NJDEP Technical Guidance Document Review Form

Document: *"FSPM Chapter 8 - Geophysical Techniques"*

Comment Period: *September 27, 2022 to November 9, 2022*
Chairperson: *Crystal Pirozek*

Comment #	Page	Section	Subsection	COMMENTS	RESPONSE
1	TOC	8.2		Use acronym "GPR"	agreed to change
2	TOC	8.6		Use acronym "IP"	agreed to change
3	TOC	8.7		Use acronym "EM"	committee decided not to change
4	4 to 5	8.1	--	Consider adding text noting that discussion of the selected technique(s), including methods, criteria, limitations, QC requirements, etc., shall be provided in the Project WP/QAPP with associated SOPs.	agreed to add
5	4	8.1		Electromagnetic and seismic methods are included in this chapter.	agreed to change
6	5	8.2		Add acronym "GPR"	agreed to change
7	5	8.2	1	Define Bistatic GPR	explained mono vs bistatic
8	5	8.2	1	Replace "ohmmeters" with "ohm-meters"	committee decided not to change
9	5	8.2	1	resolution is ± 0.1 meter	agreed to change
10	6	8.2	3	should use commas instead of semicolo: "radar waves, therefore…"	committee decided not to change
11	7	8.2	5	need closing parenthesis	agreed to change
12	7	8.3	1	the term is "gamma" not "gammas"	agreed to change
13	9	8.3	5	define diurnal	added (daily)
14	12	8.4	5	replace "2-" with "two dmensional…"	agreed to change
15	13	8.5	1	replace "ohmmeters" with "ohm-meters"	committee decided not to change
16	14	8.5	5	use only acronyms: "VES", "CST" and "ERT" -previously defined	committee decided not to change
17	14	8.5	6	Figure 8.1 - define "a", "M" and "N"	agreed to change
18	16	8.5	10.1	Paragraph seems duplicated	committee decided not to change

19	16	8.6		Add "IP" to header and use only that acronym in the body of the text.	agreed to change
20	16	8.6	1	Use only acronym "IP" previously defined	agreed to change
21	17	8.6	2	Use only acronym "IP" previously defined	agreed to change
22	17	8.6	3	Use only acronym "IP" previously defined	agreed to change
23	17	8.6	4	Use only acronym "IP" previously defined	agreed to change
24	17	8.6	5	Use only acronym "IP" previously defined	agreed to change
25	19	8.7		Add "EM" to header and use only that acronym in the body of the text.	Since its only one word, decided not to make acronym
26	19	8.7	1	Use only acronym "EM" previously defined	committee decided not to change
27	19	8.7	2	Use only acronym "EM" previously defined	committee decided not to change
28	19	8.7	3	Use only acronym "EM" previously defined	committee decided not to change
29	19	8.7	4	Use only acronym "EM" previously defined	committee decided not to change
30	19	8.7	4	replace millimhos with millisiemens	agreed to change
31	20	8.7	5	Use only acronym "EM" previously defined	committee decided not to change
32	20	8.7	6	millivolts is not a conductivity unit	changed
33	21	8.8		Add acronym "VLF"	already there
34	21	8.8	1	use only acronyms VLF and EM previouly defined	decided not to use EM acronym
35	24	8.9	2	Figure 8.2 does not show devices as multiple of 6	figure does show as multiple of 6
36	24	8.9	3	should read "… in Figure 8.3."	the figure number is correct
37	25	8.9	3.2	replace semicolons with commas	changed list to bullets
38	28	8.9	4	Figure 8.4 - define V1 and V2	V1 andV2 already defined in text, added "(V1, V2)" to text to clarfiy, Also V1 and V2 are defined in figure 8.2.
39	29	8.9	4.3	replace year 1896 with 1986	agreed to change
40	29	8.10	1	Suggest revising and adding to the last sentence of the 1st Paragraph, as follows: "Natural gamma ray and resistivity logs have been widely used, along with other traditional logging methods, in the water well industry for many years. In the past 20 years, additional advanced methods, including borehole imaging and measurement of in-borehole flow, have become standard elements of bedrock hydrogeologic studies, providing quantitative data to support water supply and environmental site remediation projects."	added to text

41	29,30	8.10	2	Suggest adding the following, after the 1st Sentence: "When correlation of borehole geophysical logs can be established among multiple holes at a site, an "indexed" key to stratigraphic units, and potentially, to specific transmissive fractures or zones, may be developed, evidence for which may be absent using other investigative methods. Application of borehole geophysics in existing wells (open-hole or cased) can often provide new understandings of site hydro-stratigraphic conditions, without the need for additional drilling. Borehole geophysics provides results that are objective and repeatable, less subject to variations of individual interpretations than descriptions of soil or rock cuttings or core. Generally, borehole geophysical records provide continuous, full coverage of the logged interval, including in fractured or weathered intervals of particular interest for groundwater studies and which can be poorly recovered by coring methods. Advanced methods, when applied with proper quality control measures, can provide abundant quantitative information on rock structure and fracture orientations, and flow conditions that is often otherwise unavailable (e.g., due to lack of surface exposure of geologic units, cost of applying other methods such as packer testing and pumping tests)."	added to text
42	30	8.10	4	Suggest modifying 1st Sentence of the 2nd Paragraph as follows: "Categories 1, 2, and 4 have historically been more commonly seen in ground water studies because they are relatively inexpensive and easily handled."	changed text
43	30	8.10	4.1	Suggest adding the following sentence to the end of the 1st Paragraph: "Natural gamma logs are key elements of sedimentary bedrock hydrogeologic studies such as those conducted for site remediation in the Newark Basin, where site-wide correlation of the logs, which regularly with rock layering, provides the initial basis for understanding the physical framework of the Leaky, Multi-unit Aquifer System (LMAS) default conceptualization embraced in NJDEP's *Ground Water Technical Ground Water Technical Guidance: Site Investigation Remedial Investigation Remedial Action Performance Monitoring*".	changed text
44	30	8.10		Suggest modifying 2nd Sentence of the 3rd Paragraph, and adding additional text, as follows: "This characteristic of the natural gamma log enables evaluation and correlation of rock or sediment units within the aquifer system stratigraphic template, using data that can be quickly collected from existing well networks. A common approach is to log all of the deepest wells (which provide the fullest vertical record) in each well nest or cluster. Frequently, even in bedrock settings, the deepest well is of PVC construction, which is highly amenable to collection of a representative, correlateable natural gamma record. It should be noted that casing shields some of the gamma rays, most notably in steel-cased portions of boreholes, thus, lowering the count rate compared to that in uncased holes. Additionally, the larger-diameter borehole present around the cased interval places the logging tool further from the borehole wall than in the lower, open-hole portion (where the probe typically rides along the "low side" of the borehole), which can also contribute to lower gamma response. While the numerical gamma count result is rarely important for groundwater studies, the diminished responses can otherwise distinct log characteristics and thereby complicate log correlation efforts. In this case, correction factors based on known casing pipe and borehole dimensions can be applied to data from the affected portion of the logging run, and reported as an additional "corrected" log, with appropriate description in the logging report."	changed in text
45	32	8.10	4.2	Suggest adding the following after the Last Sentence of this Sub-Section: "Single point resistance and normal resistivity logs are frequently used as stratigraphic evaluation tools complementary to natural gamma logs, in both consolidated and unconsolidated settings. Where high-gamma responses are due to the presence of clays, the high water saturated porosity that accompanies such lithology causes correspondingly low responses in the single point resistance and normal resistivity. Except where sands rich in potassium-feldspar are present, it is common for the gamma and electrical logs to present "hourglass" pattern, in sand/clay, sandstone/mudstone sequences. The same pattern may also be evident within vertical assemblages of predominantly fine-grained sediments or rocks, where textural variations are more subtle.	added to text
46	32	8.10	4.2	use acronym "EM" previously defined	committee decided not to change
47	33	8.10	4.3	replace 1 x 10^{-6} feet with microfeet	committee decided not to change

48	33	8.10	4.3	define vuggy porosity	added definition
49	34	8.10	4.4	Suggest revising the 4th Paragraph to read as follows: "A flowmeter measures the vertical movement of fluid in the borehole. The flowmeter can be used to detect hydraulic head differences between two aquifers, or can be used to determine if an artesian system exists. In fractured bedrock settings such as the Newark Basin rocks in New Jersey, the pattern and magnitude of in-flow and out-flow conditions, which can be interpreted from flow meter profiling of borehole crossing aquifer sub-units, aids the understanding of key transmissive fractures. Traditional "spinner" type devices employ a rotor or impeller to directly measure fluid movement. These devices typically have lower measurement limits of about 2 meters per minute for static measurements. Sensitivity can be increased by running spinner devices while "trolling" up and down the borehole at known cable speeds. More advanced flow meters are available, with lower measurement limits of less than 0.03 m/min. These include heat-pulse, or thermal, flow and electromagnetic flow meters. These flow meters can be used under static water-level conditions and pumping conditions to develop hydraulic-conductivity profiles of aquifers. Heat-pulse flow meters have been widely adopted for fractured bedrock remediation site characterization. These tools employ special divertors to channel ambient or pumping induced flow through the tool body, where the response time is measured, and used to calculate a flow rate in galls/min. Where borehole conditions are favorable and a good seal is accomplished with the flowmeter divertors, lower measurement limits of 0.03 galls/min are achievable with the heat-pulse flow meter tool."	added to text
50	36	8.10	4.5	Suggest adding sentence to the end of this Section: "In practice, the acoustic and optical televiewers often provide a complementary data set. Imaging of sedimentary bedding layers, important in bedrock such as the Leaky, Multi-unit Aquifer System of the Newark Basin, is best done with an optical televiewer. The optical televiewer can also reveal the presence of features such as NAPL staining or mineral precipitates indicating vertical flow directions at fractures. Acoustic televiewer data can show fractures through turbid water, which may exist within only a portion of the borehole (allowing optical televiewer to be used in the remainder). Acoustic televiewer data can identify some fractures not evident by optical televiewer, even in clear sections. Acoustic televiewer data may reveal correlatable sections of harder rock which are not evident based upon texture or color seen in the optical televiewer log."	added to text
51	37	8.10	5	Suggest including the following info pertaining to Acoustic and Optical televiewer and the structural data they are used to derive, which Princeton Geoscience contributed previously to the ITRC's Implementing Advanced Site Characterization Tools guidance document section for ATV and OTV: "The log analyst may use the OTV output and processing software to prepare interpretive logs, such as a Structure Log depicting the attitude (strike and dip, or dip/dip azimuth) of each planar feature identified by the log analyst. Such interpretive logs incorporate significant judgments made by the log analyst, often considering data from more than one logging tool. For example, if both OTV and ATV are run, both will be considered in developing the Structure Log. If the structural feature classifications employed by the log analyst make reference to apparent capacity of a feature to yield water to the well, the interpretive log depicting the apparent water-yielding fractures or intervals will be based upon consideration of not only the tools used for creation of the structural log, but also those indicative of potential fluid movement (i.e., fluid temperature, fluid resistivity and heat-pulse flowmeter). Structural interpretations generate based upon OTV (and ATV) logs are sensitive to conditions such as borehole deviation and variations in diameter. Borehole deviation, the departure of the borehole from vertical (measured in degrees) and the concepts of "apparent dip" vs. "true dip" are illustrated in the following figure. Obviously, a probe run in a deviated borehole will not provide accurate dip (relative to horizontal). Correction should therefore be made during log processing, utilizing deviation measurements collected by orientation sensors within the OTV probe. **(INSERT Apparent vs. True Dip figure - Slide 1)**	added some of the text. There is a little too much detail for this manual.

52				As illustrated below, where planar features intersect a portion of the borehole with enlarged diameter, a correspondingly higher-amplitude feature trace will result on the sinusoidal structure plot. As a result, dips will always be overstated through caving or soft-rock intervals where hole diameter is enlarged, if no corrections are made to properly account for the off-gauge condition of the borehole. As shown in the table below, even a one-inch enlargement of hole diameter can result in overstatement of dip by several degrees. The correction requires reference to a continuous log of borehole diameter (mechanical or acoustic caliper). Therefore, either mechanical caliper or ATV logs should also be run when OTV is used to evaluate structure. **(INSERT Borehole Washout Need for Dip Correction Figure and Table - Slides 2 and 3)** While somewhat time-consuming, employing these corrections during log processing is necessary to provide results which are accurate and comparable between locations at a site. While the incremental accuracy provided, for example, by correcting for a few degrees of vertical deviation or moderate borehole enlargement (a common condition) may seem minor, common uses of geophysical logging data imply otherwise. As shown in the down-dip well siting example illustrated in the figure and table below, dip error as small as 1 degree can result in a typical (10-foot long) monitoring well screen being placed incorrectly, missing the intended monitoring zone. [With >5 feet of error in the vertical placement, a fracture meant to be located mid-screen would be entirely missed at the down-dip location]. **(INSERT Planar Feature Dip Accuracy Needs Figure and Table - Slides 4 and 5)**	
53	37	8.10	6	Suggest revising this Section as below, including information Princeton Geoscience contributed previously to the ITRC's Implementing Advanced Site Characterization Tools guidance document: The geophysical logging professional should prepare a report including, at minimum, a copy of the logs from each run, displayed at a common vertical scale useful for the purposes intended (see example "Composite Log", below). **(INSERT Example Composite Log - Slide 6)** Each paper log record should show the name and location of the well or test boring, the date that the logging was performed, the company and individual(s) performing the logging, log headings showing the types of probes employed and scaling. Locations of the wells or borings that were logged should be documented on a site map prepared by the user of the geophysical logging data. For projects that involve more than simple plotting of raw, uncorrected data recorded by the logging equipment, a written report should accompany the logs. Such report should include description of the purposes, scope, implementation and results of the geophysical logging work; including the bases for and methods used for any interpretive aspects of the project, classification schemes employed, problems encountered and solutions applied.	added text
54	38	Ref's		Suggest adding these to the References section: https://www.nj.gov/dep/njgs/enviroed/oldpubs/bulletin77.pdf https://asct-1.itrcweb.org/4-borehole-geophysics/	references included
55	Whole Doc	8		General Comment - basic sampling program design requires a clear understanding of the Site CSM and use of professional judgment to arrive at a recommended grid or transect layout. That must be discussed in the document, and wherever in the document there is suggested spacing, that must be caveated as being only a suggestion and not a "requirement" as this is a guidance document.	professional judgement is not discussed in this document
56	Whole Doc	8		General Comment - there are various QA/QC tools for the numerous methods discussed, such as station re-occupation, running loops, pairing locations with borings as ground-truth. Some of these techniques are discussed in the document, but only very generically. Use of these methods is critical and such discussion must be elevated to stand-alone sections or expanded upon where appropriate.	the introduction already indicates that each site is unique and interpretive. Agreed to not expand

57	Whole Doc	8		General Comment - Successful application of these techniques may be limited by site geologic conditions (e.g. shallow water table, shallow peat or “muck”) and cultural features (e.g., buried slabs). The importance of a quality CSM / basic site conditions should also be used as a guide in designing geophysical investigations - suggest adding this to the intro section	this is already discussed in the introduction
58	Whole Doc	8		General comment - there are many assumptions that factor into the interpretation of geophysical data. In most cases, the scope of an RI will not allow the "fine-tuning" of such assumptions. However, to the extent that the geophysical survey provides a rational view and reliable interpretation of the subsurface, this should be acceptable, and a great improvement over other ways (e.g., a few soil boring per acre). The document should acknowledge / discuss this, but allow the investigator to determine the level of refinement that is necessary for the project DQOs.	committee decided not to change