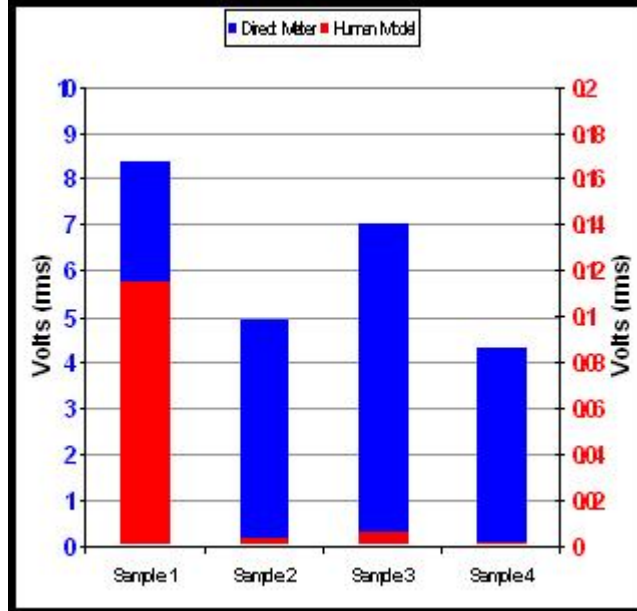




Project Set 128 B
128.004 – Elevated Neutral-to-Earth
Voltages and Urban Stray Voltage
Concerns in Distribution Systems

Doug Dorr
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Denver CO, September 2008



Project P128.004 – 2008

NEV & Urban Stray Voltage

Objectives

- Promote standardized methods to identify and deal with elevated neutral-to-earth voltages NEV and energized conductive objects

Deliverable

- Technical Update(s) – Website/Guidebook

Completion Date

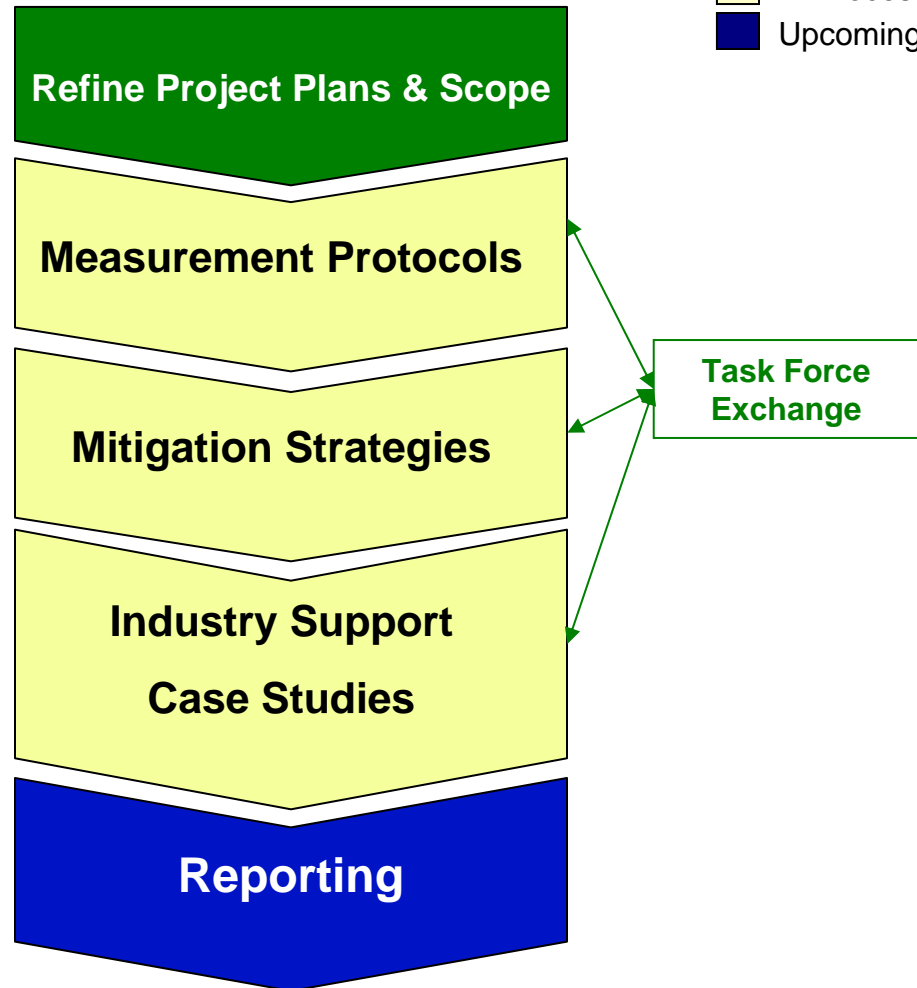
- December 2008

The Big Picture

- *Efficient diagnosis and mitigation of voltage related perception complaints benefits electric suppliers and the general public*

Budget 275K

Key Tasks and Milestones



2008 and 2009 Plans - Measurement and Mitigation Device Evaluations

- Evaluate selected measurement equipment and/or mitigation devices to support a comprehensive NEV and Urban Stray Voltage investigators toolbox
- Primary focus areas are:
 - Mitigation Techniques – NCC device
 - Existing Measurement Devices – A_p Notes and V_R
 - Developmental Measurement Device Needs – Source?





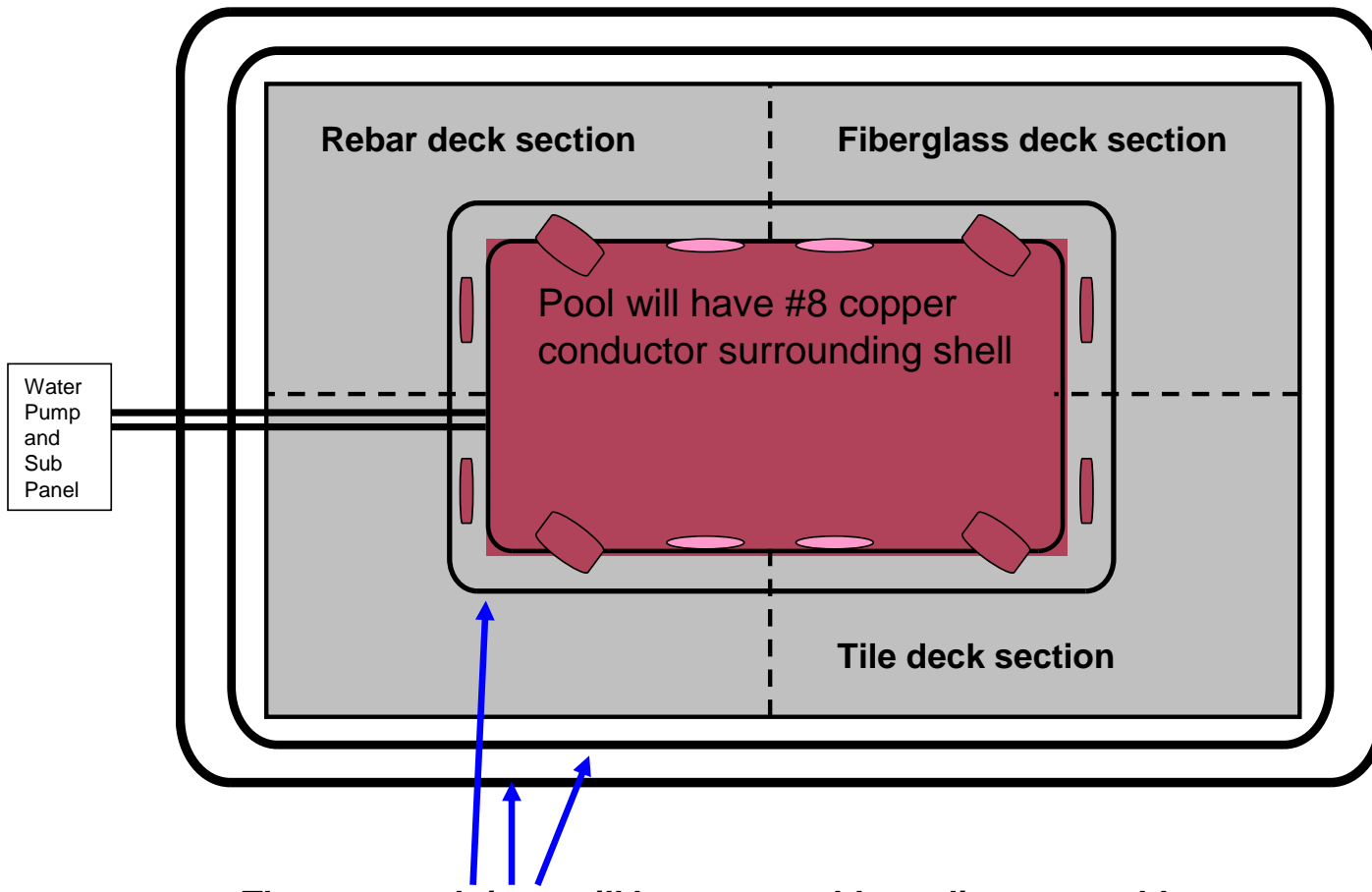
**To support the project objectives, we have constructed a controllable test area at the Lenox, MA facility
Can vary: Distribution Configurations, Neutral impedances, grounding configurations, NEV sources....**

Options for shared water main and connections to multiple residences



Supplemental Help to Support the Base Efforts

 = Underwater Light  = Metal Handrail  = Ladder



Three ground rings will be connectable or disconnectable

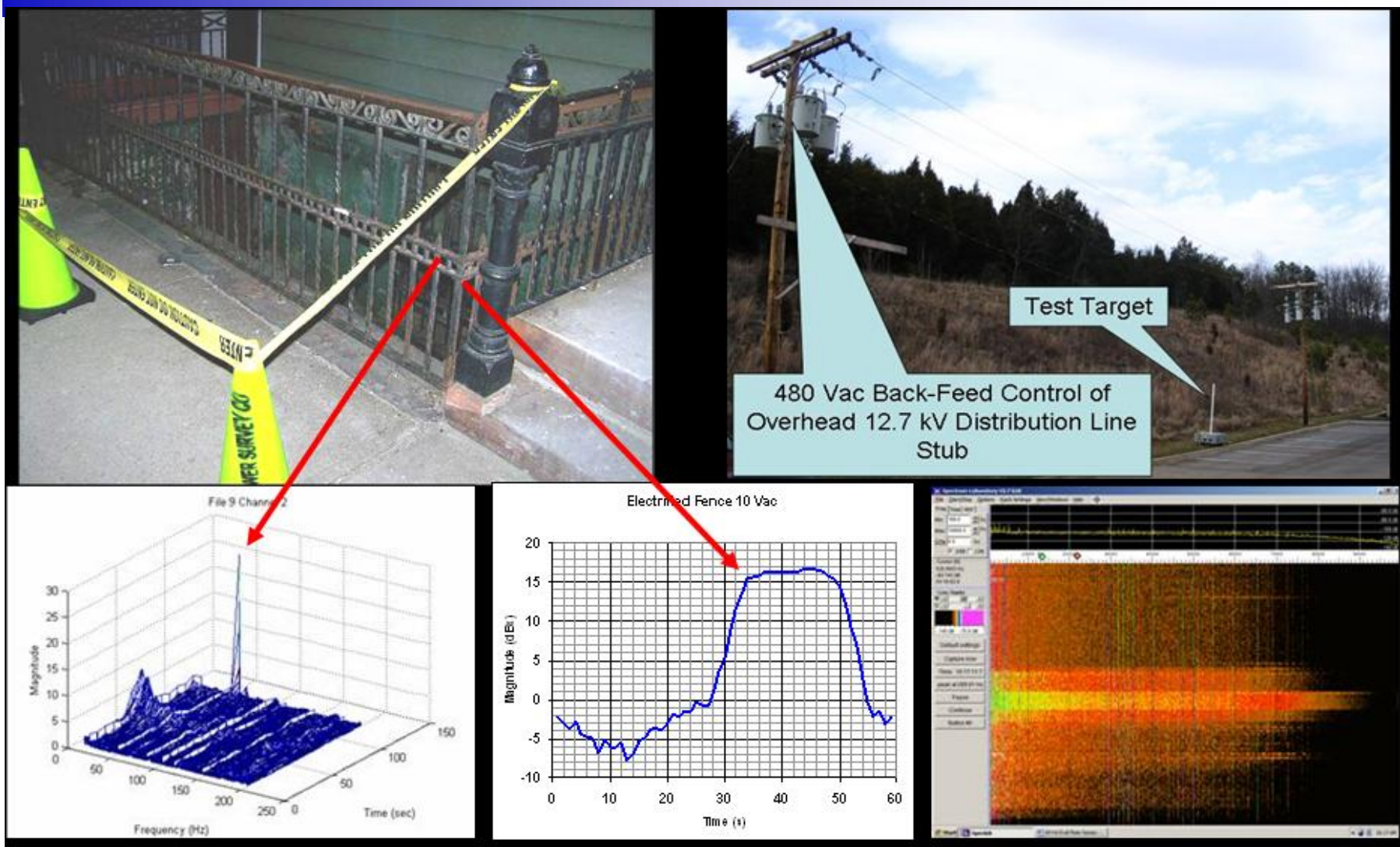
NCC Mitigation Device Tests

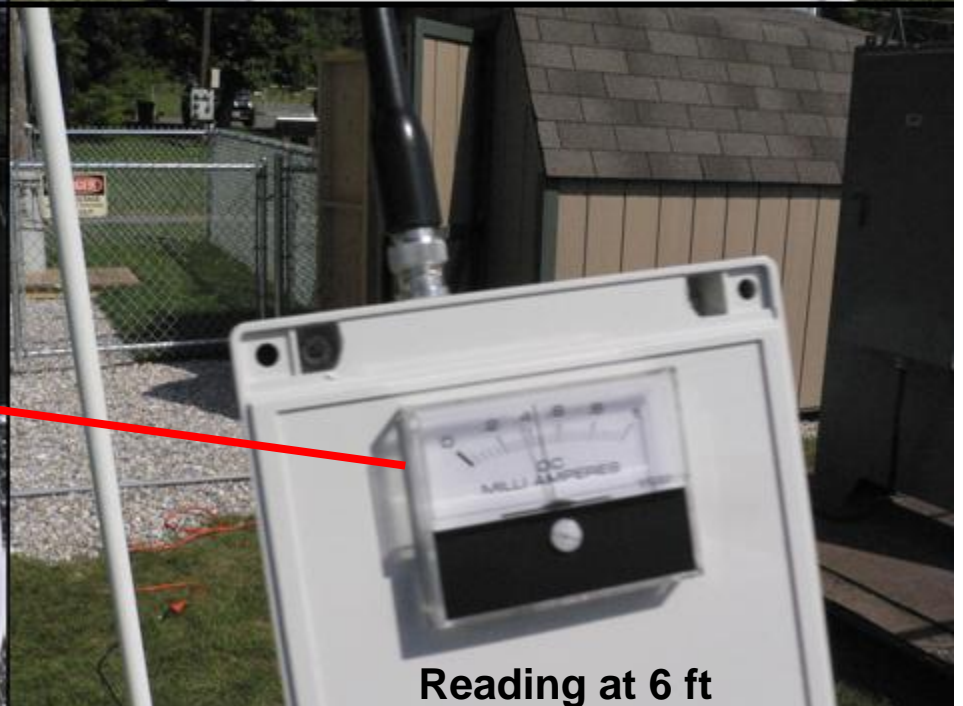
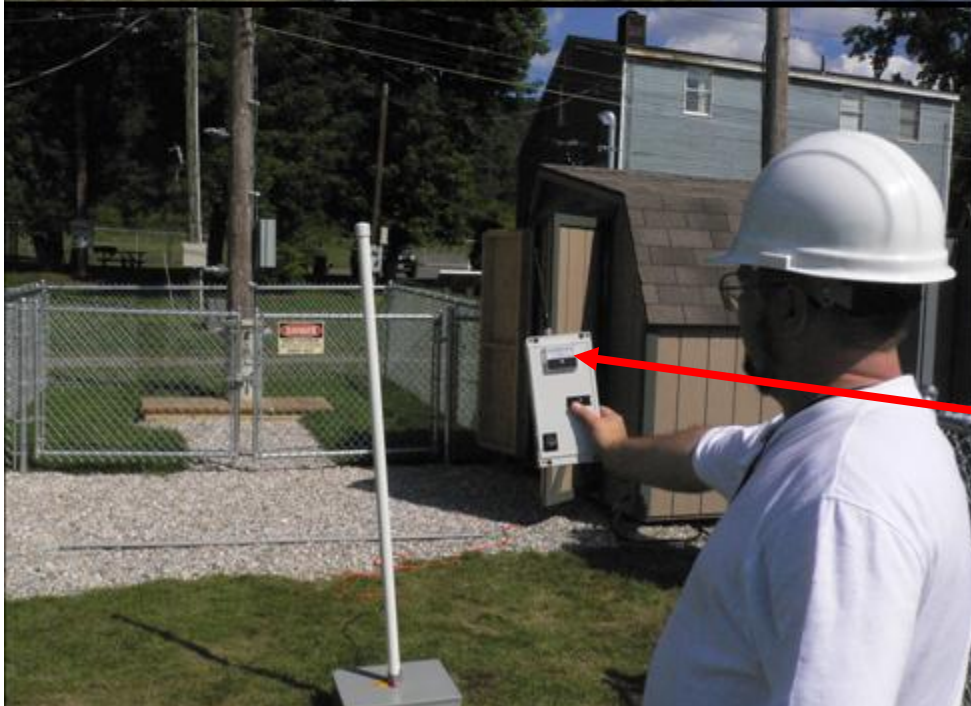
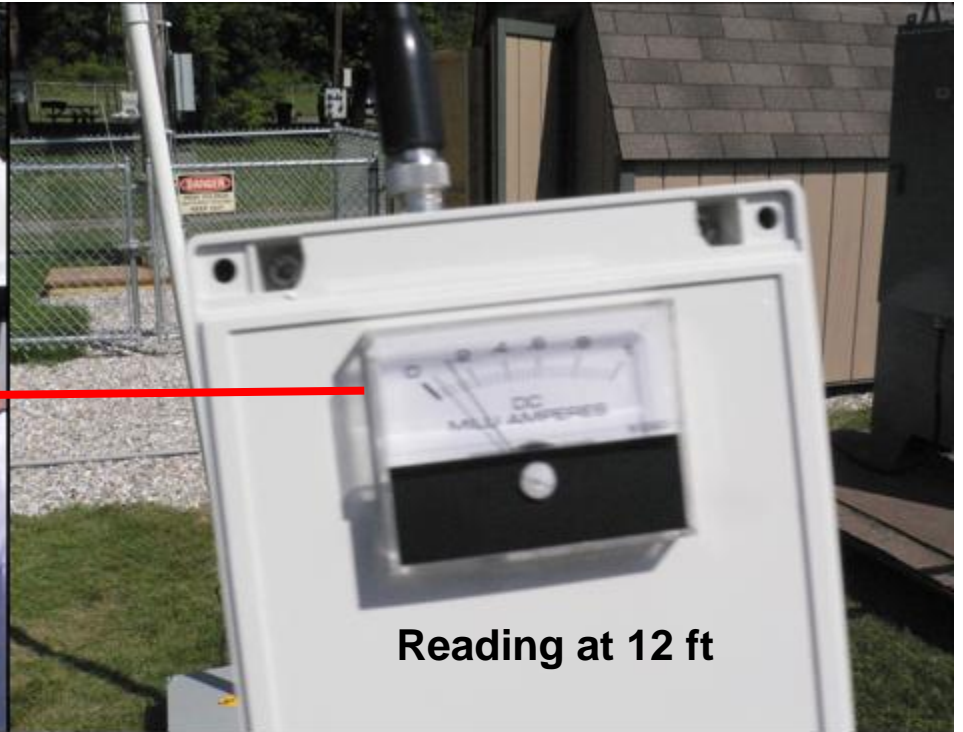
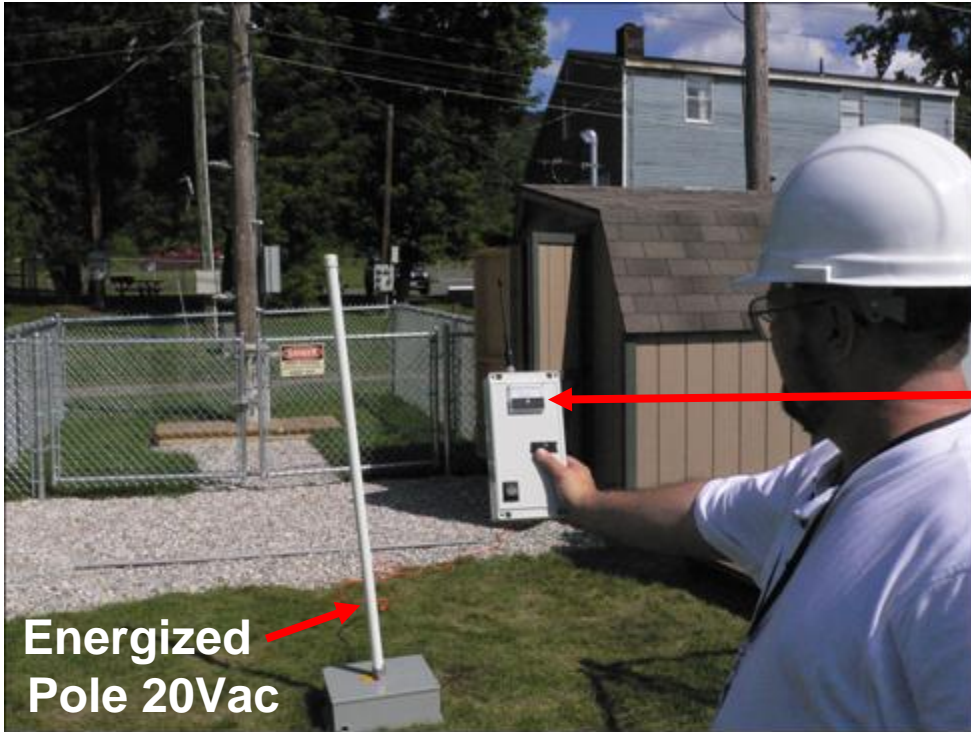
Stray Voltages

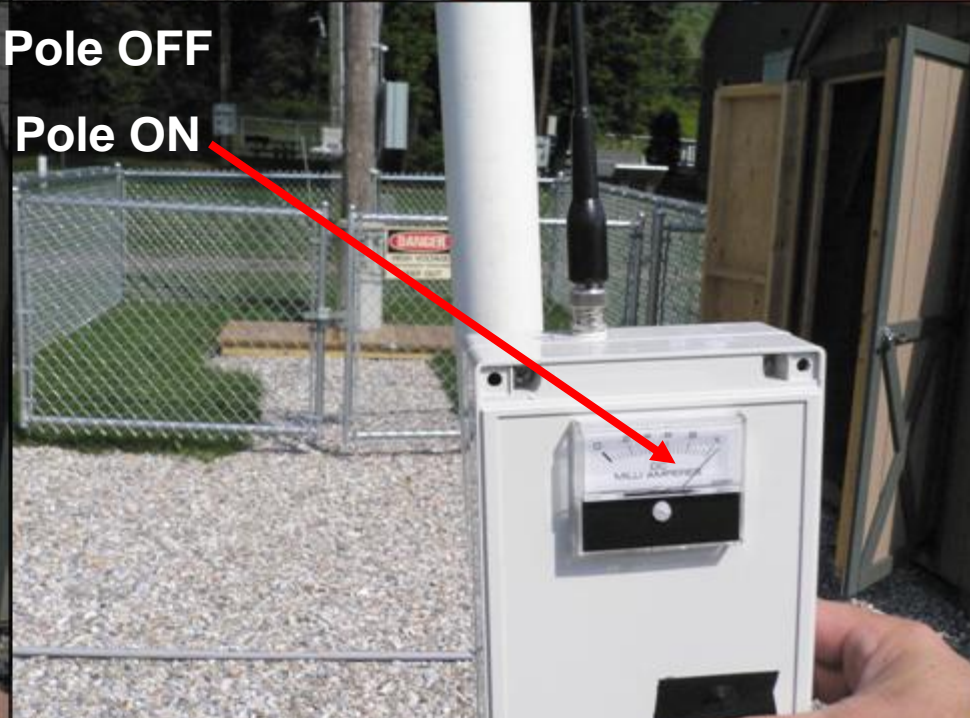
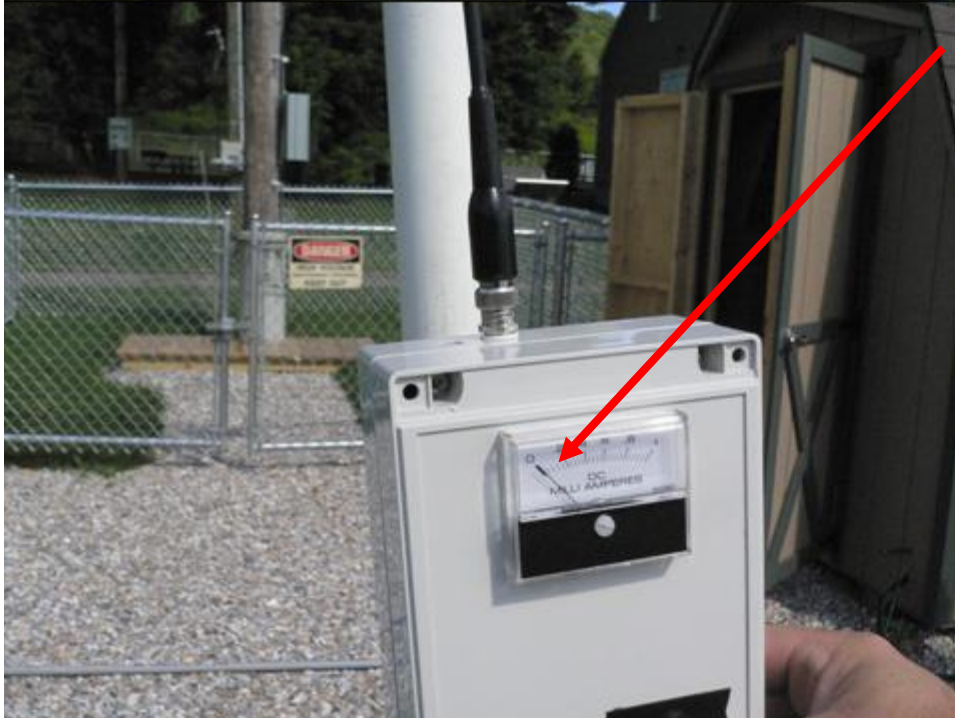
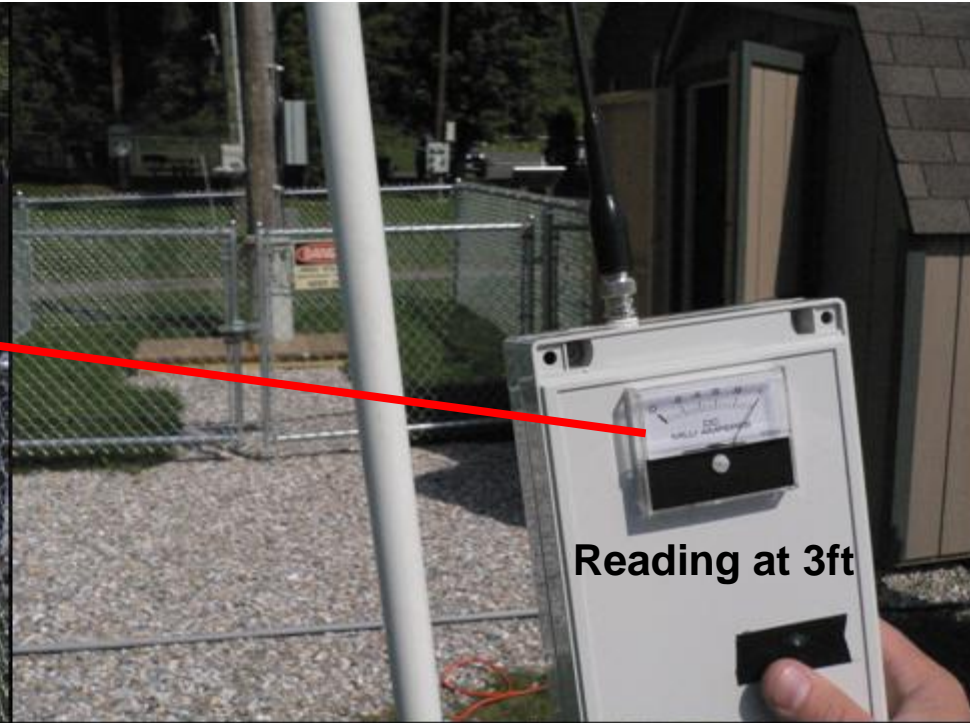
Although the issue of stray voltage is totally separate from that of magnetic fields, a beneficial effect of NCC devices is the reduction of stray system voltages caused by net currents. Stray voltage problems have received a lot of media attention and are often associated with dairy farms. In this case, a portion of distribution line primary currents may return to the substation through water pipes or other parts of the grounding system at dairy farms. When this happens, small voltage gradients are produced in the dairy farm grounding system which can cause problems with the dairy cows. Application of an NCC device can, in some situations, reduce stray voltages by reducing net currents.



More Supplemental Support that enhance the base work....Early Detection of Energized Objects (ConEd)







Contact Voltages Information Repository

- Website

- Update existing information to reflect 2008 status
- Provide additional application guidance on use of test and measurement equipment
- Provide additional application guidance on mitigation solutions
- Position papers and credible reference document repository
- Increment Case Study library

- Vision Statement

- The EPRI 'Contact Voltage' website is the preferred resource for credible and unbiased understanding of the evaluation and mitigation of contact voltage related concerns

- New Web URL: <http://strayvoltage.epri.com>

The screenshot shows a web browser window displaying the EPRI website. The address bar shows <http://strayvoltage.epri.com/>. The page title is "Elevated Neutral to Earth Voltages" and the subtitle is "An EPRI research project to evaluate neutral to earth voltage concerns and solutions on distribution systems." The main content area includes a navigation menu on the left with links for Home, Program Information, Project Information, and Participant Login. The main text describes the "EPRI NEV and Urban Stray Voltage Research Project" and mentions "128,004 Elevated Neutral to Earth and Urban Stray Voltages" as an EPRI research project. A diagram illustrates a ground rod installation with labels for "PILE", "PILE GRADING", "GROUND ROD", "NEUTRAL DRAIN", and "ABOUT 4 FEET". The page also includes a "Upcoming Events" section and a footer with contact information and copyright details.

2008 Industry Group Support

- Support ongoing IEEE “contact voltage” standards and other industry and association efforts
 - 4th Annual Jodie Lane National Conference on Urban Stray Voltage and Safety – May 29-30th 2008
 - IEEE PES Distribution Subcommittee – Stray Voltage WG Meetings – January 2008 and July 2008 Next Webcast Fall 2008
 - IEEE T&D Conference – Panel session on ‘contact voltage’ related subject matter
 - IEEE PES Summer Power Meeting – Panel Session on NEV Modeling July 2008
 - Is it time to do more? Pool and Spa Association? Host a National Conference on Contact Voltage?



Determining Voltage Levels of Concern for Human and Animal Response to AC Current

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Presentation Summary

- Parameters controlling body current and impacts
- Summary of human and animal testing
- Terminology for perceptible levels
- Existing publications with voltage or current levels
- Important criteria for developing levels of concern (LOC)
- Comparing criteria among the standards and publications
- Boiling the criteria down to a systematic process
- Application example
- Final comments and recommendations

Existing Publications with Voltage or Current Levels 15 Vac ‘Wet’ to 60 Vac Dry

Reference Document	Published Level	Concern Category
UL-101 [4]	0.75 milliamps reaction current - 2,000-ohm human body Z.	Reaction Current
UL-60950-1 [8]	42.4 Vac and 60 Vdc is the stated limit under dry conditions and human hand path.	Shock Hazard
IEC 479-1 [9]	25 Vac clearly safe, 50 Vac marginally safe (duration dependent). 1000 ohm body impedance cited	Shock Hazard
OSHA Rule” (29 CFR Part 1910) [10]	Circuits operating above 50 Vac or 50 Vdc.	Shock Hazard
NFPA 70E [11]	30 Vrms or 60 Vdc. 500-ohm wet human body resistance.	Shock Hazard
IEEE Yellow Book – Std. 902-1998 [5]	Currents as low as (10) milliamps and voltages above 50 V can cause fibrillation. 500-ohm minimum body resistance for wet conditions or cuts. 100-500 ohms for immersion (Table 7-2)	Heart Fibrillation
NACE [12]	15 volts.	Shock Hazard
NESC [13]	51 volts.	Shock Hazard
NEC® [14]	Circuits operating above 50 Vac or dc or 15 V for wet areas.	Shock Hazard
IEEE Std 80 [2]	60 Vac for 4 sec. 1000 ohm human body impedance	Shock Hazard

Soil Resistivity and Use of Load Resistors

- Question 1 - How does the actual soil moisture and content impact voltage measurements during steady state fault conditions?
- Question 2 - How does the actual resistance value selected for the measurement impact the reading?
- Question 3 – How is the harmonic spectrum of the waveshape impacted by resistivity?
- Question 4 – Do Fault voltages look different from neutral to earth voltages?

Direct Contact Measurement

- Wet and Dry Samples

- Sample 1

- 50% Clay
- 25% Sand
- 25% Salt

- Sample 2

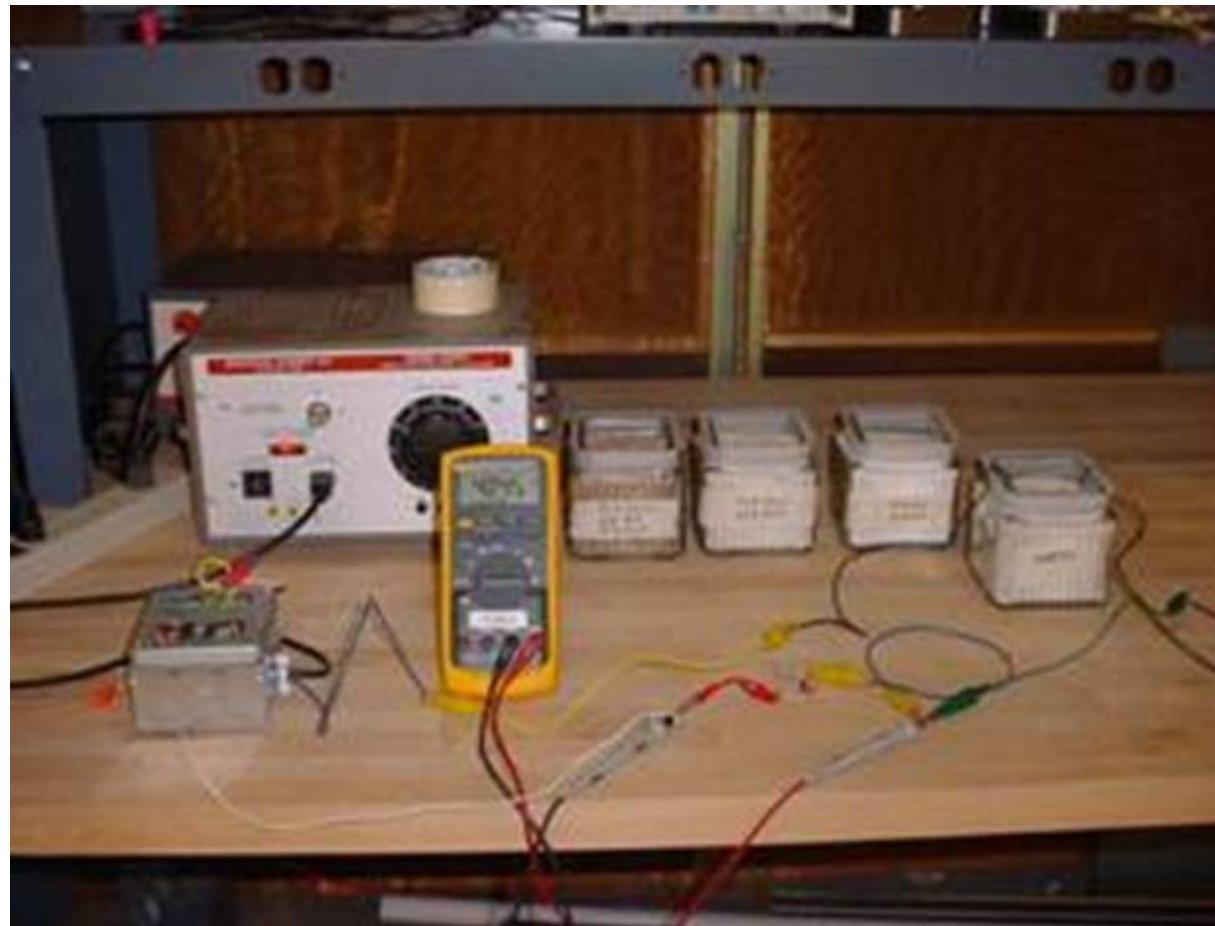
- 75% Sand
- 25% Salt

- Sample 3

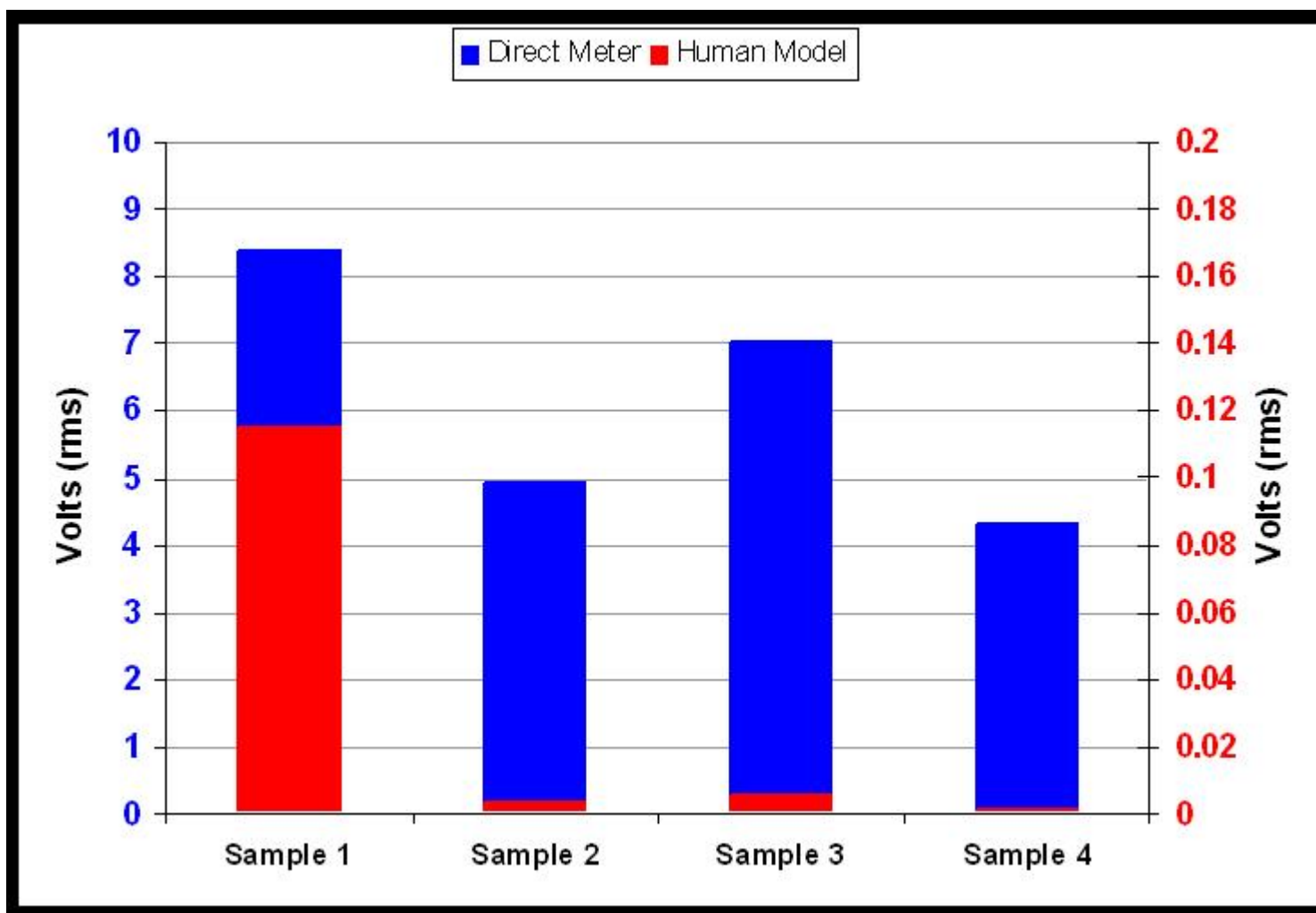
- 50% Sand
- 50% Salt

- Sample 4

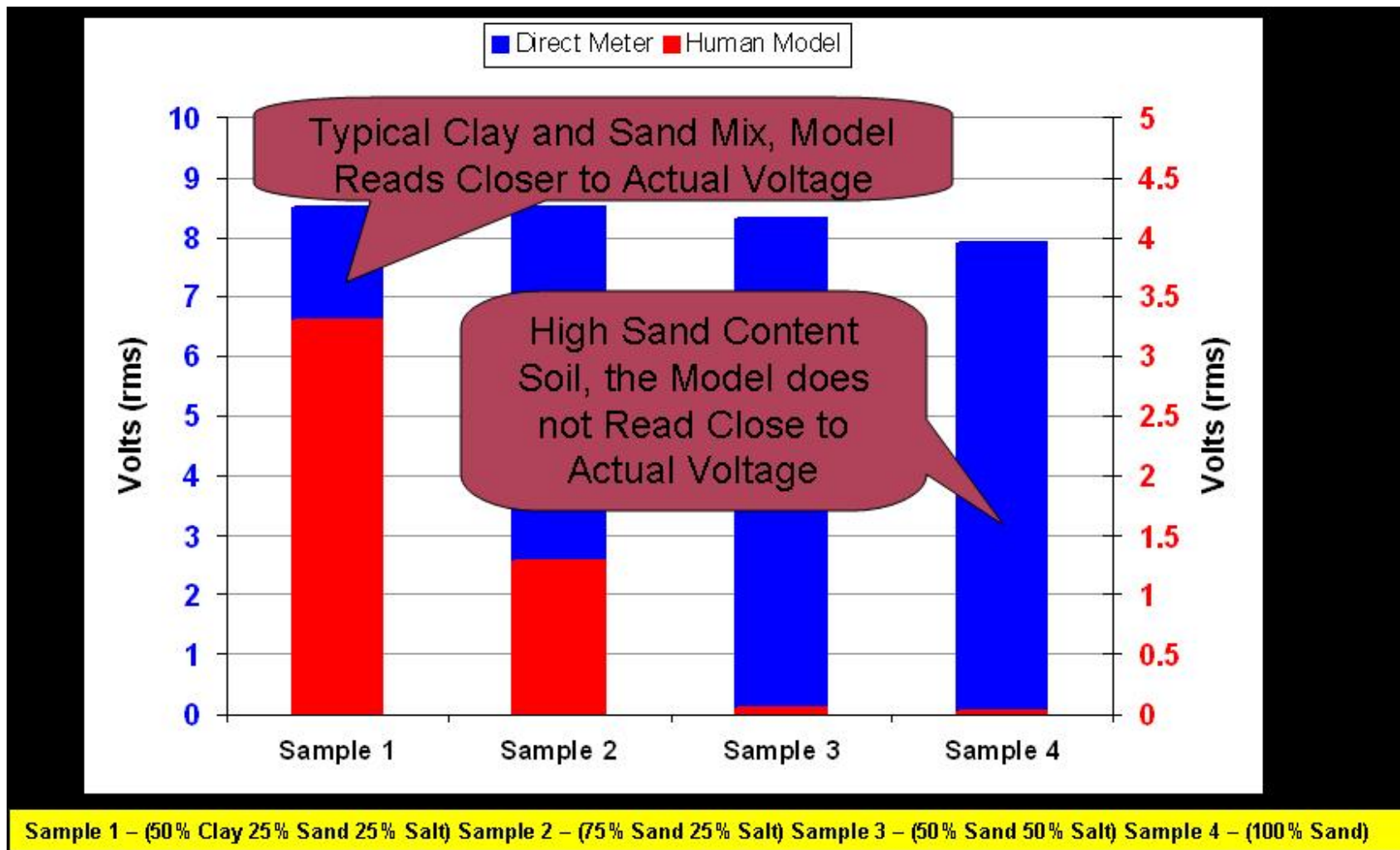
- 100% Sand



For Dry Samples (high source impedance) – Load resistor significantly changes the measured value – Red Scale = 1/50th of blue scale

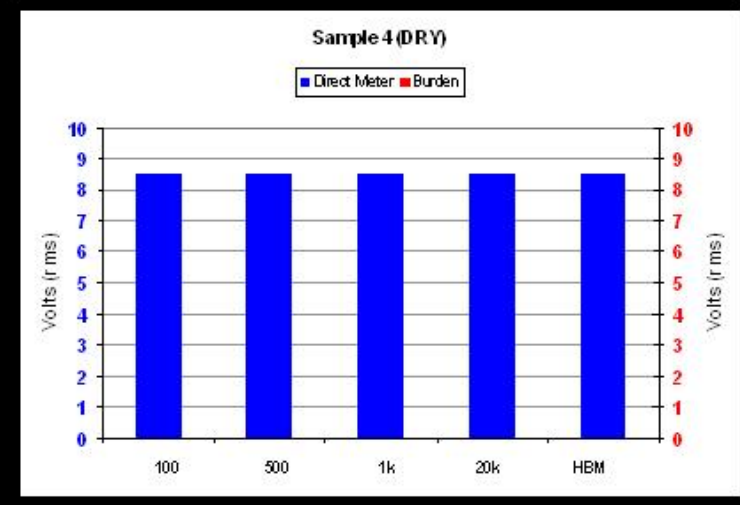
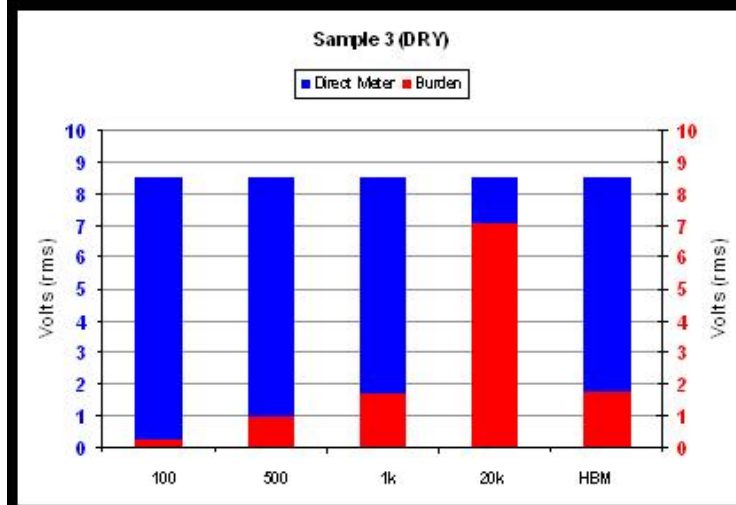
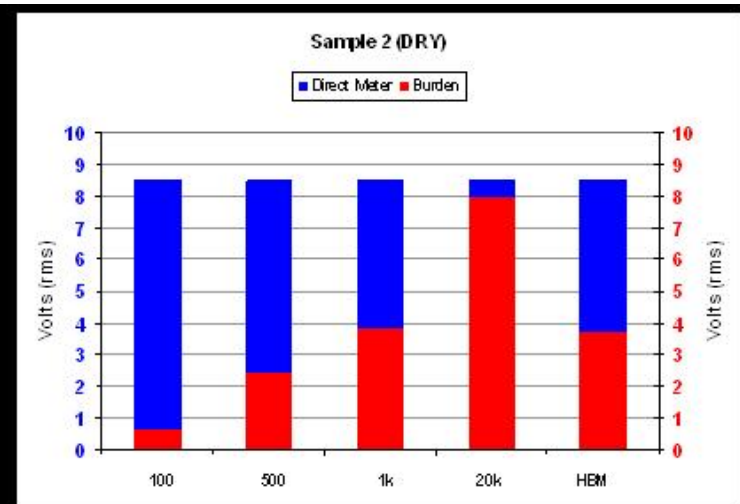
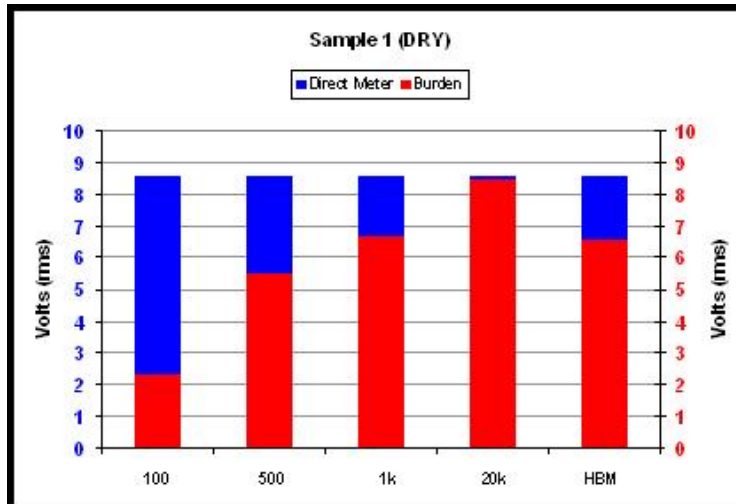


Wet samples (lower source impedance) vary depending on soil composition

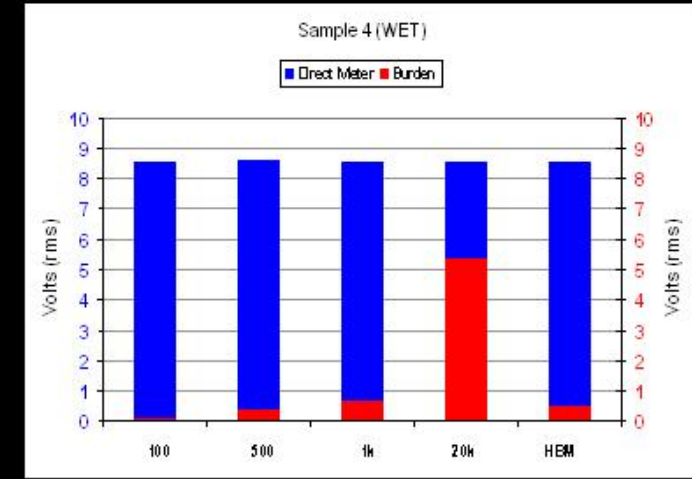
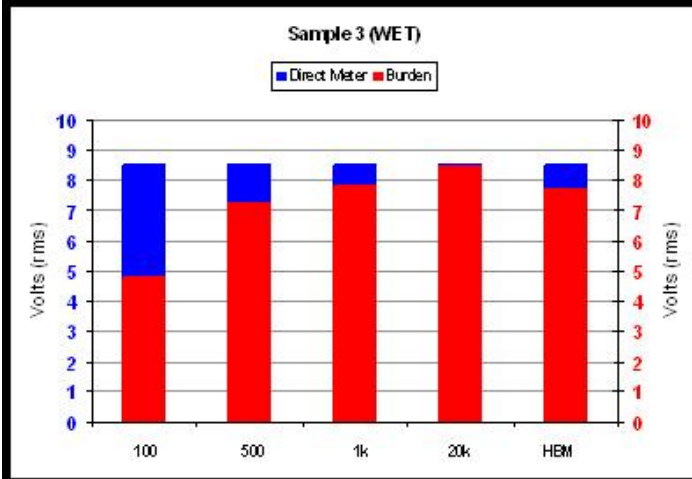
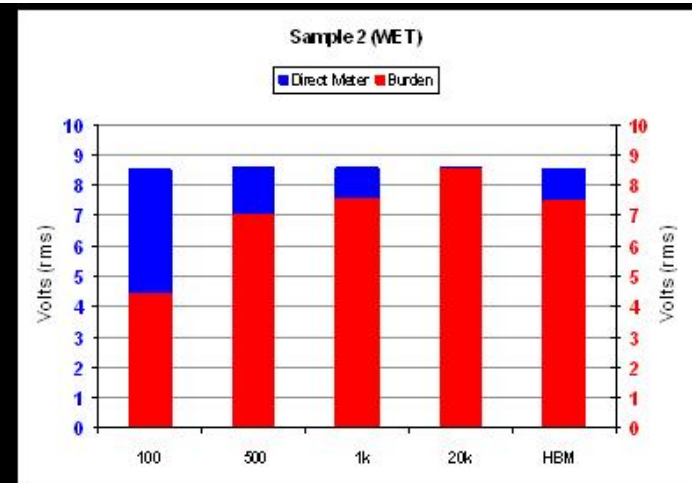
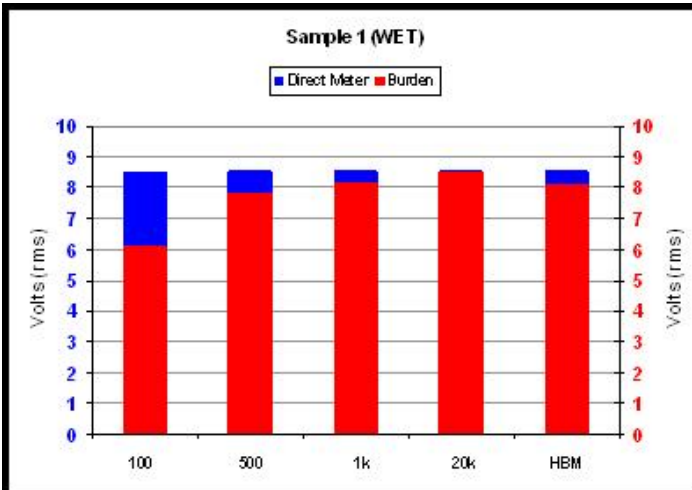


Different Burden Resistance – Dry Soil Samples vary more than wet samples – Higher resistance = less variance

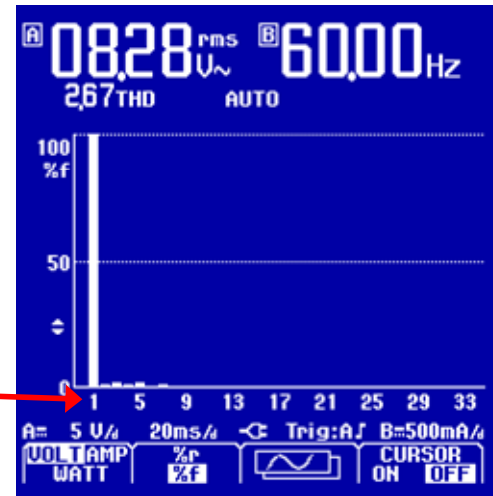
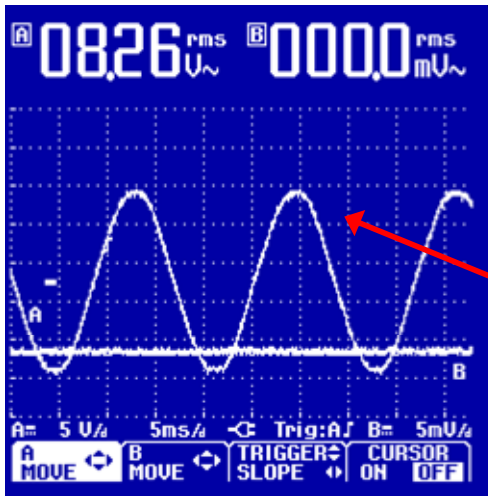
Direct Meter = Source Voltage



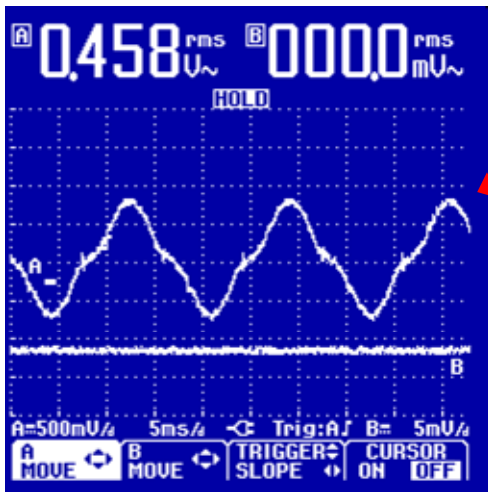
Different Burden Resistance – Wet samples are more consistent (with or without resistor)



Source Location Research



- A fault or an inadvertently energized object has a 60Hz Sinusoidal Waveform and 60Hz spectral content



- NEV has a non sinusoidal Waveform and 60Hz plus other spectral content

Prioritizing the Remaining Work....

- Sources of Input to Accomplish the Prioritization :
 - Project adviser and sponsor inputs, media coverage, IEEE and Jodie Lane industry meetings and pubs, miscellaneous telephone discussions and support requests
- Prioritization Conclusions:
 - Research should continue to center around: Diagnostics, Mitigation, System Design, Modeling, and Information Dissemination
- 2009 Efforts
 - Continue with these prioritized areas

2009 and Beyond...Contact Voltage (Stray Voltage) Research Opportunities

