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EMF Survey Report

Horseshoe Trail Elementary School
5405 E. Pinnacle Vista Drive
Cave Creek, AZ

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Conducted by:

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Environmental Testing & Technology, Inc. (ET&T) conducted a preliminary electromagnetic field (EMF) survey at the Cave Creek Horseshoe Trail Elementary School in Cave Creek, Arizona on February 13, 2006. EMF measurements were conducted at representative areas throughout the different school buildings. This report summarizes our findings and provides recommendations on EMF reduction methods.

1. Methodology and Instrumentation

Tri-axial magnetic field meters (*Teslatronics Model 710 and a Holaday HI 3627)* were used to measure the magnetic flux density which is referred to in this document as EMF levels. The unit for magnetic flux density (EMF levels) is milliGauss (mG). The frequency range for these instruments is 30 Hz to 2000 Hz. The spot measurements were conducted at approximately 1 meter (3.28 feet) above ground level in accordance with ANSI/IEEE Standard 644-1994 unless indicated otherwise. The equipment was calibrated prior to the survey according to manufacturer's recommendations.

2. Survey Findings and Recommendations

- Very low EMF levels of 0.0 to 0.2 mG were measured at the corridors of the classroom building on the first and second floor. No measurements were performed inside classrooms.

- Significantly elevated levels of 0.9 to 6.4 mG were measured in the Computer Lab. EMF levels of up to 79 mG were measured on the floor along the NE exterior wall. These fields are not related to the computer equipment. They are related to the air handling unit located on the roof. We suspect a wiring problem which is causing net or stray currents. Please refer to Section 3 *Causes of Electromagnetic Fields* for more detailed information. We recommend that a licensed electric contractor or engineer experienced with EMF trouble shooting perform a wiring and code inspection of the HVAC equipment to identify the source for net or stray current. Code violations are usually present in these situations.

- Very low EMF levels of 0.1 to 0.2 mG were detected inside the Kindergarten building.

- Low EMF levels of 0.1 to 0.4 were measured throughout the Administration building.

- Overall low EMF levels of 0.2 to 0.8 mG were measured throughout the Multi-Purpose building. However, a small area at the entry yielded level of up to 5 mG

on the floor and 1 mG at about 3 feet height. Stray or net current on conductive materials are suspected. Building plans were reviewed in conjunction with the Construction Superintendent, Steve. According to the construction superintendent, no electrical conductors or conduits, gas or water pipes are located in or below the concrete slab in this area.

- Different EMF levels were present in the Multi-Purpose building. Generally very low levels throughout the building, except for the entry area of the PE section with up to 5.9 mG on the floor. The source for the magnetic fields is most likely within or below the concrete slab. Current flow on a conductive material must be occurring otherwise magnetic fields would not be present. A more comprehensive investigation may be necessary to identify the source. However, it is a relatively small area and we suspect that students or staff members do not spent a significant about of time in this area creating a short term exposure only.

The California Department of Education (CDE) has a design goal for AC magnetic field levels in the school environment not to exceed 1.2 milliGauss (Average EMF levels in US schools - Zaffanella study 1998). Overall, the EMF levels at the Horseshoe Trail Elementary school are very low. Elevated EMF levels were detected in the Computer lab and the Physical Exercise room. Net currents and code violations are suspected. These situations can usually easily be remedied by an experienced electrical contractor.

3. Causes of Electromagnetic Fields (EMF's)

Electrical current traveling through electrical wiring (line sources) or equipment such as motors and transformers (point sources) creates magnetic fields around the wires or the equipment. The terms "line" and "point" sources are used to define the sources for the magnetic fields. The decay in the magnetic field levels over distance depends on the configuration of the electrical source (line or point). The strength of the generated magnetic field is dependent on a number of factors:

- Distance to the field source
- Amount of current flow (referred to as load or power usage)
- Distance between the conductors (lines, wires)
- Conductor configuration
- Presence of net current flow
- Whether it is a point or line source

The detected magnetic field at any location is a result of the interaction of the applicable factors. All factors being equal, the higher the current flow, the higher the

magnetic field. This is a linear correlation. The further one moves away from any source, the lower the magnetic field. The distance between the conductors in a circuit is usually unimportant in internal building wiring (as they are very close), but are very significant for power transmission and distributions lines due to the distance between the conductors.

The magnetic field level in the space between separated conductors is much higher than the field on either side of these conductors. When such conductors are relocated to be directly next to one another (as in a cable), the surrounding field drops dramatically because the opposite but equal fields nearly cancel each other. A short distance from such a cable, the field level cannot be differentiated from the background field level.

If the current flow on one wire in that cable is not equal to the other, there will be a "net" current and a resulting magnetic field that will increase in direct proportion to the magnitude of the current difference. In 110 volt building wiring systems, the two conductors or wires in a cable are termed the "hot" wire and the "neutral" wire.

Net currents in building wiring systems are a significant cause of elevated magnetic fields affecting large areas in buildings. In contrast, point sources, such as motors and transformers contain coils that cause very high local magnetic fields, but the fields drop off very rapidly with distance. For normal building wiring, the cables have the same current on the hot and the neutral conductors (no net current), the conductors are right next to each other (minimal distance between conductors), the magnetic field is reduced very rapidly with distance from the cable.

The strength of the magnetic field is reduced least for a single conductor or a cable with a net current. This is significant because in a building that has current flow on the grounding system (water pipes, and metal structural components such as beams, studs, and drop ceiling rails) and/or a net current on conductors, the magnetic field can extend far into a building space.

3.1 Current on the Building Grounding System

Current flow on the grounding system in buildings is a well-recognized phenomenon. The building grounding system is composed of interconnected metal plumbing, appliance housings, and heating ducts because code requires these to be connected to the electrical system ground. This is done to prevent electrical shock to a person if a short develops from the 120-volt hot side to any metal item.

Unfortunately, connecting all the metal to the electrical system ground/neutral can create a problem called "parallel neutral paths" and "net" currents with elevated AC magnetic field levels. The current on a neutral wire will take all available paths back to the point of origin. That is, the current will split up and flow on any and all available paths according to the resistance of the path to the current flow. The lower the resistance of a path, the more current flow will occur.

When part of the neutral current in a circuit is diverted to the grounding system because of a neutral to ground connection, there is an unbalanced current flow (net current) in the circuit and, therefore, a higher magnetic field surrounding that circuit.

3.2 Currents from Outside the Building

Under certain conditions, current outside the building returning to the power company may choose parts of a building grounding system as one of the paths back to the utility. This current can flow into the building via:

- The neutral/ground conductor in the service drop
- The metal water supply line
- The cable TV sheathing
- The buried phone cable sheathing

The source of this current flow is independent of the electrical demand in the building. Flow can take place even if the main circuit breaker for the building is off. Once this current reaches a building, it will take all available paths back to the utility. The amount of current flow on each path depends on the electrical resistance of that path. Where and if this current flows is a very complex problem depending on:

- The utility's distribution system configuration.
- The use of a metal versus plastic water supply main to the building.
- Relative location of electrical service entry, water service entry, cable TV entry.
- The resistance of the building's electrical system grounding electrode.

This means that current could be flowing on any of the metal or neutral and ground wires in the building. The more one improves (reduces the resistance of) the earth connection(s) at the building, the more current could be attracted to the building from the utility.

3.2 Common Sources for elevated EMF Levels

In addition to parallel neutral paths and current on the grounding system there are other causes for elevated magnetic field levels in buildings. The following is a list of conditions most commonly encountered during building investigations as the causative factors.

- High voltage feeder lines to in-building transformers using separated conductors that traverse or enter the building close to occupied spaces.
- Placement of step down transformers too close to occupied spaces.
- Inappropriate grounding of step down transformers
- Placement of service drops too close to occupied spaces. (In a no net current situation this is usually not a problem)
- Placement of electric meter near occupied spaces.
- Placement of circuit breaker box near occupied spaces.
- Wiring errors causing net current on internal wiring circuits.
- Connecting together of neutral wires from different circuits in the same junction box.
- Three-way light switches with neutral and hot sourced from different junction boxes.
- Bonding of neutral buss to steel cabinet or ground buss in sub-panel.
- Current flow on the building grounding system (pipes, heating duct, metal studs, drop ceiling supporting structure)

During the construction process, it is important to address and preempt these conditions from occurring. Once these conditions occur, the mechanisms needs to be identified and corrected to reduce magnetic fields to background levels.

Adherence to the National Electrical Code (NEC) is essential in creating low EMF environments. Construction specifications need to identify a mechanism for Quality control procedures to verify code compliance.

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If you have any further questions, please feel free to contact me at 760-804-9400.

Respectfully Submitted,

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