

Mysterious and Annoying – Hard-to-Detect Residential Noises

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A series of noise complaint case histories are presented along with recommendations for resolving such complaints. Recommendations include: how to search for the noise source, how to investigate possible non-acoustical explanations and how to approach the issues.

More often than we like, consultants receive calls from people annoyed by a sound that can't be easily identified. Because these types of projects often end with the consultant unsuccessful at detecting the sound and the client unsatisfied or even angry, some consultants will not take them. Others require payment in advance. Some consultants require that they be hired by a third party, such as a homeowner association, that will be more objective in evaluating the consultant's work.

When consultants arrive at the client site, they often can't measure or hear anything. The sound is sometimes described by the client as being quieter than usual that day. Other times, the client can clearly hear the sound and can't understand why the consultant can't hear or measure it.

In the following sections, we discuss cases where the sound source was found, cases where it wasn't found, possible medical explanations, and recommendations for consultants and for people bothered by hard-to-detect sounds. This article is for consultants and for people complaining about these types of sounds with recommendations on how to search for the sound source, how to investigate possible non-acoustical explanations, and how consultants and those bothered by the sound should approach the issue. Consultants may find it useful to provide copies to people suffering from these types of sounds. This article is based on a paper presented by the authors at Noise-Con 2016.¹

Cases of Sounds that were Detected

The best situation for all is when the consultant can hear and measure the sound and then find the source. If the sound is bothering only one person (or just a few) and the source hasn't already been identified, it is likely that there is a low signal-to-noise ratio and that the source is not nearby – in other words, a challenge for the consultant. The following cases include our experiences and those of other consultants:

- A resident suspected that a neighboring water treatment plant on a hill was the source of occasional nighttime rumbling noises. The real source turned out to be a train crossing a trestle over a lake and chugging up a hill several kilometers away combined with a temperature inversion and several sound bounces off the lake. As soon as the locomotive passed the edge of a canyon, the sound abruptly stopped. An outdoor sound recording was decisive in identifying the source.
- When the prevailing early-evening summer wind was from the east, residents occasionally heard a very faint “vrrmm-vrrmm” noise, and then their windows and crockery would start to shimmy and rattle. The source turned out to be a charcoal retort in which wood was heated in a 30-m-high reaction chamber to release volatiles, baking the wood to charcoal. Two side branches burned off the volatiles with the resulting gas looped back to the reaction chamber. With two side branches and one central reaction chamber, the system was only quasi-stable. Every so often, the process would drift from its stable condition, resulting in huge pressure variations for 5 to 10 minutes before restabilizing. The 50-m stack would produce a strong 10-Hz tone, which, assisted by the easterly wind, would shake houses 3 km to the



Figure 1. Typical vibrating screen.

west. A solution was devised but never implemented. Once the source was identified, the local community embraced it as a “local curiosity.”

- A complainant listened to tones of various frequencies online and identified the problem tone at his house to be at about 46 Hz. The consultant had also received a call about a low-frequency sound a year earlier from another resident about a mile away. The consultant measured a tone at 44.9 Hz in the very quiet house that was close to the threshold of hearing, but the complainant apparently had very sensitive hearing in one ear. The client had identified several locations to visit, and the culprit turned out to be a vibrating screen processing mulch (Figure 1) over 5 km away. Calculations applied to nearby measurements verified the possible level 5 km away with good propagation conditions. Near the source, the tone was present but blended in with many other sounds. At the complainant's home, the only sound heard was the fundamental of the tone.
- A woman complained about a sound in her house, and there was some discussion of a transformer station miles away. Turning off power to the house had no effect on the sound she heard. Visiting consultants could not hear any sound at all in the house. Years later, the sound she heard went away when a transformer at the station was replaced.
- A consultant could not hear a sound that disturbed a client, but his analyzer picked up a clear 10 Hz tone. It wasn't loud enough to produce rattling, but several people in the area complained. The sound was from a Chrysler plant 3 km away. Although normal audibility is typically considered 20 Hz to 20 kHz, thresholds well below 10 Hz have been documented² and are considered important in infrasound studies such as with wind turbines.
- A woman in a retirement home claimed to hear a hum when a particular air conditioner kicked on in a unit several rooms away. An analysis of the air conditioner noise showed that it couldn't be audible that far away. It turned out that her refrigerator was on the same circuit as the air conditioner in the other unit, and the voltage drop from the air conditioner coming on caused her refrigerator's compressor to hum.

Unresolved Cases

There are a wide variety of types of cases where the sound can't be heard, measured, or treated by a consultant. The following range of particulars have been encountered in these situations:

- Complaints about high- and low-frequency sounds (including perceived vibration)
- Middle-aged to older people complaining about the noise
- Men and women
- People living alone and shared households
- Previous noise exposures (possible hearing loss) and no previ-

Based on a paper presented at Noise-Con 2016, Conference on Noise Control Engineering, Providence, RI, June 2016.

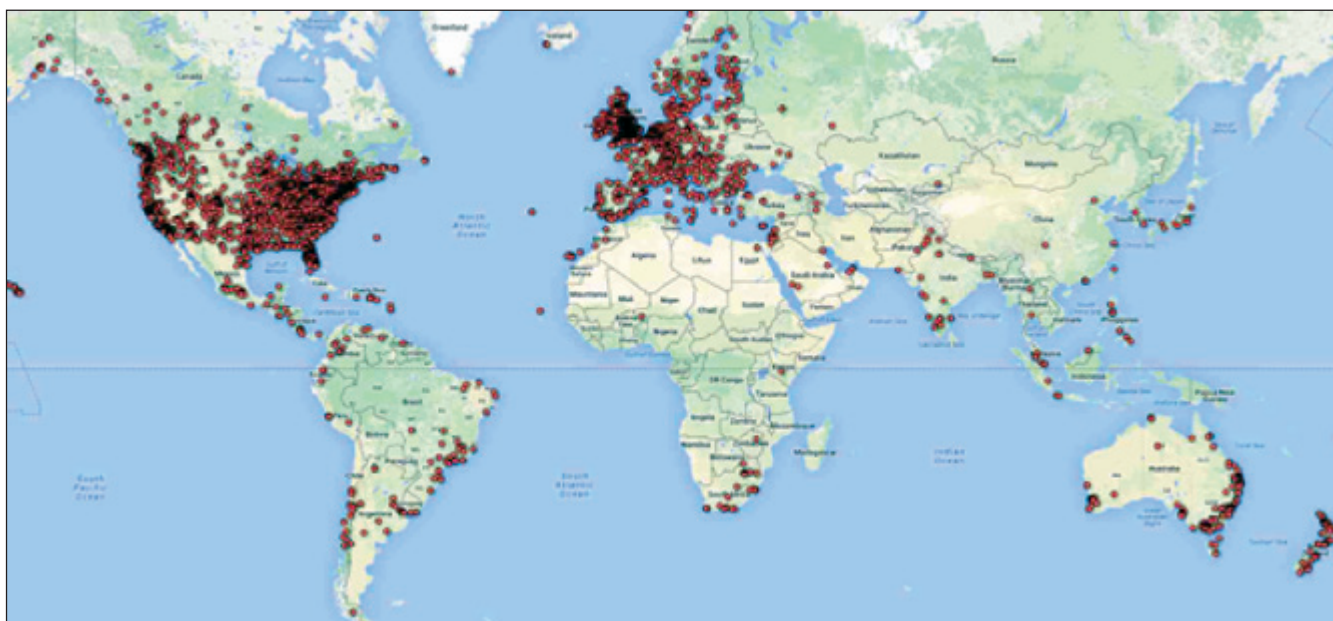


Figure 2. Locations of “hums” around the world.

ous noise exposure

So while there isn’t a profile that clearly indicates that no sound will be found by a consultant, the following situations seem common:

- The sounds are heard only inside an (otherwise) very quiet house
- The person has had the sound “confirmed” by friends or family
- A neighbor is intentionally creating the sound to annoy the complainant
- There is no correlation of the sound with wind direction or other atmospheric conditions

Although these symptoms certainly describe tinnitus, there are usually some problems with this diagnosis:

- The client usually hears it only at home and not in other quiet locations. Of course, home is where they spend lots of time relaxing and where ambient levels are very low, so perhaps they only notice it there.
- Often the sound is described as low frequency rather than the typical high-frequency ringing in the ears. Some even say they feel vibration.
- They often have friends or family that also claim to hear it, but I assume these “witnesses” are often just being sympathetic and nice. It’s also true that, if asked if they can hear something very soft, most people do hear something very soft – ambient sound levels are rarely below the threshold of hearing.
- Usually, the person has not had previous exposure to high sound levels that would have led to hearing loss, which is often associated with tinnitus.
- There is no strong reason why the tinnitus should have started at a particular time, and the person often associates the sound with some facility that started operating about the time the sound started (which is a very reasonable conclusion).
- The situation often appears to be stress related, though it is unclear if stress somehow caused/worsened the tinnitus or if tinnitus is the source of the stress (or both).
- Nearly all people insist that the sound is “real” and refuse to consider that it could be the result of a medical condition.

Here are some case histories where no external source was found:

- A person claimed to hear music all the time, even though the consultant could not detect any music. She saw a specialist, and the situation was diagnosed as a neurological disorder. WNYC’s Radiolab had an episode called “Earworms” that reported on similar phenomena. In one case, a person’s brain dealt with a lack of aural input due to hearing loss by “hearing” music, and the songs the person heard would match their mood, essentially creating a live soundtrack. This music seemed as real to the person as any other sounds.
- A client blamed an annoying sound on sonic rodent repellents.

- A consultant in south Florida had complaints over the years from a number of people hearing low-frequency tones in their houses. Although barely audible to inaudible in level, the consultant was able to measure strong tones from 20 to 40 Hz at one house that changed in level along with the person’s perception of the level of the annoying sound. The sound source could not be determined for any of the homes but was assumed to be propagating via ground vibration. Several people found improvement by using low-frequency sound maskers using subwoofers, and one person moved to an upper floor of a high-rise condominium where the sound he heard was much lower in level.
- A consultant would receive a daily phone call from a little old lady who lived alone about the humming noises and persistent vibration that she experienced in her large, silent home late at night as she sat reading. The consultant could find nothing, even as she stood beside him saying “There it is. There it is. Can’t you hear it?” She refused to consider any possible medical explanation, saying that all her friends had agreed that they could also hear it. She was convinced that her nearest neighbor was operating a pump late at night to drive her from her home. She stopped calling that consultant when he suggested the problem might not be physical and started calling another consultant daily.
- A representative of an appliance manufacturer gets regular phone calls about strange sounds from appliances. He gets similar calls about strange smells, concluding that some consumers have very heightened senses of smell and some may have very heightened senses of hearing.

The Belligerent Neighbor

We have encountered a number of cases where clients are convinced that their neighbors are intentionally producing sounds late at night for the sole purpose of annoying the client. This often follows some confrontation with the neighbor over unrelated issues. Other consultants have reported the same phenomenon. One client continued to be annoyed even after the neighbor had moved and concluded that the former neighbor has hidden noise-producing equipment in the house before they sold it and were now operating it by remote control.

Although such explanations seem far-fetched, there was a case where two neighbors sharing a common wall in public housing were quarrelling. One claimed that her neighbor was instructing her kids to make noise and was also making a drilling sound all night long. When the housing authorities inspected the neighboring residence, they discovered that the resident had in fact attached a drill to the common wall and was plugging it in each night just to annoy the neighbor.

A neighbor intentionally producing annoying sounds may oc-

asionally happen, but my opinion is that most cases result from a sensitive person with poor relations with their neighbor trying to explain a sound that is very annoying (at least to them). The heightened sensitivity of the person hearing the sound could even be related to the poor neighbor relations, unrelated to any noise issues.

Similar Phenomena

Wind Turbines. There are still debates within the acoustics community about the effect of low-frequency sounds produced by wind turbines. A small percentage of people near a small percentage of wind farms are affected, complaining about disturbed sleep, disequilibrium, nausea, vertigo, anxiety, etc.

Some acoustical experts say that there should be no effects because the wind turbine sounds are often below the threshold of hearing. Others counter that the effects may not fall within the traditional hearing mechanism.

A possible coupling mechanism between infrasound and the vestibular system via the outer hair cells of the inner ear is not well understood. Outer hair cells may respond well to low-frequency sounds and infrasound. Endolymphatic hydrops, a condition associated with Ménière's disease, may cause the ear to become more sensitive to infrasonic bias tones.³ The vestibular sense organs may respond to infrasound, and certain people may have vestibular systems that are hypersensitive to very-low-frequency and infrasound stimulation.

"The Hum." There have been a number of cases in recent decades where many people hear a low-frequency hum in a general area. This has occurred in areas all over the world (Figure 2). The sounds are most often heard indoor when ambient sound levels are very low. The typical frequency range is around 30 to 80 Hz. Here is a website with lots of information (much to be taken with a grain of salt): <http://thehum.info/>

In a few cases, a source of the hum has been found:

- In the 1980s in Sausalito, California, people who lived in houseboats along the bay began complaining about a hum that occurred during the summers. This was later found out to be the mating calls of the toadfish (also called the midshipman fish).
- In 2012, the West Seattle area was experiencing a hum that was eventually traced to blowers with damaged silencers at a loading dock.
- One possible source is the pressure of waves vibrating on the ocean floor.⁴

In most cases, the hum source has not been determined. Some experts think most cases are a combination of tinnitus and mass media. Mechanical sources are often suspected, and conspiracy theories also show up.

Diagnostic Recommendations for People Hearing Sounds

If an annoying sound is clearly audible and its source is obvious, it may be useful to hire an acoustical consultant to determine how to reduce the noise. If the sound and source are difficult to determine, it may be useful and cost effective to conduct a preliminary investigation before hiring a consultant. We recommend that the following issues be investigated.

What is the frequency (or frequencies) of a sound? A person hearing the sound can use a cellphone app to generate tones or listen to YouTube videos playing tones to try to match what is being heard. However, not all annoying sounds are tones (distinct pitches). A consultant can try the same methods to determine the sound frequency.

When is the sound heard? If the source of sound is far away, it is likely to be heard most when the wind is blowing from that direction. Noting the wind direction when the sound is heard can be a good clue about the direction of the source. Calm, cool, clear conditions in the morning can cause thermal inversions that help sound propagate long distances in all directions. Often sounds are heard primarily at night when there are very low ambient sound levels, making it possible to hear even very faint sounds.

Where is the sound heard? Is the sound heard only on a certain side of the house? Can it be heard outside? This information may be helpful in determining the direction to the source. However,

low-frequency sounds can vary greatly at different locations within a room, so it is not always possible to describe one room as "louder" and another as "quieter."

Are there any industrial facilities in the area? You can check an area map to look for nearby facilities that could be a source of noise. Distances could range from meters to kilometers. Determining probable direction based on the wind or locations where the sound is heard can help narrow the search. You can then drive around, stop, turn off your engine, and listen during a quiet time when the sound is normally audible. Things to look for include transformers, blowers, furnaces, pumps, and engines.

Could the source be something mechanical/electrical within the house? If the sound goes away when selectively turning off appliances (with switches, circuit breakers, or just unplugging), then the source of the sound can be determined or at least narrowed down.

Can the sound be recorded? Many cellphones can make recordings, and some apps can also analyze sound frequencies. However, a recording by itself is rarely conclusive. Except at rare locations, there is always some sound that can be heard, recorded, and measured. Most often this sound is not disturbing. It may be useful to compare recordings or measurements made at two different locations and times, one with the annoying sound and the other without it.

What level of sound is objectionable? As just noted, some sound is always audible nearly everywhere. However, the levels of sound that are found objectionable vary widely from person to person. The character of the sound is also a major factor. A steady, nontonal sound at 45 dBA may be acceptable to many people, but tonal, beating, low-frequency sounds (like music) may cause complaints at 30 dBA in an otherwise quiet residence.

Could it be tinnitus? Tinnitus is a condition often described as "ringing in the ears," but there are variations in the types of sounds heard. A following section on "medical explanations" describes tinnitus in more detail, including medications that can affect it. In theory, constant tinnitus sounds should be audible at any very quiet location, not just the home, but intermittent tinnitus sounds may be noticeable just at home. Try going to other very quiet locations including homes and locations far from the neighborhood to listen for the sound.

Can you hear the sound even with earmuffs on? Typical noise earmuffs are effective at blocking medium- and high-frequency sounds. Earmuffs can be combined with earplugs for more sound reduction. Active noise-cancellation (ANC) earmuffs may also block low-frequency sounds (if the seal around the ear is tight). If the sound is just as loud with ANC headphones on, the source is probably tinnitus or some related condition.

Do other people hear it? As previously noted, there are some sounds nearly everywhere, so when a friend or relative says that they also hear something, it doesn't mean that they are hearing the same thing. Unless they describe the same exact type of sound heard at the same times and locations as the person complaining (and also not heard at the same times and locations as that person), their hearing a certain sound is not proof that the annoying sound isn't tinnitus.

Do you have any hearing loss? Tinnitus and some other hearing conditions are often a result of hearing loss. An audiologist can measure hearing loss and can also provide information on the ear and possible relevant conditions. Audiologists deal primarily with middle- and high-frequency sounds, and are generally not as experienced with low-frequency sounds. They can work with a person and propose tinnitus treatments.

What can be done to reduce the noise? The first step is to determine the source of the sound that needs quieting. Sound isolation of a house can also be improved, though many treatments work best only at higher frequencies. Sound absorption inside a house can reduce sound levels. Sound masking can also help (see the next point).

What is sound masking? Although most people say they like silence (a lack of all sound), what they really want is quiet (a lack of objectionable noise). Many people find that objectionable sounds are less of a problem when the air conditioner is on because this sound helps to cover up (mask) the objectionable sound. Electronic

maskers can provide masking sound (typically steady, nontonal, broadband sound). However, this works only if the masker produces sound in the same frequency range as the objectionable sound and if the objectionable sound is not too loud (if masking sound is too loud, it can be annoying itself).

How can a consultant help? You can find acoustical consultants in the phone book, by Internet searches, and on websites for the National Council of Acoustical Consultants (NCAC) and the Institute of Noise Control Engineering (INCE). Consultants often have high-quality sound measurement equipment and knowledge of what types of equipment produce sound and how sound can travel. They can provide recommendations for noise control and sound isolation. However, it may be very difficult for a consultant to measure and track a very faint sound, especially if it is intermittent. The answers to the questions in this section will help but will not ensure that a consultant can fix the problem.

Recommendations for Consultants

For consultants, I would recommend asking the above questions before traveling to the site. Feel free to copy and edit excerpts from this article. My other recommendations are:

- Send a consultant to the site who has very good hearing. However, if the problem is reported to be low-frequency noises, it is possible that good hearing at high frequencies is not beneficial. It is even possible that someone with some high-frequency hearing loss could be more sensitive to low-frequency sounds.
- Schedule the trip when the sound is likely to be strongest, preferably right after the person confirms that the sound is loud at the time.
- Check the above diagnostic issues that the person hearing the sound should have investigated.
- If the sound is described as very low frequency, measure down to 10 Hz or below.
- Measure narrow bands to look for tones, not just 1/3 or 1/1 octave bands.
- Make audio recordings.
- Measure vibration levels on the room floor and walls if there is no obvious source of a low-level sound.
- Even if no sound source can be detected, sound masking may be a solution. It may be useful to have a portable masking unit that you can test, but if the sound is described as low frequency, the masker must be able to produce low frequencies. Subwoofers have sometimes been necessary to provide good low-frequency masking sounds.

The toughest challenge for the consultant is usually raising the issue of tinnitus. Many people do not want to consider tinnitus as a possible explanation because the sound seems real in every way and because tinnitus implies that they are experiencing something abnormal like “hearing voices.”

The sounds of tinnitus are generally perceived in the same way as regular sounds, and they seem just like any other sound. Tinnitus is a fairly common phenomenon of the auditory system, affecting nearly 50 million Americans. It may or may not explain the sound that the person is hearing, but it is worth considering if the person really wants to solve the problem.

Medical Explanations

Some people are certainly more sensitive to sounds than others. Some medical conditions may affect this. Sensitivity can also increase once a noise problem has arisen and is not addressed.

Hyperacusis is a term used to describe a condition where people are very sensitive to some sounds. These may be only certain types of sounds or only sounds at certain volumes. Like tinnitus, hyperacusis is often, but not always, related to hearing loss. There are different causes and treatments, and an audiologist can provide more information.

Misophonia is similar to hyperacusis. With this condition, people have strong adverse reactions to certain sounds. It is not a medically accepted condition, so there is no official method for diagnosis or treatment.

A useful test is to listen for the objectionable sounds while wearing very good earplugs and noise earmuffs. If the sound is

low frequency, noise-cancelling earmuffs/headphones should be used. If the problem is tinnitus (sound generated within the hearing mechanism), the sound should be audible even with the earmuffs on, and the volume of the sound should not change. If the problem is hyperacusis or misophonia (where the listener is very sensitive to sounds in the environment), the earplugs and earmuffs should significantly reduce the level of the sounds.

The human hearing system is very adept at deciphering sounds. We can pick out specific instruments within an entire orchestra. We can understand speech in a noisy environment. One theory about people who complain about relatively “soft” sounds is that their ear is sensitive to man-made sounds even at low levels. The “unnatural” or annoying characteristic of the noise may be tones, periodic variations, or some other element that makes the sound recognizable even at a very low level.

There are a number of circumstances that can result in people hearing sounds that do not exist outside of the ear including internally generated sound, ear disorders, signals created in the brain, etc. The hearing mechanism is very complex, involving mechanical, chemical, electrical, and neural systems with many possible sources of “apparent” sound that can be indistinguishable from real sounds. The most common set of symptoms is generally referred to as tinnitus.

Tinnitus is often associated with hearing loss and may be a result of the brain dealing with a lack of signals in a range of frequencies. Because hearing loss is normally at high frequencies, so are tinnitus sounds, though they sometimes occur at low frequencies. The sounds may be steady or intermittent, and loud or soft. They would typically be most noticeable in a very quiet location such as a home at night.

The following is a list of medications that can cause or affect the intensity of tinnitus:

- *Aspirin*, and other salicylates
- *Other nonsteroidal anti-inflammatory drugs (NSAIDs)*, including ibuprofen (Advil, Motrin), naproxen (Aleve, Naprosyn), and Relafen
- *Certain “mycin” antibiotics*, including ciprofloxacin (Cipro), doxycycline (Vibramycin, others), gentamicin (Garamycin), erythromycin (Ery-Tab, others), tetracycline (Sumycin), tobramycin (Nebcin), and vancomycin (Vancocin)
- *Antimalarial drugs* such as chloroquine and quinine
- *Certain anticonvulsants*, including carbamazepine (Tegretol, others) and valproic acid (Depakote, others)
- *Certain cancer drugs*, including cisplatin (Platinol) and vincristine (Oncovin, Vincasar)
- *Loop diuretics*, especially when given intravenously, including bumetanide (Bumex), furosemide (Lasix), and torsemide (Demadex)
- *Tricyclic antidepressants* such as amitriptyline (Elavil, others), clomipramine (Anafranil), and imipramine (Tofranil)

There are also recommendations for people with tinnitus to abstain from certain substances:

- Alcohol: Dilates blood vessels, causing greater blood flow, especially in the inner ear
- Salt: Noted in patients with possible endolymphatic hydrops; reduction of intake can also lower blood pressure
- Nicotine: Avoid stimulants in general
- Caffeine: Research has found no evidence that caffeine abstinence alleviates tinnitus, but acute effects of caffeine withdrawal might add to the burden of tinnitus
- Simple sugars, Aspartame and NutraSweet
- MSG

There are a number of approaches to treating people with tinnitus. These include medication, surgery, masking, magnetic stimulation, and counseling (primarily on how to deal with the sound). The following websites have information on tinnitus, and some also have forums where people discuss their situations:

- <http://www.ata.org/>
- <http://www.tinnitustalk.com>
- <http://www.healthboards.com/boards/inner-ear-disorders/>

As with most forums, there is a lot of anecdotal information that might not be scientifically valid, but many participants find the

community of the forum to be helpful.

Summary

When the source of an annoying sound cannot be readily identified, we recommend that the person hearing the sound conduct an initial study to help identify the source or at least narrow the possibilities. This information can then be used by the consultant to assist in the analysis.

Sometimes, a sound source several kilometers away is found to be the source, much to the relief of both the consultant and the person hearing the sound. Measurements of narrow-band sounds and low frequencies, along with an understanding of the timing of when the sound occurs, can help a consultant find sound sources. However, often the sound source cannot be identified or even measured.

Some individuals are possibly just very sensitive to some types of sounds, even at levels that are low and that do not bother most other people. This may be especially true for low-frequency sounds and “unnatural” sounds with tonal, rhythmic, or periodic elements. Hyperacusis and misophonia are terms sometimes used to describe high sensitivity to noise, and it is possible that these noises may even be outside what is considered the “normal” range of hearing. This high sensitivity in a small portion of the population may explain the “hums” heard at different locations around the world that have received press and have not been thoroughly explained. Wind-turbine noise is another example of a sound source with rare adverse effects that are debated by experts.

When a sound cannot be identified or measured, tinnitus should be seriously considered as the source even if the sound does not fit the common descriptions or symptoms of tinnitus. Audiologists can help to assess a person’s hearing and propose treatments.

For low-level sounds that are heard only in quiet rooms, whether from tinnitus (sounds generated within the hearing mechanism) or from environmental sources, sound masking can sometimes be a solution. The system must be designed to produce masking sounds around the same frequency as the sound causing the an-

noyance. Tinnitus may also be an explanation. Sound masking can be beneficial even with tinnitus.

Acknowledgements

Thanks to Molly Adler, Angie Campanella, Ken Cunefare, Edward Dugger, Daniel Fink, Jeff Geiler, Lincoln Gray, Rob Greene, Brenda Lonsbury-Martin, Brian Marston, Jordan Moran, David Nelson, Noral Stewart, Tom Thunder, and Richard Tyler for their contributions.

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