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April 24, 2014

Mr. Jim L. Fields
National Smoke Contaminant Testing
P.O. Box 2572
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Re: [redacted]
Colorado Springs, CO
Date of Loss: 06/11/13
Claim: [redacted]
Subject: Black Forest Fire Smoke Damage

LABORATORY REPORT: [redacted]
Narrative

Armstrong Forensic Laboratory, Inc. (Armstrong), at the request of National Smoke Contaminant Testing (NSCT), provides the following background information related to smoke contamination and damage resulting from the wildfire event known as the *Black Forest Fire* that occurred in Black Forest, Colorado between June 11, 2013 and June 20, 2013. In addition, Armstrong has been requested to provide data interpretation of the analytical results related to the referenced property as reported in Armstrong Laboratory Reports [redacted]-1 dated March 17, 2014, [redacted]1 dated March 31, 2014 and [redacted]-1 dated April 15, 2014. The samples reported in these were collected as a means of determining the extent of damage due to the Black Forest Fire to the interior and envelope of the referened property.

Armstrong has, at the request of the Homeowner, reviewed the following document(s):

1. Gandalf Associates, Inc., *Environmental Health Evaluation – Wildfire Smoke Damage Initial Inspection and Remediation Recommendations*, dated September 30, 2013.

No single report can be a definitive statement of all possible opinions due to evidence that may be presented sometime after its release. However, Armstrong has made every effort to provide all opinions related to the referenced case based on the facts that have been considered through the Homeowner, the Homeowner's Representative, document review, current industry practice related to this type of project as well as education, training and experience directly or indirectly related to this type of project. Not every debatable point within the reviewed document(s) has been itemized; where appropriate, Armstrong has provided its opinion on questionable premises or positions that have been presented and/or intimated. Attachment A of this report provides a listing of acronyms and abbreviations. Attachment B lists resources related to this type of project and references noted within Armstrong's report. Other attachments are identified in the report text.

Background

The Black Forest Fire is reportedly still under investigation although the initial 9-1-1 call was about a structure fire. The fire, which began on, or about, June 11, 2013 was reported fully contained on June 20, 2013 (~10 days later). It is known to have burned 14,280 acres of land (22.3 square miles) and destroyed or damaged over 520 residential structures as it spread to the east, north and west. Reports of heavy smoke pushed by the south/south-easterly winds traveled as far north/northwest as Denver, some 40 miles away (Wildfire Today). Figure 1 provides an overview of the area of impact from the fire with the point of origin identified.

The wildfire front (fire front) is the part of a fire where continuous flaming combustion is taking place, where unburned material transitions to active flame or the active flame transitions to burned material. (NWCG) Unless otherwise specified, the fire front is assumed to be the leading edge of the fire; however, a fire may have multiple fronts. As the front moves, the fire heats both the surrounding air and available fuel material through convection and thermal radiation. As the heat intensifies, wood will dry as the internal moisture is vaporized (~100°C or 212°F). The pyrolysis of wood begins at temperatures approaching 230°C (450°F) which releases flammable gases. Finally, wood will begin to smolder at 380°C (720°F) or, when heated sufficiently, will ignite at 590°C (1,000°F). Even before the flames of a wildfire arrive at a particular location, heat transfer from the wildfire front warms the air to 800°C (1,470°F),

The destructive nature of fire extends beyond heat and physical damage. Fires, particularly those involving man-made materials, produce chemicals that are present in the visible (and invisible) smoke. When these chemicals condense or settle onto surfaces they can contribute to its immediate and ongoing deterioration. The type of impacted material will determine the type and rate of the deterioration. Generally, such deterioration is referred to as "corrosion", with "rust", which involves the corrosion of materials made with iron (Fe), being the most common type. Numerous chemical compounds are generated in a fire including, but not limited to: hydrogen cyanide (HCN), hydrochloric acid (HCl), formaldehyde (CH_2O), acetaldehyde (C_2H_4O), acrolein (C_3H_4O) and higher molecular weight decomposition products of polymers. Particulates, such as soot and ash, which are generated by the fire and carried in the smoke, may also cause components to deteriorate. These and many other chemicals generated from a fire can, if left unattended, cause immediate and/or ongoing damage to materials as well as humans.

Smoke Contaminants and Their Impact

Smoke is a collection of airborne particulates and gases that are emitted during combustion or pyrolysis. It is primarily composed of carbon dioxide (CO_2), water vapor (H_2O), carbon monoxide (CO), and particulate matter but will also contain hydrocarbons and other organics, nitrogen oxides (NO_x) and trace metals (lead, mercury, etc.). The actual composition of smoke generated during a given event is dependent on the type of fuel; different materials produce different compounds when burned (New York City Department of Health, NYCDH and University of Washington, UofW).

When the material burning contains sulfur (S), the smoke will include hydrogen sulfide gas (H_2S), sulfur dioxide (SO_2), carbon disulfide (CS_2) and thiols. Thiols are particularly problematic because they tend to be adsorbed onto surfaces and will produce a lingering odor. When nitrogen (N) is present, hydrogen cyanide (HCN), ammonia (NH_3) and nitrogen oxides (NO_x) will be components of the smoke. Halogenated fuel sources (including polyvinyl chloride (PVC) piping) will result in the production of hydrogen chloride (HCl), halogenated methanes (chloro-, bromo-, etc.) and a variety of other halogenated carbons. Pyrolysis of burning material, especially incomplete combustion or smoldering without adequate oxygen supply, also results in the production of a large amount of hydrocarbons, both aliphatic (methane, ethane, ethylene,

acetylene) and aromatic (benzene and its derivates, polycyclic aromatic hydrocarbons). Heavier hydrocarbons may condense from the atmosphere as tar; smoke with significant tar content is will appear yellow to brown in color. Additionally, partial oxidation of the released hydrocarbons will yield a wide range of other compounds: aldehydes (e.g. formaldehyde, acrolein, and furfural), ketones, alcohols, and carboxylic acids. (Drysdale, EPA, UofW)

The documentation of the presence of hazardous air pollutants in smoke is well known; the major contaminants are the particulates and carbon monoxide. Thus, the presence of particulate (i.e., soot) generated from the fire are generally the first contaminant for structure evaluation. The most common of the gaseous contaminants after carbon monoxide are acrolein, benzene and formaldehyde (UofW).

The particulate matter of smoke is mostly comprised of carbon (soot). Additional particulate matter will include drops of condensed tar, ash, metal oxides and inorganic salts (ammonium sulfate, ammonium nitrate and sodium chloride). The tiny particles in smoke do get inside structures. "If smoke levels are high for a prolonged period of time, these particles can build up indoors." (EPA, US Forest Service).

As the superheated atmosphere of the fire is transported by the wind, the smoke (particulate and gases) can travel great distances from the source. Wherever the smoke travels to, the cooler temperature of local air and/or surfaces that the smoke comes into contact with causes the particulate and gases to condense out and impact the surface. Upon contacting the surface, the chemicals within the smoke transfer. The corrosive properties of the chemicals will then cause the substance they have contacted to begin decomposing. This decomposition can, depending on the nature and concentration of the smoke, be at a rapid rate. The chemical contaminants are insidious and will be absorbed into the substance, especially clothing, unsealed surfaces, potable water piping, wood, and other porous and semi-porous materials (clothing, fabrics, carpeting, drywall, etc.). Short term impact of these types of contaminants is typically identified through "smoke smell". Although the noxious smoke odor will diminish over time, the damage caused by the contaminants will continue. This absorption is the reason many of these items must be replaced rather than merely cleaned/decontaminated. Intuitively, the closer the cooler surfaces are to the origin of the smoke plume, the higher the deposition concentration will be. As the plume travels away from the origin, dilution will contribute to the reduction – although not elimination – of the particulate and gas contaminants.

Smoke contains a wide variety of chemicals, many of them aggressive in nature. Examples are hydrochloric acid, hydrobromic acid, hydrofluoric acid, sulfuric acid, nitric acid, phosphoric acid, and many others. Such corrosion may not be considered significant for structural materials, but delicate structures, especially microelectronics, are strongly affected. Corrosion of circuit board traces, penetration of aggressive chemicals through the casings of parts, and other effects can cause an immediate or gradual deterioration of parameters or even premature (and often delayed) failure of equipment subjected to smoke. These contaminants, if left unabated, can impact the health of individuals exposed to them even after the fire is suppressed.

Many smoke contaminants are also electrically conductive; deposition of a conductive layer on the circuits can cause crosstalks and other deterioration of the operating parameters or even cause short circuits and total failures. Electrical contacts will be affected by corrosion and by deposition of soot and other conductive particles or nonconductive layers on or across the contacts.

The odors which result from smoke can linger long after the immediate hazard of the fire and the smoke plume. This odor can cause nausea and headaches, respiratory issues, as well as an overall sense of annoyance at the constant smoke irritation for people. The lingering odor persists due to tiny microscopic particles that cling to the available surfaces (walls, furniture, floors, clothing, etc.) (TAMU).

Smoke Deposition and Sampling Techniques

There are no regulatory limits established for the presence of airborne contaminants in a residence associated with fire or fire residue. There are regulatory and industry guidelines for exposure to airborne contaminants in the workplace, however, these limits do not apply to residential exposure potential. Some interpretation can be made by reducing the industry limits from the published 8-hour limit to a 24-hour limit.

There are no regulatory limits established for the presence of surface contaminants associated with a fire loss (smoke or soot residue). General industry guidelines for these types of incidents are generally limited if available and the majority of the information deals with time of incident exposure potential rather than residual/post-event exposure potential. Armstrong has, historically, considered the presence of soot on surfaces at semi-quantitative levels of greater than 3% (>3%) in at least one-third of the sample set to be an indication of negative impact due to a fire event and restoration efforts should be considered. For surfaces that have been previously cleaned, there should be no soot/ash present in any of the samples collected. The presence of aldehydes on surfaces at levels ranging from 10 - 25x greater than a blank sample is considered elevated.

Surface vacuum sampling with a cassette filter system is a technique that will lift particulate that is not otherwise adhered to the surface. The technique is generally non-specific and will collect all particulate light enough to be removed through vacuuming. The type of analysis(ses) to be performed will dictate the type of filter to use. Generally, this technique is best used immediately following the smoke contamination event.

Surface tape-lift is a convenient sampling technique that, when properly performed, will effectively collect all deposited particulate from the surface. Care should be taken to avoid lifting the sampled surface (matrix) with the tape. The tape is then mounted on a standard microscopic slide or other appropriate "carrier" for microscopical examination.

Surface swab or wipe sampling is a typical technique that can effectively isolate certain surface contaminants for easy analysis. The surface area sampled can be utilized when comparison to other samples is needed. This is a convenient technique for non-particulate contaminant sampling (acids, aldehydes, etc.).

Each technique has its advantages and disadvantages. The analytical results are reported as qualitative (yes/no), as semi-quantitative relative to all of the surface contaminants identified through the analytical technique selected or, when the surface area is known, as a concentration. It is important to understand the relationship of the sampled surface to the whole area intended to be represented in order to clearly and accurately describe the contamination present. Additionally, surface and airborne samples for the presence of residual acrolein, formaldehyde and anions (chloride, bromide, sulfate, etc.) can be collected for evaluation of smoke contamination.

In general, structures can be assessed for the presence of soot, char and/or ash. For the purposes of smoke residual evaluations, Armstrong uses the following definitions:

Soot: the black powdery form of carbon produced when coal, wood, or oil is burned. Soot includes spherical particles of carbon that are produced by a flame as a result of incomplete combustion.

Char: material that has become blackened by burning or scorching. Char includes particles of burned carbon material that have retained some of their original morphology.

Ash: the grayish-white to black powdery residue left when something is burned.

Smoke: the collection of airborne solid and liquid particulates and gases emitted when a material is burned; generally comprised of soot, ash and charred particulate.

Based on Armstrong's experience and training, soot is best viewed using a compound microscope with a total magnification of 400x and an oblique light source. Soot particles are typically 10 – 100 nanometer (nm) in diameter (Drysdale, D. "An Introduction to Fire Dynamics" Wiley and Sons, 1985) and clumps are formed that are generally one (1) micrometer (µm) in size. Armstrong's standard operating procedure for analysis for the presence/absence of soot was developed following formal training through the McCrone Research Institute (McCrone). McCrone is an internationally recognized training provider in the field of microscopical examination located in Chicago, Illinois.

Surface evaluation for the presence of soot, char, ash, and smoke is typically conducted using tape lift sampling technique. Surface wipe sampling for the presence of aldehydes may provide some information regarding the extent of damage for structures with visible or limited fire damage (i.e., char). Aldehyde interpretation is based on direct comparison of the blank, results of samples from areas with visible char, and results of samples from areas with no visible char. In general, sample results for aldehyde evaluation collected from non-visible char areas greater than 25x the blank may be considered elevated. For structures with potential health concern of the occupant(s), 10x the blank result may be considered elevated.

Information Regarding the Residential Structure and Document Review

Based on review of the Gandalf Associates, Inc. report:

- The subject property is a [redacted] structure with an unfinished basement and attached garage.
- Evacuation of the structure was on June 11, 2013.
- The Homeowner did not return to the structure until July 28, 2013 following reported cleaning of the structure and its contents.
- Upon re-occupancy of the structure, the Homeowner observed evidence of corrosion on a number of items as well as a "pungent" odor.
- Gandalf reports a "very noticeable smoke odor present" which is reported to have been perceived to be a cigarette smoke odor, however, no visible staining or yellowing of the walls, ceiling or the furnishings was noted. No samples for the presence of cigarette by-products were reportedly collected.
- Two (2) composite vacuum samples were collected and the results reported as no detectable soot or ash/char. No specific information related to the locations sampled for the composite samples was provided.
- The analytical laboratory reported pH results for the two (2) composite samples presented.
- Gandalf Associate's concludes that there was no reason to require the additional decontamination of either the home or the contents of the home with regard to wildfire-smoke related concerns.
- Gandalf Associate's inspection was conducted on September 3, 2013.

Contrary to Gandalf Associate's conclusion and based on the analytical data presented in Armstrong Laboratory Reports [redacted]-1, [redacted]1 and [redacted]-1, it appears that the restoration efforts were not effective, complete or extensive enough to return the structure to a pre-loss condition. Following restoration of smoke contamination that includes surface cleaning, there should be no evidence of soot, char or ash. Surface sampling indicates that an excessive amount of char is present.

As noted previously, the chemical contaminants produced during a wildfire (including soot, char, ash, formaldehyde, acrolein, hydrogen chloride, and other corrosive contaminants) will, upon condensation or settling, transfer to the surfaces contacted. The corrosive properties of these contaminants will begin to damage and decompose the materials contacted. These chemical contaminants are insidious and will be "absorbed into the substance, especially clothing, unsealed surfaces, potable water piping, wood, and other porous and semi-porous materials", such as clothing, fabrics, carpeting, drywall, etc. Short term impact of these types of contaminants is typically identified through "smoke smell". Although the noxious smoke odor will diminish over time, the damage caused by the contaminants will continue. This absorption is the reason many of these items must be replaced rather than merely cleaned/decontaminated.

It is important to note that cigarette smoke does not generate airborne carbon particulate (soot) similar to smoke due to fires. Cigarette smoke is a combination of a number of chemicals within a moist, heated volume of air. It is the condensation of the moisture in the heated air that appears as white "smoke" when exhaled. Surface discoloration due to cigarette smoke appears as a pale yellow to orange discoloration due to nicotine. Generally this discoloration is localized to the surfaces in the immediate area(s) where smoking is performed. Gandalf Associates makes the point that no visible staining or yellowing of the walls, ceilings or furnishings. It can be presumed that no ashtrays or other evidence of tobacco use was noted during the September 2013 inspection.

The inclusion of a laboratory pH analysis is not fully understood, nor does the Gandalf report explain its importance. The assessment/sample collection was completed three (3) months after the wildfire incident and after, what Gandalf Associates qualifies as "professional", cleaning. Any pH readings would not be expected to be related to soot contamination or fire retardant contamination. Moreover, collecting and submitting pH samples to the laboratory further compromises the sample results as pH is a parameter typically collected in the field on a liquid.

The Gandalf Associate report does not adequately address the issue of observed corrosion and the impact wildfire smoke will have on a variety of materials and products, particularly electronics.

Armstrong's Recommendations, Opinions and Conclusions

There is no disagreement that the subject property was negatively impacted by 2013 Black Forest Fire Event. Surface samples collected from areas within the subject property by NSCT confirm the presence of smoke contamination continues to be an issue following reported "professional" cleaning of the property and the contents. Without proper remediation, neutralization and replacement of impacted materials, damage will continue.

It is likely, based on the proximity of the Wildfire Event, that smoke including particulate and noxious fumes and gases infiltrated the exterior wall cavities of the structure and became imbedded in the building materials, including the insulation material as well as infiltrated the interior of the structure. Figure 2 provides an overview of the approximate location of the Subject Property, the Wildfire Event point of origin and the environmental damage identifiable at the time the image was taken. There are no readily available studies to demonstrate the absence of short or long-term negative impact on building materials and contents. On the contrary, there are studies that demonstrate the components of smoke generate highly reactive contaminants including acid gases, aldehydes and other components that have been shown to be detrimental to building materials and other items including furniture, flooring, clothing, electronics, etc. A professional remediation effort should be thorough and extensive.

Armstrong's opinion and recommendations are made without regard to coverage. The Insurance Carrier determines coverage and any issues related to coverage are the responsibility of the Insured and the Carrier. Armstrong's opinion and recommendations are based, in part, on information obtained from incident report(s), the on-site inspection report and/or analytical results, and/or other documents provided to Armstrong. Due to the length of time between the Wildfire Event of June 2013 and any recent inspections, the presence of certain damage indicators may be reduced or non-detectable. This does not diminish the necessary and appropriate activities that should have been undertaken at the time of initial restoration.

- Based on information provided to or obtained by Armstrong, [redacted] was downwind of the Black Forest Fire for an extended period of time.
- The impact of the smoke plume within the structure is detectable.
- Restoration efforts, including cleaning, should have been conducted in a reasonable period following the fire event and should have included:
    - Surface cleaning of structure throughout the interior including flooring materials.
    - Replacement of attic insulation materials.
    - Cleaning of contents within structure at the time of the event.
    - Cleaning and disinfection of the HVAC System.
    - Evaluation for the need to repaint ceilings and walls due to the significance of the smoke damage based on proximity to the Wildfire Event.
- The use of ozone generators to reduce/eliminate air contaminants is not recommended. These types of units (ozone generator, energized oxygen generator, pure air generators, etc.) produce ozone (intentionally/unintentionally) that will react with chemical components in the air. The issue is, the concentration of ozone necessary to effectively "clean" the air exceeds the recommended exposure limit for the compound and at this concentration will react with human tissue including lung tissue, mucous membrane, etc. Use of this type of equipment should be limited to non-occupied structures and the area completely aired out before re-occupancy.
- Due to the continued presence of smoke contaminants within [redacted], proper and effective restoration is necessary.
    - Cleaning of contents within the structure.
    - Surface cleaning of all walls, ceilings, floors. Consideration of sealing the building materials should be made to eliminate the potential for smoke contaminants to become entrained into the occupied space. Where appropriate, ceilings and walls may need to be repainted to eliminate the visual impact of the smoke residue.
    - Replacement of any carpeting, including carpet pad, due to the length of time exposed to smoke contaminants.
    - Depending on the type of attic insulation material: remove and replace blown in or rolled insulation materials; foam-in-place type insulation materials may need to be encapsulated.
    - Clean and disinfection the HVAC system thoroughly and effectively to eliminate the detected smoke residue.

Closing

This Report has been prepared for the exclusive use of the Client identified on the cover page. This Report, as the work product of Armstrong's professional services, may not be altered after final issuance. The findings in this Report are based on information derived from document review and/or other services as

described. Property damage investigations are designed to be opinion-based due to the limitations of the investigative process itself. Therefore, Armstrong cannot represent that the referenced structure contains no potential hazards and is free from harmful or toxic contaminants. No warranties, expressed or implied, are made or intended through this report. Further, Armstrong's opinion and recommendations, when included, are not to be construed as medical interpretations or advice.

No other aspects of property damage were considered than what is described in this report. Armstrong reserves the right to change and/or supplement this report and any findings, opinions or recommendations if additional information becomes available and is provided.

Respectfully submitted,
ARMSTRONG FORENSIC LABORATORY, INC.

Original signed by:

Marion K. Armstrong, MSPH, MBA, CIH
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B4-0862-2 Narr/mak

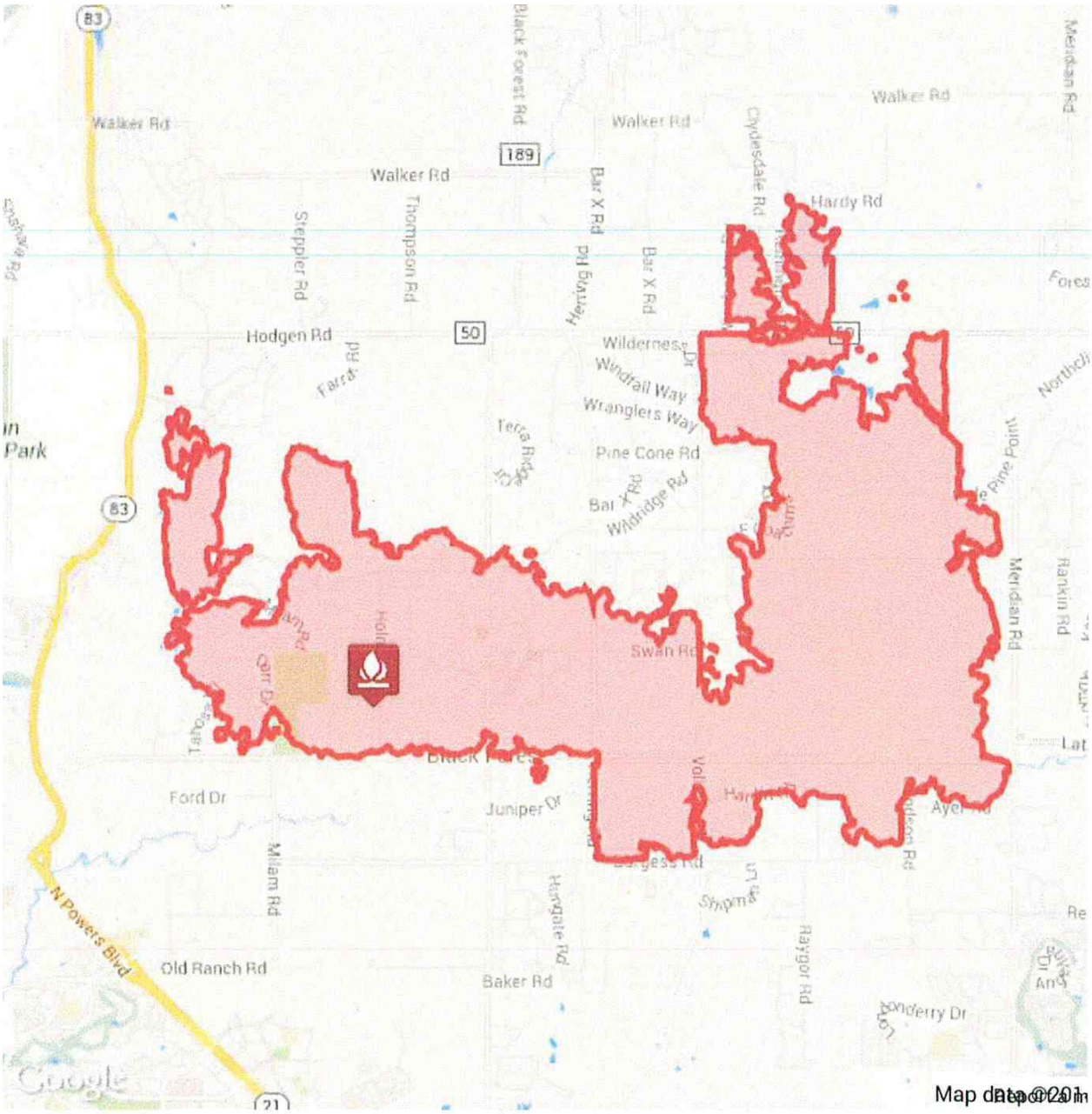

Figure 1: General Overview of Wildfire Impact Area and Perimeter
(Source: Wildfire Today <www.wildfiretoday.com)

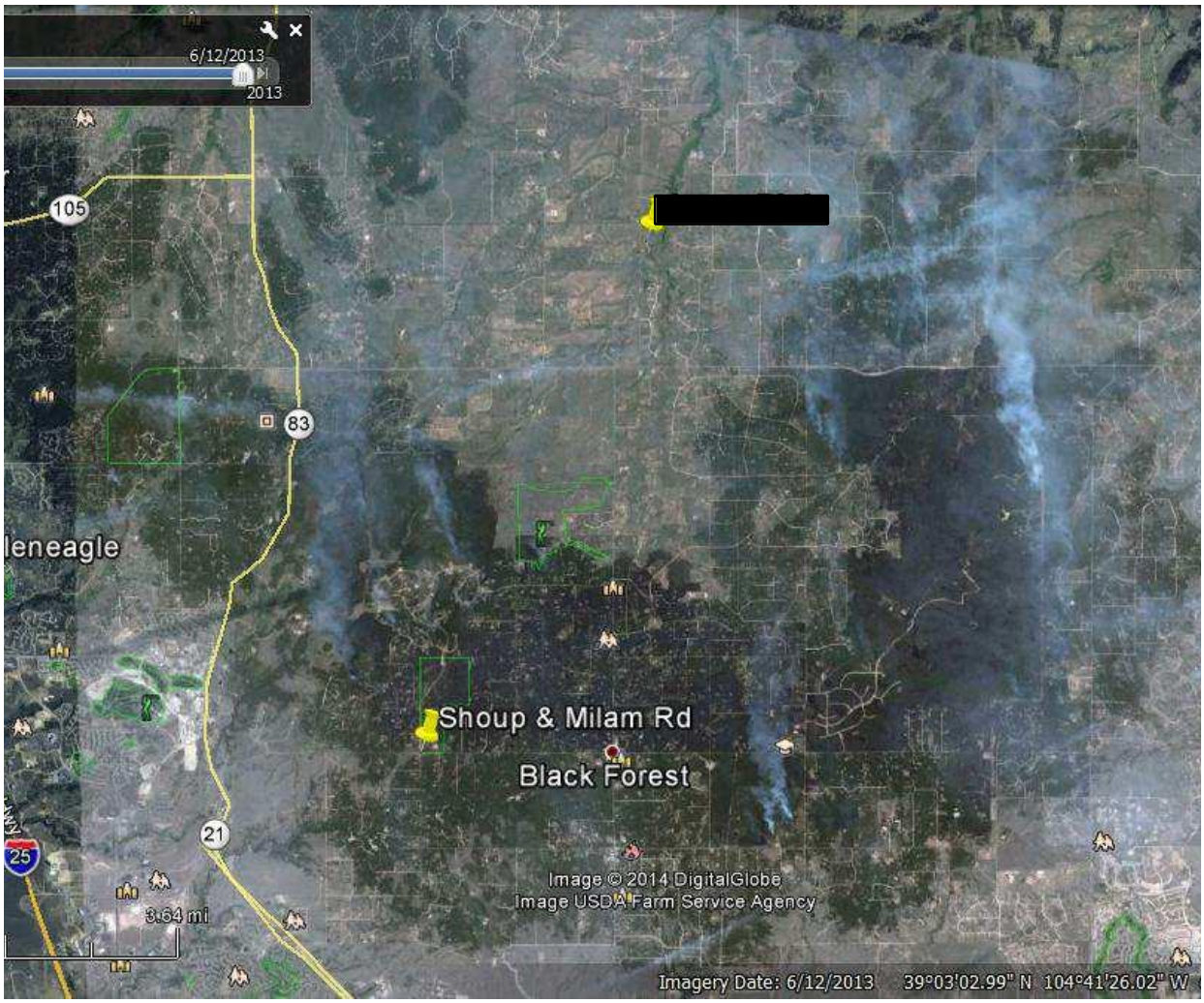

Figure 2: Overview of Subject Property Location, Wildfire Event Point of Origin and Localized Environmental Damage

(Source: Google Earth: Image Date 06/12/2013 (accessed April 23, 2014)

Attachment A: Abbreviations and Symbols

~	Approximately
@	At
%	Percent
&	And
®	Registered Trade Mark
<	less than
>	greater than
°C	degree Celsius
°F	degree Fahrenheit
+	Plus
µm	Micron; micrometer
µg/m³	Micrograms per cubic meter
µg/ft²	Micrograms per square foot
A2LA	American Association for Laboratory Accreditation
ACGIH	American Conference of Governmental Industrial Hygienists
ACS	American Chemical Society
AIHA	American Industrial Hygiene Association
AIHA-LAP	AIHA – Laboratory Accreditation Program
ANSI	American National Standards Institute
ASCLD/LAB -*International*	American Crime Laboratory Directors/Laboratory Accreditation Board – *International*
ASHRAE	American Society for Heating, Refrigeration and Air Conditioning Engineers
ATSDR	Agency for Toxic Substance Disease Registry
Avg	Average
CDC	Center for Disease Control
CIH	Certified Industrial Hygienist
COC	Chain-of-Custody
Cts/m³	Counts per cubic meter of air
DOE	Department of Energy
e.g.	For example
EAA	Environmental Analysis Associates, Inc.
EPA	Environmental Protection Agency
ESL(s)	Effective Screening Level(s)
ETC	ETC Information Services, LLC.
GC/MS	Gas Chromatography/Mass Spectroscopy
HEPA	High Efficiency Particulate in Air
Hr	Hour
HVAC	Heating, Ventilation, Air Conditioning
i.e.	That is

IAQ	Indoor Air Quality
IAQA	Indoor Air Quality Association
IICRC	Institute for Inspection, Cleaning and Restoration Certification
IOM	Institute of Medicine
ISO/IEC	International Organization for Standardization/ International Electrotechnical Commission
L	Liter
m	meter
m^3	cubic meter
Min	Minute
MRLs	Minimum Risk Level(s)
NA	Not Applicable
NCEH	National Center for Environmental Health
ND	None Detected
NELAC	National Environmental Laboratory Accreditation Conference
NIH	National Institute of Health
NIEHS	National Institute of Environmental Health Sciences
NIST	National Institute of Standards and Technology
NIOSH	National Institute of Occupational Safety and Health
NR	Not Reported
NWCG	National Wildfire Coordinating Group
OSHA	Occupational Safety and Health Administration
PJLA	Perry-Johnson Laboratory Accreditation
PLM	Polarized Light Microscopy
ppm	Parts per million
RH	Relative Humidity
RIA	Restoration Industry Association, Inc.
SEM	Scanning Electron Microscopy
SOP	Standard Operating Procedure
TAMU	Texas A&M University
TCEQ	Texas Commission on Environmental Quality
TLV	Threshold Limit Value
TWA	Time Weighted Average
TxDPS	Texas Department of Public Safety
TxDSHS	Texas Department of State Health Services
WHO	World Health Organization
X-Ray	X-radiation (electromagnetic radiation)

Attachment B: Resources and References

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