Reporting

The final report will include the objective and scope of the survey, location of the boreholes, discussion of instrumentation and procedures in the field and lab. For each borehole there will be a plot showing the dip/strike and azimuth of features. The next page shows an example.

Assumptions and limitations of the results will be discussed. Supporting references will be listed as necessary

Required Field Records

Field log for each borehole showing

a) Location and description of the borehole

b) Date of test

c) Field personnel

d) Instrumentation

e) Any deviations from test plan and action taken as a result

This procedure has been reviewed and approved by the undersigned:

Professional Geophysicist Antony J Martin Date Feb 13. 2006

QA Review ________ Date Feb 13. 2006

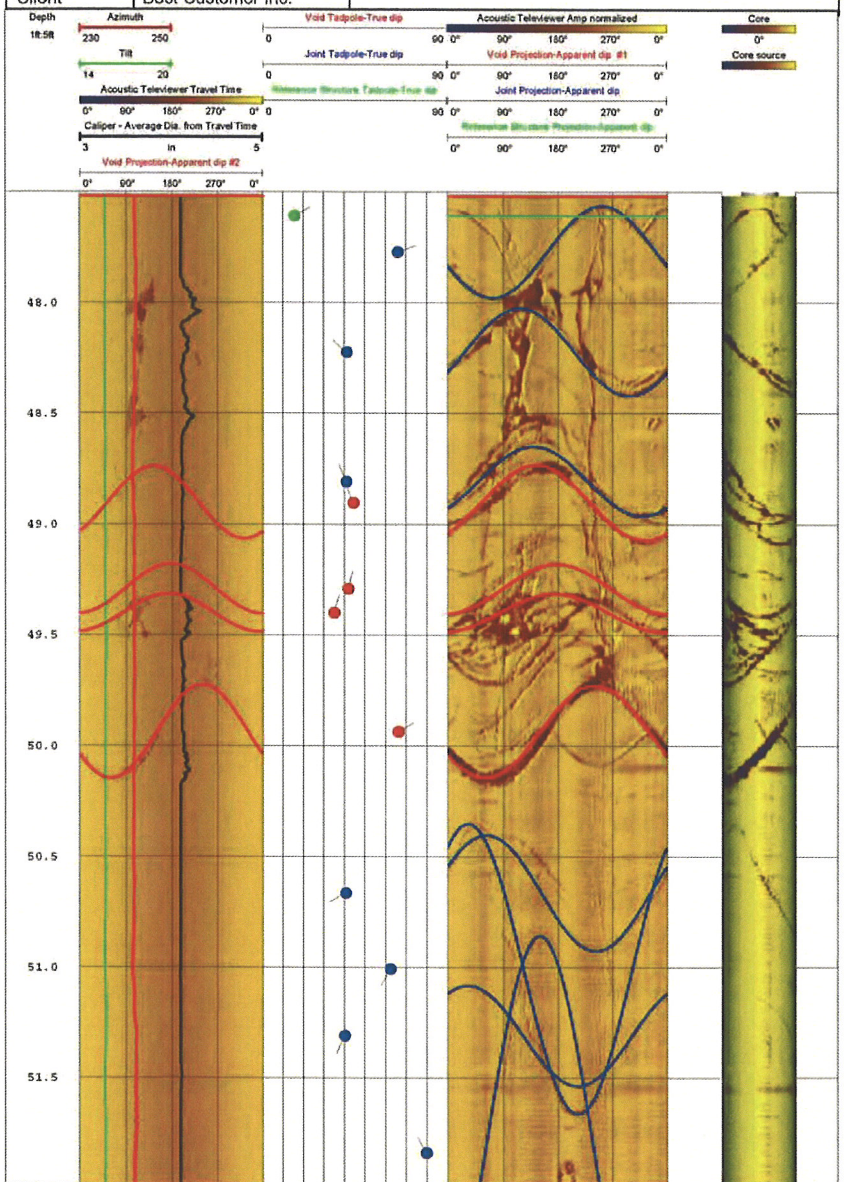
B-XXX	Company	Geovision Geophysical Services
	Location	Somewhere Dam

BH	B-XXX Acoustic Televiewer		
Date	7/8/05	BH Fluid	Air/Water
Casing	4" Steel to 15 ft		
File Name	BXXXdown1		
Depth Drilled	300 feet		
Depth Logged	299.3 feet		
Logged by	Rob Steller		
Client	Best Customer Inc.		

Notes:

1) All orientations referenced to True North

2) Tadpole tails indicate dip direction with True North as up.



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Designation: D 5753 – 05

Standard Guide for Planning and Conducting Borehole Geophysical Logging[1]

This standard is issued under the fixed designation D 5753; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide covers the documentation and general procedures necessary to plan and conduct a geophysical log program as commonly applied to geologic, engineering, ground-water, and environmental (hereafter referred to as geotechnical) investigations. It is not intended to describe the specific or standard procedures for running each type of geophysical log and is limited to measurements in a single borehole. It is anticipated that standard guides will be developed for specific methods subsequent to this guide.

1.2 Surface or shallow-depth nuclear gages for measuring water content or soil density (that is, those typically thought of as construction quality assurance devices), measurements while drilling (MWD), cone penetrometer tests, and logging for petroleum or minerals are excluded.

1.3 Borehole geophysical techniques yield direct and indirect measurements with depth of the (*1*) physical and chemical properties of the rock matrix and fluid around the borehole, (*2*) fluid contained in the borehole, and (*3*) construction of the borehole.

1.4 To obtain detailed information on operating methods, publications (for example, **2**, **5**, **7**, **18**, **24**, **29**, **34**, **35**, and **36**)[2] should be consulted. A limited amount of tutorial information is provided, but other publications listed herein, including a glossary of terms and general texts on the subject, should be consulted for more complete background information.

1.5 This guide provides an overview of the following: (*1*) the uses of single borehole geophysical methods, (*2*) general logging procedures, (*3*) documentation, (*4*) calibration, and (*5*) factors that can affect the quality of borehole geophysical logs and their subsequent interpretation. Log interpretation is very important, but specific methods are too diverse to be described in this guide.

1.6 Logging procedures must be adapted to meet the needs of a wide range of applications and stated in general terms so that flexibility or innovation are not suppressed.

1.7 *This standard does not purport to address all of the safety and liability concerns, if any, (for example, lost or lodged probes and radioactive sources*[3]*) associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:* [4]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 5088 Practice for the Decontamination of Field Equipment Used at Non-Radioactive Waste Sites

D 5608 Practice for the Decontamination of Field Equipment Used at Low Level Radioactive Waste Sites

3. Terminology

3.1 Definitions—Definitions shall be in accordance with Terminology D 653.

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[1] This guide is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.01 on Surface and Subsurface Characteristics.

Current edition approved June 1, 2005. Published June 2005. Originally approved in 1995. Last previous edition approved in 1995 as D 5753–95.

[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

[3] The use of radioactive materials required for some log measurements is regulated by federal, state, and local agencies. Specific requirements and restrictions must be addressed prior to their use.

[4] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.2 *Definitions of Terms Specific to This Standard:* Descriptions of Terms Specific to This Standard—Terms shall be in accordance with Ref (1).

4. Summary of Guide

4.1 This guide applies to borehole geophysical techniques that are commonly used in geotechnical investigations. This guide briefly describes the significance and use, apparatus, calibration and standardization, procedures and reports for planning and conducting borehole geophysical logging. These techniques are described briefly in Table 1 and their applications in Table 2.[5]

4.2 Many other logging techniques and applications are described in the textbooks in the reference list. There are a number of logging techniques with potential geotechnical applications that are either still in the developmental stage or have limited commercial availability. Some of these techniques and a reference on each are as follows: buried electrode direct current resistivity (37), deeply penetrating electromagnetic techniques (38), gravimeter (39), magnetic susceptibility (40), magnetometer, nuclear activation (41), dielectric constant (42), radar (50), deeply penetrating seismic (39), electrical polarizability (45), sequential fluid conductivity (46), and diameter (48). Many of the guidelines described in this guide also apply to the use of these newer techniques that are still in the research phase. Accepted practices should be followed at the present time for these techniques.

5. Significance and Use

5.1 An appropriately developed, documented, and executed guide is essential for the proper collection and application of borehole geophysical logs.

5.1.1 The benefits of its use include improving the following:

5.1.1.1 Selection of logging methods and equipment,

5.1.1.2 Log quality and reliability, and

5.1.1.3 Usefulness of the log data for subsequent display and interpretation.

5.1.2 This guide applies to commonly used logging methods (see Table 1 and Table 2) for geotechnical investigations.

5.1.3 It is essential that personnel (see 7.3.3) consult up-to-date textbooks and reports on each of the logging techniques, applications, and interpretation methods. A partial list of selected publications is given at the end of this guide.

5.1.4 This guide is not meant to describe the specific or standard procedures for running each type of geophysical log and is limited to measurements in a single borehole.

6. Apparatus

6.1 *Geophysical Logging System*, including probes, cable, draw works, depth measurement system, interfaces and surface controls, and digital and analog recording equipment.

6.1.1 Logging probes, also called sondes or tools, enclose the sensors, sources, electronics for transmitting and receiving signals, and power supplies.

6.1.2 Logging cable routinely carries signals to and from the logging probe and supports the weight of the probe.

6.1.3 The draw works move the logging cable and probe up and down the borehole and provide the connection with the interfaces and surface controls.

6.1.4 The depth measurement system provides probe depth information for the interfaces and surface controls and recording systems.

6.1.5 The surface interfaces and controls provide some or all of the following: electrical connection, signal conditioning, power, and data transmission between the recording system and probe.

6.1.6 The recording system includes the digital recorder and an analog display or hard copy device.

7. Calibration and Standardization of Geophysical Logs

7.1 *General*:

7.1.1 National Institute of Standards and Technology (NIST) calibration and operating procedures do not exist for the borehole geophysical logging industry. However, calibration or standardization physical models are available (see Appendix X1).

7.1.2 Geophysical logs can be used in a qualitative (for example, comparative) or quantitative manner, depending on the project objectives. (For example, a gamma-gamma log can be used to indicate that one rock is more or less dense than another, or it can be expressed in density units.)

7.1.3 The calibration and standardization scope and frequency shall be sufficient for project objectives.

7.1.3.1 Calibration or standardization should be performed each time a logging probe is modified or repaired or at periodic intervals.

7.2 *Calibration*:

7.2.1 Calibration is the process of establishing values for log response. It can be accomplished with a representative physical model or laboratory analysis of representative samples. Calibration data values related to the physical properties (for example, porosity) may be recorded in units (for example, pulses/s or µm/ft) that can be converted to apparent porosity units.

7.2.1.1 At least three, and preferably more, values are needed to establish a calibration curve, and the interface or contact between different values in the model should be recorded. Because of the variability in subsurface conditions, many more values are needed if sample analyses are used for calibration.

7.2.1.2 The statistical scatter in regression of core analysis against geophysical log values may be caused by the difference between the sample size and geophysical volume of investigation and may not represent measurement error.

7.2.2 *Physical Models*—A representative model simulates the chemical and physical composition of the rock and fluids to be measured.

7.2.2.1 Physical models include calibration pits, coils, resistors, rings, temperature baths, etc.

7.2.2.2 The calibration of nuclear probes should be performed in a physical model that is nearly infinite with respect to probe response.

[5] The references indicated in these tables should be consulted for detailed information on each of these techniques and applications.

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TABLE 1 Common Geophysical Logs

Type of Log (References)	Varieties and Related Techniques	Properties Measured	Required Hole Conditions	Other Limitations	Typical Measuring Units and Calibration or Standardization	Brief Probe Description
Spontaneous potential **(7, 8, 12)**	differential	electric potential caused by salinity differences in borehole and interstitial fluids, streaming potentials	uncased hole filled with conductive fluid	salinity difference needed between borehole fluid and interstitial fluids; needs correction for other than NaCl fluids	mV; calibrated power supply	records natural voltages between electrode in well and another at surface
Single-point resistance **(7)**	conventional, differential	resistance of rock, saturating fluid, and borehole fluid	uncased hole filled with conductive fluid	not quantitative; hole diameter effects are significant	Ω; V-Ω meter	constant current applied across lead electrode in well and another at surface of well
Multi-electrode resistivity **(7, 8, 13)**	various normal focused, guard, lateral arrays	resistivity and saturating fluids	uncased hole filled with conductive fluid	reverses or provides incorrect values and thickness in thin beds	Ω-m; resistors across electrodes	current and potential electrodes in probe and remote current and potential electrodes
Induction **(10, 11)**	various coil spacings	conductivity or resistivity of rock and saturating fluids	uncased hole or nonconductive casing; air or fluid filled	not suitable for high resistivities	mS or Ω-m; standard dry air zero check or conductive ring	transmitting coil(s) induce eddy currents in formation; receiving coil(s) measures induced voltage from secondary magnetic field
Gamma **(5, 7, 22)**	gamma spectral **(44)**	gamma radiation from natural or artificial radioisotopes	any hole conditions	may be problem with very large hole, or several strings of casing and cement	pulses per second or API units; gamma source	scintillation crystal and photomultiplier tube measure gamma radiation
Gamma-gamma **(23, 24)**	compensated (dual detector)	electron density	optimum results in uncased hole; can be calibrated for casing	severe hole-diameter effects; difficulty measuring formation density through casing or drill stem	gs/cm^3; Al, Mg, or Lucite blocks	scintillation crystal(s) shielded from radioactive source measure Compton scattered gamma
Neutron **(7, 14, 25)**	epithermal, thermal, compensated sidewall, activation, pulsed	hydrogen content	optimum results in uncased hole; can be calibrated for casing	hole diameter and chemical effects	pulses/s or API units; calibration pit or plastic sleeve	crystal(s) or gas-filled tube(s) shielded from radioactive neutron source
Acoustic velocity **(5, 26, 27)**	compensated, waveform, cement bond	compressional wave velocity or transit time, or compressional wave amplitude	fluid filled, uncased, except cement bond	does not detect secondary porosity; cement bond and wave form require expert analysis	velocity units, for example, ft/s or m/s or µs/ft; steel pipe	1 or more transmitters and 2 or more receivers
Acoustic televiewer **(28, 7)**	acoustic caliper	acoustic reflectivity of borehole wall	fluid filled, 3 to 16-in. diameter; problems in deviated holes	heavy mud or mud cake attenuate signal; very slow logging speed	orientated image-magnetometer must be checked	rotating transducer sends and receives high-frequency pulses
Borehole video	axial or side view (radial)	visual image on tape	air or clean water; clean borehole wall	may need special cable	NA[A]	video camera and light source
Caliper **(29, 7)**	oriented, 4-arm high-resolution, *x-y* or max-min bow spring	borehole or casing diameter	any conditions	deviated holes limit some types; significant resolution difference between tools	distance units, for example, in.; jig with holes or rings	1 to 4 retractable arms contact borehole wall
Temperature **(30, 31, 32)**	differential	temperature of fluid near sensor	fluid filled	large variation in accuracy and resolution of tools	°C or °F; ice bath or constant temperature bath	thermistor or solid-state sensor
Fluid conductivity **(7)**	fluid resistivity	most measure resistivity of fluid in hole	fluid filled	accuracy varies, requires temperature correction	µS/cm or Ω-m; conductivity cell	ring electrodes in a tube
Flow **(12, 33, 7)**	impellers, heat pulse	vertical velocity of fluid column	fluid filled	impellers require higher velocities. Needs to be centralized.	velocity units, for example, ft/min; lab flow column or log in casing	rotating impellers; thermistors detect heated water; other sensors measure tagged fluid.
Deviation **(4, 7, 47)**	magnetic, gyroscopic, or mechanical	horizontal and vertical displacement of borehole	any conditions (see limitations)	magnetic methods orientation not valid in steel casing	degrees and depth units; orientation and inclination must be checked	various techniques to measure inclination and bearing of borehole

[A] NA = not applicable.

TABLE 2 Log Selection Chart for Geotechnical Applications Using Common Geophysical Logs[A]

Information Desired	Acoustic		Electric and Induction					Fluid Logs				Radioactive or Nuclear				Other Methods			
	Acoustic Tele-viewer	Acoustic Velocity, Δt, CBL, VDL, FWS	Induced Polari-zation	Multi-electrode Resistivity, Normal, Lateral, Micro Guard Resistivity	Single-Point Resis-tance	Sponta-neous Poten-tial	Induc-tion (Conduc-tivity)	Flow Meter	Fluid Resistivity	Fluid Sampler	Temper-ature, Differ-ential Temper-ature	Gamma-Gamma Density	Gamma	Neutron	Spectral Gamma	Borehole Video	Caliper	Casing Collar Locator	Deviation
Lithology and Correlation																			
Bed/aquifer thickness; correlation, structure	•	•		•	•	•	★					Δ	√	Δ	√	◇	√		
Lithology—depositional environment	?	•		•	•	•	★					Δ	√	Δ	√	◇	√		
Shale or clay content			•	•		•	★					Δ	√	Δ	√				
Bulk density												Δ							
Formation resistivity				•			★												
Injection/production profiles				?			?	□	□		□	Δ		Δ					
Permeability estimates		•						□	□		□		√						
Porosity (amount and type)	•	•		•			★					Δ		Δ					
Mineral identification			•									Δ			√				
Potassium-uranium thorium content (KUT)															√				
Rock Structure																			
Strike and dip of bedding	•															◇			√
Fracture detection (number of fractures), RQD	•	•		•	•											◇	√		
Fracture orientation and character	•															◇			√
Thin bed resolution	•			?	•											◇	√		
Fluid Parameters																			
Borehole fluid characteristics								?	□	□	□								
Fluid flow						•		□	□		□					◇			
Formation water quality				•		•	★			□									
Moisture content—water saturation				?			?					Δ		Δ					
Temperature		?									□								
Water level and water table	•	•		•	•	•	?		□		□	Δ		Δ		◇			
Borehole Parameters																			
Casing evaluation integrity, leaks, damage, screen location	■	■					?	■			■					◆	√	†	
Deviation of borehole																			√
Diameter of borehole	•																√		
Examination behind casing		•					★					Δ		Δ					
Location of debris in wells	•															◆	√	√	
Well completion evaluation, for example, cement bond, seal location, grout location	?	■					★					Δ	√	Δ					

[A] Required hole conditions: ■ = cased fluid-filled hole, ◆ = clear fluid or dry cased hole, □ = screened or open fluid-filled hole, ◇ = clear fluid or dry open hole, † = steel casing only, Δ = active nuclear log to be run in stable holes, ★ = open or nonconductive cased holes, dry or fluid filled, √ = no restrictions, • = open fluid-filled hole only, and ? = possible applications.

7.2.2.3 Some probes have internal devices such as resistors, but this does not substitute for checking the probe response in an environment that simulates borehole conditions, and the use of such devices is considered standardization.

7.2.2.4 *Calibration Facilities*—Commonly used calibration pits or models for use by anyone at the present time are listed in Appendix X1 (**14-18**). The user should inquire concerning the present validity of any facility.

7.2.3 *Sample Analyses*:

7.2.3.1 Representative samples from boreholes in the project area that have been collected carefully and analyzed quantitatively also may be used to calibrate log response.

7.2.3.2 To reduce depth errors, the sample recovery of rock cores in calibration holes needs to approach 100 % for the intervals used for calibration. Log response should be used to select sample depths to span the range of desired log calibration values and to be within thick units to minimize the effects of potential depth errors. Samples need to be analyzed immediately or steps taken to preserve them for later analysis.

7.2.3.3 Samples to be used for log calibration should be analyzed only from depth intervals at which the log response is relatively uniform for a depth interval considerably greater than the vertical dimension of the volume of investigation of the logging probe. Samples near lithologic contacts or fluid interfaces should not be used because of possible boundary effects or depth errors.

7.3 *Standardization*:

7.3.1 Standardization is the process of checking the log response to reveal evidence of repeatability and consistency.

7.3.2 Standardization is needed to establish comparability between logs made with different equipment or at different times and to ensure the accuracy of measurements.

7.3.2.1 Standardization checks should include at least two different measurement values approximating the range of interest (For example, aluminum and magnesium or plastic blocks are used commonly to check the response of gamma-gamma density logging systems in the field.)

7.3.3 Standardization uses some type of a standard that may be used in the field or laboratory and repeat logs.

7.3.3.1 Log response needs to be checked using field standards often enough to satisfy the project objectives. Standardization of the log response provides the basis for correcting for changes (for example, changes in output with time due to system drift or changes of equipment).

7.3.3.2 Selected log intervals should be repeated (that is, re-logged). Repeat logs provide information on the stability of logging equipment.

7.3.3.3 A representative borehole may be used to check log response periodically. This borehole environment and the rocks and fluids penetrated may change with time.

8. Procedure

8.1 *Planning the Logging Program*:

8.1.1 A work plan should be developed prior to implementing the logging program.

8.1.2 The key steps in developing a logging work plan should include the following:

8.1.2.1 *Log Selection*—See Table 1 and Table 2.

8.1.2.2 *Personnel Selection*—See 8.3.2.

8.1.2.3 *Quality Control and Documentation*—See 8.4.

8.1.2.4 *Calibration and Standardization Procedures*—See Section 7.

8.1.2.5 *Equipment Liability*—See 1.7.

8.1.2.6 *Equipment Decontamination*—In environmental investigations, equipment decontamination may be required before, after, and between individual wells. Equipment decontamination may involve a number of standardized procedures, depending on the nature of the project (see Practices D 5088 and D 5608). A decontamination program should be agreed upon by all parties before logging commences, and procedures specified by the work plan should be followed.[6]

8.1.2.7 *Log Interpretation*—See 8.5.

8.2 *Field Assessment of Borehole Conditions*:

8.2.1 Borehole conditions can have a profound influence on the quality of log data and subsequent interpretation. Important parameters to consider include the following:

8.2.1.1 Drilling method, casing, drill hole history, and well completion materials.

8.2.1.2 *Borehole Fluid Properties*—Resistivity, temperature, density, viscosity, and chemistry at the time of logging.

8.2.1.3 Borehole diameter, rugosity, and stability.

8.2.1.4 Deviation of borehole.

8.2.1.5 Wellhead pressure.

8.2.2 *Logging Operations*:

8.2.2.1 Determine the sequence and direction of logging. The sequence in which a suite of logs is run is important from both a data quality and operational viewpoint. Because logging operations mix the borehole fluid, logs of fluid properties (for example, temperature, fluid resistivity, and fluid sampling should be run prior to other logs). Consideration should also be given to when borehole video surveys are performed because some logging tools may degrade borehole clarity. Tools that have arms or bowsprings that contact the borehole wall should be run late in the logging sequence because of the greater possibility of material from the borehole wall falling into the borehole. Because of the consequences of losing a tool with a radioactive source, these tools should be run last, and after a caliper log. Unstable boreholes should not be logged with radioactive source probes. All logs except fluid properties and video should be run with the probe moving up the borehole to reduce depth errors.

8.2.2.2 Select the depth reference. The selected depth reference needs to be stable and accessible.

8.2.2.3 Select horizontal and vertical scales.

8.2.2.4 Select the digitizing interval. See 8.3.1.2.

8.3 *Other Considerations*:

8.3.1 *Data Formats*—There are two methods of recording log data, digital and analog. Digital recording of logs should be used because of the numerous benefits of data manipulation. Digital recording is not yet practical for some logs such as video or acoustic televiewer.

8.3.1.1 An analog display should be available to be viewed in the field to verify the correct tool operation. Depth scales and units of measurement for the horizontal scale must be indicated clearly on each log.

8.3.1.2 The digital data are recorded at an operator-selected depth interval that should be as small as possible, at most, half the thickness of the smallest rock unit that can be resolved. The time interval for digital samples can also be selected by the operator. ASCII is the recommended format except for such logs as spectral gamma, full waveform sonic, borehole video, and acoustic televiewer. The digital file header should include all of the necessary information to reconstruct the logging

[6] Equipment decontamination procedures may have specific safety and equipment limitations that must be addressed prior to their use.

procedures accurately and should duplicate the information included in the written header of the log.

8.3.1.3 Unprocessed data should be available. Nonproprietary processing algorithms shall be furnished if processed data is provided.

8.3.2 *Personnel*:

8.3.2.1 Personnel not having specialized training or experience should be cautious about using borehole geophysics and should solicit assistance from qualified practitioners or attend courses on borehole geophysics.

8.3.2.2 Personnel operating logging equipment should have an understanding of the theory, field procedures, and methods of log interpretation.

8.3.2.3 A geoscientist, with experience in borehole geophysics, who understands the project objectives and local geohydrology may need to be available to examine logging results during logging operations when consistent with objectives of the program. This geoscientist is responsible for determining whether the instructions selected in the prelogging conference are being followed and whether changes should be made.

8.3.2.4 Log interpretation should be performed by a geoscientist with experience in borehole geophysics and knowledge of the site geology and hydrology.

8.4 *Field Documentation*—A documentation plan for both the analog plot and digital data file should be established and become part of the work plan. Documentation of the following procedures is needed: calibration of logging probes, field operation of geophysical logging equipment, applicable decontamination, and format for presenting geophysical well log data. Repair, standardization, and calibration information should also be documented. Probes should be numbered to simplify the identification of associated documentation. Document all field problems including equipment malfunctions. This should include the steps taken to solve the problem and how the logs might have been affected. Repeat runs and field standardization should be more frequent when equipment problems occur. The use of one borehole on the project to check the probe response may aid in the identification of equipment or other problems. Probes should be recalibrated in a physical model after major repairs have been made.

8.4.1 *Log Headings (Headers)*—The log heading should contain all of the information that is necessary to analyze the log trace. Because auxiliary documents are frequently unavailable to other users of the log, all of the critical information concerning the log should be included on the final log heading. The header information should also be included in the same computer file as the log data. The following items listed are necessary and should be included on the log headings and computer files when appropriate. If information is not available or applicable, it should be noted on the heading. The following information should be included:

8.4.1.1 *Background Well Information*:

Owner of well and address, location of well (UTM coordinates, ¼ section, etc.); date; logging contractor and address; logging operator; drilling contractor and address; client and address; observer and address; elevation of top casing and distance above ground; and drilling history, methods etc.

8.4.1.2 *Borehole Conditions*:

Casing description; description of log depth datum; elevation of log depth datum; type of drilling fluid; resistivity and temperature of borehole fluid; depth of origin of borehole fluid samples; fluid level; time since last mud circulation; bottom hole temperature; and problems and unusual conditions.

8.4.1.3 *Equipment Data and Logging Parameters*:

Description of probe reference point; model and manufacturer of logging tools; logging company tool number; date and type of last calibration; date, type, and response of field standardization; top and bottom of logged interval; logging speed and direction; vertical depth error after logging; time constant or the time interval of digital samples; identification of disk containing digitized logs; and equipment problems.

8.4.1.4 *Specific Information for Nuclear Logging Probes*:

Source description, initial source strength, and date determined; source to detector or receiver spacing; detector description; and data filtering or enhancement parameters.

8.4.1.5 *Specific Information for Acoustic and Electric Logging Probes*:

source or transmitter description and signal output; source or transmitter to detector or receiver spacing; detector or receiver description; and data filtering or enhancement parameters.

8.4.2 *Quality Control During Logging Operations*:

request changes in logging speed and time constant; repeat logs or log intervals based on field log analysis; check depth readout against log; note errors or changes on the log; and verify documentation listed above.

8.5 *Log Interpretation*—The full potential of a logging program cannot be realized until the logging measurements are interpreted. Log interpretation should start at the time of data acquisition and should continue as an iterative process throughout the project.

8.5.1 Logs should be analyzed and described as a suite and combined with information on lithology and fluid quality because of the synergistic nature of log data. The nonunique response of logs dictates the use of data from other sources to check the log interpretation, and this background data must be included in the report. A computer will be used in most cases to aid analysis of the logs, and information on the software and algorithms used should be included in the report.

8.5.2 Important interpretation steps include the following:

8.5.2.1 Establishing database (for example, format conversion, depth corrections, editing, and filtering).

8.5.2.2 Applying borehole corrections (for example, correct electric logs for borehole diameter and fluid resistivity).

8.5.2.3 Performing initial data inversion-conversion log units to values appropriate for investigation (for example, density units to porosity).

8.5.2.4 Performing large-scale data inversion (for example, cross sections, regional correlation, and model parameters).

9. Report

9.1 Depending on the project objective, report only data or data and interpretations.

9.1.1 Both types of reports should include the following:

9.1.1.1 Objectives and scope.

9.1.1.2 Field Documentation (for example, site conditions, borehole conditions, data collection procedures, calibration and standardization of logging probes, field operation of geophysical logging equipment, and format for recording geophysical log data, including any filtering or processing of the data, problems, and unusual conditions; see 8.4).

9.1.1.3 Both the digital log data and log plots.

9.1.1.4 Abstract, executive summary, or conclusions.

9.1.2 Interpretation reports should include the following:

9.1.2.1 Log composites (for example, summary plots showing logs, lithology, well construction, and water quality zones). These composites are commonly annotated to indicate the features of interest and correlated with lithologic descriptions.

9.1.2.2 Brief description of the geologic and hydrologic setting.

9.1.2.3 Specific information on log analysis, that is, depth corrections and recalibration of logs, physical models or sample analyses that were used for calibration, methods of log interpretation, software used, and copies of cross-plots or other plots of data resulting from log analysis.

9.1.2.4 Well-to-well correlation sections and comparison to surface geophysical and other testing data, when available.

10. Keywords

10.1 acoustic logging; acoustic televiewer; borehole geophysics; borehole video; caliper logging; chemical properties and physical properties; deviation; electric logging; environmental; fluid conductivity/resistivity logging; fluid logging; gamma logging; gamma-gamma logging; geology; geophysics; geotechnical; ground water; hydrology; induction logging; log calibration and standardization; log headings; neutron logging; nuclear logging; resistivity logging; singlepoint resistance logging; spontaneous potential logging; temperature logging; well logging

APPENDIX

(Nonmandatory Information)

X1. CALIBRATION FACILITIES AVAILABLE FOR PUBLIC USE (1989)

X1.1 *Name and Location*—American Petroleum Institute Calibration Facility, University of Houston, Houston, TX: four pits (14, 19, 20).

X1.2 *Who to Contact:* University of Houston, Cullen College of Engineering, (713) 749-3423.

X1.3 *Probes That Can Be Calibrated*—Pit 1: neutron and gamma-gamma; Pit 2: gamma (simulated shale); Pits 3 and 4: spectral gamma.

X1.3.1 *Name and Location*—U.S. Department of Energy, Grand Junction, CO: 20 models or pits (18).

X1.3.2 *Who to Contact*—U.S. Department of Energy, Grand Junction Operations Office, or the prime contractor at the U.S. Department of Energy office, (303) 248-7768 or 6702.

X1.4 *Probes That Can Be Calibrated*—Gamma, gamma spectral, neutron, gamma-gamma, and magnetic susceptibility. Also, wet and dry borehole size factors and a 300-ft borehole with radium foil at known depths for check of depth measurements.

X1.4.1 *Name and Location*—U.S. Bureau of Mines density pits Pit 1: six holes and magnetic susceptibility (Pits 2). Denver Federal Center, Lakewood, CO: Pit six holes; Pit 2: three holes (17).

X1.4.2 *Who to Contact*—U.S. Geological Survey, Water Resources Division, Borehole Geophysics Project, Building 25, Denver Federal Center, (303) 236-5913.

X1.5 *Probes That Can Be Calibrated*—Pit 1: gamma-gamma, acoustic, resistivity; and Pit 2: magnetic susceptibility.

X1.5.1 *Name and Location*—U.S. Department of Energy, Fractured igneous rock calibration models, Denver Federal Center, Lakewood, CO: Three models or pits (16).

X1.5.2 *Who to Contact*—U.S. Geological Survey, Water Resources Division, Borehole Geophysics Project, Building 25, Denver Federal Center, (303) 236-5913.

X1.6 *Probes That Can Be Calibrated*—Fracture detection probes, neutron, gamma-gamma, short-spaced resistivity, and acoustic velocity.

X1.7 *Other Facilities*—The Geological Survey of Canada is developing a system of deep test holes and calibration facilities that are presently available at several locations in Canada. Gamma, gamma spectral, and coal property models are completed, and other physical property models are under construction (15). Calibration facilities at universities, private logging companies, and government agencies may also be available at other locations for use by outside logging groups.

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