996), both under natural-state flow conditions and while tracer is injected in a neighboring well (i.e., interference tests).

Along with the method, a code was developed called BORE (Hale and Tsang, 1988), which performed the forward calculation to produce wellbore FEC profiles given different inflow positions, rates, and concentrations. The code has been well used over the last decade. However, it appears now that there is a need to revise the code to make it more suitable for current computer environments and to add new capabilities. Thus, the code has been updated to run under current operating systems, provide interactive modification of model parameters, and produce graphical comparisons between model and field data. More importantly, the revised code allows the possible inclusion of both flows into and out of the well at various depths, a feature that has been observed in real field conditions when different layers penetrated by the well have different hydraulic heads. Furthermore, the new code allows the calculation of the case with equal inflow and outflow at the same depth level, which is effectively the special case of horizontal flow across the wellbore. Drost (1968) proposed a measurement of solute dilution in the wellbore to evaluate ambient horizontal flow velocity in the formation and it has become a well-accepted method. The new code provides the opportunity to analyze such cases and to identify the depth interval of horizontal flow to within ~0.1 m as well as to estimate the flow rate. Moreover, one can analyze the combination of horizontal flow across the wellbore and vertical diffusion or dispersion along the length of the wellbore, which is not possible with Drost's solution.

The report is organized as follows. In Section 2, the basic capabilities of the revised code, called BORE II, are described, and the key parameters associated with BORE II are defined. Details of the mathematical background and numerical approach are described in Appendix 1, which is adapted from Hale and Tsang (1988). A user's guide is presented in Section 3, which includes a description of BORE II's interactive user interface, required input items, and options available when running BORE II. Four example applications are given in Section 4 to conclude the report.

We are still open to further improvements of BORE II; any suggestions and comments are invited and should be addressed to the authors.

2. BORE II Capabilities

BORE II calculates FEC as a function of space and time in a wellbore containing multiple feed points given the pumping rate of the well, the inflow or outflow rate of each feed point, its location and starting time, and, for inflow points, its ion concentration. A simple polynomial correlation between ion concentration, C, and FEC is assumed. Ion transport occurs by advection and diffusion along the wellbore, with instantaneous mixing of feed-point fluid throughout the wellbore cross-section. These assumptions allow use of a one-dimensional model. BORE II divides the wellbore section under study into equal height cells and solves the advection/diffusion equation using the finite difference method. Further details of the mathematical and numerical approach are given in Appendix 1.

Inflow and Outflow Feed Points

The original BORE code (Hale and Tsang, 1988) considered inflow points only, so flow through the wellbore was upward at all depths. BORE II allows both inflow and outflow points, so flow in the wellbore can be upward, downward, or horizontal at different depths and flow at either end of the wellbore section being studied can be into or out of the wellbore section or be zero. By convention, upward flow in the wellbore is positive and flow into the wellbore is positive.

Steady and Varying Fluid Flow

The original BORE code considered steady fluid flow, so feed points had constant flow rates. They also had constant concentrations, but delayed starting times for feed-point concentration to enter the wellbore were allowed. BORE II permits both steady and varying fluid flow. For the steady-flow case, the user specifies flow rate, concentration, and concentration start time for each feed point, but for outflow points (those with negative flow rates) the concentration and concentration start time are not used. Variable flow rate or concentration can be specified for feed points by interpolating from a table of time, flow rate, and concentration. If a table includes both positive and negative flow rates (i.e., a feed point alternates between inflow and outflow), the concentration for the positive flow rate is used when interpolating between positive and negative flow rates.

Concentration Boundary Conditions

If the flow at the top of the wellbore section under study is into the wellbore, the initial concentration for the uppermost cell in the wellbore is used as the inflow concentration. Analogously, if flow at the bottom of the wellbore section is a flow up from greater depths, the initial concentration for the lowermost cell in the wellbore is used as the inflow concentration. Furthermore, for inflow points with a concentration start time greater than zero, the initial concentration of the wellbore is used as the inflow concentration for times less than concentration start time.

Horizontal Flow

The special case of horizontal flow through the wellbore, as described by Drost (1968), can also be considered, by locating an inflow point and an outflow point with equal magnitude flow rates at the same depth. The flow rates may be specified as either (1) the Darcy velocity through the aquifer or (2) the volumetric flow rate into/out of the wellbore. BORE II multiplies Darcy velocity by the cross-sectional area of the feed point (wellbore diameter times cell height) and Drost's α_h convergence factor to convert it to a volumetric flow rate. The value of α_h can range from 1 (no convergence) to 4 (maximum possible convergence, which occurs for the case of a thick, highly-permeable well screen). Drost suggested that for a uniform aquifer with no well screen, $\alpha_h = 2$, and that for typical applications, a good choice for α_h is 2.5. Horizontal flow feed points may have time-varying flow rates, but for Darcy-velocity calculations to make sense, the inflow and outflow rates must be equal and opposite at any time. Thus, if a feed point location changes from a horizontal flow point to a non-horizontal flow point with time, volumetric flow rates must be specified rather than Darcy velocities.

BORE II Parameters

The key parameters associated with BORE II are defined below.

Parameter	I/O units*	Description
C	g/L	Ion concentration in the wellbore; converted to FEC using FEC = $\gamma + \beta C + \alpha C^2$, where α, β, and γ are user-specified constants (default values are provided in the code, see Section 3)
C_i	g/L	Ion concentration of *i*th feed point
C_0	g/L	Initial ion concentration in wellbore
D_0	m^2/s	Diffusion coefficient (may include dispersive effects as well molecular diffusion)
d_w	cm	Wellbore diameter (assumed constant)
FEC	μS/cm	Fluid electrical conductivity
q	L/min	Fluid flow rate in wellbore (upward flow is positive)
q_i	L/min	Fluid flow rate of *i*th feed point; positive for inflow and negative for outflow
q_w	L/min	Fluid flow rate in wellbore at $x_{\max}$, specified by the user
q_0	L/min	Fluid flow rate in wellbore at $x_{\min}$ (or any depth of interest), calculated internally
T or TEMP	^{o}C	Temperature (assumed constant)
t	hr	Time
$t_{\max}$	hr	Maximum simulation time
t_{0i}	hr	Concentration start time of *i*th feed point
v_d	m/day	Darcy velocity through aquifer for horizontal flow ($q_i = v_d \alpha_h \Delta x\, d_w$)
x	m	Depth (positive, increases down the wellbore)
$x_{\min}$, $x_{\max}$	m	Top and bottom, respectively, of wellbore interval being studied
Δx	m	Cell height for wellbore discretization
α_h	–	Drost (1968) convergence factor for horizontal flow

*I/O units are chosen for convenience; all quantities are converted to SI units before BORE II calculations.

3. BORE II User's Guide

Operating System

BORE II may be run under Windows 95, 98, or 2000 by double-clicking the executable icon (BOREII.EXE) in Windows Explorer, by double-clicking on a desktop shortcut key to BOREII.EXE, or by typing BOREII in the Run command in the Start Menu or in a DOS-prompt window. BORE II will not run in stand-alone DOS or in the DOS-mode of Windows. BORE II was compiled using Microsoft Fortran PowerStation™ Version 4.0, but this software is not necessary to run the program.

BORE II Graphical Output

The primary user interface with BORE II is interactive, with the user responding to on-screen prompts to modify model parameters and choose options (described below) for the real-time graphical display of model results and data. The basic BORE II output screen consists of three windows.

- The borehole profile window shows FEC profiles as a function of depth and time. Simulation time t is shown in the upper left corner. Fluid flow rate at a user-specified depth in the wellbore, q_0, is shown in the middle of the top line (the depth at which q_0 is calculated is set by option P). The depth of a C-t plot is also shown.

- The inflow parameters window shows the feed-point characteristics for the model that can be modified with option M (location, flow rate, and concentration). Often there are more feed points than can be displayed at once on the screen. BORE II starts out showing the first few (deepest) feed points, then shows the feed points in the neighborhood of any point that is being modified.

- The dialog window allows the user to select options (described below) when running BORE II.

On computers with small screens, it may be desirable to run BORE II in full-screen mode, so that the entire BORE II screen can be seen at once without scrolling. Full-screen mode is entered by pressing Alt-VF (or on some computers by pressing Alt-Enter). Pressing Esc (or Alt-Enter) terminates full-screen mode. There are three potential problems associated with the use of full-screen mode.

(1) The status line describing what BORE II is doing (e.g., running, waiting for input) is not visible.

(2) Drawing an x-t plot (options X, S, D, F, and I), which creates a new window, may be very slow and the graphics quality poor.

(3) On some computers, text is difficult to read after closing the x-t plot window.

To address the latter two problems, one may terminate full-screen mode before using options X, S, D, F, and I. The new window will be small, but after drawing is complete it may be expanded by pressing Alt-VF to enter full-screen mode. Full-screen mode should be terminated before the new window is closed to avoid the final problem.

To print an image of the screen, press Alt-PrintScreen to copy the screen image into the clipboard. Then open a program such as Microsoft Paint and paste in the image. It can be manipulated, saved in a variety of graphics formats, or printed from Paint. The image can also be pasted directly into another Windows application such as MS Word.

Input/Output File Overview

Running BORE II requires one or two external files: a file with an initial set of model input parameters (mandatory, known as the input file) and a file with observed data (optional, known as the data file). These files are plain ASCII text, and must reside in the same folder as the BORE II executable. The input file contains model parameters such as the depth interval being studied, feed point characteristics, problem simulation time, and *C*-to-FEC conversion factors. The data file contains observed values of FEC and temperature, and optionally contains other fluid properties such as pH. Detailed instructions for preparing an input file and a data file are given below.

BORE II always creates a temporary file, called BOREII.TMP (see options C and R), and optionally creates a new input file (see option V), which is useful if model parameters have been changed during the BORE II run.

Line-by-line Instructions for Input File

After starting BORE II, the user is prompted to choose the input file from the list of files residing in the folder where the BORE II executable is. Input file names with more than 8 characters before a period or blanks will appear in the list of files in an abbreviated form. File names can be at most 20 characters long.

A sample input file is provided that can be modified as needed using a text editor such as Notepad or a word processor such as MS Word. If a word processor is used to create or modify an input file, be sure that the file is saved as plain ASCII text.

The input file is designed to be self-documenting, with header lines preceding data lines. These header lines must be present, but BORE II does not use the text on them. Data entries are read in free format, with individual entries on a given line separated by blanks, tabs, or commas. This means that entries cannot be left blank, even if they are not being used (e.g., concentration for an outflow point). Unused entries may be set to zero or any convenient value. Comments may be added on data lines, after the requisite number of entries. In the sample input file, comments begin with an exclamation point.

Item	**Computer Variables**	**Unit**	**Description**
1.	TITLE	–	A description of the problem, 80 characters maximum
2 header for wellbore geometry			

2.	RXMIN	m	Top of study area, $x_{\min}$
	RXMAX	m	Bottom of study area, $x_{\max}$
	RDIAM	cm	Wellbore diameter, d_w
3 header for flow parameters			
3.	RQW	L/min	Flow into (positive) or out of (negative) the bottom of the study area, q_w
	HALPHA	–	Factor to account for convergence of horizontal flow lines toward the wellbore, α_h (Drost, 1968) Range: 1.0 – 4.0; default value: 2.5 Only used for horizontal flow

4 header for feed points			
4.	IINFN	–	Number of feed points (maximum 180)
	IQFLAG	–	Variable flow-rate flag – a 3 digit integer used to identify feed points with variable flow (suggested value 999)
5 header for constant- flow-rate feed points			
5. Repeat IINFN times	RINFX	m	Location of feed point, x_i * For horizontal flow put two feed points at the same location, with equal magnitude, opposite sign flow rates
	RINFQ	L/min (m/day if IINFV=1)	Constant inflow rate (positive) or outflow rate (negative) of feed point, q_i For a variable flow rate, set RINFQ = IIIJJ, where III = IQFLAG, and JJ is a two digit integer giving the number of times in the variable-flow-rate table, which follows in 5a For horizontal flow, v_d replaces q_i if IINFV = 1
	RINFC	g/L	Constant feed point concentration, C_i - only used for inflow points For a variable concentration, set RINFQ = IIIJJ, where III = IQFLAG, and JJ is a two digit integer giving the number of times in the variable-flow-rate table, which follows in 5a
	RINFT	hr	Start time for constant feed point concentration, t_{0i} - only used for inflow points Feed point concentration is C_0 of cell containing feed point for t < t_{0i}
	IINFV	–	Horizontal flow Darcy-velocity flag (must be zero for non-horizontal flow case): = 0: RINFQ is flow rate q_i into/out of the wellbore in L/min = 1: RINFQ is +/–Darcy velocity v_d through the aquifer in m/day

5a header for variable-flow-rate table (only when RINFQ = IQFLAGJJ)			
5a. Repeat JJ times when RINFQ = IQFLAGJJ	RINFQT	hr	Time t_j (set $t_1 = 0$, set $t_{JJ} > t_{\max}$)
	RINFQQ	L/min (m/day if IINFV=1)	Volumetric flow rate q_j at time t_j For horizontal flow, v_d replaces q_j if IINFV = 1
	RINFCC	g/L	Concentration C_j at t_j
6 header for misc. parameters			
6.	TMAX	hr	Maximum simulation time, $t_{\max}$
	DPYMAX	μS/cm	Maximum FEC for plots
	RK	m^2/s	Diffusion coefficient, D_0
7 header for C-to-FEC conversion			
7.	RGAMMA	μS/cm	Conversion from C in g/L to FEC in μS/cm: $FEC = \gamma + \beta C + \alpha C^2$ Default values (for 20°C): $\gamma = 0$, $\beta = 1870$, $\alpha = -40$ Set $\gamma = 0$, $\beta = 1$, $\alpha \approx 1.e\text{-}8$ for FEC ≈ C
	RBETA	[μS/cm]/ [g/L]	
	RALPHA	$[\mu S/cm]/[g/L]^2$	
8 header for initial conditions			
8.	IC0FLAG	–	Initial concentration flag: = 0: $C_0 = 0$, no further input for item 8 < 0: read uniform non-zero C_0 in 8a > 0: read IC0FLAG (x,$C_0(x)$) pairs in 8b to describe variable initial concentration
8a header for uniform initial conditions (only when IC0FLAG < 0)			
8a. when IC0FLAG<0	RC0	g/L	Uniform non-zero C_0
8b header for non-uniform initial conditions (only when IC0FLAG > 0)			
8b. repeat IC0FLAG times when IC0FLAG>0	RX	m	x value*
	RC0	g/L	$C_0(x)$
9 header for data file name			
9.	CFDATA	–	Name of data file, 20 characters maximum; 'NONE' if there is no data file

*see Appendix 1, Section A1.5, for additional information on locating feed points and specifying non-uniform initial conditions

Sample Input File

An input file illustrating many of these options is shown below. Text or numbers following an exclamation point (!) are comments, and are not used by BORE II.

```
TITLE: Sample Input File with flow from below, horizontal flow, variable
flow
XMIN(m)     XMAX(m)     DIAM(cm)
.0000       60.00       7.600
QW(L/min)   HALPHA      !QW=flow from below; HALPHA=hor. flow
constriction
 0.50       0.          !default value of HALPHA will be used
#FEED_PTS   VARIABLE_FLOWRATE_IDENTIFIER
   4               999
DEPTH(m)    Q (L/min)    C(g/L)      T0(hr)      Q/V_FLAG
 25.        +1.          6.0         .0000       1 !1st 2 feed pts-hor.
flow
 25.        -1.          6.0         .0000       1 !C & T0 not used
(outflow)
 30.        99905.       6.0         .0000       0 !C & T0 not used
(table)
     T(hr)       Q(L/min)    C(g/L)      !#entries is two digits after
999
      .0000       .0000        6.        !first time in table is zero
      .3000       .2800E-01    5.
      .5000       .3200        4.
      1.000       .4600        3.
      1.500       .4600        2.        !last time in table is > tmax
 35.        .5           4.0         .2000       0 !final feed pt
TMAX(hr)    FECMAX      DIFFUSION_COEF.(m2/s)
 1.000      5000.       .7500E-09
RGAMMA      RBETA       RALPHA      !FEC = RGAMMA + C*RBETA + C*C*RALPHA
0.          0.          0.          !default values will be used
IC0FLAG     !If 0, C0=0; If <0, read one C0; If >0,read IC0FLAG (X,C0)
pairs
    1
X(m)        C0(g/L)           !#entries is IC0FLAG
60.         2.                !Concentration associated with Qw
DATA_FILE   !'NONE' if there is no data file
NONE
```

The first two feed points represent constant horizontal flow, and since the Q/V flag (IINFV) is one, flow rate is given as Darcy velocity through the aquifer in m/day. The third feed point has variable flow rate and concentration, with a five-entry table specifying the variation with time. The fourth feed point is an inflow point with constant flow rate and concentration and a non-zero concentration start time.

Note that the flow from below, q_w, is positive (into the wellbore section), so the corresponding concentration is specified as the initial condition of the lowermost cell in the wellbore (at $x = x_{\min}$) by using IC0FLAG = 1. If IC0FLAG = 0, the concentration associated with q_w would be zero, and if IC0FLAG = -1, the concentration associated with q_w would be the uniform non-zero initial concentration in the wellbore.

When BORE II writes an input file (option V), it changes several things to the file form shown above. Comments found in the original input file are not reproduced, but two comments are added. First, the cell height and the equation used to calculate it are shown on the line with $x_{\min}$, $x_{\max}$, and d_w. Second, if feed points represent horizontal flow, then the flag IINVF is set to 0, flow rate is given in L/min, and the corresponding Darcy velocity through the aquifer in m/day is added as a comment. Finally, if IC0FLAG > 0, BORE II sets IC0FLAG to the number of wellbore cells, and explicitly shows every (x, $C_0(x)$) pair. This option is useful for identifying the *x* values of various cells, which may expedite assignment of feed point locations or initial conditions. Part of the input file created by BORE II for the above sample is shown below.

```
TITLE: Sample Input File with flow from below, horizontal flow, variable
flow
XMIN(m)     XMAX(m)     DIAM(cm)    !DX(m) = MAX(|XMIN - XMAX|/180,
DIAM/100)
 .0000       60.00       7.600      ! .3333
QW(L/min)   HALPHA      !QW=flow from below; HALPHA=hor. flow
constriction
 .5000       2.500
#FEED_PTS   VARIABLE_FLOWRATE_IDENTIFIER
    4               999
DEPTH(m)    Q(L/min)    C(g/L)      T0(hr)      Q/V_FLAG    !Vd(m/day)
 35.00        .5000      4.000       .2000        0
 30.00      99905.       6.000       .0000        0
     T(hr)       Q(L/min)    C(g/L)      !#entries is two digits after
999
      .0000       .0000       6.000
      .3000       .2800E-01   5.000
      .5000       .3200       4.000
      1.000       .4600       3.000
      1.500       .4600       2.000
 25.00       .4398E-01   6.000       .0000        0         ! 1.000
 25.00      -.4398E-01   6.000       .0000        0         !-1.000
TMAX(hr)    FECMAX      DIFFUSION_COEF.(m2/s)
 1.000       5000.       .7500E-09
RGAMMA      RBETA       RALPHA      !FEC = RGAMMA + C*RBETA + C*C*RALPHA
 .0000       1870.      -40.00
IC0FLAG     !If 0, C0=0; If <0, read one C0; If >0,read IC0FLAG (X,C0)
pairs
  179
X(m)        C0(g/L)           !#entries is IC0FLAG
 59.83       2.000
 59.50       .0000
 59.17       .0000
 58.83       .0000
…(169 entries with C0=0 not shown)…
 2.167       .0000
 1.833       .0000
 1.500       .0000
 1.167       .0000
 .8333       .0000
 .5000       .0000
DATA_FILE   !'NONE' if there is no data file
NONE
```

Line by Line Instructions for Data File

The data file is read in the fixed format shown below. If data are available in a different format, an auxiliary program should be used to convert it to this form (a simple preprocessor called PREBORE, described in Appendix 2, converts the data file format used by BORE to the new format shown below). Note that because a fixed format is used, blank entries are allowed; they are interpreted as zero.

Lines 1-8 are header lines, not used by BORE II.

Each line of the remainder of the file contains:

Variable	*x*	FEC	TEMP	DAT3	DAT4	DAT5	HR	MIN	SEC
Units	m	μS/cm	^{o}C				–	–	–
Format	F10.3	F10.3	F10.3	E10.3	E10.3	E10.3	I3	I2	I2
Columns	1-10	11-20	21-30	31-40	41-50	51-60	62-64	66-67	69-70

The entries DAT3, DAT4, and DAT5 represent optional data types that may be collected with certain logging tools, such as pH and dissolved oxygen (see options A and Y for ways to display this data). Note that there is one blank column before each of the HR, MIN, and SEC entries, to make the data file more readable. The first time entry corresponds to $t = 0$ for the model.

BORE II Options

The following options are available on the BORE II main menu. Either uppercase or lowercase letters may be used, and should be followed by pressing ENTER.

C – (C)-x plot – Displays FEC versus depth for data and/or model continuously in time (an animation); stores [*x* (m), *t* (sec), data FEC (μS/cm), model FEC (μS/cm)] in file BOREII.TMP for later use by option R or post-processing.

T – c-(T) plot – Displays FEC versus time for data and model for a chosen depth.

R – d/m cu(R)ve – Displays FEC versus depth plots for data and model at a series of times (snapshots of the option C display); uses results of most recent option C, read from BOREII.TMP. Does not work if there is no data file or if there are only data at one depth in data file.

N – i(N)flow-c – Displays inflow FEC for a chosen feed point as a function of time.

A – p(A)ram display – Displays all data profiles (FEC, TEMP, DAT3, DAT4, DAT5) simultaneously, using user-specified plot limits (selections 3-6). For selection 1, all points are connected on one continuous curve; for selection 2, points that are beyond depth or time limits start new curve segments.

X – (X)-t plot – Displays a color-coded plot of model FEC versus depth and time in a new window, then repeats the plot in the borehole profile window.

S – tool (S)tudy x-t plot – Same as X, but limits display to what would be obtained with a tool whose parameters (number of probes, gap between probes, and tool velocity) are specified by the user.

D – (D)ata x-t – Displays a color-coded plot of data traces versus depth and time in a new window, then repeats the plot in the borehole profile window (data type specified by option Y, default is FEC).

F – (F)ill data x-t – Same as D, except that data traces are interpolated to fill the *x-t* plane.

I – d/m d(I)ff x-t – Displays a color-coded plot of the difference between model and data FEC versus depth and time in a new window, then repeats the plot in the borehole profile window. User selects whether to show data traces (mode 1) or filled data (mode 2).

M – (M)odify inp– Opens interactive session for modifying location, flow rate, and concentration of feed points, or adding new feed points. User is prompted to enter feed point number and given the chance to modify or maintain current parameters. To add a new feed point, specify a feed point number greater than that for any existing feed point. If horizontal flow is implemented using option M, flow rate must be specified as volumetric flow rate through the wellbore in L/min.

P – (P)lot adjust – Sets new values of parameter minimum and maximum; $t_{\max}$; difference range for option I; and depth for which wellbore flow rate q_0 is displayed in borehole profile window (default depth is $x_{\min}$).

G – (G)rid – Sets grid spacing for new window showing x-t plots.

Y – data t(Y)pe – Chooses data type (FEC, TEMP, DAT3, DAT4, DAT5) to display in options C, T, D, and F. Model results always show FEC, so option C and T plots, which show both model and data, must be read carefully. Note that options R and I are not affected by the choice of data type, but always compare model and data FEC.

Z – print – Displays instructions for printing a screen image.

V – sa(V)e – Creates a new input file with current model parameters. User is prompted for new file name.

Q – (Q)uit – Terminates BORE II program.

4. Example Applications

Five example applications are presented to illustrate the capabilities of BORE II. Although BORE II simulates the forward problem (it produces wellbore FEC profiles given different inflow positions, rates, and concentrations), it is most commonly used in an inverse mode, in which inflow positions, rates and concentrations are varied by trial and error until the model matches observed values of wellbore FEC profiles. Initial guesses for the trial and error process may be obtained using direct integral methods (Tsang and Hale, 1989; Tsang et al., 1990) or other means (see example 2 below). Example applications 3, 4, and 5 demonstrate such comparisons to real data provided to us as typical field data sets by G. Bauer (private communication, 2000). The results of these example applications do not necessarily provide physically realistic flow rates and inflow concentrations, because they employ the artificial equality FEC = C. Furthermore, rough matches to real data, as are obtained here, can often be obtained equally well with a variety of different parameters (i.e., the solution of the inverse problem is non-unique). The input files for the example applications are shown in Appendix 3.

	Problem	Data File	Input File	Features
1	Up flow	up_num.dbt (numerically simulated)	up_num.inp	Advection and dilution, diffusion/dispersion minor
2	Horizontal flow	hor_an.dbt (analytical solution)	hor_an.inp	Dilution only, no advection or diffusion/dispersion One pair inflow/outflow points
3	Horizontal flow	hor_real.dbt (real data)	hor_real.inp	Dilution and diffusion/dispersion Multiple pairs inflow/outflow points Initial time added to data

4	Down flow	down_c.dbt (real data)	down_c.inp	Advection, dilution, and diffusion/dispersion Variable inflow concentration
5	Combination flow	comb_ic.dbt (real data)	comb_ic.inp	Advection, dilution, and diffusion/dispersion Non-uniform initial conditions

1. Up Flow – Numerically Simulated Data

Perhaps the most common application of BORE II is to the case of up flow - when one pumps from the top of the wellbore section, and fluid enters the wellbore at one or more feed points. Figure 1 shows *C* versus *x* for several times for a typical up flow case (obtained with BORE II option R). Each feed point has the same inflow rate and the same concentration, and there is also up flow from below. At early times, the feed points show up as individual FEC peaks, but as time passes, the deeper peaks merge with those above them, creating a step-like structure. The data set for this example is not real, but the results of a numerical simulation using the flow and transport simulator TOUGH2 (Pruess, 1987; 1991; 1995; 1998). TOUGH2 has been verified and validated against analytical solutions, other numerical models, and laboratory and field data. The TOUGH2 simulation uses a one-dimensional model with the same cell spacing as BORE II and constant mass sources located at the BORE II feed points. Thus, BORE II and TOUGH2 are solving the same problems, and comparing the results for wellbore FEC profiles verifies that the BORE II calculations are done correctly.

2. Horizontal Flow – Analytical Solution and Numerically Simulated Data

For horizontal flow in the absence of diffusion/dispersion along the wellbore, an analytical solution for the concentration observed in the wellbore as a function of time, *C*(*t*), is given by (Drost, 1968):

$$C(t) = C_i - [C_i - C(0)]\exp\left(\frac{-2tv_d\alpha_h}{\pi r_w}\right), \qquad (1)$$

where C_i is the formation (inflow) concentration, *t* is time (s), v_d is the Darcy velocity through the aquifer (m/s), α_h is the aquifer-to-wellbore convergence factor, and r_w is the wellbore radius (m). Figure 2 shows the analytical solution and the BORE II results for this problem, obtained using option T. The agreement is excellent. Note that for small values of v_d, if C(0) = 0, the analytical solution becomes approximately

$$C(t) = C_i\left\lfloor 1 - \exp\left(\frac{-2tv_d\alpha_h}{\pi r_w}\right)\right\rfloor \approx C_i\left\lfloor 1 - \left(1 - \frac{2tv_d\alpha_h}{\pi r_w}\right)\right\rfloor = \frac{C_i\,2tv_d\alpha_h}{\pi r_w}. \qquad (2)$$

Thus, any combination of C_i and v_d whose product is a constant gives the same value of C. This condition corresponds to the early-time straight-line portion of Figure 2. The analytical solution may be implemented in a spreadsheet to expedite the choice of BORE II parameters, by examining the solution for various values of v_d and C_i. Note that care must be taken to use a consistent set of units for t, v_d, and r_w in Equations (1) and (2). For example, when time is in seconds, BORE II input parameters v_d in m/day and r_w in cm must be converted to m/s and m, respectively.

Figure 2 also shows the evolution of concentration at and near a horizontal flow layer when diffusion/dispersion along the wellbore is significant ($D_0 = 10^{-5}$ m^2/s). For this case, the analytical solution is not applicable, but BORE II results compare very well to numerically simulated data obtained using TOUGH2. When dispersion is significant, use of the Drost solution generally results in an underestimation of C_i and an overestimation of v_d. These errors do not arise when using BORE II, since diffusion/dispersion can be explicitly included.

3. Horizontal Flow – Real Data

As indicated in Figure 2, the addition of diffusion or dispersion modifies the depth-FEC profile arising from a thin layer of horizontal flow, by widening the base of the FEC peak. A thick layer of horizontal flow produces a distinct signature, with an FEC response that has a wide peak as well as a wide base. To model a thick layer of horizontal flow, one may use several adjacent inflow/outflow point pairs in the model. Figure 3 compares model and data profiles (G. Bauer, private communication, 2000) of C versus x for several times, using option R. Seven pairs of inflow/outflow points are used, assigned to seven adjacent cells. By multiplying the number of inflow/outflow pairs by cell thickness, one may estimate the thickness of the layer of horizontal flow, in this case 2.3 m. See Appendix 1, Section A1.5, for additional information about assigning feed points to specific cells.

For this particular data set, the earliest observations show a variable FEC profile. One possible way to address this is to specify a non-uniform initial concentration distribution in the wellbore. An alternative approach (used here) is to add a dummy entry to the data file, specifying a time prior to the first real data time, at which the FCE distribution in the wellbore is assumed to be uniform. In general, it is not possible to determine when, if ever, the FEC distribution in the wellbore is uniform, but the approach can work quite well, as shown in Figure 4, which shows C versus t at the center of the horizontal flow zone (option T). The data zero time taken from the header of the data file, where the date and time of the logging run are specified.

4. Down Flow – Real Data

Figure 5 compares model and data profiles (G. Bauer, private communication, 2000) of C versus x for several times (option R) for a case with primarily down flow. A uniform non-zero initial concentration is used (IC0FLAG < 0) to approximate the low, slightly variable initial concentration. Two shallow inflow points have variable concentrations that increase in time, which suggests that de-ionized water penetrated into the fractures when it was introduced into the wellbore to establish low-concentration initial conditions for logging. A low-concentration feed point at *x* = 158.5 m creates up flow above it, but the remainder of the wellbore section shows down flow.

5. Combination Flow – Real Data

Figure 6 compares model and data profiles (G. Bauer, private communication, 2000) of *C* versus *x* for several times (option R) for a case with combination flow. A non-uniform initial condition has been used, which is extracted from the data file using the preprocessor PREBORE (see Appendix 2). Note that there are more entries in the initial condition specification (232) than there are cells in the model (179). Thus, some cells are assigned more than one initial condition. For cells where this occurs, only the final initial condition assigned is used. See Appendix 1, Section A1.5, for additional information on specifying non-uniform conditions. Figure 7 shows the same information as Figure 6, but plotted in a different way, with the difference between data and model FEC plotted as an *x*-*t* plot (option I). The blue and orange diagonal features indicate that the largest discrepancy between model and data gradually deepens with time.

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Appendix 1: Mathematical Background and Numerical Approach

The principal equation governing wellbore FEC variation is the equation for the transport of mass (or ion concentration) in the wellbore. However, additional consideration must be given to the determination of FEC as a function of ion concentration and the temperature dependence of FEC.

A1.1 FEC as a Function of Concentration

The relationship between ion concentration and FEC is reviewed, for example, by Shedlovsky and Shedlovsky (1971), who give graphs and tables relating these two quantities. Hale and Tsang (1988) made a sample fit for the case of NaCl solution at low concentrations and obtained

$$\mathrm{FEC} = 1{,}870\ C - 40\ C^2, \qquad \text{(A.1)}$$

where C is ion concentration in kg/m^3 ($\approx$ g/L) and FEC is in μS/cm at 20^{o}C. The expression is accurate for a range of C up to $\approx$ 6 kg/m^3 and FEC up to 11,000 μS/cm. The quadratic term can be dropped if one is interested only in values of C up to $\approx$ 4 kg/m^3 and FEC up to 7,000 μS/cm, in which case the error will be less than 10%.

Fracture fluids typically contain a variety of ions, the most common being Na^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}, and HCO_3^-. If a hydrochemical analysis has been completed, various methods are available for computing an equivalent NaCl concentration for other ions. Schlumberger (1984) presents charts of multiplicative factors that convert various solutes to equivalent NaCl concentrations with respect to their effect on electric conductivity.

A1.2 Temperature Dependence of FEC

BORE II calculations are made assuming a uniform temperature throughout the wellbore. Actual wellbore temperatures generally vary with depth, so temperature corrections must be applied to field FEC data to permit direct comparison with model output.

The effect of temperature T on FEC can be estimated using the following equation (Schlumberger, 1984)

$$\mathrm{FEC}(20^o\,\mathrm{C}) = \frac{\mathrm{FEC}(\mathrm{T})}{1 + \mathrm{S}(\mathrm{T} - 20^o\,\mathrm{C})}, \qquad \text{(A.2)}$$

where $S = 0.024$.

Generally, temperature increases with depth below the land surface. If full temperature logs are available, these data can be used to correct the corresponding FEC values. However, if no complete logs are available, a simplifying assumption may be made that the temperature variation in the wellbore is linear and can be modeled by:

$$T = Ax + B, \qquad \text{(A.3)}$$

where *A* and *B* are parameters determined by fitting any available temperature versus depth data. If the fit is unsatisfactory, other relationships with higher order terms must be used.

A1.3 Governing Equation

The differential equation for mass or solute transport in a wellbore is:

$$\frac{\partial}{\partial x}\left(D_o \frac{\partial C}{\partial x}\right) - \frac{\partial}{\partial x}(Cv) + S = \frac{\partial C}{\partial t}, \tag{A.4}$$

where *x* is depth, *t* is time, and *C* is ion concentration. The first term is the diffusion term, with D_0 the diffusion/dispersion coefficient in m^2/s, the second term is the advective term, with *v* the fluid velocity in m/s, and *S* is the source term in kg/m^3s. This one-dimensional partial differential equation is solved numerically using the finite difference method, with upstream weighting used in the advective term. The following initial and boundary conditions are specified:

$$C(x,0) = C_0(x), \tag{A.5}$$

$C(x_{min},t) = C_0(x_{min})$ for flow into the wellbore from above,

$C(x_{max},t) = C_0(x_{max})$ for flow into the wellbore from below,

$D_0 = 0$ for $x < x_{min}$ and $x > x_{max}$.

The first condition allows for the specification of initial ion concentrations in the wellbore. The second and third conditions allow for advective flow of ions into the wellbore interval from above and below. The final condition indicates that diffusion and dispersion do not take place across the boundaries of the wellbore interval. In general, advection will be the dominant process at the boundaries. If diffusion or dispersion is dominant for a particular problem, the boundaries should be extended in order to prevent improper trapping of electrolyte.

A1.4 Discretization in Time

Time stepping is explicit, with the time step Δt determined by stability constraints for advection

$$\Delta t \le \frac{\pi d_w{}^2 \Delta x}{8 q_{max}}, \tag{A.6}$$

and diffusion

$$\Delta t \le \frac{\Delta x^2}{4 D_0}, \tag{A.7}$$

where q_{max} (m^3/s) is the maximum fluid flow rate anywhere in the wellbore. BORE II starts its calculation at $t = 0$. The first time in the data file is also identified with $t = 0$. If it is apparent that model and data times are not synchronized, then one may insert an additional line into the data file after the header lines, with an earlier time than the first real data time, in order to reset the data zero time. On the inserted line, FEC, *x*, and other data entries may be left blank or copied from the first real data line.

A1.5 Discretization in Space

The wellbore interval between $x_{\min}$ and $x_{\max}$ is uniformly divided into N cells and it is assumed that the wellbore has uniform diameter, d_w. Cell height Δx is determined as the larger of $(x_{\max} - x_{\min})/180$ and d_w. Position values indicate depth in the wellbore and thus x is zero at the surface and increases downward. The cell index increases upward, with cells 1 and N located at the bottom and top, respectively, of the wellbore interval. In general, the ith node (the center of the ith cell) is located at

$$x_i = x_{\max} - (i\text{-}1/2)\Delta x, \qquad \text{(A.8)}$$

with the ith cell extending from $x_{\max} - (i - 1)\Delta x$ to $x_{\max} - i\Delta x$.

BORE II assigns feed points and initial concentrations to cell i if the location of the feed point or $C_0(x)$ value lies within the boundaries of the ith cell. If multiple feed points are assigned to the same cell, they will all be accounted for, but if multiple initial conditions are assigned to the same cell, only the final one assigned will be used. By definition, the lower boundary of cell 1 is at $x_{\max}$, but due to round-off errors, the upper boundary of cell N may not be at $x_{\min}$. Hence, it is often useful to know the x coordinates of each node. These are displayed in the input file written by BORE II (option V) when IC0FLAG > 0. Thus, if the user sets IC0FLAG = 1, inputs one (x, $C_0(x)$) pair, and uses option V, then a new input file will be created with IC0FLAG = N and a complete list of the x coordinates for all nodes, with $C_0 = 0$ for all cells except the one identified in the original input file. Alternatively, if the initial conditions are taken from the data file with PREBORE (or taken from any source that is independent of the nodal coordinates), then using option V will create an input file that shows the actual initial conditions assigned to each cell.

The list of nodal x coordinates may be useful when modeling a thick fracture zone or aquifer, in order to place one feed point in each cell over a given depth range. Similarly, when using IC0FLAG > 0 to specify non-uniform initial concentrations, one must assign a C_0 value to each cell in the interval of interest in order to obtain a continuous C profile, because no interpolation is done between scattered initial concentrations. Finally, knowing the coordinate of the top cell in the model is useful for assigning the initial concentration that serves as the boundary condition for inflow into the wellbore interval from above. For inflow from below, either $x = x_1$ or $x = x_{\max}$ may be used.

A1.6 Calculation of Flow Rates

Feed point flow rates may be constant in time, in which case a steady-state flow field is assumed in the wellbore, or variable, with feed point flow rates determined by linear interpolation between tabulated values. Although feed point flow rate may vary, true transient wellbore flow including fluid compressibility effects is not considered. Rather, the wellbore fluid flow field is assumed to change instantly from one steady-state flow field to another. In other words, the flow rate out of cell i is always the sum of the flow rates from all feed point locations within the boundaries of cell i plus the flow rate out of cell i-1.

Appendix 2: The Preprocessor PREBORE

PREBORE is a simple Fortran program that does preprocessing for BORE II. It runs under either Windows or DOS. PREBORE converts the old BORE data file format into the new BORE II data file format. Depth is converted from feet to meters, and other data columns are realigned. PREBORE can also create a file with (x,C_0) pairs to be added to the BORE II input file as initial conditions (this option requires that x values steadily increase or steadily decrease in each profile).

If data file conversion is being done, the user is prompted to enter the old and new data file names.

If a file with initial conditions is being created, the user is prompted for the following information: the name of the BORE II data file; a name for the initial condition file; which profile in the data file to use; the direction of logging (downward assumes x values increase in the data file, upward assumes they decrease, and both assumes the profiles alternately increase and decrease in x); and the conversion factors (γ, β, α) between FEC and C (default values 0, 1870, -40). In addition to creating an ASCII text file with (x,C_0) pairs, which may be added to the BORE II input file using a text editor or word processor, PREBORE prints out the number of pairs on the screen, which should be used for IC0FLAG. Note that IC0FLAG may be greater than the number of cells in the model (usually about 180), but that in this case not all the C_0 values will be used (see Appendix 1, Section A1.5).

Data file conversion and initial condition creation can be done in the same PREBORE run. In this case the user must specify both old and new data file names in addition to the parameters describing the creation of initial conditions.

Appendix 3: Input Files for Example Applications

A2.1 Example Application 1 – Up Flow – up_num.inp

```
TITLE: up flow with flow from below, compare to synthetic data
XMIN(m)     XMAX(m)     DIAM(cm)    !DX(m) = MAX(|XMIN - XMAX|/180,
DIAM/100)
 .0000       180.0       14.00      ! 1.000
QW(L/min)   HALPHA      !QW=flow from below; HALPHA=hor. flow
constriction
 .7500       2.500
#FEED_PTS   VARIABLE_FLOWRATE_IDENTIFIER
    3               999
DEPTH(m)    Q(L/min)    C(g/L)      T0(hr)      Q/V_FLAG    !Vd(m/day)
 160.5       .7500       100.0       .0000        0
 130.5       .7500       100.0       .0000        0
 50.50       .7500       100.0       .0000        0
TMAX(hr)    FECMAX      DIFFUSION_COEF.(m2/s)
 24.00       100.0       .7500E-09
RGAMMA      RBETA       RALPHA      !FEC = RGAMMA + C*RBETA + C*C*RALPHA
 .0000       1.000       .1000E-07
IC0FLAG     !If 0, C0=0; If <0, read one C0; If >0,read IC0FLAG (X,C0)
pairs
    0
DATA_FILE   !'NONE' if there is no data file
up_num.dbt
```

A2.2 Example Application 2 – Horizontal Flow Analytical Solution – hor_an.inp

```
TITLE: Horizontal Flow - Compare to Analytical Solution
XMIN(m)     XMAX(m)     DIAM(cm)
0.000       50.000      7.600
QW(L/min)   HALPHA
0.          2.850000
#FEED_PTS   VARIABLE_FLOWRATE_IDENTIFIER
       2    999
DEPTH(m)    Vd(m/d)     C(g/L)      T0(hr)      Q/V_FLAG
  25.0000     1.        1000.     .0000          1
  25.0000    -1.        1000.     .0000          1
TMAX(hr)    FECMAX      DIFFUSION_COEF.(m2/s)
3.0000      1000.       1.e-10
RGAMMA      RBETA       RALPHA
0.000000    1.000000    1.e-08
IC0FLAG
0
DATA_FILE
hor_an.dbt
```

The input file for the case with significant dispersion is identical, except that the diffusion coefficient is increased from 10^{-10} m^2/s to 10^{-5} m^2/s.

A2.3 Example Application 3 – Horizontal Flow - hor_real.inp

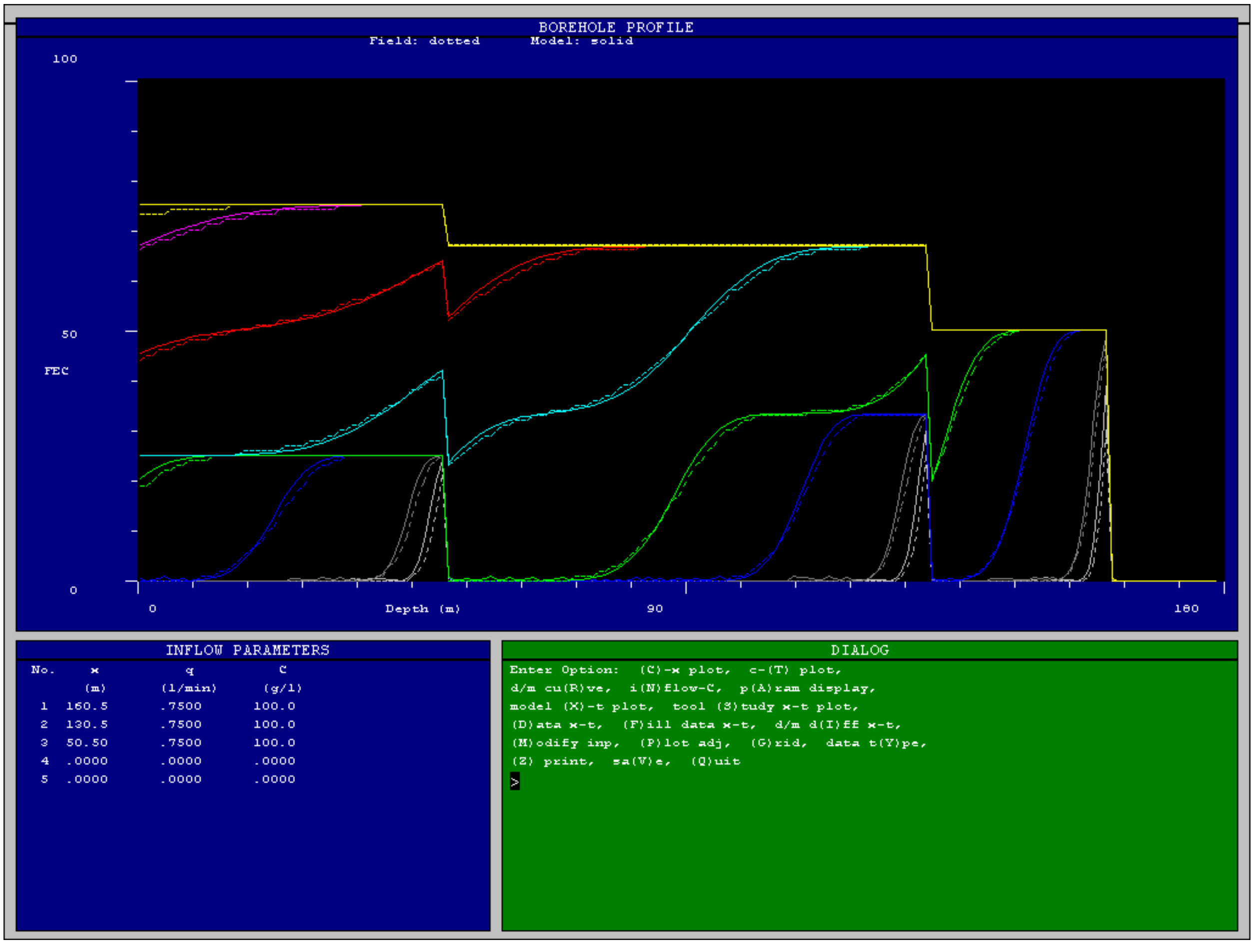
```
TITLE: Horizontal Flow Example
XMIN(m)     XMAX(m)     DIAM(cm)    !DX(m) = MAX(|XMIN - XMAX|/180,
DIAM/100)
 .0000       60.00       7.600      ! .3333
QW(L/min)   HALPHA      !QW=flow from below; HALPHA=hor. flow
constriction
 .0000       2.500
#FEED_PTS   VARIABLE_FLOWRATE_IDENTIFIER
   14               999
DEPTH(m)    Q(L/min)    C(g/L)      T0(hr)      Q/V_FLAG    !Vd(m/d)
 26.73       .5295E-02   730.0       .0000        0         ! .1204
 26.73      -.5295E-02   .0000       .0000        0         !-.1204
 26.39       .5295E-02   730.0       .0000        0         ! .1204
 26.39      -.5295E-02   .0000       .0000        0         !-.1204
 26.06       .5295E-02   730.0       .0000        0         ! .1204
 26.06      -.5295E-02   .0000       .0000        0         !-.1204
 25.73       .5295E-02   730.0       .0000        0         ! .1204
 25.73      -.5295E-02   .0000       .0000        0         !-.1204
 25.39       .5295E-02   730.0       .0000        0         ! .1204
 25.39      -.5295E-02   .0000       .0000        0         !-.1204
 25.06       .5295E-02   730.0       .0000        0         ! .1204
 25.06      -.5295E-02   .0000       .0000        0         !-.1204
 24.73       .5295E-02   730.0       .0000        0         ! .1204
 24.73      -.5295E-02   .0000       .0000        0         !-.1204
TMAX(hr)    FECMAX      DIFFUSION_COEF.(m2/s)
 4.000       400.0       .7500E-04
RGAMMA      RBETA       RALPHA      !FEC = RGAMMA + C*RBETA + C*C*RALPHA
 .0000       1.000       .1000E-07
IC0FLAG     !If 0, C0=0; If <0, read one C0; If >0,read IC0FLAG (X,C0)
pairs
    0
DATA_FILE   !'NONE' if there is no data file
hor_real.dbt
```

A2.4 Example Application 4 – Down Flow – down_c.inp

```
TITLE: downflow, variable source conc., uniform non-zero initial conc.
XMIN(m)     XMAX(m)     DIAM(cm)    !DX(m) = MAX(|XMIN - XMAX|/180,
DIAM/100)
 140.0       240.0       7.600      ! .5556
QW(L/min)   HALPHA      !QW=flow from below; HALPHA=hor. flow
constriction
 .0000       2.850
#FEED_PTS   VARIABLE_FLOWRATE_IDENTIFIER
   12               999
DEPTH(m)    Q(L/min)    C(g/L)      T0(hr)      Q/V_FLAG    !Vd(m/day)
 239.0      -.7000       .0000       .4000        0
 212.0      -1.000       .0000       .4000        0
 187.0       .7500       1800.       .4000        0
 183.0       .1900       1900.       .4000        0
 181.0       .1200       1900.       .4000        0
 178.0       .5000E-01   1900.       .4000        0
 176.0       .4000E-01   1900.       .4000        0
 174.0       .3000E-01   1900.       .4000        0
 171.0       .1000E-01   1900.       .4000        0
 164.4      99905.       1900.       .4000        0
     T(hr)       Q(L/min)    C(g/L)      !#entries is two digits after
999
      .0000       .4400       80.00
      .4000       .4400       100.0
      1.200       .4400       1100.
      1.900       .4400       1650.
      4.500       .4400       1950.
 162.0      99904.       1800.       .0000        0
     T(hr)       Q(L/min)    C(g/L)      !#entries is two digits after
999
      .0000       .6000E-01   80.00
      .4000       .6000E-01   200.0
      1.900       .6000E-01   1650.
      4.500       .6000E-01   1950.
 158.5       .1000       80.00       .0000        0
TMAX(hr)    FECMAX      DIFFUSION_COEF.(m2/s)
 4.400       1700.       .1000E-02
RGAMMA      RBETA       RALPHA      !FEC = RGAMMA + C*RBETA + C*C*RALPHA
 .0000       1.000       .1000E-07
IC0FLAG     !If 0, C0=0; If <0, read one C0; If >0,read IC0FLAG (X,C0)
pairs
   -1
C0 (g/L)    !Uniform, non-zero C0
 80.00
DATA_FILE   !'NONE' if there is no data file
down_c.dbt
```

A2.5 Example Application 5 – Combination Flow – comb_ic.inp

```
TITLE: Combination flow example, non-uniform initial concentration
XMIN(m)     XMAX(m)     DIAM(cm)    !DX(m) = MAX(|XMIN - XMAX|/180,
DIAM/100)
 .00000      50.000      7.6000     ! .2778
QW(L/min)   HALPHA      !QW=flow from below; HALPHA=hor. flow
constriction
 .00000      2.8500
#FEED_PTS   VARIABLE_FLOWRATE_IDENTIFIER
   12               999
DEPTH(m)    Q(L/min)    C(g/L)      T0(hr)      Q/V_FLAG    !Vd(m/day)
 45.000     -.13000      .00000      .00000       0
 33.300      .11000      800.00      .15000       0
 33.300     -.31000      .00000      .00000       0
 27.500     -1.0500      .00000      .00000       0
 25.700      .30000      810.00      .15000       0
 25.400      .30000      810.00      .15000       0
 25.140      .30000      810.00      .15000       0
 24.900      .30000      810.00      .15000       0
 23.500      .12000      800.00      .15000       0
 21.500      .40000E-01  800.00      .15000       0
 14.000      .15000E-01  750.00      .15000       0
 12.200      .10000E-01  750.00      .15000       0
TMAX(hr)    FECMAX      DIFFUSION_COEF.(m2/s)
 1.0000      1000.0      .50000E-03
RGAMMA      RBETA       RALPHA      !FEC = RGAMMA + C*RBETA + C*C*RALPHA
 .00000      1.0000      .10000E-07
IC0FLAG     !If 0, C0=0; If <0, read one C0; If >0,read IC0FLAG (X,C0)
pairs
  232
X(m)        C0(g/L)           !#entries is IC0FLAG
1.524       2
1.615       2
1.707       3
1.829       3
1.951       3
2.073       3
2.225       3
2.377       3
2.53        3
2.713       3
2.865       3
3.018       3
3.353       589
3.536       597
3.719       588
3.871       583
4.054       584
…(208 entries not shown)…
43.282      2
43.8        2
43.983      2
44.166      1
44.318      1
44.501      1
44.684      1
DATA_FILE   !'NONE' if there is no data file
comb_ic.dbt
```



```
INFLOW PARAMETERS
No.    x        q        C
      (m)    (l/min)   (g/l)
 1  160.5     .7500    100.0
 2  130.5     .7500    100.0
 3  50.50     .7500    100.0
 4  .0000     .0000    .0000
 5  .0000     .0000    .0000
```

```
DIALOG
Enter Option:  (C)-x plot,  c-(T) plot,
d/m cu(R)ve,  i(N)flow-C,  p(A)ram display,
model (X)-t plot,  tool (S)tudy x-t plot,
(D)ata x-t,  (F)ill data x-t,  d/m d(I)ff x-t,
(M)odify inp,  (P)lot adj,  (G)rid,  data t(Y)pe,
(Z) print,  sa(V)e,  (Q)uit
>
```

Figure 1. Concentration (=FEC) versus depth at a series of times for example application 1 - up flow. Data are numerically simulated using the TOUGH2 code. Figure is a BORE II screen-print after running option R.

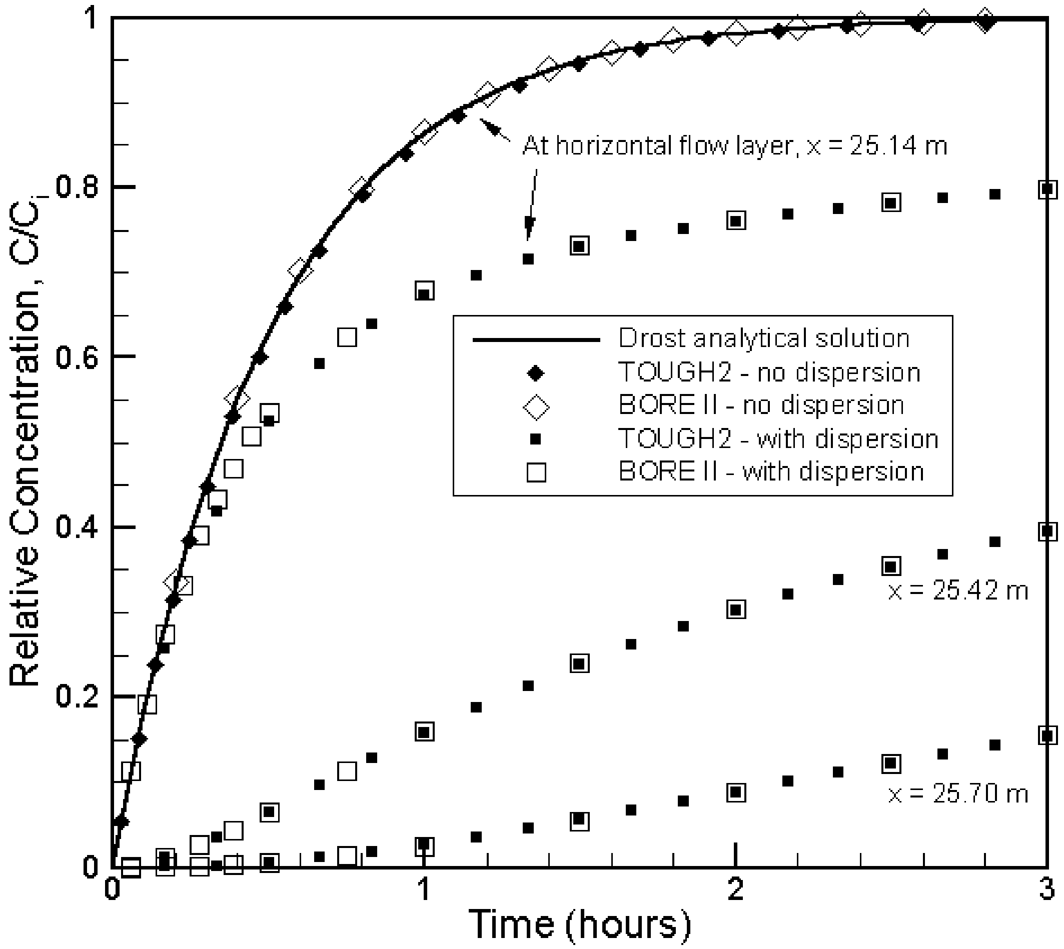


Figure 2. Relative concentration versus time for example application 2 – horizontal flow. When diffusion/dispersion is negligible, the concentration increase only occurs at the depth of the horizontal flow layer. The solid line shows the analytical solution as given by Drost (1968), Equation (1).

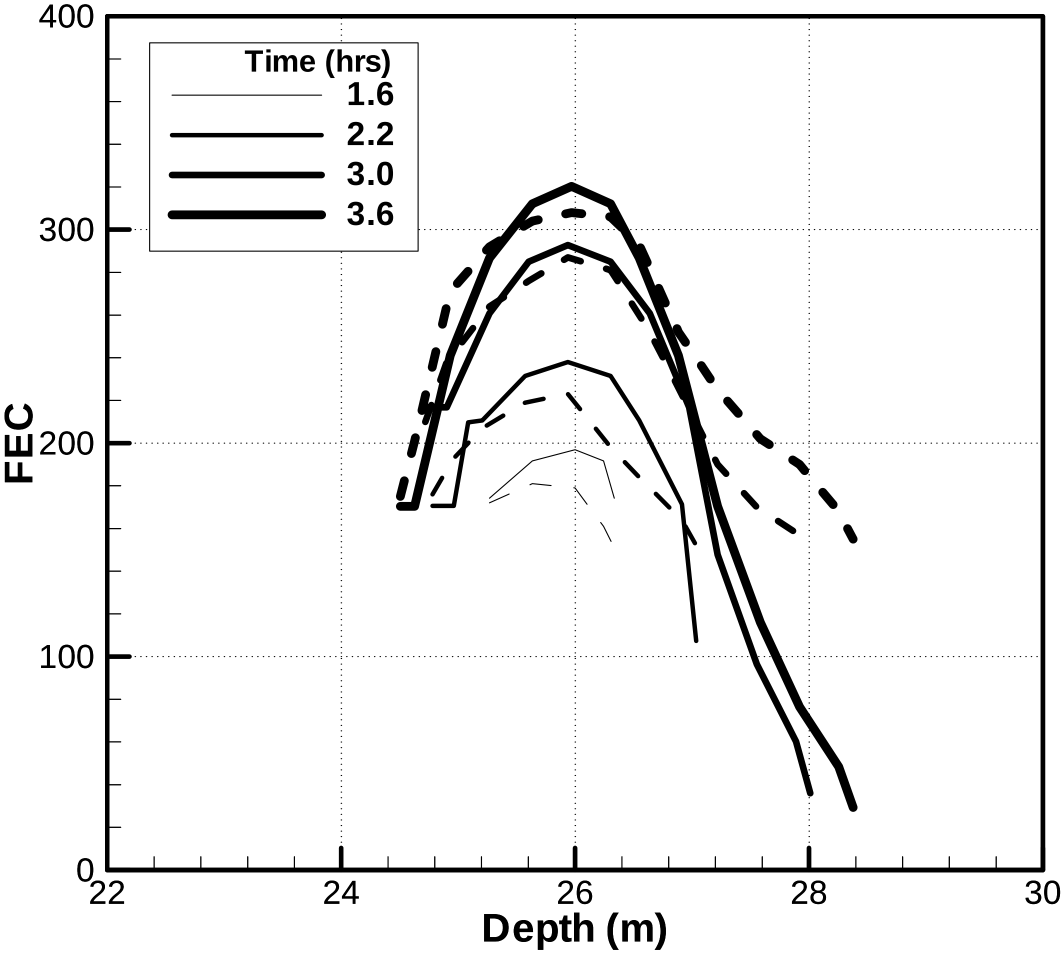


Figure 3. Concentration (= FEC) versus depth at a series of times for example application 3 – a thick layer of horizontal flow. Dashed lines represent field data, solid lines represent BORE II results. Diffusion/dispersion is significant.

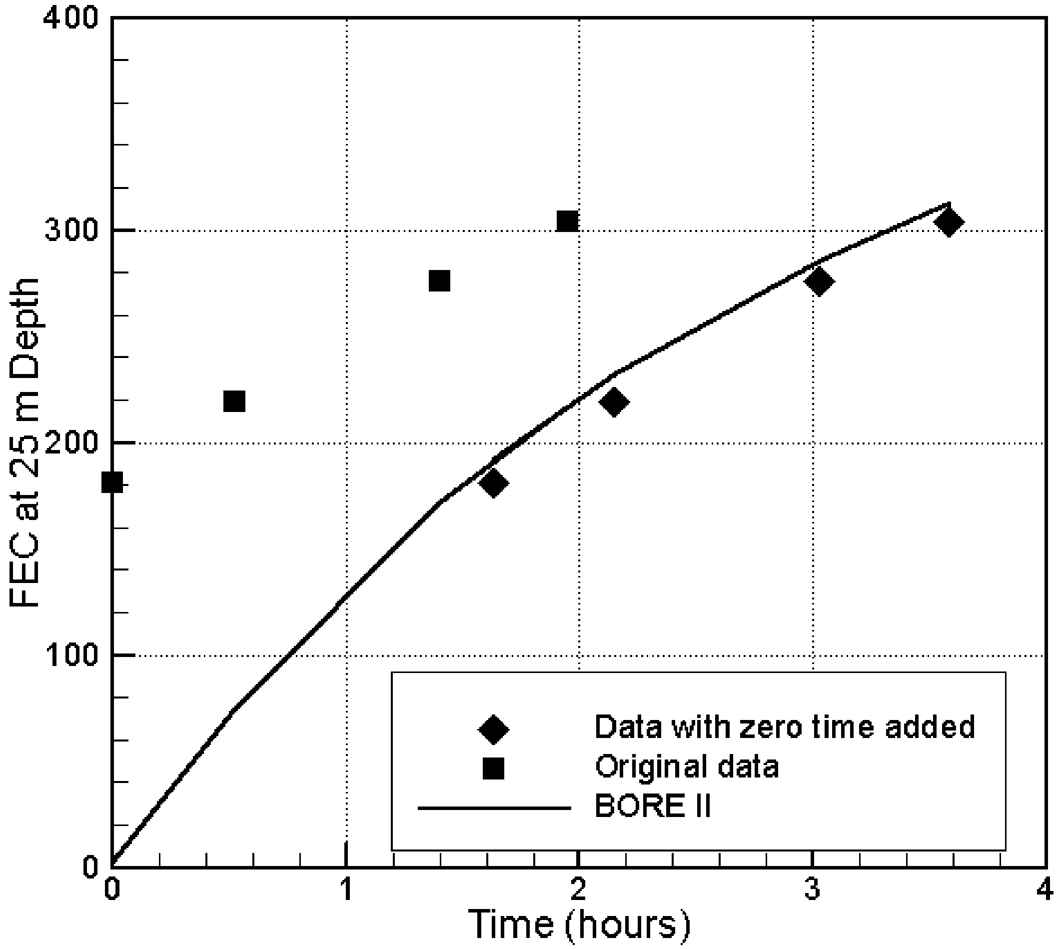
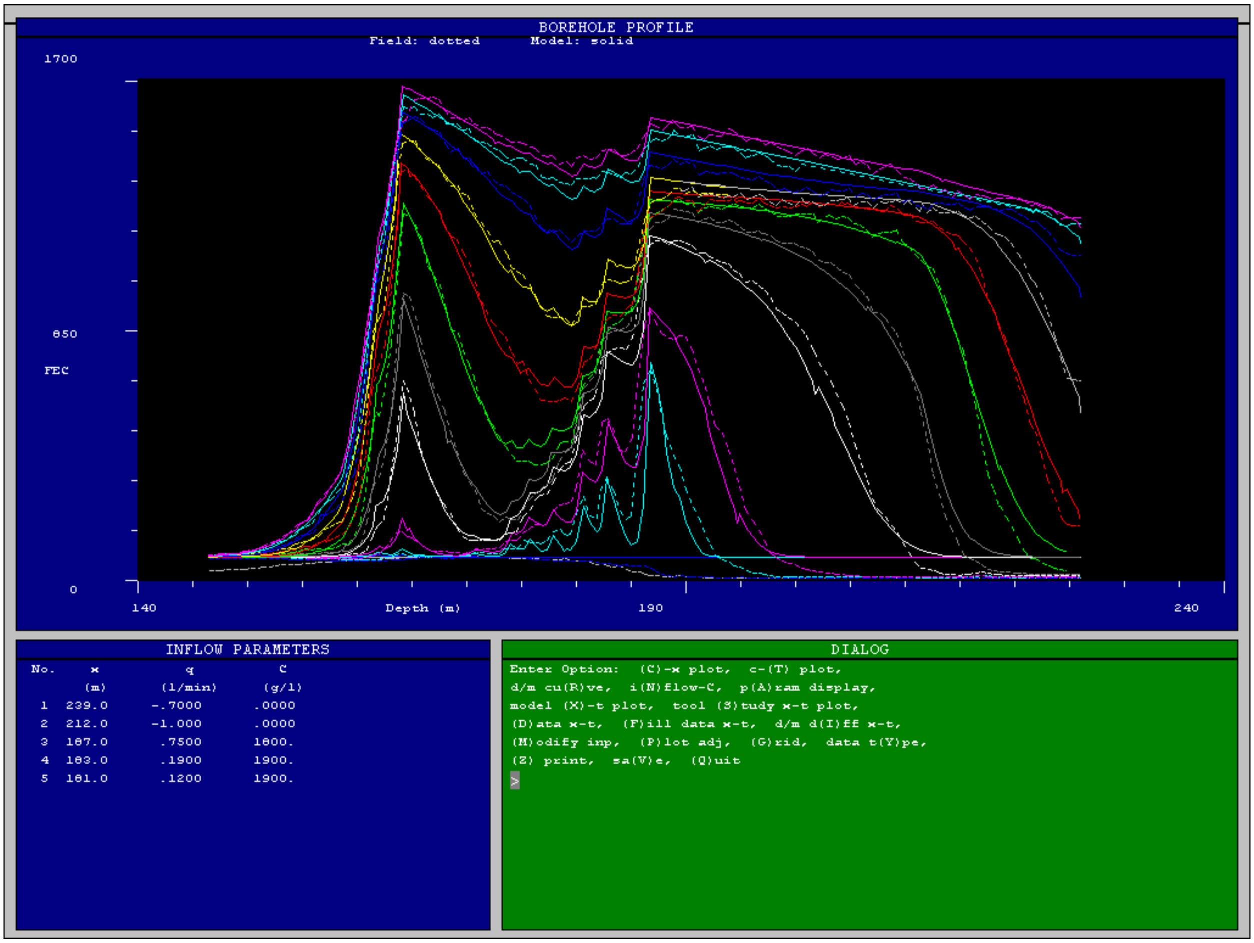


Figure 4. Concentration (= FEC) versus time at the center of the horizontal flow zone of example application 3, illustrating the addition of a data zero time.



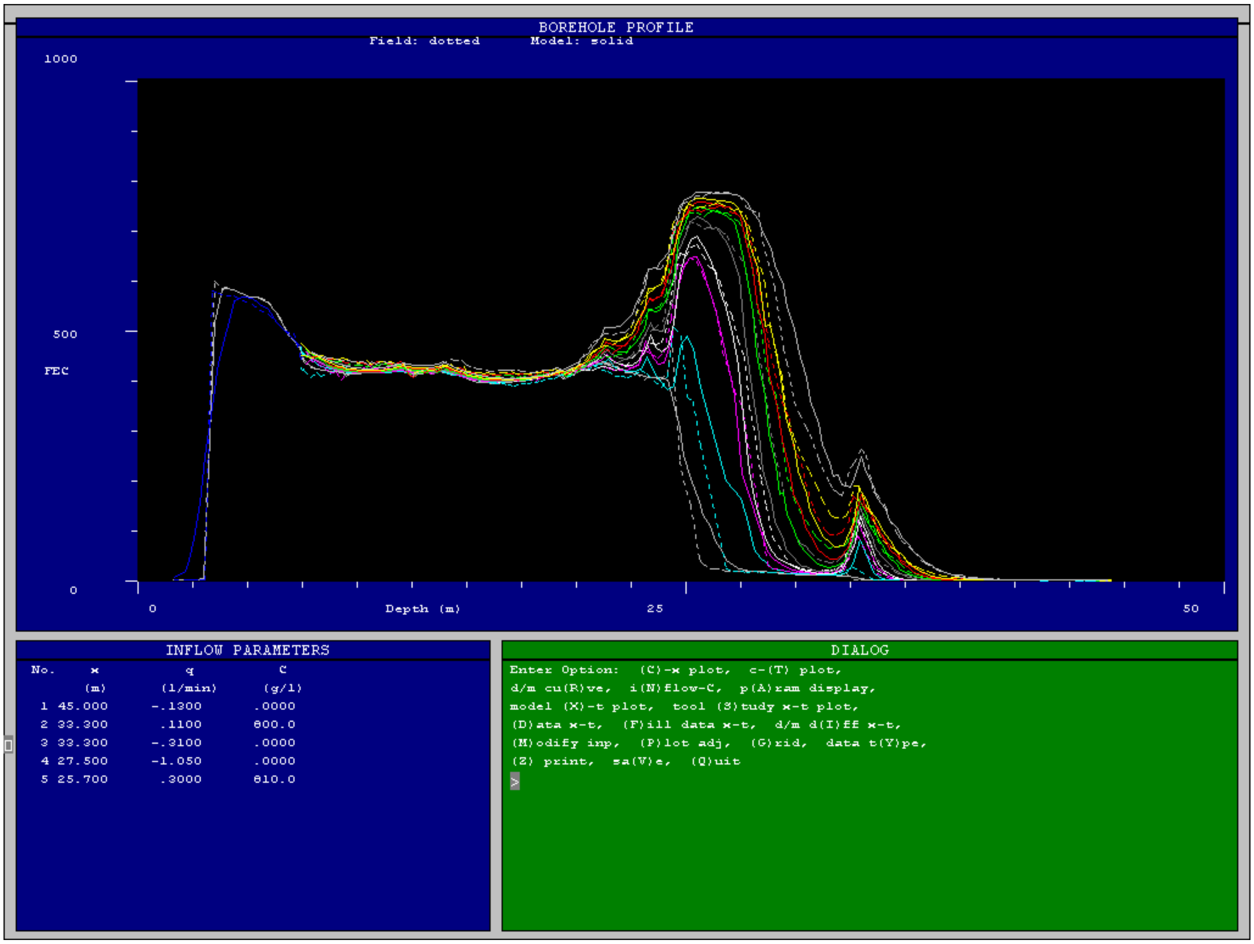
INFLOW PARAMETERS

No.	x (m)	q (l/min)	C (g/l)
1	239.0	-.7000	.0000
2	212.0	-1.000	.0000
3	187.0	.7500	1800.
4	183.0	.1900	1900.
5	181.0	.1200	1900.

DIALOG

```
Enter Option:  (C)-x plot,  c-(T) plot,
d/m cu(R)ve,  i(N)flow-C,  p(A)ram display,
model (X)-t plot,  tool (S)tudy x-t plot,
(D)ata x-t,  (F)ill data x-t,  d/m d(I)ff x-t,
(M)odify inp,  (P)lot adj,  (G)rid,  data t(Y)pe,
(Z) print,  sa(V)e,  (Q)uit
>
```

Figure 5. Concentration (= FEC) versus depth at a series of times for example application 4 – down flow. Figure is a BORE II screen-print after running option R.



```
No.    x         q          C
      (m)     (l/min)     (g/l)
 1 45.000     -.1300      .0000
 2 33.300      .1100      800.0
 3 33.300     -.3100      .0000
 4 27.500     -1.050      .0000
 5 25.700      .3000      810.0
```

```
Enter Option:  (C)-x plot,  c-(T) plot,
d/m cu(R)ve,  i(N)flow-C,  p(A)ram display,
model (X)-t plot,  tool (S)tudy x-t plot,
(D)ata x-t,  (F)ill data x-t,  d/m d(I)ff x-t,
(M)odify inp,  (P)lot adj,  (G)rid,  data t(Y)pe,
(Z) print,  sa(V)e,  (Q)uit
>
```

Figure 6. Concentration (= FEC) versus depth at a series of times for example application 5 – combination flow. Figure is a BORE II screen-print after option R.

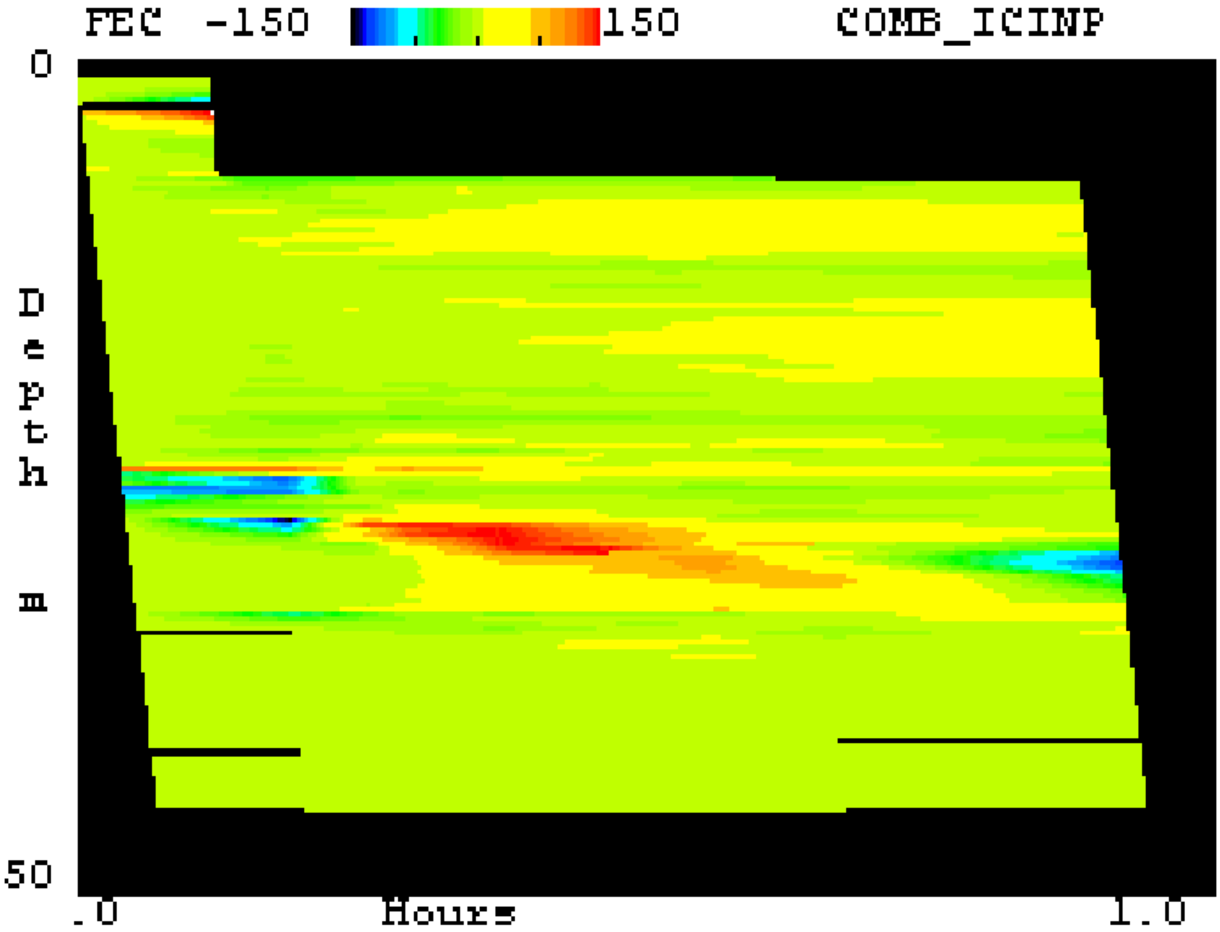


Figure 7. FEC difference between model and data as a function of depth and time (an *x*-*t* plot) for example application 5 – combination flow. Figure is a BORE II screen-print after option I, mode 2.

APPENDIX C

LIMITATIONS

LIMITATIONS

COLOG's logging was performed in accordance with generally accepted industry practices. COLOG has observed that degree of care and skill generally exercised by others under similar circumstances and conditions. Interpretations of logs or interpretations of test or other data, and any recommendation or hydrogeologic description based upon such interpretations, are opinions based upon inferences from measurements, empirical relationships and assumptions. These inferences and assumptions require engineering judgment, and therefore, are not scientific certainties. As such, other professional engineers or analysts may differ as to their interpretation. Accordingly, COLOG cannot and does not warrant the accuracy, correctness or completeness of any such interpretation, recommendation or hydrogeologic description.

All technical data, evaluations, analysis, reports, and other work products are instruments of COLOG's professional services intended for one-time use on this project. Any reuse of work product by Client for other than the purpose for which they were originally intended will be at Client's sole risk and without liability to COLOG. COLOG makes no warranties, either express or implied. Under no circumstances shall COLOG or its employees be liable for consequential damages.

HydroPhysical™ and Geophysical Logging Results
Former LO-58 Nike Battery Launch Site,
Maine Formerly Used Defense Sites (FUDS)
Caribou, ME

Prepared for
Weston Solutions, Inc.
January 13, 2009

Prepared by
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Geophysical Engineer	Asst. Gen. Manager/Senior Hydrogeologist

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Caribou, ME

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DW-2 Logging Results

Figures and Tables – DW-2

IV. Appendices

List of Acronyms

Weston Solutions – Weston Solutions, Inc.
gpm – gallons per minute
FEC – Fluid Electrical Conductivity
OBI – Optical Borehole Imager (optical televiewer)
ABI – Acoustic Borehole Imager (acoustic televiewer)
WSP – Wireline Straddle Packer
VSP – Vertical Seismic Profile
ft – feet
min. – minute
cm – centimeters
s – second
µS – micro Siemons
HpL™ - HydroPhysical™ Logging
DI – De-ionized, e.g., DI water
ftbtoc – feet below top of casing
GS – Ground Surface

HydroPhysical™ and Geophysical Logging Results
Former LO-58 Nike Battery Launch Site,
Maine Formerly Used Defense Sites (FUDS)
Caribou, ME

I. Executive Summary

The results of the HydroPhysical™ and geophysical logging performed in two open boreholes and five 2-inch PVC wells at the Former LO-58 Nike Battery Launch Site, Maine Formerly Used Defense Sites (FUDS) in Caribou, Maine identified water-bearing fractures ranging in flow rates from 0.005 to 5.69 gpm. High-angle fractures with aperture were identified in each of the two open boreholes and wireline straddle packer testing indicated the high-angle fractures are likely providing a vertical conduit for hydraulic communication outside the influence of the borehole. Fracture-specific transmissivities calculated using the hydrophysical data in the two open boreholes range from 0.20 to 220 feet^2/day. Fracture-specific FEC did not vary significantly between the boreholes, with FEC ranging from 321 to 597 µS/cm.

Ambient testing identified horizontal flow in DW-1 and downward vertical flow within the fluid column in DW-2. The difference is likely due to the highly fractured borehole in DW-1 with some of those water-bearing fractures high-angle, resulting in an interconnected network of fractures that have pressure-equilibrated outside the influence of the borehole. In DW-2, a significantly deeper borehole, though there are still high-angle fractures identified, their aperture and water-bearing potential are not as significant and likely lack the vertical hydraulic potential in the middle portion of DW-2.

Please refer to Table Summary:1 for a complete summary of the HydroPhysical™ logging results. All depths reported herein are referenced to the top of steel or PVC casings.

Table Summary 1: Summary of Hydrophysical Logging Results; Weston Solutions; LO-58; Caribou, ME.

Well ID	Water Bearing Interval #	Interval of Flow (feet)	Interval Specific Flow Rate During Ambient Testing (gpm)	Interval Specific Flow Rate During Pumping (gpm)	Transmissivity (ft2/day)	Interval-Specific Fluid Electrical Conductivity (uS/cm)
DW-1	**1**	27.3 - 31.7	0.085	0.207	8.51E+00	376
	2	34.6 - 35.0	0.011	0.195	1.28E+01	376
	3	37.4 - 38.4	0.000	0.745	5.18E+01	428
	4	40.4 - 48.6	0.140	2.00	1.29E+02	357
	5	49.0 - 50.2	0.018	0.416	2.76E+01	375
	6	52.7 - 53.6	0.058	1.65	1.11E+02	375
	7	54.4 - 58.1	0.000	0.838	5.82E+01	375
DW-2	**1**	19.5 - 19.6	0.026	0.01	2.95E+00	321
	2	30.4 - 31.6	0.297	5.69	2.20E+02	378
	3	38.2 - 41.8	0.016	0.374	1.43E+01	528
	4	44.9 - 51.4	0.074	0.081	2.82E-01	512
	5	96.4 - 97.0	-0.370	0.000	1.48E+01	432
	6	143.3 - 144.3	0.000	0.008	3.20E-01	432
	7	179.2 - 183.0	0.000	0.015	6.00E-01	431
	8	189.5 - 191.0	-0.185	0.051	9.45E+00	429
	9	191.4 - 218.3	0.000	0.008	3.20E-01	429
	10	227.4 - 228.2	0.000	0.005	2.00E-01	597
	11	243.7 - 279.2	0.000	0.024	9.61E-01	597

Wire-Line Straddle Packer (WSP) Summary

Former Nike Battery Launch Site LO-58, Maine Formerly Used Defense Site

Well Field Sample ID Sample Date Depth Interval (ft bgs)	Maine Exposure Guideline (µg/L)	EPA Maximum Contaminant Limit (µg/L)	DW-1					
			LS58DW1-0508-29 5/20/2008 (water) 24.98 to 33.15	LS58DW1-0508-34 5/20/2008 33.75 to 38.5	LS58DW1-0508-34E 5/20/2008	LS58DW1-0508-41 5/19/2008 41.2 to 51.9	LS58DW1-0508-51 5/19/2008 51.0 to 58.1 (bottom)	LS58DW1-0508-56 5/18/2008 56.6 to 58.1 (bottom)
Volatile Organic Compunds by U.S. Environmetal Protection Agency Method 524.2 (µg/L)								
Benzene	6	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	70	NE	**0.52**	0.5 U	0.5 U	**0.24 J**	0.5 U	**0.34 J**
cis-1,2-Dichloroethylene	70	70	0.5 U	**0.44 J**	**0.45 J**	**1.2**	**0.96**	**0.52**
Trichloroethylene	32	5	**1.8**	**2.5**	**2.5**	**3.4**	**3.1**	**2**
Toluene	1,400	1,000	**120 D**	**25**	**22**	**12**	0.5 U	**22**
1,2-Ethylene Dibromide, 1,2-Dibromo-3-Chloropropane, and 1,2,3-Trichloropronane by U.S. Environmetal Protection Agency Method 504.1 (µg/L)								
No analytes detected								
Gasoline Range Organics by Maine Health and Environmental Testing Laboratory Method 4.1.17 (µg/L)								
Gasoline Range Organics	50	NE	**156**	**24**	**23**	**14**	10 U	**27**
Diesel Range Organics by Maine Health and Environmental Testing Laboratory Method 4.1.25 (µg/L)								
Diesel Range Organics	50	NE	50 U	50 U	50 U	**51**	50 U	**350**

Well Field Sample ID Sample Date Depth Interval (ft bgs)	Maine Exposure Guideline (µg/L)	EPA Maximum Contaminant Limit (µg/L)	DW-2					
			LS58DW2-0508-16 5/16/2008 16.0 to 20.0	LS58DW2-0508-28.5 5/16/2008 28.5 to 32.5	LS58DW2-0508-37 5/17/2008 37.0 to 41.7	LS58DW2-0508-94.5 5/17/2008 94.5 to 98.5	LS58DW2-0508-189 5/17/2008 187.9 to 192.2	LS58DW2-0508-265 5/17/2008 265 to 284.0 (bottom)
Volatile Organic Compunds by U.S. Environmetal Protection Agency Method Method 524.2 (µg/L)								
Benzene	6	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloroform	70	NE	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U U
cis-1,2-Dichloroethylene	70	70	0.5 U	0.5 U	0.5 U	0.5 U	**0.23 J**	0.5 U
Trichloroethylene	32	5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Toluene	1,400	1,000	**2.4**	0.5 U	0.5 U	**5.5**	2.3 U1	0.79 U1
1,2-Ethylene Dibromide, 1,2-Dibromo-3-Chloropropane, and 1,2,3-Trichloropronane by U.S. Environmetal Protection Agency Method 504.1 (µg/L)								
No analytes detected								
Gasoline Range Organics by Maine Health and Environmental Testing Laboratory Method 4.1.17 (µg/L)								
Gasoline Range Organics	50	NE	10 U	10 U	10 U	10 U	10 U	10 U
Diesel Range Organics by Maine Health and Environmental Testing Laboratory Method 4.1.25 (µg/L)								
Diesel Range Organics	50	NE	**1,050**	50 U	50 U	50 U	50 U	**80**

Notes:

NE = Standard not established.
µg/L = Micrograms per liter (parts per billion).
ft bgs = Feet below ground surface.
Bold = Substance Detected.
Blue Highlight = Exceeds Maine Exposure Guideline.

D = Result from dilution analysis.
J = Quantitation approximate.
U = substance not detected at the listed detection limit.
U1 = Toluene qualifiued as not detected due to detection in rinsate blank.

II. Introduction

In accordance with COLOG's proposal dated February 23, 2007, COLOG has applied HydroPhysical™ (HpL™) and geophysical logging methods and wireline straddle packer methods to characterize the formation waters and orientation of identified fractures and features intersecting two open boreholes and five PVC wells at the Former LO-58 Nike Battery Launch Site, Maine Formerly Used Defense Sites (FUDS) in Caribou, Maine. The objectives of the investigation were to:

1) Evaluate temperature and fluid electrical conductivity under pre-testing conditions.
2) Identify fractures and features intersecting the borehole and evaluate their orientation.
3) Characterize and quantify flow in the borehole under both non-stressed (ambient) and stressed (pumping) conditions.
4) Evaluate the vertical distribution of flow and interval-specific permeability for all identified water-producing fractures or intervals.
5) Sample and stress test water-bearing intervals using the WSP to acquire depth-specific groundwater samples.
6) Apply surface geophysical methods and downhole methods to estimate subsurface velocities.

The two open boreholes logged with the hydrophysical and geophysical logging methods at the LO-58 site are: DW-1 (AMAC well) and DW-2 (VFW well). The five PVC wells tested are: MW-1, MW-2, MW-3, MW-4 and MW-5. The geophysical and hydrophysical logging methods used to achieve the objectives were HydroPhysical™ logging, optical televiewer, acoustic televiewer, 3-arm caliper, natural gamma, water quality (pH, ORP, DO), EM induction conductivity, electric resistivity, VSP, wireline straddle packer, downhole video and full waveform sonic. The two open boreholes were tested under both non-stressed, or ambient, conditions and stressed, or pumping, conditions to fully evaluate the water-bearing horizons intersecting the boreholes. The PVC wells were not hydrophysically tested. All depths reported herein are referenced to the top of steel casings in the case of the open boreholes and PVC casings in the case of the wells.

COLOG's logging of the three subject wellbores was performed over the period of May 5th through May 20th, 2008.

Well Construction Summary

Former Nike Battery Launch Site LO-58, Maine Formerly Used Defense Sites

Well ID	MW-01	MW-02	MW-03	MW-04	MW-05	DW-1	DW-2
Ground Elevation (ft amsl)	577.3	587.6	567.5	603.4	575.9	571	546.5
Protective Casing Elevation (ft amsl)	578.96	590.13	571.07	605.84	575.88	573	539.5
Top of Inner Casing Elevation (ft amsl)	578.79	589.36	570.63	605.45	575.72	na	na
Casing Stickup (ft)	1.66	2.53	3.57	2.44	-0.02	2.4	-6
Well Total Depth (ft bmp)	142	62	47	82	82	58.1	284
Casing Diameter (inches)	2	2	2	2	2	6	6
Screened Interval Elevation (ft amsl)	435.69 to 445.69	527.76 to 537.76	521.78 to 531.78	522.75 to 532.75	497.92 to 507.92	514.9 to 563	524.5 to 255.5
Casing Bottom Elevation (ft amsl)	435.69	527.76	521.78	522.75	497.92	514.9	255.5
Depth to Water (ft bmp)	28.27	34.32	20.10	40.82	25.32	25.92	8.86
Groundwater Elevation (ft amsl)	550.52	555.04	550.53	564.63	550.4	547.08	530.64

Notes:

Elevations for well DW-1 and DW-2 are approximate, and not the result of a precise survey.

ft bmp = feet below measuring point.

ft amsl = feet above mean sea level.

Groundwater depth measurements were made on 21 May 2008.

III. Methodology

A. HydroPhysical™ Logging (HpL™)

The HydroPhysical™ logging technique involves pumping the wellbore and then pumping while injecting into the Wellbore with deionized water (DI). During this process, profiles of the changes in fluid electrical conductivity of the fluid column are recorded. These changes occur when electrically contrasting formation water is drawn back into the borehole by pumping or by native formation pressures (for ambient flow characterization). A downhole wireline HydroPhysical™ tool, which simultaneously measures fluid electrical conductivity (FEC) and temperature is employed to log the physical/chemical changes of the emplaced fluid.

The computer programs FLOWCALC and/or BOREII (Hale and Tsang, 1988 and (Daughtery and Tsang, 2000) can be utilized to evaluate the inflow quantities of the formation water for each specific inflow location. FLOWCALC is used to estimate the interval-specific flow rates for the production test results based on "hand-picked" values of FEC and depth. The values are determined from the "Pumping" and "Pumping During DI Injection logs". Numerical modeling of the reported data is performed using code BORE/BOREII. These methods accurately reflect the flow quantities for the identified water bearing intervals.

In addition to conducting HydroPhysical™ logging for identification of the hydraulically conductive intervals and quantification of the interval specific flow rates, additional logging runs are also typically performed. Prior to emplacement of DI, ambient fluid electrical conductivity and temperature (FEC/T) logs are acquired to assess the ambient fluid conditions within the borehole. During these runs, no pumping or DI emplacement is performed, and precautions are taken to preserve the existing ambient geohydrological and geochemical regime. These ambient water quality logs are performed to provide baseline values for the undisturbed borehole fluid conditions prior to testing.

For interval-specific permeability estimations, COLOG utilizes Hvorslev's 1951 porosity equation in conjunction with the HpL™ results. Several assumptions are made for estimating the permeability of secondary porosity. First, the type of production test COLOG performs in the field may significantly affect the accuracy of the transmissivity estimation. The permeability equation is relatively sensitive to overall observed drawdown. For a high yield wellbore, drawdown will usually stabilize and an accurate observed drawdown can be estimated. However, for a low yield wellbore, drawdown usually does not stabilize but instead, water level continues to drop until it reaches the pump inlet and the test is complete. In this case COLOG utilizes the maximum observed drawdown. The inaccuracy arises in the fact that overall observed drawdown does not stabilize and therefore is more an arbitrary value dependent on the placement of the pump downhole. Secondly, in an environment where flow originates from secondary porosity the length of the interval is derived from the either the thickness of the fracture down to 0.1 feet or the thickness of the fracture network producing water. This assumption of a fracture network producing water versus a porous media is not how the permeability equation was designed to be used. In lieu of a more appropriate equation unknown to COLOG at this time, COLOG utilizes Hvorslev's 1951 porosity equation based on its sensitivity to interval-specific flow which can be measured accurately, drawdown which can be measured accurately in the case of a high yield wellbore and its insensitivity to effective radius. The insensitivity to effective radius is critical when an observation well is not available to measure drawdown at a known distance from the subject wellbore.

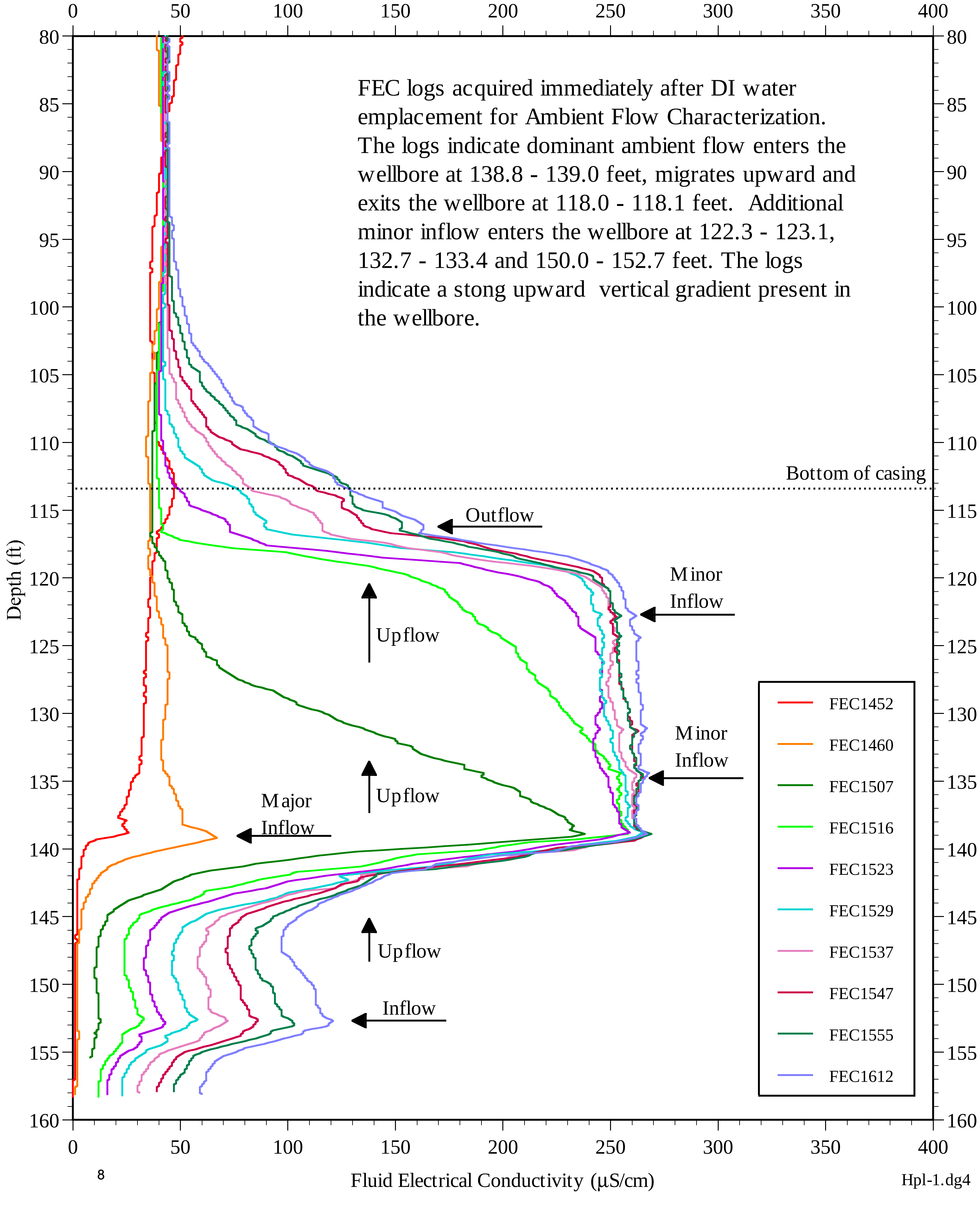
How to Interpret HydroPhysical™ Logs

Figure HpL:1 below is an example data set for an ambient flow evaluation. The data represents HpL™ logs acquired immediately after deionized (DI) water emplacement for ambient flow evaluation. For ambient flow evaluation the wellbore fluids are first replaced with DI water (termed "emplacement"), then a series of fluid electrical conductivity (FEC) logs are acquired over a period of a time to monitor ground water entering the wellbore under natural pressures and migrating either vertically or horizontally through the wellbore. The wellbore fluids are replaced with DI water without disturbing the ambient free-water level by injecting DI water at the bottom of the wellbore and extracting wellbore water at exactly the same rate at the free-water surface. However, at the beginning of the DI water emplacement, a slightly depressed free-water level (approximately one tenth of a foot below ambient free water-level) is achieved and maintained throughout the test. This procedure is implemented to ensure that little to no DI water is able to enter the surrounding formation during DI water emplacement. By acquiring FEC logs during the emplacement of DI water and by continuously measuring water level with a downhole pressure transducer the emplacement can be properly monitored and controlled to minimize the disturbance of the recorded ambient water. After the wellbore fluids are replaced with DI water, the injection and extraction pumps are turned off and in most cases the downhole plumbing is removed from the wellbore. A check valve is installed in the pump standpipe to ensure water in the standpipe does not drain back into the wellbore. While the plumbing is removed from the wellbore DI water is injected from the top of the wellbore to maintain ambient water level. Often a baseline FEC log is acquired during the final stages of the emplacement of DI water to provide baseline conditions just before the ceasing of pumping. Figure HpL:1 illustrates ambient flow entering the wellbore at depths of 150.0 to 152.7, 138.8 to 139.0, 132.7 to 133.4, 122.3 to 123.1 and 118.0 to 118.1 feet. The location of these intervals is illustrated by the sharp increases or "spikes" in FEC. The increase in FEC over time at these four intervals is characteristic of ambient inflow. The upward vertical trend in this inflow is also apparent from the FEC logs. For example, the dominant inflowing zone at 138.8 to 139.0 feet illustrates a major growth in FEC above the inflow "spike", and little growth below the "spike." The zone at 118.0 to 118.1 feet is the termination of all inflow into the well. The sum of the four inflow zones make up the outflow of this zone, and this value, along with the value of the four inflow zones is computed using code BOREII.

COLOG uses three types of tests to identify the water-bearing intervals in a wellbore under stressed conditions. In the lowest yield environment (less than 0.5-0.7 gpm) a slug test approach is utilized. In a relatively low-yield wellbore environment a pump after emplacement (PAE) test is conducted, and in a relatively medium to high-yield wellbore environment a pump and inject (PNI) test is conducted. The decision on the type of test to perform on a specific wellbore is made in the field based on the ability of the wellbore to recover to ambient free-water level when a disturbance in water level is introduced into the well, i.e. inserting tools and/or pluming into the well.

In a low-yield wellbore environment a slug or PAE test is utilized to identify the water-bearing intervals under stressed conditions. These tests are similar in protocol and involve first a replacement of wellbore fluids with DI water in a manner identical to that of the emplacement during an ambient flow evaluation. Often a baseline FEC log is acquired during the final stages of the emplacement of DI water to provide baseline conditions just before the ceasing of injection pumping. Following the cessation of injection pumping, the extraction pump is left used to either pull an instantaneous slug (slug test) or is used to pump at a relatively steady low rate of flow in the wellbore (approximately 1-2 gpm). During this time numerous FEC logs are acquired over time. The location of water-bearing intervals is apparent by the sharp increases or "spikes" in FEC over time. The rate at which these intervals inflow is calculated using BOREII and is based on the rate of increase of mass (area under the curve using the FEC log as the curve). Flow direction is easily determined by tracking the center of mass of the area under the curve. In

FIGURE HpL:1. EXAMPLE OF HYDROPHYSICAL LOGS DURING AMBIENT FLOW CHARACTERIZATION WITH EXAMPLE INTERPRETATION.

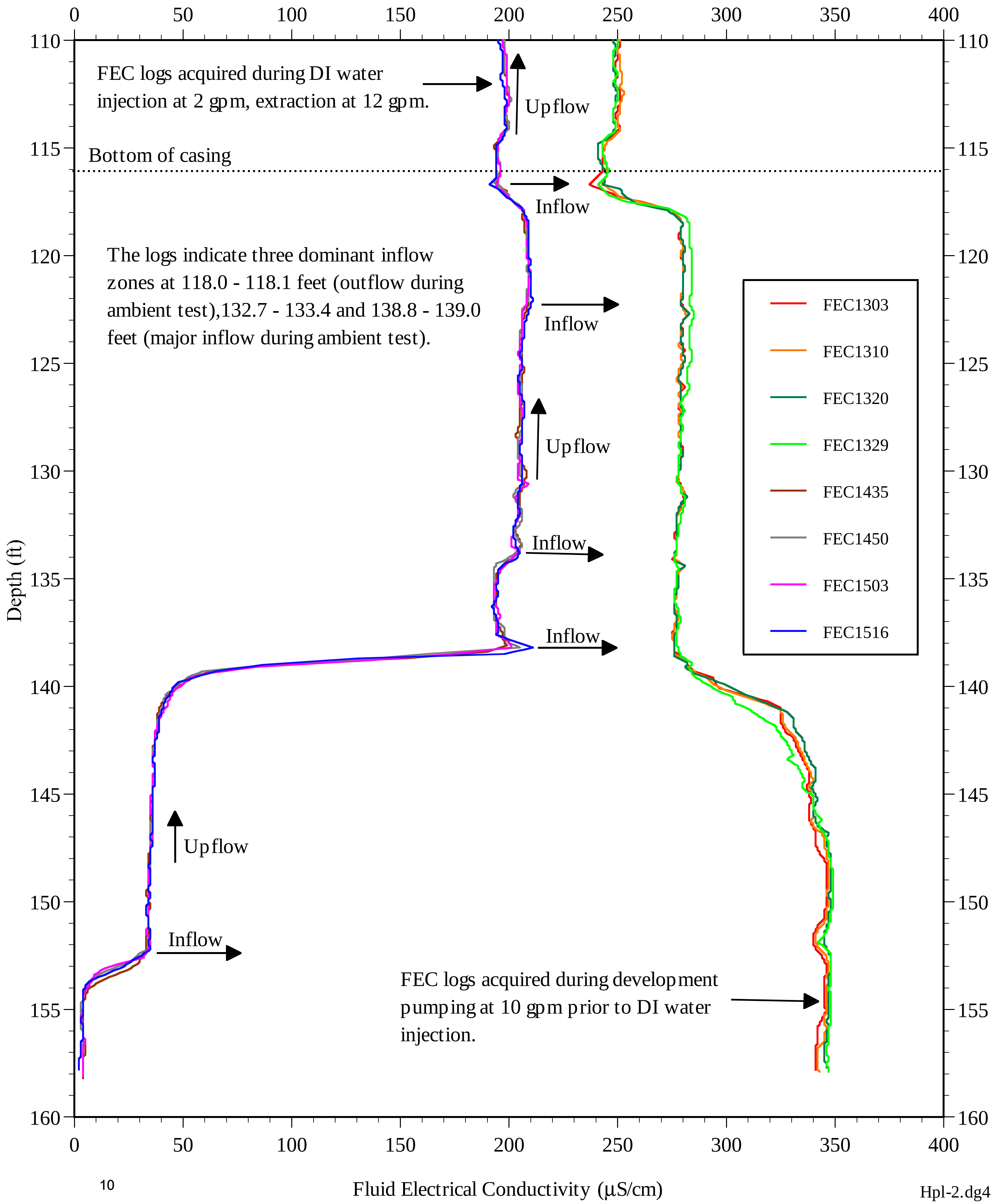


Hpl-1.dg4

most cases, if pumping is being conducted flow is traveling up the wellbore towards the pump which is situated inside casing.

Figure HpL:2 is an example data set from a production test (stress test) from the same wellbore as above. The data represents HpL^{TM} logs acquired during a PNI test. The set of FEC logs on the right of this figure (FEC1303, FEC1310, FEC1320, and FEC1329) illustrate the condition of the wellbore during development pumping. In the case of this example, the wellbore was stressed at a rate of approximately 10 gpm until a relatively steady-state condition was achieved in the wellbore. A steady-state condition is apparent when the FEC logs begin to repeat as they do in figure HpL:2. Repeatable FEC logs indicate that the hydrochemistry of the water inflowing to the wellbore is not changing over time (steady-state) and that the flow rates of all inflow zones is also not changing over time. Additionally, the drawdown is monitored continuously to observe a "slowing down" in the rate of increase of drawdown. When drawdown (water level) is stable, the inflow rates of the various inflow zones are assumed to be steady. By contrast, if DI water injection is begun in the early stages of pumping when drawdown is still increasing, i.e. water level is dropping rapidly, the inflow rates of the various inflow zones would increase with time as less wellbore storage is used to maintain a particular pumping rate. The remaining FEC logs (FEC1435, FEC1450, FEC1503, and FEC1516) illustrate the conditions in the wellbore during pumping and injection procedures. Fluid was extracted from the wellbore at a rate of approximately twelve gpm while DI water was simultaneously injected at the bottom of the wellbore at a rate of approximately two gpm, until a relatively steady-state condition existed in the well. Water-bearing intervals in the wellbore are identified by changes or "steps" in FEC throughout the FEC logs. The flow rate of these intervals is computed using BOREII and/or Flowcalc software. Every location that the FEC increases in these logs is a zone of inflow. Similarly, where the logs decrease in FEC indicates a zone of inflow with water lower in FEC than the water in the wellbore. A zone exhibiting a decrease in FEC on the injection logs should also decrease at the same depth on the development (pre-DI water injection) logs. Please see Appendix B for a detailed discussion of code BOREII used to numerically model the reported field FEC logs.

FIGURE HpL:2. EXAMPLE OF HYDROPHYSICAL LOGS DURING A 10 GPM PRODUCTION TEST WITH EXAMPLE INTERPRETATION.



Sensitivity of Transmissivity to Effective Radius

An estimation of transmissivity (T) has be made for all identified water-bearing intervals using an equation after Hvorslev (1951) assuming steady-state radial flow in an unconfined aquifer:

$$T = KL = \frac{q_i}{2\pi\Delta h_w}\ln\left(\frac{r_e}{r_w}\right)$$

where K is the hydraulic conductivity, q_i is the interval specific inflow rate calculated using HpL™ results (or “Delta Flow” from the table which equals “Interval-Specific Flow Rate During Pumping Conditions” minus “Ambient Flow Rate” if any), r_w is the borehole radius, r_e is the effective pumping radius, Δh_w is the observed maximum drawdown and L is the thickness of the zone through which flow occurs. The thickness, or length of the interval is calculated using a combination of both the HpL™ data and other geophysical data such as optical televiewer data. L can usually be estimated with a high degree of confidence based on both of those data sets. Q_i, or Delta Flow, can also be estimated accurately using code BOREII (see appendix B) for the HpL™ data sets. Δh_w is estimated with a high degree of confidence using Cologs’ downhole pressure transducer and a laptop to record water-level data every second. Additionally, the borehole radius is confirmed quite readily from caliper data or core data. For this example, r_w equals 0.20 feet, r_e has been assumed to be approximately 100 feet and the observed maximum drawdown was estimated at 9.98 feet (the drawdown plot). By applying L and q_i from the HpL™ results under the two pressure conditions, the interval specific transmissivity can be calculated for each identified water-producing interval.

Colog utilizes Hvorslevs’ 1951 equation when an observation well a known distance away with measurable drawdown is not available. Essentially, Hvorslevs’ 1951 equation is similar to the prevalent Theis equation minus the observation well drawdown information. In replace of the observation well drawdown data Hvorslevs’ equation uses an assumed “effective radius” divided by the borehole radius. One benefit to using Hvorslevs’ 1951 equation when observation well data is unavailable is the insensitivity of the equation to the assumed effective radius as this is the only “unknown” variable in the equation. All other variables are known or calculated with a high degree of confidence. Only the effective radius is unproven, or unsupported, but its value can be estimated with some degree of accuracy.

The following example will illustrate the insensitivity of Hvorslevs’ 1951 equation to the assumed effective radius of an aquifer. The greatest magnitude of change in this example between r_e of 50 feet and r_e of 300 feet is 2.22 feet^2/day transmissivity.

Interval (feet)	**Length of Interval (feet)**	**Q_i - Delta Flow (gpm)**	**Borehole Radius (feet)**	**Transmissivity Using r_e of 50 Feet**	**Transmissivity Using r_e of 100 Feet**	**Transmissivity Using r_e of 300 Feet**
118.0 – 118.1	0.1	3.997	0.20	6.78 x E^{01}	7.63 x E^{01}	8.98 x E^{01}
122.3 – 123.1	0.8	0.335	0.20	5.68 x E^{00}	6.39 x E^{00}	7.53 x E^{00}
132.7 – 133.4	0.7	1.217	0.20	2.06 x E^{01}	2.32 x E^{01}	2.73 x E^{01}
138.8 – 139.0	0.2	3.961	0.20	6.72 x E^{01}	7.56 x E^{01}	8.90 x E^{01}
150.0 – 152.7	2.7	0.197	0.20	3.34 x E^{00}	3.76 x E^{00}	4.43 x E^{00}

B. Optical Televiewer (OBI)

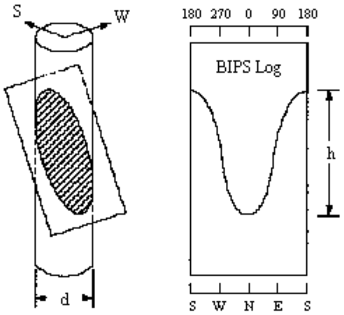
The optical televiewer provides the highest resolution available for fracture and feature analysis in boreholes. This technology is based on direct optical observation of the borehole wall face. Precise measurements of dip angle and direction of bedding and joint planes, along with other geological analyses, are possible in both air and clear fluid filled boreholes.

Theory of Operation

A small light ring illuminates the borehole wall allowing a camera to directly image the borehole wall face. A conical mirror housed in a clear cylindrical window focuses a 360° optical "slice" of the borehole wall into the camera's lens. As the optical televiewer tool is lowered down the hole, the video signal from this camera is transmitted uphole via the wireline to the optical televiewer surface instrumentation.

The signal is digitized in real time by capturing 360 pixels around a 0.5 mm ring from the conical image. The rings are stacked and unwrapped to a 2-D image of the borehole wall. A digital fluxgate magnetometer is used to determine the orientation of the digital image. A secondary mechanical compass is imaged along with the analog signal to insure proper orientation of the digital image.

The optical televiewer image is an oriented, 2-D picture of the borehole wall unwrapped from south to south or north to north depending on the software used (Figure 1). Planar features that intersect the borehole appear to be sinusoids on the unwrapped image. To calculate the dip angle of a fracture or bedding feature the amplitude of the sinusoid (h) and the borehole diameter (d) are required. The angle of dip is equal to the arc tangent of h/d, and the dip direction is picked at the trough of the sinusoid (Figure 1).



Dip Direction = Orientation of Sinusoid Minimum
Dip Angle = ArcTan h/d
where: h = height of sinusoid
d = borehole diameter

Figure 1: Geometric representation of a north dipping fracture plane and corresponding log.

Sinusoidal features were picked throughout wells by visual inspection of the digital optical televiewer images using interactive software. The software performed the orientation calculations and assigned depths to the fractures or bedding features at the inflection points (middles) of the sinusoids. Features were subjectively ranked for flow potential using COLOG's Ranking System for optical televiewer features included in this report. The features picked along with their assigned ranks, orientations and depths are presented in tables for each well. Orientations are based on magnetic north and are corrected for declination. The Stereonet plots and Rose Diagrams provide useful information concerning the statistical distribution and possible patterns or trends that may exist from the optical televiewer feature orientations.

Interpreting Optical Televiewer Data

Data acquired from the optical televiewer is typically in the form of dip direction/dip angle, i.e. 230/45. When plotted in 2-D color, the fractures and features intersecting the borehole appear as sinusoids as discussed above. Using the software program WellCAD version 3.2, the user identifies the features/fractures and has the software assign and record a dip angle and direction based on the above algorithm as described in the "Theory" section. The data can easily be converted into table format for display in Excel or any tabular editing program. From the data table, rose diagrams and/or stereonets can be generated if requested.

Rose Diagrams

A rose diagram is a polar diagram in which radial length of the petals indicates the relative frequency (percentage) of observation of a particular angle or fracture dip direction or range of angles or dip directions. Rose diagrams are used to identify patterns (if any) in the frequency of dip angles or directions for a particular data set. Figures 3 and 4 are example rose diagrams from an optical televiewer data set of fractures and features.

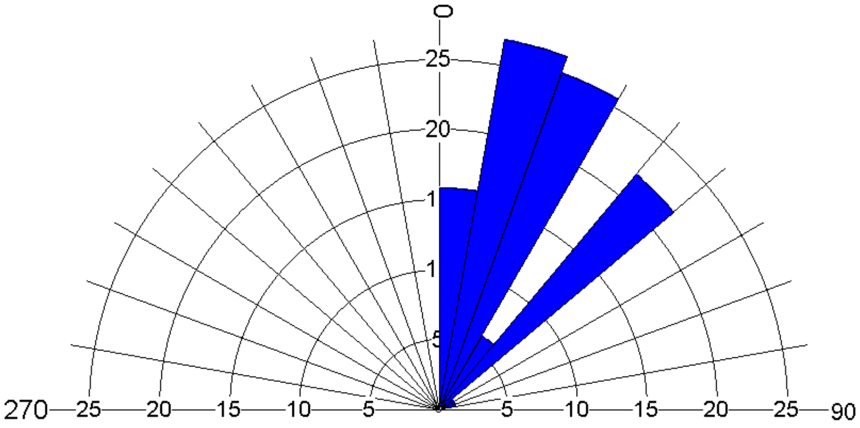


Figure 3: Example rose diagram from an optical televiewer data set illustrating the frequency (%) of dip angles.

Figure 3 above indicates, from an example data set, that approximately 16 percent of the fractures/features have a dip angle between 0 and 10 degrees, approximately 27 percent of the fractures/features have a dip angle between 11 and 20 degrees, approximately 25.5 percent between 21 and 30 degrees, approximately 6 percent between 31 and 40 degrees and 22 percent between 41 and 50 degrees. A quick glance at Figure 3 identifies a pattern of dip angle where greater than 50 percent of the fracture/features identified have a dip angle between 11 and 30 degrees. Additionally, no high-angle (greater than 50 degrees) fractures/features were identified from this data set.

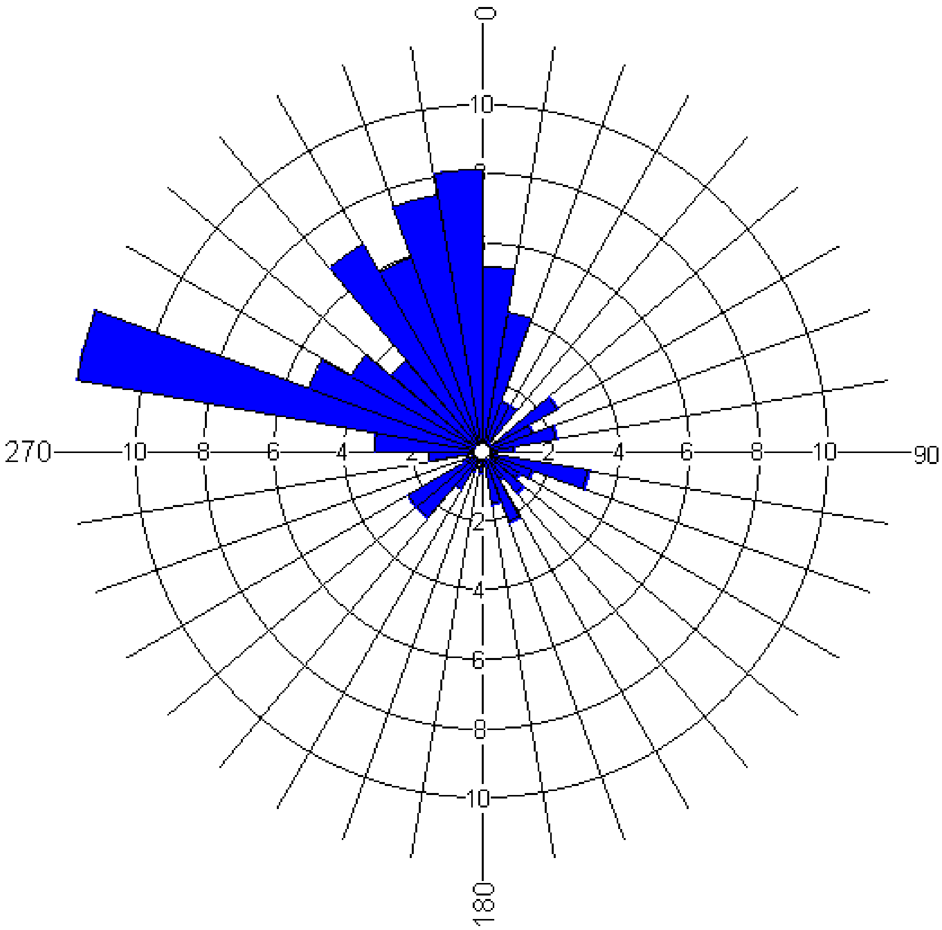


Figure 4: Example rose diagram from an optical televiewer data set illustrating the frequency (%) of dip direction.

Figure 4 (example data set) above indicates, with a quick glance, that the majority of the fractures/features dip in the direction of northwest. Specifically, approximately 62 percent of the identified fractures/features have a dip direction of 280 degrees (west) to 20 degrees (north).

Stereonets

For stereonets, COLOG utilizes a Schmidt net, an equal-area plot of longitude and latitude used in plotting geologic data such as the direction of structural features. Here, the angle indicates dip direction and the distance from the center indicates the dip magnitude. The further from the center the shallower the dip angle. Figure 5 below is an example stereonet diagram from an acoustic televiewer data set of fractures and features.

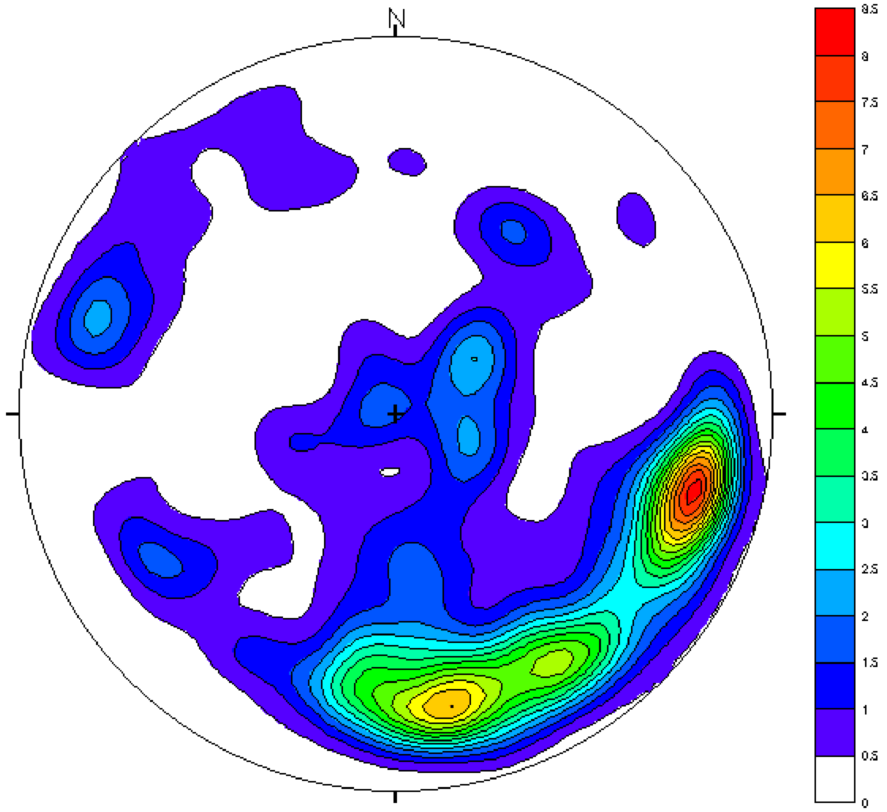


Figure 5: Example stereonet from an optical televiewer data set illustrating the frequency (%) of dip direction and dip angle in 2-D space.

Figure 5 above indicates, with a quick glance, that two distinct patterns exist in the example data set. A cluster of fractures/features with similar dip direction of approximately 110 degrees and similar steep dip angles is apparent. A second cluster, slightly less dense, is apparent with similar dip directions of approximately 170 degrees (almost due south) and similarly steep dip angles.

Please refer to the following Ranking System for Optical Televiewer Features for an explanation of the qualitative ranks assigned each optical televiewer feature identified.

Ranking System for Optical Televiewer Features

	Rank	Color Code	Observation	Flow Rating System
	0	Gray ●	Non-flow feature (bedding, healed fracture, staining, foliation, vein, etc.)	Sealed, no flow
	1	Cyan ●	Weak feature (not continuous around the borehole)	Partial open crack
	2	Blue ●	Clean, distinct feature	Continuous Open crack
	3	Red ●	Distinct feature with apparent aperture	Wide open crack Or cracks
	4	Magenta ●	Very distinct, wide possible interconnected fracture	Very wide crack or multiple interconnected fractures
	5	Green ●	Major fracture zone with large openings.	Major fracture with large openings or breakouts

This ranking system is based on a system developed and applied by Paillet (USGS, WRD, Borehole Research Project) as a subjective evaluation of permeability potential. In general, the higher the rank, the greater the likelihood of fracture interconnection and subsequent increased permeability. Tadpoles represent individual features, where the tail points in the direction of dip (clockwise from the top, 0-359). The head is positioned vertically according to the median depth of the feature and positioned horizontally according to the feature dip angle (0-90 from horizontal).

C. Facsimile 40 - Acoustic Televiewer (FAC-40 ATV or ABI-40)

The FAC-40 ATV, from Advanced Logic Technologies (ALT), provides a detailed, oriented image of acoustic reflections from the borehole wall. A unique focusing system resolves bedding features as small as 2 mm and is capable of detecting fractures with apertures as small as 0.1 mm. The acoustic image is precisely oriented using a 3-axis magnetometer with dual accelerometers, which also combine to measure deviation (or drift) of the borehole trajectory.

Theory

The FAC-40 transmits ultrasonic pulses from a rotating sensor and records the signals reflected from the interface between the borehole fluid and the borehole wall (Figure 1). The amplitude of these reflections is representative of the hardness of the formation surrounding the borehole, while the travel time represents the borehole shape and diameter. As many as 288 reflections may be recorded per revolution at up to 12 revolutions per second. The digital amplitude or travel time data are presented using a variety of color schemes that represent the borehole wall.

This ATV image is an oriented, 2-D picture of the borehole wall unwrapped from north to north (Figure 2). Planar features that intersect the borehole appear to be sinusoids on the unwrapped image· To calculate the dip angle of a fracture or bedding feature the amplitude of the sinusoid (h) and the borehole diameter (d) are required. The angle of dip is equal to the arc tangent of h/d, and the dip direction is picked at the trough of the sinusoid (Figure 2).

Sinusoidal features are picked by visual inspection of the amplitude and travel time images using interactive software called WellCAD, version 4.1. The software performs the orientation calculations and assigns a depth to the fracture or bedding feature at the inflection point (middle) of the sinusoid. Features may be subjectively ranked for flow potential using the ranking system developed by the USGS presented in Table 1. Statistical analysis of the fracture/feature data such as stereonet plots and rose diagrams provide useful information concerning the statistical distribution and possible patterns or trends that may exist in the set of fracture/feature orientations.

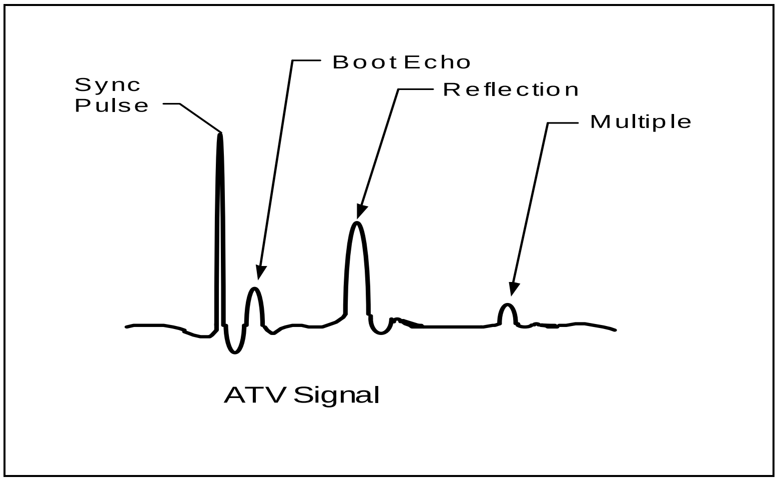


Figure 1: Returned signal.

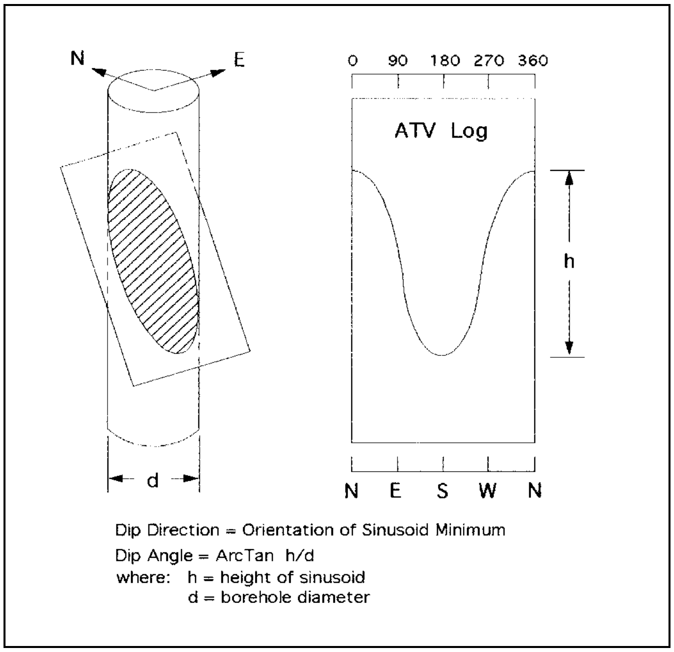


Figure 2: Geometric representation of a fracture plane and corresponding ATV log.

Acoustic Televiewer Caliper Log

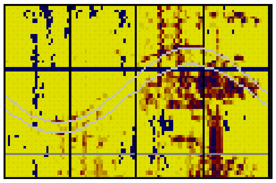
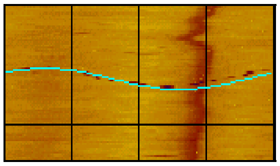
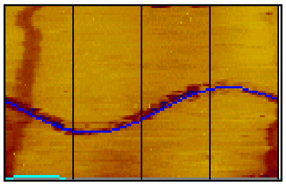
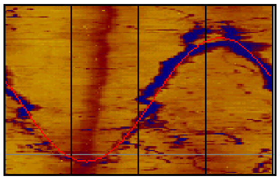
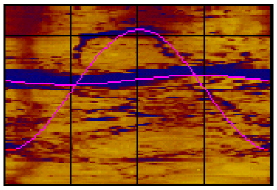
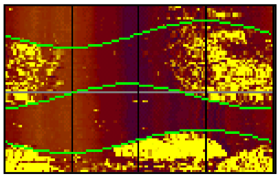
An unconventional caliper log may be generated from the travel time data acquired by the Fac-40 acoustic televiewer. Using WellCAD version 3.2, an estimation of the distance from the probe to the borehole wall can be made by incorporating the travel time of the acoustic signal with an estimation of the velocity of the wellbore fluid. The time it takes the acoustic signal to travel through a known viscous medium and back to the probe is directly related to the distance between the signal generator and the borehole wall provided the borehole fluid viscosity remains constant and the probe is properly centralized. The distance from the probe to the borehole wall is then corrected for the radius of the probe producing a borehole diameter in inches.

Applications

The high resolution reflection images and the precise travel time measurements make the FAC-40 ATV a versatile tool. Possible applications include:

- Fracture detection and evaluation
- Detection of thin beds
- Determination of bedding dip
- Lithological characterization
- Casing inspection
- High resolution caliper measurements

Ranking System for Acoustic Televiewer Features

	Rank	Color Code	Observation	Flow Rating System
	0	Gray	Non-flow feature (bedding, healed fracture, vein, etc.)	Sealed, no flow
	1	Cyan	Weak feature (not continuous around the borehole)	Partial open crack
	2	Blue	Clean, distinct feature	Continuous Open crack
	3	Red	Distinct feature with apparent aperture (visible on travel-time image)	Wide open crack Or cracks
	4	Magenta	Very distinct, wide possible interconnected fracture	Very wide crack or multiple interconnected fractures
	5	Green	Major fracture zone, visible on both the amplitude and travel time images	Major fracture with large openings or breakouts

This ranking system is based on a system developed and applied by Paillet (USGS, WRD, Borehole Research Project) as a subjective evaluation of permeability potential. In general, the higher the rank, the greater the likelihood of fracture interconnection and subsequent increased permeability.

D. 3-Arm Caliper

The caliper log represents the average borehole diameter determined by the extension of 1 or 3 spring-loaded arms. The measurement of the borehole diameter is determined by the change in the variable pot resistors in the probe, which are internally connected to the caliper arms.

Caliper logs may show diameter increases in cavities and, depending on drilling techniques used, in weathered zones. An apparent decrease in borehole diameter may result from mud or drill-cutting accumulation along the sides of the borehole (mudcake), a swelled clay horizon or a planned change in drill bit size. The bottom of the boring can also induce a small diameter reading from the caliper due to the caliper leaning up against on side of the borehole. The caliper log is often a useful indicator of fracturing. The log anomalies do not directly represent the true in-situ fracture size or geometry. Rather, they represent areas of borehole wall breakage associated with the mechanical weakening at the borehole-fracture intersection. Caliper anomalies may represent fractures, bedding planes, lithologic changes or solution openings. Generally, in solid bedrock caliper log anomalies indicate the intervals where fractures intersect boreholes.

COLOG records the caliper log with either a single-arm caliper measurement using the decentralization arm of the density probe or a separate stand-alone three-arm caliper. Calibrations of the probe are done routinely on the bench and in the field directly before the tool is placed into the borehole. Calibration standards consist of rings of known diameters that are placed over the extended arms as the tool response at these diameters is recorded. Additionally, as with other geophysical measurements, a repeat section may be collected and compared with original logs for consistency and accuracy.

Fundamental assumptions and limitations inherent in these procedures are as follows:

- Excessive borehole diameters (greater than 36 inches) may limit the range of borehole caliper measurements. Holes greater than 12 inches must be logged with extended arms for hole diameters up to 36 inches.

- Since the caliper probe is an electro-mechanical device, a certain amount of error is inherent in the measurement. These errors are due to: 1) averaging hole diameter using three arms, 2) non-linearity of the measurement resistor, 3) tolerance in the mechanical movement of the caliper arms (mechanical hysteresis).

E. Natural Gamma

The natural gamma log (also known as gamma or gamma ray log) provides a measurement recorded in counts per second (CPS), that is proportional to the natural radioactivity of the formation. Actual counts depend upon the detector size and efficiency but are often normalized in API units. 200 API units equal the detector response in a specially constructed physical model designed to simulate the typical shale. For most of COLOG's gamma probes, 1 API unit is approximately equal to 1.25 CPS. The depth of investigation for the gamma log is typically 10 to 12 inches. Gamma logs provide formation clay and shale content and general stratigraphic correlation in sedimentary formations. In general, the natural gamma ray activity of clay-bearing sediments is much higher than that of quartz sands and carbonates. Gamma logs are also used in hard rock environments to differentiate between different rock types and in mining applications for assessment of radioactive mineralization such as uranium, potash, etc.

Gamma radiation is measured with scintillation NaI detectors. The gamma-emitting radioisotopes that naturally occur in geologic materials are Potassium40 and nuclides in the Uranium238 and Thorium232 decay series. Potassium40 occurs with all potassium minerals, including potassium feldspars. Uranium238 is typically associated with dark shales and uranium mineralization. Thorium232 is typically associated with biotite, sphene, zircon and other heavy minerals.

The usual interpretation of the gamma log, for hydrogeology applications, is that measured counts are proportional to the quantity of clay minerals present. This assumes that the natural radioisotopes of potassium, uranium, and thorium occur in exchange ions, which are attached to the clay particles. Thus, the correlation is between gamma counts and the cation exchange capacity (CEC). Usually gamma logs show an inverse linear correlation between gamma counts and the average grain size (higher counts indicate smaller grain size, lower counts indicate larger grain size). This relation can become invalid if there are radioisotopes in the mineral grains themselves (immature sandstones or arkose), and if there are differences in the CEC of clay minerals in the different parts of the formation. Both of these situations are possible in many environments. The former situation would most likely occur in basal conglomerates composed of granitic debris, and the latter where clay occurs as a primary sediment in shale and another as an authigenic mineral deposited in pore spaces during diagenesis.

The assumption of a linear relationship between clay mineral fraction in measured gamma activity can be used to produce a shale fraction calibration for a gamma log in the form:

$$Csh = (G-Gss) / (Gsh - Gss)$$

Where Csh is the shale volume fraction, G is the measured gamma activity; Gss is the gamma activity in clean sandstone or limestone; Gsh is the gamma activity measured in shale.

Calibration of the gamma logging tool is usually performed in large physical models such as the API test pits in Houston, or the DOE uranium calibration test pits. In hydrogeology, the gamma measurement is usually a relative log and quantitative calibrations are not routinely performed. However, the stability and repeatability of the natural gamma measurement is routinely checked with a sleeve of known radioactivity. It is also common to routinely check the gamma log by repeat logging a section of a well. Natural radioactive decay follows a Gaussian distribution; that is, approximately 67% of the radioactive response occurs within ± the square root of the count rate. For instance, if a background radiation of 100 CPS is being measured, there is approximately ± 10 CPS variability.

Fundamental assumptions and limitations inherent in these procedures are as follows:

- The natural gamma ray log, as with all nuclear or radiation logs, have a fundamental advantage over most other logs in that they may be recorded in either cased or open holes that are fluid or air filled. Borehole fluid and casing may attenuate the gamma values.

- Excessive borehole rugosity, often caused by air drilling, may degrade natural gamma ray log results.

F. Electrical Measurements

All electrical logs require the presence of the borehole fluid to carry the current from the probe to the formation, and therefore these devices do not work above fluid level. Quantitative formation electrical resistivity, spontaneous potential and qualitative single point resistance can be measured with a combination tool. The operational features of each measurement is discussed under the measurement heading.

16-inch and 64-inch Normal Resistivities

Formation resistivity is dependent on the fluid salinity, permeability, and connected fracture paths within the depth of investigation of the measurement. Measured resistivity is also controlled by particle surface conduction in clastic environments. The resistivity measurement decreases in larger diameter boreholes and areas in which the borehole has been broken out, and/or highly fractured. The above responses allow interpretation of lithologic types, correlation of beds, estimation of fluid quality and possible fractured zones.

A constant current is supplied to the downhole current electrode and the resulting voltage drop is measured on the return electrodes 16" and 64" away from the current electrode. The resistivity of the surrounding media (which includes the borehole fluid) is derived from Ohm's Law and the geometry of the electrode arrangement. The static electric field which results from the geometric arrangement of electrodes is ideally a sphere 16" or 64" in radius (for the short and long normal functions respectively). The presence of the borehole diameter and mudcake affects the measurement sphere by decreasing the lateral extent, and increasing the vertical extent. Borehole corrections based on the borehole fluid resistivity can be made, but these corrections do not address the effects of vertical averaging. Accurate interpretation of the logs minimizes this averaging effect. The influence of the borehole size becomes less with smaller diameter boreholes. Calibration of the 16" and 64" normals is performed in the field with a resistance box which tests a range of known resistivities from 0.0 ohm-m to 10,000 ohm-m.

Single Point Resistance (SPR)

The SPR measurement is controlled by rock and fluid parameters in much the same way as resistivity logs. SPR is a simple system of two electrodes (the resistivity current electrode) and a surface electrode. Current is passed through the formation and voltage differences are measured between the two electrodes. The measured resistance includes the resistance of the cable, borehole fluid, and the formation around the borehole. The current density is higher near the borehole electrode and surface electrode. Since the current density at the surface electrode is constant, formation variations close to the probe produce the resistance changes visible on the logs. Since there is a single downhole electrode, not an array, the log effectively shows a point measurement. This gives a very "responsive", high vertical resolution measurement. Though the single point resistance cannot be calibrated quantitatively, its instantaneous response is a good boundary indicator, and does show a more well defined response than the 16" or 64" normals.

Spontaneous Potential (SP)

The SP is a measurement of the naturally occurring potential in the borehole. This naturally occurring potential is most often caused by a concentration gradient between the borehole fluid and formation fluid (electro-chemical), and requires the presence of a clay rich/porous media interface to occur. Reduction/oxidation (redox) interfaces and streaming potentials (electro-kenetic) caused by the flow of fluid in or out of the borehole are also causes for the occurrence of spontaneous potential. In fresh water environments where the drilling fluid is natural or the salinity is near the formation pore fluid salinity the electro-chemical potential is minimized. The absence of sulfide mineralization or fluid movement into or out of the formation may minimize the redox and streaming potentials.

Fundamental assumptions and limitations inherent in these procedures are as follows:

- The range within which a given device is accurate is different for the different measurement techniques. This range shall be specified for each device, and the appropriate device shall be selected for the borehole under investigation.

- The properties of the borehole and borehole fluid influence the response of normal resistivity logs in what is commonly known as “Borehole Effects”. As the hole diameter increases, these effects become more pronounced. These effects have been quantified, and log data may be corrected based on standard techniques.

- The geometry of the logging probe such as the positions of the source and measurement electrodes of resistivity type probes affects the measurement values.

- The ability of a given measurement to accurately measure resistivity across a thin bed is a function of the geometry and of the resistivity contrast and bed thickness.

- The distance away from the borehole which influences a given measurement is a function of the geometry and the radial distribution of electrical properties.

- The log should be recorded with the tool moving **up** the borehole, but measurements can be made while logging downward also. In fact, in deep wells, it is suggested that data be recorded while running in the well, just in case hole conditions or tool problems prevent getting a good log in the up direction.
- The electric resistivity measurement is adversely affected by metalic or ferrous material in the vicinity of the probe.

- Electric resistivity measurements can not be performed through PVC, fiberglass or steel casing.

G. Fluid Temperature/Resistivity (Conductivity)

Geothermal gradients in the near surface earth are usually dominated by conduction, and are generally linear increasing with depth due to the relative constancy of the thermal conductivity of earth materials. Convective heat flow within the borehole fluid is caused by formation fluid entering or leaving the borehole at some permeable interval. Therefore, deviations from the linear thermal gradient can be attributed to fluid movement. Both the thermal gradient and fluid resistivity profile of the borehole fluid can be obtained with the same probe. The temperature is measured with a thermistor and the fluid resistivity is measured with a closely spaced Wenner electrical array.

Slope changes in both the temperature and fluid resistivity logs may be indicative of fluid flow between the formation and the borehole. Both responses are affected by drilling method, time since circulation, mud type or additives and well development procedures.

A differential temperature log is a calculated curve that amplifies slight slope changes in the temperature gradient and can assistance in the interpretation of the fluid temperature log. As the probe is lowered downhole, small changes in the slope of the temperature curve are identified by a differential curve that is plotted from a center zero line. The differential temperature is constructed by using a temperature point at one depth and subtracting a point at a lower depth throughout the entire logged interval.

(temperature value Depth 1) **-** (temperature value Depth 2) = differential value

In real time the differential values are calculated across the acquisition digitizing interval (e.g. 0.1 to 0.5 ft). Because of the small digitizing interval the calculated real time differential curve may only identify larger temperature gradient deviations. Another differential temperature can be constructed in post processing over a larger sample interval (sometimes up to 2 ft). This log commonly provides a more diagnostic differential curve and is used frequently in the temperature profile interpretation.

The fluid resistivity in the borehole is controlled primarily by the salinity. Therefore, salinity stratification, or the introduction of a fluid of different water quality into the borehole, can be observed by changes in the fluid resistivity log. Often, the exchange of fluid between the formation and the borehole, influences both the temperature and the fluid resistivity so that the response is evident in both logs.

Temperature corrected resistivity can be converted to equivalent NaCl salinity in parts per million (Bateman and Konen, 1977). A salinity profile can then be plotted which indicates the general water quality trend of the borehole fluid. If the assumption is made that the borehole fluid is in equilibrium with the formation fluid, then the borehole salinity profile can be interpreted as a formation fluid salinity profile. Differences between these profiles from well to well, may contain information concerning the extent of hydraulic connectivity in the area.

Fundamental assumptions and limitations inherent in these procedures are as follows:

- The borehole temperature log is usually the first log run in a borehole and, unlike virtually all other logs, is run while the probe is moving down the hole. The exception to running this probe first, however, would be if any optical measurement is to be acquired. The idea is that the logging of the temperature/resistivity probe may stir up the wellbore fluids inhibiting the optical device.

- The recorded borehole temperature is only that of the fluid surrounding the probe, which may or may not be representative of the temperature in the surrounding rocks.

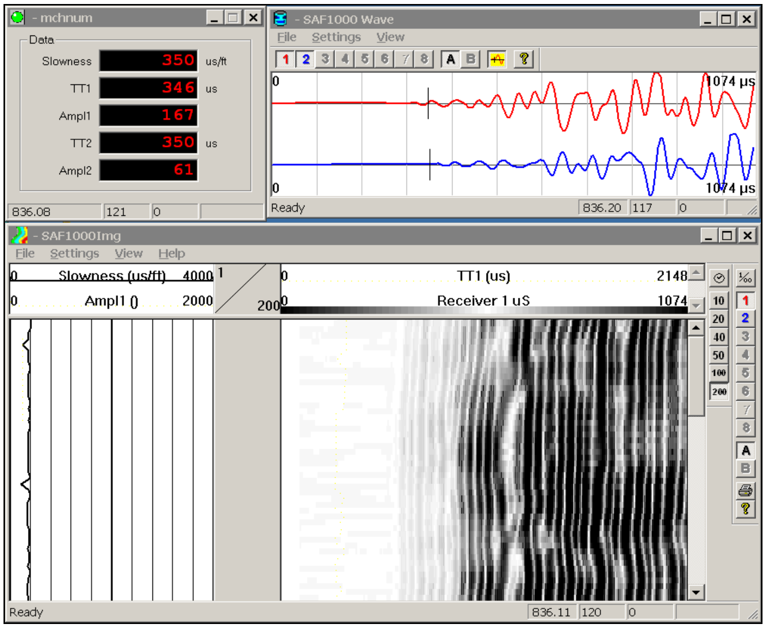
- In most wells the geothermal gradient is considerably modified by fluid movement in the borehole and adjacent rocks.

- Temperature logs are generally recommended for uncased fluid-filled boreholes, but may be used in fluid-filled cased wells for some applications.

H. Full Waveform Sonic

Full Waveform Sonic Methodology

Digital full-waveform sonic (FWS) data is acquired with a Mount Sopris Instruments 2SAF probe, that can be configured with two or three receivers at fixed separations from the sonic transmitter. The acquisition software allows the real-time viewing of the waveforms as they are written directly to hard disk. The waveforms can also subsequently be viewed and processed for amplitude, frequency, and velocity information. Functionality and repeatability of the probe is monitored by logging in an ungrouted, fluid-filled, steel pipe, and by repeat logging of boreholes at each project.



Slowness 350 us/ft
TT1 346 us
Ampl1 167
TT2 350 us
Ampl2 61

Figure: Real-time presentation from the sonic acquisition software, illustrating the output of a 2SAF configured with two receivers.

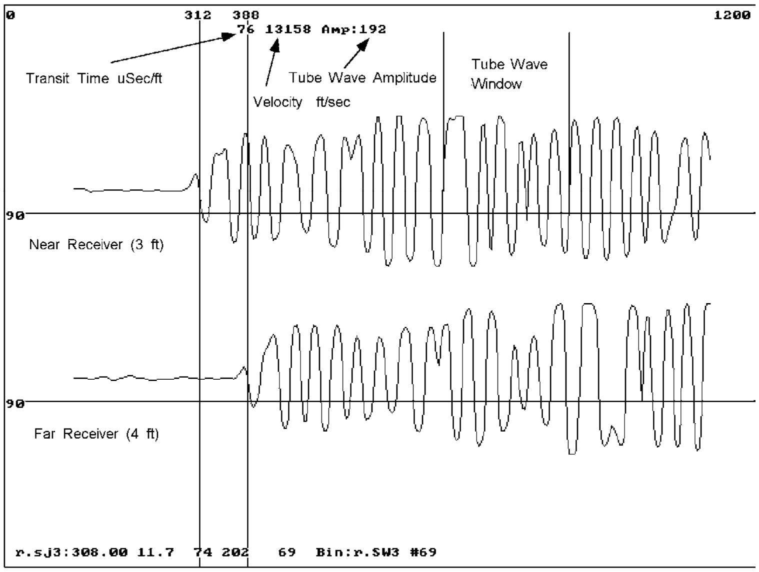


Figure: Example of a typical waveform pair with the tube wave annotated.

The FWS log, recorded in the time domain at two or three downhole receivers, consists of interacting sonic waves generated by a 30 kHz acoustic energy pulse from the downhole transmitter. Sonic logs can only be obtained in the fluid filled portion of the borehole, and the propagation of these waves is controlled by the borehole wall/fluid interface, at which head waves are critically refracted and complicated reflections occur.

Sonic transit time is the compression-wave travel time, per foot of rock, and represents the inverse of velocity (i.e., greater transit time equals slower velocity). Often referred to as "delta-T" because it is the difference in arrival times between two receivers spaced one foot apart, transit time can be used to characterize rock lithology, consolidation, and presence of discontinuities. These characterizations, however, usually require calibration from core data unless regional relationships are available. Transit times are also used to help in the processing of seismic reflection and refraction data.

The tube wave is a guided fluid wave that travels along the borehole wall/fluid boundary at a velocity slightly slower than the speed of sound in water.

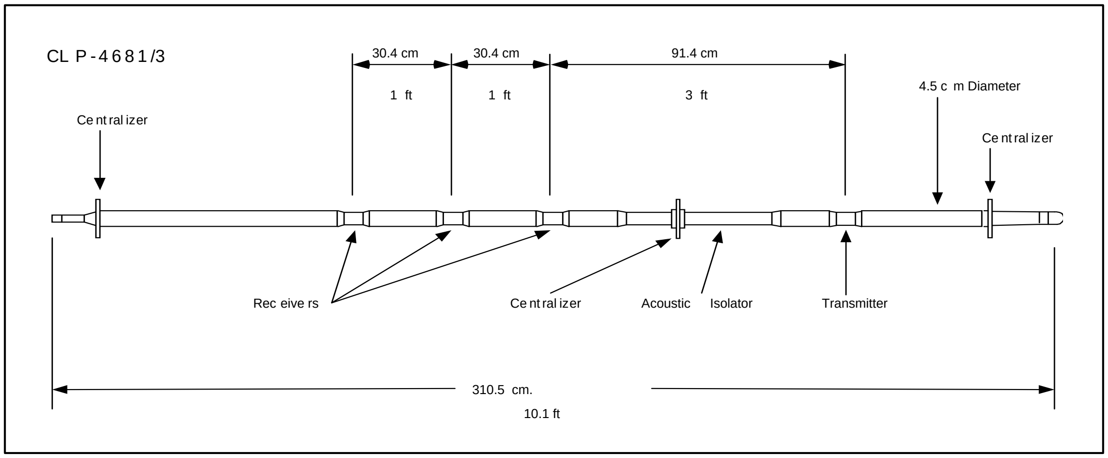


Figure: Probe schematic for the 2SAF sonic probe.

Vertical stacking of the individual waveforms creates the full waveform display, which uses a banded presentation to represent the sinusoidal nature of sonic waves. By convention, black bands represent high amplitude waves above the centerline, dark gray is the low amplitude portion of the positive wave, while light grey is the low amplitude portion of the negative wave below the centerline, and white is the high amplitude portion of the negative wave. The degree of discontinuity of the rock is reflected by the deviation from parallel banding in the FWS VDL display. The velocities and other information obtained from sonic logs are used to determine the lithology, formation porosity, cement bonding, formation weathering, rock strength, and to identify fractures.

I. Formation Conductivity (Induction)

The induction measurement is made by using a magnetic field to induce electric currents in the material being surveyed. Because the magnitude of these electric currents is proportional to the conductivity of the media being measured, the magnetic field generated by the induced electric current is measured.

The tool is designed to measure formation conductivity in millisiemens per meter (mS/m) which is converted to resistivity in software. This probe also measures the rate of change of the magnetic susceptibility as a percent of primary magnetic field, however the tool has been optimized for conductivity readings and the magnetic susceptibility measurements are qualitative. For the purposes of this investigation, the magnetic susceptibility measurements provided no additional information and were not plotted.

Fundamental assumptions and limitations inherent in these procedures are as follows:

- The EM induction measurement is adversely affected by metallic or ferrous material in the vicinity of the probe.

- The EM induction measurement can be effected, though not adversely, but the conductivity of the wellbore fluid present and the fluid in the formation.

- Because the EM induction measurement is spherical, major borehole washouts may effect the measurement of formation conductivity at that depth.

- The EM induction measurement can be performed through PVC casing if need be.

MW-1 Geophysical Report

1.0 Geophysical Logging

On May 5th and May 8th, 2008, downhole geophysical investigations were performed in boring MW-1. The geophysical logs performed were: ambient fluid temperature and fluid conductivity, natural gamma, EM conductivity and vertical seismic profiling (VSP). The data for these logs are presented in the MW-1 Geophysical Summary Plot at the end of this well report.

1.1 Ambient Fluid Temperature/Fluid Conductivity

On May 5th, 2008, an ambient fluid temperature and electrical fluid conductivity (FEC) profile was acquired in MW-1 to a depth of 142.5 feet. The ambient temperature log is relatively featureless with the exception of an anomaly at approximately 48.9 feet. As this anomaly is at a depth corresponding to blank PVC casing, this anomaly is likely not the result of flow. At the screened interval of interest of 133.0 to 143.0 feet the ambient fluid temperature and FEC profiles are relatively featureless. The ambient FEC profile registers a nominal 294 to 296 µS/cm at the screened interval. The ambient temperature profile registers a nominal 6.70 degrees C at the top of the fluid column and 5.11 degrees C at the interval of interest.

1.2 Natural Gamma

On May 5th, 2008, a natural gamma profile was acquired in MW-1 to a depth of 141.7 feet. The natural gamma profile is relatively featureless ranging in gamma counts of 22 to 91 counts per second (CPS).

1.3 EM Induction Conductivity

On May 5th, 2008, an EM conductivity profile was acquired in MW-1 to a depth of 140.5 feet. The EM conductivity profile registers an anomaly at 133 feet indicating the top of the screened interval and at 21.7 feet indicating water level. The EM conductivity log registers a nominal 175 mSeimans/meter above 133 feet and 183.6 mSeimans/meter below 133 feet.

1.4 Vertical Seismic Profile (VSP)

On May 8th, 2008, a vertical seismic profile (VSP) investigation was conducted in MW-1 to a depth of 140 feet. Four distinct intervals of specific velocity were observed in MW-1 at 15 to 47.5, 47.5 to 77.5, 77.5 to 130 and 130 to 140 feet, registering 5,706, 8,200, 12,400 and 3,338 feet per second (fps). The deepest calculated velocity is derived from low P-wave energy data. As such, the calculated value of 3,338 fps is suspect. The higher velocity value is consistent with limestone bedrock.

Project:	LO-58	Well ID:	MW-1	Date Logged:	5 May 2008
Location:	Aroostook County, Caribou, ME	Log Ref.:	Top PVC Casing	Hole Diameter:	8" nom. to TD
Depth Logger:	143.1 ft	Log Ref. Elev.:	578.79 ft above MSL	Csg Size/Type:	2" PVC
Depth Driller:	142 ft bgs	Recorded by:	G. Bauer	Witnessed by:	A. Fuller

LOGS & TOOLS

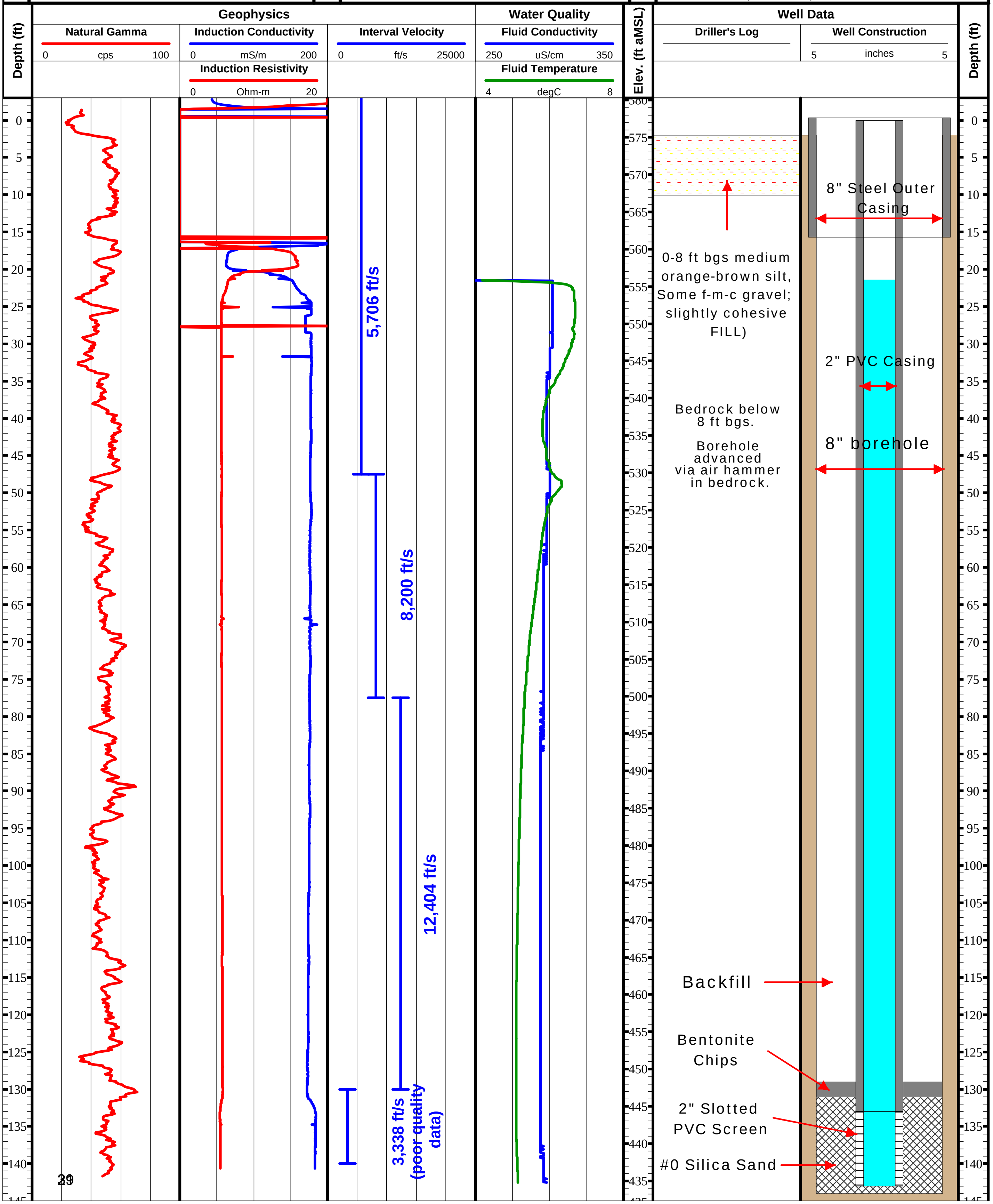
Gamma: Gamma SN# 311, depth err. -0.04 ft, speed 10 ft/min
Ind. Cond./Res.: 2PIA SN# 2041, depth err. -0.18 ft, speed 10 ft/min
Fluid Temp./Cond.: HpL SN# A, depth err. 0.1 ft, speed 5 ft/min

COMMENTS

Ground Elevation: 577.3 ft. aMSL.
Natural Gamma log includes K, U, and Th.
Water Quality logs performed under ambient conditions.
Ambient Water Level about 21.4 ft (19.7 ft bgs).
Borehole was not logged while drilling.

COMMENTS

All depths here referenced to top PVC casing unless noted otherwise.
Measured casing stick up above ground surface: PVC 1.75 ft, Steel 2.0 ft.
Steel outer casing total depth 15.7 ft, estimated from induced cond. log.
Other well Consturction info taken directly from drilling report.
Measured and drill report PVC stickup differ.



MW-2 Geophysical Report

1.0 Geophysical Logging

On May 7th and May 8th, 2008, downhole geophysical investigations were performed in boring MW-2. The geophysical logs performed were: ambient fluid temperature and fluid conductivity, natural gamma, EM conductivity, vertical seismic profiling (VSP) and water chemistry (pH, ORP, DO). The data for these logs are presented in the MW-2 Geophysical Summary Plot at the end of this well report.

1.1 Ambient Fluid Temperature/Fluid Conductivity

On May 7th, 2008, an ambient fluid temperature and electrical fluid conductivity (FEC) profile was acquired in MW-2 to a depth of 61.7 feet. The ambient temperature log indicates an anomaly at the top of the screened interval at 52 feet. Above 52 the temperature log registers a nominal 6.01 degrees C. Below 52 feet the temperature log registers a nominal 5.15 degrees C. The temperature profile is featureless within the screened interval. The ambient FEC profile registers a nominal 368 µS/cm at the top of the screened interval at 52 feet and is observed to increase with depth to 377 µS/cm at 61.7 feet (TD).

1.2 Natural Gamma

On May 7th, 2008, a natural gamma profile was acquired in MW-2 to a depth of 57.6 feet. The natural gamma profile indicates a high-gamma count anomaly at 46 to 50 feet. The natural gamma profile ranges from 16 to 92 CPS.

1.3 EM Induction Conductivity

On May 7th, 2008, an EM conductivity profile was acquired in MW-2 to a depth of 59.4 feet. The EM conductivity profile does not register usable data, for unknown reasons, though the anomalies have the character of registering metal nearby. It is possible there is rebar or other metal under the asphalt in the immediate vicinity of the well. Two different EM conductivity probes were utilized on MW-2 and both registered the same result, along with repeat logs.

1.4 Vertical Seismic Profile (VSP)

On May 8th, 2008, a vertical seismic profile (VSP) investigation was conducted in MW-2 to a depth of 57.5 feet. Three distinct intervals of specific velocity were observed in MW-2 at 5 to 15, 15 to 30 and 30 to 57.5 feet, registering 5,936, 1,921 and 7,178 fps.

1.5 Water Chemistry (pH, ORP, DO)

On May 7th, 2008, an ambient pH, oxidation-reduction potential (ORP) and dissolved oxygen (DO) profile was acquired in MW-2 to a depth of 61.8 feet. The pH profile registers a high-pH anomaly at water level, which is typical of this type of log. Below water level the pH measurement decreases with depth until the top of screened interval at 52 feet. Below 52 feet the pH registers a nominal 7.45 through the screened interval. The DO measurement registers regular low-DO anomalies every 4 feet approximately, perhaps the result of casing joints. Within the screened interval the DO measurement increases with depth, registering 2.36 to 2.47 percent.

Project: LO-58	Well ID: MW-2	Date Logged: 7 May 2008
Location: Aroostook County, Caribou, ME	Log Ref.: Top PVC Casing	Hole Diameter: 8" Nom. to TD
Depth Logger: 61.6 ft	Log Ref. Elev.: 589.36 ft above MSL	Csg Size/Type: 2" PVC
Depth Driller: 62 ft bgs	Recorded by: G. Bauer	Witnessed by: A. Fuller

LOGS & TOOLS

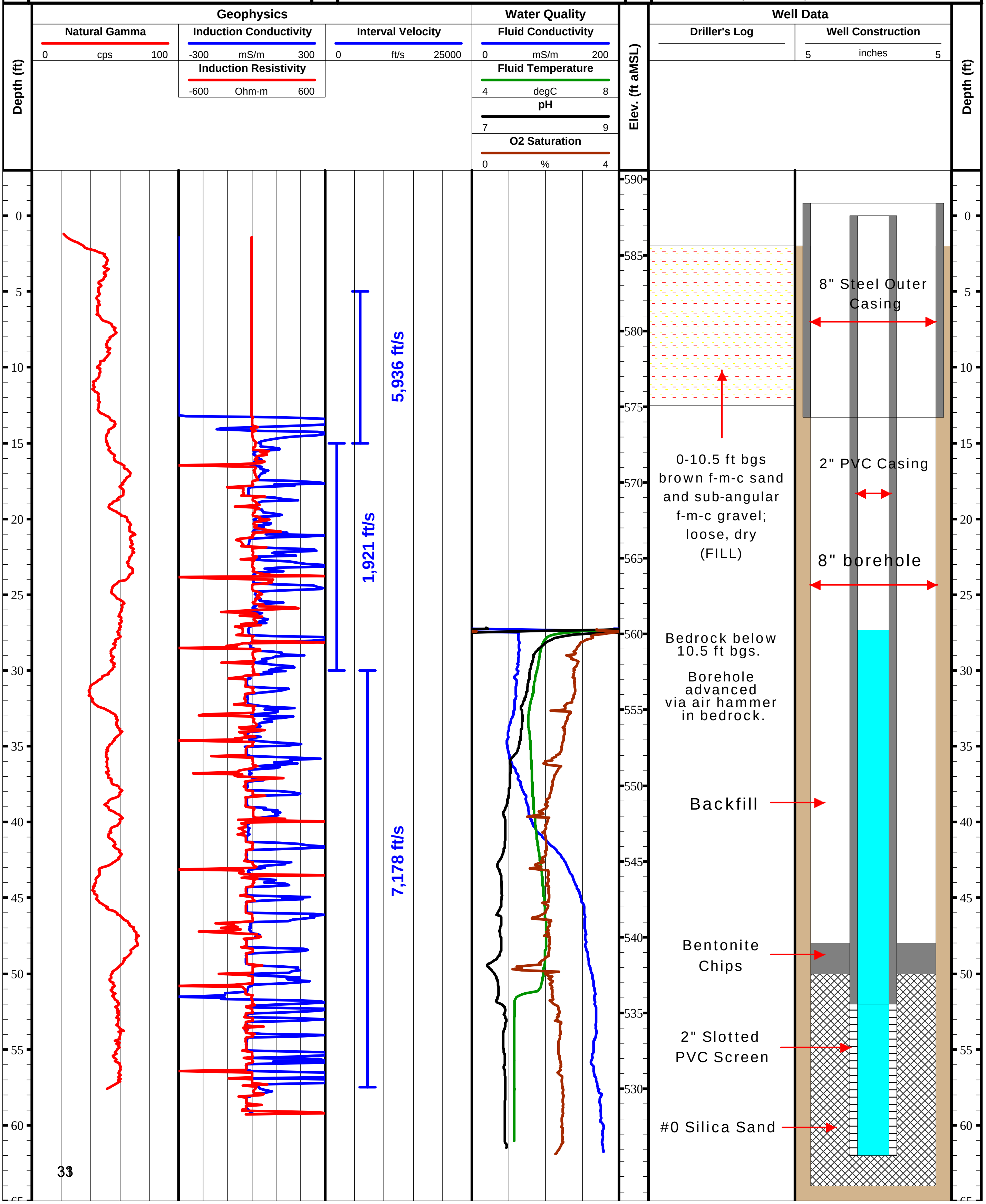
Gamma: Gamma SN# 311, depth err. 0.10 ft, speed 10 ft/min
Cond./Res.: 2PIA SN# 2041, depth err. 0.10 ft, speed 10 ft/min
Fluid Temp: HpL SN# A, depth err. 0.08 ft, speed 5 ft/min
Fluid Cond/pH/O2: WQ SN# 3048, depth err. 0.08 ft, speed 4.5 ft/min

COMMENTS

Ground Elevation: 587.6 ft aMSL.
Natural Gamma log includes K, U, and Th.
Water Quality logs performed under ambient conditions.
Ambient Water Level about 27.4 ft (25.7 ft bgs).
Suspected metel underground affecting logs. Missile pad area.

COMMENTS

All depths here referenced to top PVC casing unless noted otherwise.
Measured casing stick up above ground surface: PVC 1.75 ft, Steel 2.54 ft.
Steel outer casing total depth 13.3 ft bgs, estimated from induced cond. log.
Other well consturction info taken directly from drilling report.
Measured and drill report PVC stickup differ.



MW-3 Geophysical Report

1.0 Geophysical Logging

On May 6th and May 8th, 2008, downhole geophysical investigations were performed in boring MW-3. The geophysical logs performed were: ambient fluid temperature and fluid conductivity, natural gamma, EM conductivity, vertical seismic profiling (VSP) and water chemistry (pH, DO). The data for these logs are presented in the MW-3 Geophysical Summary Plot at the end of this well report.

1.1 Ambient Fluid Temperature/Fluid Conductivity

On May 6th, 2008, an ambient fluid temperature and electrical fluid conductivity (FEC) profile was acquired in MW-3 to a depth of 48.4 feet. The ambient temperature log indicates an anomaly at the top of the screened interval at 39 feet. Below 39 feet the temperature log registers a nominal 6.38 to 6.63 degrees C. The temperature profile is featureless within the screened interval. The ambient FEC profile registers approximately 663 µS/cm at the top of the screened interval at 39 feet and 643 µS/cm at near TD. The FEC observed in MW-3 is notably higher than other wells on site.

1.2 Natural Gamma

On May 6th, 2008, a natural gamma profile was acquired in MW-3 to a depth of 47.5 feet. The natural gamma profile is relatively featureless with gamma counts ranging from 50 to 69 CPS, with the exception of the low gamma counts that are likely the result of near-surface effect.

1.3 EM Induction Conductivity

On May 6th, 2008, an EM conductivity profile was acquired in MW-3 to a depth of 46.5 feet. The EM conductivity profile is rather erratic below 31.5 feet registering approximately 100 to 150 mSeimans/meter. Below 43.1 feet the conductivity log registers -1,400 mSeimans/meter – possibly the effect of metal near the well.

1.4 Vertical Seismic Profile (VSP)

On May 8th, 2008, a vertical seismic profile (VSP) investigation was conducted in MW-3 to a depth of 45 feet. Three distinct intervals of specific velocity were observed in MW-3 at 5 to 20, 20 to 30 and 30 to 45 feet, registering 2,031, 3,435 and 11,492 fps. The deepest interval was calculated using a two-point calculation between 30 and 45 feet due to high scatter in the data set.

1.5 Water Chemistry (pH, DO)

On May 6th, 2008, an ambient pH, oxidation-reduction potential (ORP) and dissolved oxygen (DO) profile was acquired in MW-3 to a depth of 48.4 feet. The pH profile registers a low-pH anomaly at 39 feet. Below 39 feet the pH registers a nominal 7.57 with a minor high-pH anomaly at 42.3 feet. The DO measurement registers a low-DO anomaly at 39 feet, the top of the screened interval. Below 39 feet the DO registers 10.67 to 10.8 percent.

Project: LO-58	Well ID: MW-3	Date Logged: 6 May 2008
Location: Aroostook County, Caribou, ME	Log Ref.: Top PVC Casing	Hole Diameter: 8" Nom. to TD
Depth Logger: 48.85 ft	Log Ref. Elev.: 570.63 ft above MSL	Csg Size/Type: 2" PVC
Depth Driller: 47 ft bgs	Recorded by: G. Bauer	Witnessed by: A. Fuller

LOGS & TOOLS

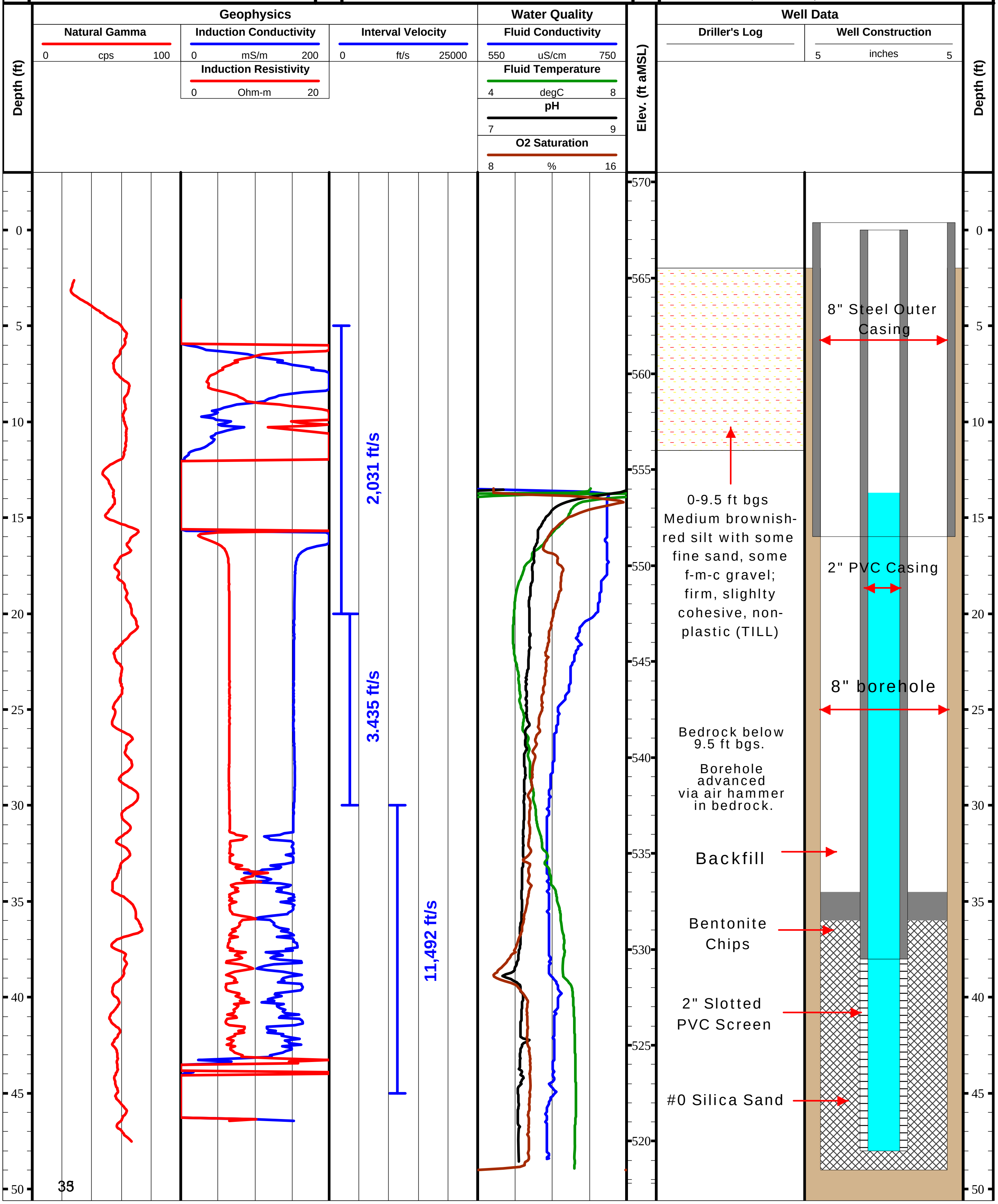
Gamma: Gamma SN# 311, depth err. 0.10 ft, speed 10 ft/min
Cond./Res.: 2PIA SN# 2041, depth err. 0.10 ft, speed 10 ft/min
Fluid Cond: HpL SN# A, depth err. 0.10 ft, speed 5 ft/min
Fluid Temp/pH/O2: WQ SN# 3048, depth err. 0.08 ft, speed 4.0 ft/min

COMMENTS

Ground Elevation: 567.5 ft aMSL.
Natural Gamma log includes K, U, and Th.
Water Quality logs performed under ambient conditions.
Ambient Water Level about 13.7 ft (10.32 ft bgs).

COMMENTS

All depths here referenced to top PVC casing unless noted otherwise.
Measured casing stick up above ground surface: PVC 3.38 ft, Steel 3.79 ft.
Steel outer casing total depth 16.0 ft bgs, estimated from induced cond. log.
Other well construction info taken directly from drilling report.
Measured and drill report PVC stickup differ.



MW-4 Geophysical Report

1.0 Geophysical Logging

On May 6th and May 8th, 2008, downhole geophysical investigations were performed in boring MW-4. The geophysical logs performed were: ambient fluid temperature and fluid conductivity, natural gamma, EM conductivity and vertical seismic profiling (VSP). The data for these logs are presented in the MW-4 Geophysical Summary Plot at the end of this well report.

1.1 Ambient Fluid Temperature/Fluid Conductivity

On May 6th, 2008, an ambient fluid temperature and electrical fluid conductivity (FEC) profile was acquired in MW-4 to a depth of 82.3 feet. The ambient temperature log is relatively featureless in the interval of interest, ranging in temperature from 4.16 to 4.13 degrees C. The ambient FEC profile indicates some stratification of wellbore fluids inside the blank casing at 58 feet. Below 58 feet the ambient FEC profile registers a nominal 416 to 421 µS/cm within the screened interval. A minor high-FEC anomaly is observed at 79 feet within the screened interval.

1.2 Natural Gamma

On May 6th, 2008, a natural gamma profile was acquired in MW-4 to a depth of 81.2 feet. The natural gamma profile is relatively featureless ranging in gamma counts of 29 to 75 counts per second (CPS).

1.3 EM Induction Conductivity

On May 6th, 2008, an EM conductivity profile was acquired in MW-4 to a depth of 80.1 feet. The EM conductivity profile registers an anomaly at 72 feet indicating the top of the screened interval and 31.2 feet indicating water level. The EM conductivity log registers a nominal 176 mSeimans/meter above 72 feet and 186 mSeimans/meter below 72 feet.

1.4 Vertical Seismic Profile (VSP)

On May 8th, 2008, a vertical seismic profile (VSP) investigation was conducted in MW-4 to a depth of 80 feet. Three distinct intervals of specific velocity were observed in MW-3 at 5 to 30, 30 to 47.5 and 47.5 to 80 feet, registering 4,529, 6,548 and 6,678 fps. The deepest interval was calculated using a two-point calculation between 47.5 and 80 feet due to high scatter in the data set.

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WESTON SOLUTIONS

Project: LO-58

Location: Aroostook County, Caribou, ME

Depth Logger: 82.7 ft

Depth Driller: 82 ft bgs

Well ID: MW-4

Log Ref.: Top PVC Casing

Log Ref. Elev.: 605.45 ft above MSL

Recorded by: G. Bauer

Date Logged: 6 May 2008

Hole Diameter: 8" Nom. to TD

Csg Size/Type: 2" PVC

Witnessed by: A. Fuller

LOGS & TOOLS

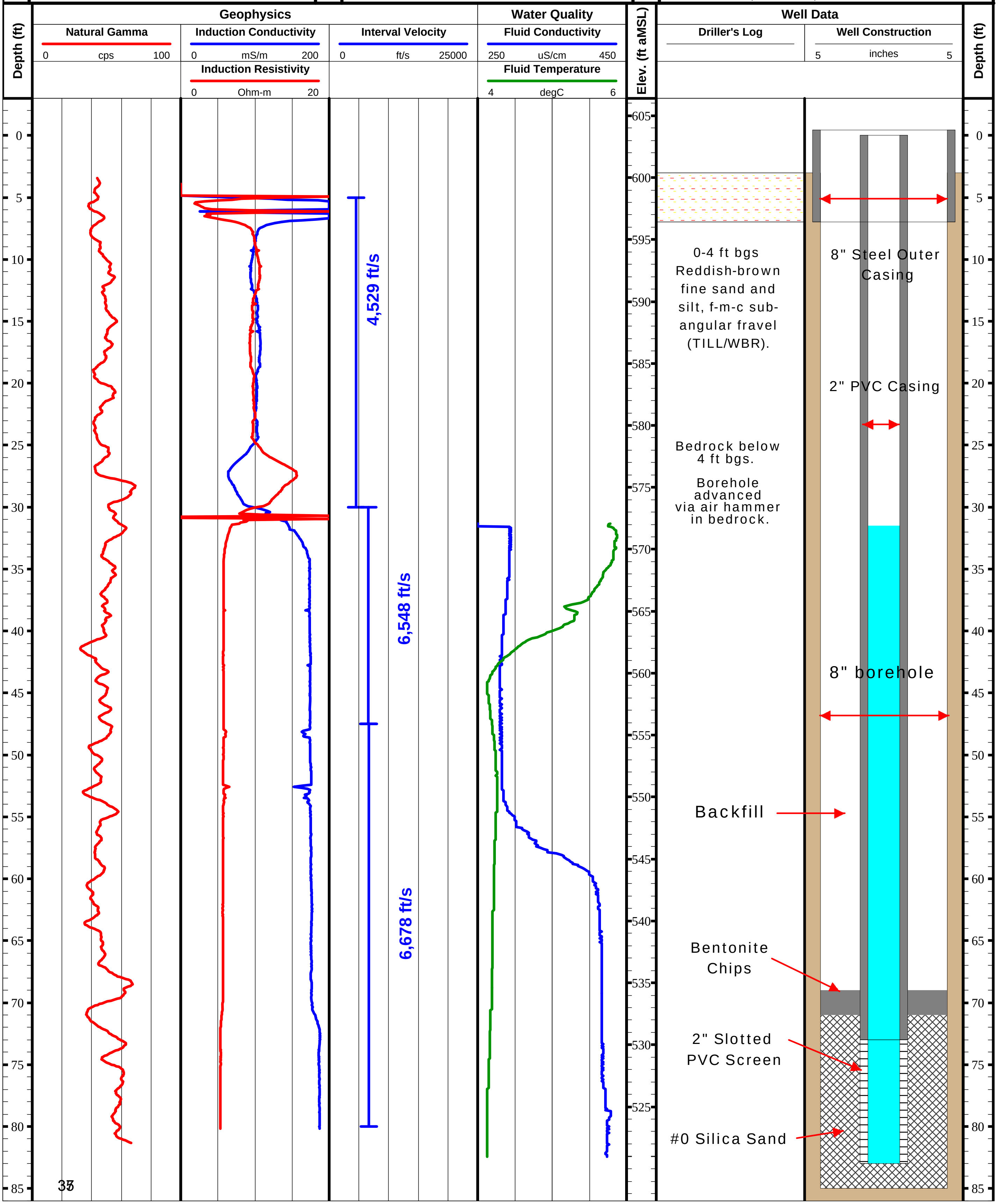
Gamma: Gamma SN# 311, depth err. -0.08 ft, speed 10 ft/min
Cond./Res.: 2PIA SN# 2041, depth err. 0.16 ft, speed 10 ft/min
Fluid Temp./Cond.: HLP SN# A, depth err. 0.1 ft, speed 5 ft/min

COMMENTS

Ground Elevation: 603.4 ft. aMSL.
Natural Gamma log includes K, U, and Th.
Water Quality logs performed under ambient conditions.
Ambient Water Level about 31.5 ft (29.5 ft bgs).

COMMENTS

All depths here referenced to top PVC casing unless noted otherwise.
Measured casing stick up above ground surface: PVC 2.0 ft, Steel 2.42 ft.
Steel outer casing total depth 7.0 ft, est from induced conductivity log.
Other well construction data taken directly from drilling report.
Measured and drill report PVC stickup differ.



MW-5 Geophysical Report

1.0 Geophysical Logging

On May 8th and May 9th, 2008, downhole geophysical investigations were performed in boring MW-5. The geophysical logs performed were: ambient fluid temperature and fluid conductivity, natural gamma, EM conductivity, vertical seismic profiling (VSP) and water chemistry (pH, DO). The data for these logs are presented in the MW-5 Geophysical Summary Plot at the end of this well report.

1.1 Ambient Fluid Temperature/Fluid Conductivity

On May 8th, 2008, an ambient fluid temperature and electrical fluid conductivity (FEC) profile was acquired in MW-5 to a depth of 77.7 feet. The ambient temperature log decreases with depth below 42 feet. In the screened interval the temperature log is relatively featureless decreasing from 4.6 to 4.55 degrees C. The ambient FEC profile registers approximately 454 µS/cm at the top of the screened interval at 70 feet and 461 µS/cm at TD.

1.2 Natural Gamma

On May 8th, 2008, a natural gamma profile was acquired in MW-5 to a depth of 73.8 feet. The natural gamma profile is relatively featureless with the exception of a high-gamma anomaly at 62 to 67 feet. The natural gamma profile ranges in gamma counts from 50 to 90 CPS.

1.3 EM Induction Conductivity

On May 8th, 2008, an EM conductivity profile was acquired in MW-5 to a depth of 75.7 feet. The EM conductivity profile is somewhat erratic below water level at 20 feet, registering approximately 142 mSeimens/meter and increasing with depth. The conductivity profile registers approximately 158 mSeimens/meter near TD with a high-induction conductivity anomaly at 70.6 feet, within the screened interval.

1.4 Vertical Seismic Profile (VSP)

On May 9th, 2008, a vertical seismic profile (VSP) investigation was conducted in MW-5 to a depth of 75 feet. Five distinct intervals of specific velocity were observed in MW-5 at 2.5 to 5, 5 to 17.5, 17.5 to 27.5, 32.5 to 57.5 and 60 to 70 feet, registering 984, 3,385, 5,244, 15,936 and 20,307 fps. A low-velocity anomaly is observed at 57.5 to 60 feet with poor P-wave energy returned.

1.5 Water Chemistry (pH, DO)

On May 8th, 2008, an ambient pH and dissolved oxygen (DO) profile was acquired in MW-5 to a depth of 77.6 feet. The pH profile registers low-pH anomalies at 61.7, 64.8 and 67.9 feet. The pH profile registers a nominal 7.09 pH above the screened interval and 7.27 near TD. The DO measurement indicates an erratic profile with regular anomalies that may be related to casing joints. The DO registers approximately 0.16 percent within the screened interval.

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WESTON SOLUTIONS

Project: LO-58

Well ID: MW-5

Date Logged: 7-8 May 08

Location: Aroostook County, Caribou, ME

Log Ref.: Top PVC Casing

Hole Diameter: 8" nom. to TD

Depth Logger: 77.8 ft

Log Ref. Elev.: 575.72 ft above MSL

Csg Size/Type: 2" PVC

Depth Driller: 82 ft bgs

Recorded by: G. Bauer

Witnessed by: A. Fuller

LOGS & TOOLS

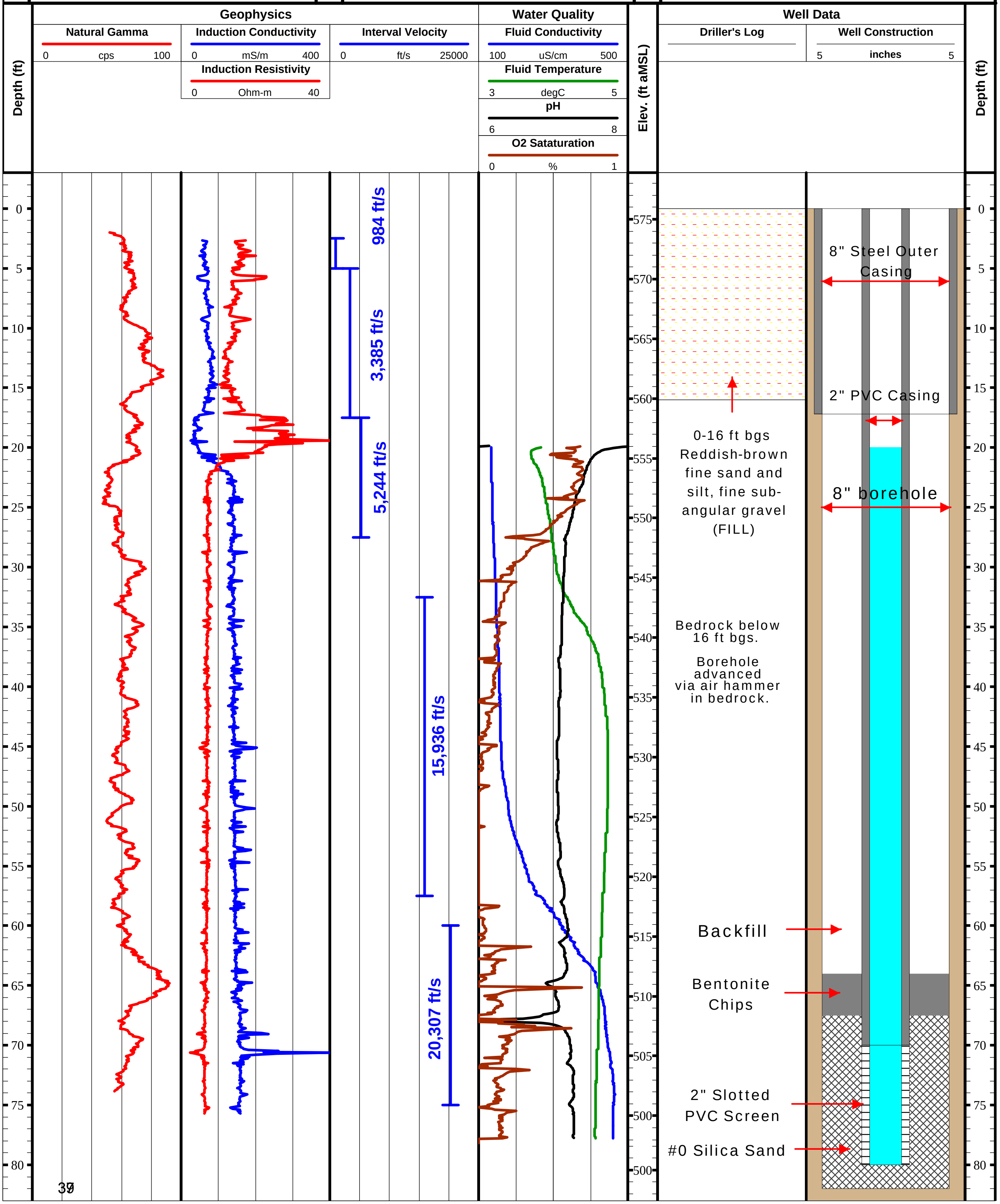
Gamma: 2PEA SN# 2955, depth err. 0.10 ft, speed 10 ft/min
Cond./Res.: 2PIA SN# 2041, depth err. 0.10 ft, speed 10 ft/min
Fluid Cond/Temp: HLP SN# A, depth err. 0.10 ft, speed 5 ft/min
Fluid pH/O2: WQ SN# 3048, depth err. 0.10 ft, speed 4 ft/min

COMMENTS

Ground Elevation: 575.9 ft aMSL.
Natural Gamma log includes K, U, and Th.
Water Quality logs performed under ambient conditions.
Ambient Water Level about 20 ft (20 ft bgs).

COMMENTS

All depths here referenced to top PVC casing unless noted otherwise.
Measured casing stick up above ground surface: PVC 0.0 ft, Steel 0.0 ft.
Steel outer casing total depth is undetermined from data. Guess is shown.



DW-1 Logging Results

1.0 HydroPhysical™ Logging

1.1 Ambient Fluid Electrical Conductivity and Temperature Log: DW-1

At 1202 hours on May 13th, 2008, after a calibration check of the fluid electrical conductivity (FEC) and temperature logging tool, the fluid column was logged for FEC and temperature profiles with COLOG's 1.5-inch diameter HpL™ probe. These logs were performed prior to the installation of any pumping equipment. Please refer to Figure DW-1:1. The ambient FEC profile indicates a relatively featureless profile with a notable increase at approximately 38.7 feet. The ambient FEC profile registers a nominal FEC of approximately 303 µS/cm above 38.7 feet and approximately 343 µS/cm below 42 feet. The anomaly observed in the ambient FEC profile correlates well with a water-bearing interval identified during hydrophysical testing. The ambient temperature profile is relatively rugose exhibiting a temperature range of 4.73 to 5.21 degrees C. Anomalies observed in the ambient temperature profile at approximately 27.3, 35.0, 37.2, 53.2 and 55.2 feet correlate well with identified water-bearing intervals. In vertically flowing conditions, where water enters the borehole, termed inflow, a change in either FEC is typically seen

.

1.2 Ambient Flow Characterization: DW-1

On May 13th, 2008, an ambient flow characterization was conducted in the boring DW-1. For ambient flow assessment, the formation water in the borehole was diluted with deionized water (DI) and the boring left in an undisturbed state to allow any natural flow to occur. After DI water emplacement the pump was removed from the boring to insure that water in the pump standpipe would not drain back into the boring. Prior to this period and throughout all HpL™ testing, water levels were monitored and recorded. Ambient flow evaluation is reported for the period after the water surface returned to near pre-emplacement levels. A series of FEC and temperature logs were then conducted to identify changes in the fluid column associated with ambient flow. Ambient flow characterization is conducted to evaluate the presence of both vertical and horizontal ambient flow.

On May 13th, 2008, at 1318 hours (t = 0 minutes, elapsed time of test), dilution of the fluid column was complete. Minimal to no DI water was lost to the formation due to the slightly depressed head maintained during emplacement procedures. During the 18.5 hours following the emplacement of DI water, multiple logs were conducted. Of these logs, 9 are presented in Figure DW-1:2. The designation of each logging with the FEC tool is indicated in the figure legend by the time of logging (e.g., FEC1318 versus a subsequent logging at FEC1334), thus the progressing of curves to the right in this figure represents changes in FEC over the total logging period. The last four digits of each log ID correspond to the time at which that particular log was started. Only logs acquired during logging in the downward direction are presented as the design of the FEC/Temperature probe allows the most accurate data to be collected in the downward direction. The logs acquired in the upward logging direction are not representative of downhole conditions and are therefore omitted. These logs illustrate significant change at several intervals throughout the length of the borehole. These dramatic changes in the FEC profiles with respect to time are associated with ambient horizontal flow occurring within the borehole.

Formation water migration by horizontal flow through the fluid column is indicated by the increase in FEC over time in the data presented in Figure DW-1:2 for the intervals 27.3 to 31.7, 34.6 to 35.0, 40.4 to 48.6, 49.0 to 50.2, and 52.7 to 53.6 feet. Numerical modeling of the reported field data using code BOREII of the horizontal flow intervals suggests the volumetric flow rate observed in the wellbore for these intervals are 0.085, 0.011, 0.14, 0.018, and 0.058 gpm, respectively. Correcting for convergence of flow at the wellbore and factoring the length of the interval, this flow rate equates to a Darcy velocity, or specific discharge of groundwater in the aquifer of 2.84, 3.91, 2.53, 2.28, and 9.56 feet/day, respectively. Please refer to Figure DW-1:2 and Table DW-1:1 for a complete summary of the HydroPhysical™ logging results. Please refer to Appendix B for a discussion of the methodology and code used to calculate these values. The ambient depth to water at the time of testing was 22.39 ftbtoc.

1.3 Flow Characterization During 6 GPM Production Test: DW-1

Pumping of borehole fluids and simultaneous DI injection was conducted at one pumping rate to establish the inflow locations and evaluate the interval specific inflow rates. Pumping at a given rate was conducted until reasonably constant drawdown was observed. When constant drawdown was observed, DI injection was initiated at about 20-30% of the pumping rate and the extraction pumping rate was increased to maintain a constant total formation production rate (i.e. pumping rate prior to DI injection). These procedures were conducted at a differential rate of 6.04 gpm.

On May 14th, 2008, at 1000 hours (t = 0 minutes elapsed time of testing), development pumping was initiated at approximately 6.6 gpm. Prior to initiating pumping, the ambient depth to water was recorded at 22.79 ftbtoc. All drawdown values are referenced to this ambient water level. Time dependent depth to water, totals and flow rate information were recorded digitally every second and are presented in Figure DW-1:3. Pumping was maintained at a time-averaged rate of 6.64 gpm until 1215 hours (t = 135 minutes, elapsed time of testing). During development pumping numerous FEC logs were acquired to monitor the development process and assist in identifying the depths of flow zones. Of these FEC logs, six (FEC1041 through FEC1150) are presented in Figure DW-1:4. The FEC logs acquired during development pumping illustrate a reasonably stable, repeatable condition of the fluid column with local inflow locations identified by spikes or incremental step increases or decreases in FEC. DI water injection from the bottom of the wellbore was initiated at 1215 hours at a time-averaged rate of 1.39 gpm while the total extraction rate was increased to a time-averaged rate of 7.43 gpm, resulting in a total borehole formation time-averaged production rate of 6.04 gpm. These flow conditions were maintained until 1323 hours (t = 203 minutes) during which time a reasonably constant drawdown of approximately 3.02 feet was observed. COLOG defines reasonably constant drawdown as drawdown that fluctuates less than 10 percent of the total drawdown. The FEC logs acquired during dilution procedures illustrate a reasonably stable condition of the fluid column with local inflow locations identified by spikes or incremental step increases in FEC. Seven inflow zones were identified from these logs at 27.3 to 31.7, 34.6 to 35.0, 37.4 to 38.4, 40.4 to 48.6, 49.0 to 50.2, 52.7 to 53.6, and 54.4 to 58.1 feet with flow rates ranging of 0.207, 0.195, 0.745, 2.00, 0.416, 1.65, and 0.838 gpm, respectively. The logs indicate the interval 40.4 to 48.6 and 52.7 to 53.6 feet dominated flow during pumping, producing 3.65 gpm or 60 percent of the total flow. Please refer to Table DW-1:1 for a summary of HydroPhysical™ flow results and the depths of individual inflow zones.

1.4 Estimation of Interval Specific Transmissivity: DW-1

An estimation of transmissivity (T) can be made using an equation after Hvorslev (1951) assuming steady-state radial flow in an unconfined aquifer:

$$T = KL = \frac{q_i}{2\pi\Delta h_w} \ln\left(\frac{r_e}{r_w}\right)$$

where K is the hydraulic conductivity, q_i is the interval specific inflow rate calculated using HpL™ results, r_w is the borehole radius (0.26 ft), r_e is the effective pumping radius, Δh_w is the observed maximum drawdown (22.79 feet) and L is the thickness of the zone through which flow occurs. For our calculations, COLOG used r_e of 300 feet (assumed). By applying L and q_i from the HpL™ results under the two pressure conditions, the interval specific transmissivity can be calculated for each identified water producing interval. These calculations were made at each identified interval and are presented in Table DW-1:1. In summary, the intervals 40.4 to 48.6 and 52.7 to 53.6 feet exhibited the highest transmissivities of approximately 129 and 111 ft^2/day, respectively.

2.0 Geophysical Logging

On May 11th, 2008 through May 20th, 2008, downhole geophysical and hydrogeologic investigations were performed in boring DW-1. The geophysical and hydrogeologic logs performed were: optical televiewer (OBI), acoustic televiewer (ATV), 3-arm caliper, natural gamma, electric resistivity, EM induction conductivity, water chemistry (pH, ORP, DO), full waveform sonic, vertical seismic profile (VSP), wireline straddle packer (WSP) and downhole video. The data for these logs are presented in the DW-1 Geophysical/HydroPhysical™ Summary Plot and Figures DW-1:5, 6, 7 and 8 and Table DW-1:2 for the statistical analysis of all fractures/features, Table DW-1:3 for a summary of the VSP velocities and Figures DW-1:9A through E and Table DW-1:4 for the WSP pressure data and results at the end of this well report. The downhole video was provided to the client in the field at the time of logging.

2.1 Optical Televiewer (OBI)/Acoustic Televiewer (ABI)

On May 11th, 2008 optical and acoustic televiewer logging was performed in DW-1 to a depth of 58.1 feet. The televiewers identified features at depths correlating well with the HpL™ and caliper data. The features observed by the OBI at water-bearing intervals identified from the HpL™ data had apparent aperture and in some cases evidence of staining. Twenty high-angle fractures or features (dip angles greater than 45 degrees) were identified in DW-1. Four of these high-angle features are qualitatively ranked 2 or greater suggesting the potential for vertical hydraulic communication outside the influence of the borehole. However, none of these high-angle fracture or features are found deeper than 55 feet – all are shallow features. Data acquired during WSP testing confirms the presence of vertical hydraulic communication between several water-bearing zones in the immediate vicinity of the borehole.

2.2 Three-Arm Caliper

On May 11th, 2008 three-arm caliper logging was performed in DW-1 to a depth of 57.7 feet. The caliper log indicates a relatively rugose borehole with nine major inflections observed at approximately 10.4 to 12.6, 18.5, 23.0, 26.9, 34.7, 37.9, 40.4 to 45.1, 46.8 to 48.2 and 52.4 to 53.5 feet. The inflections, or borehole enlargements, observed in the caliper log correlate well with water-bearing zones and fractures identified by the hydrophysical and optical televiewer data. The caliper log registers an approximately nominal 6.25-inch diameter borehole below casing at 10.4 feet.

2.3 Natural Gamma

On May 11th, 2008 natural gamma logging was performed, in conjunction with the electric resistivity logging, in DW-1. The natural gamma measurement reached to a depth of 54.1 feet. The natural gamma is relatively featureless with minor fluctuations in gamma counts, expected in limestone. The natural gamma log registers an approximately nominal 44 to 70 counts per second.

2.4 Electric Resistivities (8, 16, 32, 64-inch Normal Resistivities, SP, SPR)

On May 11th, 2008 electric resistivity logging was performed, in conjunction with the natural gamma log, in DW-1 to a depth of 57.8 feet. The electric measurements consist of 8, 16, 32 and 64-inch "normal" resistivities, spontaneous potential (SP) and single-point resistance (SPR). The normal resistivities registered approximately 850 Ohm-meters (8-inch resistivity) to 3,690 Ohm-meters (64-inch resistivity). A notable anomaly in the electric resistivity is observed at approximately 47 to 48 feet. The higher spaced resistivities (32 and 64-inch) register lower resistivities below this depth. Above 47 to 48 feet, the higher spaced resistivities register a marked increase in resistivity, typical of more massive limestone. However, the limestone above this depth is marked with large, occasionally high-angle, fractures. The SP is also relatively featureless registering a nominal 125 to 246 milivolts below water level. The SPR measurement registers low-resistivity anomalies at 37.8, 40.4 to 48.2 and 52.8 feet, correlating well with identified major fractures. The SPR registers 432 to 791 Ohms.

2.5 EM Induction Conductivity

On May 11th, 2008 EM induction conductivity logging was performed in DW-1 to a depth of 55.8 feet. The induction conductivity log is featureless with the exception of anomalies at the bottom of casing at 10.5 feet and water level at approximately 21.4 feet. The induction conductivity registers a nominal 43 miliS/meter above water level and 154 miliS/meter below water level.

2.6 Water Chemistry (pH, ORP, DO)

On May 11th, 2008, pH, oxidation-reduction potential (ORP) and dissolved oxygen (DO) measurements were acquired under ambient conditions in DW-1 to a depth of 57.6 feet. The pH measurement is relatively featureless with the exception of a high-pH anomaly at waters surface. The pH measurement registers a nominal pH ranging from 7.41 to 7.50. The ORP measurement indicates a gradual increase in oxidation potential with depth. The ORP measurement registers approximately 137 mV at waters surface and 195 mV near total depth. The dissolved oxygen measurement is relatively variable with significant fluctuations in DO. The DO measurement registers an increase in dissolved oxygen with depth, registering zero from waters surface to approximately 37.6 feet where the data indicates an increase in DO. Near total depth the DO is observed to be approximately 1.57 percent.

2.7 Full Waveform Sonic

On May 11th, 2008 full waveform sonic logging was performed in DW-1 to a depth of 58.1 feet. The sonic registered slower velocity anomalies at 37.4 to 46.4, 48.4 and 53.1 feet, correlating well with identified fractures and water-bearing zones observed in the optical televiewer, caliper and hydrophysical data. The sonic registered p-wave velocities ranging from 9,340 to 19,550 feet/second. The lower value of p-wave velocity correlates well with velocities identified using vertical seismic profiling (VSP).

2.8 Vertical Seismic Profile (VSP)

On May 8th, 2008 a vertical seismic profile (VSP) was conducted in DW-1 to a depth of 55 feet. The VSP investigation in DW-1 identified 3 specific intervals of specific velocity at 5 to 10, 10 to 25 and 25 to 55 feet, registering 1,670, 7,135 and 8,493 feet/second (fps), respectively. All of the DW-1 velocity calculations are effectively two-point calculations, using arrival times at the beginning & end of the indicated depth ranges. Late arrivals indicate possible low-velocity zones near 20 & 50 feet deep. The 1,670 fps value is consistent with dry overburden. The higher values are relatively low for bedrock velocities, but consistent with highly fractured bedrock.

2.9 Wireline Straddle Packer (WSP)

On May 18th through 20th, 2008 wireline straddle packer (WSP) testing was conducted in DW-1 at five intervals:

33.15 to 24.98 feet (the top of water table)
33.75 to 38.5 feet
41.2 to 51.9 feet
51.0 to 58.1 feet (total depth)
54.0 to 58.1 feet (total depth)

WSP testing was conducted to acquire a fracture-specific groundwater sample from each major water-bearing fracture identified during hydrophysical production testing. In addition to collecting a representative groundwater sample from each interval, development pumping was conducted at each interval and pressures above, below and in the interval of interest recorded to estimate fracture-specific permeability for each interval tested. Please see Tables WSP Summary and DW-1:4 for a complete summary of wireline straddle packer testing results.

Several different configurations of the WSP were utilized to properly characterize the numerous fracture zones in this borehole. Due to either a long length of fracture zone that is intended to be tested, or the fracture of interest being close to water level of the bottom of the borehole, the WSP was configured several different ways:

Interval 33.15 to 24.98 feet (water level) – the top of the upper packer was situated at 33.15 feet and only the upper packer was inflated. The middle zone of the packer assembly was sealed from the upper interval and pumping was conducted from a 2-inch pump lowered to the interval of interest, 33.15 feet up to water level (24.98 ftbtoc). In this configuration, both the middle and lower pressure transducers are recording the same interval of interest – the entire interval below the upper packer to TD. Notice there is no evidence of vertical hydraulic communication outside the influence of the borehole between water-bearing fractures in the test interval of 33.15 feet up to water level and water-bearing fractures below the upper packer (bottom of the upper packer seal approximately 35 feet) based on the non-response to pumping registered by the middle and lower pressure transducers. However, the pumping rate of 0.25 gpm is very low with respect to the yields of the identified water-bearing fractures below this interval of interest. As such, any vertical hydraulic communication at this testing flow rate would likely not be measured in the pressure transducers below this interval of interest. Please see Figure DW-1:9A and Table DW-1:4 for a complete summary of the data acquired and results for this interval.

Interval 33.75 to 38.5 feet – The WSP was utilized in its standard configuration, with a 4.8-foot interval, both packers inflated, and all pressure transducers measuring pressure in their respective zones of interest. The data clearly indicates vertical hydraulic communication outside the influence of the borehole between water-bearing fractures in the interval of interest at 33.75 to 38.5 feet and the lower interval below the lower packer based on the correlating responses observed in the middle and lower pressure transducers. The data indicates a small correlating response in the upper pressure transducer, likely observed during this test due to the higher pumping rate of 2.73 gpm during stress testing compared to the pumping rate of 0.25 gpm during stress testing of the upper interval 33.15 feet to water level. Please see Figure DW-1:9B and Table DW-1:4 for a complete summary of the data acquired and results for this interval.

Interval 41.2 to 51.9 feet – For this interval of interest, the WSP was reconfigured for a longer length between packers. For this test the interval was lengthened to 10.7 feet due to the highly fractured interval and lack of pertinent, solid borehole to place a packer for a good seal. The data clearly indicates vertical hydraulic communication outside the influence of the borehole between water-bearing fractures in the interval of interest at 41.2 to 51.9 feet and the upper and lower intervals surrounding the interval of interest based on the correlating responses observed in the upper and lower pressure transducers. This is not unexpected based on the high-angle fractures with aperture identified in the optical and acoustic televiewer data in this interval. Please see Figure DW-1:9C and Table DW-1:4 for a complete summary of the data acquired and results for this interval.

Interval 51.0 feet to TD – For this interval of interest, the WSP was reconfigured by removing the lower packer in order to enable the sample port of the WSP to reach this interval of interest near the bottom of the borehole. For this test the middle and lower pressure transducers are both in the interval of interest and register the same changes in pressure. The interval of interest is considered to be from the base of the upper packer to total depth of the borehole – 58.2 feet. The data clearly indicates vertical hydraulic communication outside the influence of the borehole between water-bearing fractures in the interval of interest at 51.0 to TD and the upper interval above this interval of interest based on the correlating response observed in the upper pressure transducers. This is not unexpected based on the high-angle fractures with aperture identified in the optical and acoustic televiewer data. Please see Figure DW-1:9D and Table DW-1:4 for a complete summary of the data acquired and results for this interval.

Interval 54.0 feet to TD – For this interval of interest, the WSP was reconfigured by removing the lower packer in order to enable the sample port of the WSP to reach this interval of interest near the bottom of the borehole. For this test the middle and lower pressure transducers are both in the interval of interest and register the same changes in pressure. The interval of interest is considered to be from the base of the upper packer to total depth of the borehole – 58.2 feet. The data clearly indicates vertical hydraulic communication outside the influence of the borehole between water-bearing fractures in the interval of interest at 54.0 to TD and the upper interval above this interval of interest based on the correlating response observed in the upper pressure transducers. Please see Figure DW-1:9E and Table DW-1:4 for a complete summary of the data acquired and results for this interval.

3.0 Data Summary

Processing and interpretation of the geophysical and HydroPhysical™ logs in DW-1 suggest the presence of seven producing intervals for this borehole. Numerical modeling of the reported HydroPhysical™ field data was performed using computer programs FLOWCALC and/or BOREII. These analyses were performed to estimate the rate of inflow for each identified hydraulically conductive borehole interval during DI injection procedures. The results of these analyses are presented in Table DW-1:1. For code comparisons to field data please see Appendix D. In summary, the intervals at 40.4 to 48.6 and 52.7 to 53.6 feet dominated flow during pumping, producing 3.65 gpm or 60 percent of the total flow. Five of the seven identified producing intervals correlate well with water-bearing zones identified during ambient testing. The remaining two intervals were not actively flowing water during ambient testing.

During ambient testing, boring DW-1 exhibited a complex network of horizontal flow zones. Five ambient inflow intervals are identified at 27.3 to 31.7, 34.6 to 35.0, 40.4 to 48.6, 49.0 to 50.2, and 52.7 to 53.6 feet, with observed flow rates of 0.085, 0.011, 0.14, 0.018, and 0.058 gpm respectively. Ambient flow from these inflow intervals is observed to migrate horizontally across the borehole. Correcting for convergence to the wellbore and factoring the length of the interval, this flow rate equates to Darcy velocities of 2.84, 3.91, 2.53, 2.28, and 9.56 ft/day, respectively.

The optical and acoustic televiewers identified features at depths correlating well with the HpL™ and caliper data. The features observed by the OBI at water-bearing intervals identified from the HpL™ data had apparent aperture and in some cases evidence of staining. Two hundred twenty high-angle fractures or features (dip angles greater than 45 degrees) were identified in DW-1. Seventeen of these high-angle features are qualitatively ranked 2 or greater suggesting the potential for vertical hydraulic communication outside the influence of the borehole. Data acquired during WSP testing confirms the presence of vertical hydraulic communication between several water-bearing zones in the immediate vicinity of the borehole.

The seven interval-specific transmissivity estimates calculated using the hydrophysical data in DW-1 ranged from 8.51 to 129 ft^2/day, with the interval at 40.4 to 48.6 feet registering the highest transmissivity. The ranges of transmissivities suggest that flow originates from secondary porosity consisting of large discrete fractures at the major inflow zones and minor fractures or features with less inter-connectiveness at the minor inflow zones. Interval-specific FEC ranged from 357 to 428 µS/cm.

The WSP sampling results identified contaminant concentrations in each of the five sampled intervals. Of particular note is a high toluene anomaly of 120 µg/L in the uppermost sample interval of 33.2 to water level (24.86 ftbtoc). Each of the five sampled intervals at 33.2 to water level, 33.8 to 38.5, 41.2 to 51.9, 51.0 to 58.2 (TD) and 54.0 to 58.2 feet registered concentrations of TCE of 1.8, 2.5, 3.4, 3.1 and 2 µg/L, respectively. Please see Table WSP Summary in the Executive Summary for a complete summary of the sample results.

Fracture inter-connectiveness in the immediate vicinity of a wellbore can be inferred by the similarity, or lack there of, of parameters such as interval-specific transmissivity estimates and interval-specific FEC, along with the presence of high-angle fractures and pressure differentials within the borehole. Similar transmissivity and FEC estimates would suggest an inter-connected network of fractures or aquifers in the immediate vicinity of the wellbore. High-angle fractures with aperture may provide a conduit for vertical communication. Moreover, although a pressure differential would seem to suggest the driving force for vertical communication is present, typically substantially vertically interconnected fractures or aquifers tend to pressure-equilibrate in the immediate vicinity of the wellbore. Thus, the presence of a pressure differential in a wellbore may suggest a lack of vertical communication between fractures or aquifers in the immediate vicinity of the borehole.

The data acquired in DW-1 exhibited dissimilar interval-specific transmissivity but similar FEC estimates. The televiewers identified high-angle fractures with aperture and the WSP registered pressure correlations above and below several tested intervals. The data strongly suggest the fractures are vertically inter-connected in the immediate vicinity of the wellbore. Please see Table DW-1:1 for a summary of the HydroPhysical™ and geophysical logging results which includes the locations, flow rates and transmissivity and hydraulic conductivity estimates assessed by COLOG.

FIGURE DW-1:1. Ambient Temperature And Fluid Electrical Conductivity; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-1

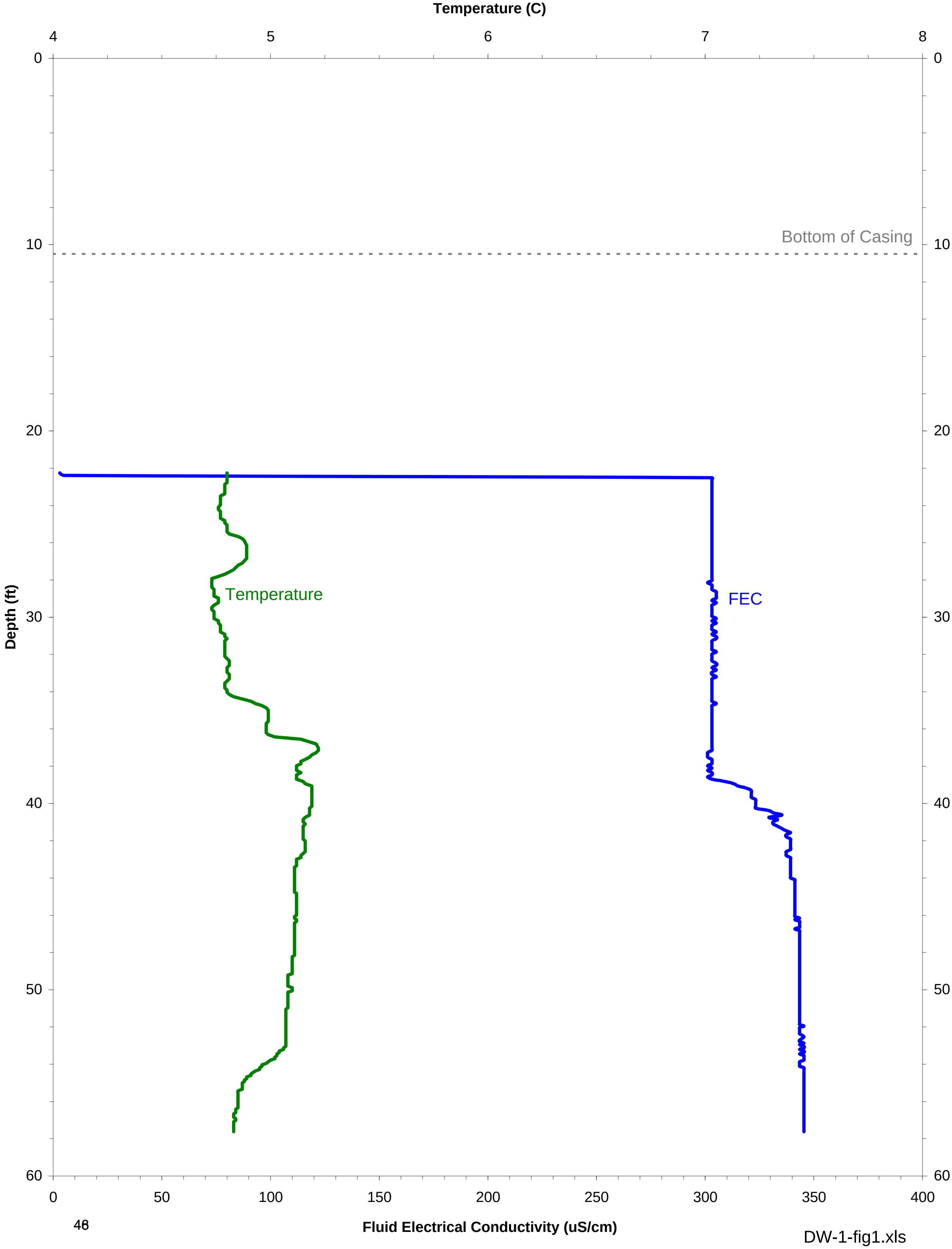
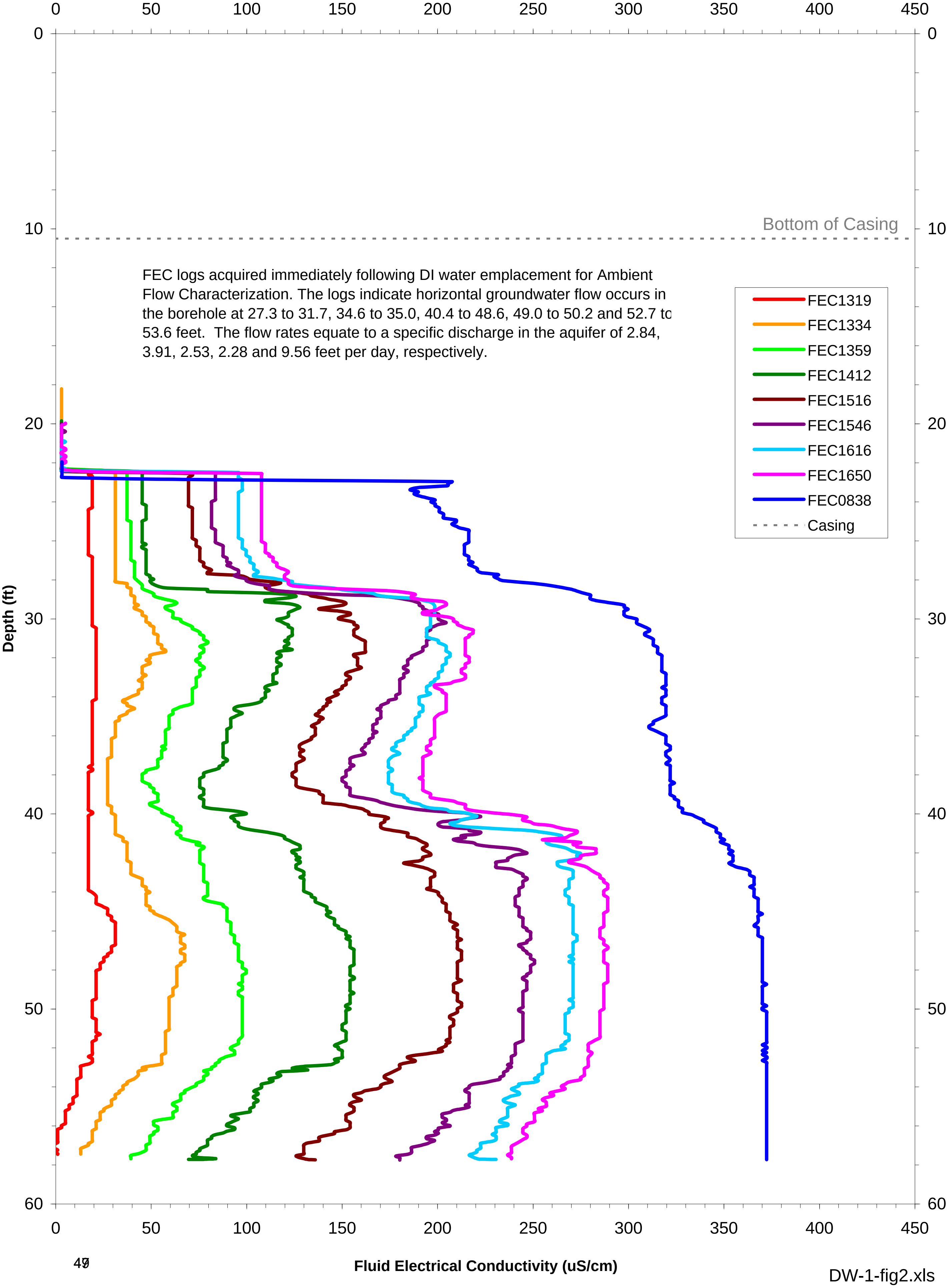


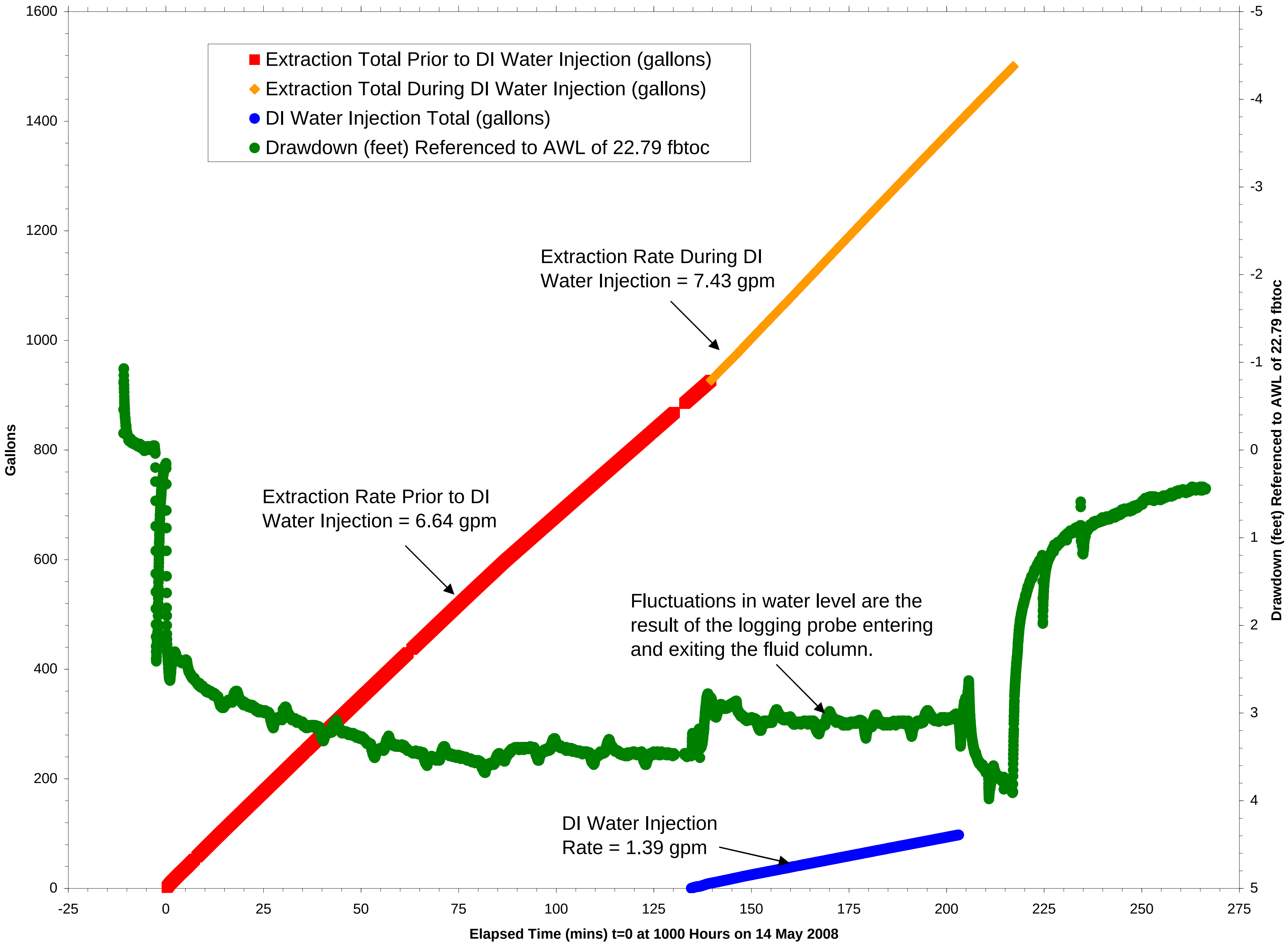
FIGURE DW-1:2. Summary of Hydrophysical Logs During Ambient Flow Characterization; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-1



FEC logs acquired immediately following DI water emplacement for Ambient Flow Characterization. The logs indicate horizontal groundwater flow occurs in the borehole at 27.3 to 31.7, 34.6 to 35.0, 40.4 to 48.6, 49.0 to 50.2 and 52.7 to 53.6 feet. The flow rates equate to a specific discharge in the aquifer of 2.84, 3.91, 2.53, 2.28 and 9.56 feet per day, respectively.

DW-1-fig2.xls

FIGURE DW-1:3. Pumping And Drawdown Data During 6 GPM Production Test; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-1



Extraction Rate During DI Water Injection = 7.43 gpm

Extraction Rate Prior to DI Water Injection = 6.64 gpm

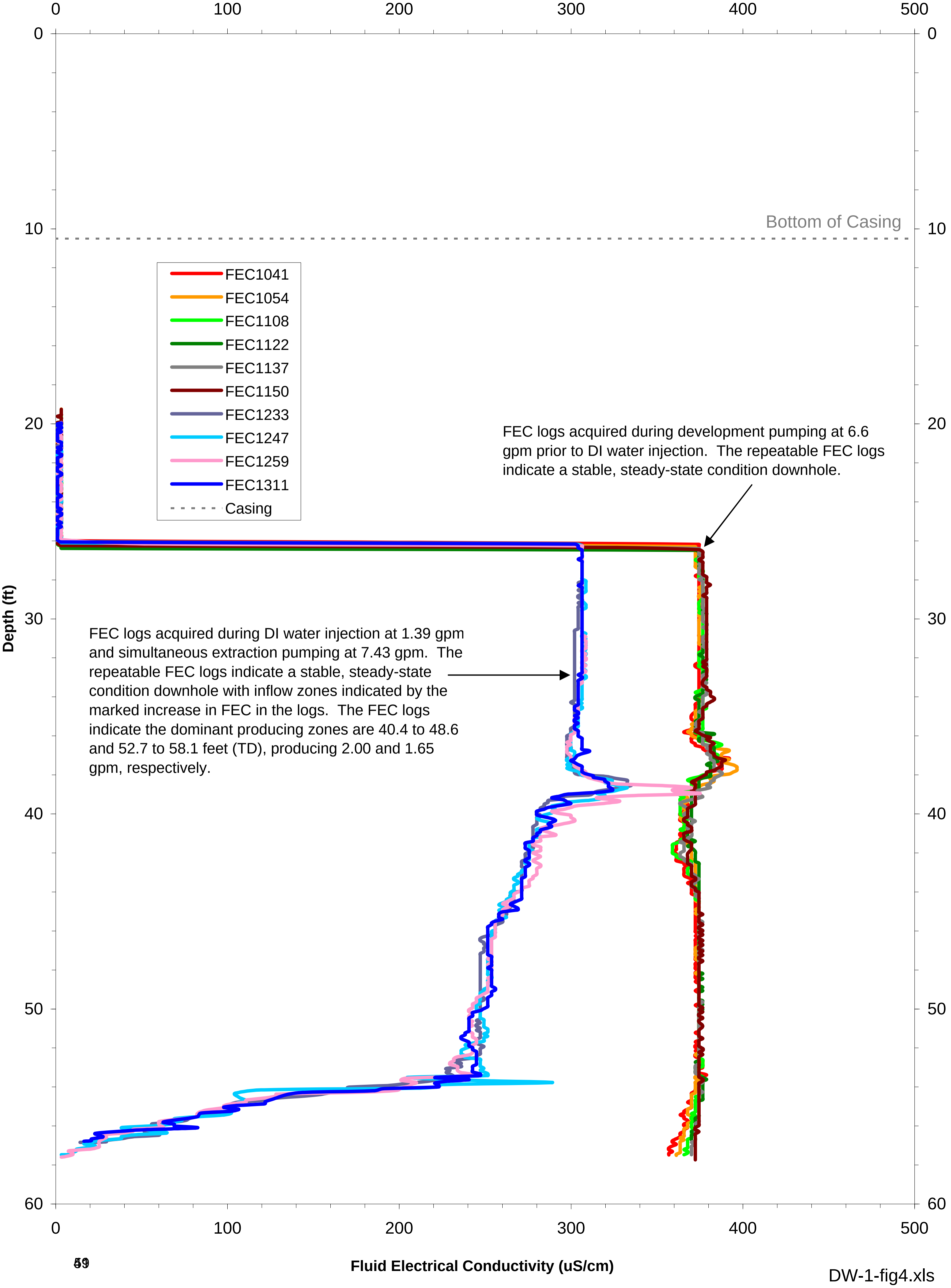
Fluctuations in water level are the result of the logging probe entering and exiting the fluid column.

DI Water Injection Rate = 1.39 gpm

50

DW-1-fig3.xls

FIGURE DW-1:4. Summary of Hydrophysical Logs 6 GPM Hydrophysical Production Test; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-1



FEC logs acquired during development pumping at 6.6 gpm prior to DI water injection. The repeatable FEC logs indicate a stable, steady-state condition downhole.

FEC logs acquired during DI water injection at 1.39 gpm and simultaneous extraction pumping at 7.43 gpm. The repeatable FEC logs indicate a stable, steady-state condition downhole with inflow zones indicated by the marked increase in FEC in the logs. The FEC logs indicate the dominant producing zones are 40.4 to 48.6 and 52.7 to 58.1 feet (TD), producing 2.00 and 1.65 gpm, respectively.

Table DW-1:1. Summary Of HydroPhysical^{TM} Logging Results With Hydraulic Conductivity And Transmissivity Estimations; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-1

Well Name	DW-1
Ambient Depth to Water (ftbtoc)	22.79
Diameter of Borehole (ft)	0.52
Maximum Drawdown (ft)	3.11
Effective Radius (ft)	300

Interval No.	Top of Interval (ft)	Bottom of Interval (ft)	Length of Interval (ft)	Ambient Flow[1] (gpm)	Darcy Velocity in Aquifer[2] (Specific Discharge) (ft/day)	Interval Specific Flow Rate During Pumping (gpm)	Delta Flow[3] (gpm)	Delta Flow (ft^3/min.)	Interval Specific Hydraulic Conductivity[4] (ft/day)	Transmissivity (ft2/day)	Interval Specific Fluid Electrical Conductivity (microS/cm)
1	27.3	31.7	4.4	0.085	2.84	0.207	0.123	0.016	1.93E+00	8.51E+00	376
2	34.6	35.0	0.4	0.011	3.91	0.195	0.184	0.025	3.20E+01	1.28E+01	376
3	37.4	38.4	1.0	0.000	0.00	0.745	0.745	0.100	5.18E+01	5.18E+01	428
4	40.4	48.6	8.2	0.140	2.53	2.00	1.860	0.249	1.58E+01	1.29E+02	357
5	49.0	50.2	1.2	0.018	2.28	0.416	0.398	0.053	2.30E+01	2.76E+01	375
6	52.7	53.6	0.9	0.058	9.56	1.65	1.592	0.213	1.23E+02	1.11E+02	375
7	54.4	58.1	3.7	0.000	0.00	0.838	0.838	0.112	1.57E+01	5.82E+01	375

[1] Horizontal flow is identified in this borehole under ambient conditions.

[2] Darcy Velocity is calculated using the observed volumetric flow rate, the cross-sectional area of the flow interval in the wellbore and a wellbore convergence factor of 2.5 (Drost, 1968). The Darcy Velocity is only applicable to ambient horizontal flow

[3] Delta Flow is the difference between Interval-Specific Flow Rate (during pumping) and Ambient Flow Rate.

[4] Hydraulic conductivity and transmissivity estimates are based on single well drawdown data, a porus-medium equivilent model and Hvorslev's 1951 porosity equatior

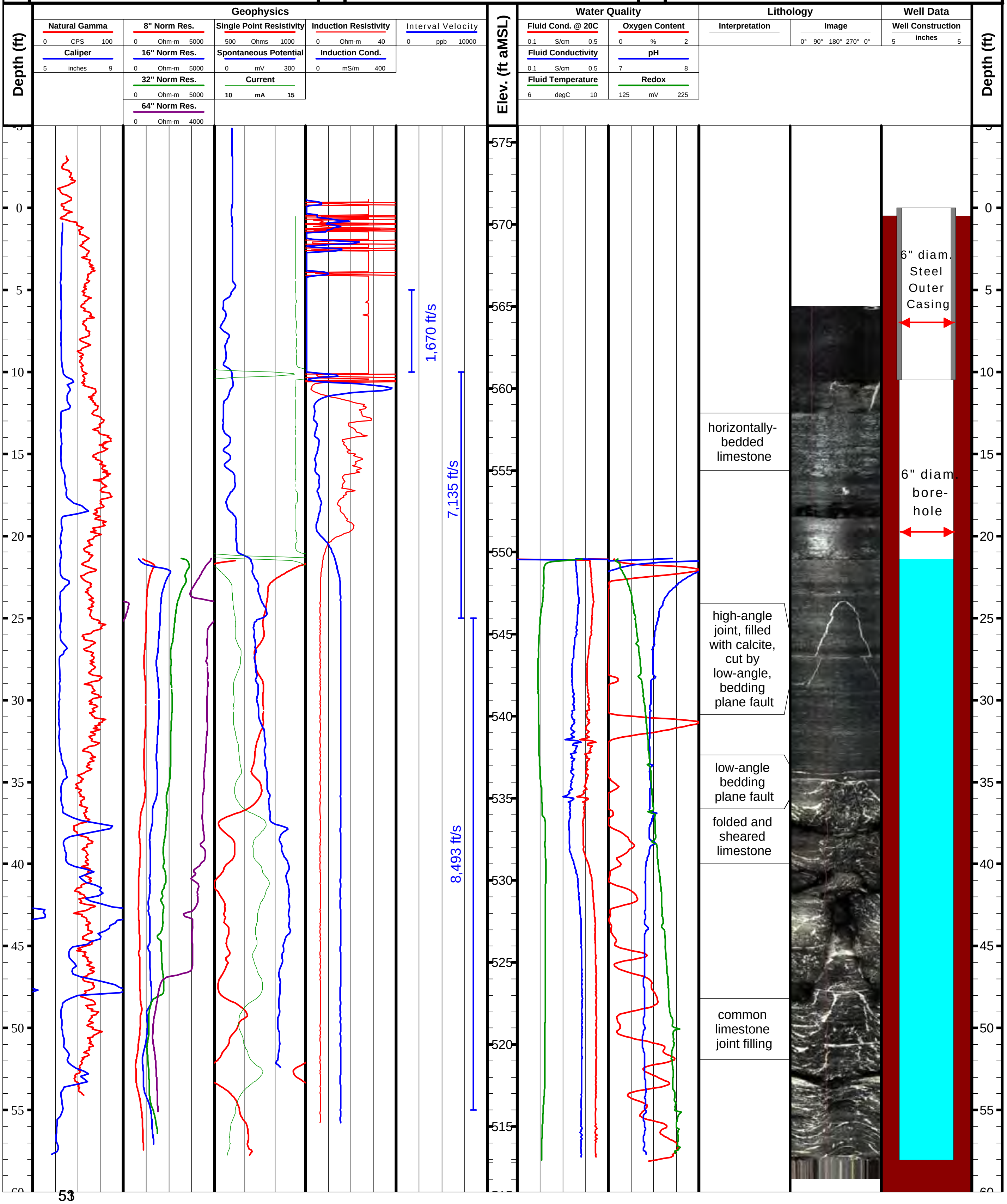
NA - Not Applicable

Project:	LO-58	Well ID:	DW-01 (AMAC Well)	Date Logged:	11-20 May 08
Location:	Aroostook County, Caribou, ME	Log Ref.:	Top Steel Casing	Hole Diameter:	6" nom. to TD
Depth Logger:	58.1 ft	Log Ref. Elev.:	~573 ft above MSL	Csg Size/Type:	6" Steel
Depth Driller:	No Data	Recorded by:	G. Bauer	Witnessed by:	J. Schmidl

LOGS & TOOLS: See Individual Logs

COMMENTS:
Ground Elevation: ~571ft. aMSL.
Natural Gamma log includes K, U, and Th.
Water Quality logs performed under ambient conditions.
Ambient Water Level about 21.4 ft (20.9 ft bgs).
Logs relative to Truth North (mag dec = 20W)

COMMENTS:
All depths here referenced to top steel casing unless noted otherwise.
Measured casing stick up above ground surface: 0.5 ft.
Steel outer casing total depth 10.5 ft, estimated from image log.



Project: LO-58

Well ID: DW-01 (AMAC Well)

Date Logged: 11-20 May 08

Location: Aroostook County, Caribou, ME

Log Ref.: Top Steel Casing

Hole Diameter: 6" nom. to TD

Depth Logger: 58.1 ft

Log Ref. Elev.: ~573 ft above MSL

Csg Size/Type: 6" Steel

Depth Driller: No Data

Recorded by: G. Bauer

Witnessed by: J. Schmidl

LEGEND

Tadpoles at depth of planar structure, pointing towards strike, and centered on dip. Projections corresponding to each tadpole shown in adjacent column.

Structure Tadpoles

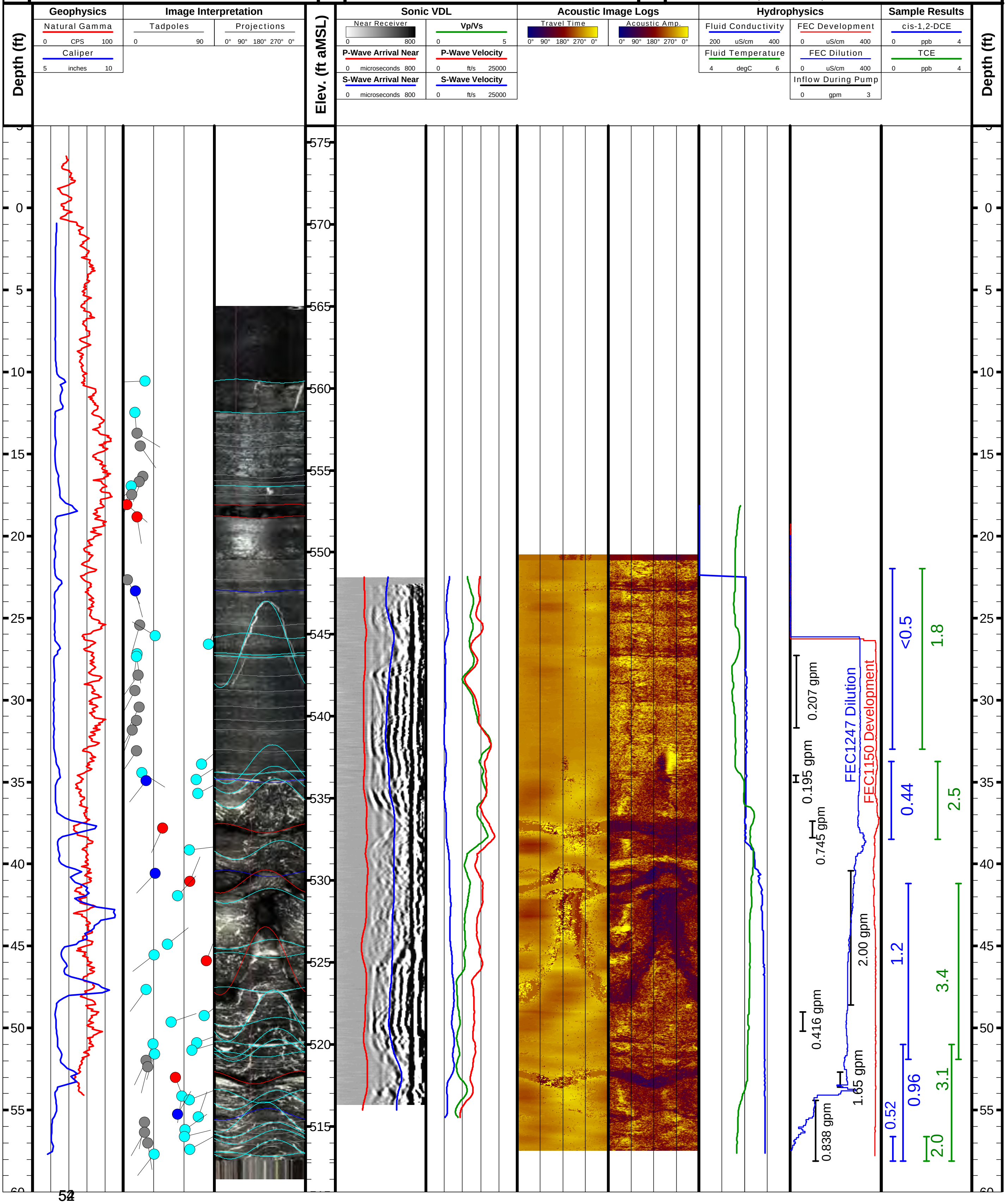
● Partial Fracture	● Healed Fracture/Bedding Plane
● Complete Fracture	● Open Fracture
● Wide Fracture/Multiple Fractures	● Washout/Wide Fracture Zone

COMMENTS

Ground Elevation: ~571 ft. aMSL.
Natural Gamma log includes K, U, and Th.
Water Quality logs performed under ambient conditions.
Ambient Water Level about 21.4 ft (20.9 ft bgs).
Logs relative to Truth North (mag dec = 20W)

COMMENTS

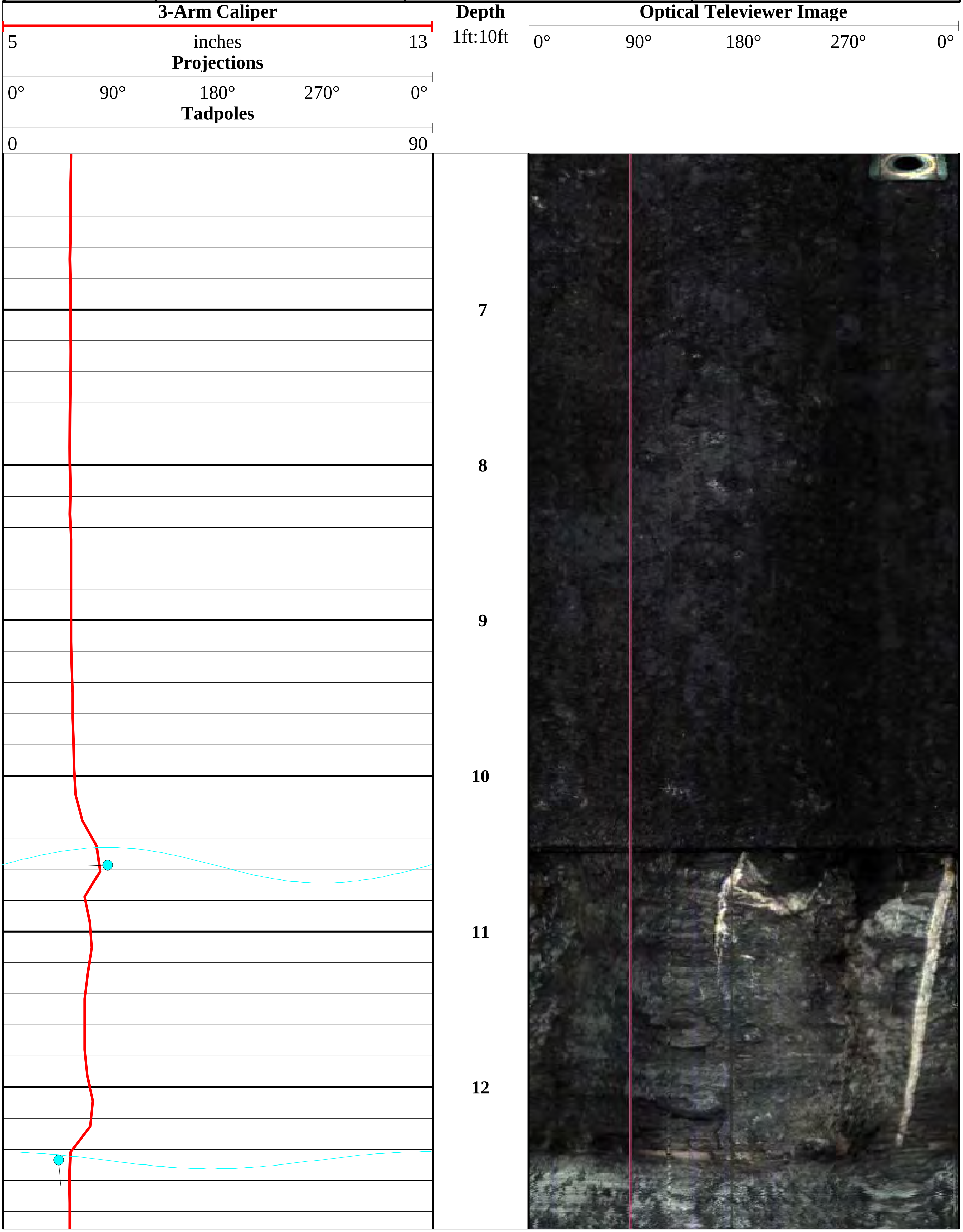
All depths here referenced to top steel casing unless noted otherwise.
Measured casing stick up above ground surface: 0.5 ft.
Steel outer casing total depth 10.5 ft, estimated from image log.
Other well Consturction info taken directly from drilling report.
Measured and drill report PVC stickup differ.

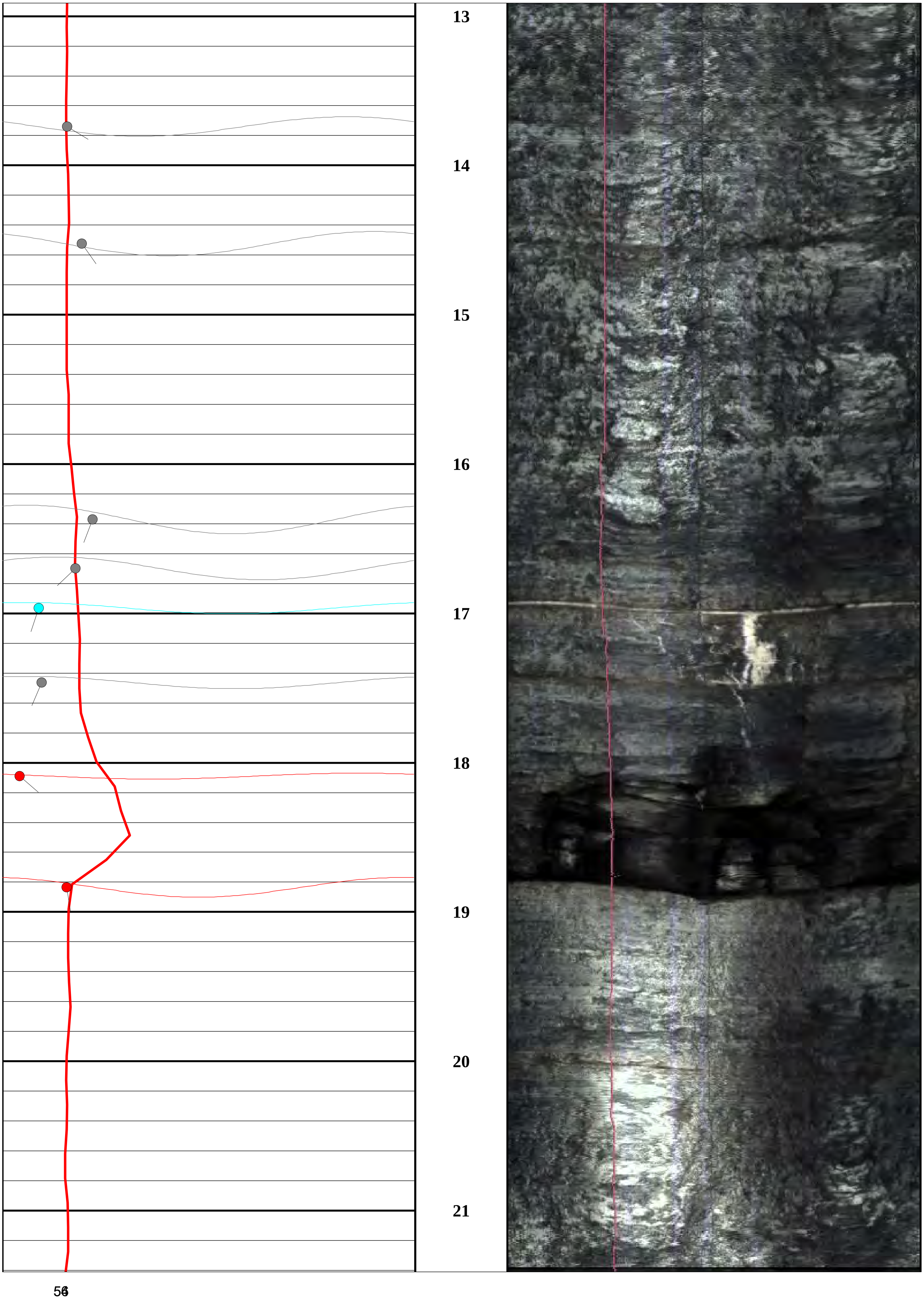


Optical Televiewer Image Plot - True North

COMPANY: Weston Solutions
PROJECT: LO-58
DATE LOGGED: 12 May 2008
WELL: DW-01 (AMAC Well)

COLOG Main Office
810 Quail Street, Suite E, Lakewood, CO 80215
Phone: (303) 279-0171, Fax: (303) 278-0135
www.colog.com

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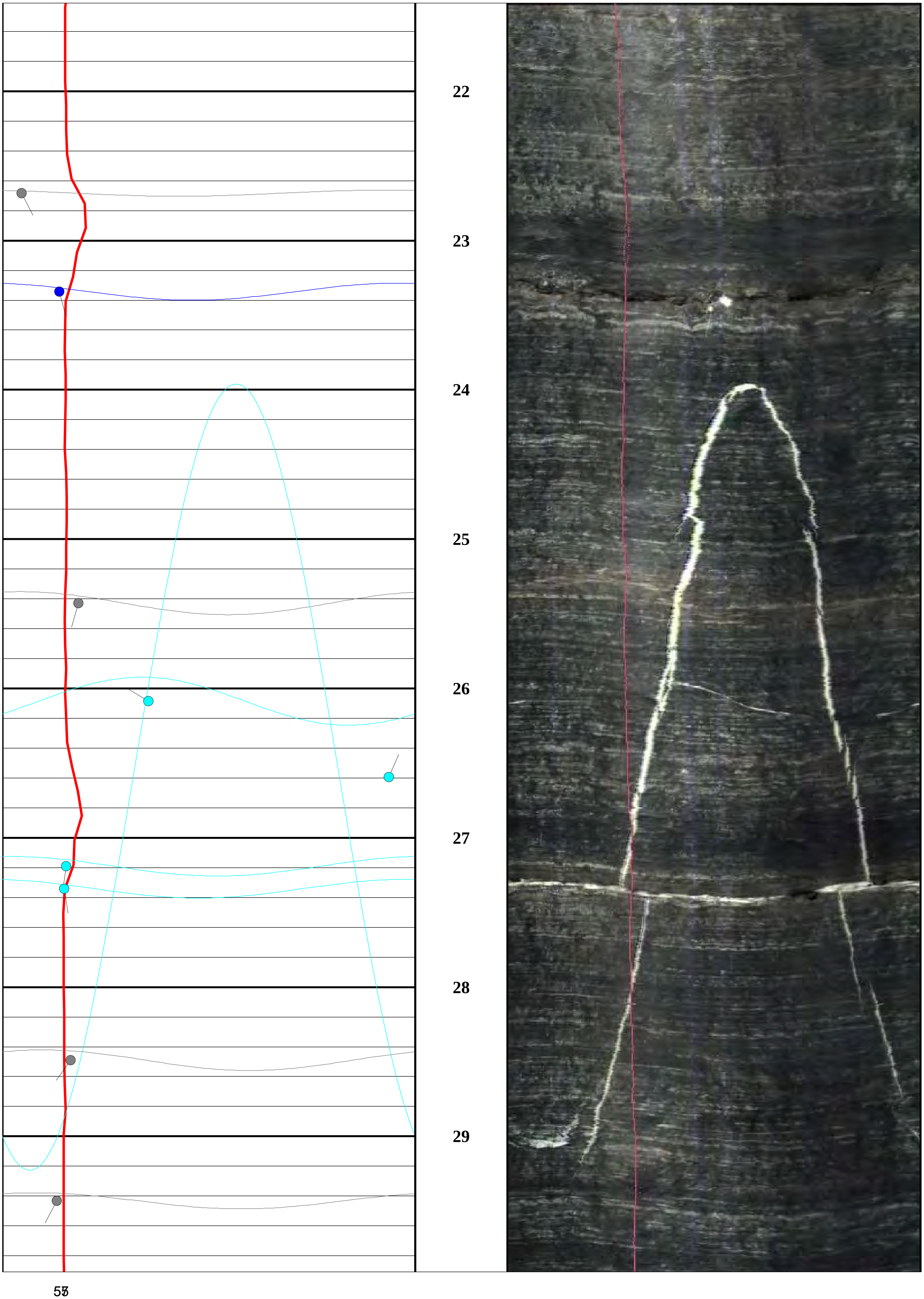
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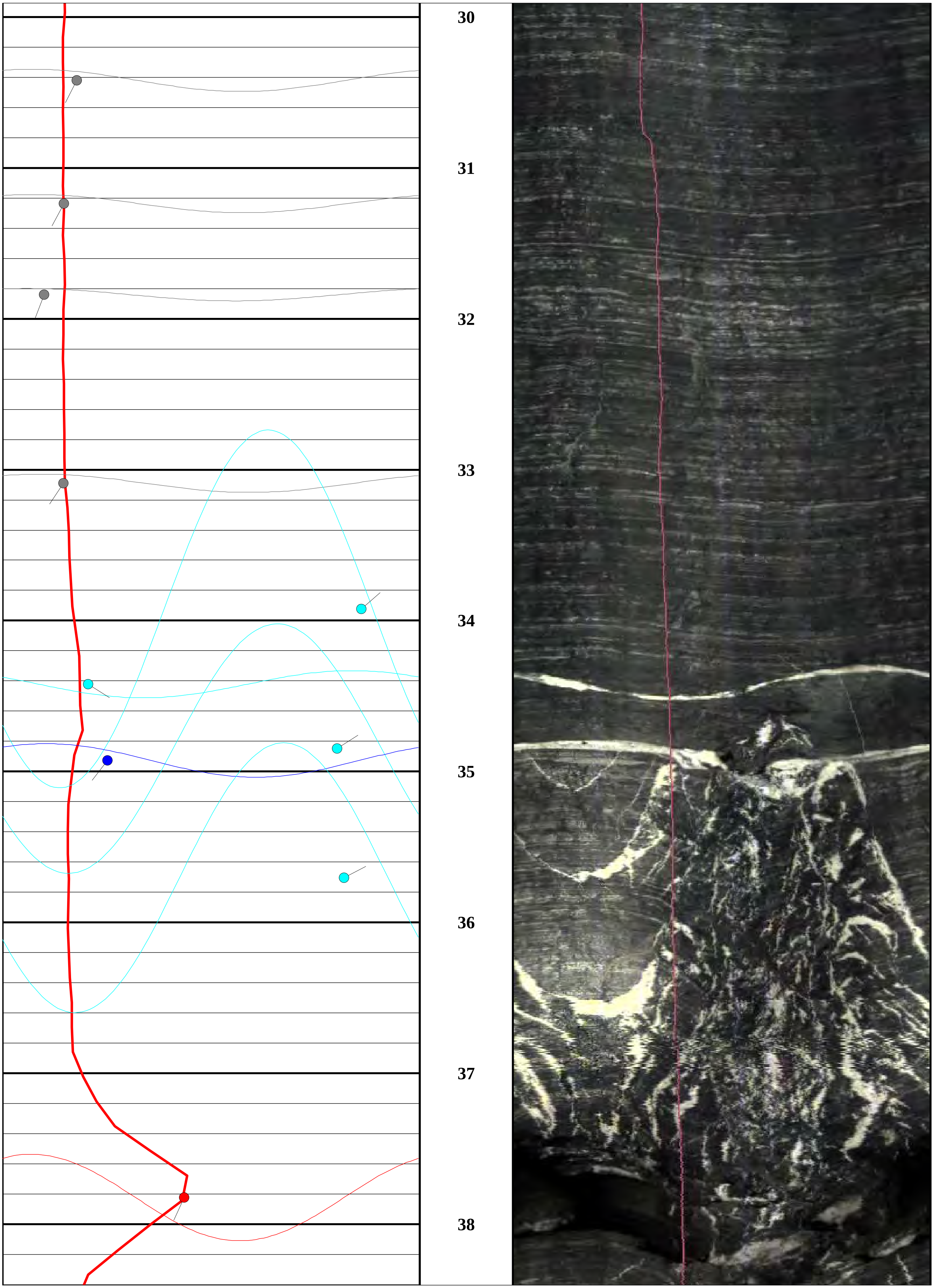
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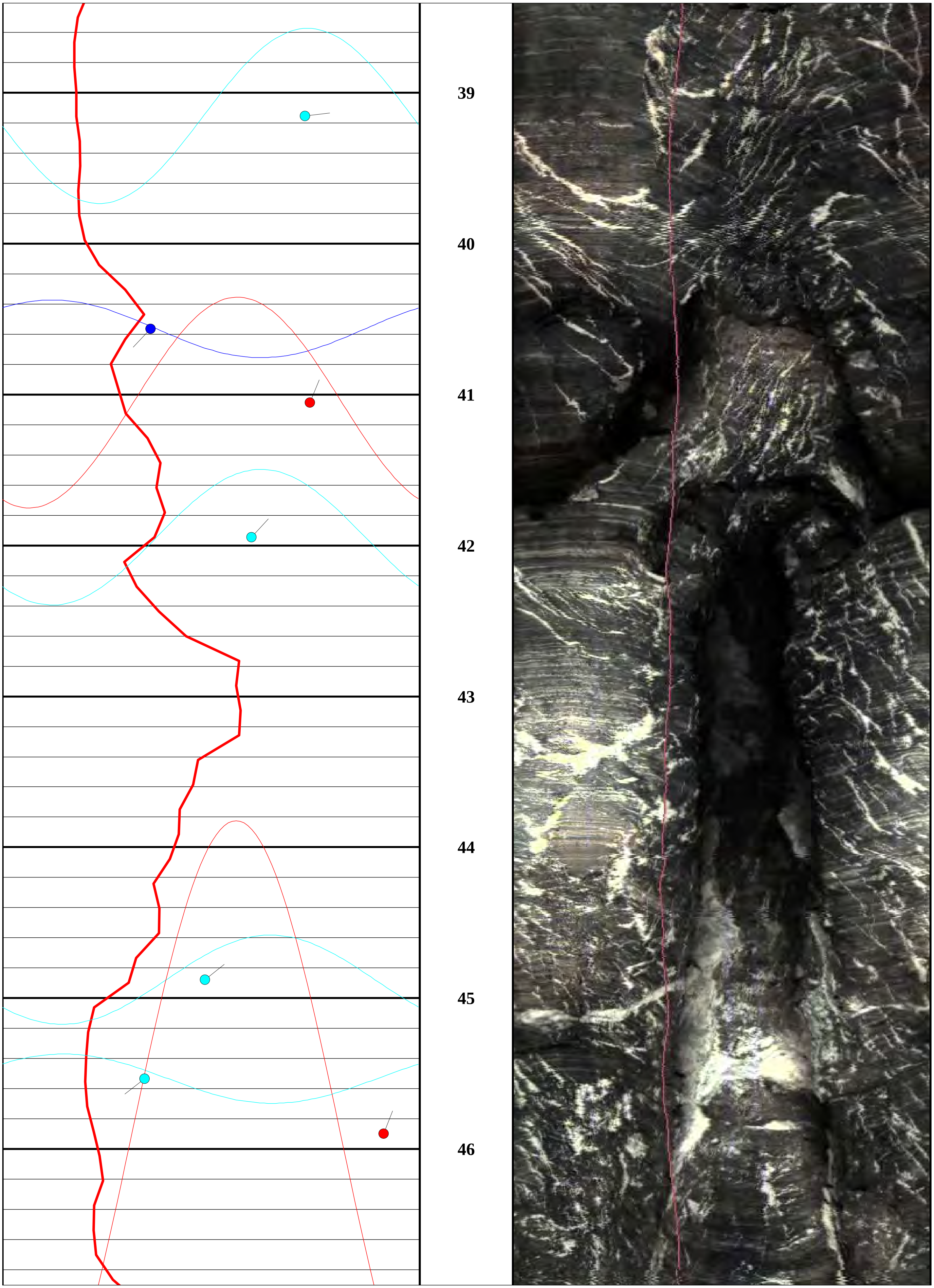
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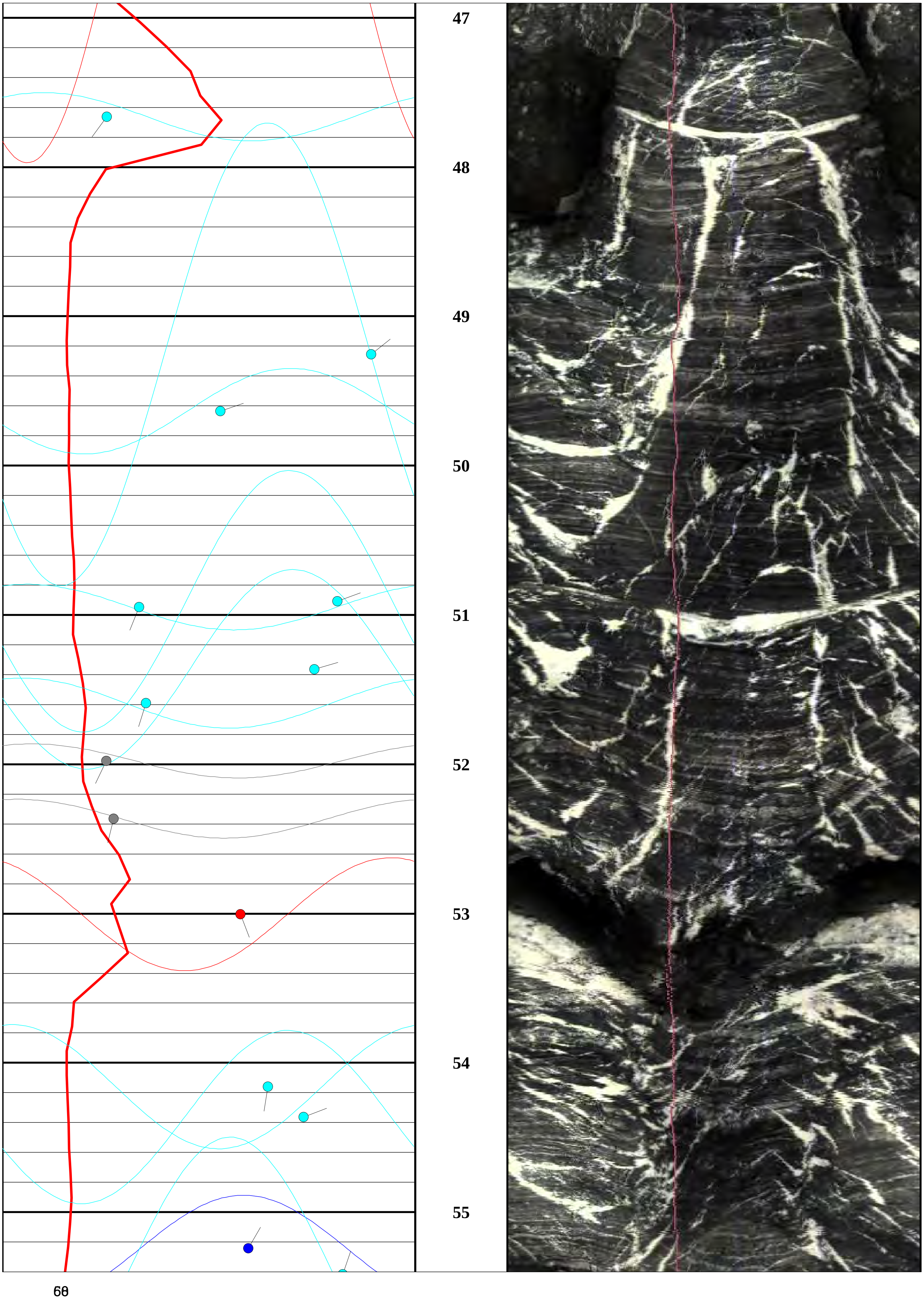
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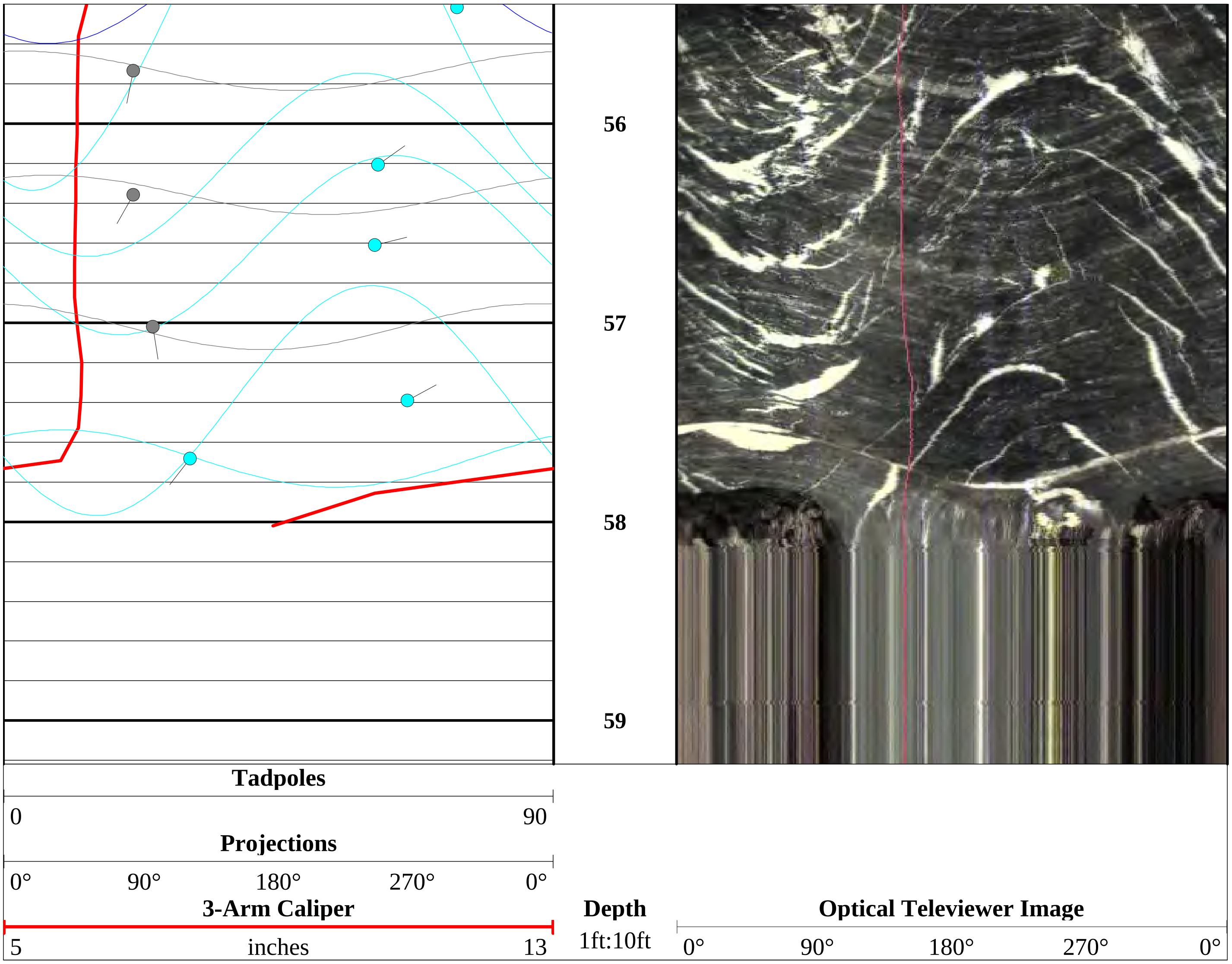
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3-Arm Caliper
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inches
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Depth
1ft:10ft
Optical Televiewer Image
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90°
180°
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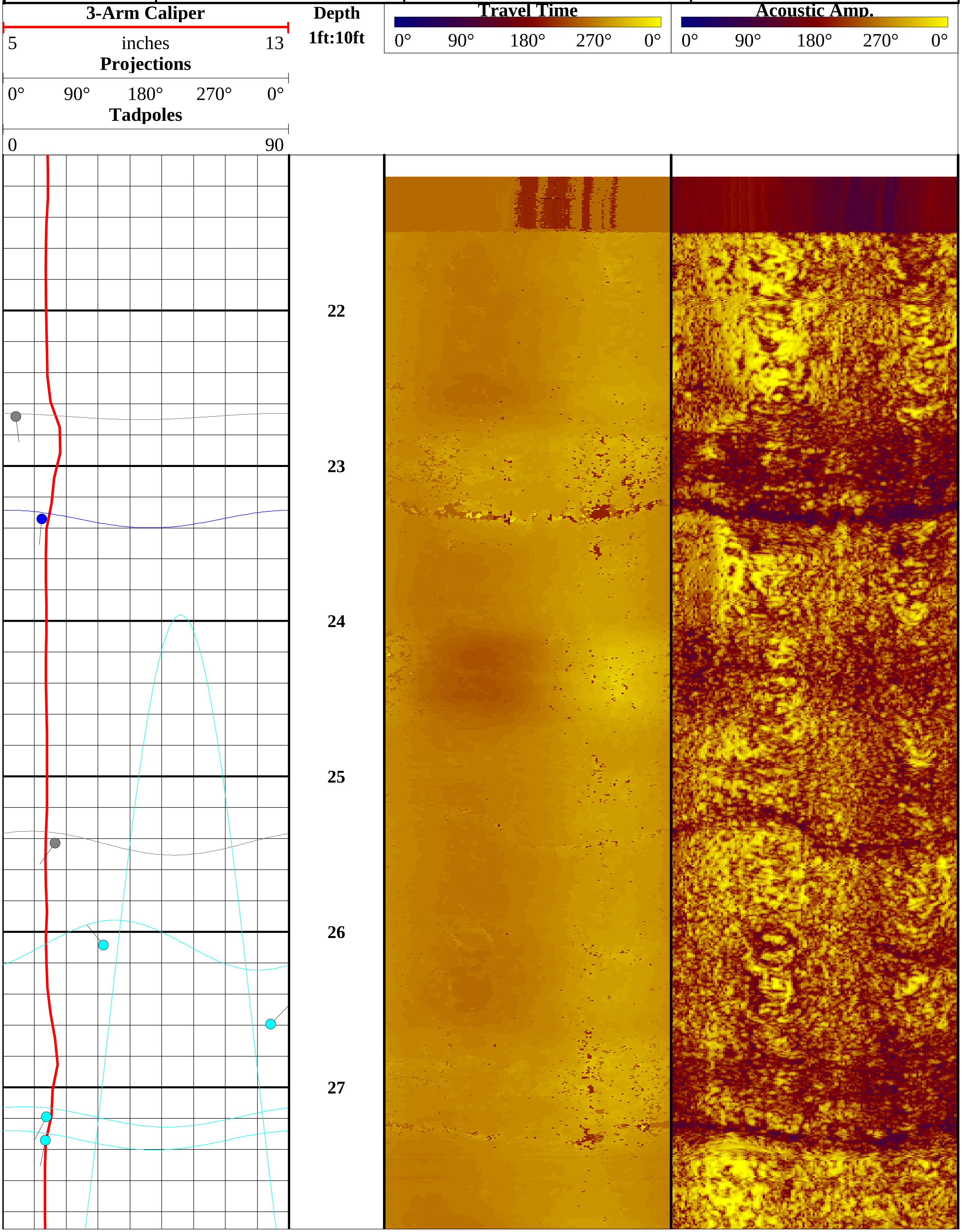
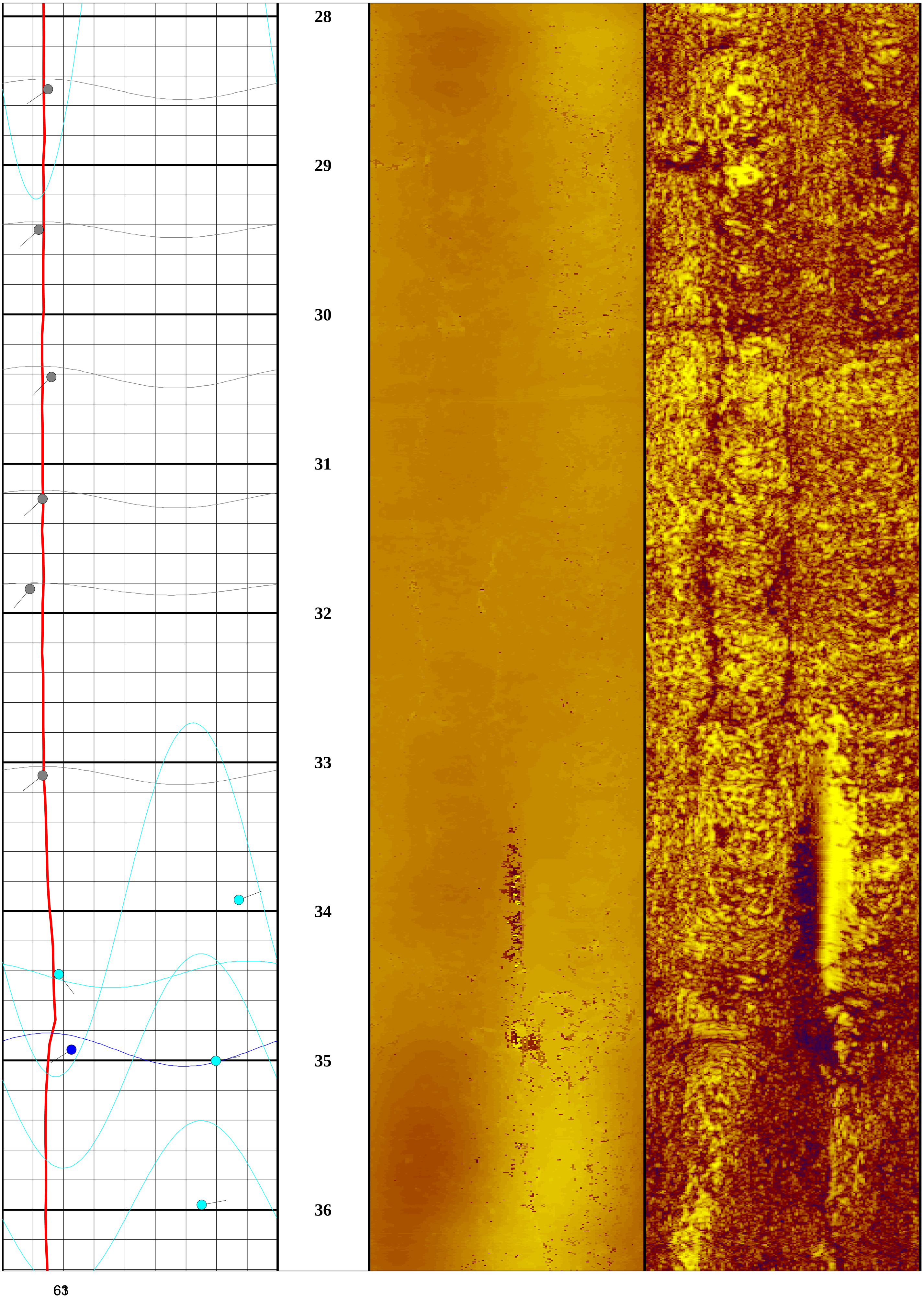
BOREHOLE GEOPHYSICS & HYDROPHYSICS
COLOG
A DIVISION OF LAYNE CHRISTENSEN COMPANY

Acoustic Televiewer Image Plot

COMPANY: Weston Solutions
PROJECT: LO-58
DATE LOGGED: 11 May 2008
WELL: DW-1

COLOG Main Office
810 Quail Street, Suite E, Lakewood, CO 80215
Phone: (303) 279-0171, Fax: (303) 278-0135
www.colog.com

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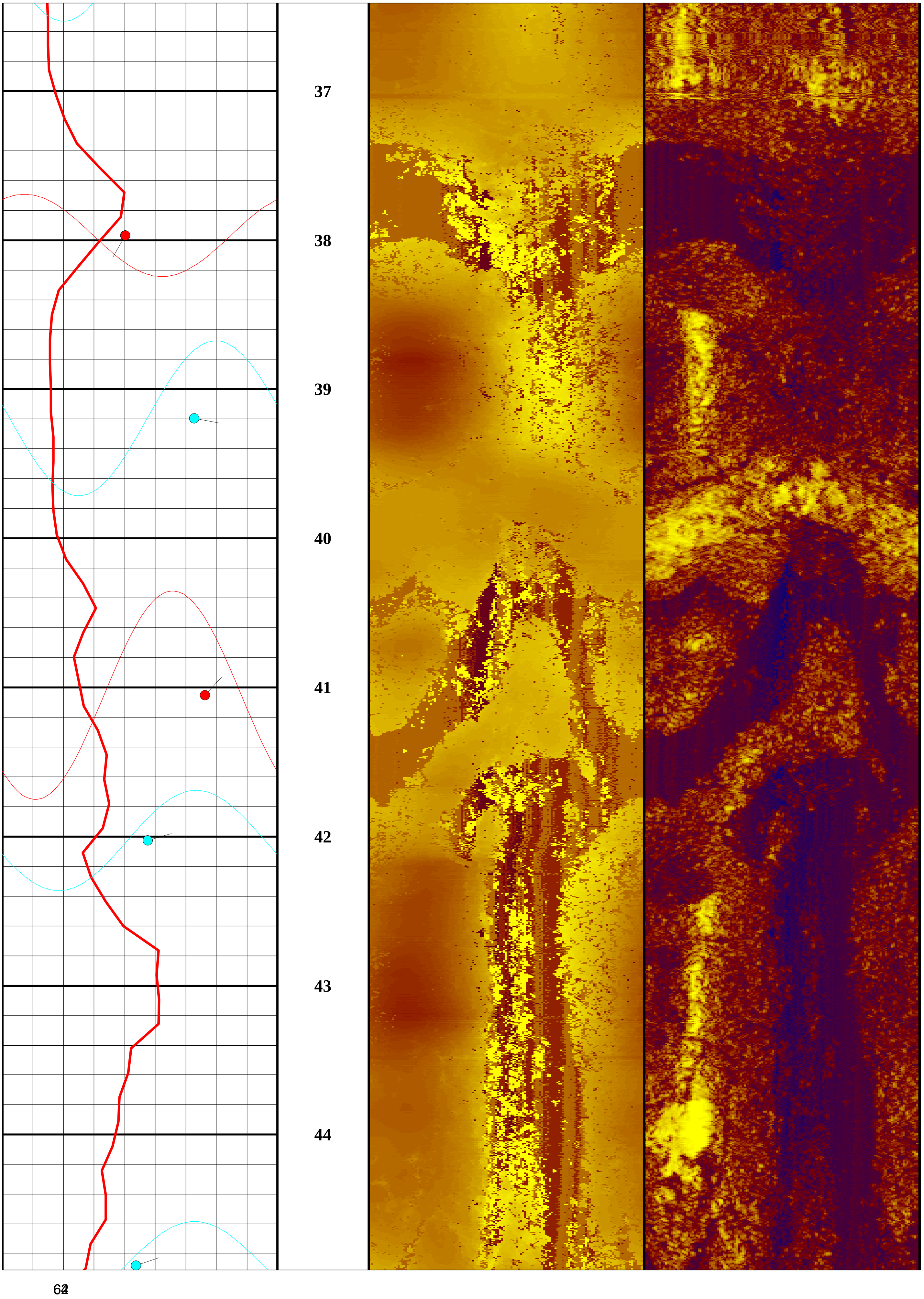
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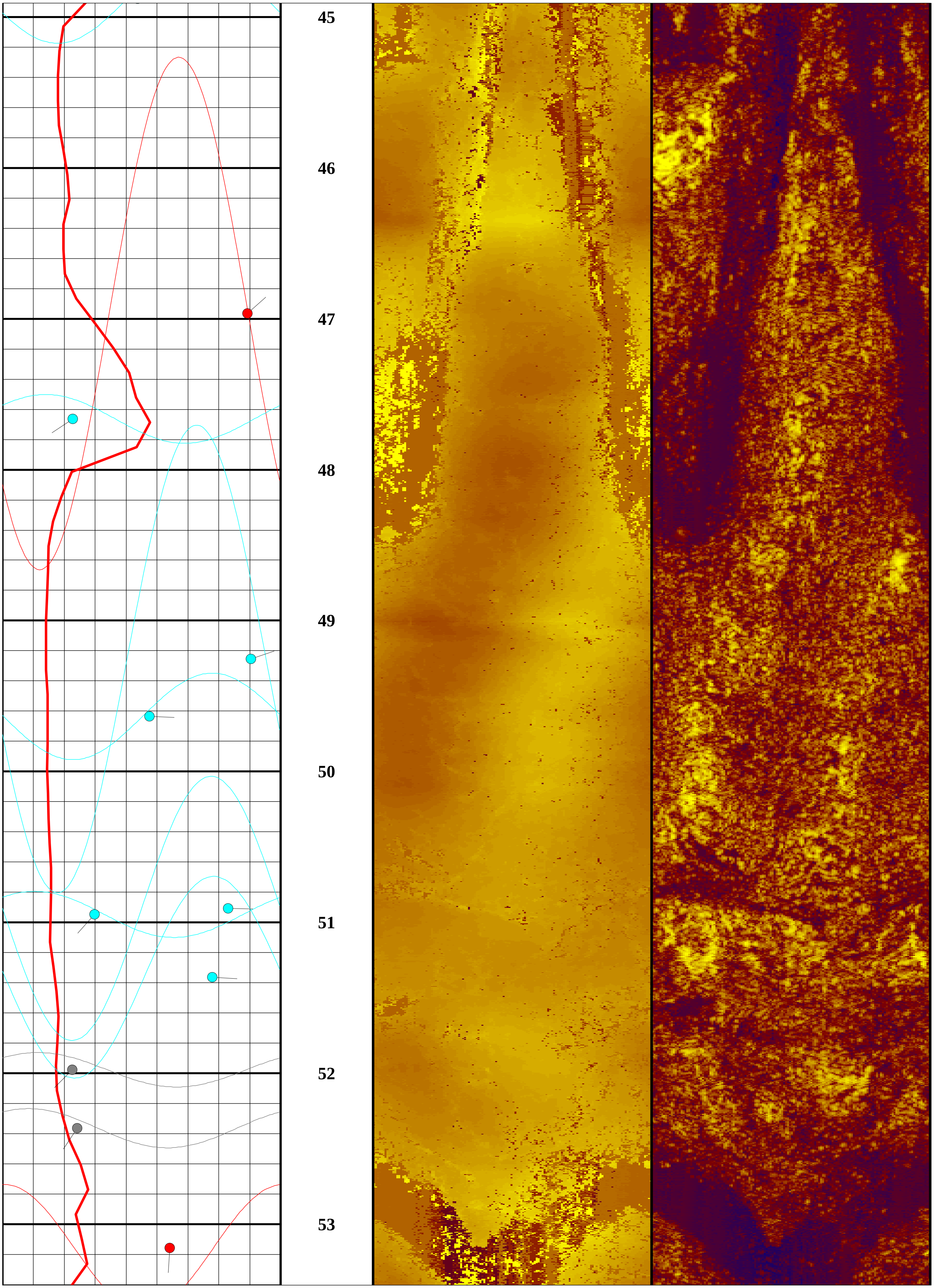
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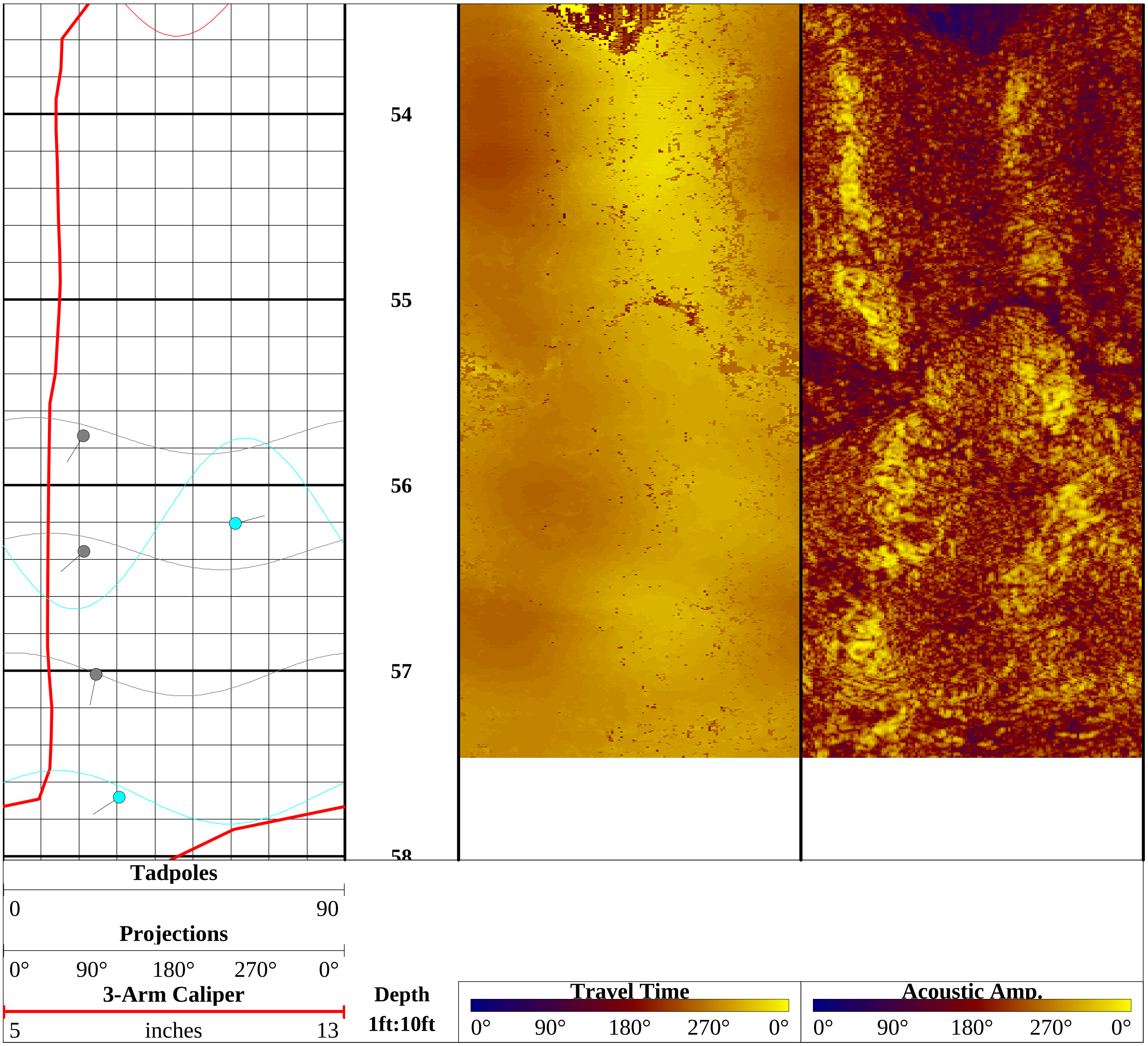
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Projections
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1ft:10ft
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Acoustic Amp.
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180°
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Figure DW-1:5. Rose Diagram of Optical Televiewer Features
Weston Solutions
MEFUDS; LO-58
Wellbore: DW-1
May 11, 2008

Dip Direction

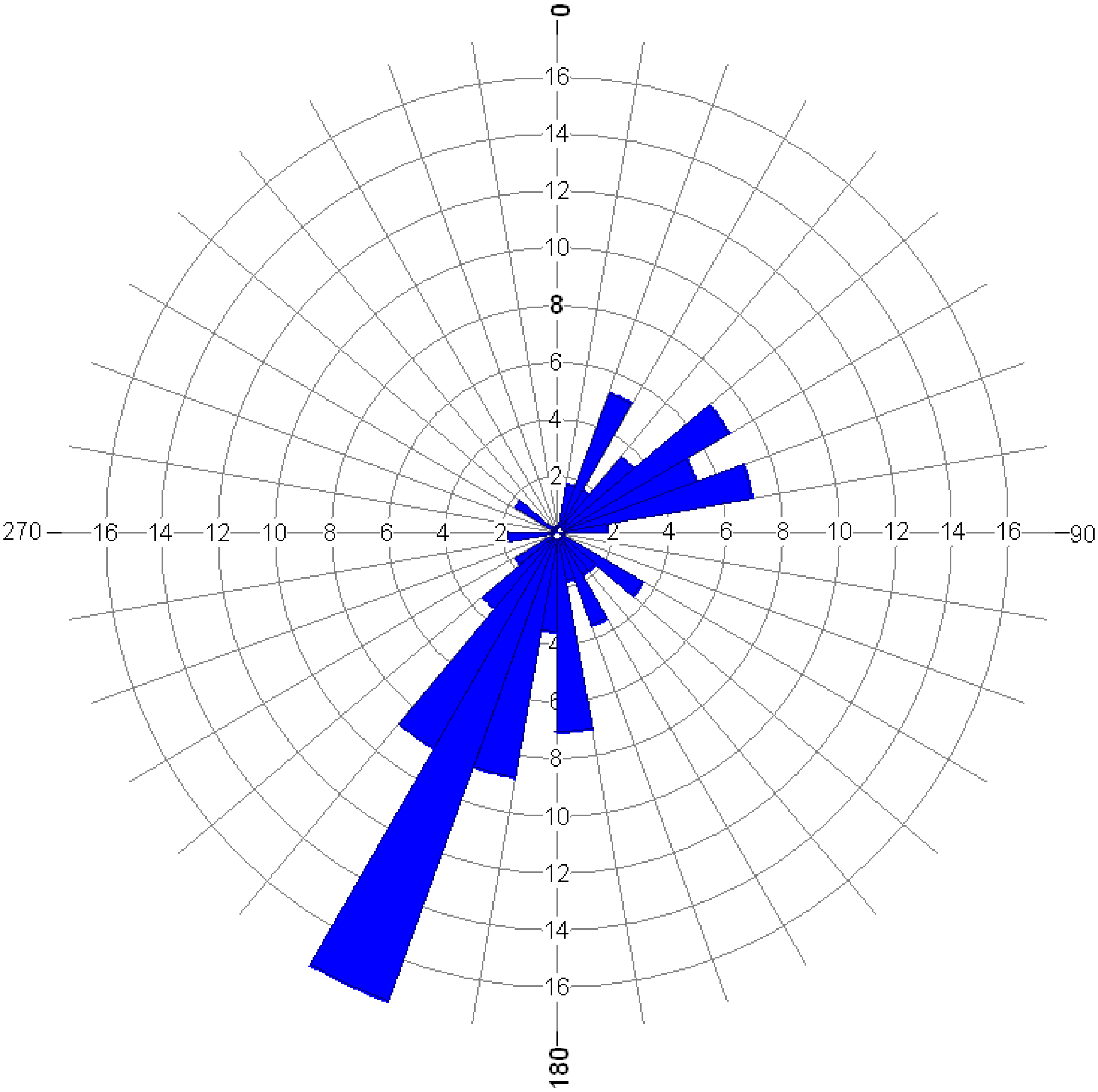


Figure DW-1:6. Rose Diagram of Optical Televiewer Features
Weston Solutions
MEFUDS; LO-58
Wellbore: DW-1
May 11, 2008

Dip Angles

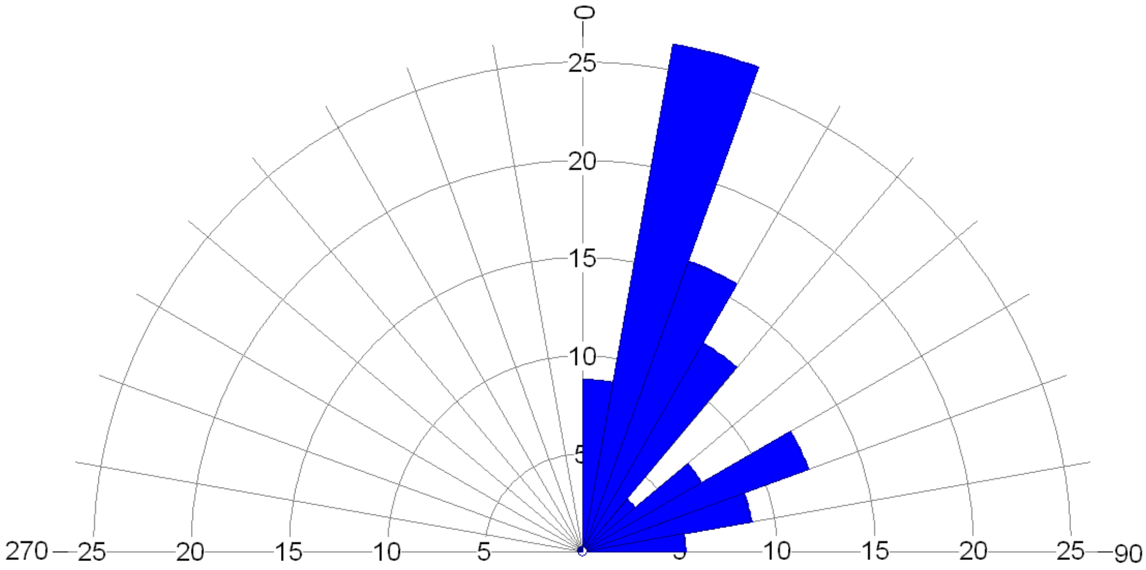


Figure DW-1:7. Stereonet of Optical Televiewer Features
Weston Solutions
MEFUDS; LO-58
Wellbore: DW-1
May 11, 2008

Schmidt Projection with Contours

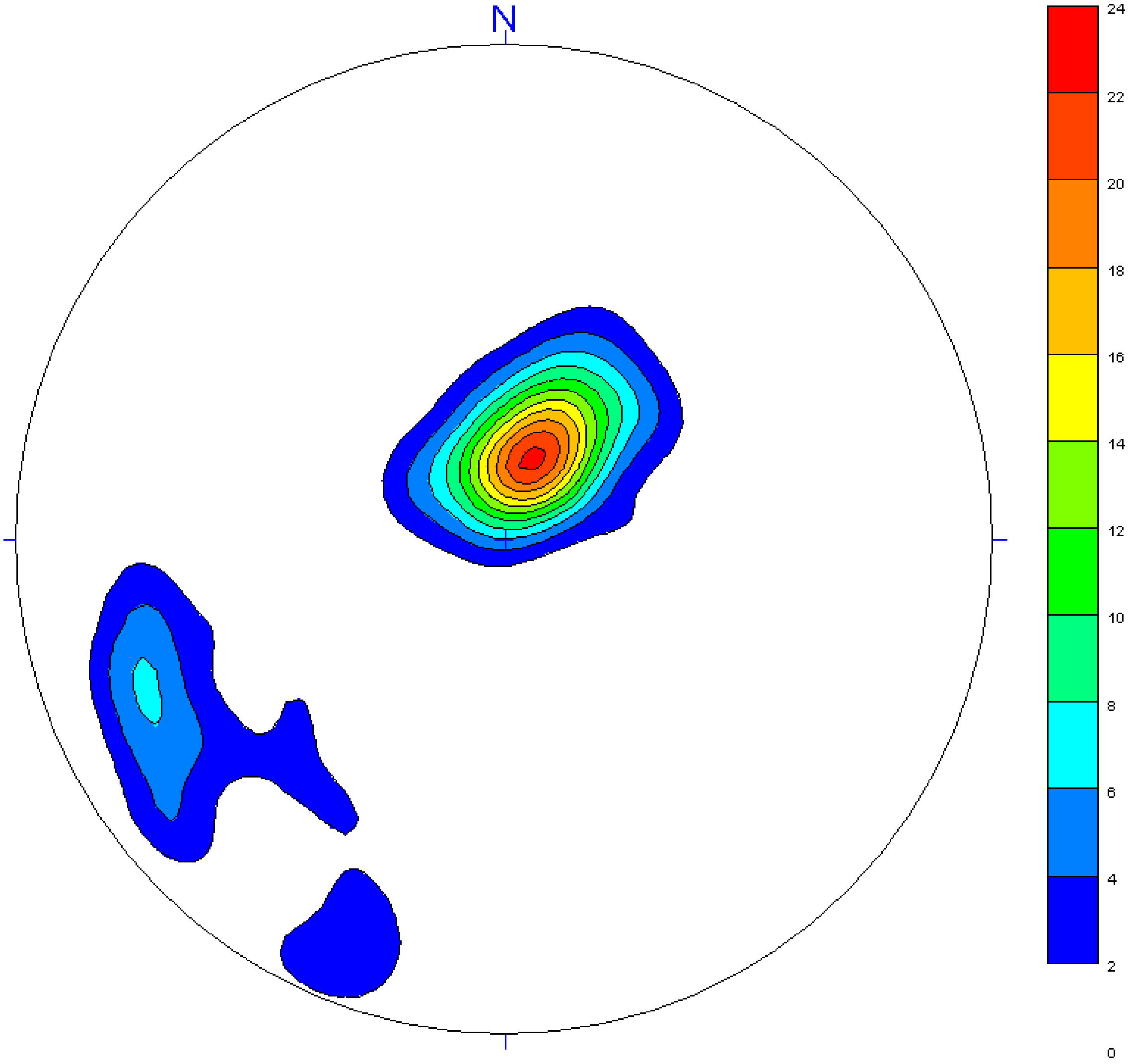


Figure DW-1:8. Stereonet of Optical Televiewer Features
Weston Solutions
MEFUDS; LO-58
Wellbore: DW-1
May 11, 2008

Schmidt Projection with Feature Ranks

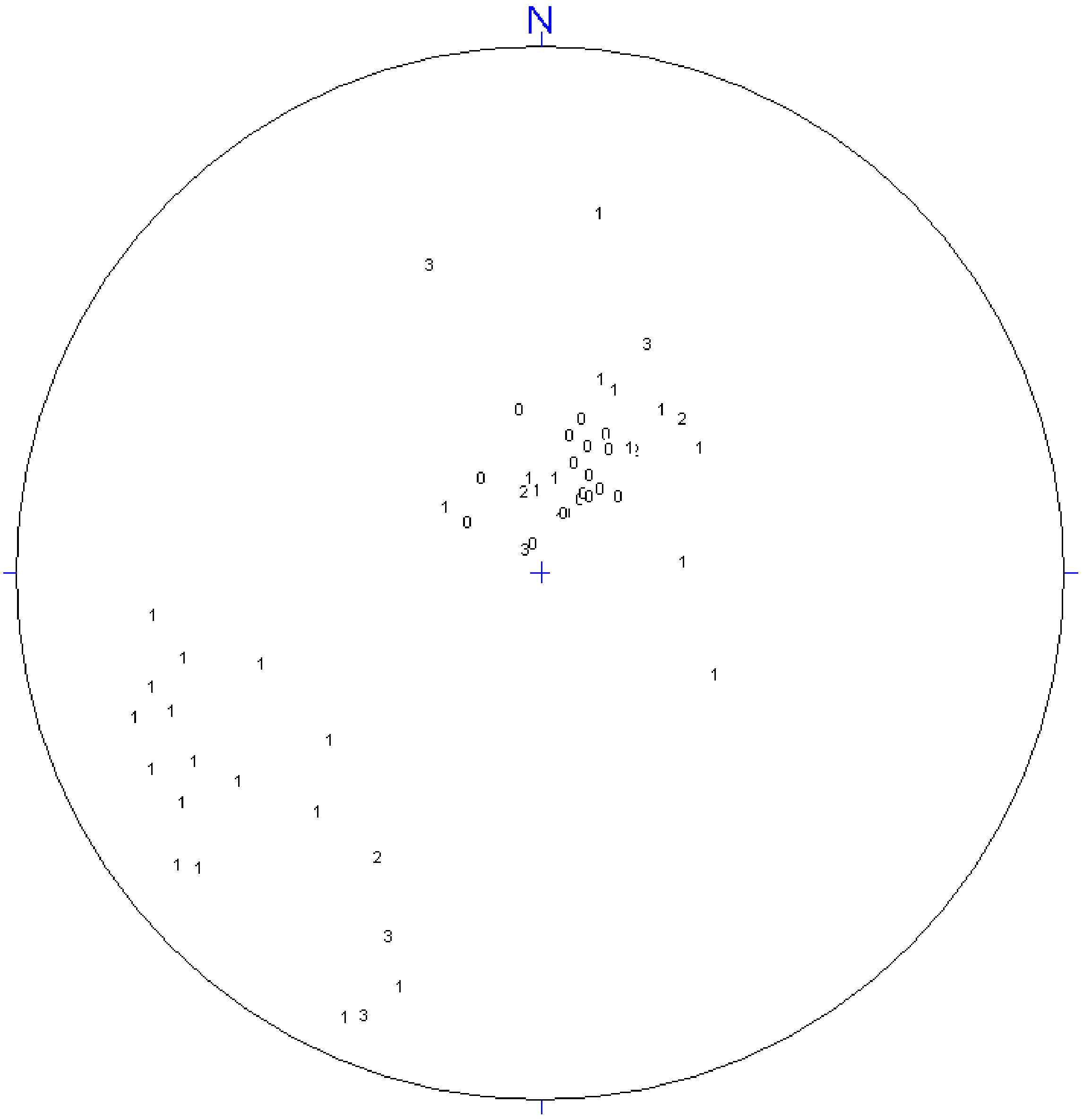


Table DW-1:2. Orientation Summary Table
Image Features
Weston Solutions
LO-58;
Wellbore: DW-1
May 11, 2008

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
1	3.22	10.6	268	22	1
2	3.80	12.5	175	12	1
3	4.19	13.7	120	14	0
4	4.43	14.5	144	17	0
5	4.99	16.4	200	20	0
6	5.09	16.7	227	16	0
7	5.17	17.0	199	8	1
8	5.32	17.5	203	9	0
9	5.51	18.1	130	4	3
10	5.74	18.8	171	14	3
11	6.91	22.7	153	4	0
12	7.11	23.3	165	12	2
13	7.75	25.4	196	17	0
14	7.95	26.1	302	32	1
15	8.11	26.6	24	84	1
16	8.29	27.2	187	14	1
17	8.33	27.3	171	14	1
18	8.68	28.5	215	15	0
19	8.97	29.4	208	12	0
20	9.27	30.4	206	16	0
21	9.52	31.2	208	13	0
22	9.70	31.8	200	9	0
23	10.09	33.1	213	13	0
24	10.34	33.9	49	77	1
25	10.49	34.4	121	18	1
26	10.62	34.9	57	72	1
27	10.65	34.9	218	23	2
28	10.88	35.7	63	74	1
29	11.53	37.8	205	39	3
30	11.93	39.2	83	65	1
31	12.36	40.6	223	32	2
32	12.51	41.1	23	66	3
33	12.79	42.0	43	54	1
34	13.68	44.9	51	44	1
35	13.88	45.5	233	31	1
36	13.99	45.9	22	82	3
37	14.53	47.7	216	23	1
38	15.01	49.3	51	80	1
39	15.13	49.6	71	48	1
40	15.52	50.9	70	73	1
41	15.53	51.0	202	30	1
42	15.65	51.4	73	68	1
43	15.72	51.6	197	31	1
44	15.84	52.0	205	23	0

All directions are with respect to true north (magnatic declination 20W).

Table DW-1:2. Orientation Summary Table
Image Features
Weston Solutions
LO-58;
Wellbore: DW-1
May 11, 2008

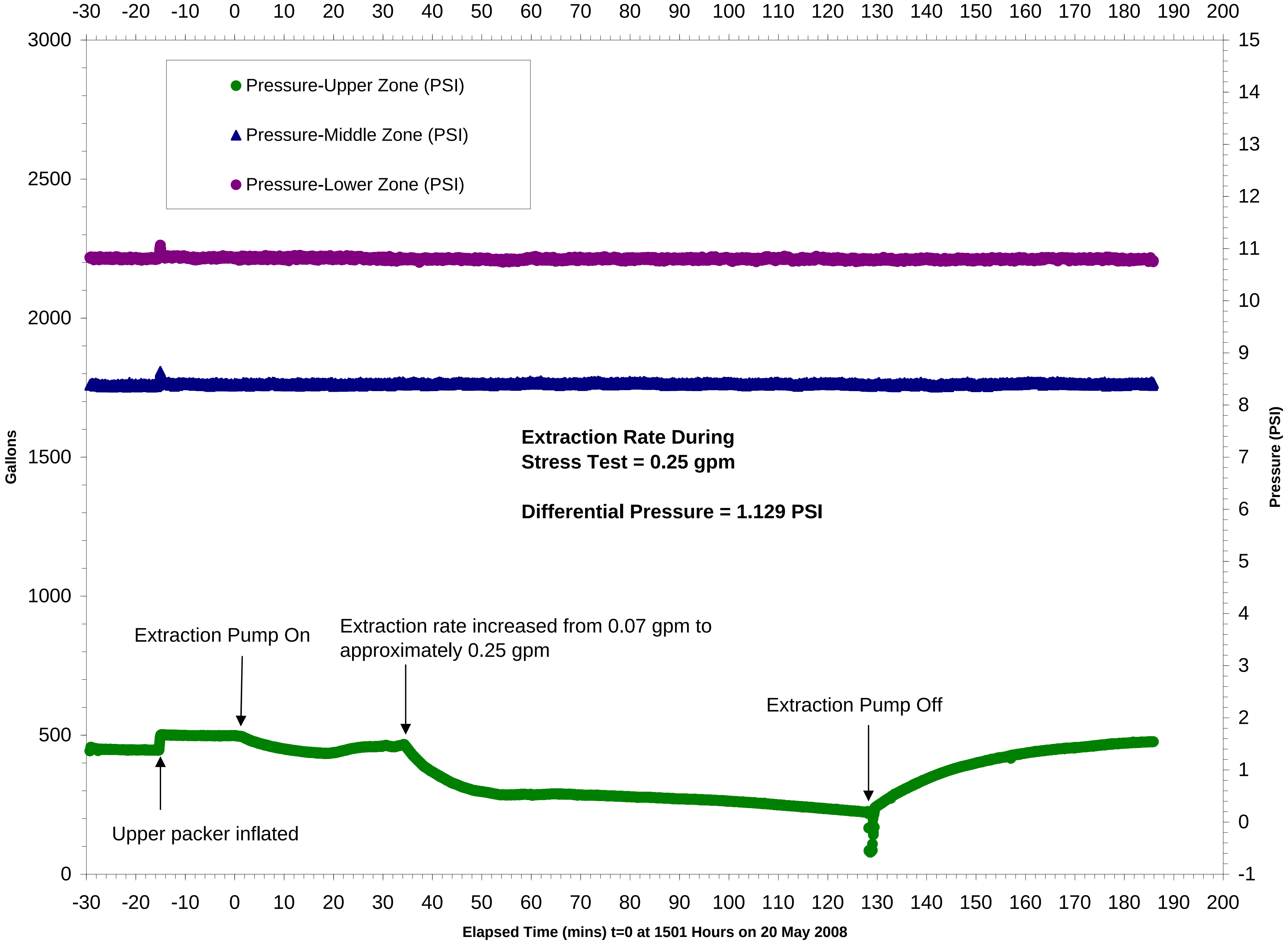
Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
45	15.96	52.4	194	24	0
46	16.16	53.0	159	52	3
47	16.51	54.2	189	58	1
48	16.57	54.4	69	66	1
49	16.84	55.2	30	54	2
50	16.89	55.4	19	74	1
51	16.99	55.7	191	21	0
52	17.13	56.2	55	61	1
53	17.18	56.4	209	21	0
54	17.25	56.6	76	61	1
55	17.38	57.0	171	25	0
56	17.49	57.4	61	66	1
57	17.58	57.7	217	31	1

All directions are with respect to true north (magnatic declination 20W).

Table DW-1:3. Summary of Vertical Seismic Profile Results; Weston Solutions; LO-58, Caribou, ME; Wellbore: DW-1

Well	Depth Interval (ftbtoc)	Interval-Specific Velocity (feet/second)	Comments
DW-01	5 - 10	1,670	Consistent with overburden
	10 - 25	7,135	Consistent with highly fractured bedrock
	25 - 55	8,493	Consistent with highly fractured bedrock

FIGURE DW-1:9A. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 33.15 feet and Up; Weston Solutions; LO-58; Aroostook County; Caribou, ME; Wellbore: DW-1



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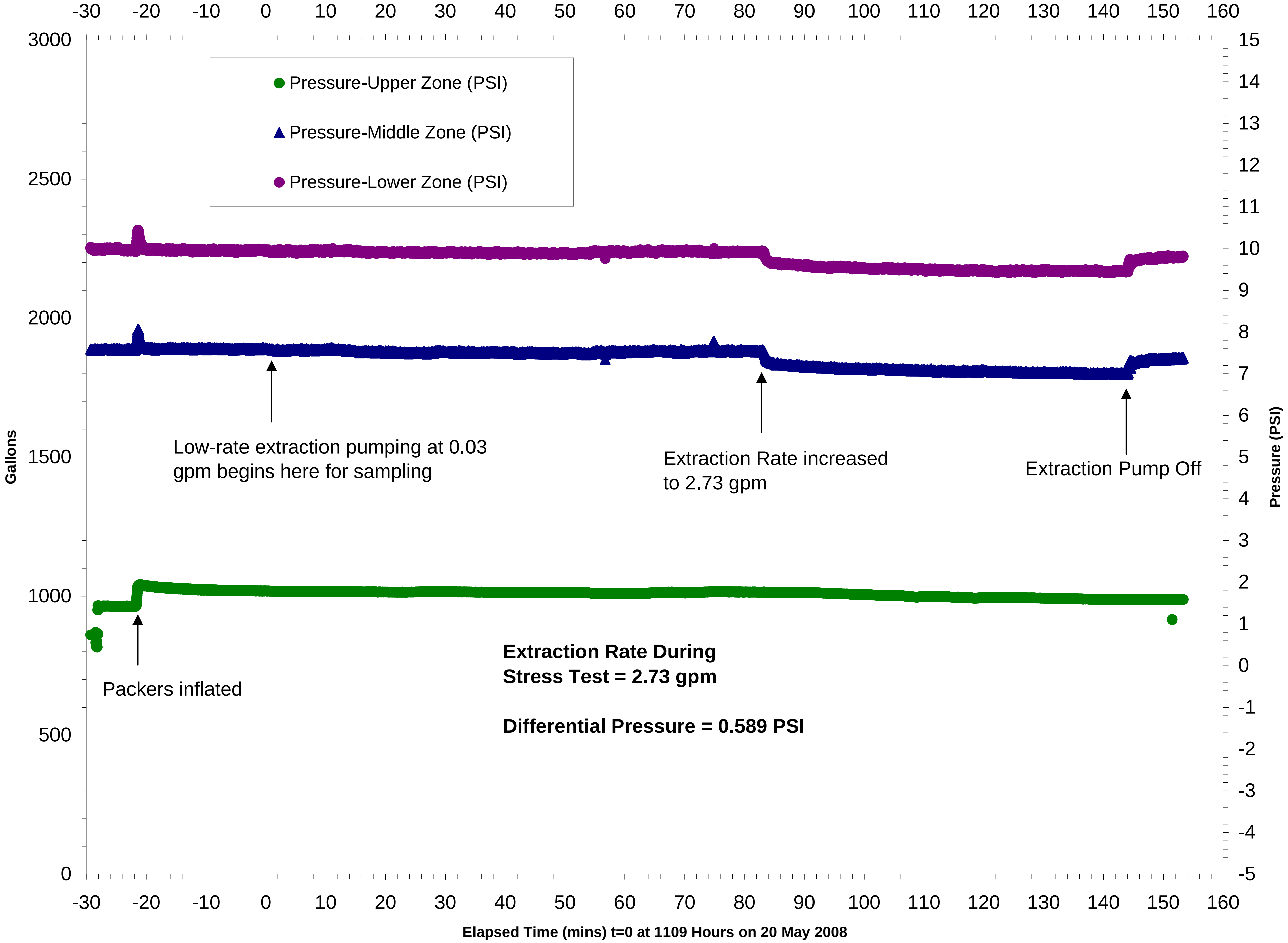
RS-1522-fig3.xls

FIGURE DW-1:9B. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 33.75 to 38.5 Feet; Weston Solutions; LO-58; Aroostook County; Caribou, ME; Wellbore: DW-1



Low-rate extraction pumping at 0.03 gpm begins here for sampling

Extraction Rate increased to 2.73 gpm

Extraction Pump Off

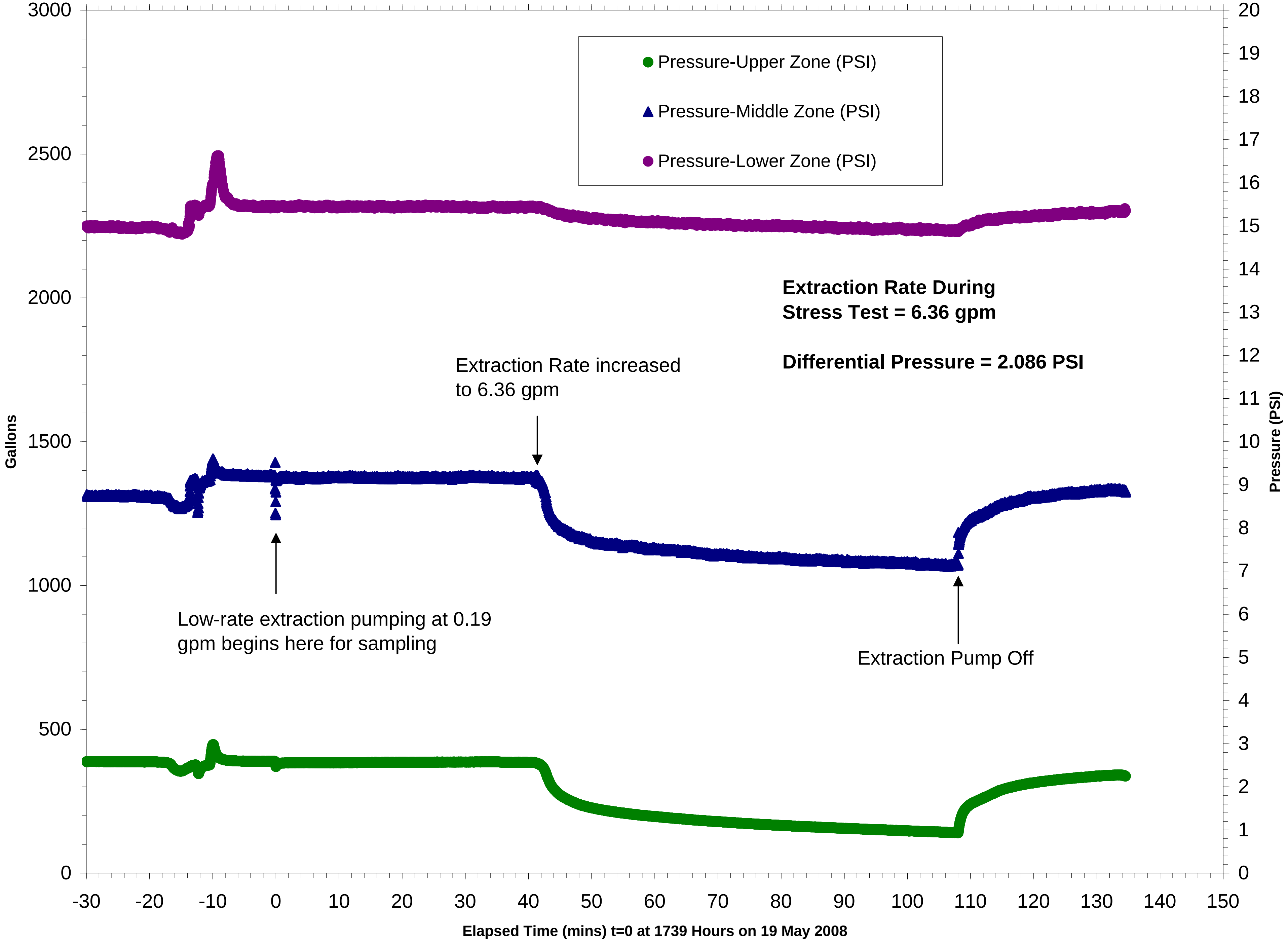
Packers inflated

Extraction Rate During Stress Test = 2.73 gpm

Differential Pressure = 0.589 PSI

RS-1522-fig3.xls

FIGURE DW-1:9C. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 41.2 to 51.9 Feet; Weston Solutions; LO-58; Aroostook County; Caribou, ME; Wellbore: DW-1



Extraction Rate During Stress Test = 6.36 gpm

Differential Pressure = 2.086 PSI

Extraction Rate increased to 6.36 gpm

Low-rate extraction pumping at 0.19 gpm begins here for sampling

Extraction Pump Off

RS-1522-fig3.xls

FIGURE DW-1:9D. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 51.0 to 58.2 Feet (TD); Weston Solutions; LO-58; Aroostook County; Caribou, ME; Wellbore: DW-1

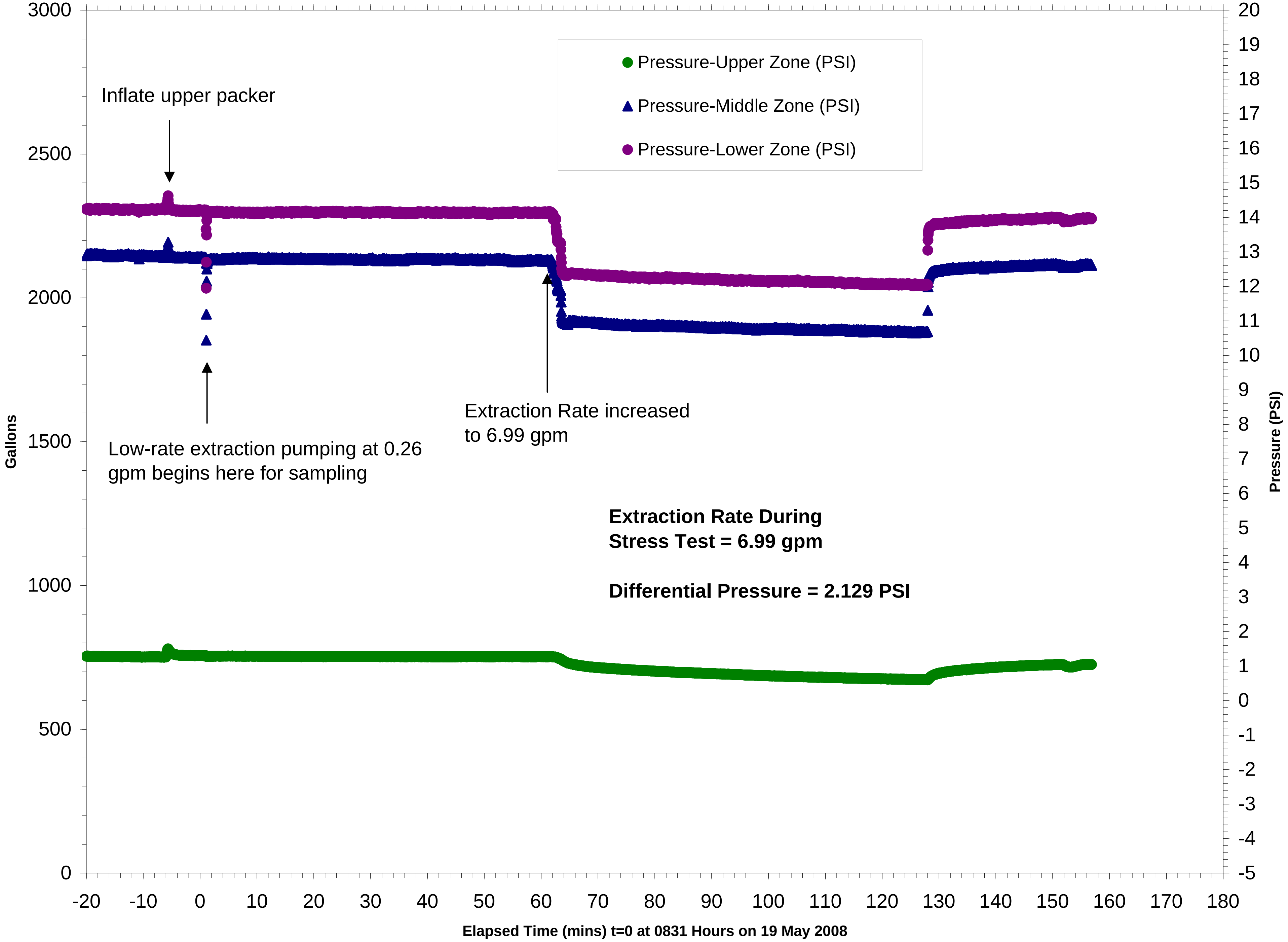
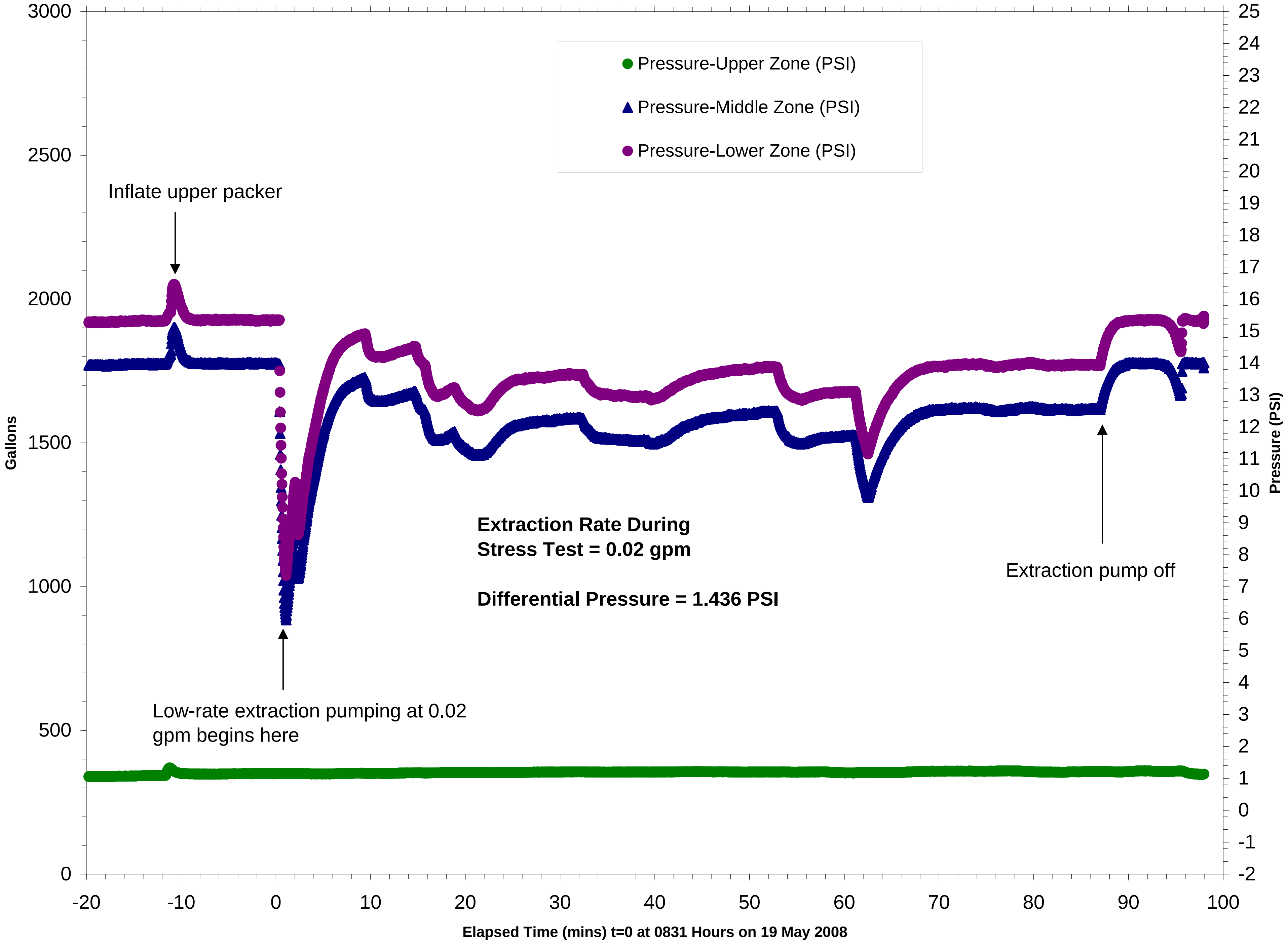


FIGURE DW-1:9E. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 54.0 to 58.2 Feet (TD); Weston Solutions; LO-58; Aroostook County; Caribou, ME; Wellbore: DW-1



RS-1522-fig3.xls

Table DW-1:4. Summary Of Wireline Straddle Packer Testing With With Hydraulic Conductivity And Transmissivity Estimations; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-1

Well Name	DW-01
Ambient Depth to Water (ftbtoc)	24.86
Diameter of Borehole (ft)	0.52
Effective Radius (ft)	300

Interval No.	Top of Interval (ft)	Bottom of Interval (ft)	Length of Interval (ft)	Differential Pressure (PSI)	Differential Head (feet)[1]	Interval Specific Flow Rate: WSP Stress Test (gpm)	Interval Specific Hydraulic Conductivity[4] (ft/day)	Transmissivity (ft2/day)	Interval Specific Fluid Electrical Conductivity (microS/cm)
1*	24.9	33.2	8.3	1.129	2.607	0.25	1.86E+01	1.55E+02	439
2	33.8	38.5	4.7	0.589	1.360	2.73	6.90E+02	3.24E+03	461
3	41.2	51.9	10.7	2.086	4.818	6.36	1.99E+02	2.13E+03	433
4**	51.0	58.2	7.2	2.129	4.917	6.99	3.19E+02	2.30E+03	459
5**	54.0	58.2	4.2	1.436	3.316	0.02	2.32E+00	9.75E+00	424

* The reported top depth is ambient water level.

** The reported bottom depth of these intervals is the total depth (TD) of the borehole.

[1] Differential Head is the difference between ambient pressure and pumping pressure, converted to feet.

DW-2 Logging Results

1.0 HydroPhysical™ Logging

1.1 Ambient Fluid Electrical Conductivity and Temperature Log: DW-2

At 0933 hours on May 9th, 2008, after a calibration check of the fluid electrical conductivity (FEC) and temperature logging tool, the fluid column was logged for FEC and temperature profiles with COLOG's 1.5-inch diameter HpL™ probe. These logs were performed prior to the installation of any pumping equipment. Please refer to Figure DW-2:1. The ambient FEC profile indicates a relatively featureless profile with the exception of FEC anomalies at 32, 52 and a notable increase at approximately 191.1 feet. The nominal FEC above 191.1 feet is approximately 392 µS/cm while the nominal FEC below 191.1 feet is approximately 596 µS/cm. The ambient temperature profile indicates a gradual increase in temperature with depth with an inflection at approximately 191.1 feet. The anomaly observed in the ambient FEC profile at 191.1 feet indicates a strong correlation with the identified water-bearing feature observed during hydrophysical ambient and stressed testing. In vertically flowing conditions, where water enters the borehole, termed inflow, a change in either FEC is typically seen.

1.2 Ambient Flow Characterization: DW-2

On May 14th, 2008, ambient flow characterization was conducted in the boring DW-2. For ambient flow assessment, the formation water in the borehole was diluted with deionized water (DI) and the boring left in an undisturbed state to allow any natural flow to occur. After DI water emplacement the pump was removed from the boring to insure that water in the pump standpipe would not drain back into the boring. Prior to this period and throughout all HpL™ testing, water levels were monitored and recorded digitally every second. Ambient flow evaluation is reported for the period after the water surface returned to near pre-emplacement levels. A series of FEC and temperature logs were then conducted to identify changes in the fluid column associated with ambient flow. Ambient flow characterization is conducted to evaluate the presence of both vertical and horizontal ambient flow.

On May 14th, 2008, at 1818 hours (t = 0 minutes, elapsed time of test), dilution of the fluid column was complete. Minimal to no DI water was lost to the formation due to the slightly depressed head maintained during emplacement procedures. During the 15.5 hours following the emplacement of DI water, multiple logs were conducted. Of these logs, 8 are presented in Figure DW-2:2. The designation of each logging with the FEC tool is indicated in the figure legend by the time of logging (e.g., FEC1818 versus a subsequent logging at FEC1840), thus the progressing of curves to the right in this figure represents changes in FEC over the total logging period. The last four digits of each log ID correspond to the time at which that particular log was started. Only logs acquired during logging in the downward direction are presented as the design of the FEC/Temperature probe allows the most accurate data to be collected in the downward direction. The logs acquired in the upward logging direction are not representative of downhole conditions and are therefore omitted. These logs illustrate significant change at several intervals throughout the length of the borehole. These dramatic changes in the FEC profiles with respect to time are associated with ambient vertical flow occurring within the borehole.

Formation water migration as a result of downward vertical flow within the fluid column is indicated by the increase in FEC over time in Figure DW-2:2 beginning near the base of casing and at 31 feet. Numeric modeling of the reported field data suggests groundwater enters the wellbore at 19.5 to 19.6, 30.4 to 31.6, 38.2 to 41.8, and 44.9 to 51.4 feet at rates of 0.026, 0.297, 0.016 and 0.074 gpm, respectively. The combined inflow of 0.413 gpm of these four intervals is observed to migrate vertically downward through the borehole based on the migration of the center of mass of the area under the curve. The modeling suggests groundwater exits the borehole at depths of 96.4 to 97.0 and 189.5 to 191.0 feet, at rates of 0.370 and 0.185 gpm, respectively. Evidence for these outflow zones is observed in the logs presented in Figure DW-2:2. Where the velocity of the water slows within the borehole ("downstream" of an outflow zone) a change in slope, or truncation, of the FEC logs is observed. All flow rates are based on the rate of increase of mass at their respective intervals. Of particular note is the FEC anomaly observed at the base of the borehole at 280 feet. This early increase in mass is not the result of ambient flow. Notice the mass at this depth, or area under the curve, does not increase with time, but instead disperses. During removal of the plumbing at the conclusion of the emplacement groundwater was momentarily allowed to enter the borehole at this depth near the bottom of the borehole. Over the course of the Ambient Flow Characterization however, no additional groundwater entered the borehole at this depth. As such, this water-bearing interval is not considered to produce groundwater to the borehole under ambient conditions. Please refer to Table DW-2:1 and Summary:1 for a complete summary of the HydroPhysical™ logging results. Please refer to Appendix B for a discussion of the methodology and code used to calculate these values. The ambient depth to water at the time of testing was 4.31 ftbtoc.

1.3 Flow Characterization During 6 GPM Production Test: DW-2

Pumping of borehole fluids and simultaneous DI injection was conducted at one pumping rate to establish the inflow locations and evaluate the interval specific inflow rates. Pumping at a given rate was conducted until reasonably constant drawdown was observed. When constant drawdown was observed, DI injection was initiated at about 20% of the pumping rate and the extraction pumping rate was increased to maintain a constant total formation production rate (i.e. pumping rate prior to DI injection). These procedures were conducted at a differential rate of 6.35 gpm.

On May 15th, 2008, at 1148 hours (t = 0 minutes elapsed time of testing), development pumping was initiated at approximately 6 gpm. Prior to initiating pumping, the ambient depth to water was recorded at 4.54 ftbgs. All drawdown values are referenced to this ambient water level. Time dependent depth to water, totals and flow rate information were recorded digitally every second and are presented in Figure DW-2:3. Pumping was maintained at a time-averaged rate of 6.25 gpm until 1740 hours (t = 352 minutes, elapsed time of testing). During development pumping numerous FEC logs were acquired to monitor the development process and assist in identifying the depths of flow zones. Of these FEC logs, nine are presented in Figure DW-2:4A. The FEC logs acquired during development pumping illustrate the development process of the borehole fluids, with local inflow locations indicated by the depths at which FEC is observed to increase over time. DI water injection from the bottom of the wellbore was initiated at 1740 hours at a time-averaged rate of 1.3 gpm while the total extraction rate was increased to a time-averaged rate of 7.65 gpm, resulting in a total borehole formation time-averaged production rate of 6.35 gpm. These flow conditions were maintained until 2332 hours (t = 704 minutes) during which time a reasonably constant drawdown of approximately 5.40 feet was observed. The FEC logs acquired during dilution procedures are presented in Figure DW-2:4B, along with the last four development logs for comparison, and illustrate a reasonably stable condition of the fluid column with local inflow locations identified by spikes or incremental step increases in FEC. Eleven inflow zones were identified from these logs ranging in flow from 0.005 to 5.69 gpm with the dominant inflow zone at 30.4 to 31.6 feet, producing 5.69 gpm, or 90 percent of the total formation production rate. Please refer to Table DW-2:1 for a summary of HydroPhysical™ flow results and the depths of individual inflow zones.

1.4 Estimation of Interval Specific Transmissivity: DW-2

An estimation of transmissivity (T) can be made using an equation after Hvorslev (1951) assuming steady-state radial flow in an unconfined aquifer:

$$T = KL = \frac{q_i}{2\pi\Delta h_w} \ln\left(\frac{r_e}{r_w}\right)$$

where K is the hydraulic conductivity, q_i is the interval specific inflow rate calculated using HpL™ results, r_w is the borehole radius (0.26 ft), r_e is the effective pumping radius, Δh_w is the observed maximum drawdown (5.40 feet) and L is the thickness of the zone through which flow occurs. For our calculations, COLOG used r_e of 300 feet (assumed). By applying L and q_i from the HpL™ results under the two pressure conditions, the interval specific transmissivity can be calculated for each identified water producing interval. These calculations were made at each identified interval and are presented in Table DW-2:1. In summary, the interval 30.4 to 31.6 feet exhibited the highest transmissivity of approximately 216 ft^2/day.

2.0 Geophysical Logging

On May 8th through May 17th, 2008, downhole geophysical and hydrogeologic investigations were performed in boring DW-1. The geophysical and hydrogeologic logs performed were: optical televiewer (OBI), acoustic televiewer (ATV), 3-arm caliper, natural gamma, electric resistivity, EM induction conductivity, water chemistry (pH, ORP, DO), full waveform sonic, vertical seismic profile (VSP) and wireline straddle packer (WSP). The data for these logs are presented in the DW-2 Geophysical/HydroPhysical™ Summary Plots and Figures DW-2:5, 6, 7 and 8 and Table DW-2:2 for the statistical analysis of all fractures/features, Table DW-2:3 for a summary of the VSP velocities and Figures DW-2:9A through E and Table DW-2:4 for the WSP pressure data and permeability results at the end of this well report.

2.1 Optical Televiewer (OBI)/Acoustic Televiewer (ABI)

On May 8th, 2008 optical and acoustic televiewer logging was performed in DW-2 to a depth of 280.6 feet. The televiewers identified features at depths correlating well with the HpL™ and caliper data. The features observed by the OBI at water-bearing intervals identified from the HpL™ data had apparent aperture and in some cases evidence of staining. Two hundred twenty high-angle fractures or features (dip angles greater than 45 degrees) were identified in DW-2. Seventeen of these high-angle features are qualitatively ranked 2 or greater suggesting the potential for vertical hydraulic communication outside the influence of the borehole. Data acquired during WSP testing confirms the presence of vertical hydraulic communication between several water-bearing zones in the immediate vicinity of the borehole.

2.2 Three-Arm Caliper

On May 9th, 2008 three-arm caliper logging was performed in DW-2 to a depth of 284.2 feet. The caliper log indicates a relatively rugose borehole with eight notable inflections observed at approximately 31.3, 45.4, 96.5, 158.6, 170.7, 179.7, 190.9 and 244.0 feet. All but two of the inflections, or borehole enlargements, at 158.6 and 170.7 feet, observed in the caliper log correlate well with water-bearing zones and fractures identified by the hydrophysical and optical televiewer data. The caliper log registers an approximately nominal 6.4-inch diameter borehole below casing at 14.6 feet.

2.3 Natural Gamma

On May 10th, 2008 natural gamma logging was performed, in conjunction with the electric resistivity logging, in DW-1. The natural gamma measurement reached to a depth of 279.1 feet. The natural gamma is relatively featureless with minor fluctuations in gamma counts, expected in limestone. The natural gamma log registers an approximately nominal 27 to 62 counts per second.

2.4 Electric Resistivities (8, 16, 32, 64-inch Normal Resistivities, SP, SPR)

On May 11th, 2008 electric resistivity logging was performed, in conjunction with the natural gamma log, in DW-1 to a depth of 280.2 feet. The electric measurements consist of 8, 16, 32 and 64-inch "normal" resistivities, spontaneous potential (SP) and single-point resistance (SPR). The normal resistivities registered approximately 923 Ohm-meters (8-inch resistivity) to 2,480 Ohm-meters (64-inch resistivity). A notable anomaly in the electric resistivity is observed at approximately 31.6 to 161.3 feet where the electric resistivities uniformly register higher resistivities, indicative of pertinent limestone. Low resistivity anomalies are observed at 30 to 33 and 161 to 191 feet, indicative of a fractured environment under these conditions. The SP is relatively featureless registering a gradual increase in potential with depth, registering 44 to 358 milivolts below water level. The SPR measurement correlates well with the normal resistivities and also registers low-resistivity anomalies at 30 to 33 and 161 to 191 feet. The SPR registers 427 to 2,119 Ohms.

2.5 EM Induction Conductivity

On May 10th, 2008 EM induction conductivity logging was performed in DW-2 to a depth of 279.5 feet. The induction conductivity log is featureless with the exception of a minor anomaly at 255 feet. The induction conductivity registers a nominal 196 mS/meter above 255 feet and 149 mS/meter below 255 feet.

2.6 Water Chemistry (pH, ORP, DO)

On May 9th, 2008, pH, oxidation-reduction potential (ORP) and dissolved oxygen (DO) measurements were acquired under ambient conditions in DW-2 to a depth of 280.4 feet. The pH measurement is relatively featureless with the exception of an anomaly at 191 feet where the pH registers approximately 7.53 above 191 feet. Below 191 feet the pH log registers an approximately uniform 7.69. The ORP measurement indicates a gradual increase in oxidation potential with depth until 191 feet. The ORP measurement indicates approximately 135 mV near water surface and 247 mV at 191 feet. Below 191 feet the ORP log gradually decreases to TD, registering 185 mV at TD. The dissolved oxygen measurement registers a nominal 0.35 percent from water surface to 191 feet. Below 191 feet the DO measurement registers zero. It should be noted that no ambient flow is identified below 191 feet – a stagnant zone.

2.7 Full Waveform Sonic

On May 9th, 2008 full waveform sonic logging was performed in DW-2 to a depth of 277.2 feet. The sonic registered slower velocity anomalies at 29, 45, 67, 188 and 274 feet, correlating well with identified fractures and water-bearing zones observed in the optical televiewer, caliper and hydrophysical data. The sonic registered P-wave velocities ranged from 12,060 to 24,900 feet/second, correlating well with the velocities identified using vertical seismic profiling (VSP).

2.8 Vertical Seismic Profile (VSP)

On May 7th, 2008 a vertical seismic profile (VSP) was conducted in DW-2 to a depth of 200 feet. The VSP investigation in DW-2 identified three specific intervals of specific velocity at 25 to 30, 35 to 115 and 115 to 185 feet, registering 1,789, 10,255 and 17,274 feet/second (fps), respectively. However, due to the cement vault and backfill encasing the well casing and the presence of asphalt at the surface, the velocity reported here at 25 to 30 feet is suspect. Below 185 feet the P-wave energy was too little to report usable data.

2.9 Wireline Straddle Packer (WSP)

On May 16th and 17th, 2008 wireline straddle packer (WSP) testing was conducted in DW-2 at six intervals:

16.0 to 20.0 feet
28.5 to 32.5 feet
37.0 to 41.7 feet
94.5 to 98.5 feet
187.9 to 192.2 feet
265.4 to 284.0 feet (bottom of the borehole)

WSP testing was conducted to acquire a fracture-specific groundwater sample from each major water-bearing fracture identified during hydrophysical production testing. In addition to collecting a representative groundwater sample from each interval, development pumping was conducted at each interval and pressures above, below and in the interval of interest recorded to estimate fracture-specific permeability for each interval tested. Please see Tables WSP Summary and DW-1:4 for a complete summary of wireline straddle packer testing results.

Interval 16.0 to 20.0 feet – The WSP was utilized in its standard configuration, both packers inflated, and all pressure transducers measuring pressure in their respective zones of interest. During low-rate pumping for sampling the pump cavitated several times indicating the lack of significant yield from this interval. It is apparent from the WSP pumping that this interval cannot yield more than approximately 0.01 gpm. During pumping on this interval, no correlating response from either the upper or lower pressure transducer was observed, suggesting no vertical hydraulic communication exits outside the influence of the borehole between this interval and fracture/features in close proximity above and below this interval. The pumping rate of approximately 0.01 gpm during sampling was also used as the “stress test” pumping rate. Please see Figure DW-2:9A and Table DW-1:4 for a complete summary of the data acquired and results for this interval.

Interval 28.5 to 32.5 feet – The WSP was utilized in its standard configuration, both packers inflated, and all pressure transducers measuring pressure in their respective zones of interest. The data clearly indicates vertical hydraulic communication outside the influence of the borehole between water-bearing fractures in the interval of interest at 28.5 to 32.5 feet and the upper and lower intervals surrounding the interval of interest based on the correlating responses observed in the upper and lower pressure transducers. This is not unexpected based on the numerous fractures of approximately 30 to 50 degrees dip in and in the immediate vicinity of the interval of interest. Please see Figure DW-2:9B and Table DW-2:4 for a complete summary of the data acquired and results for this interval.

Interval 37.0 to 41.7 feet – The WSP was utilized in its standard configuration, both packers inflated, and all pressure transducers measuring pressure in their respective zones of interest. The data clearly indicates vertical hydraulic communication outside the influence of the borehole between water-bearing fractures in the interval of interest at 37.0 to 41.7 feet and the upper and lower intervals surrounding the interval of interest based on the correlating responses observed in the upper and lower pressure transducers. This is not unexpected based on the numerous fractures of approximately 30 to 50 degrees dip in and in the immediate vicinity of the interval of interest. Please see Figure DW-2:9C and Table DW-2:4 for a complete summary of the data acquired and results for this interval.

Interval 94.5 to 98.5 – The WSP was utilized in its standard configuration, both packers inflated, and all pressure transducers measuring pressure in their respective zones of interest. The data clearly indicates vertical hydraulic communication outside the influence of the borehole between water-bearing fractures in the interval of interest at 94.5 to 98.5 feet and the lower interval below this interval of interest based on the correlating response observed in the lower pressure transducers. No response is observed in the upper interval pressure transducer. This is not unexpected based on the identification of a downward pressure gradient and the fact this interval was identified as a thief zone (water exited the borehole at approximately 97 feet) during ambient testing. The presence of a pressure differential between this interval and the upper interval suggests little to no significant vertical hydraulic communication outside the influence of the borehole. The data does indicate a vertical hydraulic connection between the interval of interest and the lower zone however. During ambient testing the lower flow interval of 189.5 to 191.0 feet was also identified as an outflow zone (less significant pressure differential between 189.5 to 191.0 and this flow interval of 96.4 to 97.0 feet) and is likely the flow interval hydraulically interconnected with this WSP sample interval. Please see Figure DW-2:9D and Table DW-2:4 for a complete summary of the data acquired and results for this interval.

Interval 187.9 to 192.2 feet – The WSP was utilized in its standard configuration, both packers inflated, and all pressure transducers measuring pressure in their respective zones of interest. The data clearly indicates vertical hydraulic communication outside the influence of the borehole between water-bearing fractures in the interval of interest at 187.9 to 192.2 feet and the lower interval below this interval of interest based on the correlating response observed in the lower pressure transducers. No response is observed in the upper interval pressure transducer. This is not unexpected based on the identification of a downward pressure gradient and the fact this interval was identified as a thief zone (water was observed to exit the borehole at approximately 189.5 to 191.0 feet) during ambient testing. The presence of a pressure differential between this interval and the upper interval suggests little to no significant vertical hydraulic communication outside the influence of the borehole. The data does indicate a vertical hydraulic connection between the interval of interest and the lower zone however. Please see Figure DW-2:9E and Table DW-2:4 for a complete summary of the data acquired and results for this interval.

3.0 Data Summary

Processing and interpretation of the geophysical and HydroPhysical™ logs in DW-2 suggest the presence of eleven producing intervals for this borehole. Numerical modeling of the reported HydroPhysical™ field data was performed using computer programs FLOWCALC and/or BOREII. These analyses were performed to estimate the rate of inflow for each identified hydraulically conductive borehole interval during DI injection procedures. The results of these analyses are presented in Table DW-2:1. For code comparisons to field data please see Appendix D. In summary, the interval at 30.4 to 31.6 feet dominated flow during pumping, producing 5.69 gpm or 90 percent of the total flow. Six of the eleven identified producing intervals correlate well with water-bearing zones identified during ambient testing. The remaining five intervals were not actively flowing water during ambient testing.

During ambient testing, boring DW-2 exhibited a straight-forward downward flow regime. Four water-bearing intervals were identified to contribute groundwater to the wellbore during ambient testing, the dominant interval being 30.4 to 31.6 feet, contributing 0.297 gpm, or 72 percent of the aggregate 0.413 ambient inflow. Two water-bearing intervals are identified under ambient conditions to thieve water from the wellbore at 96.4 to 97.0 and 189.5 to 191.0 feet, taking 0.370 and 0.185 gpm, respectively, from the wellbore.

The optical and acoustic televiewers identified features at depths correlating well with the HpL™ and caliper data. The features observed by the OBI at water-bearing intervals identified from the HpL™ data had apparent aperture and in some cases evidence of staining. Two hundred twenty high-angle fractures or features (dip angles greater than 45 degrees) were identified in DW-2. Seventeen of these high-angle features are qualitatively ranked 2 or greater suggesting the potential for vertical hydraulic communication outside the influence of the borehole. Data acquired during WSP testing confirms the presence of vertical hydraulic communication between several water-bearing zones in the immediate vicinity of the borehole.

The eleven interval-specific transmissivity estimates calculated using the hydrophysical data in DW-2 ranged from 0.20 to 216 ft^2/day, with the interval at 30.4 to 31.6 feet registering the highest transmissivity. The ranges of transmissivities suggest that flow originates from secondary porosity consisting of large discrete fractures at the major inflow zones and minor fractures or features with less inter-connectiveness at the minor inflow zones.

The WSP sampling results identified contaminant concentrations in four of the six sampled intervals. The two contaminants that registered identifiable concentrations are cis-1,2-DCE and toluene. The sample interval 187.9 to 192.2 feet registered only cis-1,2-DCE at 0.23 µg/L. The sample intervals 16.0 to 20.0, 37.0 to 41.7 and 94.5 to 98.5 feet registered only toluene at 2.4, 4 and 5.5 µg/L, respectively. Please see Table WSP Summary in the Executive Summary for a complete summary of the sample results.

Fracture inter-connectiveness in the immediate vicinity of a wellbore can be inferred by the similarity, or lack there of, of parameters such as interval-specific transmissivity estimates and interval-specific FEC, along with the presence of high-angle fractures and pressure differentials within the borehole. Similar transmissivity and FEC estimates would suggest an inter-connected

network of fractures or aquifers in the immediate vicinity of the wellbore. High-angle fractures with aperture may provide a conduit for vertical communication. Moreover, although a pressure differential would seem to suggest the driving force for vertical communication is present, typically substantially vertically interconnected fractures or aquifers tend to pressure-equilibrate in the immediate vicinity of the wellbore. Thus, the presence of a pressure differential in a wellbore may suggest a lack of vertical communication between fractures or aquifers in the immediate vicinity of the borehole.

The data acquired in DW-2 exhibited dissimilar interval-specific transmissivity but similar FEC estimates. The televiewers identified high-angle fractures with aperture and the WSP registered pressure correlations above and below several tested intervals. Though a pressure differential was identified under ambient conditions, the WSP data support the suggestion that certain intervals are not hydraulically connected over the intervals in which the pressure differential under ambient conditions was observed in the borehole. The data suggest the fractures are moderately vertically inter-connected in the immediate vicinity of the wellbore, primarily in the upper intervals. Please see Table DW-2:1 for a summary of the HydroPhysical™ and geophysical logging results which includes the locations, flow rates and transmissivity and hydraulic conductivity estimates assessed by COLOG.

FIGURE DW-2:1. Ambient Temperature and Fluid Electrical Conductivity;Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2

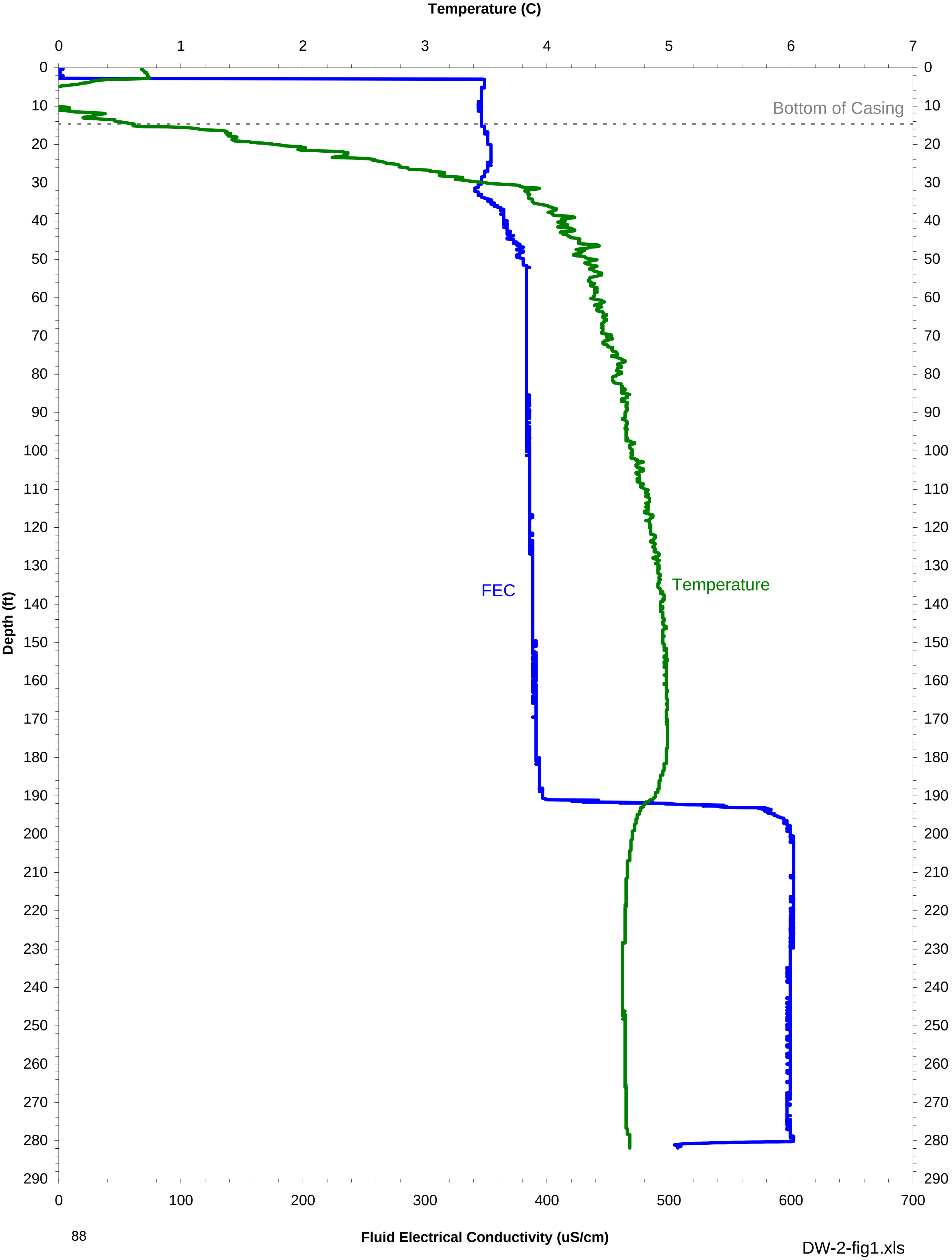


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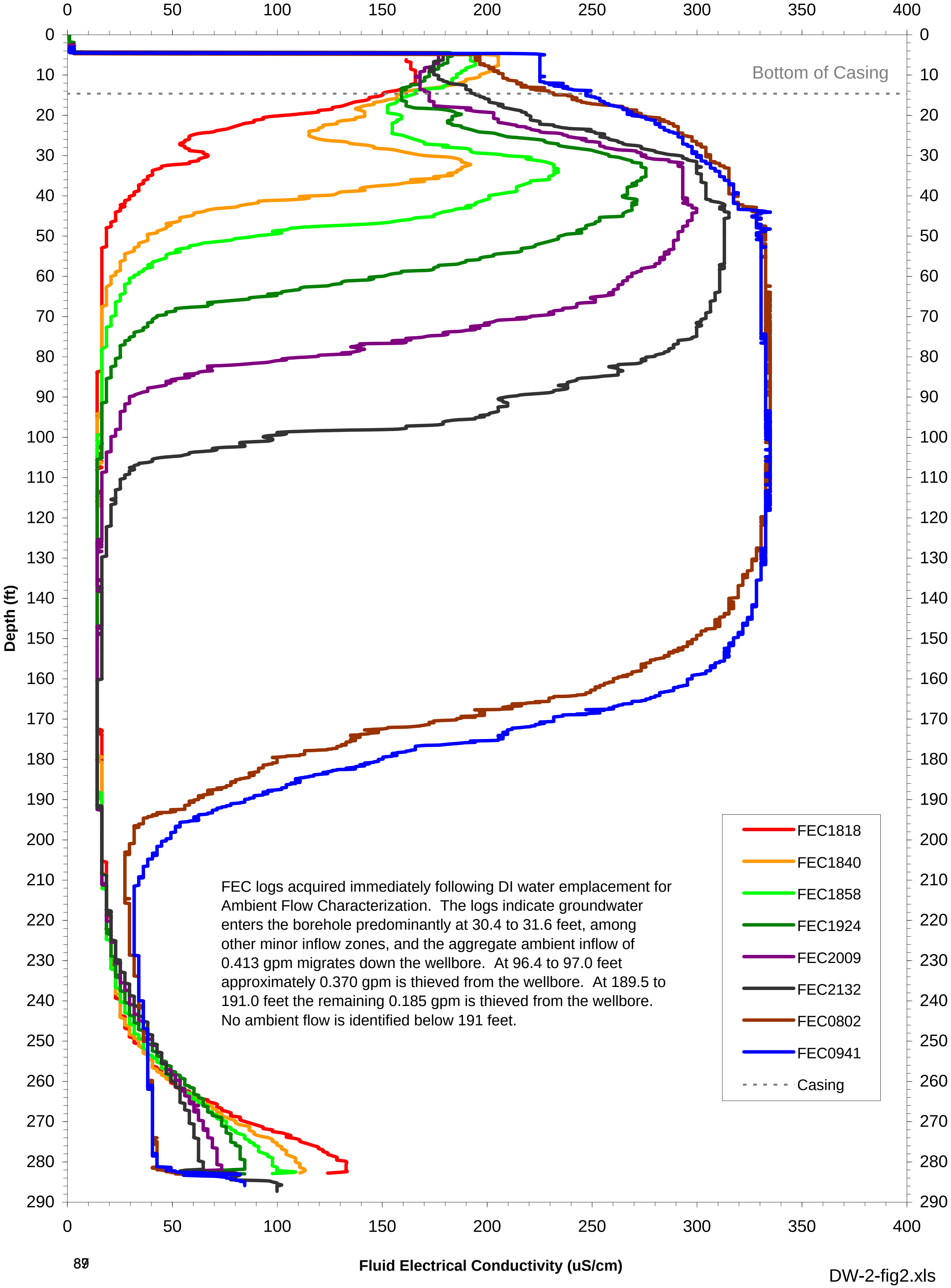
FIGURE DW-2:2. Summary of Hydrophysical Logs During Ambient Flow Characterization; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2



FEC logs acquired immediately following DI water emplacement for Ambient Flow Characterization. The logs indicate groundwater enters the borehole predominantly at 30.4 to 31.6 feet, among other minor inflow zones, and the aggregate ambient inflow of 0.413 gpm migrates down the wellbore. At 96.4 to 97.0 feet approximately 0.370 gpm is thieved from the wellbore. At 189.5 to 191.0 feet the remaining 0.185 gpm is thieved from the wellbore. No ambient flow is identified below 191 feet.

FIGURE DW-1:3. Pumping And Drawdown Data During 6 GPM Production Test; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-1

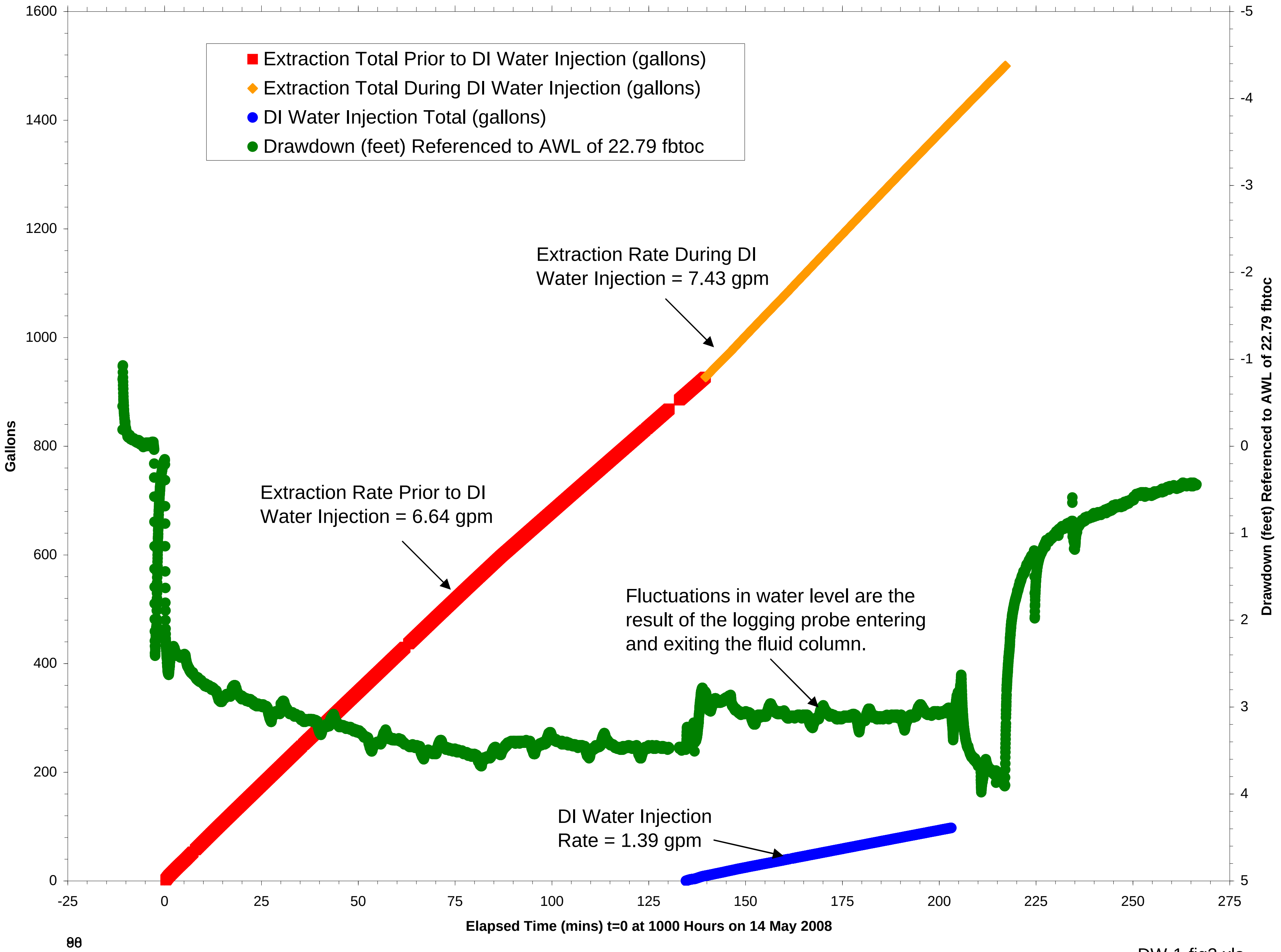


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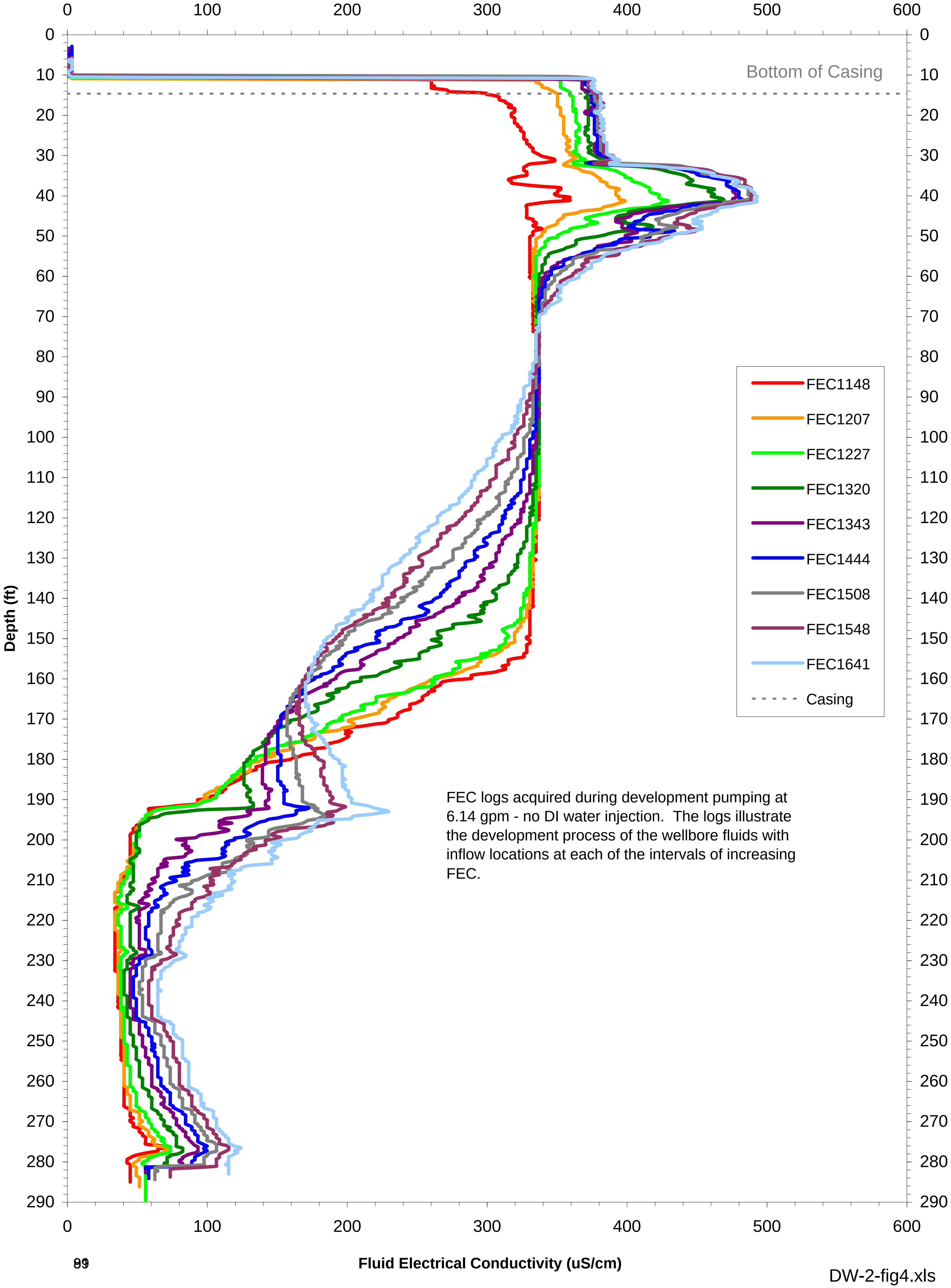
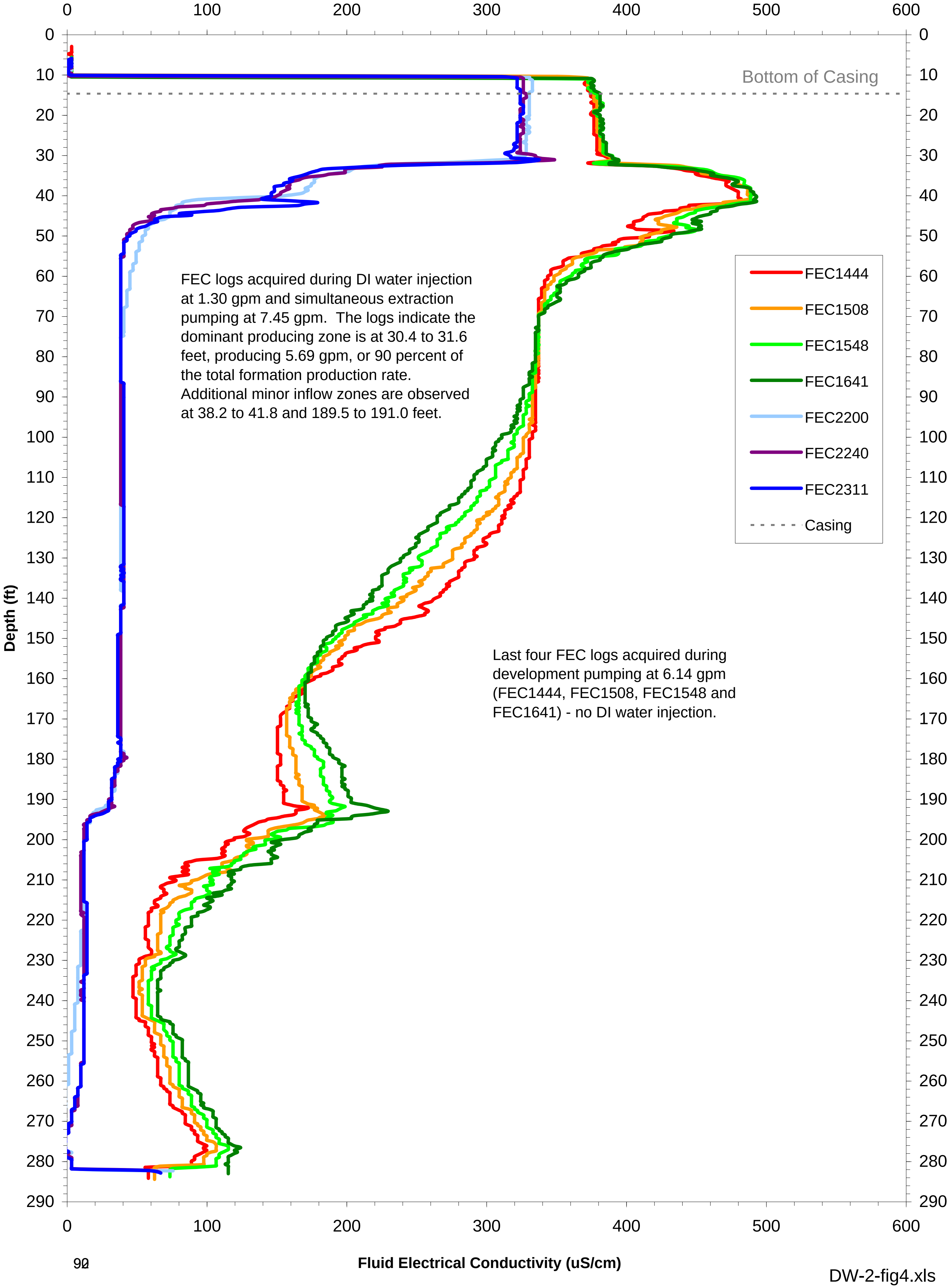
FIGURE DW-2:4A. Summary of Hydrophysical Logs During Development Pumping at 6 GPM; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2



FEC logs acquired during development pumping at 6.14 gpm - no DI water injection. The logs illustrate the development process of the wellbore fluids with inflow locations at each of the intervals of increasing FEC.

DW-2-fig4.xls

FIGURE DW-2:4B. Summary of Hydrophysical Logs During 6 GPM Hydrophysical Production Test; Weston Solution; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2



FEC logs acquired during DI water injection at 1.30 gpm and simultaneous extraction pumping at 7.45 gpm. The logs indicate the dominant producing zone is at 30.4 to 31.6 feet, producing 5.69 gpm, or 90 percent of the total formation production rate. Additional minor inflow zones are observed at 38.2 to 41.8 and 189.5 to 191.0 feet.

Last four FEC logs acquired during development pumping at 6.14 gpm (FEC1444, FEC1508, FEC1548 and FEC1641) - no DI water injection.

Table DW-2:1. Summary Of HydroPhysical™ Logging Results With Hydraulic Conductivity And Transmissivity Estimations; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2

Well Name	DW-2
Ambient Depth to Water (ftbtoc)	4.54
Diameter of Borehole (ft)	0.52
Maximum Drawdown (ft)	5.40
Effective Radius (ft)	300

Interval No.	Top of Interval (ft)	Bottom of Interval (ft)	Length of Interval (ft)	Ambient Flow[1] (gpm)	Darcy Velocity in Aquifer[2] (Specific Discharge) (ft/day)	Interval Specific Flow Rate During Pumping (gpm)	Delta Flow[3] (gpm)	Delta Flow (ft^3/min.)	Interval Specific Hydraulic Conductivity[4] (ft/day)	Transmissivity (ft2/day)	Interval Specific Fluid Electrical Conductivity (microS/cm)
1	19.5	19.6	0.1	0.026	NA	0.10	0.074	0.010	3.68E+01	2.95E+00	321
2	30.4	31.6	1.2	0.297	NA	5.69	5.393	0.721	1.80E+02	2.16E+02	378
3	38.2	41.8	3.6	0.016	NA	0.374	0.358	0.048	3.98E+00	1.43E+01	528
4	44.9	51.4	6.5	0.074	NA	0.081	0.007	0.001	4.33E-02	2.82E-01	512
5	96.4	97.0	0.6	-0.370	NA	0.000	0.370	0.049	2.47E+01	1.48E+01	NA
6	143.3	144.3	1.0	0.000	NA	0.008	0.008	0.001	3.20E-01	3.20E-01	432
7	179.2	183.0	3.8	0.000	NA	0.015	0.015	0.002	1.58E-01	6.00E-01	431
8	189.5	191.0	1.5	-0.185	NA	0.051	0.236	0.032	6.30E+00	9.45E+00	429
9	191.4	218.3	26.9	0.000	NA	0.008	0.008	0.001	1.19E-02	3.20E-01	429
10	227.4	228.2	0.8	0.000	NA	0.005	0.005	0.001	2.50E-01	2.00E-01	597
11	243.7	279.2	35.5	0.000	NA	0.024	0.024	0.003	2.71E-02	9.61E-01	597

[1] Downward vertical flow is identified in this borehole under ambient conditions.

[2] Darcy Velocity is calculated using the observed volumetric flow rate, the cross-sectional area of the flow interval in the wellbore and a wellbore convergence factor of 2.5 (Drost, 1968). The Darcy Velocity is only applicable to ambient horizontal flow

[3] Delta Flow is the difference between Interval-Specific Flow Rate (during pumping) and Ambient Flow Rate.

[4] Hydraulic conductivity and transmissivity estimates are based on single well drawdown data, a porus-medium equivilent model and Hvorslev's 1951 porosity equatior

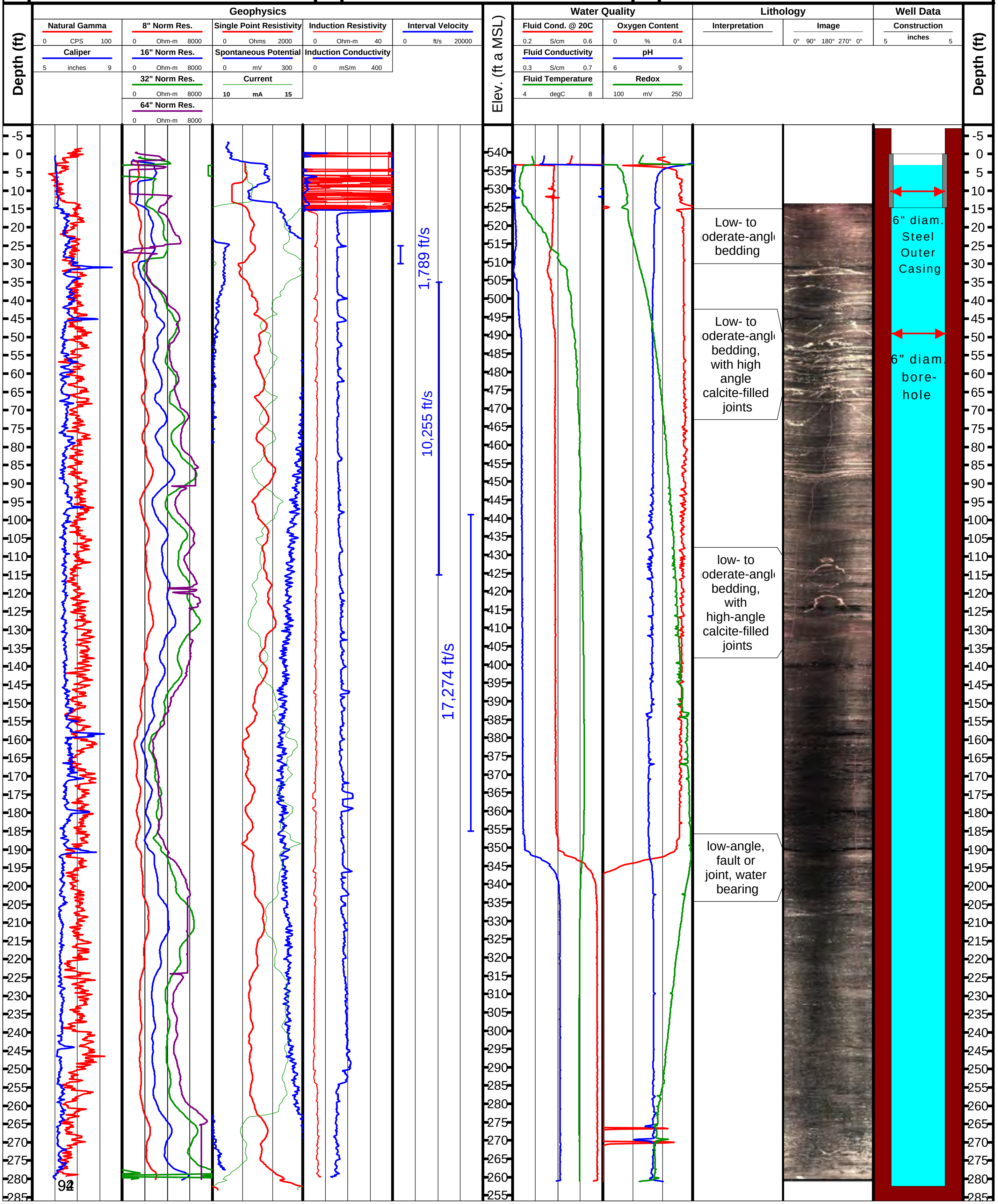
NA - Not Applicable

Project: LO-58	**Well ID:** DW-02 (VFW Well)	**Date Logged:** 8-15 May 08
Location: Aroostook County, Caribou, ME	**Log Ref.:** Top Steel Casing	**Hole Diameter:** 6" nom. to TD
Depth Logger: 283 ft	**Log Ref. Elev.:** ~539.5 ft above MSL	**Csg Size/Type:** 6" Steel
Depth Driller: No Data	**Recorded by:** G. Bauer	**Witnessed by:** J. Schmidl

LOGS & TOOLS: See Individual Logs

COMMENTS:
Ground Elevation: ~546.5 ft. aMSL.
Natural Gamma log includes K, U, and Th.
Water Quality logs performed under ambient conditions.
Ambient Water Level about 2.9 ft (9.9 ft bgs).
Logs relative to Truth North (mag dec = 20W)

COMMENTS:
All depths here referenced to top steel casing unless noted otherwise.
Measured casing stick down below ground surface: 7.0 ft.
Steel outer casing total depth 14.6 ft, estimated from image log.



Project: LO-58	**Well ID:** DW-02 (VFW Well)	**Date Logged:** 8-15 May 08
Location: Aroostook County, Caribou, ME	**Log Ref.:** Top Steel Casing	**Hole Diameter:** 6" nom. to TD
Depth Logger: 283 ft	**Log Ref. Elev.:** ~539.5 ft above MSL	**Csg Size/Type:** 6" Steel
Depth Driller: No Data	**Recorded by:** G. Bauer	**Witnessed by:** J. Schmidl

LEGEND

Tadpoles at depth of planar structure, pointing towards strike, and centered on dip. Projections corresponding to each tadpole shown in adjacent column.

Structure Tadpoles

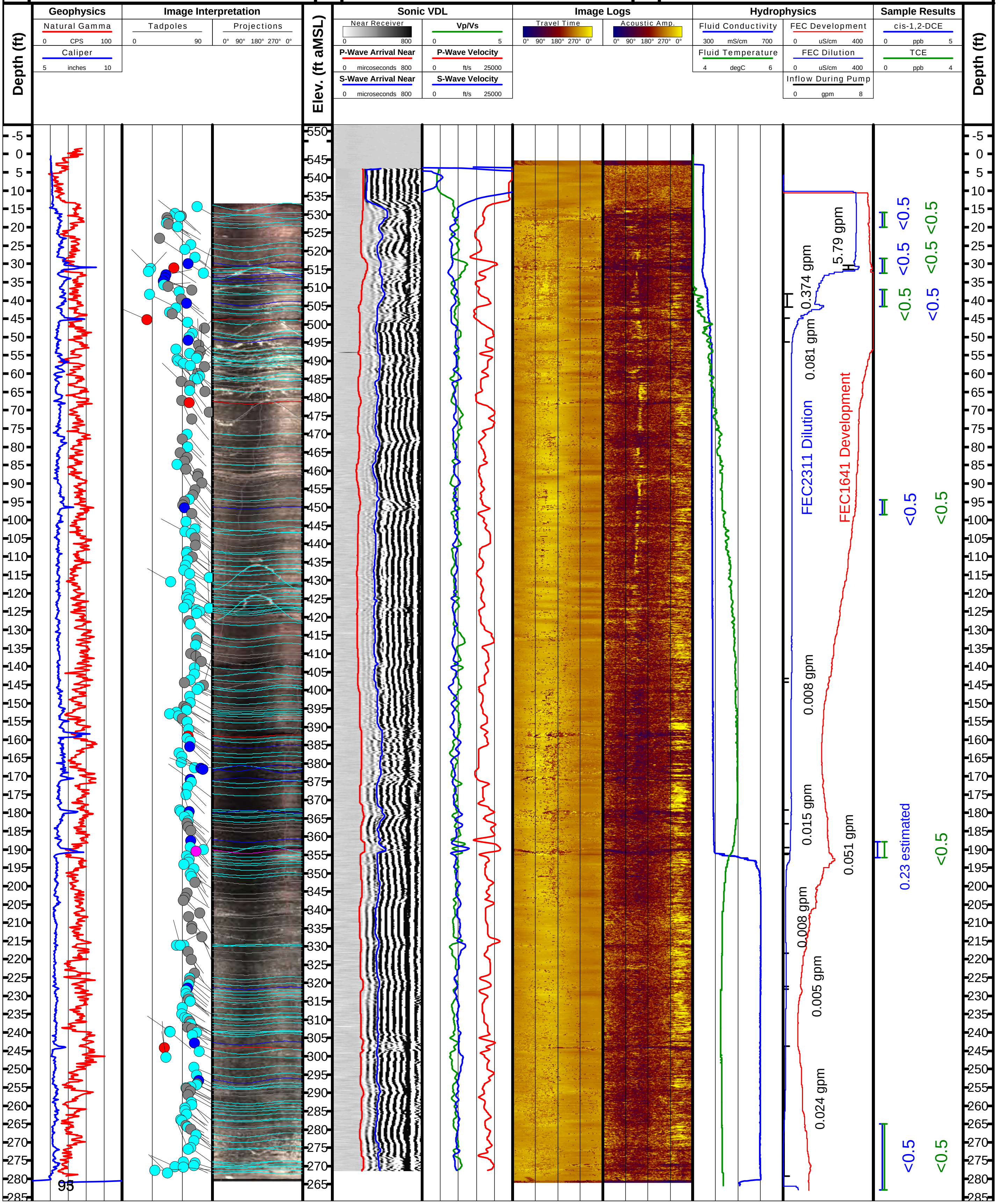
🟢 Washout/Wide Fracture Zone	🟣 Wide Fracture/Multiple Fractures
🔴 Open Fracture	🔵 Complete Fracture
⚫ Healed Fracture/Bedding Plane	● Partial Fracture

COMMENTS

Ground Elevation: ~546.5 ft. aMSL.
Natural Gamma log includes K, U, and Th.
Water Quality logs performed under ambient conditions.
Ambient Water Level about 2.9 ft (9.9 ft bgs).
Logs relative to Truth North (mag dec = 20W)

COMMENTS

All depths here referenced to top steel casing unless noted otherwise.
Measured casing stick down below ground surface: 7.0 ft.
Steel outer casing total depth 14.6 ft, estimated from image log.



Optical Televiewer Image Plot - True North

COMPANY: Weston Solutions
PROJECT: LO-58
DATE LOGGED: 8 May 2008
WELL: DW-2

COLOG Main Office
810 Quail Street, Suite E, Lakewood, CO 80215
Phone: (303) 279-0171, Fax: (303) 278-0135
www.colog.com

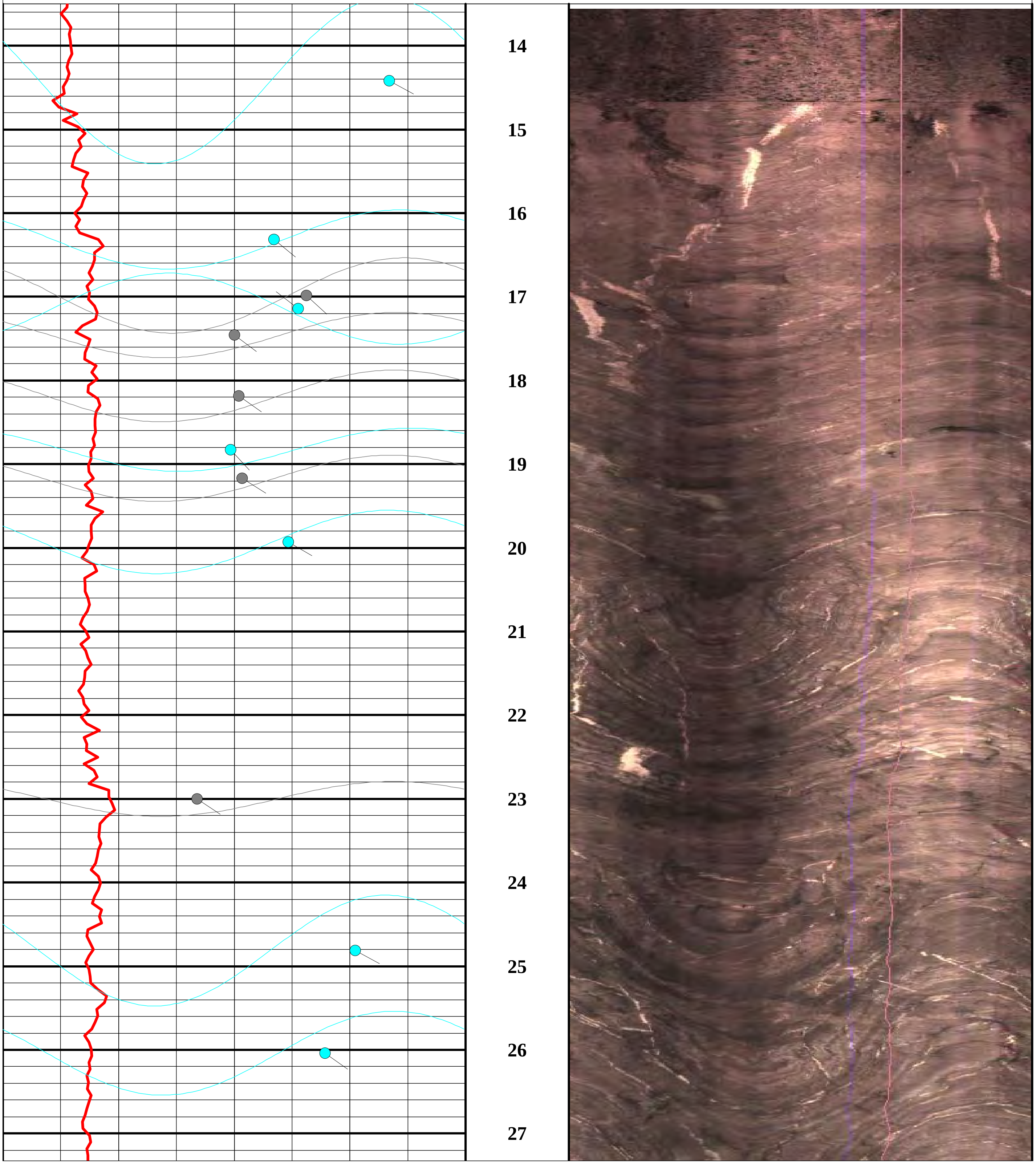
3-Arm Caliper
5 inches 13

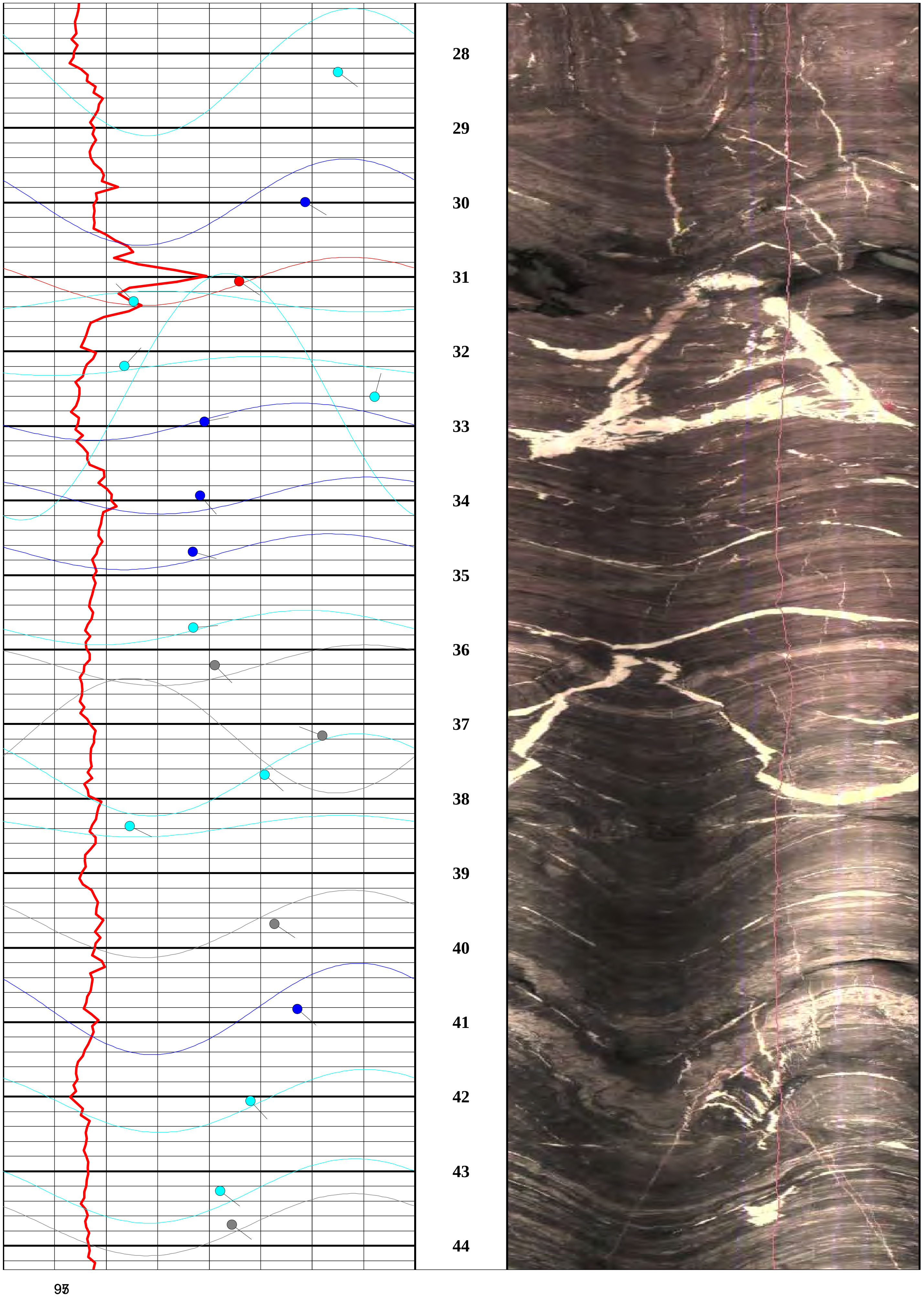
Projections
0° 90° 180° 270° 0°

Tadpoles
0 90

Depth
1ft:20ft

Optical Televiewer Image
0° 90° 180° 270° 0°

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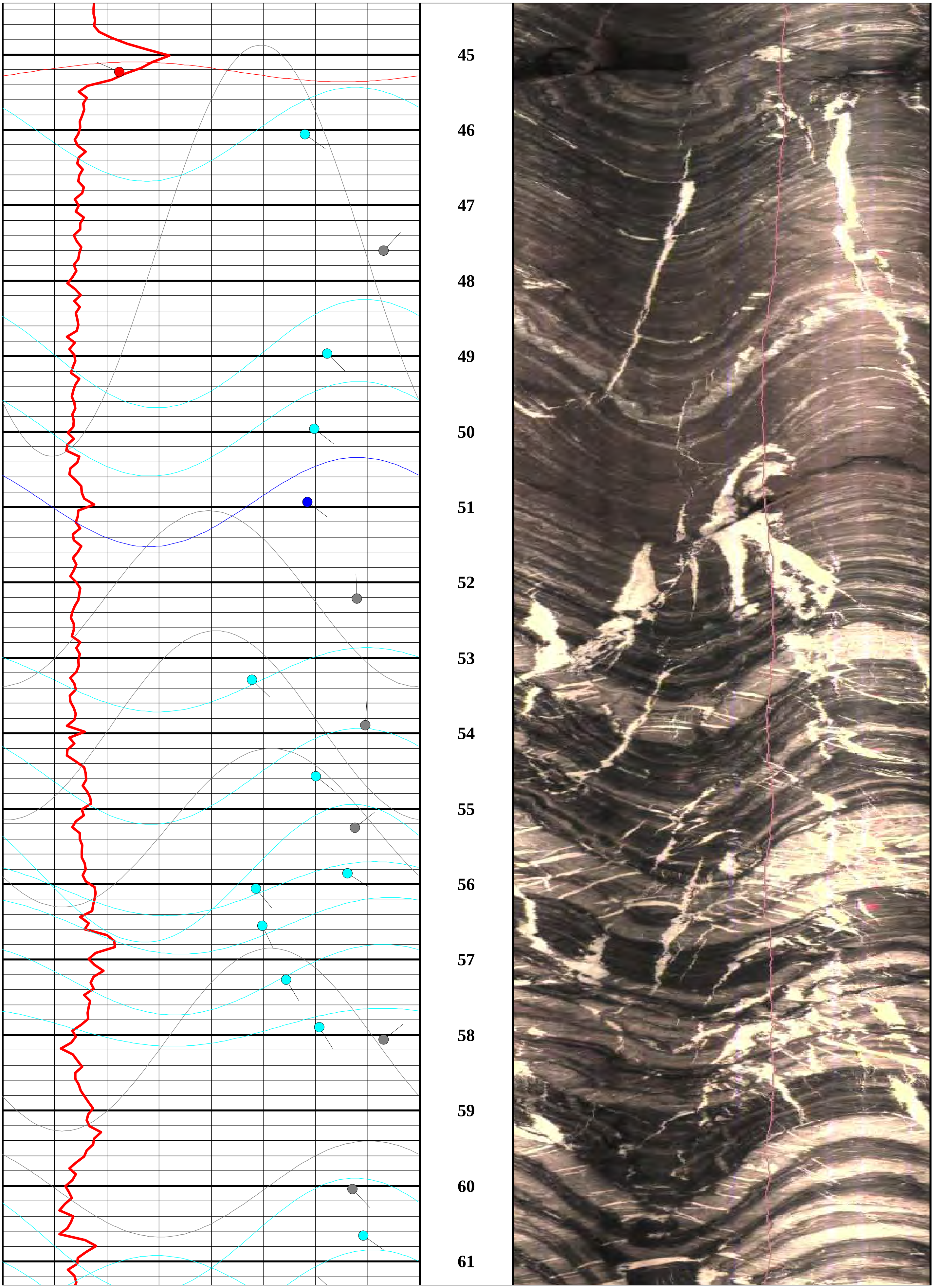
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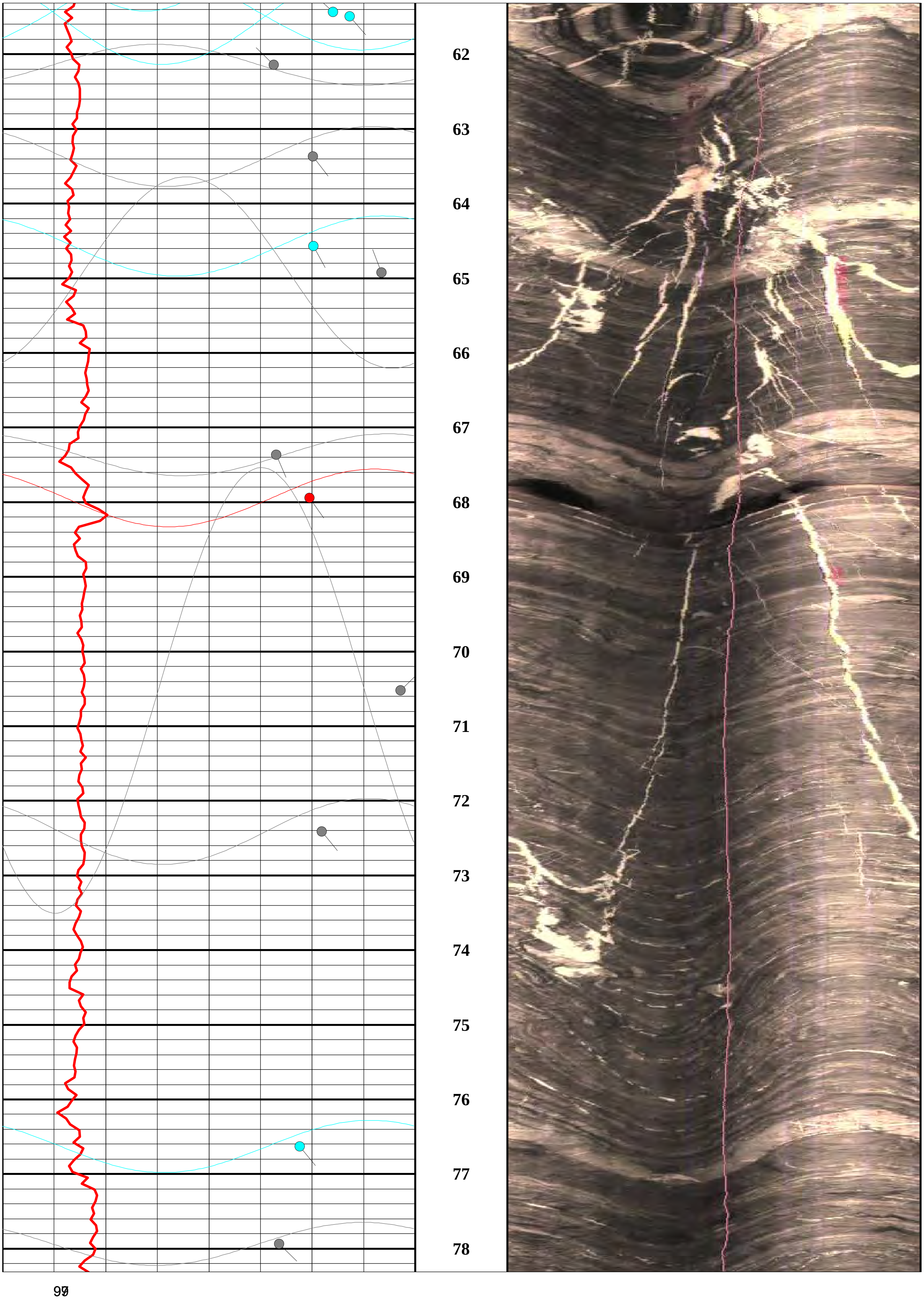
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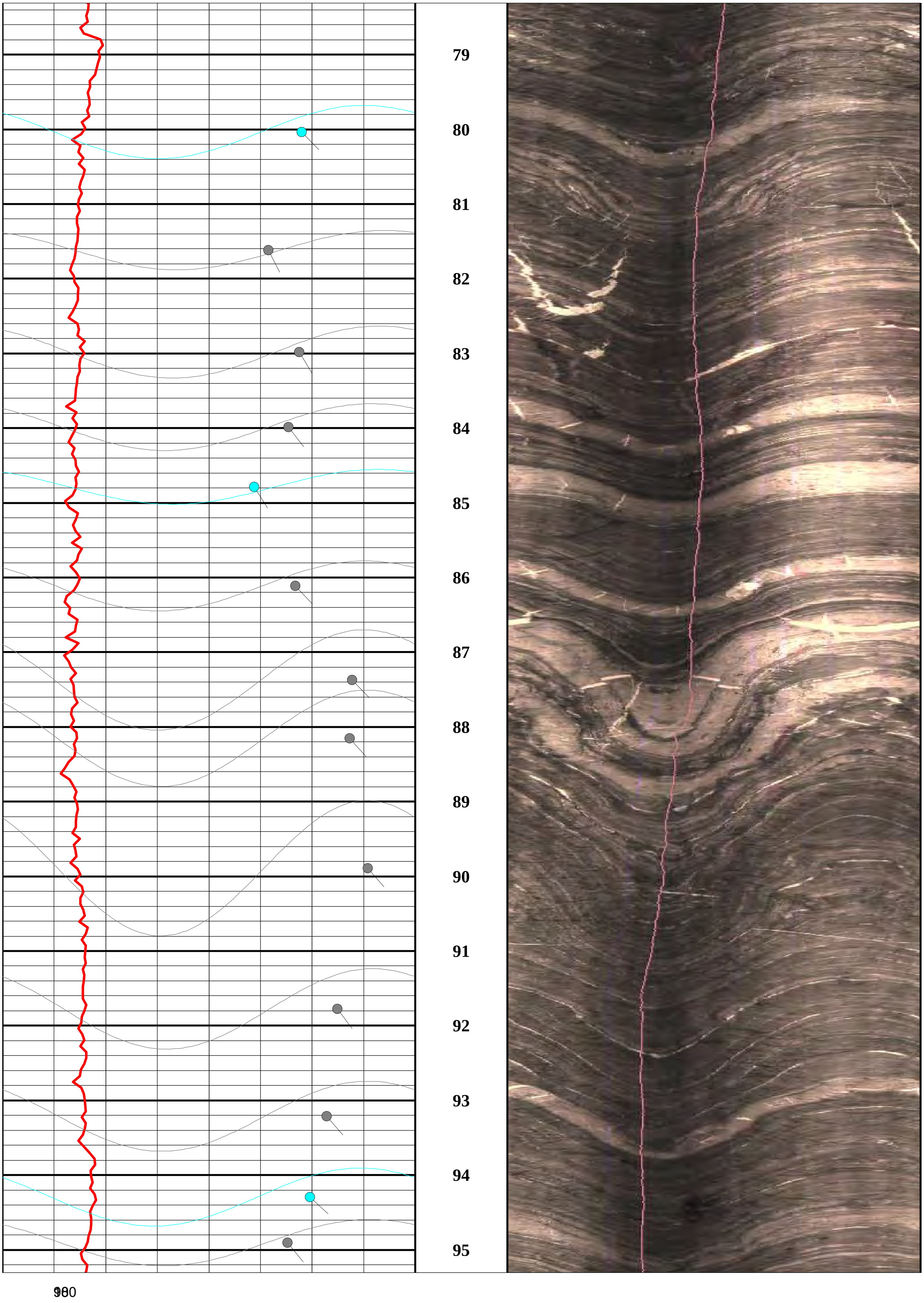
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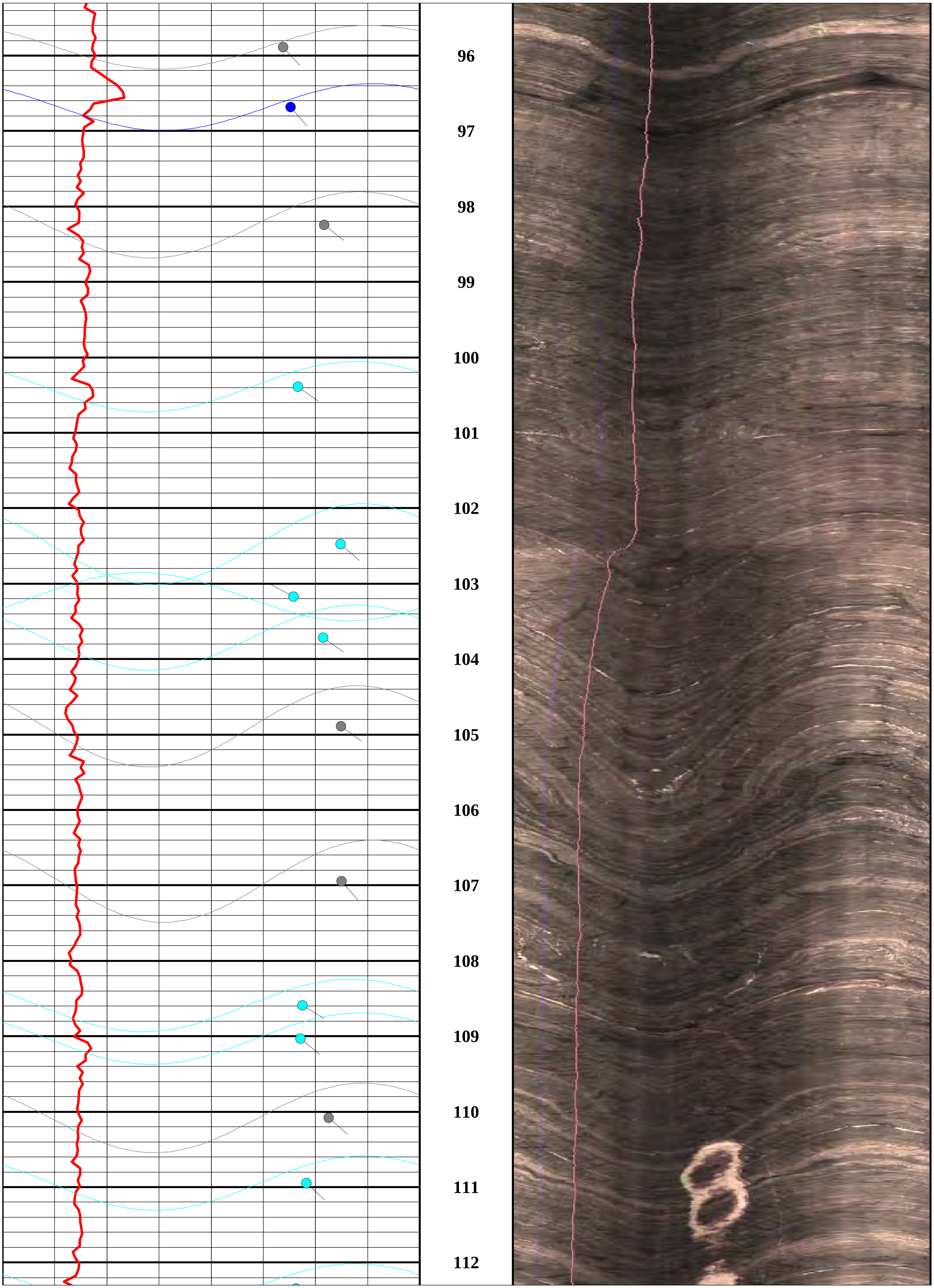

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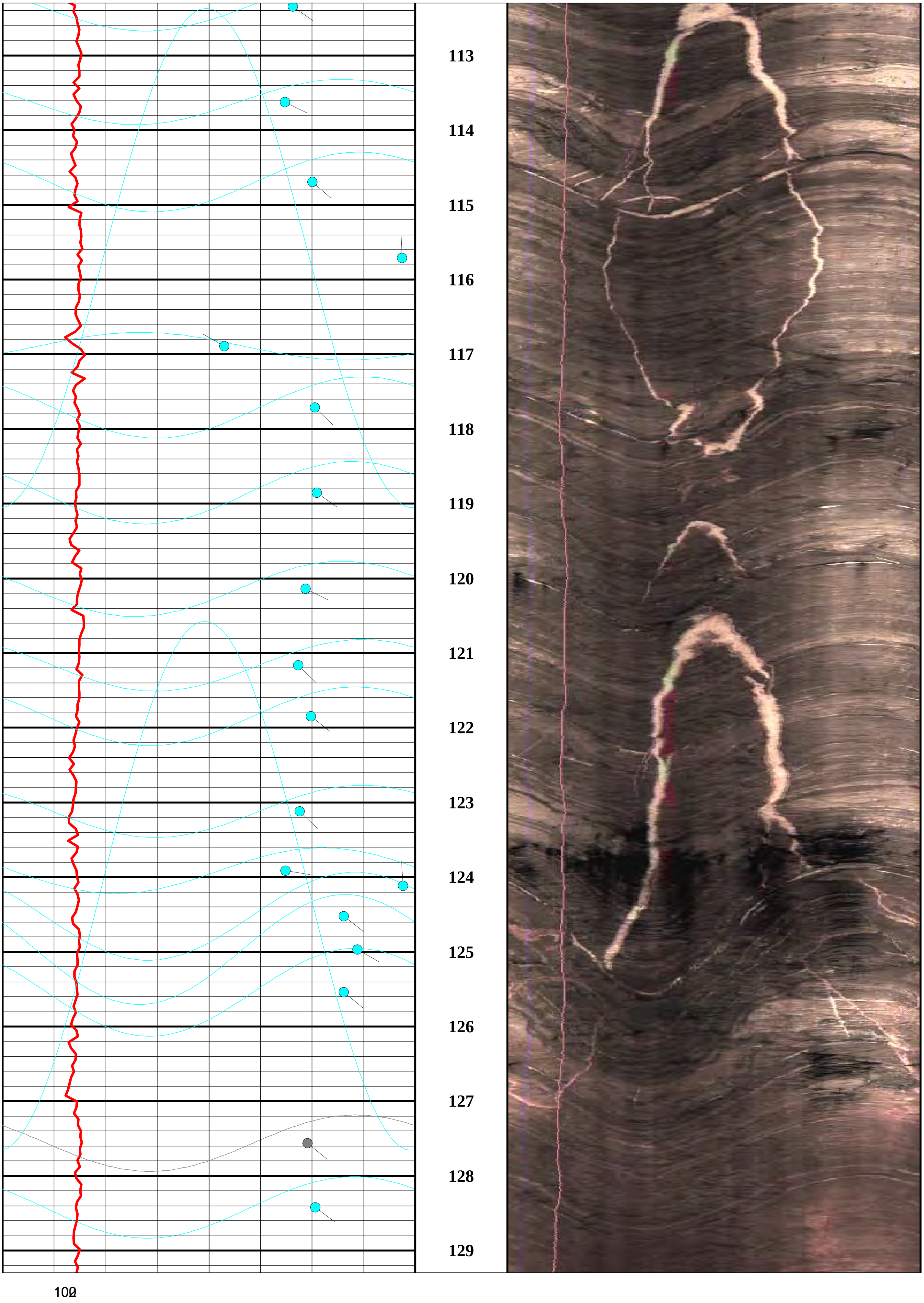
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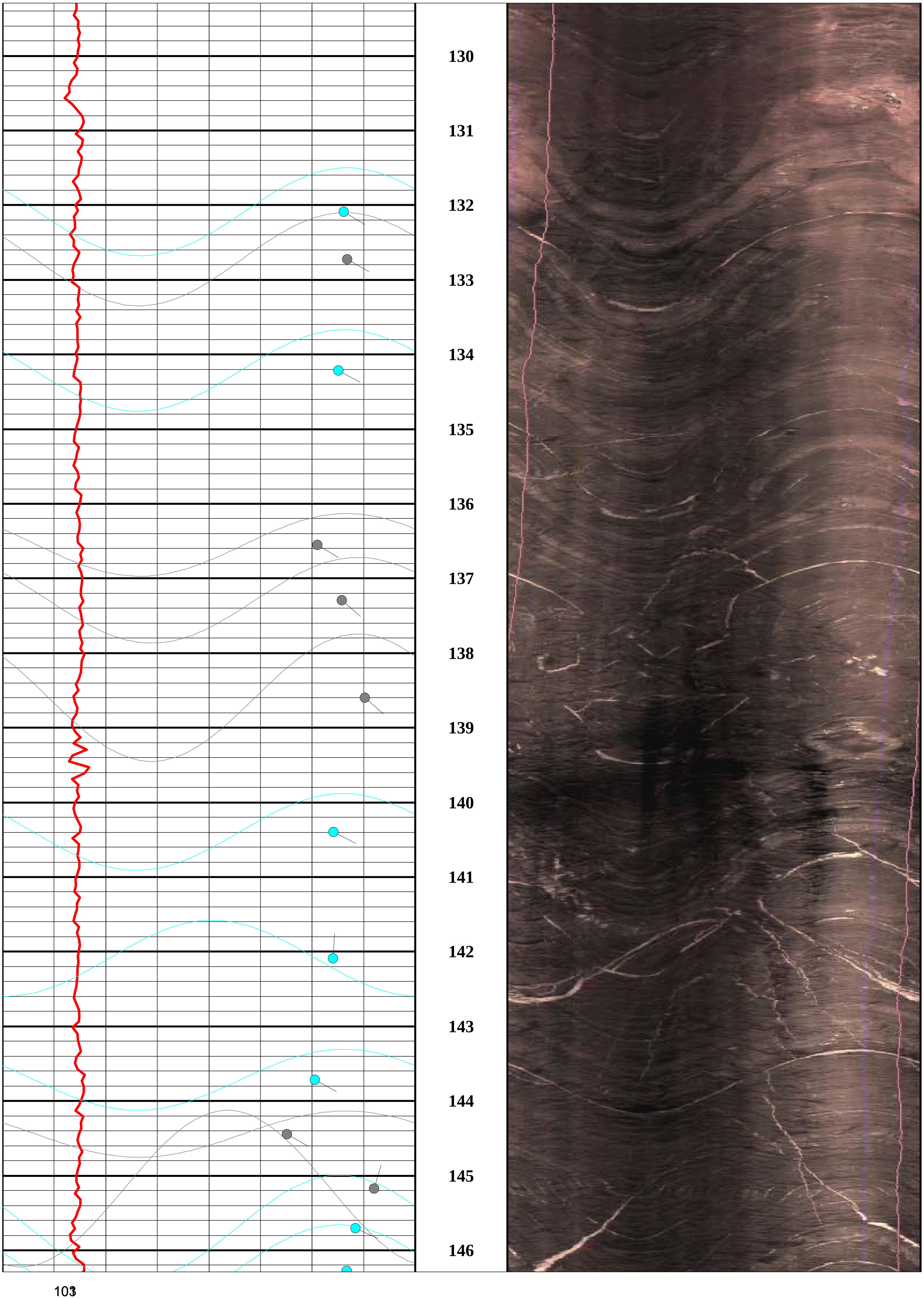
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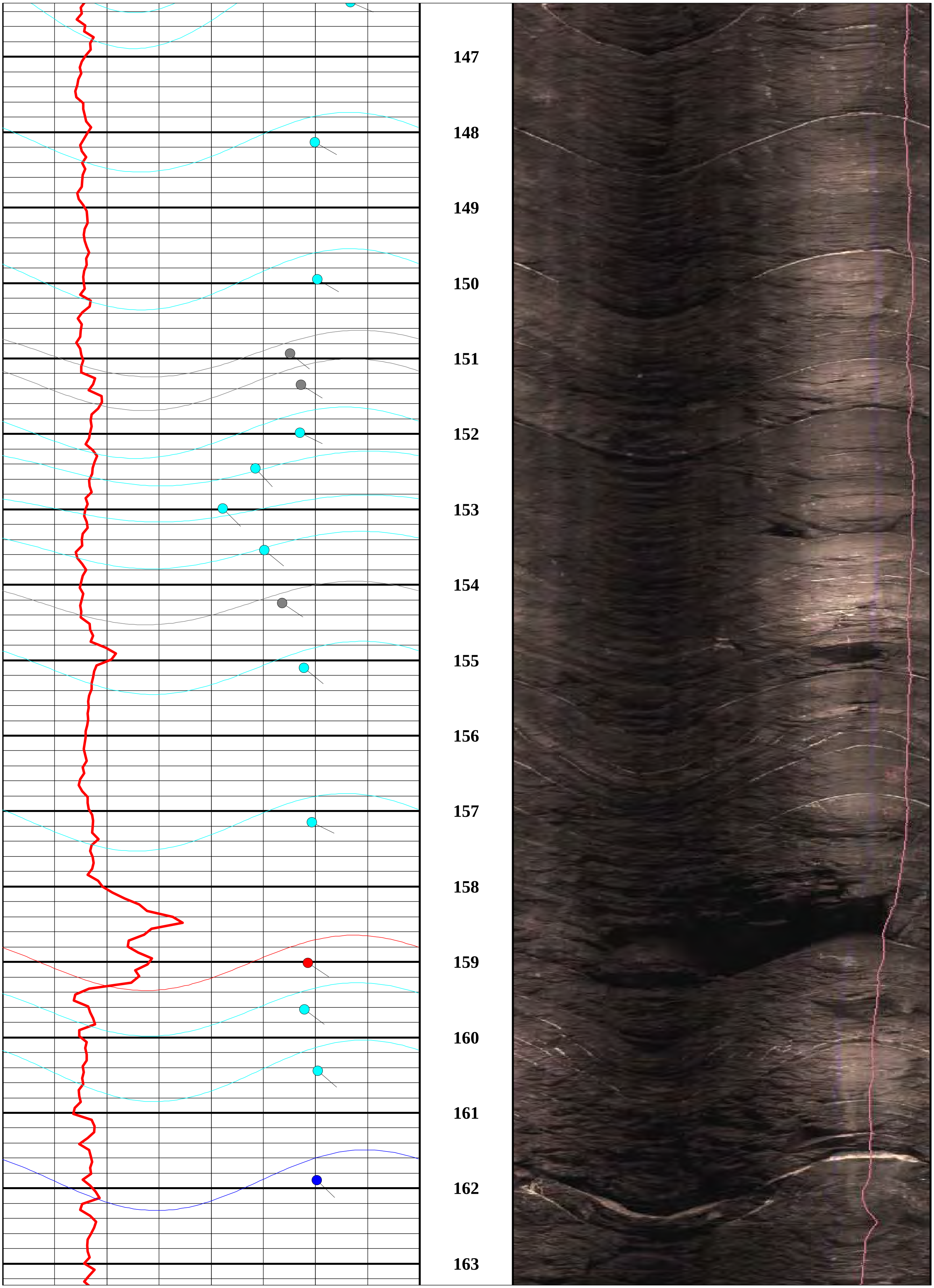
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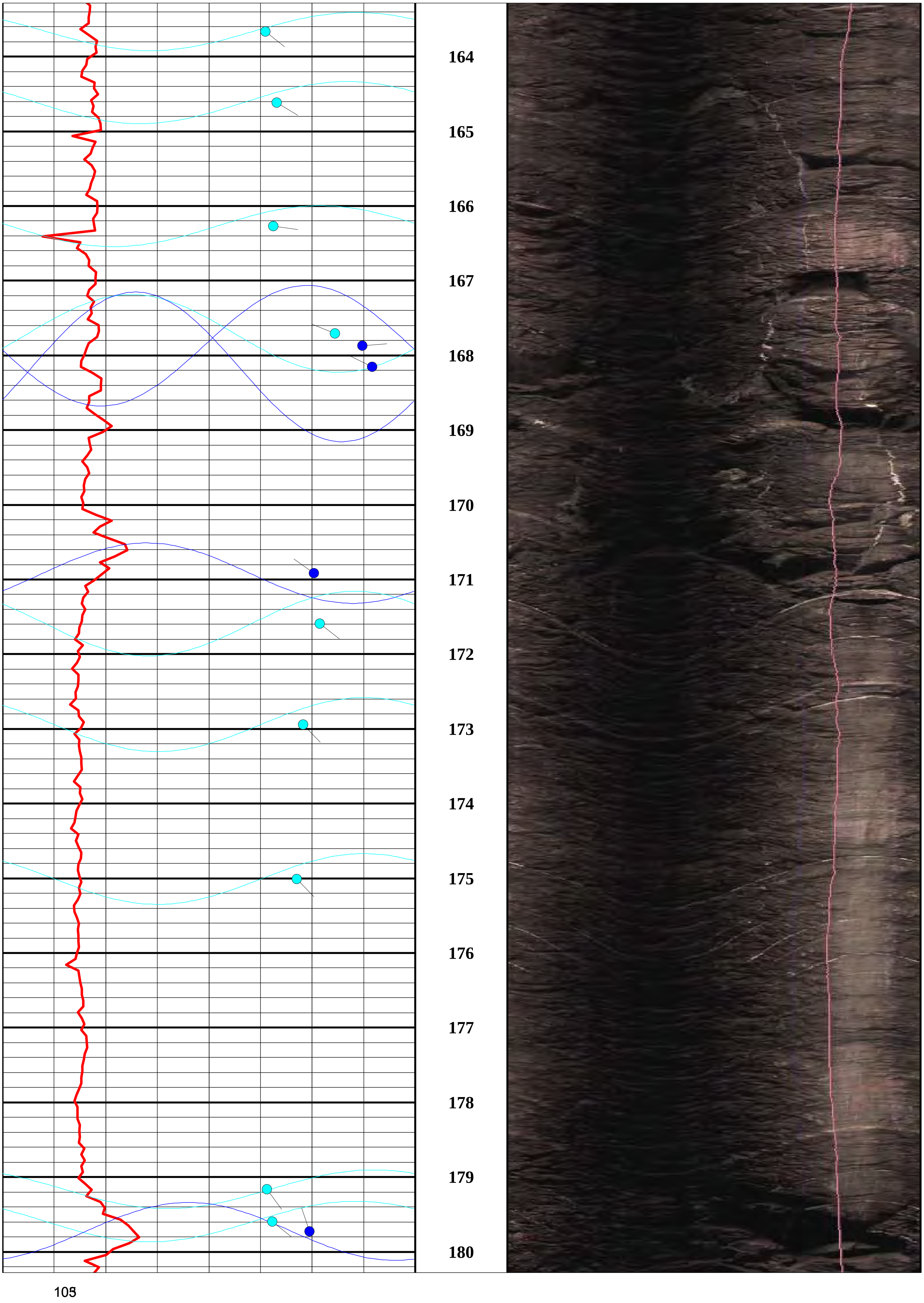
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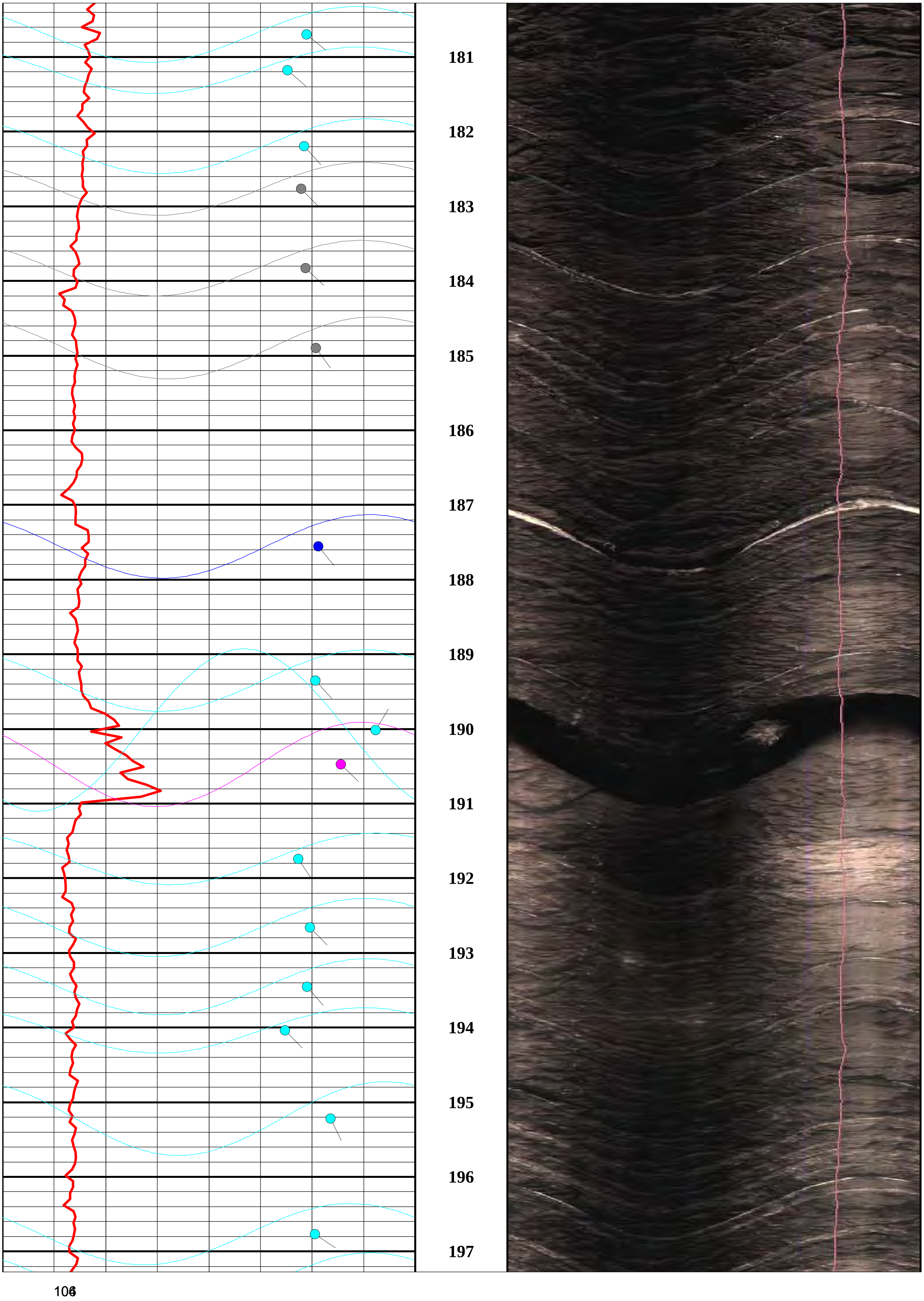
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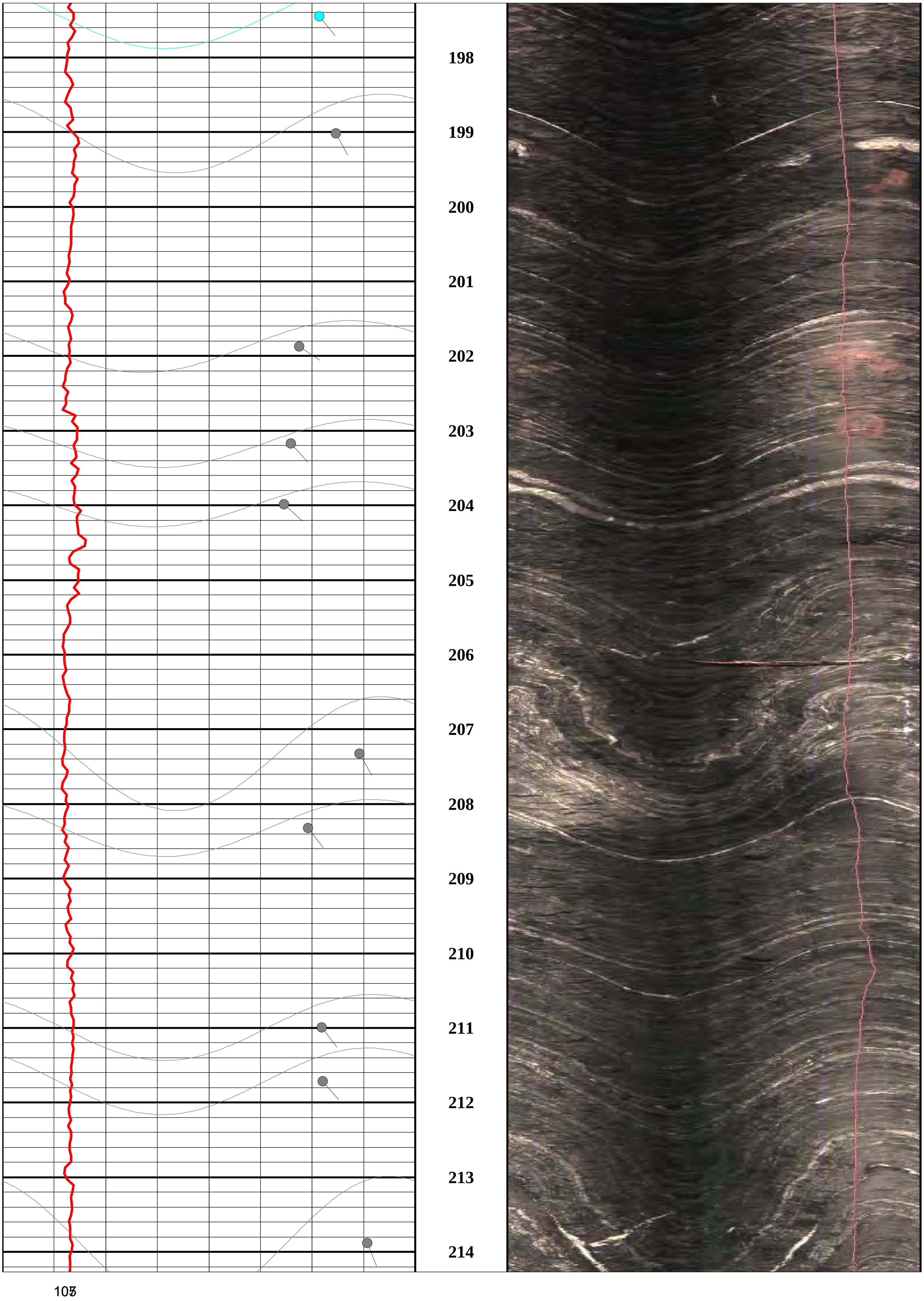
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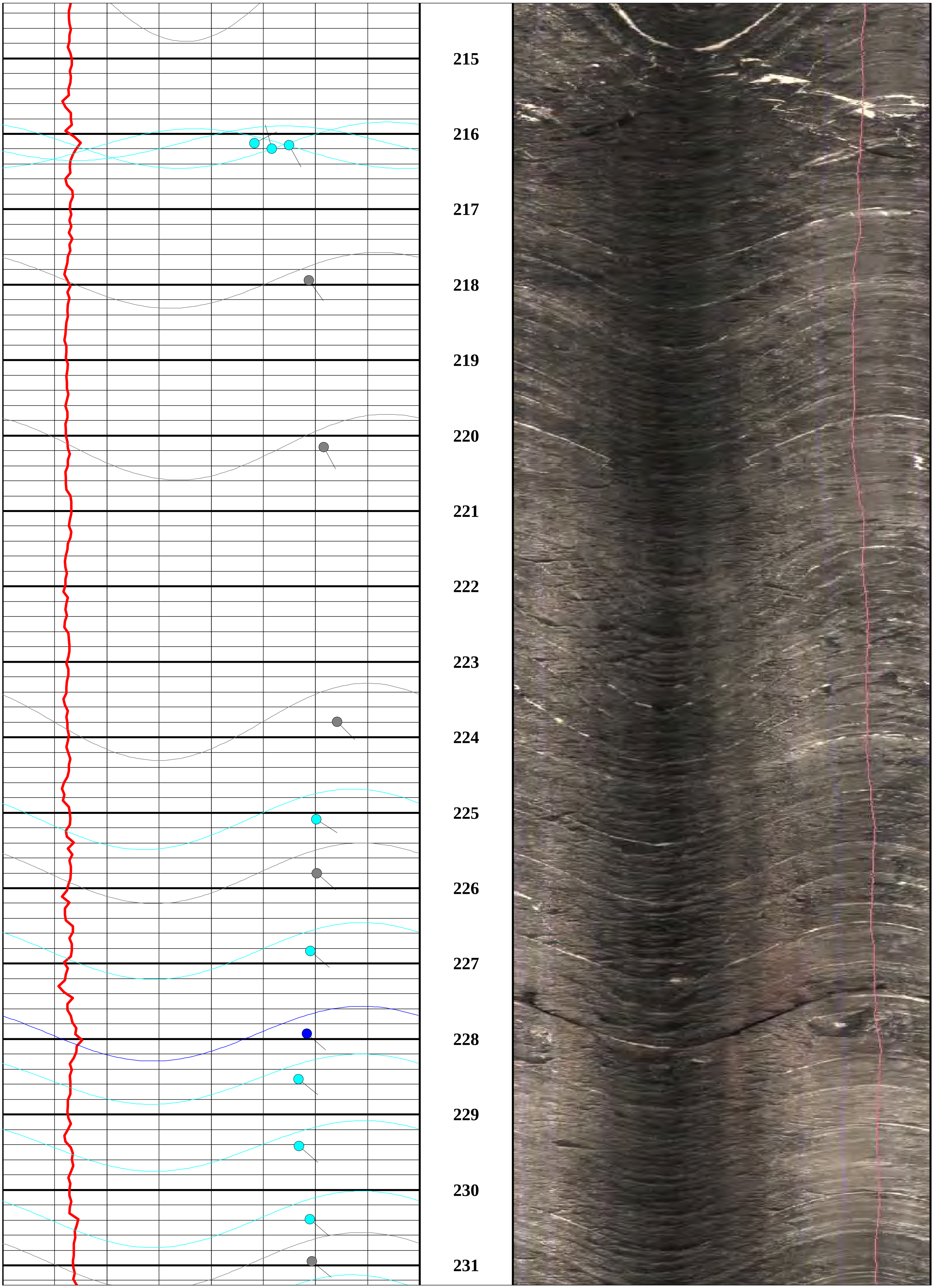
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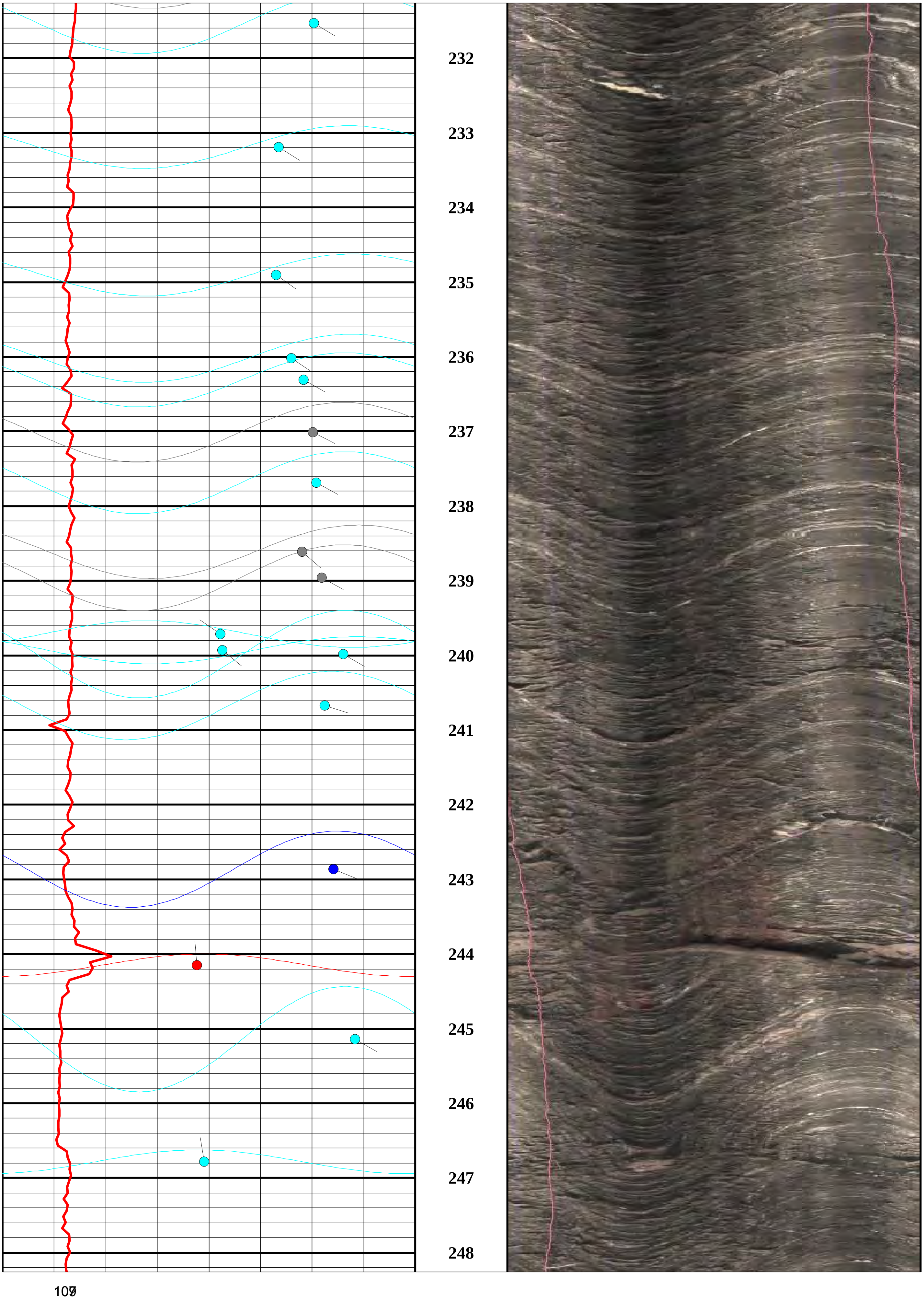
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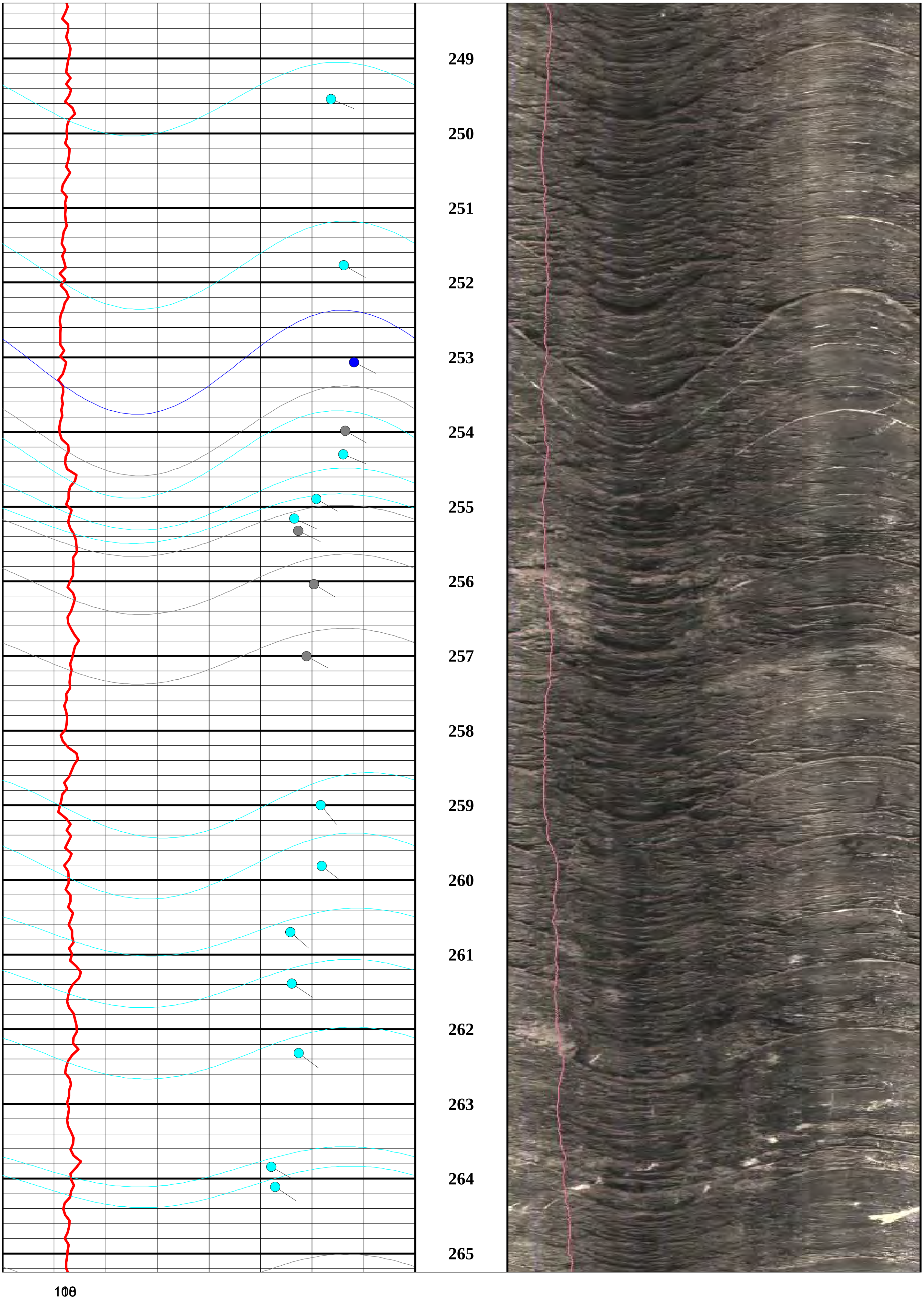
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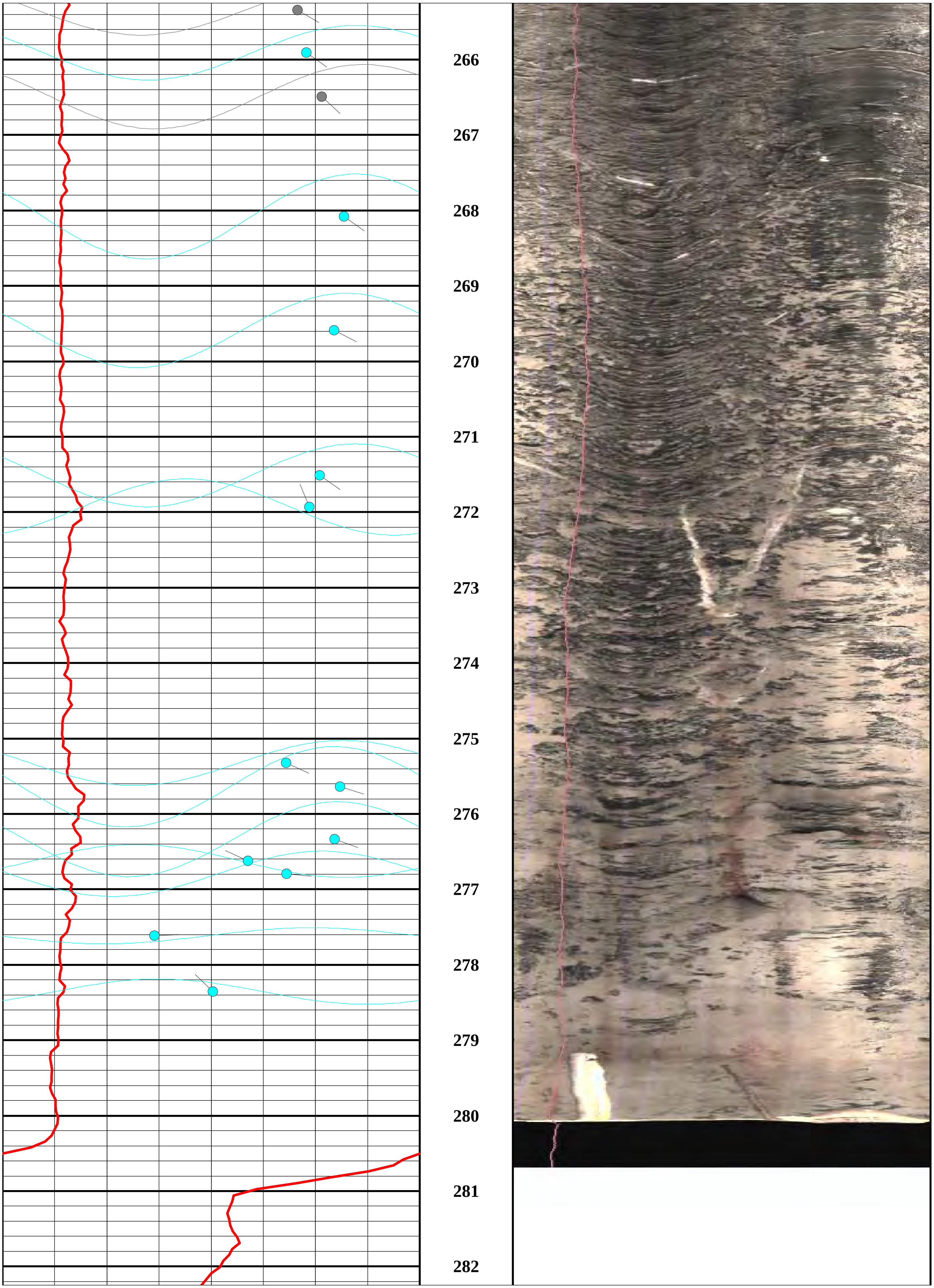
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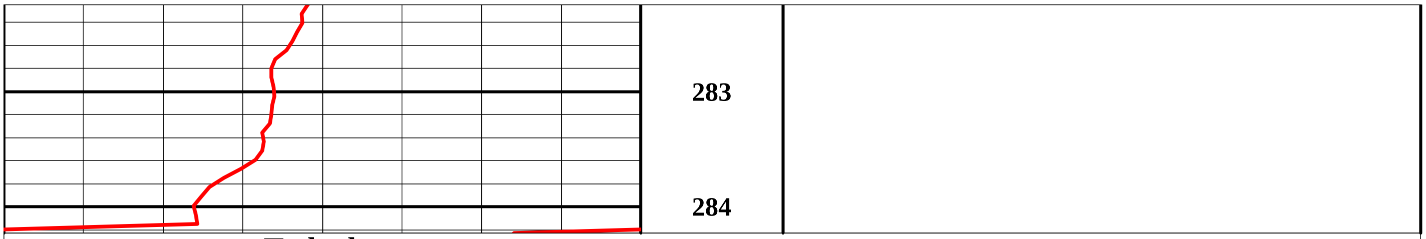


Tadpoles

0 90

Projections

0° 90° 180° 270° 0°

3-Arm Caliper

5 inches 13

Depth

1ft:20ft

Optical Televiewer Image

0° 90° 180° 270° 0°

Acoustic Televiewer Image Plot-True North

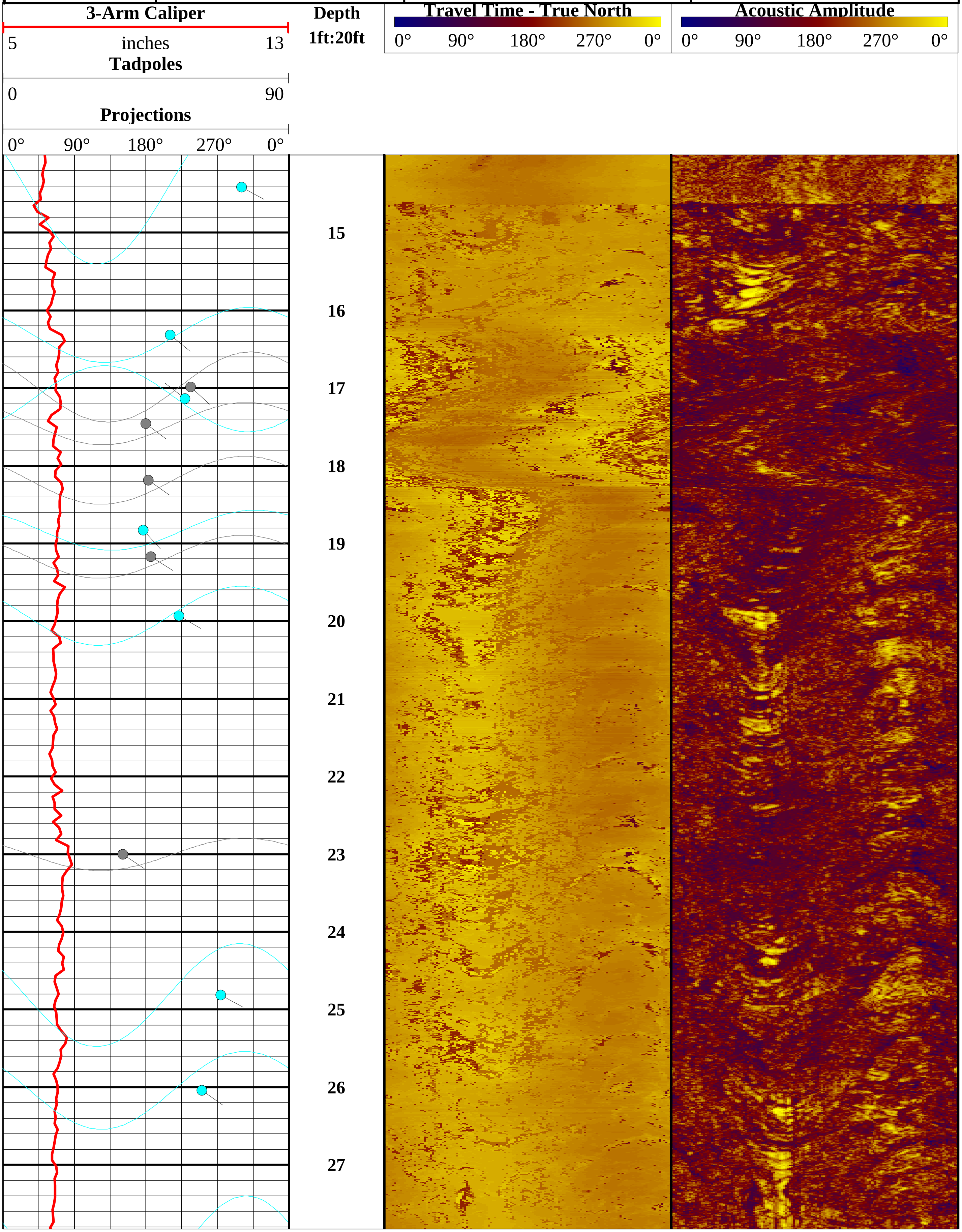
COMPANY: Weston Solutions

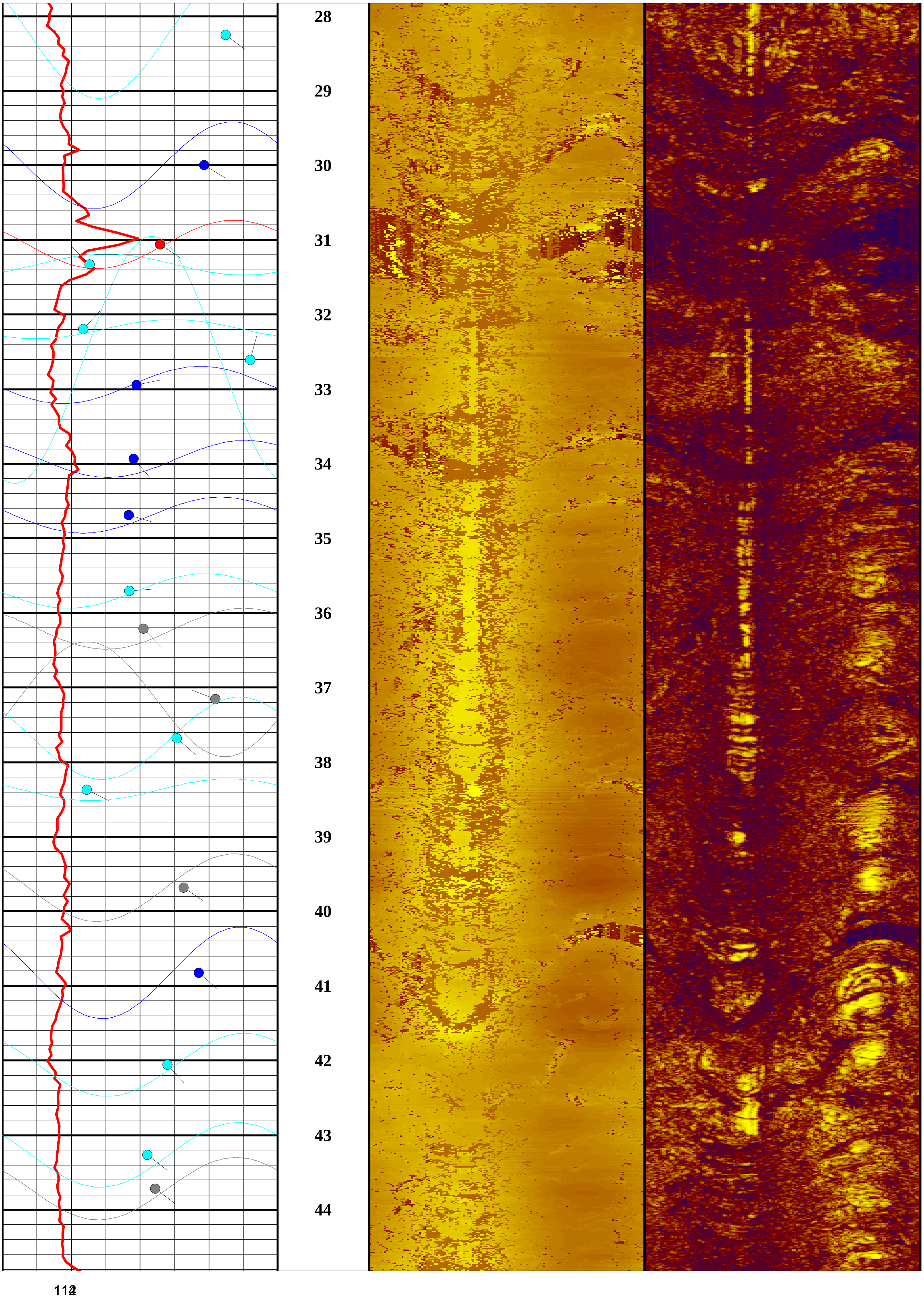
PROJECT: LO-58

DATE LOGGED: 10 May 2008

WELL: DW-2 (Adj. to True North)

COLOG Main Office
810 Quail Street, Suite E, Lakewood, CO 80215
Phone: (303) 279-0171, Fax: (303) 278-0135
www.colog.com

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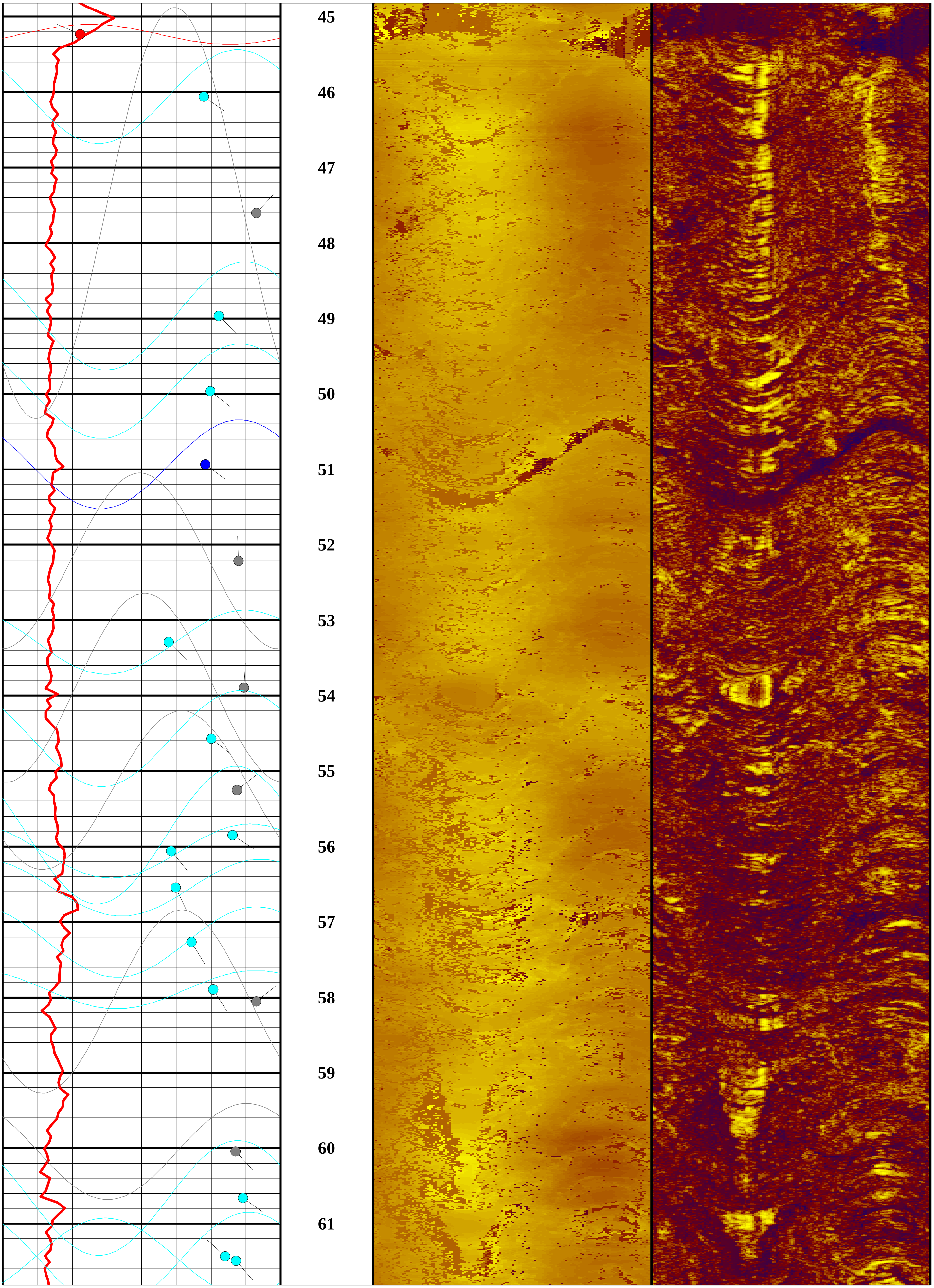
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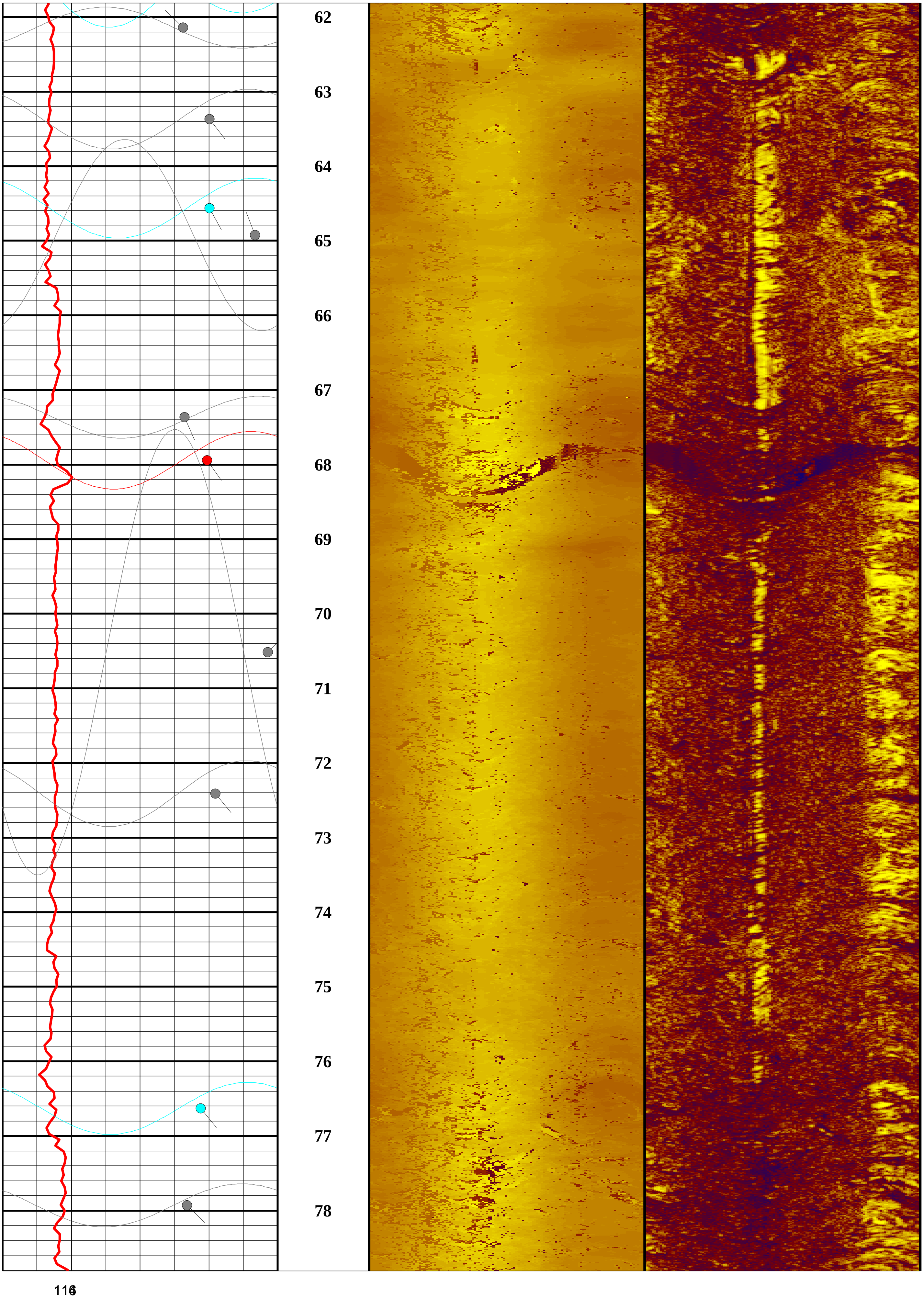
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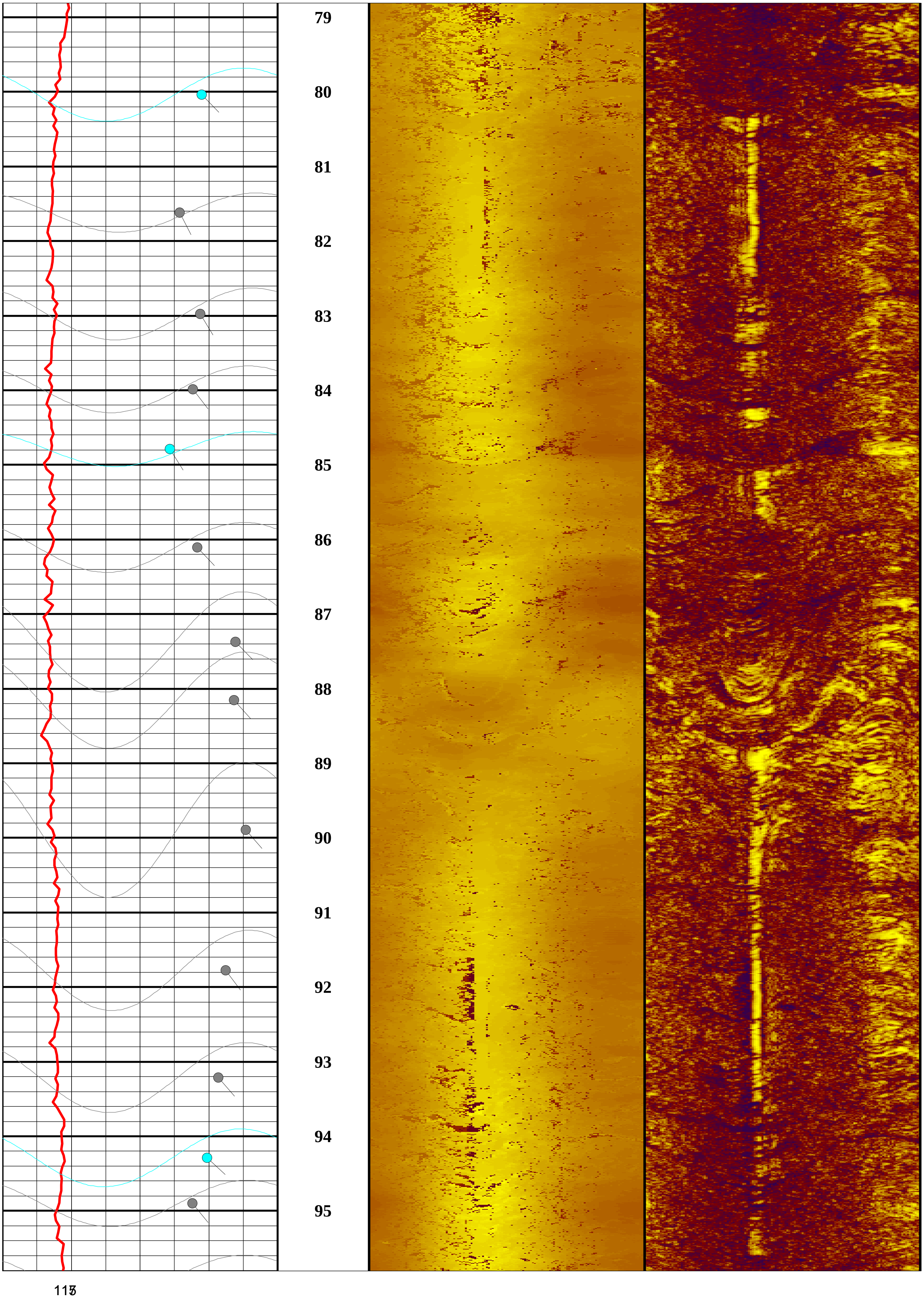
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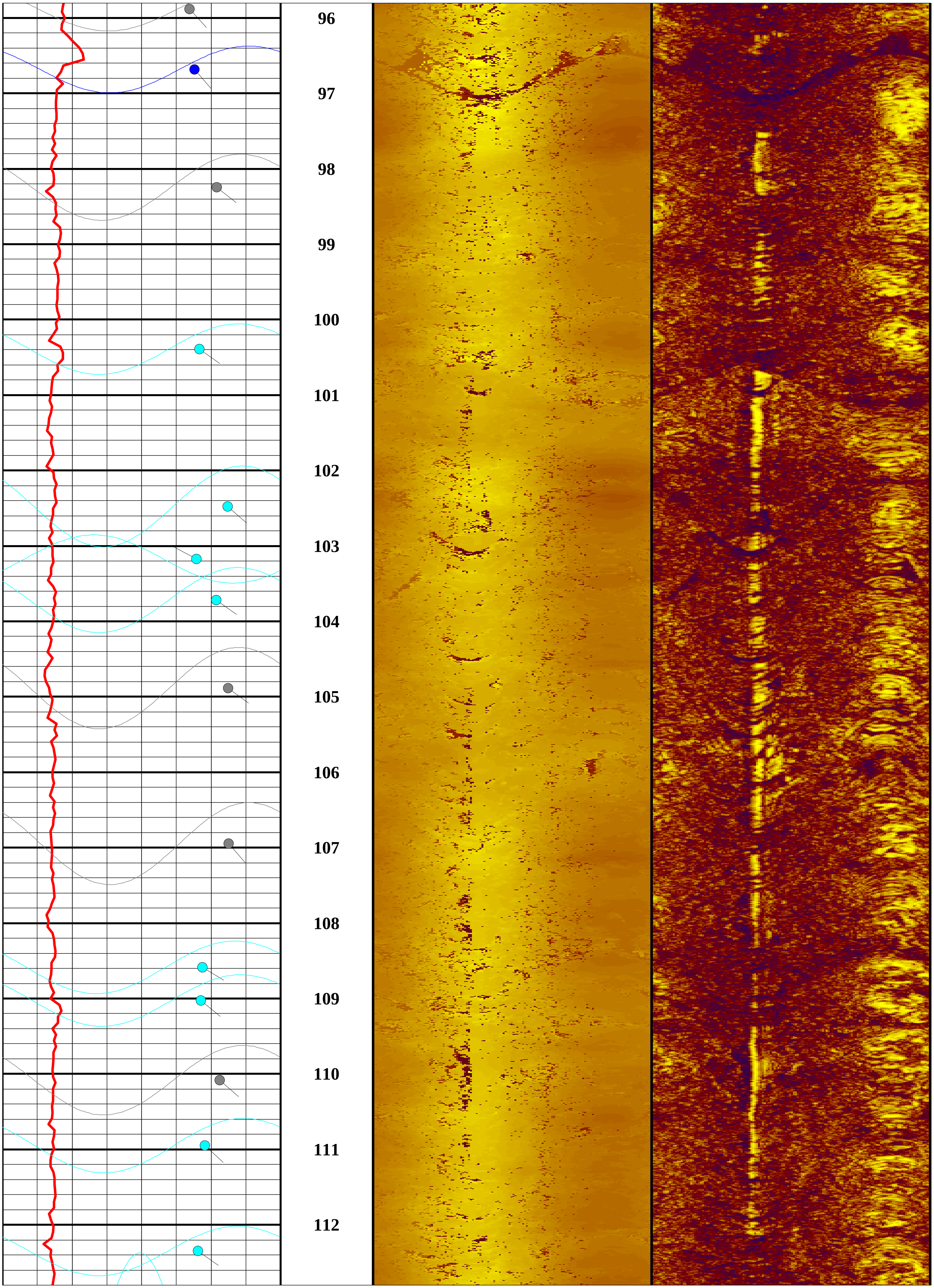
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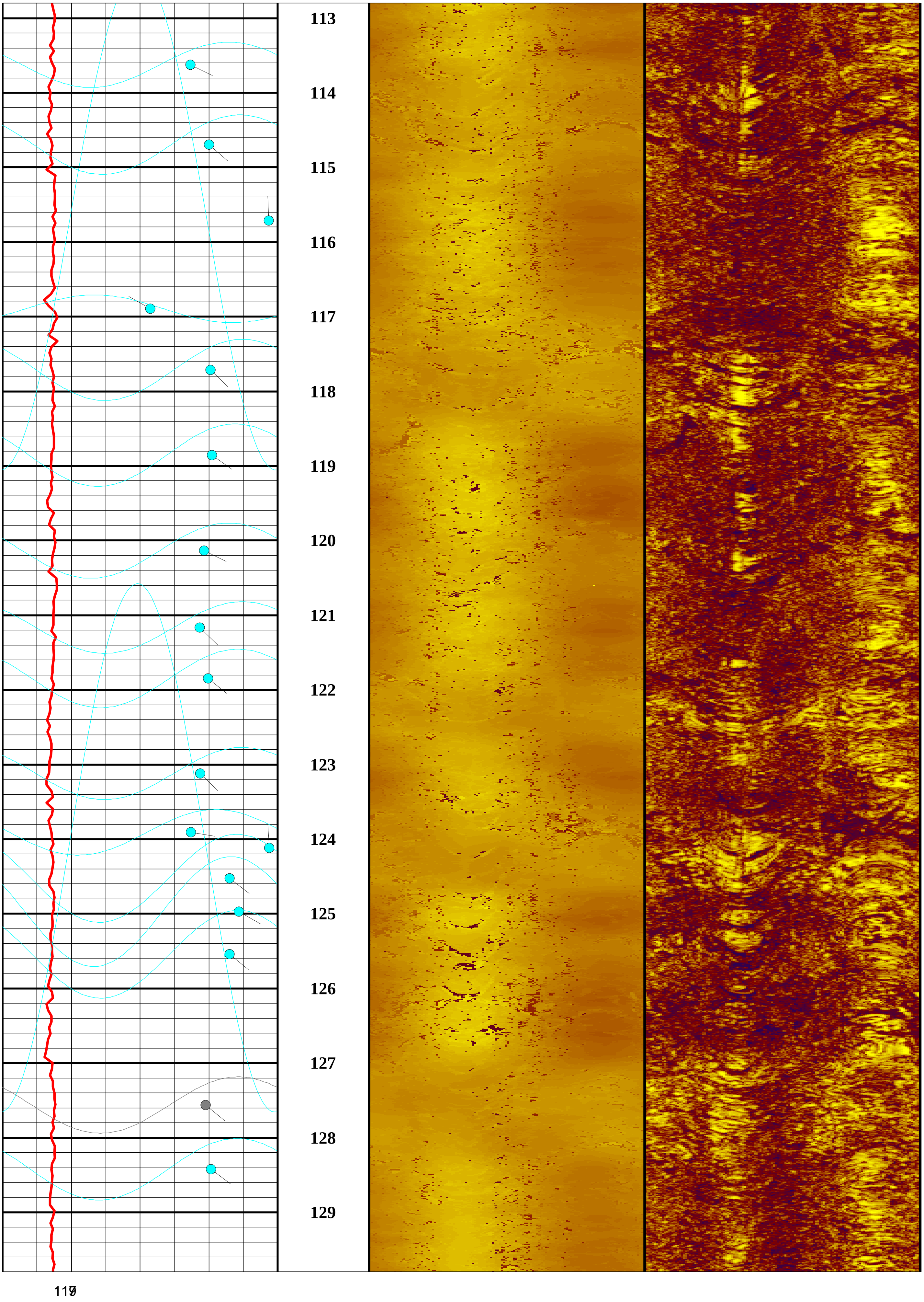
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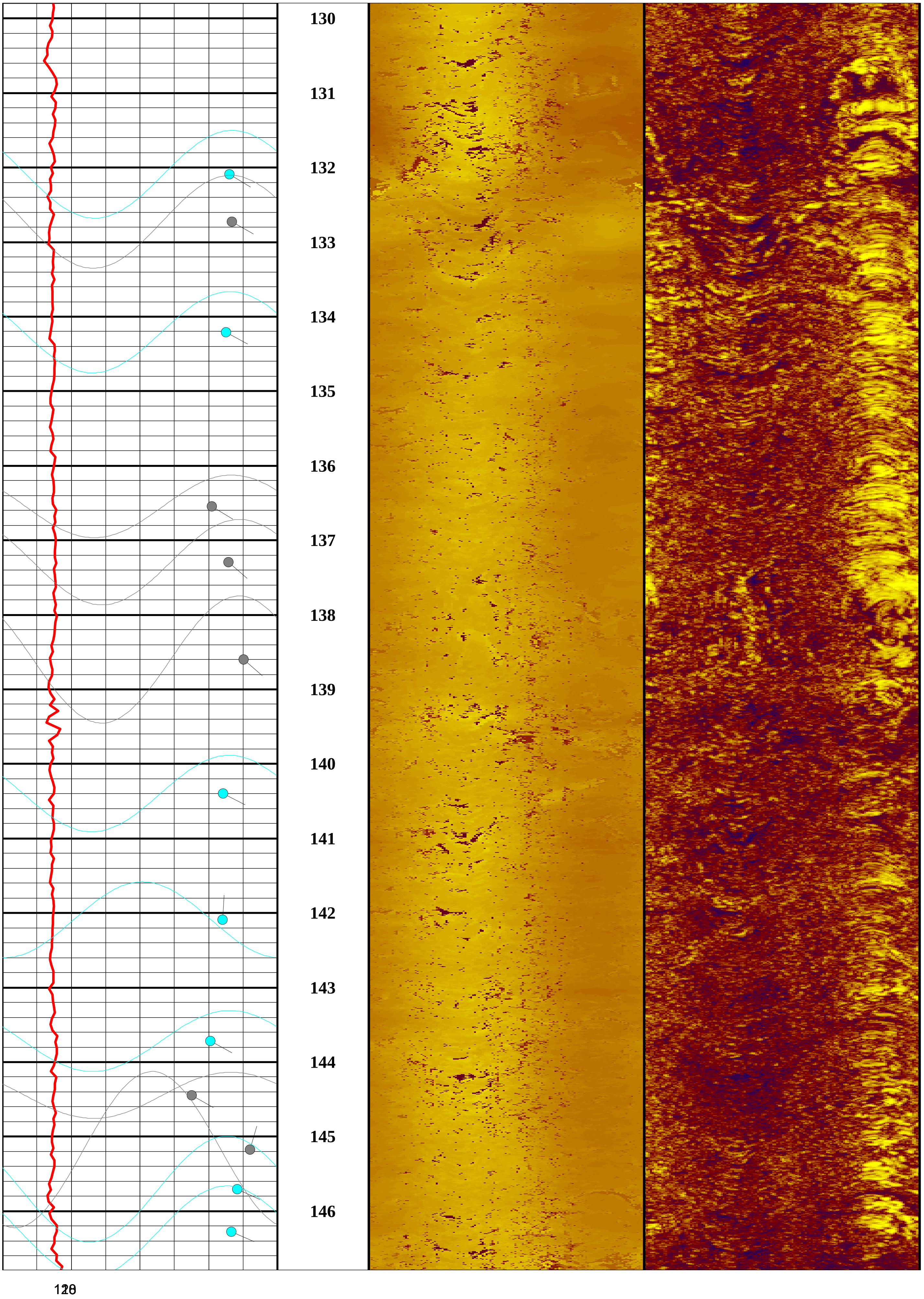
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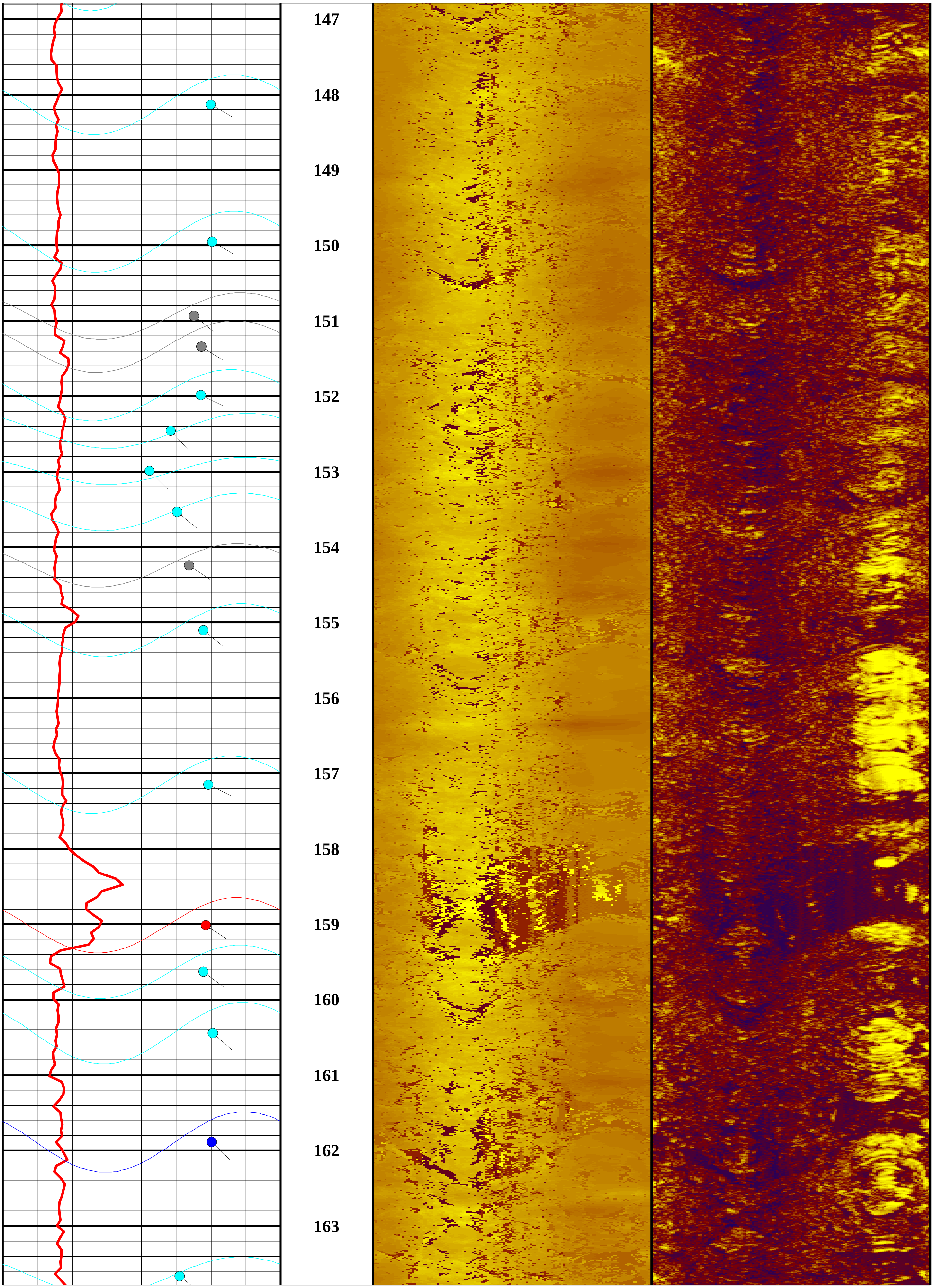
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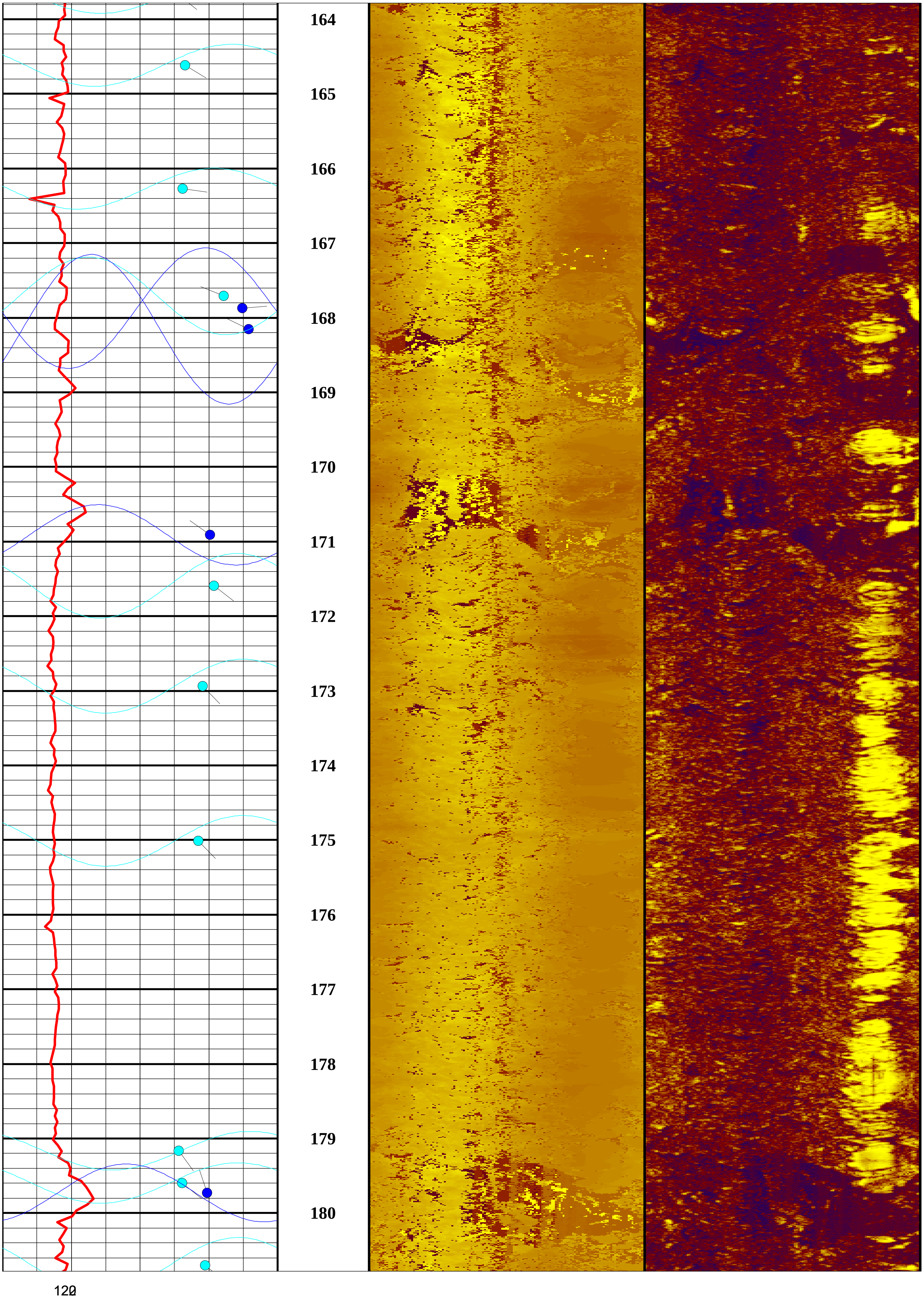
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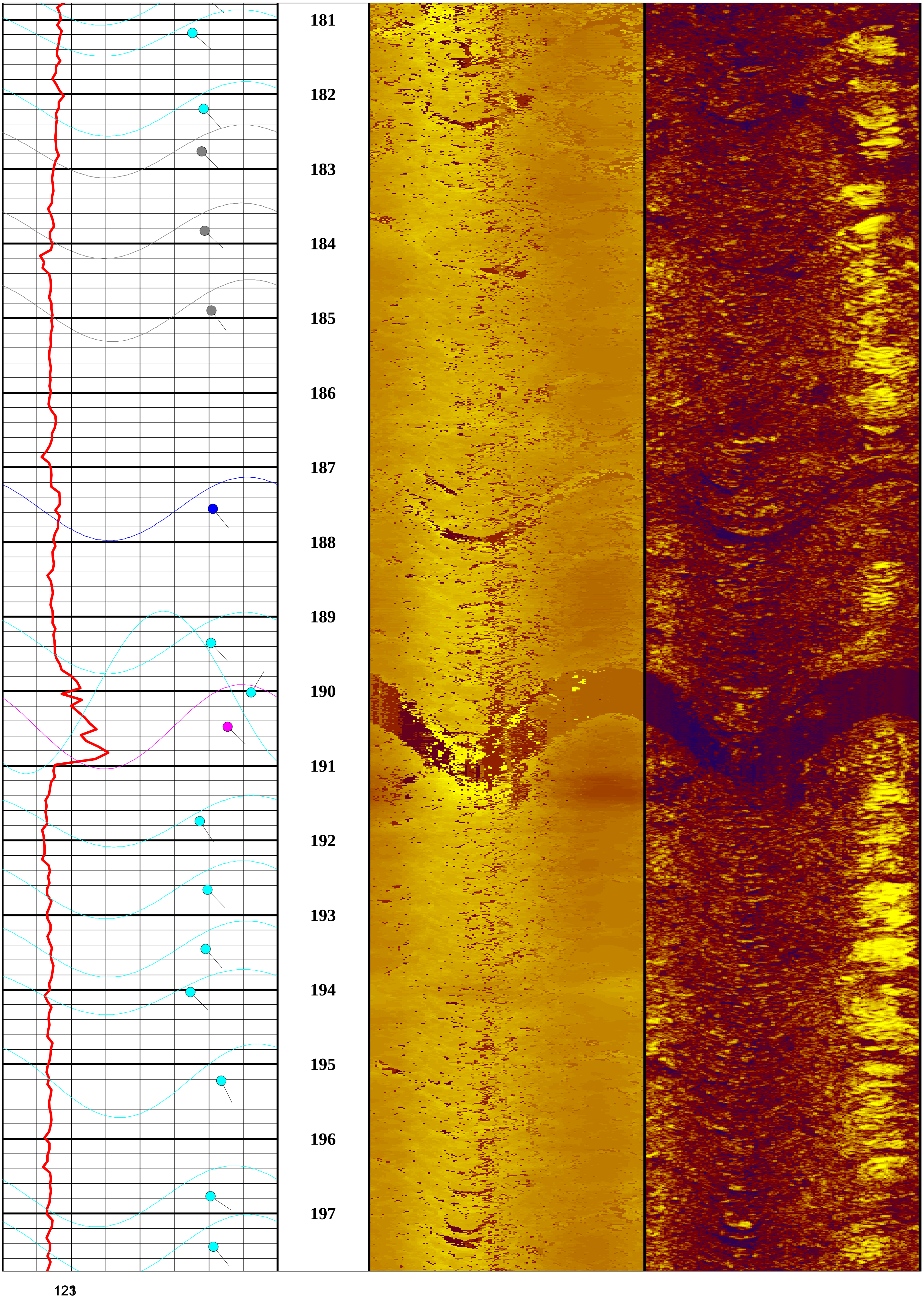
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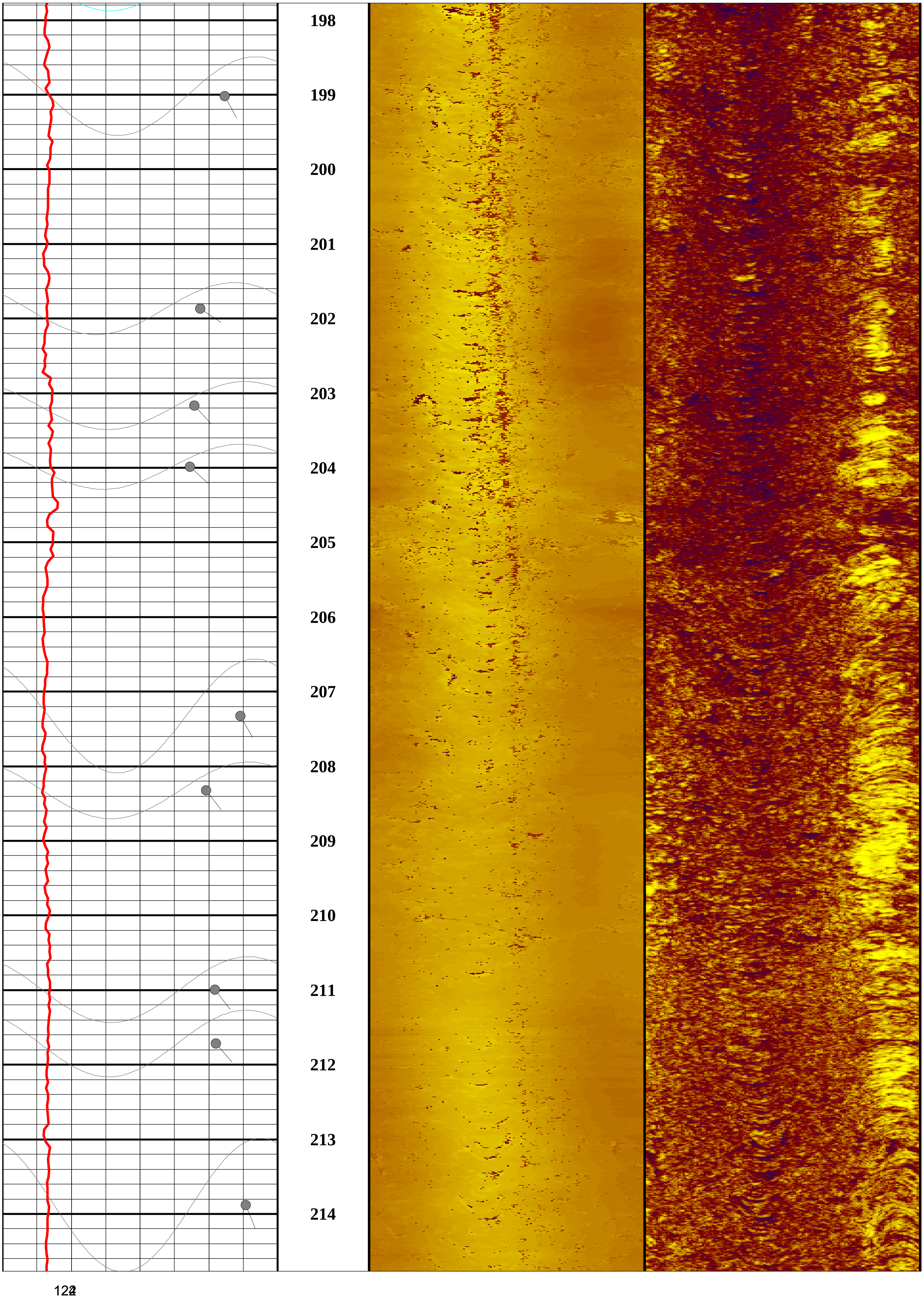
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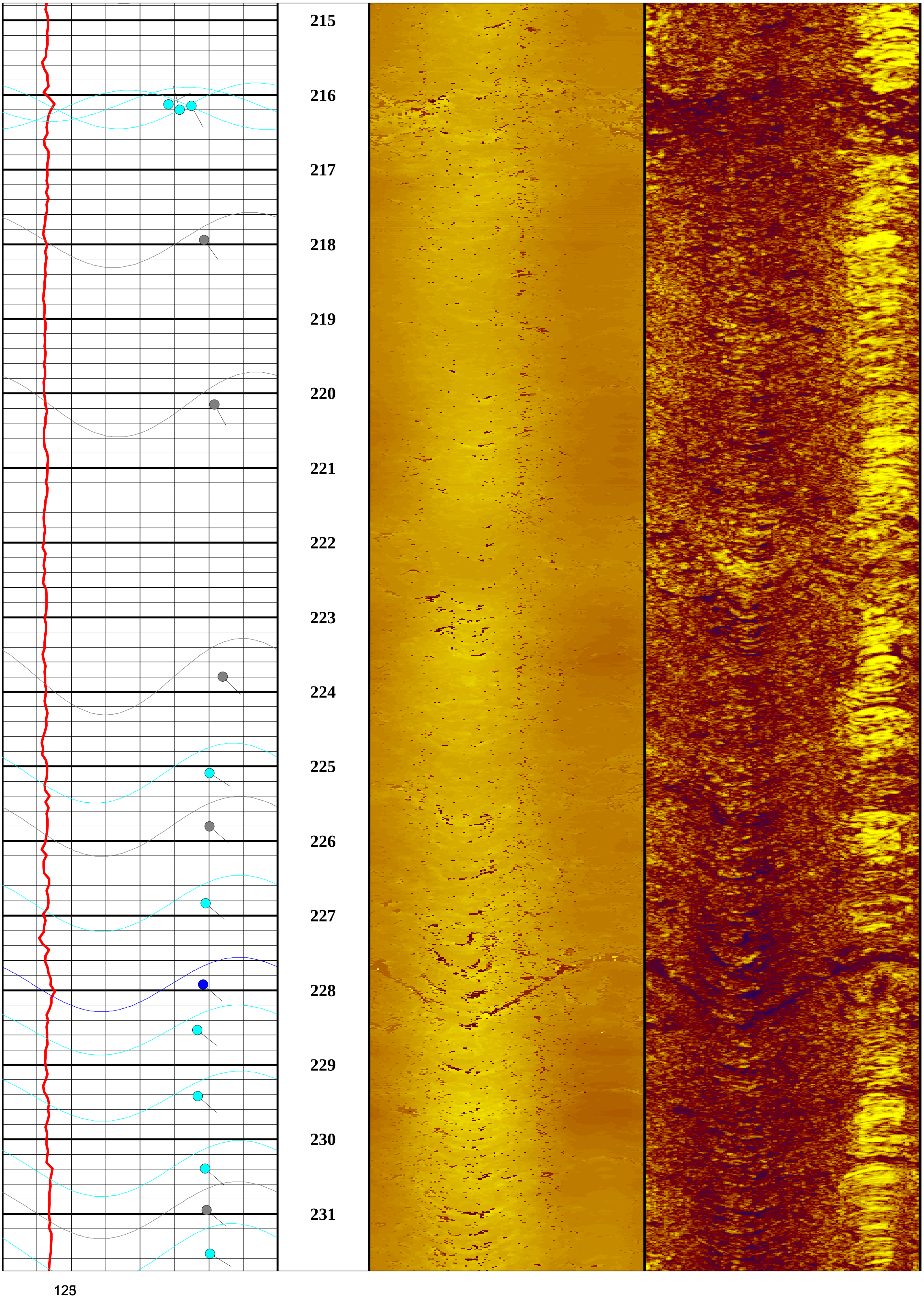
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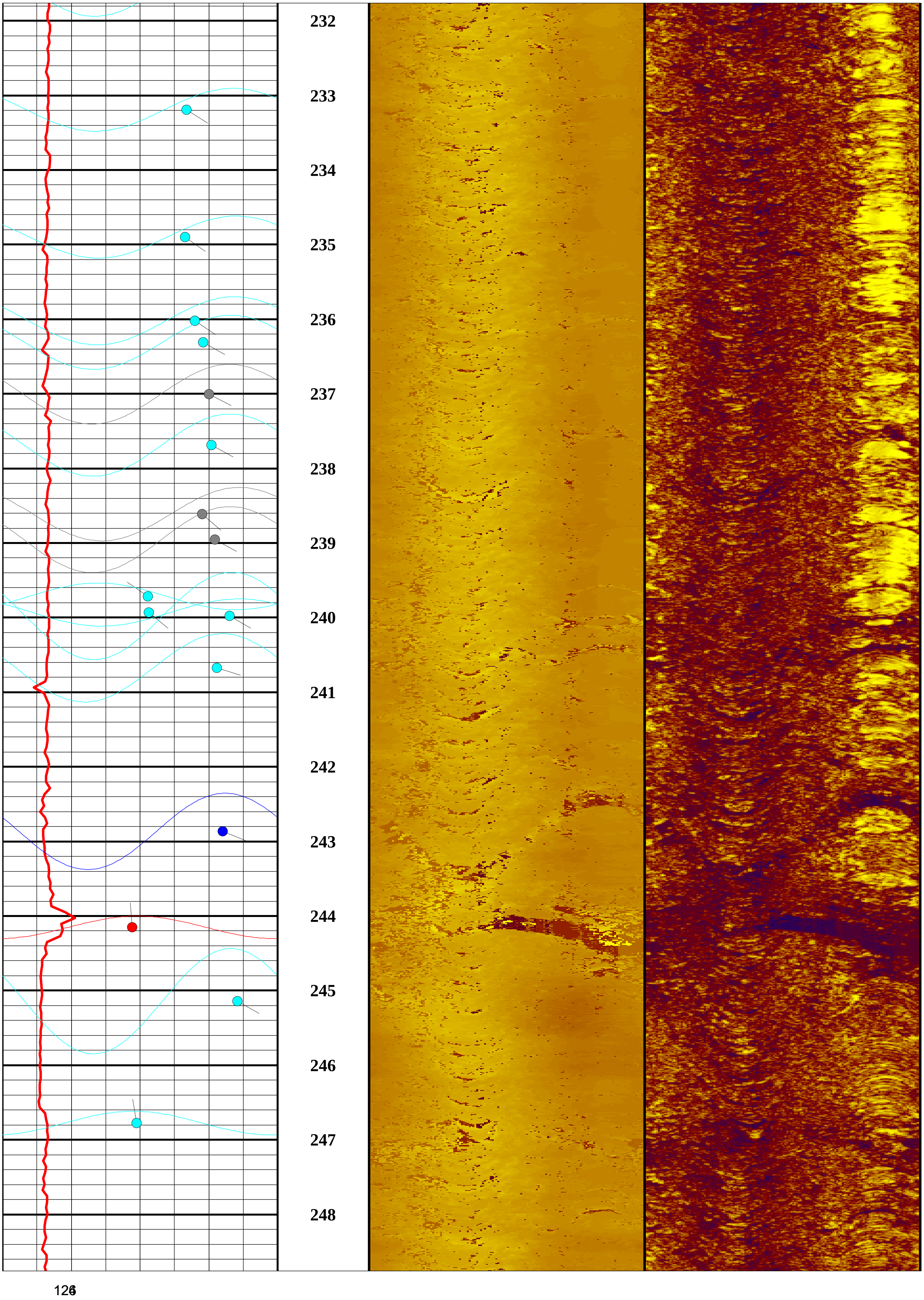
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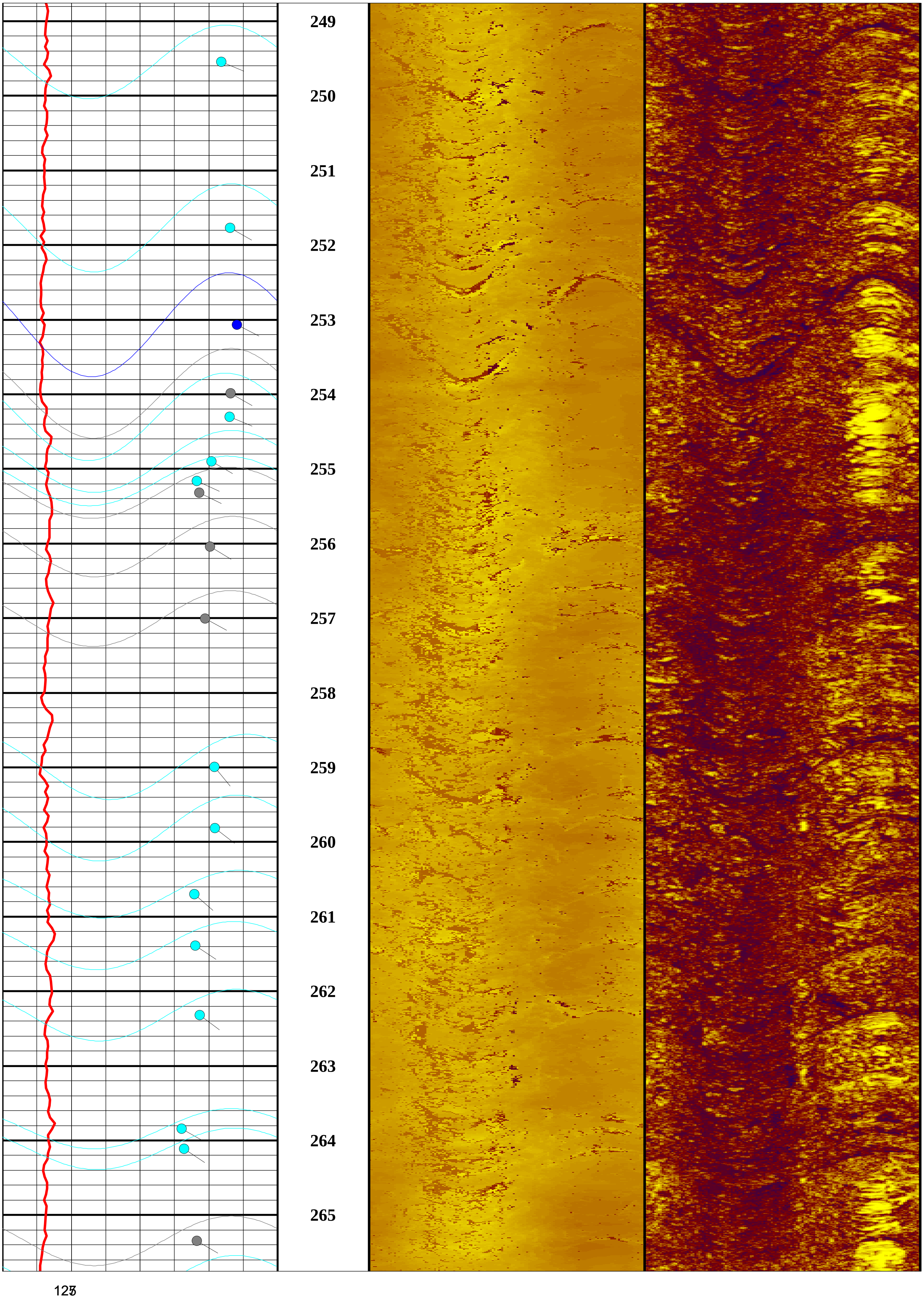
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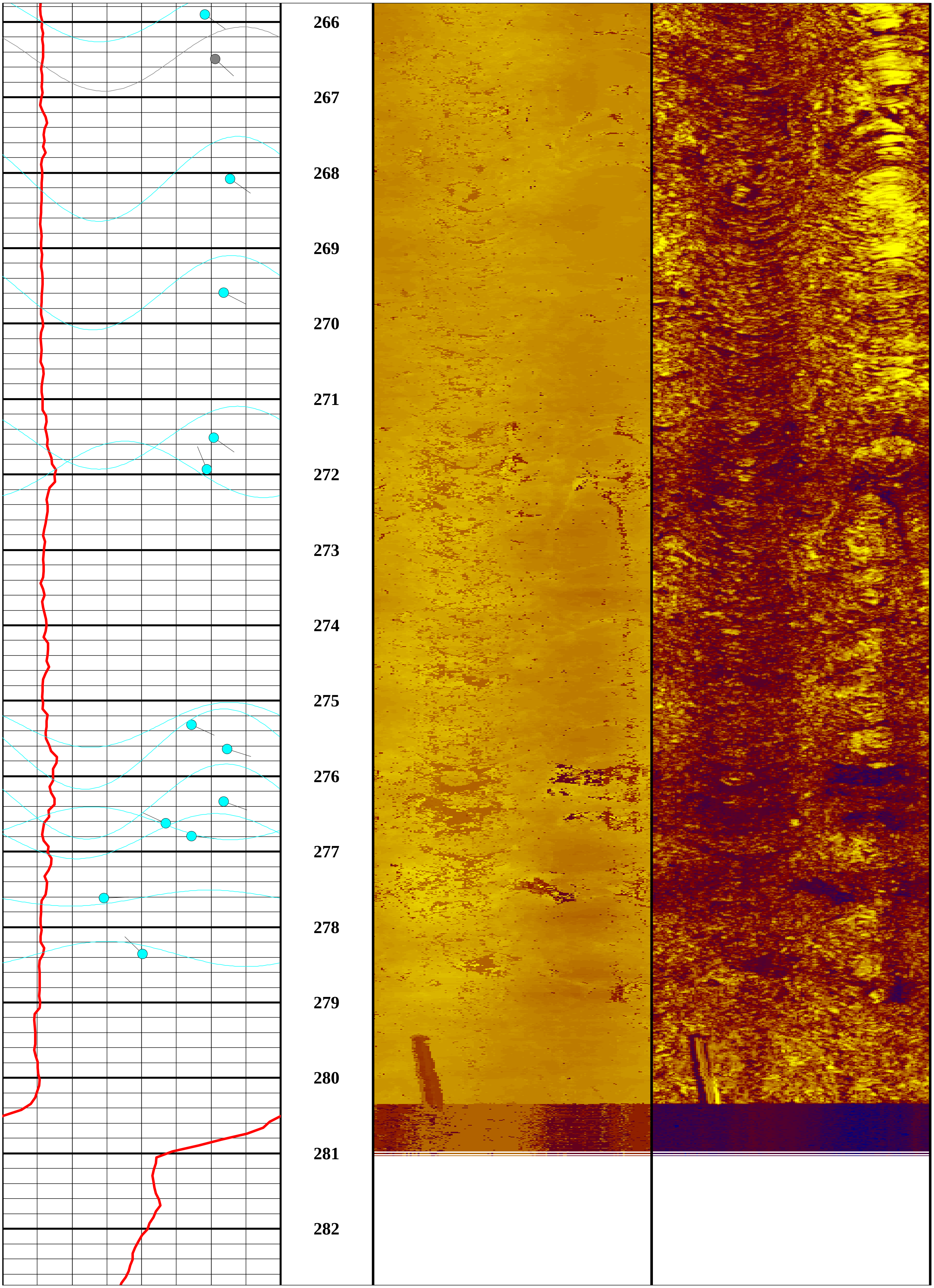
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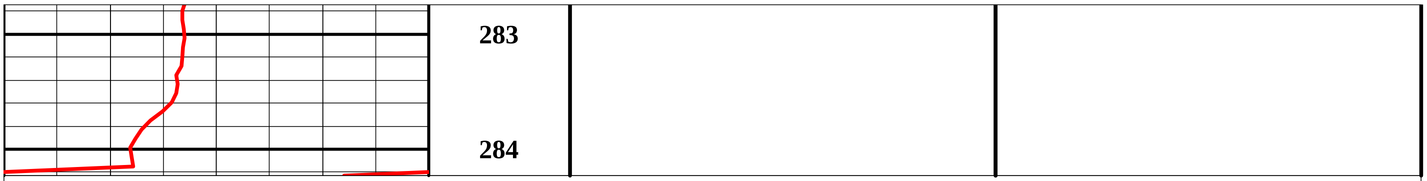


Projections

0° 90° 180° 270° 0°

Tadpoles

0 90

3-Arm Caliper

5 inches 13

Depth

1ft:20ft

Travel Time - True North

0° 90° 180° 270° 0°

Acoustic Amplitude

0° 90° 180° 270° 0°

Figure DW-2:5. Rose Diagram of Optical Televiewer Features
Weston Solutions
MEFUDS; LO-58
Wellbore: DW-2
May 8, 2008

Dip Direction

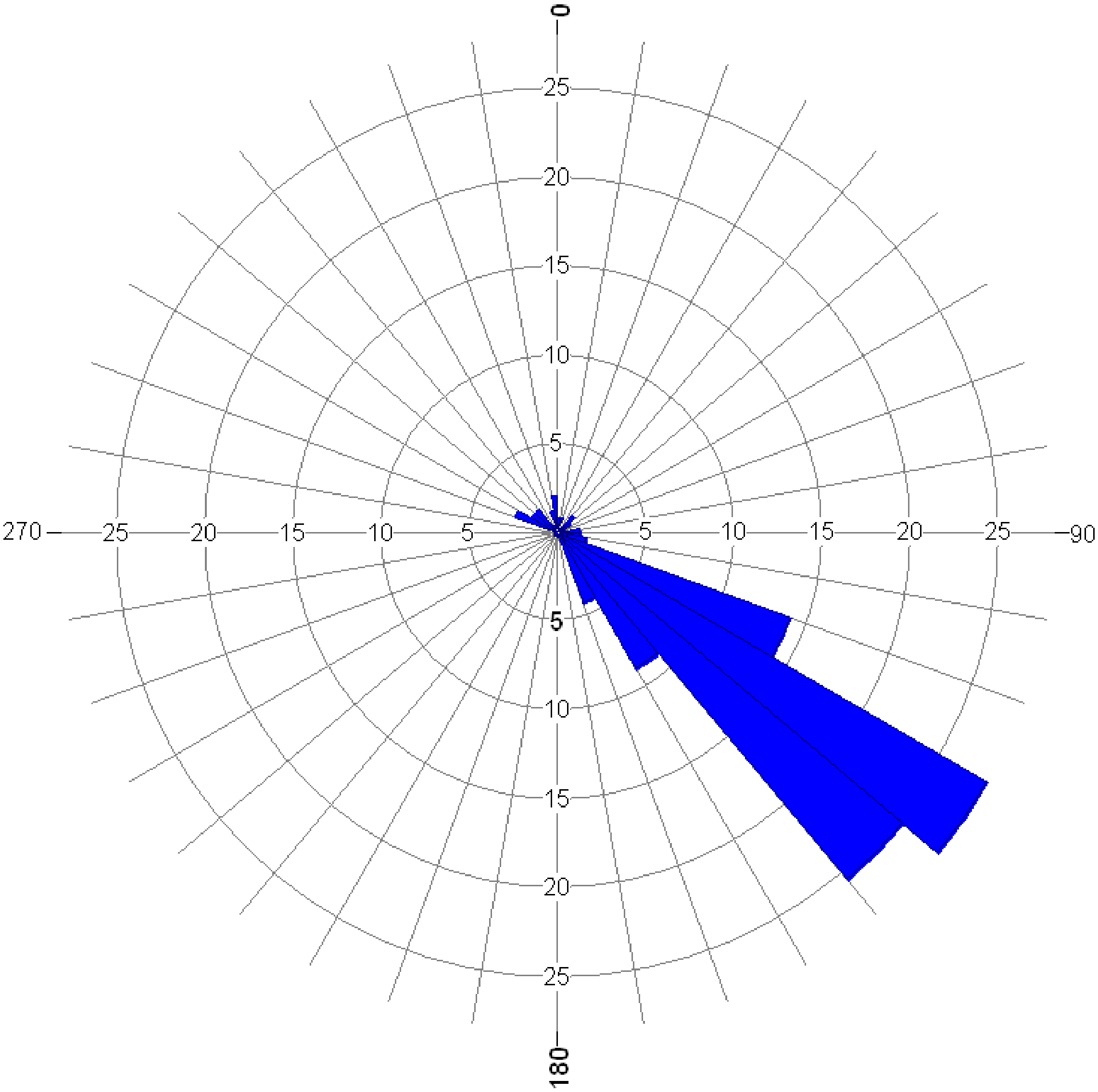


Figure DW-2:6. Rose Diagram of Optical Televiewer Features
Weston Solutions
MEFUDS; LO-58
Wellbore: DW-2
May 8, 2008

Dip Angles

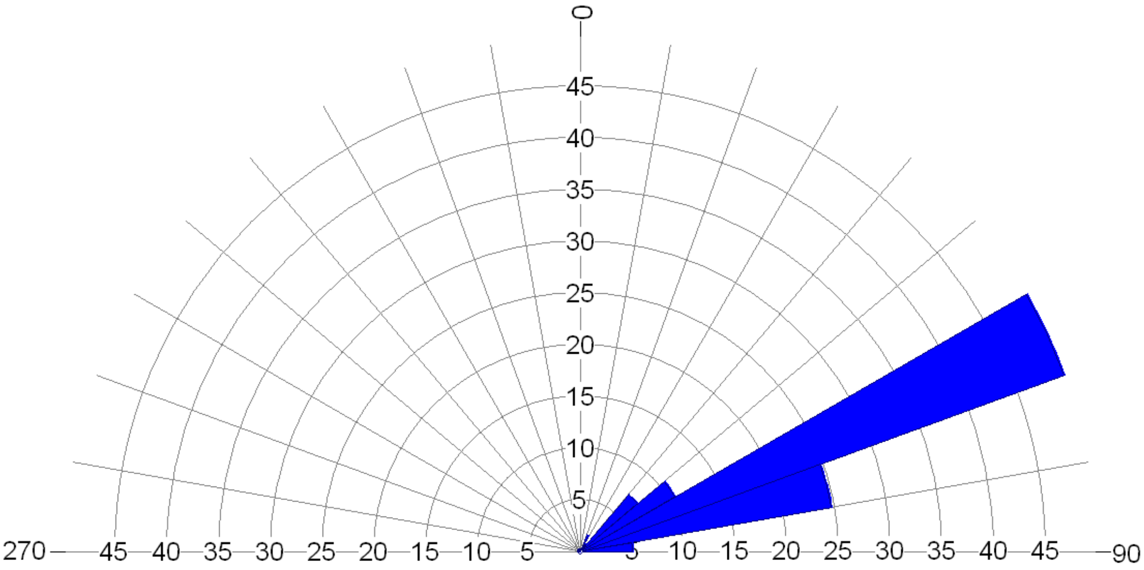


Figure DW-2:7. Stereonet of Optical Televiewer Features
Weston Solutions
MEFUDS; LO-58
Wellbore: DW-2
May 8, 2008

Schmidt Projection with Contours

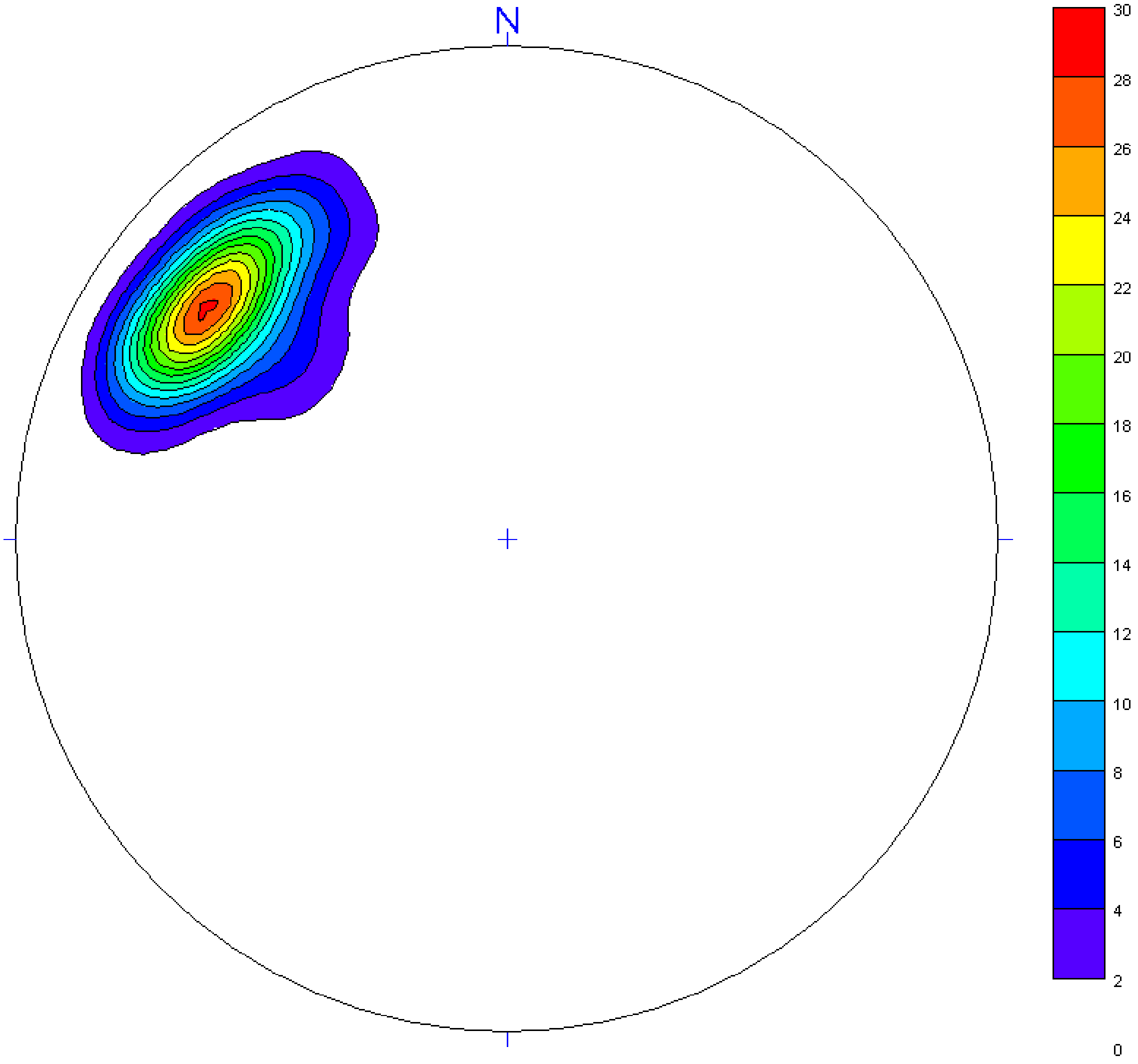


Figure DW-2:8. Stereonet of Optical Televiewer Features
Weston Solutions
MEFUDS; LO-58
Wellbore: DW-2
May 8, 2008

Schmidt Projection with Feature Ranks

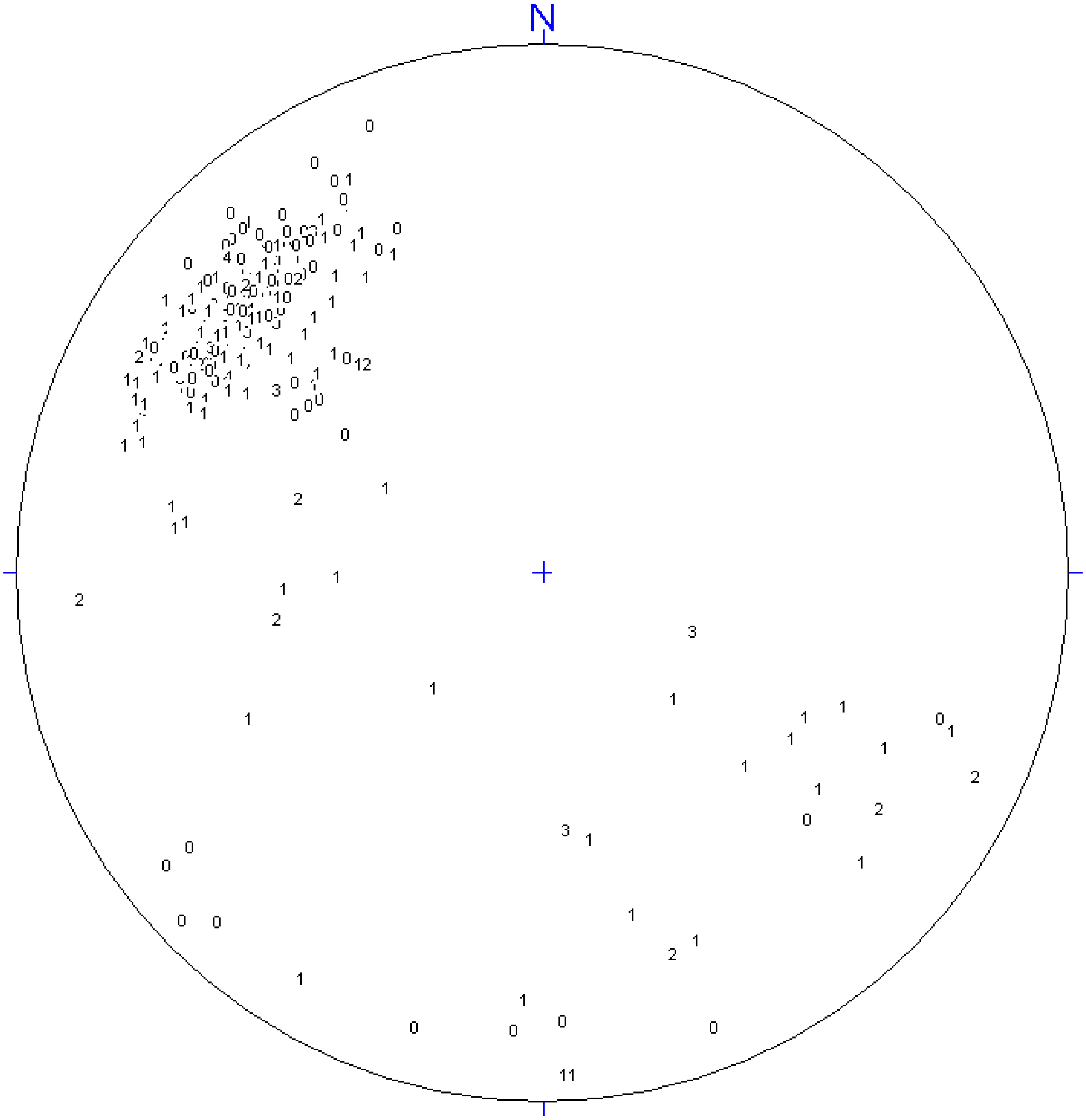


Table DW-2:2. Orientation Summary Table
Image Features
Weston Solutions
LO-58;
Wellbore: DW-2
May 8, 2008

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
1	4.40	14.4	118	75	1
2	4.97	16.3	129	53	1
3	5.18	17.0	132	59	0
4	5.22	17.1	309	57	1
5	5.32	17.5	126	45	0
6	5.54	18.2	124	46	0
7	5.74	18.8	137	44	1
8	5.84	19.2	121	47	0
9	6.07	19.9	120	56	1
10	7.01	23.0	123	38	0
11	7.56	24.8	118	69	1
12	7.94	26.0	124	63	1
13	8.61	28.3	126	73	1
14	9.14	30.0	120	66	2
15	9.47	31.1	123	52	3
16	9.55	31.3	316	29	1
17	9.81	32.2	43	26	1
18	9.94	32.6	16	81	1
19	10.04	33.0	79	44	2
20	10.34	33.9	138	43	2
21	10.57	34.7	105	41	2
22	10.88	35.7	85	42	1
23	11.04	36.2	136	46	0
24	11.32	37.2	291	70	0
25	11.48	37.7	130	57	1
26	11.70	38.4	116	28	1
27	12.09	39.7	124	59	0
28	12.44	40.8	131	64	2
29	12.82	42.1	137	54	1
30	13.19	43.3	128	47	1
31	13.33	43.7	126	50	0
32	13.79	45.2	294	25	3
33	14.04	46.1	124	65	1
34	14.51	47.6	43	82	0
35	14.93	49.0	134	70	1
36	15.23	50.0	127	67	1
37	15.53	50.9	127	66	2
38	15.91	52.2	358	76	0
39	16.24	53.3	134	54	1
40	16.43	53.9	4	78	0
41	16.63	54.6	128	68	1
42	16.84	55.3	52	76	0
43	17.02	55.9	122	75	1
44	17.09	56.1	141	55	1

All directions are with respect to true north (magnatic declination 20W).

Table DW-2:2. Orientation Summary Table
Image Features
Weston Solutions
LO-58;
Wellbore: DW-2
May 8, 2008

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
45	17.24	56.6	154	56	1
46	17.46	57.3	149	61	1
47	17.65	57.9	147	68	1
48	17.70	58.1	52	82	0
49	18.30	60.1	136	76	0
50	18.49	60.7	125	78	1
51	18.72	61.4	313	72	1
52	18.74	61.5	139	76	1
53	18.94	62.1	314	59	0
54	19.32	63.4	142	68	0
55	19.68	64.6	151	68	1
56	19.79	64.9	340	83	0
57	20.53	67.4	156	60	0
58	20.71	67.9	145	67	3
59	21.49	70.5	46	87	0
60	22.07	72.4	140	70	0
61	23.36	76.6	141	65	1
62	23.75	77.9	134	60	0
63	24.40	80.0	135	65	1
64	24.88	81.6	152	58	0
65	25.29	83.0	148	65	0
66	25.60	84.0	142	62	0
67	25.84	84.8	148	55	1
68	26.25	86.1	136	64	0
69	26.63	87.4	135	76	0
70	26.87	88.2	138	76	0
71	27.40	89.9	138	80	0
72	27.97	91.8	143	73	0
73	28.41	93.2	139	71	0
74	28.74	94.3	132	67	1
75	28.93	94.9	140	62	0
76	29.23	95.9	136	61	0
77	29.47	96.7	139	62	2
78	29.94	98.2	128	70	0
79	30.60	100.4	125	64	1
80	31.24	102.5	131	73	1
81	31.45	103.2	298	63	1
82	31.61	103.7	125	69	1
83	31.97	104.9	126	73	0
84	32.60	107.0	139	73	0
85	33.10	108.6	121	65	1
86	33.23	109.0	129	64	1
87	33.55	110.1	131	70	0
88	33.82	111.0	132	66	1

All directions are with respect to true north (magnatic declination 20W).

Table DW-2:2. Orientation Summary Table
Image Features
Weston Solutions
LO-58;
Wellbore: DW-2
May 8, 2008

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
89	34.24	112.3	124	63	1
90	34.63	113.6	116	62	1
91	34.96	114.7	131	68	1
92	35.27	115.7	358	87	1
93	35.63	116.9	300	48	1
94	35.88	117.7	134	68	1
95	36.23	118.9	125	69	1
96	36.62	120.1	116	66	1
97	36.93	121.2	134	65	1
98	37.14	121.9	128	67	1
99	37.53	123.1	134	65	1
100	37.77	123.9	99	62	1
101	37.83	124.1	357	87	1
102	37.95	124.5	127	74	1
103	38.09	125.0	119	77	1
104	38.26	125.5	129	74	1
105	38.88	127.6	128	67	0
106	39.14	128.4	127	68	1
107	40.26	132.1	121	74	1
108	40.46	132.7	119	75	0
109	40.91	134.2	118	73	1
110	41.62	136.6	120	69	0
111	41.85	137.3	130	74	0
112	42.25	138.6	130	79	0
113	42.79	140.4	117	72	1
114	43.31	142.1	3	72	1
115	43.81	143.7	118	68	1
116	44.03	144.4	119	62	0
117	44.25	145.2	16	81	0
118	44.41	145.7	114	77	1
119	44.59	146.3	114	75	1
120	45.15	148.1	119	67	1
121	45.70	150.0	120	68	1
122	46.01	150.9	128	62	0
123	46.13	151.4	121	64	0
124	46.32	152.0	116	64	1
125	46.47	152.5	137	55	1
126	46.63	153.0	135	48	1
127	46.80	153.5	129	57	1
128	47.01	154.2	124	60	0
129	47.27	155.1	130	65	1
130	47.90	157.2	116	67	1
131	48.47	159.0	123	66	3
132	48.66	159.6	127	65	1

All directions are with respect to true north (magnatic declination 20W).

Table DW-2:2. Orientation Summary Table
Image Features
Weston Solutions
LO-58;
Wellbore: DW-2
May 8, 2008

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
133	48.90	160.4	131	68	1
134	49.34	161.9	133	68	2
135	49.89	163.7	128	57	1
136	50.18	164.6	120	60	1
137	50.68	166.3	97	59	1
138	51.12	167.7	292	73	1
139	51.17	167.9	86	79	2
140	51.25	168.2	296	81	2
141	52.09	170.9	306	68	2
142	52.30	171.6	127	69	1
143	52.71	172.9	135	66	1
144	53.34	175.0	135	64	1
145	54.61	179.2	144	58	1
146	54.74	179.6	128	59	1
147	54.78	179.7	342	67	2
148	55.08	180.7	129	66	1
149	55.22	181.2	131	62	1
150	55.53	182.2	138	66	1
151	55.71	182.8	136	65	0
152	56.03	183.8	133	66	0
153	56.36	184.9	144	68	0
154	57.17	187.6	140	69	2
155	57.71	189.4	137	68	1
156	57.92	190.0	31	81	1
157	58.06	190.5	134	74	4
158	58.44	191.7	146	65	1
159	58.72	192.7	135	67	1
160	58.96	193.5	139	67	1
161	59.14	194.0	135	62	1
162	59.50	195.2	153	72	1
163	59.98	196.8	123	68	1
164	60.18	197.5	141	69	1
165	60.66	199.0	151	73	0
166	61.53	201.9	123	65	0
167	61.93	203.2	138	63	0
168	62.18	204.0	132	61	0
169	63.19	207.3	150	78	0
170	63.50	208.3	142	67	0
171	64.31	211.0	142	70	0
172	64.53	211.7	139	70	0
173	65.19	213.9	158	80	0
174	65.87	216.1	63	54	1
175	65.88	216.2	151	62	1
176	65.90	216.2	346	58	1

All directions are with respect to true north (magnatic declination 20W).

Table DW-2:2. Orientation Summary Table
Image Features
Weston Solutions
LO-58;
Wellbore: DW-2
May 8, 2008

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
177	66.43	217.9	144	66	0
178	67.10	220.2	151	69	0
179	68.21	223.8	135	72	0
180	68.61	225.1	122	68	1
181	68.83	225.8	130	68	0
182	69.14	226.8	130	67	1
183	69.47	227.9	130	66	2
184	69.66	228.5	128	64	1
185	69.93	229.4	131	64	1
186	70.22	230.4	130	66	1
187	70.39	231.0	129	67	0
188	70.57	231.5	121	68	1
189	71.08	233.2	121	60	1
190	71.60	234.9	125	60	1
191	71.94	236.0	124	63	1
192	72.03	236.3	119	66	1
193	72.24	237.0	117	68	0
194	72.45	237.7	118	69	1
195	72.73	238.6	130	65	0
196	72.84	239.0	118	70	0
197	73.07	239.7	305	48	1
198	73.13	239.9	130	48	1
199	73.15	240.0	120	74	1
200	73.36	240.7	107	70	1
201	74.02	242.9	111	72	2
202	74.42	244.2	356	42	3
203	74.72	245.1	119	77	1
204	75.22	246.8	351	44	1
205	76.06	249.5	112	72	1
206	76.74	251.8	119	74	1
207	77.14	253.1	117	77	2
208	77.42	254.0	119	75	0
209	77.51	254.3	112	74	1
210	77.69	254.9	120	68	1
211	77.77	255.2	114	64	1
212	77.82	255.3	116	65	0
213	78.04	256.0	121	68	0
214	78.34	257.0	118	66	0
215	78.94	259.0	140	69	1
216	79.19	259.8	127	70	1
217	79.46	260.7	130	63	1
218	79.67	261.4	123	63	1
219	79.96	262.3	126	65	1
220	80.42	263.8	119	59	1

All directions are with respect to true north (magnatic declination 20W).

Table DW-2:2. Orientation Summary Table
Image Features
Weston Solutions
LO-58;
Wellbore: DW-2
May 8, 2008

Feature No.	Depth (meters)	Depth (feet)	Dip Direction (degrees)	Dip Angle (degrees)	Feature Rank (0 to 5)
221	80.50	264.1	124	60	1
222	80.88	265.3	120	64	0
223	81.05	265.9	125	66	1
224	81.23	266.5	131	69	0
225	81.71	268.1	125	74	1
226	82.17	269.6	116	72	1
227	82.76	271.5	124	69	1
228	82.88	271.9	338	66	1
229	83.92	275.3	114	61	1
230	84.02	275.6	106	73	1
231	84.23	276.3	109	72	1
232	84.32	276.6	295	53	1
233	84.37	276.8	96	61	1
234	84.62	277.6	87	33	1
235	84.84	278.4	315	45	1

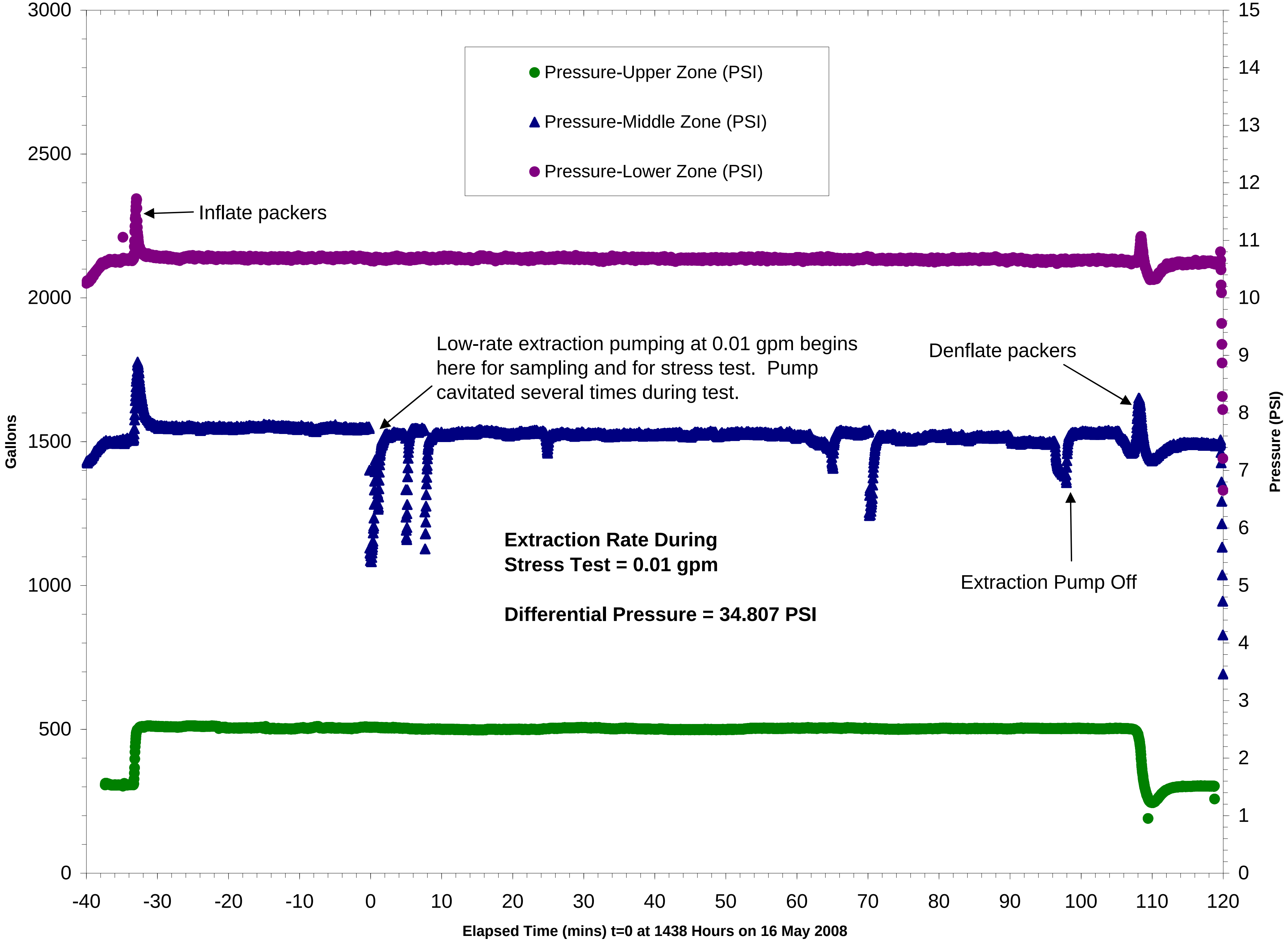
All directions are with respect to true north (magnatic declination 20W).

Table DW-2:3. Summary of Vertical Seismic Profile Results; Weston Solutions; LO-58, Caribou, ME; Wellbore: DW-2

Well	Depth Interval (ftbtoc)	Interval-Specific Velocity (feet/second)	Comments
DW-02	20 - 30	1,789	Signal degraded due to cement vault, asphalt
	35 - 115	10,255	Consistent with highly fractured bedrock
	115 - 185	17,274	Consistent with highly fractured bedrock

Note: P-wave signal degradation is observed in all test stations likely due to the cement vault and backfill arround the steel casing and the asphalt surface. Moreover, seismograms at 195 and 200 feet had too little P-wave seismic energy to estimate velocities.

FIGURE DW-1:9A. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 16.0 to 20.0 Feet; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2



Inflate packers

Low-rate extraction pumping at 0.01 gpm begins here for sampling and for stress test. Pump cavitated several times during test.

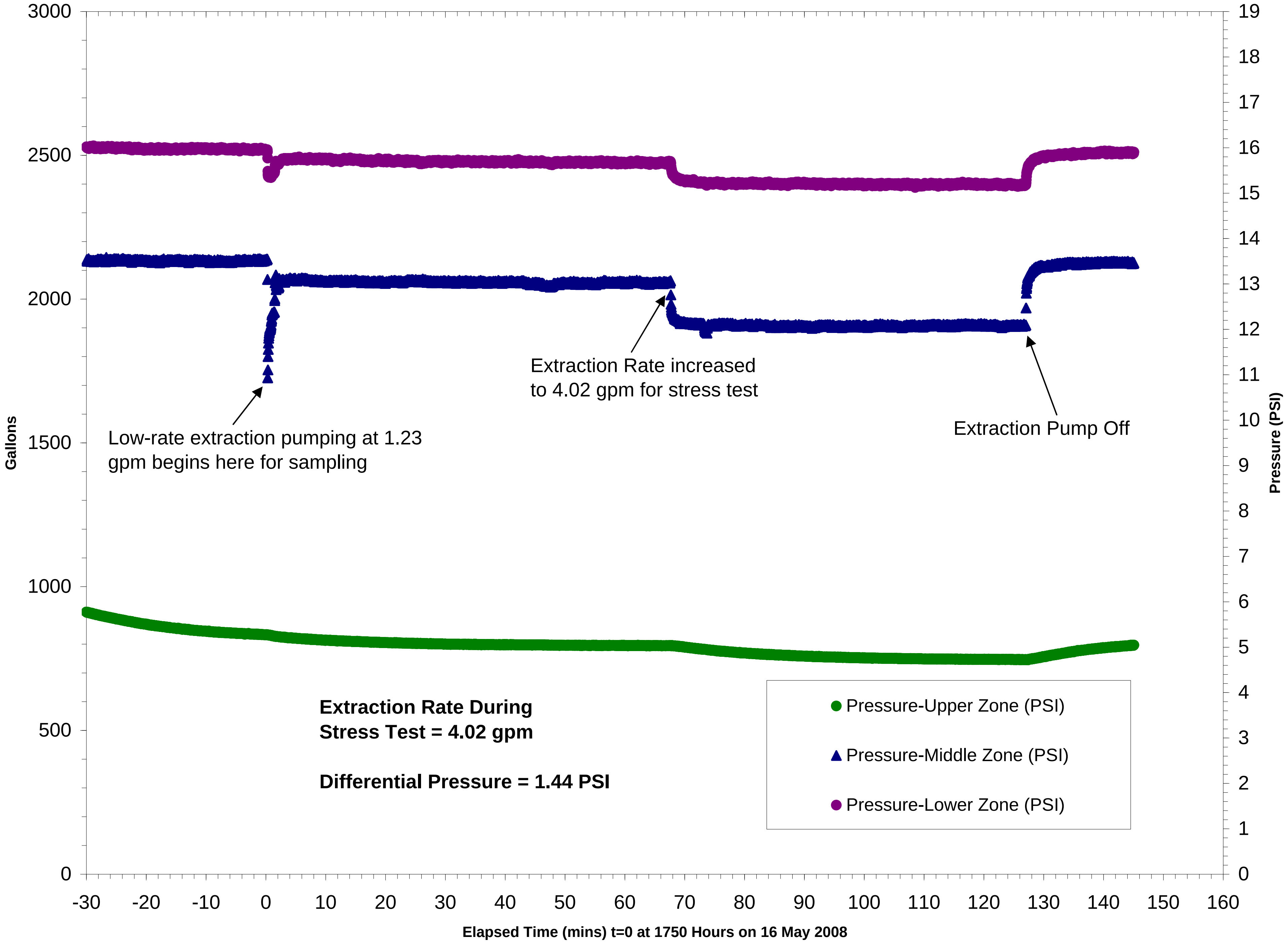
Denflate packers

Extraction Rate During Stress Test = 0.01 gpm

Differential Pressure = 34.807 PSI

Extraction Pump Off

FIGURE DW-1:9B. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 28.5 to 32.5 Feet; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2



Low-rate extraction pumping at 1.23 gpm begins here for sampling

Extraction Rate increased to 4.02 gpm for stress test

Extraction Pump Off

Extraction Rate During Stress Test = 4.02 gpm

Differential Pressure = 1.44 PSI

FIGURE DW-1:9C. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 37.0 to 41.7 Feet; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2

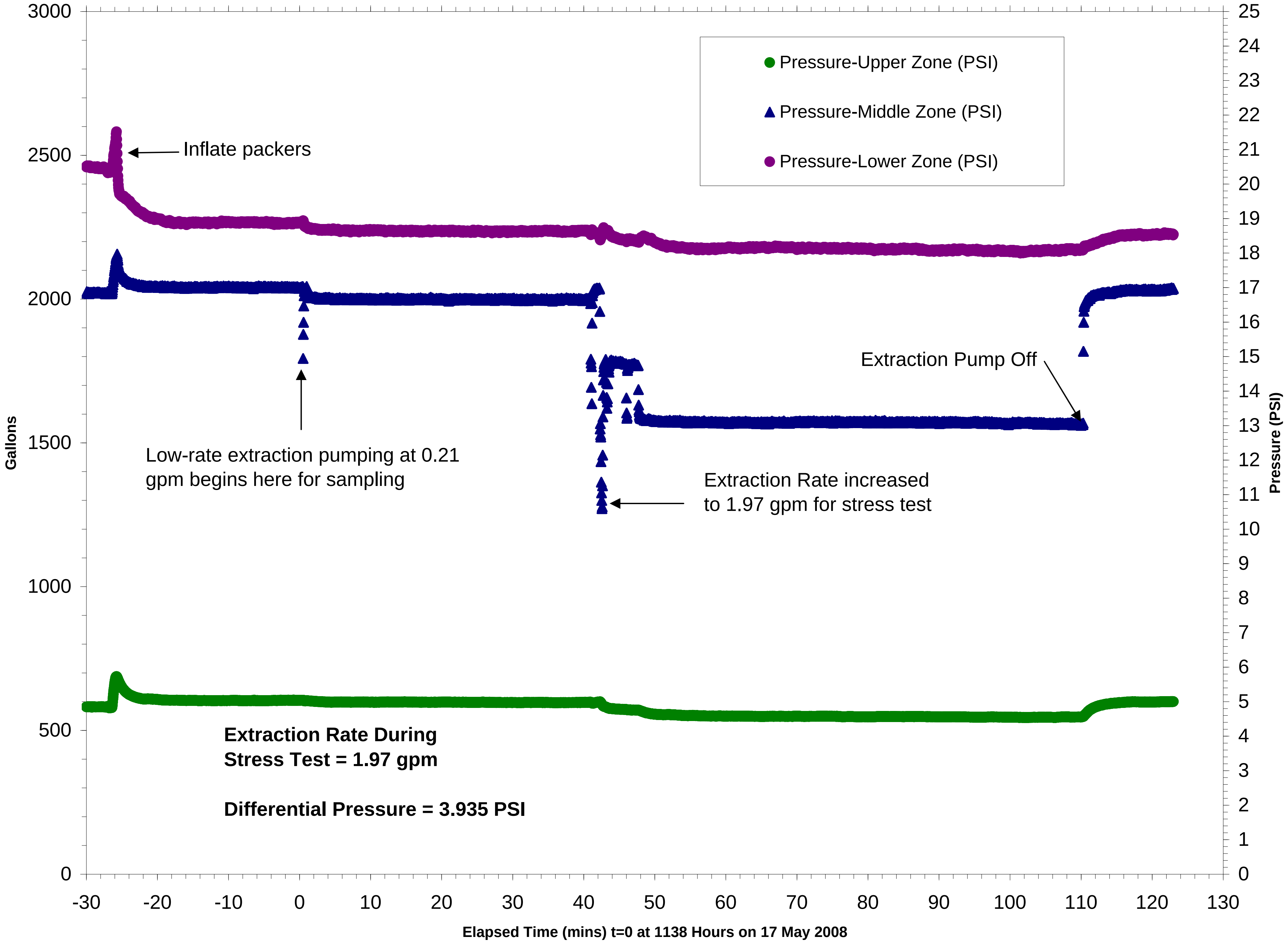
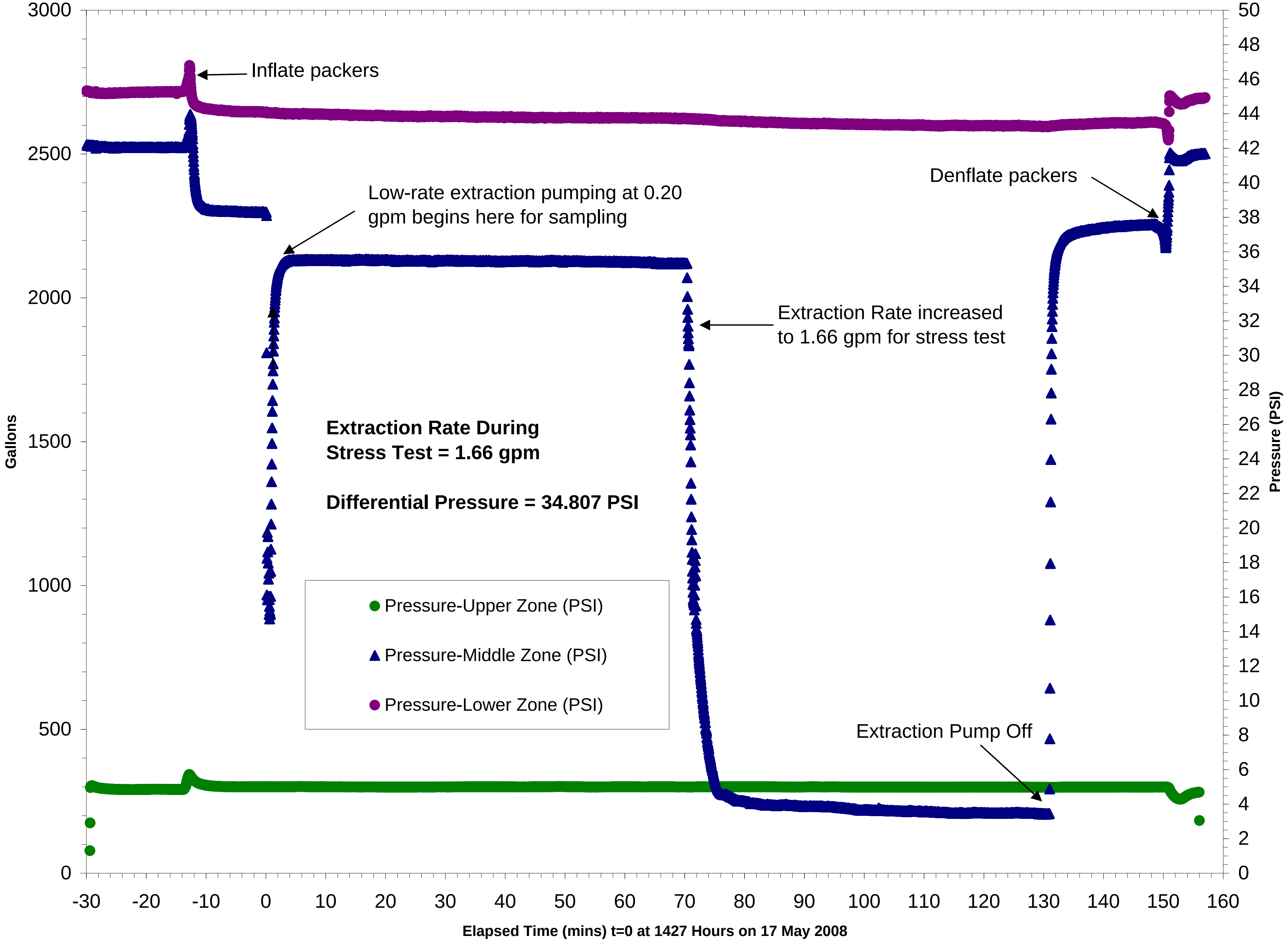


FIGURE DW-1:9D. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 94.5 to 98.5 Feet; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2



Inflate packers

Low-rate extraction pumping at 0.20 gpm begins here for sampling

Denflate packers

Extraction Rate increased to 1.66 gpm for stress test

Extraction Rate During Stress Test = 1.66 gpm

Differential Pressure = 34.807 PSI

Extraction Pump Off

FIGURE DW-1:9E. Pressure and Extraction Rate Data During Wireline Straddle Packer Sampling at 187.9 to 192.2 Feet; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2

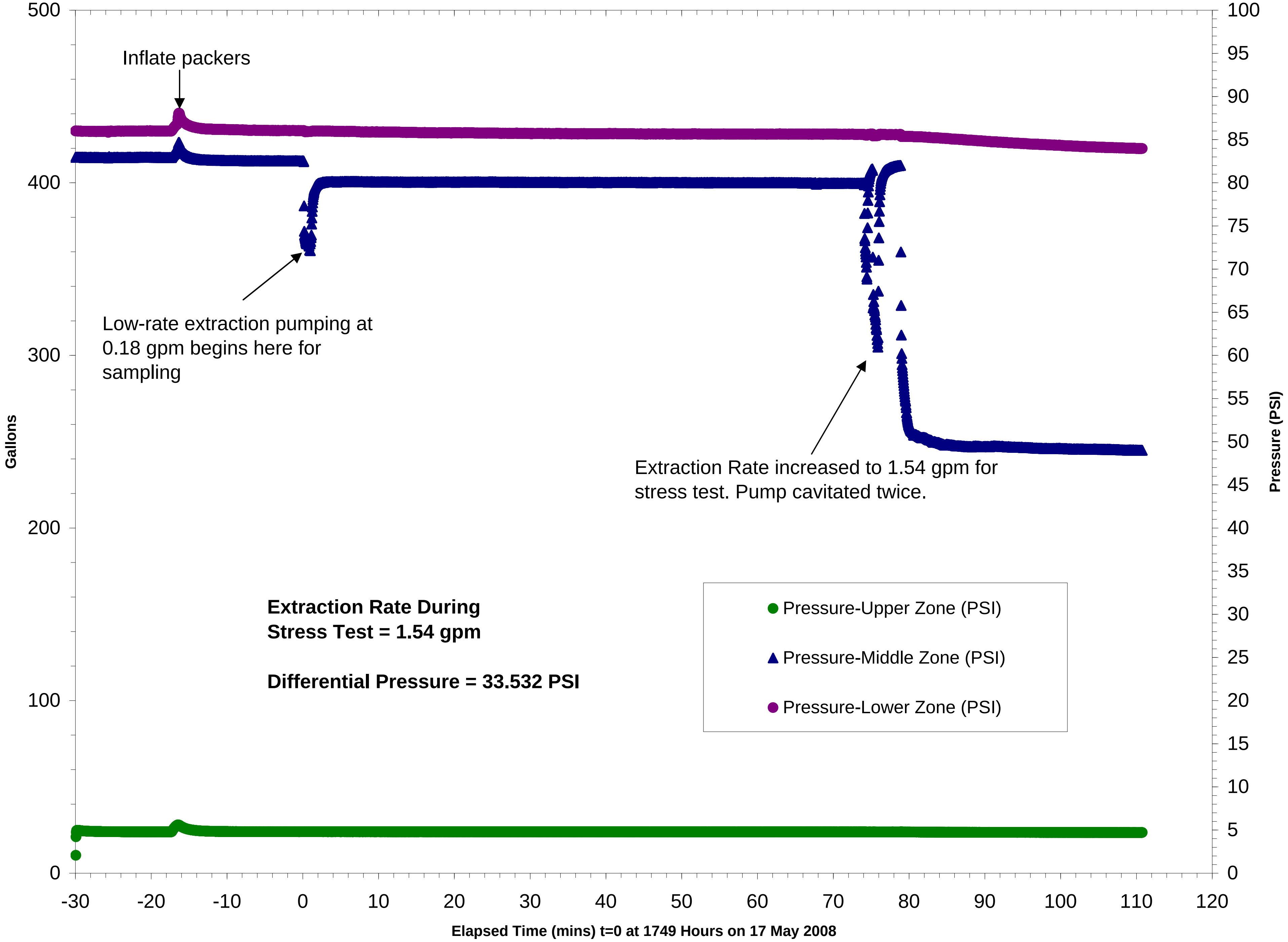


Table DW-2:4. Summary Of Wireline Straddle Packer Testing With Hydraulic Conductivity And Transmissivity Estimations; Weston Solutions; MEFUDS; LO-58; Caribou, ME; Wellbore: DW-2

Well Name	DW-02
Ambient Depth to Water (ftbtoc)	4.94
Diameter of Borehole (ft)	0.52
Effective Radius (ft)	300

Interval No.	Top of Interval (ft)	Bottom of Interval (ft)	Length of Interval (ft)	Differential Pressure (PSI)	Differential Head (feet)[1]	Interval Specific Flow Rate: WSP Stress Test (gpm)	Interval Specific Hydraulic Conductivity[4] (ft/day)	Transmissivity (ft2/day)	Interval Specific Fluid Electrical Conductivity (microS/cm)
1	16.0	20.0	4.0	0.120	0.277	0.01	1.46E+01	5.83E+01	430
2	28.5	32.5	4.0	1.440	3.326	4.02	4.89E+02	1.95E+03	450
3	37.0	41.7	4.7	3.935	9.088	1.97	7.46E+01	3.50E+02	451
4	94.5	98.5	4.0	34.807	80.386	1.66	8.35E+00	3.34E+01	435
5	187.9	192.2	4.3	33.532	77.441	1.54	7.48E+00	3.22E+01	438
6*	265.0	284.0	19.0	56.592	130.697	0.41	2.67E-01	5.07E+00	225

* The reported bottom depth of this interval is the total depth (TD) of the borehole.

[1] Differential Head is the difference between ambient pressure and pumping pressure, converted to feet.

APPENDIX A

STANDARD OPERATING PROCEDURES FOR HYDROPHYSICAL™ LOGGING

Standard Operating Procedures
HydroPhysical™ Logging for Aquifer Characterization

1. Purpose

Application of the HydroPhysical™ (HpL™) logging method to analyze and determine:

- The location of hydraulically conductive intervals within a wellbore
- The interval specific rate of inflow during well production, in conjunction with the drawdown data, can be used to estimate interval specific hydraulic conductivity or transmissivity
- Ambient (non-pumping) flow conditions (inflow and outflow rates, and locations)
- The hydrochemistry (fluid electrical conductivity (FEC) and temperature) of the associated formation waters

In addition, when downhole, discrete point fluid sampling is coupled with the HydroPhysical™ Logging technique, analysis of the actual contaminant concentrations associated with each identified conductive interval is accomplished for any aqueous phase contaminant.

2. Equipment and Materials

This SOP specifically applies to application of the technique using COLOG's HydroPhysical™ Logging Truck 16, which has been specially configured to handle those field conditions associated with small diameter, low-moderate yield wells The maximum capability of the van is to a total depth of 700 ft and 350 ft total drawdown (maximum depth to water) . In the event of high yield wells, the wireline capability of any COLOG truck can be used to accompany fluid management equipment.

- HydroPhysical™ logging truck field equipment includes:

- Fluid management system
    - Back Pressure Regulator or orifices
    - Rubber hose (0.75-inch i.d.) for injection
    - Submersible Pump
    - Evacuation Line
    - Storage tanks (as required) with inlet/outlet valves
    - Surface Pump
    - Fluid management manifold/Monitoring Panel
    - Data Acquisition System (for recording volumes, flow rates, time)
    - Wireline System
    - Wireline winch unit
    - Depth encoder
    - Water level indicator
    - Computer System

  - HydroPhysical™ Logging tool
  - Downhole Fluid Sampler
- Deionizing Units
- Deionized water (prepared with wellbore fluids or transported on-site)
- Standard Reference Solutions - Electrical conductivity reference solutions (set of 3 solutions).

3. Procedures

1.) Review well construction details and complete general well information sheet. The HydroPhysical™ logging technique involves dilution of the wellbore fluids with DI water and profiling of the wellbore dynamics using a HydroPhysical™ logging tool. Significant aberrations or reductions in the borehole diameter should be identified as the downhole equipment can become lodged in the borehole. Additionally, application of the technique requires certain wellbore conditions:

- In open bedrock boreholes, casing must be installed through the overburden and grouted at the rock/alluvium interface to inhibit water leakage into the borehole from the saturated alluvium. For cased boreholes, the well should be fully cased and gravel packed with single or multiple screened intervals;
- The diameter of the borehole must be approximately 4 inches or greater for application with the slim-tool (1.5-inch o.d.). Two inch i.d. boreholes may be tested using the slug test approach described in Section 5.
- For newly drilled wells, cuttings and drill fluids must be removed from the affected fractures by standard well development procedures.

2.) Review and record additional wellbore construction/site details and fill out the general well information form which includes the following information:

- Ambient depth-to-water
- Depth of casing
- Total depth of well
- Lithology (if available)
- Estimated well yield and any available drawdown data
- Type and concentration of contamination

3.) Prepare the deionized (DI) water. Consult with DI water tank firm for assistance if necessary. If DI water has not been transported to the site, surface or groundwater may be used if it is of suitable quality Generally source water containing less than 1000 micro Siemens per centimeter (µS/cm) and less then 200 ppb VOCs will not significantly affect the deionizing units, but this should be confirmed with DI water firm. If the groundwater from the well under construction cannot be used for DI water generation, then DI water must be transported to the site and containerized at the wellhead.

Depending on the amount of HydroPhysical™ testing to be performed (ambient and/or during production) the typical volume of DI water required for each borehole is approximately three times the volume of the standing column of formation water in the wellbore per type of HydroPhysical™ characterization.

If preparation takes place on site, pump the source water through a pre-filter, to the deionizing units, and into the storage tanks.

Monitor the FEC of the DI water in-line to verify homogeneity; the target value is 5 to 25 µS/cm.

4.) Calibrate the HydroPhysical™ logging tool using standard solutions prepared and certified by a qualified chemical supply manufacturer. Fill out tool calibration form following the steps defined in the software program, "tools" under the directory, calibration. Also use a separate field temperature / FEC / pH meter to support calibration data. Record the results of the tool calibrations, specifically noting any problems on the tool calibration form. Also record the certification number of the standard solutions.

5.) Set datum on the depth encoder with the FEC sensor on the tool as 0 depth at the top of casing. If inadequate space is available at the wellhead, measure 10 feet from the FEC sensor up the cable (using measuring tape) and reference with a wrap of electrical tape. Lower the tool down the hole to the point where the tape equals the elevation at the top of the casing and reference that as 10 feet depth on the depth encoder.

6.) Place the top of the tool approximately 3 feet below the free-water surface to allow it to achieve thermal equilibrium. Monitor the temperature output until thermal stabilization is observed at approximately ± .02 °C.

7.) After thermal stabilization of the logging tool is observed, log the ambient conditions of the wellbore (temperature and FEC). Fill out the water quality log form. During the logging run, the data are plotted in real time in log format on the computer screen and, the data string is simultaneously recorded on the hard drive.

Log the ambient fluid conditions in both directions (i.e. record down and up). The ideal logging speed is 5 feet per minute (fpm). For deeper wells the logging speed can be adjusted higher, but the fpm should not exceed 20.

At completion of the ambient log, place the tool approximately 10 feet below the free water surface. The tool will remain there during equipment set up as long as borehole conditions permit. Establish and record ambient depth to water using top of protective casing as datum.

8.) Attach back pressure regulator or orifice, if used, and weighted boot, to end of emplacement line and secure. Insure that the injection line is of adequate length to reach the bottom of the wellbore.

9.) Lower the flexible emplacement line to the bottom of the well allowing one foot of clearance from the well bottom to the outlet of the injection line.

10.) Lower tool about 10 feet below the water surface. The tool will be stationed beneath the submersible pump during non-logging times.

11.) Lower submersible pump in the well to a depth just above the logging tool. Record approximate depth of the pump location.

12.) Record all initial readings of gauges at elapsed time 0.0 minutes. Fill out well testing data form.

13.) Mark hoses with a round of electrical tape for reference. In addition, establish datum for tool depth to the nearest foot and mark on wire with wrap of tape. Reset datum on optical encoder for this depth.

14.) When ambient flow characterization is to be conducted, it should be done now, before disturbing the aquifer (i.e. by pumping). Fill out ambient flow characterization (AFC) form. Skip to Section 17 for procedures.

15.) After AFC, if performed, conduct a controlled, short term well production test (pump test) to characterize the overall hydraulics of the wellbore (drawdown at given pumping rate provides total well transmissivity or yield) and to make an initial assessment of formation water hydrochemistry. Begin pumping at a total extraction flow rate appropriate for wellbore under investigation (see Section 4 Special Notes). During this period, record elapsed time of pumping, depth to water, total gallons extracted, and extraction flow rate at approximately one minute intervals.

During extraction, log the fluid column continuously until at least three wellbore volumes have been extracted from the wellbore, or a stabilized water level elevation is obtained.

Review fluid logging results to verify that true formation water is present within the affected borehole interval and that the vertical distribution of water quality parameters within this interval is stable.

16.) Review data obtained during the pumping test to determine DI water emplacement and pumping/logging procedures. Extraction procedures for detection and characterization of hydraulically conductive intervals and the formation water hydrochemistry are determined based on the pumping test information. The emplacement, testing and pumping procedures will differ depending upon well yield and determined lengths of intervals of interest. In wellbore situations where intervals of interest are small (less than 30 feet) and hydraulic characteristics observed during borehole advancement and preliminary hydraulic testing indicate hydraulically conductive intervals with extremely low flow rates (i.e. <0.10 gpm/foot of drawdown), a slug testing procedure can be employed. In wellbore cases where the preliminary hydraulic testing indicates low to moderate total yield (i.e. 0.10 < Q < 4 gpm/foot of drawdown), constant low flow rate pumping after DI water emplacement procedures can be employed. In wellbore situations where intervals of interest are large, and high total yield (i.e. > 4 gpm/foot of drawdown) is observed, constant pumping during DI water injection procedures will be employed.

17.) When the fluid column is to be replaced with DI water, (vertical flow characterization, slug testing, logging during pumping after DI water emplacement) the following emplacement procedures apply:

Pump the DI water to the bottom of the wellbore using the surface pump and the injection riser. Simultaneously use the submersible pump to maintain a stable, elevated total head by extracting groundwater from near the free-water surface. When groundwater from the subject well is used for DI water generation, generate DI water from the extracted formation water and re-circulated to the well bottom via the solid riser.

Use the water level meter to observe the elevated total head during emplacement. If borehole conditions permit (i.e. the absence of constricted borehole intervals), the logging tool is used to monitor the advancement of the fluid up the borehole as it displaces the standing formation water. Draw the logging tool up the wellbore in successive increments as the DI water is emplaced. Monitor the electrical conductivity of the fluid expelled from the evacuation pump during emplacement procedures. When FEC values are representative of the DI water, or sufficiently diluted formation water, terminate emplacement procedures.

Emplacement is complete when DI water, or sufficiently diluted formation water, is observed from the evacuation pump or when logging tool stationed near the pump indicates DI water or sufficiently diluted formation water.

Upon completion, turn off the evacuation pump. Then turn off the injection line.

18.) Record volumes of extracted and injected fluids on the well testing data form. Calculate the volume of DI water lost to the formation.

19.) Take initial background HydroPhysical™ log, or begin continuous logging depending upon extraction method (i.e. slug vs. continuous).

20.) Pumping and testing procedures vary depending upon wellbore hydraulics and construction detail.

21.) Continuous logging is conducted until stabilized and consistent diluted FEC logs are observed. If inflow characterization at a second pumping rate is desired, increase extraction rate and assure the proper DI water injection rate. Perform continuous logging until stabilized and consistent FEC logs are observed and all diluted formation water is re-saturated with formation water.

22.) After stabilized and consistent FEC traces are observed, terminate DI water injection. Reduce the total extraction flow rate to the net formation rate and conduct continuous logging. Conduct logging until stable and consistent FEC values are observed.

23.) Conduct depth specific sampling at this time.

24.) At the conclusion of the above procedures, assess the wellbore fluid conditions and compare them with those observed during the original pumping (Step 14).

25.) Turn all pumps off. First remove the extraction pump from the borehole. During removal, thoroughly clean the evacuation line (2-inch o.d.) with a brush and alconox and rinse DI water. Also clean the outside of the pump. Place the pump in a drum of DI water and flush DI water through the system.

Remove the tool. Clean the wireline for the tool in a similar manner during its withdrawal from the borehole.

Remove the injection line from the well. Follow the same procedures when cleaning the injection line as for the evacuation line.

Store the pumps and logging tools properly for transport.

Place cover on well and lock (if available).

4. Special Notes

On-site pre-treatment of groundwater using activated carbon, can be conducted prior to DI water generation, if there is a contaminated groundwater source. In addition, on-site treatment can also be considered to handle extracted fluids that would require containerization and treatment prior to disposal.

The rate(s) of pumping are determined by drawdown information previously obtained or at rate(s) appropriate for the wellbore diameter and saturated interval thickness. The appropriate extraction rate is a function of length of saturated interval, borehole diameter, and previous well yield knowledge. The appropriate pumping procedures to be employed are also dictated by the length of the exposed rock interval. In general, the extraction flow rate should be sufficient to induce adequate inflow from the producing intervals. The concern is that the extraction flow rate does not cause extreme drawdown within the well i.e. lowering the free water surface to within the interval of investigation.

5. Discussion

LOW YIELD: Extraction Slug Test After DI water Emplacement

In wells with very low total flow capability (i.e. < 0.10 gpm/foot of drawdown), perform a slug test in accordance with procedures developed by Hvorslev (1951). Rapidly extract a small volume of water from near the free water surface using the extraction riser and pump. A drop in piezometric head of about 2 feet should be adequate for the initial test. Record the rise in the free water surface with time and develop a conventional time-lag plot.

When the free water surface has recovered to a satisfactory elevation, log the wellbore fluid conditions. Repeat the procedures described above with successive increases in the drop of piezometric head (or volume extracted). Let the wellbore recover and record the rise in the free water surface. Repeat logging of the wellbore fluid after the free water surface has recovered to a satisfactory elevation. The number of slug tests performed is determined in the field after review of previous logging results.

MODERATE YIELD: Time Series HydroPhysical™ Logging During Continuous Pumping After DI water Emplacement

In the case of moderate yield wells (i.e. 0.10 < Y < 4 gpm/foot of drawdown), maintain a constant flow rate from the evacuation pump and record the total volume of groundwater evacuated from the wellbore. Employ a continuous reading pressure transducer (or equivalent device) to monitor the depressed total head during pumping, along with the associated pumping rate.

Hold the flow rate from the evacuation pump constant at a rate determined for the specific borehole. <u>Drawdown of the free water surface produced during pumping should not overlap any identified water producing interval.</u> Conduct hydrophysical logging continuously. The time interval is a function of flow rate and is specific to each well. The number of logging runs and the length of time required to conduct all loggings is a function of the particular hydraulic conditions. Logging and pumping is continued until the fluid column is re-saturated with formation water (i.e. all DI water is removed from the borehole).

HIGH YIELD: Time Series Wellbore Fluid Logging During Continuous Pumping and Simultaneous DI Water Injection

When wells exhibit high yield (> 4 gpm/foot of drawdown), as determined by a review of the interval of interest, the borehole diameter and the results obtained from previous information and preliminary hydraulic testing, the appropriateness of time series fluid logging during continuous pumping and simultaneous DI water injection is determined.

In this case, maintain a constant flow rate from the evacuation pump and record this rate and the associated drawdown. During this period, conduct hydrophysical logging until reasonably similar HydroPhysical™ logs are observed and stabilized drawdown is achieved. After reasonably similar downhole fluid conditions are observed and simultaneous with extraction pumping, inject DI water at the bottom of the well at a constant rate of 10 to 20% of that employed for extraction. Increase the total rate of extraction to maintain total formation production reasonably similar to that prior to DI water injection (i.e. increase the total extraction by amount equal to the DI water injection rate).

Periodically record the total volume and flow rate of well fluids evacuated and the total volume and flow rate of DI water injected. Use a continuous reading pressure transducer or similar device to monitor the depressed total head during pumping. Record the depressed total head (piezometric surface) periodically, with the associated pumping and injection data.

The evacuation and DI water injection flow rates are held constant at a rate determined for the specific wellbore. Drawdown of the free water surface during pumping must not overlap any identified water producing intervals. HydroPhysical™ Logging is conducted continuously. The number of logging runs and the length of time required to conduct all loggings is a function of the particular hydraulic conditions exhibited by the well under investigation.

APPENDIX B

BORE II MODELING SOFTWARE

LBNL-46833

BORE II – A Code to Compute Dynamic Wellbore Electrical Conductivity Logs with Multiple Inflow/Outflow Points Including the Effects of Horizontal Flow across the Well

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Abstract

Dynamic wellbore electrical conductivity logs provide a valuable means to determine the flow characteristics of fractures intersecting a wellbore, in order to study the hydrologic behavior of fractured rocks. To expedite the analysis of log data, a computer program called BORE II has been developed that considers multiple inflow or outflow points along the wellbore, including the case of horizontal flow across the wellbore. BORE II calculates the evolution of fluid electrical conductivity (FEC) profiles in a wellbore or wellbore section, which may be pumped at a low rate, and compares model results to log data in a variety of ways. FEC variations may arise from inflow under natural-state conditions or due to tracer injected in a neighboring well (interference tests). BORE II has an interactive, graphical user interface and runs on a personal computer under the Windows operating system. BORE II is a modification and extension of an older code called BORE, which considered inflow points only and did not provide an interactive comparison to field data. In this report, we describe BORE II capabilities, provide a detailed user's guide, and show a series of example applications.

1. Introduction

The variation of formation permeability surrounding a wellbore is useful information not only for identifying hydraulically conducting fractures or other high-conductivity features intercepted by the well, but also for quantifying the heterogeneity of the medium. These are essential data in the evaluation of in-situ flow and transport characteristics at a given site.

Methods to evaluate permeability values along the depth of a well include the packer method, in which constant pressure, constant flow, or pulse tests are conducted in packed-off intervals in a wellbore, and various downhole flow meters. The packer method has the disadvantage that it is very time consuming and costly, and the vertical resolution is limited by the interval between the two packers that can be set in the well. Flow meter methods such as spinners and heat pulse flow meters generally allow better vertical resolution than the packer method, but they are not as accurate in determining permeability, because they mostly measure the wellbore fluid velocity, which is very sensitive to variations in the wellbore radius.

In 1990, Tsang et al. (1990) proposed a method using logs of fluid electric conductivity (FEC) at successive times under constant-pumping conditions to obtain inflow from the formation into the well as a function of depth in the well. In this method, the wellbore is first filled by de-ionized water or water of a constant salinity (i.e., ion concentration) distinct from that of the formation water. This is usually done by passing the de-ionized water down a tube to the bottom of the wellbore at a given rate while simultaneously pumping at the top of the well at the same rate. After this is done, the well is pumped at a constant flow rate, which can be adjusted to optimize wellbore flow conditions. An electric resistivity probe is lowered into the wellbore to scan FEC as a function of depth along the wellbore. This is what is called fluid conductivity logging. A series of five or six such logs are obtained at time intervals over a one- or two-day period. At the depth levels where water enters the wellbore, the conductivity log displays peaks, which grow with time and become skewed in the direction of water flow. By analyzing these logs, it is possible to obtain the permeability and salinity of each hydrologic layer transmitting water. The method has been very successful, being much more accurate than flow meters and much more efficient (much cheaper) than packer tests (Tsang et al. 1990), particularly in low permeability formations. A typical 1000-m section in a deep hole can be tested in two or three days at a spatial resolution of ~0.10 m all along the length of the wellbore section. The method is now being widely used in Europe and the U.S. (Marschall and Vomvoris, 1995; Pedler et al., 1992; Bauer and LoCoco, 1996), both under natural-state flow conditions and while tracer is injected in a neighboring well (i.e., interference tests).

Along with the method, a code was developed called BORE (Hale and Tsang, 1988), which performed the forward calculation to produce wellbore FEC profiles given different inflow positions, rates, and concentrations. The code has been well used over the last decade. However, it appears now that there is a need to revise the code to make it more suitable for current computer environments and to add new capabilities. Thus, the code has been updated to run under current operating systems, provide interactive modification of model parameters, and produce graphical comparisons between model and field data. More importantly, the revised code allows the possible inclusion of both flows into and out of the well at various depths, a feature that has been observed in real field conditions when different layers penetrated by the well have different hydraulic heads. Furthermore, the new code allows the calculation of the case with equal inflow and outflow at the same depth level, which is effectively the special case of horizontal flow across the wellbore. Drost (1968) proposed a measurement of solute dilution in the wellbore to evaluate ambient horizontal flow velocity in the formation and it has become a well-accepted method. The new code provides the opportunity to analyze such cases and to identify the depth interval of horizontal flow to within ~0.1 m as well as to estimate the flow rate. Moreover, one can analyze the combination of horizontal flow across the wellbore and vertical diffusion or dispersion along the length of the wellbore, which is not possible with Drost's solution.

The report is organized as follows. In Section 2, the basic capabilities of the revised code, called BORE II, are described, and the key parameters associated with BORE II are defined. Details of the mathematical background and numerical approach are described in Appendix 1, which is adapted from Hale and Tsang (1988). A user's guide is presented in Section 3, which includes a description of BORE II's interactive user interface, required input items, and options available when running BORE II. Four example applications are given in Section 4 to conclude the report.

We are still open to further improvements of BORE II; any suggestions and comments are invited and should be addressed to the authors.

2. BORE II Capabilities

BORE II calculates FEC as a function of space and time in a wellbore containing multiple feed points given the pumping rate of the well, the inflow or outflow rate of each feed point, its location and starting time, and, for inflow points, its ion concentration. A simple polynomial correlation between ion concentration, C, and FEC is assumed. Ion transport occurs by advection and diffusion along the wellbore, with instantaneous mixing of feed-point fluid throughout the wellbore cross-section. These assumptions allow use of a one-dimensional model. BORE II divides the wellbore section under study into equal height cells and solves the advection/diffusion equation using the finite difference method. Further details of the mathematical and numerical approach are given in Appendix 1.

Inflow and Outflow Feed Points

The original BORE code (Hale and Tsang, 1988) considered inflow points only, so flow through the wellbore was upward at all depths. BORE II allows both inflow and outflow points, so flow in the wellbore can be upward, downward, or horizontal at different depths and flow at either end of the wellbore section being studied can be into or out of the wellbore section or be zero. By convention, upward flow in the wellbore is positive and flow into the wellbore is positive.

Steady and Varying Fluid Flow

The original BORE code considered steady fluid flow, so feed points had constant flow rates. They also had constant concentrations, but delayed starting times for feed-point concentration to enter the wellbore were allowed. BORE II permits both steady and varying fluid flow. For the steady-flow case, the user specifies flow rate, concentration, and concentration start time for each feed point, but for outflow points (those with negative flow rates) the concentration and concentration start time are not used. Variable flow rate or concentration can be specified for feed points by interpolating from a table of time, flow rate, and concentration. If a table includes both positive and negative flow rates (i.e., a feed point alternates between inflow and outflow), the concentration for the positive flow rate is used when interpolating between positive and negative flow rates.

Concentration Boundary Conditions

If the flow at the top of the wellbore section under study is into the wellbore, the initial concentration for the uppermost cell in the wellbore is used as the inflow concentration. Analogously, if flow at the bottom of the wellbore section is a flow up from greater depths, the initial concentration for the lowermost cell in the wellbore is used as the inflow concentration. Furthermore, for inflow points with a concentration start time greater than zero, the initial concentration of the wellbore is used as the inflow concentration for times less than concentration start time.

Horizontal Flow

The special case of horizontal flow through the wellbore, as described by Drost (1968), can also be considered, by locating an inflow point and an outflow point with equal magnitude flow rates at the same depth. The flow rates may be specified as either (1) the Darcy velocity through the aquifer or (2) the volumetric flow rate into/out of the wellbore. BORE II multiplies Darcy velocity by the cross-sectional area of the feed point (wellbore diameter times cell height) and Drost's α_h convergence factor to convert it to a volumetric flow rate. The value of α_h can range from 1 (no convergence) to 4 (maximum possible convergence, which occurs for the case of a thick, highly-permeable well screen). Drost suggested that for a uniform aquifer with no well screen, $\alpha_h = 2$, and that for typical applications, a good choice for α_h is 2.5. Horizontal flow feed points may have time-varying flow rates, but for Darcy-velocity calculations to make sense, the inflow and outflow rates must be equal and opposite at any time. Thus, if a feed point location changes from a horizontal flow point to a non-horizontal flow point with time, volumetric flow rates must be specified rather than Darcy velocities.

BORE II Parameters

The key parameters associated with BORE II are defined below.

Parameter	I/O units*	Description
C	g/L	Ion concentration in the wellbore; converted to FEC using FEC $= \gamma + \beta C + \alpha C^2$, where α, β, and γ are user-specified constants (default values are provided in the code, see Section 3)
C_i	g/L	Ion concentration of *i*th feed point
C_0	g/L	Initial ion concentration in wellbore
D_0	m^2/s	Diffusion coefficient (may include dispersive effects as well molecular diffusion)
d_w	cm	Wellbore diameter (assumed constant)
FEC	μS/cm	Fluid electrical conductivity
q	L/min	Fluid flow rate in wellbore (upward flow is positive)
q_i	L/min	Fluid flow rate of *i*th feed point; positive for inflow and negative for outflow
q_w	L/min	Fluid flow rate in wellbore at $x_{\max}$, specified by the user
q_0	L/min	Fluid flow rate in wellbore at $x_{\min}$ (or any depth of interest), calculated internally
T or TEMP	^{o}C	Temperature (assumed constant)
t	hr	Time
$t_{\max}$	hr	Maximum simulation time
t_{0i}	hr	Concentration start time of *i*th feed point
v_d	m/day	Darcy velocity through aquifer for horizontal flow ($q_i = v_d \alpha_h \Delta x\, d_w$)
x	m	Depth (positive, increases down the wellbore)
$x_{\min}$, $x_{\max}$	m	Top and bottom, respectively, of wellbore interval being studied
Δx	m	Cell height for wellbore discretization
α_h	–	Drost (1968) convergence factor for horizontal flow

*I/O units are chosen for convenience; all quantities are converted to SI units before BORE II calculations.

3. BORE II User's Guide

Operating System

BORE II may be run under Windows 95, 98, or 2000 by double-clicking the executable icon (BOREII.EXE) in Windows Explorer, by double-clicking on a desktop shortcut key to BOREII.EXE, or by typing BOREII in the Run command in the Start Menu or in a DOS-prompt window. BORE II will not run in stand-alone DOS or in the DOS-mode of Windows. BORE II was compiled using Microsoft Fortran PowerStation™ Version 4.0, but this software is not necessary to run the program.

BORE II Graphical Output

The primary user interface with BORE II is interactive, with the user responding to on-screen prompts to modify model parameters and choose options (described below) for the real-time graphical display of model results and data. The basic BORE II output screen consists of three windows.

- The borehole profile window shows FEC profiles as a function of depth and time. Simulation time t is shown in the upper left corner. Fluid flow rate at a user-specified depth in the wellbore, q_0, is shown in the middle of the top line (the depth at which q_0 is calculated is set by option P). The depth of a C-t plot is also shown.

- The inflow parameters window shows the feed-point characteristics for the model that can be modified with option M (location, flow rate, and concentration). Often there are more feed points than can be displayed at once on the screen. BORE II starts out showing the first few (deepest) feed points, then shows the feed points in the neighborhood of any point that is being modified.

- The dialog window allows the user to select options (described below) when running BORE II.

On computers with small screens, it may be desirable to run BORE II in full-screen mode, so that the entire BORE II screen can be seen at once without scrolling. Full-screen mode is entered by pressing Alt-VF (or on some computers by pressing Alt-Enter). Pressing Esc (or Alt-Enter) terminates full-screen mode. There are three potential problems associated with the use of full-screen mode.

(1) The status line describing what BORE II is doing (e.g., running, waiting for input) is not visible.

(2) Drawing an x-t plot (options X, S, D, F, and I), which creates a new window, may be very slow and the graphics quality poor.

(3) On some computers, text is difficult to read after closing the x-t plot window.

To address the latter two problems, one may terminate full-screen mode before using options X, S, D, F, and I. The new window will be small, but after drawing is complete it may be expanded by pressing Alt-VF to enter full-screen mode. Full-screen mode should be terminated before the new window is closed to avoid the final problem.

To print an image of the screen, press Alt-PrintScreen to copy the screen image into the clipboard. Then open a program such as Microsoft Paint and paste in the image. It can be manipulated, saved in a variety of graphics formats, or printed from Paint. The image can also be pasted directly into another Windows application such as MS Word.

Input/Output File Overview

Running BORE II requires one or two external files: a file with an initial set of model input parameters (mandatory, known as the input file) and a file with observed data (optional, known as the data file). These files are plain ASCII text, and must reside in the same folder as the BORE II executable. The input file contains model parameters such as the depth interval being studied, feed point characteristics, problem simulation time, and *C*-to-FEC conversion factors. The data file contains observed values of FEC and temperature, and optionally contains other fluid properties such as pH. Detailed instructions for preparing an input file and a data file are given below.

BORE II always creates a temporary file, called BOREII.TMP (see options C and R), and optionally creates a new input file (see option V), which is useful if model parameters have been changed during the BORE II run.

Line-by-line Instructions for Input File

After starting BORE II, the user is prompted to choose the input file from the list of files residing in the folder where the BORE II executable is. Input file names with more than 8 characters before a period or blanks will appear in the list of files in an abbreviated form. File names can be at most 20 characters long.

A sample input file is provided that can be modified as needed using a text editor such as Notepad or a word processor such as MS Word. If a word processor is used to create or modify an input file, be sure that the file is saved as plain ASCII text.

The input file is designed to be self-documenting, with header lines preceding data lines. These header lines must be present, but BORE II does not use the text on them. Data entries are read in free format, with individual entries on a given line separated by blanks, tabs, or commas. This means that entries cannot be left blank, even if they are not being used (e.g., concentration for an outflow point). Unused entries may be set to zero or any convenient value. Comments may be added on data lines, after the requisite number of entries. In the sample input file, comments begin with an exclamation point.

Item	Computer Variables	Unit	Description
1.	TITLE	–	A description of the problem, 80 characters maximum
2 header for wellbore geometry			

2.	RXMIN	m	Top of study area, x_{min}
	RXMAX	m	Bottom of study area, x_{max}
	RDIAM	cm	Wellbore diameter, d_w
3 header for flow parameters			
3.	RQW	L/min	Flow into (positive) or out of (negative) the bottom of the study area, q_w
	HALPHA	–	Factor to account for convergence of horizontal flow lines toward the wellbore, α_h (Drost, 1968) Range: 1.0 – 4.0; default value: 2.5 Only used for horizontal flow

4 header for feed points			
4.	IINFN	–	Number of feed points (maximum 180)
	IQFLAG	–	Variable flow-rate flag – a 3 digit integer used to identify feed points with variable flow (suggested value 999)
5 header for constant- flow-rate feed points			
5. Repeat IINFN times	RINFX	m	Location of feed point, x_i * For horizontal flow put two feed points at the same location, with equal magnitude, opposite sign flow rates
	RINFQ	L/min (m/day if IINFV=1)	Constant inflow rate (positive) or outflow rate (negative) of feed point, q_i For a variable flow rate, set RINFQ = IIIJJ, where III = IQFLAG, and JJ is a two digit integer giving the number of times in the variable-flow-rate table, which follows in 5a For horizontal flow, v_d replaces q_i if IINFV = 1
	RINFC	g/L	Constant feed point concentration, C_i - only used for inflow points For a variable concentration, set RINFQ = IIIJJ, where III = IQFLAG, and JJ is a two digit integer giving the number of times in the variable-flow-rate table, which follows in 5a
	RINFT	hr	Start time for constant feed point concentration, t_{0i} - only used for inflow points Feed point concentration is C_0 of cell containing feed point for t < t_{0i}
	IINFV	–	Horizontal flow Darcy-velocity flag (must be zero for non-horizontal flow case): = 0: RINFQ is flow rate q_i into/out of the wellbore in L/min = 1: RINFQ is +/–Darcy velocity v_d through the aquifer in m/day

5a header for variable-flow-rate table (only when RINFQ = IQFLAGJJ)			
5a. Repeat JJ times when RINFQ = IQFLAGJJ	RINFQT	hr	Time t_j (set $t_1 = 0$, set $t_{JJ} > t_{\max}$)
	RINFQQ	L/min (m/day if IINFV=1)	Volumetric flow rate q_j at time t_j For horizontal flow, v_d replaces q_j if IINFV = 1
	RINFCC	g/L	Concentration C_j at t_j
6 header for misc. parameters			
6.	TMAX	hr	Maximum simulation time, $t_{\max}$
	DPYMAX	μS/cm	Maximum FEC for plots
	RK	m^2/s	Diffusion coefficient, D_0
7 header for C-to-FEC conversion			
7.	RGAMMA	μS/cm	Conversion from C in g/L to FEC in μS/cm: FEC = $\gamma + \beta C + \alpha C^2$ Default values (for 20°C): $\gamma = 0$, $\beta = 1870$, $\alpha = -40$ Set $\gamma = 0$, $\beta = 1$, $\alpha \approx 1.e\text{-}8$ for FEC $\approx C$
	RBETA	[μS/cm]/ [g/L]	
	RALPHA	[μS/cm]/ $[g/L]^2$	
8 header for initial conditions			
8.	IC0FLAG	–	Initial concentration flag: = 0: $C_0 = 0$, no further input for item 8 < 0: read uniform non-zero C_0 in 8a > 0: read IC0FLAG (x,$C_0(x)$) pairs in 8b to describe variable initial concentration
8a header for uniform initial conditions (only when IC0FLAG < 0)			
8a. when IC0FLAG<0	RC0	g/L	Uniform non-zero C_0
8b header for non-uniform initial conditions (only when IC0FLAG > 0)			
8b. repeat IC0FLAG times when IC0FLAG>0	RX	m	x value*
	RC0	g/L	$C_0(x)$
9 header for data file name			
9.	CFDATA	–	Name of data file, 20 characters maximum; 'NONE' if there is no data file

*see Appendix 1, Section A1.5, for additional information on locating feed points and specifying non-uniform initial conditions

Sample Input File

An input file illustrating many of these options is shown below. Text or numbers following an exclamation point (!) are comments, and are not used by BORE II.

```
TITLE: Sample Input File with flow from below, horizontal flow, variable
flow
XMIN(m)     XMAX(m)     DIAM(cm)
.0000       60.00       7.600
QW(L/min)   HALPHA      !QW=flow from below; HALPHA=hor. flow
constriction
 0.50       0.          !default value of HALPHA will be used
#FEED_PTS   VARIABLE_FLOWRATE_IDENTIFIER
   4               999
DEPTH(m)    Q (L/min)    C(g/L)      T0(hr)      Q/V_FLAG
 25.        +1.          6.0         .0000       1 !1st 2 feed pts-hor.
flow
 25.        -1.          6.0         .0000       1 !C & T0 not used
(outflow)
 30.        99905.       6.0         .0000       0 !C & T0 not used
(table)
     T(hr)       Q(L/min)    C(g/L)      !#entries is two digits after
999
      .0000       .0000        6.        !first time in table is zero
      .3000       .2800E-01    5.
      .5000       .3200        4.
      1.000       .4600        3.
      1.500       .4600        2.        !last time in table is > tmax
 35.        .5           4.0          .2000      0 !final feed pt
TMAX(hr)    FECMAX      DIFFUSION_COEF.(m2/s)
 1.000      5000.       .7500E-09
RGAMMA      RBETA       RALPHA      !FEC = RGAMMA + C*RBETA + C*C*RALPHA
0.          0.          0.          !default values will be used
IC0FLAG     !If 0, C0=0; If <0, read one C0; If >0,read IC0FLAG (X,C0)
pairs
    1
X(m)        C0(g/L)           !#entries is IC0FLAG
60.         2.                !Concentration associated with Qw
DATA_FILE   !'NONE' if there is no data file
NONE
```

The first two feed points represent constant horizontal flow, and since the Q/V flag (IINFV) is one, flow rate is given as Darcy velocity through the aquifer in m/day. The third feed point has variable flow rate and concentration, with a five-entry table specifying the variation with time. The fourth feed point is an inflow point with constant flow rate and concentration and a non-zero concentration start time.

Note that the flow from below, q_w, is positive (into the wellbore section), so the corresponding concentration is specified as the initial condition of the lowermost cell in the wellbore (at $x = x_{min}$) by using IC0FLAG = 1. If IC0FLAG = 0, the concentration associated with q_w would be zero, and if IC0FLAG = -1, the concentration associated with q_w would be the uniform non-zero initial concentration in the wellbore.

When BORE II writes an input file (option V), it changes several things to the file form shown above. Comments found in the original input file are not reproduced, but two comments are added. First, the cell height and the equation used to calculate it are shown on the line with x_{min}, x_{max}, and d_w. Second, if feed points represent horizontal flow, then the flag IINVF is set to 0, flow rate is given in L/min, and the corresponding Darcy velocity through the aquifer in m/day is added as a comment. Finally, if IC0FLAG > 0, BORE II sets IC0FLAG to the number of wellbore cells, and explicitly shows every (x, $C_0(x)$) pair. This option is useful for identifying the *x* values of various cells, which may expedite assignment of feed point locations or initial conditions. Part of the input file created by BORE II for the above sample is shown below.

```
TITLE: Sample Input File with flow from below, horizontal flow, variable
flow
XMIN(m)     XMAX(m)     DIAM(cm)    !DX(m) = MAX(|XMIN - XMAX|/180,
DIAM/100)
 .0000       60.00       7.600      ! .3333
QW(L/min)   HALPHA      !QW=flow from below; HALPHA=hor. flow
constriction
 .5000       2.500
#FEED_PTS   VARIABLE_FLOWRATE_IDENTIFIER
    4               999
DEPTH(m)    Q(L/min)    C(g/L)      T0(hr)      Q/V_FLAG    !Vd(m/day)
 35.00       .5000       4.000       .2000        0
 30.00      99905.       6.000       .0000        0
     T(hr)       Q(L/min)    C(g/L)      !#entries is two digits after
999
      .0000       .0000       6.000
      .3000       .2800E-01   5.000
      .5000       .3200       4.000
      1.000       .4600       3.000
      1.500       .4600       2.000
 25.00       .4398E-01   6.000       .0000        0         ! 1.000
 25.00      -.4398E-01   6.000       .0000        0         !-1.000
TMAX(hr)    FECMAX      DIFFUSION_COEF.(m2/s)
 1.000       5000.       .7500E-09
RGAMMA      RBETA       RALPHA      !FEC = RGAMMA + C*RBETA + C*C*RALPHA
 .0000       1870.      -40.00
IC0FLAG     !If 0, C0=0; If <0, read one C0; If >0,read IC0FLAG (X,C0)
pairs
  179
X(m)        C0(g/L)           !#entries is IC0FLAG
 59.83       2.000
 59.50       .0000
 59.17       .0000
 58.83       .0000
…(169 entries with C0=0 not shown)…
 2.167       .0000
 1.833       .0000
 1.500       .0000
 1.167       .0000
 .8333       .0000
 .5000       .0000
DATA_FILE   !'NONE' if there is no data file
NONE
```

Line by Line Instructions for Data File

The data file is read in the fixed format shown below. If data are available in a different format, an auxiliary program should be used to convert it to this form (a simple preprocessor called PREBORE, described in Appendix 2, converts the data file format used by BORE to the new format shown below). Note that because a fixed format is used, blank entries are allowed; they are interpreted as zero.

Lines 1-8 are header lines, not used by BORE II.

Each line of the remainder of the file contains:

Variable	*x*	FEC	TEMP	DAT3	DAT4	DAT5	HR	MIN	SEC
Units	m	μS/cm	^{o}C				–	–	–
Format	F10.3	F10.3	F10.3	E10.3	E10.3	E10.3	I3	I2	I2
Columns	1-10	11-20	21-30	31-40	41-50	51-60	62-64	66-67	69-70

The entries DAT3, DAT4, and DAT5 represent optional data types that may be collected with certain logging tools, such as pH and dissolved oxygen (see options A and Y for ways to display this data). Note that there is one blank column before each of the HR, MIN, and SEC entries, to make the data file more readable. The first time entry corresponds to $t = 0$ for the model.

BORE II Options

The following options are available on the BORE II main menu. Either uppercase or lowercase letters may be used, and should be followed by pressing ENTER.

C – (C)-x plot – Displays FEC versus depth for data and/or model continuously in time (an animation); stores [*x* (m), *t* (sec), data FEC (μS/cm), model FEC (μS/cm)] in file BOREII.TMP for later use by option R or post-processing.

T – c-(T) plot – Displays FEC versus time for data and model for a chosen depth.

R – d/m cu(R)ve – Displays FEC versus depth plots for data and model at a series of times (snapshots of the option C display); uses results of most recent option C, read from BOREII.TMP. Does not work if there is no data file or if there are only data at one depth in data file.

N – i(N)flow-c – Displays inflow FEC for a chosen feed point as a function of time.

A – p(A)ram display – Displays all data profiles (FEC, TEMP, DAT3, DAT4, DAT5) simultaneously, using user-specified plot limits (selections 3-6). For selection 1, all points are connected on one continuous curve; for selection 2, points that are beyond depth or time limits start new curve segments.

X – (X)-t plot – Displays a color-coded plot of model FEC versus depth and time in a new window, then repeats the plot in the borehole profile window.

S – tool (S)tudy x-t plot – Same as X, but limits display to what would be obtained with a tool whose parameters (number of probes, gap between probes, and tool velocity) are specified by the user.

D – (D)ata x-t – Displays a color-coded plot of data traces versus depth and time in a new window, then repeats the plot in the borehole profile window (data type specified by option Y, default is FEC).

F – (F)ill data x-t – Same as D, except that data traces are interpolated to fill the *x*-*t* plane.

I – d/m d(I)ff x-t – Displays a color-coded plot of the difference between model and data FEC versus depth and time in a new window, then repeats the plot in the borehole profile window. User selects whether to show data traces (mode 1) or filled data (mode 2).

M – (M)odify inp– Opens interactive session for modifying location, flow rate, and concentration of feed points, or adding new feed points. User is prompted to enter feed point number and given the chance to modify or maintain current parameters. To add a new feed point, specify a feed point number greater than that for any existing feed point. If horizontal flow is implemented using option M, flow rate must be specified as volumetric flow rate through the wellbore in L/min.

P – (P)lot adjust – Sets new values of parameter minimum and maximum; t_{max}; difference range for option I; and depth for which wellbore flow rate q_0 is displayed in borehole profile window (default depth is x_{min}).

G – (G)rid – Sets grid spacing for new window showing *x*-*t* plots.

Y – data t(Y)pe – Chooses data type (FEC, TEMP, DAT3, DAT4, DAT5) to display in options C, T, D, and F. Model results always show FEC, so option C and T plots, which show both model and data, must be read carefully. Note that options R and I are not affected by the choice of data type, but always compare model and data FEC.

Z – print – Displays instructions for printing a screen image.

V – sa(V)e – Creates a new input file with current model parameters. User is prompted for new file name.

Q – (Q)uit – Terminates BORE II program.

4. Example Applications

Five example applications are presented to illustrate the capabilities of BORE II. Although BORE II simulates the forward problem (it produces wellbore FEC profiles given different inflow positions, rates, and concentrations), it is most commonly used in an inverse mode, in which inflow positions, rates and concentrations are varied by trial and error until the model matches observed values of wellbore FEC profiles. Initial guesses for the trial and error process may be obtained using direct integral methods (Tsang and Hale, 1989; Tsang et al., 1990) or other means (see example 2 below). Example applications 3, 4, and 5 demonstrate such comparisons to real data provided to us as typical field data sets by G. Bauer (private communication, 2000). The results of these example applications do not necessarily provide physically realistic flow rates and inflow concentrations, because they employ the artificial equality FEC = *C*. Furthermore, rough matches to real data, as are obtained here, can often be obtained equally well with a variety of different parameters (i.e., the solution of the inverse problem is non-unique). The input files for the example applications are shown in Appendix 3.

	Problem	Data File	Input File	Features
1	Up flow	up_num.dbt (numerically simulated)	up_num.inp	Advection and dilution, diffusion/dispersion minor
2	Horizontal flow	hor_an.dbt (analytical solution)	hor_an.inp	Dilution only, no advection or diffusion/dispersion One pair inflow/outflow points
3	Horizontal flow	hor_real.dbt (real data)	hor_real.inp	Dilution and diffusion/dispersion Multiple pairs inflow/outflow points Initial time added to data

4	Down flow	down_c.dbt (real data)	down_c.inp	Advection, dilution, and diffusion/dispersion Variable inflow concentration
5	Combination flow	comb_ic.dbt (real data)	comb_ic.inp	Advection, dilution, and diffusion/dispersion Non-uniform initial conditions

1. Up Flow – Numerically Simulated Data

Perhaps the most common application of BORE II is to the case of up flow - when one pumps from the top of the wellbore section, and fluid enters the wellbore at one or more feed points. Figure 1 shows *C* versus *x* for several times for a typical up flow case (obtained with BORE II option R). Each feed point has the same inflow rate and the same concentration, and there is also up flow from below. At early times, the feed points show up as individual FEC peaks, but as time passes, the deeper peaks merge with those above them, creating a step-like structure. The data set for this example is not real, but the results of a numerical simulation using the flow and transport simulator TOUGH2 (Pruess, 1987; 1991; 1995; 1998). TOUGH2 has been verified and validated against analytical solutions, other numerical models, and laboratory and field data. The TOUGH2 simulation uses a one-dimensional model with the same cell spacing as BORE II and constant mass sources located at the BORE II feed points. Thus, BORE II and TOUGH2 are solving the same problems, and comparing the results for wellbore FEC profiles verifies that the BORE II calculations are done correctly.

2. Horizontal Flow – Analytical Solution and Numerically Simulated Data

For horizontal flow in the absence of diffusion/dispersion along the wellbore, an analytical solution for the concentration observed in the wellbore as a function of time, *C*(*t*), is given by (Drost, 1968):

$$C(t) = C_i - [C_i - C(0)]\exp\left(\frac{-2tv_d\alpha_h}{\pi r_w}\right), \qquad (1)$$

where C_i is the formation (inflow) concentration, t is time (s), v_d is the Darcy velocity through the aquifer (m/s), α_h is the aquifer-to-wellbore convergence factor, and r_w is the wellbore radius (m). Figure 2 shows the analytical solution and the BORE II results for this problem, obtained using option T. The agreement is excellent. Note that for small values of v_d, if C(0) = 0, the analytical solution becomes approximately

$$C(t) = C_i\left\lfloor 1 - \exp\left(\frac{-2tv_d\alpha_h}{\pi r_w}\right)\right\rfloor \approx C_i\left\lfloor 1 - \left(1 - \frac{2tv_d\alpha_h}{\pi r_w}\right)\right\rfloor = \frac{C_i\,2tv_d\alpha_h}{\pi r_w}. \qquad (2)$$

Thus, any combination of C_i and v_d whose product is a constant gives the same value of C. This condition corresponds to the early-time straight-line portion of Figure 2. The analytical solution may be implemented in a spreadsheet to expedite the choice of BORE II parameters, by examining the solution for various values of v_d and C_i. Note that care must be taken to use a consistent set of units for t, v_d, and r_w in Equations (1) and (2). For example, when time is in seconds, BORE II input parameters v_d in m/day and r_w in cm must be converted to m/s and m, respectively.

Figure 2 also shows the evolution of concentration at and near a horizontal flow layer when diffusion/dispersion along the wellbore is significant ($D_0 = 10^{-5}$ m^2/s). For this case, the analytical solution is not applicable, but BORE II results compare very well to numerically simulated data obtained using TOUGH2. When dispersion is significant, use of the Drost solution generally results in an underestimation of C_i and an overestimation of v_d. These errors do not arise when using BORE II, since diffusion/dispersion can be explicitly included.

3. Horizontal Flow – Real Data

As indicated in Figure 2, the addition of diffusion or dispersion modifies the depth-FEC profile arising from a thin layer of horizontal flow, by widening the base of the FEC peak. A thick layer of horizontal flow produces a distinct signature, with an FEC response that has a wide peak as well as a wide base. To model a thick layer of horizontal flow, one may use several adjacent inflow/outflow point pairs in the model. Figure 3 compares model and data profiles (G. Bauer, private communication, 2000) of C versus x for several times, using option R. Seven pairs of inflow/outflow points are used, assigned to seven adjacent cells. By multiplying the number of inflow/outflow pairs by cell thickness, one may estimate the thickness of the layer of horizontal flow, in this case 2.3 m. See Appendix 1, Section A1.5, for additional information about assigning feed points to specific cells.

For this particular data set, the earliest observations show a variable FEC profile. One possible way to address this is to specify a non-uniform initial concentration distribution in the wellbore. An alternative approach (used here) is to add a dummy entry to the data file, specifying a time prior to the first real data time, at which the FCE distribution in the wellbore is assumed to be uniform. In general, it is not possible to determine when, if ever, the FEC distribution in the wellbore is uniform, but the approach can work quite well, as shown in Figure 4, which shows C versus t at the center of the horizontal flow zone (option T). The data zero time taken from the header of the data file, where the date and time of the logging run are specified.

4. Down Flow – Real Data

Figure 5 compares model and data profiles (G. Bauer, private communication, 2000) of C versus x for several times (option R) for a case with primarily down flow. A uniform non-zero initial concentration is used (IC0FLAG < 0) to approximate the low, slightly variable initial concentration. Two shallow inflow points have variable concentrations that increase in time, which suggests that de-ionized water penetrated into the fractures when it was introduced into the wellbore to establish low-concentration initial conditions for logging. A low-concentration feed point at x = 158.5 m creates up flow above it, but the remainder of the wellbore section shows down flow.

5. Combination Flow – Real Data

Figure 6 compares model and data profiles (G. Bauer, private communication, 2000) of C versus x for several times (option R) for a case with combination flow. A non-uniform initial condition has been used, which is extracted from the data file using the preprocessor PREBORE (see Appendix 2). Note that there are more entries in the initial condition specification (232) than there are cells in the model (179). Thus, some cells are assigned more than one initial condition. For cells where this occurs, only the final initial condition assigned is used. See Appendix 1, Section A1.5, for additional information on specifying non-uniform conditions. Figure 7 shows the same information as Figure 6, but plotted in a different way, with the difference between data and model FEC plotted as an x-t plot (option I). The blue and orange diagonal features indicate that the largest discrepancy between model and data gradually deepens with time.

Acknowledgements

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Appendix 1: Mathematical Background and Numerical Approach

The principal equation governing wellbore FEC variation is the equation for the transport of mass (or ion concentration) in the wellbore. However, additional consideration must be given to the determination of FEC as a function of ion concentration and the temperature dependence of FEC.

A1.1 FEC as a Function of Concentration

The relationship between ion concentration and FEC is reviewed, for example, by Shedlovsky and Shedlovsky (1971), who give graphs and tables relating these two quantities. Hale and Tsang (1988) made a sample fit for the case of NaCl solution at low concentrations and obtained

$$\text{FEC} = 1{,}870\, C - 40\, C^2, \qquad \text{(A.1)}$$

where C is ion concentration in kg/m^3 ($\approx$ g/L) and FEC is in μS/cm at 20^{o}C. The expression is accurate for a range of C up to $\approx$ 6 kg/m^3 and FEC up to 11,000 μS/cm. The quadratic term can be dropped if one is interested only in values of C up to $\approx$ 4 kg/m^3 and FEC up to 7,000 μS/cm, in which case the error will be less than 10%.

Fracture fluids typically contain a variety of ions, the most common being Na^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}, and HCO_3^-. If a hydrochemical analysis has been completed, various methods are available for computing an equivalent NaCl concentration for other ions. Schlumberger (1984) presents charts of multiplicative factors that convert various solutes to equivalent NaCl concentrations with respect to their effect on electric conductivity.

A1.2 Temperature Dependence of FEC

BORE II calculations are made assuming a uniform temperature throughout the wellbore. Actual wellbore temperatures generally vary with depth, so temperature corrections must be applied to field FEC data to permit direct comparison with model output.

The effect of temperature T on FEC can be estimated using the following equation (Schlumberger, 1984)

$$\text{FEC}(20^o\,\text{C}) = \frac{\text{FEC}(\text{T})}{1 + \text{S}(\text{T} - 20^o\,\text{C})}, \qquad \text{(A.2)}$$

where $S = 0.024$.

Generally, temperature increases with depth below the land surface. If full temperature logs are available, these data can be used to correct the corresponding FEC values. However, if no complete logs are available, a simplifying assumption may be made that the temperature variation in the wellbore is linear and can be modeled by:

$$T = Ax + B, \qquad \text{(A.3)}$$

where *A* and *B* are parameters determined by fitting any available temperature versus depth data. If the fit is unsatisfactory, other relationships with higher order terms must be used.

A1.3 Governing Equation

The differential equation for mass or solute transport in a wellbore is:

$$\frac{\partial}{\partial x}\left(D_o \frac{\partial C}{\partial x} \right) - \frac{\partial}{\partial x}(Cv) + S = \frac{\partial C}{\partial t}, \qquad (A.4)$$

where x is depth, t is time, and C is ion concentration. The first term is the diffusion term, with D_0 the diffusion/dispersion coefficient in m^2/s, the second term is the advective term, with v the fluid velocity in m/s, and S is the source term in kg/m^3s. This one-dimensional partial differential equation is solved numerically using the finite difference method, with upstream weighting used in the advective term. The following initial and boundary conditions are specified:

$C(x,0) = C_0(x)$, (A.5)

$C(x_{min},t) = C_0(x_{min})$ for flow into the wellbore from above,

$C(x_{max},t) = C_0(x_{max})$ for flow into the wellbore from below,

$D_0 = 0$ for $x < x_{min}$ and $x > x_{max}$.

The first condition allows for the specification of initial ion concentrations in the wellbore. The second and third conditions allow for advective flow of ions into the wellbore interval from above and below. The final condition indicates that diffusion and dispersion do not take place across the boundaries of the wellbore interval. In general, advection will be the dominant process at the boundaries. If diffusion or dispersion is dominant for a particular problem, the boundaries should be extended in order to prevent improper trapping of electrolyte.

A1.4 Discretization in Time

Time stepping is explicit, with the time step Δt determined by stability constraints for advection

$$\Delta t \le \frac{\pi d_w{}^2 \Delta x}{8 q_{max}}, \qquad (A.6)$$

and diffusion

$$\Delta t \le \frac{\Delta x^2}{4 D_0}, \qquad (A.7)$$

where q_{max} (m^3/s) is the maximum fluid flow rate anywhere in the wellbore. BORE II starts its calculation at $t = 0$. The first time in the data file is also identified with $t = 0$. If it is apparent that model and data times are not synchronized, then one may insert an additional line into the data file after the header lines, with an earlier time than the first real data time, in order to reset the data zero time. On the inserted line, FEC, *x*, and other data entries may be left blank or copied from the first real data line.

A1.5 Discretization in Space

The wellbore interval between $x_{\min}$ and $x_{\max}$ is uniformly divided into N cells and it is assumed that the wellbore has uniform diameter, d_w. Cell height Δx is determined as the larger of $(x_{\max} - x_{\min})/180$ and d_w. Position values indicate depth in the wellbore and thus x is zero at the surface and increases downward. The cell index increases upward, with cells 1 and N located at the bottom and top, respectively, of the wellbore interval. In general, the *i*th node (the center of the *i*th cell) is located at

$$x_i = x_{\max} - (i\text{-}1/2)\Delta x, \qquad \text{(A.8)}$$

with the *i*th cell extending from $x_{\max} - (i - 1)\Delta x$ to $x_{\max} - i\Delta x$.

BORE II assigns feed points and initial concentrations to cell i if the location of the feed point or $C_0(x)$ value lies within the boundaries of the *i*th cell. If multiple feed points are assigned to the same cell, they will all be accounted for, but if multiple initial conditions are assigned to the same cell, only the final one assigned will be used. By definition, the lower boundary of cell 1 is at $x_{\max}$, but due to round-off errors, the upper boundary of cell N may not be at $x_{\min}$. Hence, it is often useful to know the x coordinates of each node. These are displayed in the input file written by BORE II (option V) when IC0FLAG > 0. Thus, if the user sets IC0FLAG = 1, inputs one $(x, C_0(x))$ pair, and uses option V, then a new input file will be created with IC0FLAG = N and a complete list of the x coordinates for all nodes, with $C_0 = 0$ for all cells except the one identified in the original input file. Alternatively, if the initial conditions are taken from the data file with PREBORE (or taken from any source that is independent of the nodal coordinates), then using option V will create an input file that shows the actual initial conditions assigned to each cell.

The list of nodal x coordinates may be useful when modeling a thick fracture zone or aquifer, in order to place one feed point in each cell over a given depth range. Similarly, when using IC0FLAG > 0 to specify non-uniform initial concentrations, one must assign a C_0 value to each cell in the interval of interest in order to obtain a continuous C profile, because no interpolation is done between scattered initial concentrations. Finally, knowing the coordinate of the top cell in the model is useful for assigning the initial concentration that serves as the boundary condition for inflow into the wellbore interval from above. For inflow from below, either $x = x_1$ or $x = x_{\max}$ may be used.

A1.6 Calculation of Flow Rates

Feed point flow rates may be constant in time, in which case a steady-state flow field is assumed in the wellbore, or variable, with feed point flow rates determined by linear interpolation between tabulated values. Although feed point flow rate may vary, true transient wellbore flow including fluid compressibility effects is not considered. Rather, the wellbore fluid flow field is assumed to change instantly from one steady-state flow field to another. In other words, the flow rate out of cell i is always the sum of the flow rates from all feed point locations within the boundaries of cell i plus the flow rate out of cell i-1.

Appendix 2: The Preprocessor PREBORE

PREBORE is a simple Fortran program that does preprocessing for BORE II. It runs under either Windows or DOS. PREBORE converts the old BORE data file format into the new BORE II data file format. Depth is converted from feet to meters, and other data columns are realigned. PREBORE can also create a file with (x,C_0) pairs to be added to the BORE II input file as initial conditions (this option requires that x values steadily increase or steadily decrease in each profile).

If data file conversion is being done, the user is prompted to enter the old and new data file names.

If a file with initial conditions is being created, the user is prompted for the following information: the name of the BORE II data file; a name for the initial condition file; which profile in the data file to use; the direction of logging (downward assumes x values increase in the data file, upward assumes they decrease, and both assumes the profiles alternately increase and decrease in x); and the conversion factors (γ, β, α) between FEC and C (default values 0, 1870, -40). In addition to creating an ASCII text file with (x,C_0) pairs, which may be added to the BORE II input file using a text editor or word processor, PREBORE prints out the number of pairs on the screen, which should be used for IC0FLAG. Note that IC0FLAG may be greater than the number of cells in the model (usually about 180), but that in this case not all the C_0 values will be used (see Appendix 1, Section A1.5).

Data file conversion and initial condition creation can be done in the same PREBORE run. In this case the user must specify both old and new data file names in addition to the parameters describing the creation of initial conditions.

Appendix 3: Input Files for Example Applications

A2.1 Example Application 1 – Up Flow – up_num.inp

```
TITLE: up flow with flow from below, compare to synthetic data
XMIN(m)     XMAX(m)     DIAM(cm)    !DX(m) = MAX(|XMIN - XMAX|/180,
DIAM/100)
 .0000       180.0       14.00      ! 1.000
QW(L/min)   HALPHA      !QW=flow from below; HALPHA=hor. flow
constriction
 .7500       2.500
#FEED_PTS   VARIABLE_FLOWRATE_IDENTIFIER
    3               999
DEPTH(m)    Q(L/min)    C(g/L)      T0(hr)      Q/V_FLAG    !Vd(m/day)
 160.5       .7500       100.0       .0000        0
 130.5       .7500       100.0       .0000        0
 50.50       .7500       100.0       .0000        0
TMAX(hr)    FECMAX      DIFFUSION_COEF.(m2/s)
 24.00       100.0       .7500E-09
RGAMMA      RBETA       RALPHA      !FEC = RGAMMA + C*RBETA + C*C*RALPHA
 .0000       1.000       .1000E-07
IC0FLAG     !If 0, C0=0; If <0, read one C0; If >0,read IC0FLAG (X,C0)
pairs
    0
DATA_FILE   !'NONE' if there is no data file
up_num.dbt
```

A2.2 Example Application 2 – Horizontal Flow Analytical Solution – hor_an.inp

```
TITLE: Horizontal Flow - Compare to Analytical Solution
XMIN(m)     XMAX(m)     DIAM(cm)
0.000       50.000      7.600
QW(L/min)   HALPHA
0.          2.850000
#FEED_PTS   VARIABLE_FLOWRATE_IDENTIFIER
       2    999
DEPTH(m)    Vd(m/d)     C(g/L)      T0(hr)      Q/V_FLAG
  25.0000     1.        1000.     .0000          1
  25.0000    -1.        1000.     .0000          1
TMAX(hr)    FECMAX      DIFFUSION_COEF.(m2/s)
3.0000      1000.       1.e-10
RGAMMA      RBETA       RALPHA
0.000000    1.000000    1.e-08
IC0FLAG
0
DATA_FILE
hor_an.dbt
```

The input file for the case with significant dispersion is identical, except that the diffusion coefficient is increased from 10^{-10} m^2/s to 10^{-5} m^2/s.

A2.3 Example Application 3 – Horizontal Flow - hor_real.inp

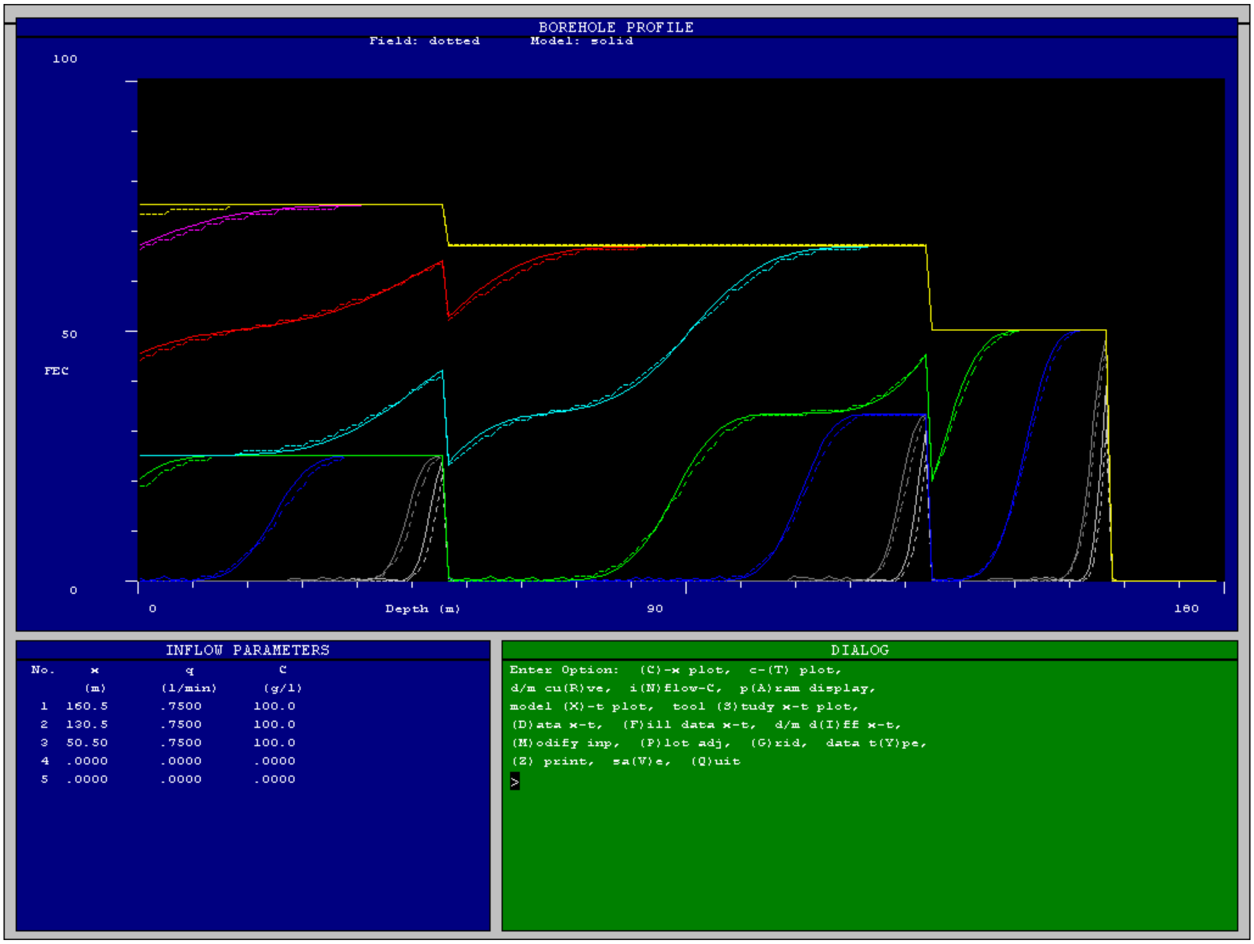
```
TITLE: Horizontal Flow Example
XMIN(m)     XMAX(m)     DIAM(cm)    !DX(m) = MAX(|XMIN - XMAX|/180,
DIAM/100)
 .0000       60.00       7.600      ! .3333
QW(L/min)   HALPHA      !QW=flow from below; HALPHA=hor. flow
constriction
 .0000       2.500
#FEED_PTS   VARIABLE_FLOWRATE_IDENTIFIER
   14                999
DEPTH(m)    Q(L/min)    C(g/L)      T0(hr)      Q/V_FLAG    !Vd(m/d)
 26.73       .5295E-02   730.0       .0000        0         ! .1204
 26.73      -.5295E-02   .0000       .0000        0         !-.1204
 26.39       .5295E-02   730.0       .0000        0         ! .1204
 26.39      -.5295E-02   .0000       .0000        0         !-.1204
 26.06       .5295E-02   730.0       .0000        0         ! .1204
 26.06      -.5295E-02   .0000       .0000        0         !-.1204
 25.73       .5295E-02   730.0       .0000        0         ! .1204
 25.73      -.5295E-02   .0000       .0000        0         !-.1204
 25.39       .5295E-02   730.0       .0000        0         ! .1204
 25.39      -.5295E-02   .0000       .0000        0         !-.1204
 25.06       .5295E-02   730.0       .0000        0         ! .1204
 25.06      -.5295E-02   .0000       .0000        0         !-.1204
 24.73       .5295E-02   730.0       .0000        0         ! .1204
 24.73      -.5295E-02   .0000       .0000        0         !-.1204
TMAX(hr)    FECMAX      DIFFUSION_COEF.(m2/s)
 4.000       400.0       .7500E-04
RGAMMA      RBETA       RALPHA      !FEC = RGAMMA + C*RBETA + C*C*RALPHA
 .0000       1.000       .1000E-07
IC0FLAG     !If 0, C0=0; If <0, read one C0; If >0,read IC0FLAG (X,C0)
pairs
    0
DATA_FILE   !'NONE' if there is no data file
hor_real.dbt
```

A2.4 Example Application 4 – Down Flow – down_c.inp

```
TITLE: downflow, variable source conc., uniform non-zero initial conc.
XMIN(m)     XMAX(m)     DIAM(cm)    !DX(m) = MAX(|XMIN - XMAX|/180,
DIAM/100)
 140.0       240.0       7.600      ! .5556
QW(L/min)   HALPHA      !QW=flow from below; HALPHA=hor. flow
constriction
 .0000       2.850
#FEED_PTS   VARIABLE_FLOWRATE_IDENTIFIER
   12               999
DEPTH(m)    Q(L/min)    C(g/L)      T0(hr)      Q/V_FLAG    !Vd(m/day)
 239.0      -.7000       .0000       .4000        0
 212.0      -1.000       .0000       .4000        0
 187.0       .7500       1800.       .4000        0
 183.0       .1900       1900.       .4000        0
 181.0       .1200       1900.       .4000        0
 178.0       .5000E-01   1900.       .4000        0
 176.0       .4000E-01   1900.       .4000        0
 174.0       .3000E-01   1900.       .4000        0
 171.0       .1000E-01   1900.       .4000        0
 164.4      99905.       1900.       .4000        0
     T(hr)       Q(L/min)    C(g/L)      !#entries is two digits after
999
      .0000       .4400       80.00
      .4000       .4400       100.0
      1.200       .4400       1100.
      1.900       .4400       1650.
      4.500       .4400       1950.
 162.0      99904.       1800.       .0000        0
     T(hr)       Q(L/min)    C(g/L)      !#entries is two digits after
999
      .0000       .6000E-01   80.00
      .4000       .6000E-01   200.0
      1.900       .6000E-01   1650.
      4.500       .6000E-01   1950.
 158.5       .1000       80.00       .0000        0
TMAX(hr)    FECMAX      DIFFUSION_COEF.(m2/s)
 4.400       1700.       .1000E-02
RGAMMA      RBETA       RALPHA      !FEC = RGAMMA + C*RBETA + C*C*RALPHA
 .0000       1.000       .1000E-07
IC0FLAG     !If 0, C0=0; If <0, read one C0; If >0,read IC0FLAG (X,C0)
pairs
   -1
C0 (g/L)    !Uniform, non-zero C0
 80.00
DATA_FILE   !'NONE' if there is no data file
down_c.dbt
```

A2.5 Example Application 5 – Combination Flow – comb_ic.inp

```
TITLE: Combination flow example, non-uniform initial concentration
XMIN(m)     XMAX(m)     DIAM(cm)    !DX(m) = MAX(|XMIN - XMAX|/180,
DIAM/100)
 .00000      50.000      7.6000     ! .2778
QW(L/min)   HALPHA      !QW=flow from below; HALPHA=hor. flow
constriction
 .00000      2.8500
#FEED_PTS   VARIABLE_FLOWRATE_IDENTIFIER
   12               999
DEPTH(m)    Q(L/min)    C(g/L)      T0(hr)      Q/V_FLAG    !Vd(m/day)
 45.000     -.13000      .00000      .00000       0
 33.300      .11000      800.00      .15000       0
 33.300     -.31000      .00000      .00000       0
 27.500     -1.0500      .00000      .00000       0
 25.700      .30000      810.00      .15000       0
 25.400      .30000      810.00      .15000       0
 25.140      .30000      810.00      .15000       0
 24.900      .30000      810.00      .15000       0
 23.500      .12000      800.00      .15000       0
 21.500      .40000E-01  800.00      .15000       0
 14.000      .15000E-01  750.00      .15000       0
 12.200      .10000E-01  750.00      .15000       0
TMAX(hr)    FECMAX      DIFFUSION_COEF.(m2/s)
 1.0000      1000.0      .50000E-03
RGAMMA      RBETA       RALPHA      !FEC = RGAMMA + C*RBETA + C*C*RALPHA
 .00000      1.0000      .10000E-07
IC0FLAG     !If 0, C0=0; If <0, read one C0; If >0,read IC0FLAG (X,C0)
pairs
  232
X(m)        C0(g/L)           !#entries is IC0FLAG
1.524       2
1.615       2
1.707       3
1.829       3
1.951       3
2.073       3
2.225       3
2.377       3
2.53        3
2.713       3
2.865       3
3.018       3
3.353       589
3.536       597
3.719       588
3.871       583
4.054       584
…(208 entries not shown)…
43.282      2
43.8        2
43.983      2
44.166      1
44.318      1
44.501      1
44.684      1
DATA_FILE   !'NONE' if there is no data file
comb_ic.dbt
```



```
                 INFLOW PARAMETERS
No.    x          q          C
      (m)      (l/min)     (g/l)
 1  160.5      .7500      100.0
 2  130.5      .7500      100.0
 3  50.50      .7500      100.0
 4  .0000      .0000      .0000
 5  .0000      .0000      .0000
```

```
                              DIALOG
Enter Option:  (C)-x plot,  c-(T) plot,
d/m cu(R)ve,  i(N)flow-C,  p(A)ram display,
model (X)-t plot,  tool (S)tudy x-t plot,
(D)ata x-t,  (F)ill data x-t,  d/m d(I)ff x-t,
(M)odify inp,  (P)lot adj,  (G)rid,  data t(Y)pe,
(Z) print,  sa(V)e,  (Q)uit
>
```

Figure 1. Concentration (=FEC) versus depth at a series of times for example application 1 - up flow. Data are numerically simulated using the TOUGH2 code. Figure is a BORE II screen-print after running option R.

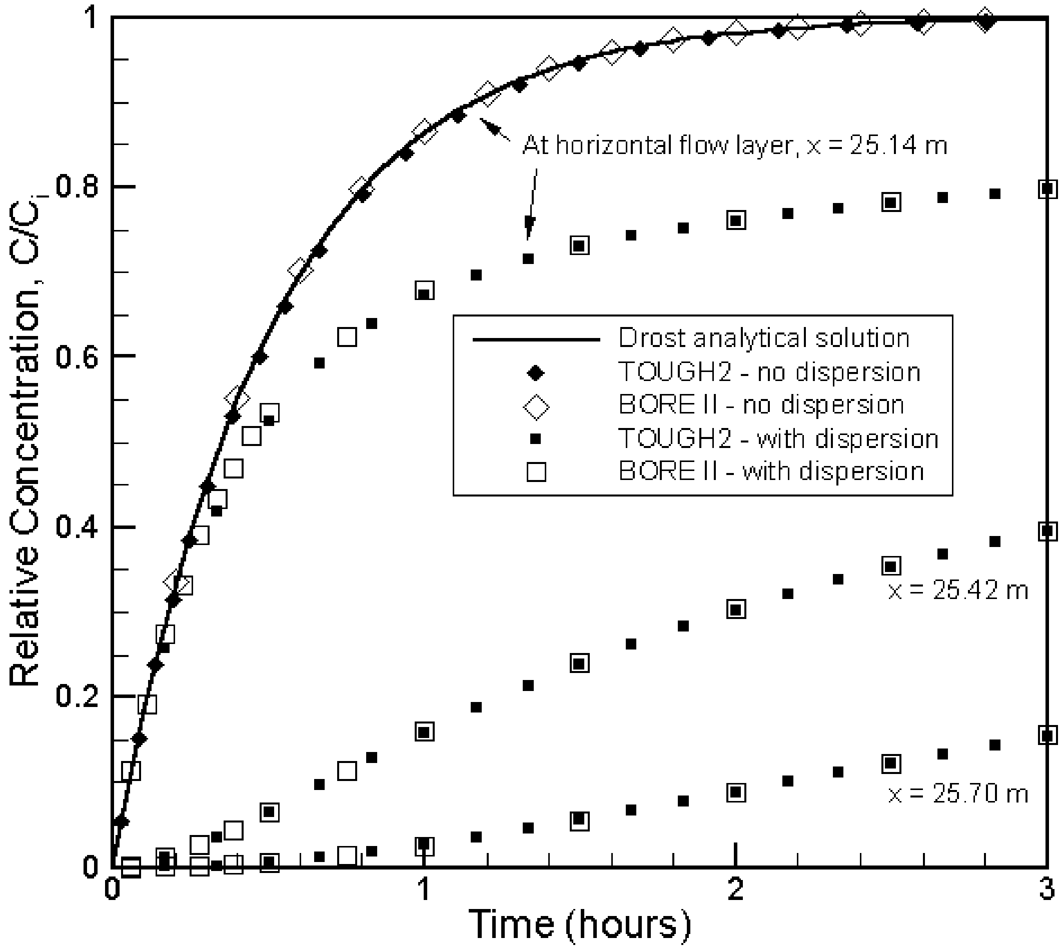


Figure 2. Relative concentration versus time for example application 2 – horizontal flow. When diffusion/dispersion is negligible, the concentration increase only occurs at the depth of the horizontal flow layer. The solid line shows the analytical solution as given by Drost (1968), Equation (1).

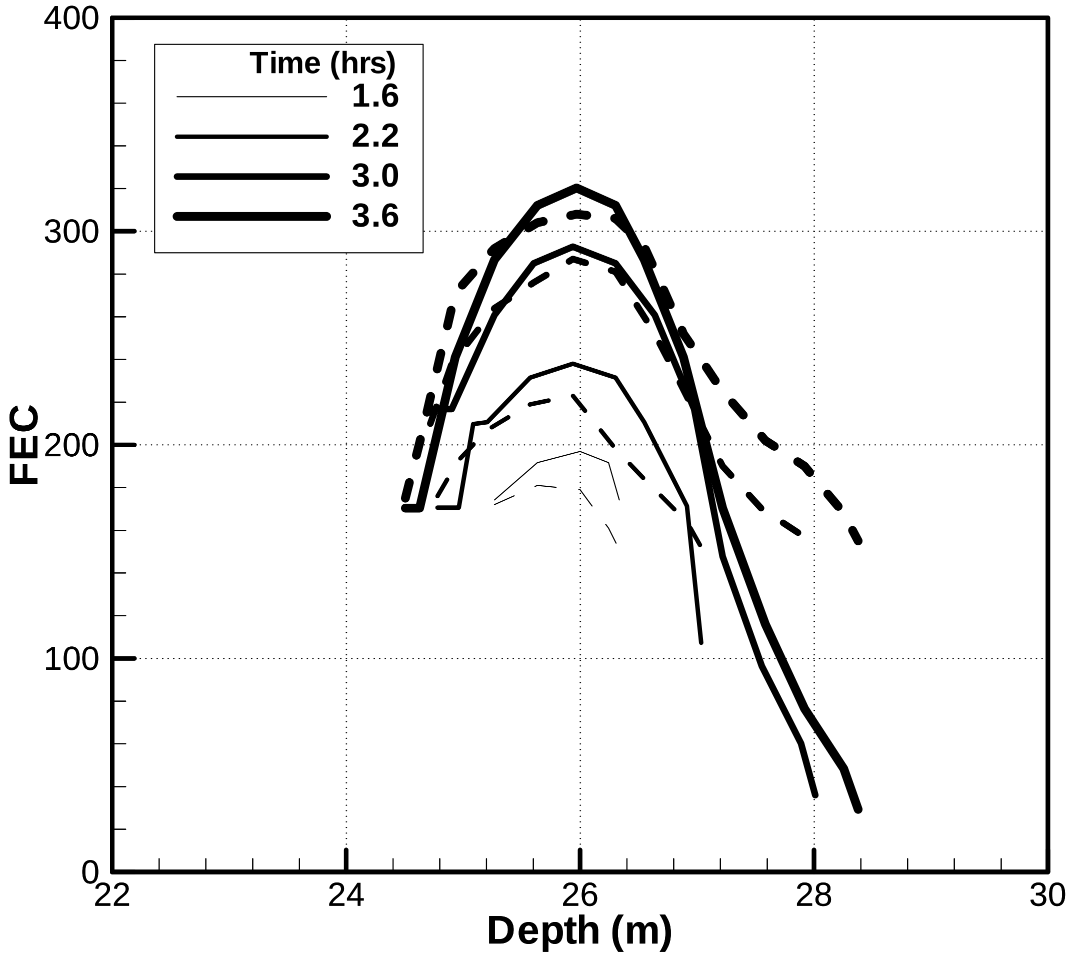


Figure 3. Concentration (= FEC) versus depth at a series of times for example application 3 – a thick layer of horizontal flow. Dashed lines represent field data, solid lines represent BORE II results. Diffusion/dispersion is significant.

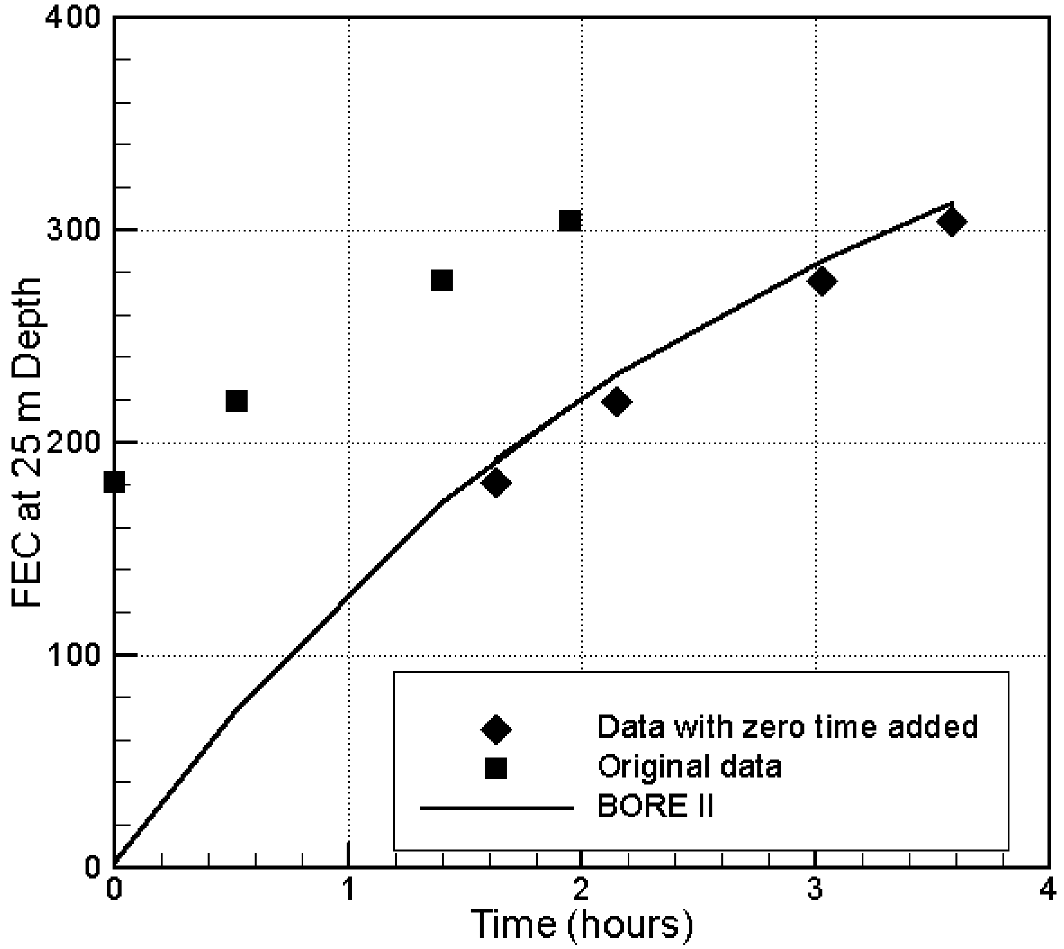
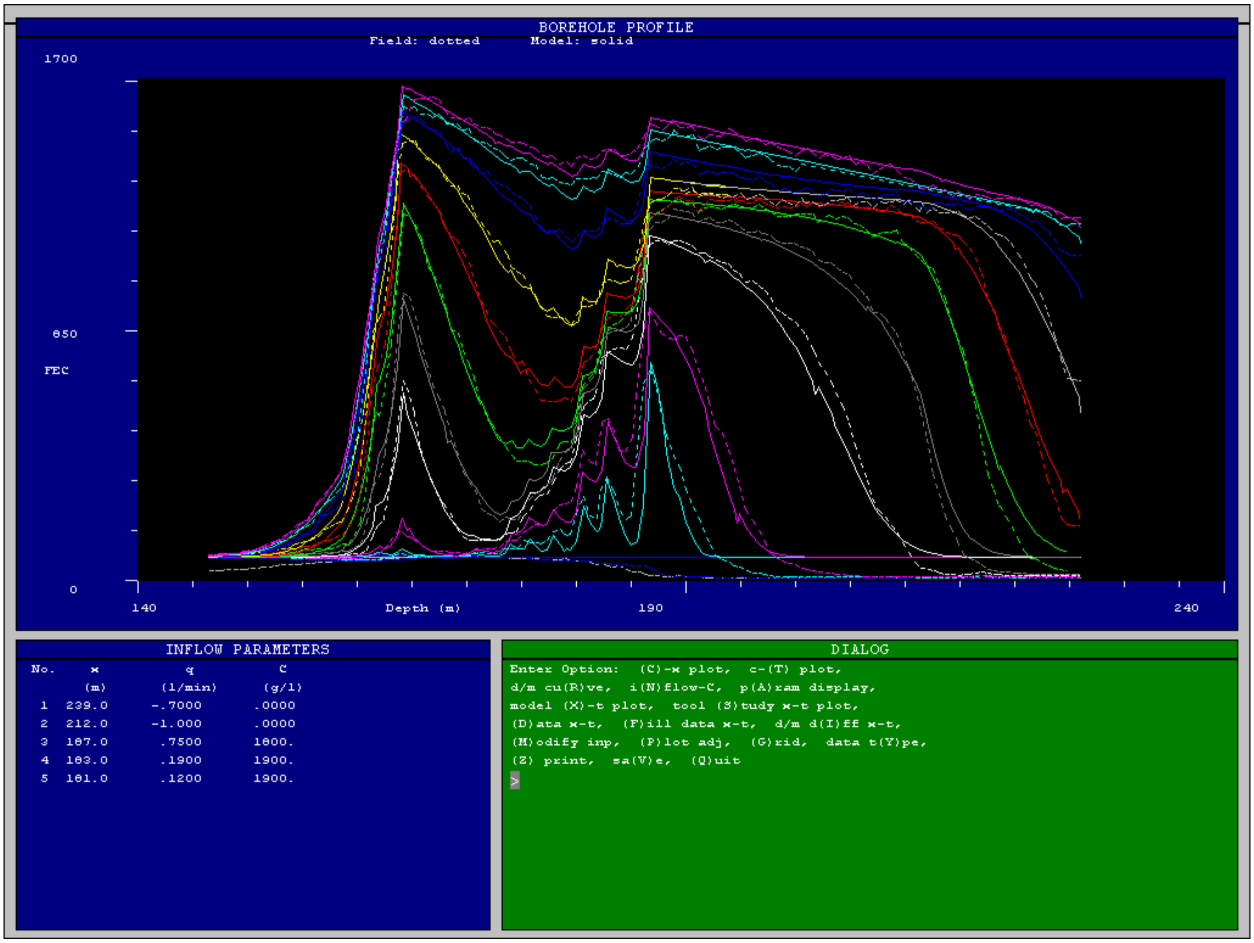


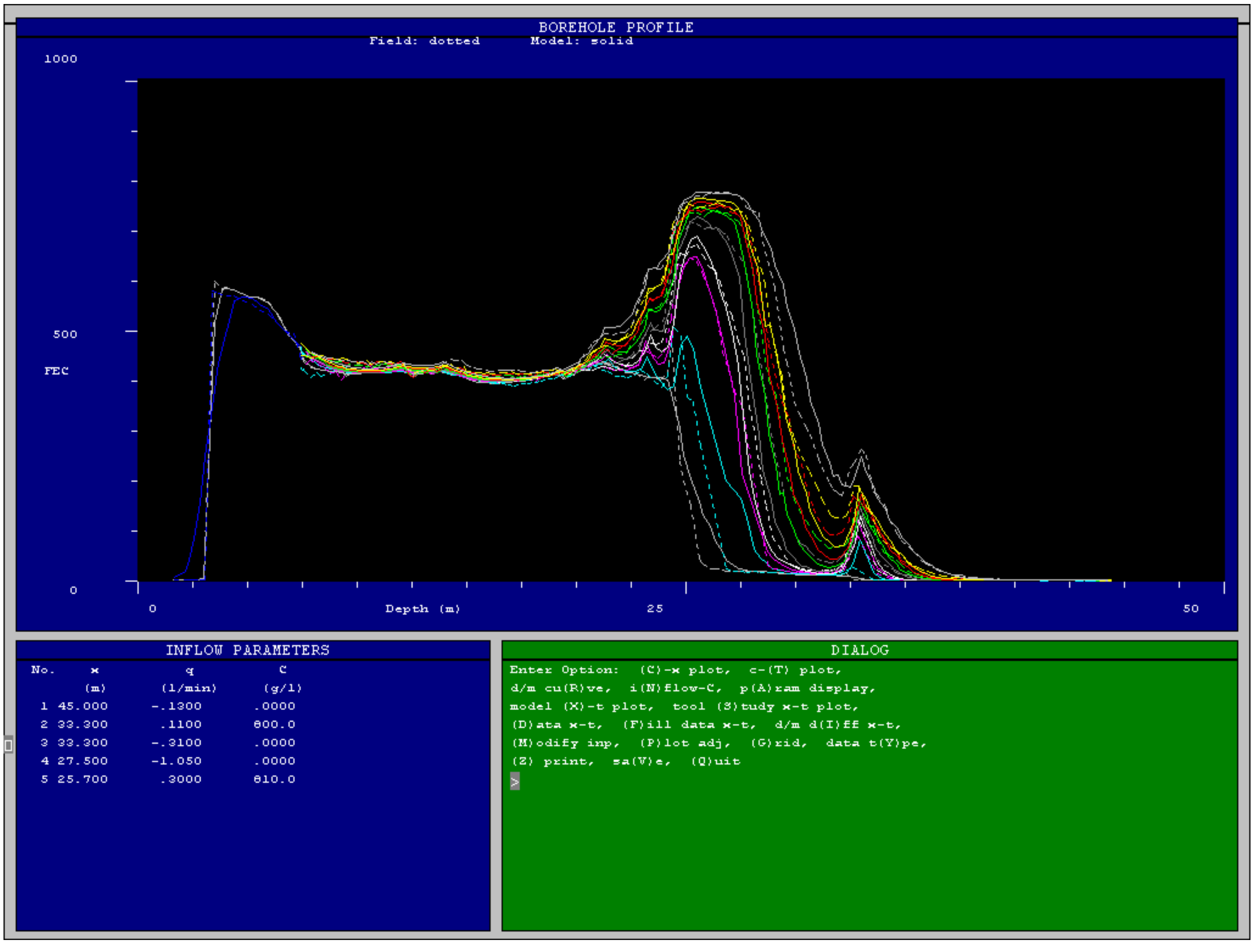
Figure 4. Concentration (= FEC) versus time at the center of the horizontal flow zone of example application 3, illustrating the addition of a data zero time.



```
No.    x        q         C
      (m)    (l/min)    (g/l)
 1  239.0    -.7000     .0000
 2  212.0    -1.000     .0000
 3  187.0     .7500     1800.
 4  183.0     .1900     1900.
 5  181.0     .1200     1900.
```

```
Enter Option:  (C)-x plot,  c-(T) plot,
d/m cu(R)ve,  i(N)flow-C,  p(A)ram display,
model (X)-t plot,  tool (S)tudy x-t plot,
(D)ata x-t,  (F)ill data x-t,  d/m d(I)ff x-t,
(M)odify inp,  (P)lot adj,  (G)rid,  data t(Y)pe,
(Z) print,  sa(V)e,  (Q)uit
>
```

Figure 5. Concentration (= FEC) versus depth at a series of times for example application 4 – down flow. Figure is a BORE II screen-print after running option R.



```
                 INFLOW PARAMETERS
 No.      x            q            C
         (m)        (l/min)       (g/l)
  1 45.000        -.1300        .0000
  2 33.300         .1100        800.0
  3 33.300        -.3100        .0000
  4 27.500        -1.050        .0000
  5 25.700         .3000        810.0
```

```
                         DIALOG
Enter Option:  (C)-x plot,  c-(T) plot,
d/m cu(R)ve,  i(N)flow-C,  p(A)ram display,
model (X)-t plot,  tool (S)tudy x-t plot,
(D)ata x-t,  (F)ill data x-t,  d/m d(I)ff x-t,
(M)odify inp,  (P)lot adj,  (G)rid,  data t(Y)pe,
(Z) print,  sa(V)e,  (Q)uit
>
```

Figure 6. Concentration (= FEC) versus depth at a series of times for example application 5 – combination flow. Figure is a BORE II screen-print after option R.

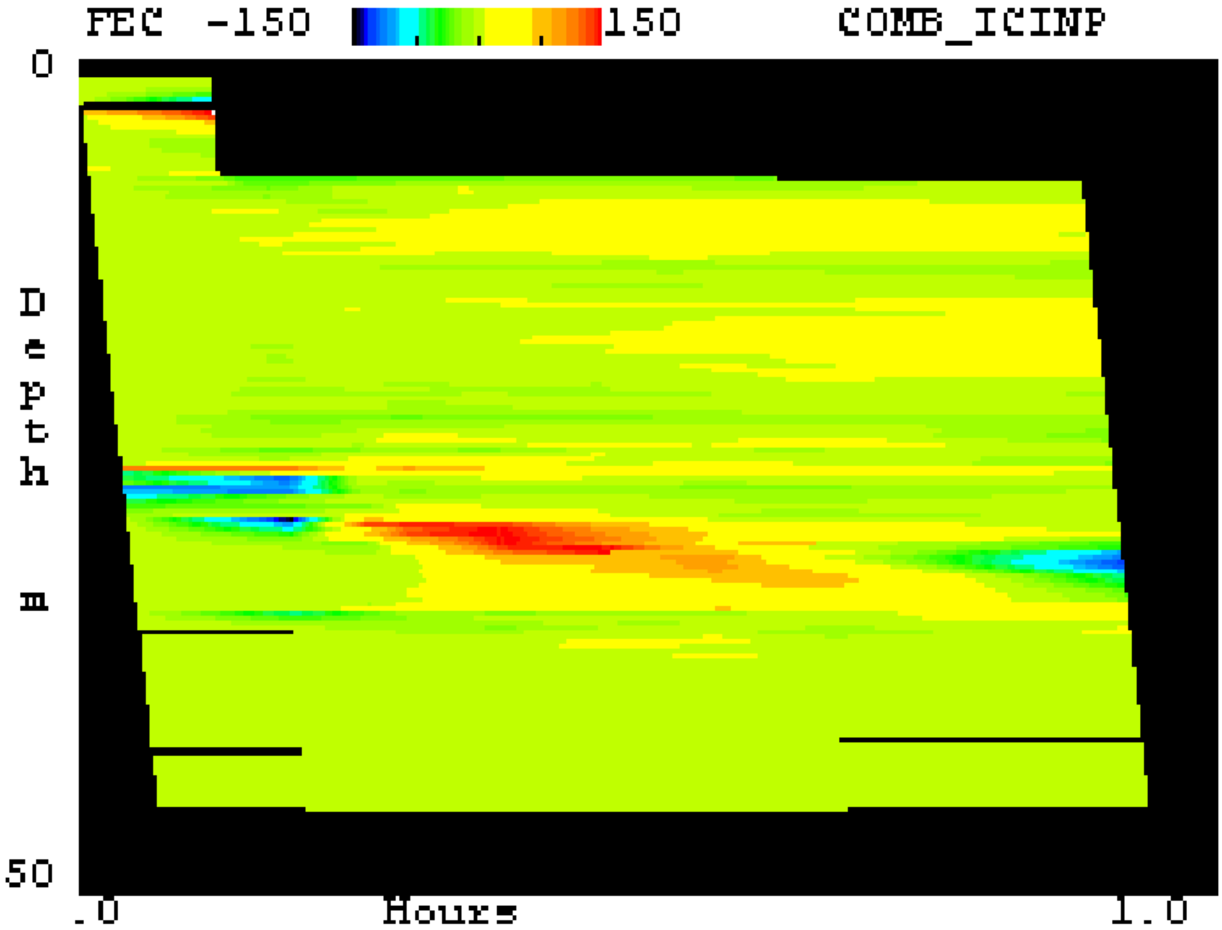
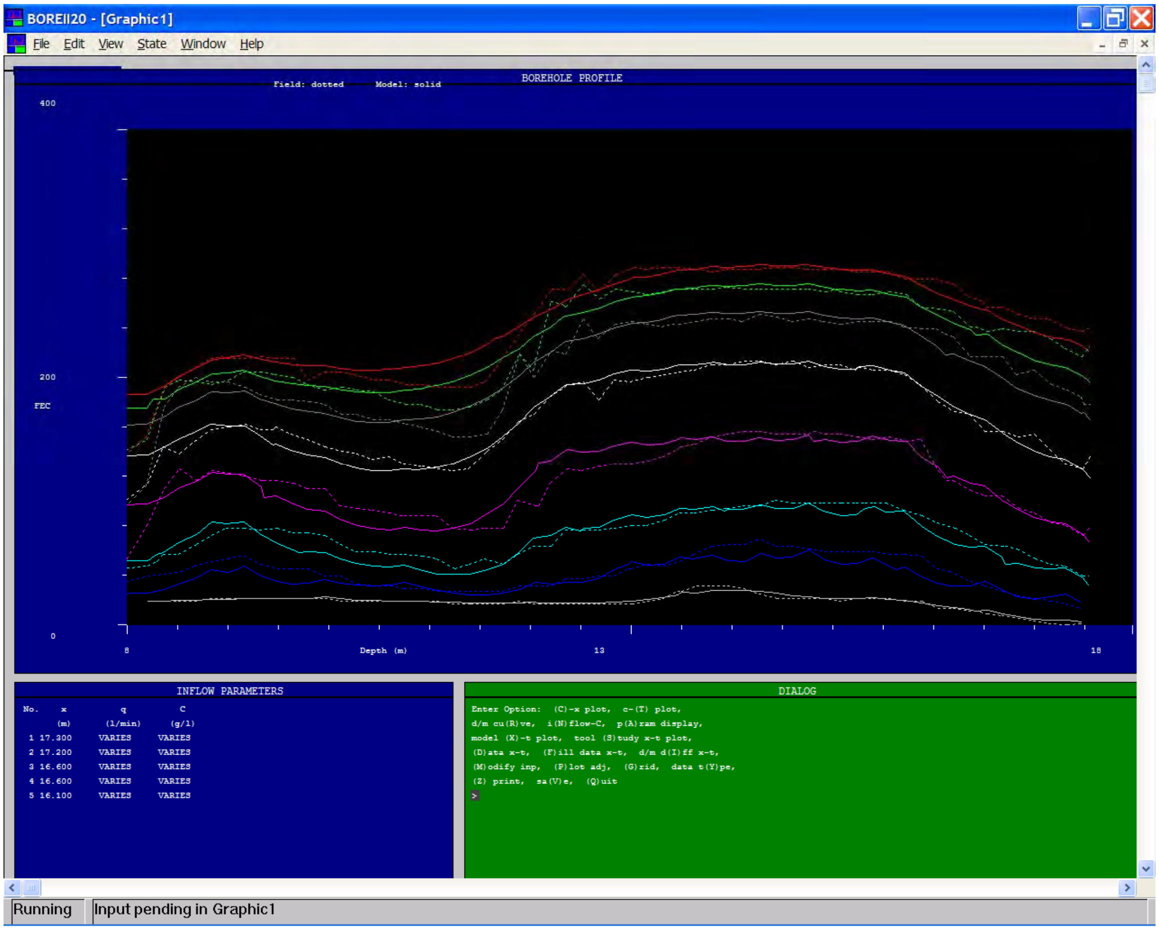


Figure 7. FEC difference between model and data as a function of depth and time (an *x-t* plot) for example application 5 – combination flow. Figure is a BORE II screen-print after option I, mode 2.

APPENDIX C

BORE II MODELING CODE COMPARISONS



INFLOW PARAMETERS

No.	x (m)	q (l/min)	C (g/l)
1	17.300	VARIES	VARIES
2	17.200	VARIES	VARIES
3	16.600	VARIES	VARIES
4	16.600	VARIES	VARIES
5	16.100	VARIES	VARIES

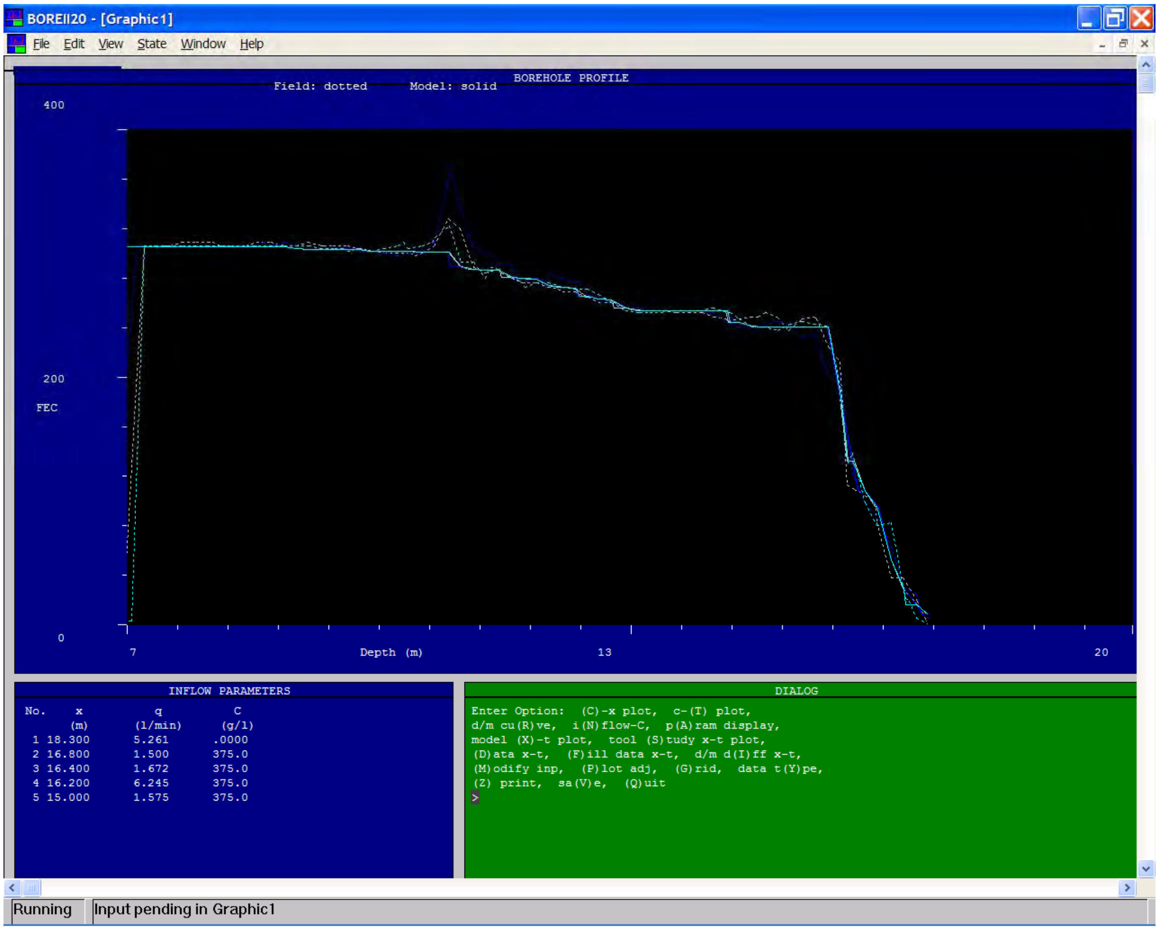
DIALOG

```
Enter Option:  (C)-x plot,  c-(T) plot,
d/m cu(R)ve,  i(N)flow-C,  p(A)ram display,
model (X)-t plot,  tool (S)tudy x-t plot,
(D)ata x-t,  (F)ill data x-t,  d/m d(I)ff x-t,
(M)odify inp,  (P)lot adj,  (G)rid,  data t(Y)pe,
(Z) print,  sa(V)e,  (Q)uit
>
```

Figure Appendix C:1. BORE II Code Comparison of Field FEC Profiles Acquired During Ambient Flow Characterization and Model. Wellbore DW-1.

- Field FEC Profiles = Dotted
- Model = Solid

Note: Significant borehole diameter changes in this borehole made modeling of this data set more difficult to match precisely. As such, effort was concentrated on the areas of known water-bearing fractures and proper gauge borehole. Areas where dispersion was the only factor on the mass and areas of large borehole diameter changes were not intensely modeled. Depths of the water-bearing fractures are cross-referenced with the optical televiewer and caliper data.

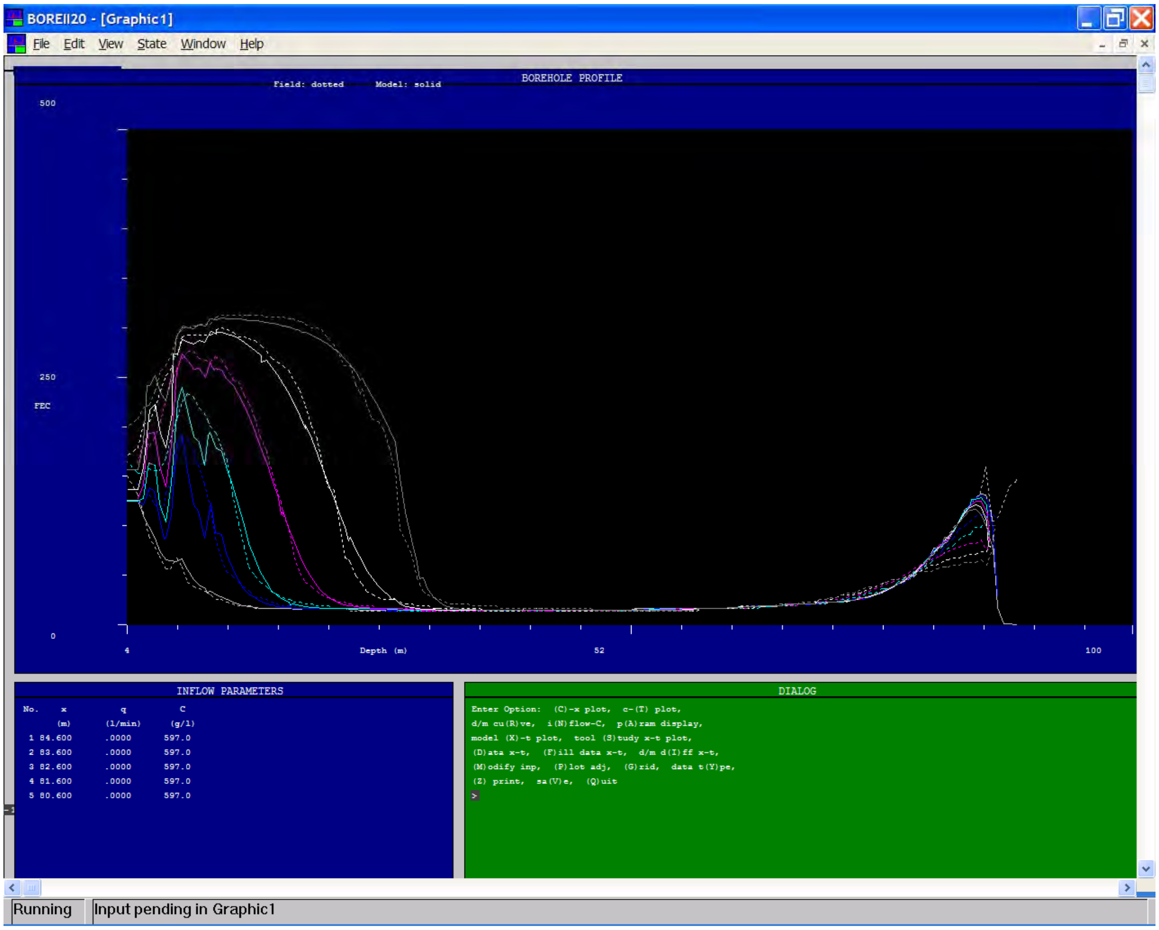


```
                INFLOW PARAMETERS
No.    x          q          C
      (m)      (l/min)     (g/l)
 1 18.300      5.261      .0000
 2 16.800      1.500      375.0
 3 16.400      1.672      375.0
 4 16.200      6.245      375.0
 5 15.000      1.575      375.0
```

```
DIALOG
Enter Option:  (C)-x plot,  c-(T) plot,
d/m cu(R)ve,  i(N)flow-C,  p(A)ram display,
model (X)-t plot,  tool (S)tudy x-t plot,
(D)ata x-t,  (F)ill data x-t,  d/m d(I)ff x-t,
(M)odify inp,  (P)lot adj,  (G)rid,  data t(Y)pe,
(Z) print,  sa(V)e,  (Q)uit
>
```

Figure Appendix C:2. BORE II Code Comparison of Field FEC Profiles Acquired During Hydrophysical Production Test at 6 GPM and Model. Wellbore DW-1.

- Field FEC Profiles = Dotted
- Model = Solid



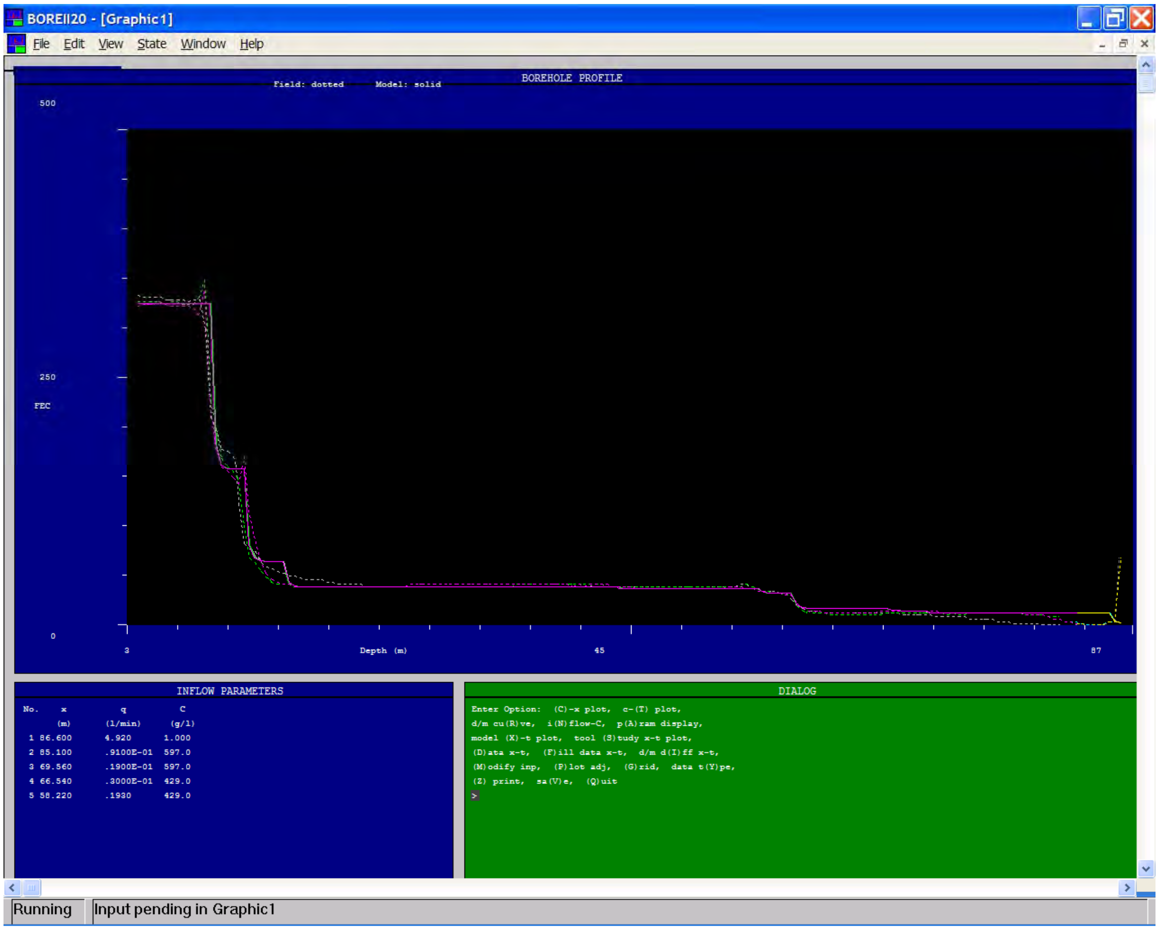
```
INFLOW PARAMETERS
No.    x          q         C
      (m)      (l/min)    (g/l)
 1 84.600      .0000      597.0
 2 83.600      .0000      597.0
 3 82.600      .0000      597.0
 4 81.600      .0000      597.0
 5 80.600      .0000      597.0
```

```
DIALOG
Enter Option:  (C)-x plot,  c-(T) plot,
d/m cu(R)ve,  i(N)flow-C,  p(A)ram display,
model (X)-t plot,  tool (S)tudy x-t plot,
(D)ata x-t,  (F)ill data x-t,  d/m d(I)ff x-t,
(M)odify inp,  (P)lot adj,  (G)rid,  data t(Y)pe,
(Z) print,  sa(V)e,  (Q)uit
>
```

```
Running    Input pending in Graphic1
```

Figure Appendix C:3. BORE II Code Comparison of Field FEC Profiles Acquired During Ambient Flow Characterization and Model. Wellbore DW-2.

- Field FEC Profiles = Dotted
- Model = Solid



```
INFLOW PARAMETERS
No.    x          q          C
      (m)      (l/min)     (g/l)
 1 86.600     4.920      1.000
 2 85.100     .9100E-01  597.0
 3 69.560     .1900E-01  597.0
 4 66.540     .3000E-01  429.0
 5 58.220     .1930      429.0
```

```
DIALOG
Enter Option:  (C)-x plot,  c-(T) plot,
d/m cu(R)ve,  i(N)flow-C,  p(A)ram display,
model (X)-t plot,  tool (S)tudy x-t plot,
(D)ata x-t,  (F)ill data x-t,  d/m d(I)ff x-t,
(M)odify inp,  (P)lot adj,  (G)rid,  data t(Y)pe,
(Z) print,  sa(V)e,  (Q)uit
>
```

Figure Appendix C:4. BORE II Code Comparison of Field FEC Profiles Acquired During Hydrophysical Production Test at 6 GPM and Model. Wellbore DW-2.

- Field FEC Profiles = Dotted
- Model = Solid

APPENDIX D

LIMITATIONS

LIMITATIONS

COLOG's logging was performed in accordance with generally accepted industry practices. COLOG has observed that degree of care and skill generally exercised by others under similar circumstances and conditions. Interpretations of logs or interpretations of test or other data, and any recommendation or hydrogeologic description based upon such interpretations, are opinions based upon inferences from measurements, empirical relationships and assumptions. These inferences and assumptions require engineering judgment, and therefore, are not scientific certainties. As such, other professional engineers or analysts may differ as to their interpretation. Accordingly, COLOG cannot and does not warrant the accuracy, correctness or completeness of any such interpretation, recommendation or hydrogeologic description.

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