Elementary, My Dear Watson...

By Neil McManus, CIH, ROH, CSP

With these immortal words (although apparently never actually appearing in the Sherlock Holmes stories), Sir Arthur Conan Doyle told the world about the powers of observation through the brilliant mind of the consulting detective, Sherlock Holmes. Holmes told us that "people see, but fail to observe." The powers of observation used in the anticipation, recognition, evaluation and solving of problems are as important and applicable in the arena of building restoration as they are in occupational health and safety.

Building restoration is dedicated to the return of the internal and external building environment to the condition that preceded a downgrading and sometimes catastrophic event. Now, this might be somewhat too literal a statement of the goals and aims of this industry, as returning a building to the condition that preceded the downgrading event, in itself, might not be desirable.

To illustrate, restoring a building experiencing water intrusion due to pre-existing causes to pre-event conditions without identifying, assessing and correcting all sources of intrusion is futile and potentially receptive of negative repercussions. Fixing damage from a plumbing leak, while not identifying and addressing longstanding leakage from a roof leak, is pointless.

This kind of discussion takes an interesting direction in houses used as marijuana grow operations. Some municipalities require assessment and certification in a document by a professional that the interior environment of the house is "essentially free from mold." Now, if one accepts that distinguishing mold associated with the marijuana plants from that due to water incursion, and growth on building materials from that due to other house plants from that in outdoor air is essentially impossible, then where does that lead us?

First, in order to protect the interests of the assessor, as well as the restoration company that participated in the process of clean-up and preparation, this means that the house must be in pristine condition. Getting to that point means identifying and correcting all sources of moisture and removal of all mold in the normal airspace of the building and the roof space through extreme cleaning of all fabrics, furnishings and carpets and surfaces. To put it succinctly, the place must be cleaner than clean and drier than dry, so that one can say that this is as clean as it gets. If one can say that, there is no leeway for attack.

Following the advice of Sherlock Holmes is critical for the success and growth of the building restoration industry. Why? Well, if one takes the attitude that the job is simply to restore the building without investigating to identify and ensure correction of all downgrading conditions prior to starting the work, the problem that prompted the work could easily reoccur. When that happens, the restoration company will have a tough time explaining its way out of the situation.

Saying that some other deficiency was the cause without bringing this forth at the time of performance of the work will not be helpful. Ensuring that the building is sound at the time of starting the work will ensure protection for all parties, and a customer, who while not happy to learn of pre-existing causes of growth, must at least acknowledge the professionalism of the approach taken by the restoration company to identify and document all issues involving the building. At that point, the customer becomes an active participant in decision-making. This circumvents claims of ignorance brought about by lack of disclosure by the restoration company. After all, the restoration company has had access to areas of a building to which few building owners ever go.

Or is It?

The following examples provide additional illustration of situations where the skills of Sherlock Holmes were essential to identifying and solving problems. (Note: while the following stories reflect actual occurrences, the details are modified to ensure the privacy of the situations.)

Example 1: The Job's Not Done 'Til It's Done

This situation concerned a house that is about 20 years old and contains two living floors, a partial basement and a crawl-space, and faces east on a residential street. The roof is composed of framing covered by a layer of tar paper and cedar shakes. The roof is original to the house. The present owner has lived in the house for about 12 years and reported that the house had never experienced leakage until the episode under consideration, and no leakage subsequent to it.

The east side of the building contains two balconies that are accessed from the second floor. The floor of the balconies forms part of the roof of rooms on the first floor of the east side of the building. Void spaces containing steeply pitched roof sections enclose the balconies. The east wall of the second story forms the exterior wall facing the balconies. Thus, the balconies are completely enclosed by walls and are not visible from the street.

The balconies are constructed bathtub-style. That is, the enclosing walls are contiguous with the floor. The walls are framed and covered with a cementitious material on the exposed side. The walls extend slightly wider than the upward curve of the floor material. The floor contains a green coating. The balconies each contain two drains, one located in the floor on the east wall and the other about 1.5 inch (3 cm) above the floor on the outside wall on the north or south side of the building. Drain openings are about 1 inch (2.5 cm) in diameter. The drains lead into void spaces located beside the balcony.

A consequence of the design of the balconies is that all precipitation must exit through the drains. This construction requires ongoing inspection and maintenance, as the small openings are easily blocked by leaves and debris. The in-floor design is also prone to leakage into the void space above the first floor rooms. Small drain openings are satisfactory for collection of rain, but face severe limitations when snow and ice are involved. Ice can block the drains and requires thawing to maintain the opening. To illustrate, at the time of the visit, the drain on the roof above one the balconies was blocked and water was streaming over the edge.

The bathtub style of construction of the floor of the balcony is capable of accommodating a volume of water greater in depth than the higher opening of the drains. The membrane continues up the side of the enclosure to at least as high as is visible. The protected height is not obvious from visual inspection.

The owners of the house were absent for the month of November. They had arranged to have the house inspected every few days in order to maintain insurance coverage.

Near the end of November the monitor reported that the ceiling in one of the rooms had partially collapsed. This coincided with the occurrence of some extremely severe weather in the Vancouver area. This weather brought prolonged heavy rain, high winds, snow and a repeated freeze-thaw cycle. The high winds knocked out power to a large number of customers of BC Hydro (the provincial electrical utility) on several occasions.

Inspection of the roof space indicated wetting at the leading edge of the east side of the roof where spillover from the embedded drains had occurred. Timbers and surfaces in the roof space were covered with moisture.

Demolition of the ceiling in the rooms at the front of the house exposed all areas under the balconies. This included the piping used to drain the balconies. The vertical drains

Figure 1. Drain fittings on the bottom of the balcony. Note the glued fittings.

Figure 2. Inserted drain fitting. This picture shows the metal drain fitting inserted into the plastic drain pipe. The fitting and the pipe were not sealed together. Blockage of water flow in the drain pipe caused by an ice dam led to backflow into the ceiling cavity.

contained fittings that were glued together. The horizontal drains contained a flanged metal fitting normally used in drains on tar and gravel roofs. In this case, the metal drain pipe of the fitting fitted inside the plastic drain pipe in a manner similar to what would occur in the metal tubing used in a roof drainage system.

Inspection of this area indicated no obvious historic growth and provided no obvious clues about the source(s) of the moisture that triggered this event. These observations supported the story provided by the homeowner that this episode was a "one-off" event. "One-off" events are very difficult to solve; yet, they must be, otherwise, there was a risk of reoccurrence of the situation.

So, what caused this event? The pieces of this puzzle are all here. Solving this puzzle prior to rebuilding this house was absolutely critical to the soundness of the work and the long-term credibility of the restoration company with the homeowner and the insurance company that underwrote this work. The solution comes through observing what we have seen.

Figure 3. Exterior walls (outside) following replacement of siding. This picture shows the original siding and the new siding installed by the building envelope contractor. Note the vertical orientation of the planks of original siding and the gaps at the end of the planks caused by shrinkage due to drying of the lumber. Warping can cause separation of one plank from another. These effects of aging create paths for leakage of moisture and liquid water.

The key to the situation was the manner of inserting the piping of the metal flange into the plastic drain pipe. Insertion of an improvised wire "fish" demonstrated that the interface between the plastic and the metal was not sealed. Winter conditions in Vancouver can change rapidly from snow to rain to freeze to thaw to freeze, and so on. Under such conditions, freeze-up in drain piping of small diameter located in an isolated and unheated void space is a realistic possibility. Freeze-up readily occurs in drain pipes of small diameter that leads from roofs. Freeze-up in the drain pipe followed by rain following the unusual and severe weather that occurred during the period would lead to back-up in the drain pipe and overflow into the ceiling space and the damage that subsequently occurred.

Example 2: Gee, Where'd That *Stachy* Come From?

This situation concerned a wetting episode of prolonged duration along the west exterior wall in a townhouse estimated to be 35 to 40 years old. The wetting episode resulted from a problem associated with the siding. The exterior of this building consists of wooden planks applied vertically with a thin strip of wood covering the seams. Over time, the planks shrank in length, warped and otherwise deteriorated. This situation led to the opening of gaps at the ends and sides of individual planks, thus creating pathways for entry of moisture into the building envelope.

A building envelope contractor removed and replaced the exterior sheathing and the interior drywall along the exterior walls. Gaps at seams and exposed nails were evident in the drywall, as finishing work had not occurred.

A building restoration company was brought in to do interior work in response to concerns regarding wetting of the floor observed during wetting of the walls. The company isolated most of the unit including the previously repaired outside walls in an enclosure containing a negative air mover sized for the location and operated the bathroom fan to induce additional flow. The restoration company removed all of the flooring back to the concrete and some drywall from walls for the bathroom and closets in the enclosed area.

The restoration company reported that the interior of the dwelling remained dry during their period of work activity.

Figure 3

Work activity occurred during a period of heavy driving rain, some of which wetted the sides of the building previously repaired by the contractor. The company also performed tests using a garden hose on the sides of the building.

Figure 4. Exterior wall (inside). This picture shows the drywall newly applied by the building envelope contractor and an existing interior wall. Minor gaps and penetrations in the drywall presumably provided the path for entry of Stachybotrys spores from the exterior wall cavities.

At the time of the visit, the enclosed area had the typical appearance of a remediated work area: an air mover that discharged to the outdoors, sheet poly enclosure and flaps, bare concrete floor, partially removed drywall, and so on. The exterior walls contained the newly applied, unfinished drywall. There was nothing in this situation that appeared to be extraordinary.

Air sampling occurred following shut down of the airmover and the bathroom fan and inspection of the enclosed area. All surfaces appeared to be dry and clean and contained no visible mold. Air sampling occurred using both total spore (Air-o-Cell) and culturable (chloramphenicol-impregnated rose bengal agar) sampling methods. (Chloramphenicol inhibits growth of bacteria.)

Figure 4

The overall spore levels in the enclosed area of the dwelling were about twice what is observed in clean, dry buildings that have not experienced wetting issues. What was startling in the fungal population was the presence and level of the *Stachybotrys* spores. These samples contained some of the highest levels of *Stachybotrys* spores ever observed by this author. The observation indicated serious problems in the structure.

Stachybotrys is not observed in outdoor air samples in this climate and almost never in indoor air samples. When observed in indoor air samples, *Stachybotrys* is associated with building materials that have undergone prolonged and extensive wetting.

The newly applied drywall encountered during the visit provided no hint for the findings determined in the air samples. Normally, when visible, *Stachybotrys* would be observable as black patches. The preferred food source for *Stachybotrys* is cellulose, as found in wood, and of course, paper. These observations presumably meant that the *Stachybotrys* was present in the wall cavities.

What was the source of the *Stachbotrys* spores and why were they airborne in such high concentration? To this point, the exact location remains unknown. The building envelope contractor returned to this dwelling and removed the drywall on exterior walls to the 4-foot level and spray-applied a paint-like coating to the exposed wall cavity. (This activity occurred independently from actions of the building restoration company and the author.) Subsequent air sampling under similar conditions indicated the absence of *Stachybotrys* spores in air inside the dwelling.

The answer to the second question presumably reflected the status of the wall cavities on outer walls of the building and the nature of the ventilation. These walls were subject to wind pressure and the negative pressure created by the negative air mover and bathroom fan. The differential pressure created the motive force for airflow inward through leakage paths in the building envelope. The inward air flow created the turbulence needed to aerosolize spores contained in the wall cavities. Long-term wetting of building materials in the exterior wall cavities created the growth opportunity for *Stachybotry*s.

The repair and follow-up by a building-envelope contractor not knowledgeable in mold remediation created the conditions for the spread of *Stachybotrys* spores into the airspace of the dwelling. This situation argues for versatility in the building restoration industry for response capability to both exterior and interior damage caused by water incursion.

Example 3: Attic Spaces Aren't Part of the Dwelling, Or Are They?

The attic occupies the airspace below the roof and above the uppermost floor of a dwelling. Normal expectation is that heated air in a dwelling will rise into the attic space through penetrations in walls and from there, escape outdoors through vents in the roof. Or will it?

This example involved a two-story building in a condominium complex. Each suite occupies a part of either the ground or second floor. The second story suites have access to the roof space. The complex is about 18 years old.

This building had experienced problems with condensation in the attic space attributed to inadequate venting. Condensation in an attic space can lead to growth of fungi (yeast and mold) when the temperature is suitable.

The present homeowner moved into her suite early last year. She commented that within two weeks of moving into the building, respiratory symptoms began. These included symptoms typically reported by people affected by exposure to mold spores: eye, nose and throat irritation. The most severe of these symptoms was spontaneous bleeding of the nose. The homeowner also reported symptoms of chronic fatigue and fibromyalgia. These are also reported by people affected by mold spores in air.

Inspection of the suite indicated that the fan above the stove in the kitchen vented into the suite and did not discharge outdoors. Fans in the bathrooms produced very weak capture of air. The clothes dryer appeared to vent outside, judging by the piping that penetrated through the roof. Anaemic performance by fans or recirculation of humidified air, as in the case of the range hood, needlessly raised the humidity in the suite during water use and unnecessarily promoted growth of mold.

The homeowner sought assistance for her situation and spoke with a building restoration company. A representative inspected the attic space and reported the presence of visible mold and droplets of moisture on surfaces of the roof structure. Air and surface sampling subsequently confirmed heavy contamination of the attic air space and active growth on surfaces. Air samples also indicated that the interior of the dwelling had spore levels and types typical of what are observed in clean dry buildings.

The homeowner commented that her symptoms appeared to be worse during cold weather. Given a path, cold air in roof spaces does flow downward in cold weather into occupied spaces. To confirm this, open the hatch leading to the attic space in a home during the cold weather months. Further, this homeowner commented that she had observed the flow of cold air into the dwelling from openings in walls through which pipes passed in the kitchen, storage room, cupboards and bathrooms.

These observations provide a plausible route of entry for fungal spores from the roof space into the occupied space of the dwelling. The linkage in occurrence of respiratory symptoms by the homeowner to the occurrence of cold weather provides support to the hypothesis that fungal growth in the roof space is the cause of the respiratory symptoms experienced by this individual.

This anecdote provides ample evidence that people who live and work in buildings are important partners in diagnosing problems. This homeowner turned out to be a keen observer and a worthy contributor to understanding the dynamics of this situation. She was able to link conditions in the environment to the symptoms that had affected her. Investigators are

wise to take the time to involve occupants in their investigations and deliberations.

Example 4: Follow That Moisture, Follow That Mold

Investigators seldom have the luxury of taking the number of samples needed to provide conclusive evidence about a situation. Such is the nature of the business. This situation reflected an opportunity to learn by sampling. An insurance adjuster posed the question about whether the mold growth observed during emergency work by a restoration company in response to a water incursion was new or historic.

To my knowledge, there is no straight-forward way to do this. What is possible is to pursue the question from the standpoint of what is observed in buildings following wetting events. *Aspergillus/Penicillium* and other species, starting with *Cladosporium* are observed following discrete wetting events. Mycelial fragments indicate that active growth is occurring.

Stachybotrys provides a point of comparison. *Aspergillus* and *Penicillium* are observable sometimes, but not frequently in outdoor air samples When present, the levels usually are low compared to what is observable in water-damaged areas.

Stachybotrys, by contrast, is not observed in outdoor air samples in this climate and almost never in indoor air samples. When observed in indoor air samples, *Stachybotrys* is associated with building materials that have undergone prolonged and extensive wetting.

Figure 5. Wall showing extent of migration of water from the ceiling. Surface sampling indicated mold contamination in the area wetted located above the tape and lack of contamination in areas of the wall located below the tape that had not experienced wetting.

This dwelling is a multi-story townhouse with a common garage underneath. The wetting episode resulted from a problem associated with the roof. This problem was corrected prior to the visit. The wetting was observed in the second story bathroom located below the roof. A common wall shared with the neighboring unit was affected as water passed down to the ceiling-to-wall interface in the dining room located below. Observation indicated no evidence for wetting down to the parking garage. The construction of the common wall cavity between adjacent units involved a double layer of drywall on the one side and a single layer on the other. The dwelling affected had the double layer of drywall.

During exploratory work involving the wetted wall, the restoration company discovered growth of mold at the interface between the two panels of drywall. They left the walls intact, save for the holes created by exploratory activity.

Samples obtained at different locations on surfaces known to have been wetted contained *Aspergillus/Penicillium* spores. These spores were not present on a surface known not to have been wetted and immediately below one known to have been wetted. (*Aspergillus* and *Penicillium* spores are similar in appearance and difficult to differentiate. Labs often report them together.) These samples also indicated the absence or very low presence of mycelial fragments. Mycelial fragments indicate active growth, as would occur in wet or damp materials following a wetting event.

The weight of evidence provided in the air and surface samples, in context with experience gleaned from previous situations, lead to the conclusion of a situation consistent with short-term wetting from the problem involving the roof.

Example 5: Was There a Marijuana Grow Op in This House?

This work was prompted by concerns about the status of the indoor environment expressed by the owners of a house. They had occupied the dwelling for about one year and were experiencing respiratory symptoms associated with living there.

This house is about 50 years old, and contains a main floor and full basement. In its original configuration, the house contained a sunken carport that opened into the basement at one end. This subsequently was converted into additional living space in the basement and as an addition to the main floor.

The homeowners commented that the previous owner had gutted and replaced many of the interior surfaces. This seems to be an unusual step to take in preparing a house for sale. Indoor environmental practitioners and building restoration professionals likely would already have formed hypotheses about such a property on reading those words. Unfortunately, to most people these suggest the opportunity to acquire a dwelling that offers a fresh start, rather than merely a coat of paint. The occurrence of respiratory symptoms linked to occupancy in the dwelling was an indicator that something was wrong.

The sample obtained on the main floor contained some of the spore types observed in outdoor air and small numbers of other fungal types. This air sample, with allowance for the presence of spores associated with outdoor air, was typical of what is observed in normal clean, dry buildings. The sample obtained in the roof space contained the same spore types observed in outdoor air at a lower level plus small concentrations of other fungal types.

The fungal population in the air sample obtained from the west side of the basement was reflective of that obtained on the main floor. The air sample obtained in the east side of the basement contained fungal types present in the outdoor sample, as well as fungal types not present in other samples indoors and outdoors. The level of *Cladosporium* spores was considerably higher than in other indoor samples. *Cladosporium* spores and *Aspergillus* and *Penicillium* spores are associated with respiratory symptoms in sensitized individuals. The presence of higher levels of mycelial fragments than in other indoor samples suggests that active growth is occurring in this area. Active growth is usually reflective of dampness.

The east side of the basement contained fungal spores unique to that area. This strongly suggested the occurrence, past or present, of a growth opportunity. Growth opportunities require moisture. Growth opportunities can result from wetting events and growth of plants indoors. The latter can include marijuana grow-operations. There is no easy way to differentiate between these situations. The presence of mycelial fragments is suggestive that growth is occurring and that sufficient moisture for growth is present. Exploratory and cleaning activities are required.

The presence of higher levels of mycelial fragments than in other indoor samples suggests that active growth is occurring in this area.

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