FILE

171

18-488-EL-BGN

EXHIBIT FOR PUBLIC HEARING HELD ON 8/2/19
At Tiffin University Marion Center

Edward Clark	Exhibit 1
Belker	Exhibit 1
Popa	Exhibit 1
Robert Berg	Exhibit 1
Poffenbaugh	Exhibit 1
Seaman	Exhibit 1
Gail Moyer	Exhibit 1
Didion	Exhibit 1
Corran	Exhibit 1
Keith Moyer	Picture
Gail Moyer	Picture

THE OHIO POWER SITING BOARD

IN THE MATTER OF THE APPLICATION OF SENECA WIND FARM, LLC FOR A TO SITE WIND-POWERED ELECTRIC GENERATION FACILITY IN SENECA COUNTY, OHIO.

Case No. 18-488-EL-BGN

* * * * * * * * * * * * * *

PUBLIC HEARING

DATE: Tuesday, July 23, 2019

TIME: 3:00 p.m.

PLACE: Tiffin University Marion Center
235 Miami Street
Tiffin, Ohio 44883

REPORTER: KRISTIE L. BIRCH

CLASSIC REPORTING SERVICE
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Suite 1200
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Ohio | Power Siting Board

Public Hearing

Case number 18-0488-EL-BGN

PLEASE SIGN-IN ONLY IF YOU WISH TO PROVIDE TESTIMONY | **Hearing Date: July 23, 2019**

	Name (Please Print)	Address	
1.	Michael Bertolone	3515 Prospect Ave Cleveland Oh	44115
2.	Michael Curran	6026 County Rd 47, New Riegel	OH 44853
3.	PAUL DVORAK	20016 WILDWOOD, STRONGSVILLE	OH 44149
4.	PATRICK J O'CONNOR	1901 E Shoreland Ave Rocky River	44116
5.	Tom Schock	3941 Fielding Dr, North Olmsted	44070
6.	CASEY DIDION	6040 COUNTY RD 113 BELLEVUE	44811
7.	Jennine Reinhart-Kramer	55 Spring Lane Tiffin, OH	44883
8.	DENNIS SCHREINER	8403 SR 99, SANDUSKY, OH	44870
9.	Jeanette Cope	7685 St Hwy 53N, Upper Sandusky	43351
10.	Jim Schumacher	16094 TR 104 Attica	44807

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Public Hearing

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Name (Please Print)	Address
11. PAUL E JONES	9140 ETR 121 Republic
12. Jim Feasel	1121 E CR 16 Tiffin Oh
13. Gail L Moyer	3040 S. SR. 67 Tiffin, OH
14. Anne Fry	3886 S CR 43 Bloomville, OH
15. Jan Sampson	6305 S. Twp. Rd. 151 Tiffin, OH
16. William Seaman	4584 SR 547 Bellevue ohio
17. WALT POFFENBAUGH	5094 N. GREENFIELD, OH 44890
18. Linda Coffman	6851 S. State Rt 231, Tiffin, OH
19. Robert Berg	800 E. TR. 58 Tiffin OH44883
20. Dorothy Berg	800 E. TR 58 Tiffin, OH44883

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	Name (Please Print)	Address
21.	MARILYN HORNETT	17284 E. TR 104 ATTICA OH 44807
22.	LINDA MORSHER	7355 Twp Rd 81 Bell 44811
23.	~~Patricia Dillon~~	~~4765 Williams Rd Bellevue 4481~~
24.	~~Deb Heckerd~~	7731 E 224 Bloomville 44818
25.	Gene Thompson	265 East CR. 16 44883
26.	Dr. Roy Zinn	4766 SR 231, Tiffin, OH 44883
27.	Joyce Ziegler	7551 S. Twp. Rd. 171 Bloomville Oh.
28.	~~[illegible]~~	
29.	Gary J Lescalleet	3544 E. Co Rd Tiffin Ohio 44883
30.	Julie Meyer	142 Crestview Tiffin 44883

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	Name (Please Print)	Address	
31.	Victoria Ziegler	120 Crestview Dr Tiffin, Ohio	
32.	Mike Ziegler	8240 S. Twp Rd 171 Bloomville Ohio	
33.	~~Becky Wilhelm~~	5410 E CR 16 Tiffin	
34.	Christina Papa	3336 Willoughby Rd Willard OH 44890	
35.	David A Barhan Becker	1334 E Twp Rd 8 Republic 44867	
36.	~~DALE EVERHART~~	2266 W. TWP. RD. 165 TIFFIN 44883	
37.	~~Karen Popenberg~~	10383 W US 224 Alvada, OH 44802	
38.	~~Matt Honeynett~~	7575 E CR 12 Bloomville	
39.	Holly Motil	7545 Knauss Rd., Bloomville, OH 44818	
40.	Robert Manz	225 East Twp Rd 42 Tiffin 44883	

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	Name (Please Print)	Address
41.	~~Fred~~ FRED ZIRGER	2091 S. TWP. RD 113 TIFFIN
42.	Dennis J. ALT	1445 STRYKY Bellevue
43.	~~Jim Donaldson~~	58 Braden Ct; Tiffin OH
44.	JASON SMITH	5514 E. TWP. Rd. 130 REPUBLIC, OHIO 44867
45.	~~MARYHOU BOEHNER~~	8361 N SR 19 GREENSPRINGS OH 44833
46.	~~Kathy Yost~~	3206 S. CoRd 7 Tiffin OH 44883
47.	~~Bill Harper~~	72 Golfview Drive Tiffin
48.	~~Laurie Shellhouse~~	161 & Twp Rd 28 Tiffin
49.	~~Nathan Miller~~	13531 E. CR. 36 Republic
50.	~~Pamela Cramer~~	5108 S Co Rd 43 Tiffin, OH

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Name (Please Print)	Address
51. Darylene M. Dunn	7534 E. Co. Rd. 12 Bloomville
52. Keith Moyer	3040 S. St. Rt. 67 Tiffin
53. ~~Susie Riedlinger~~	~~PO Box 88 3288 St Rt 4 Attica~~
54. ~~Dan Tiell (Deb)~~	~~5243 W. Twp Rd 90 New Riegel~~
55. ~~Cheryl Mira~~	~~11110 St Rt 269, Bellevue, OH~~
56. ~~David G Ziegler~~	~~4894 E. Twp Rd. 58 Bloomville, Oh.~~
57. Lisa Handshoe	6085 E. St. Rt. 18. Republic, Oh
58. Kip Siesel	2412 S. Reynolds Rd. Toledo, OH.
59. Dan White	4080 E. Twp. Rd. 58 Bloomville, OH.
60. Kurt Leax	5251 E CR 16 Tiffin Oh 44883.

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	Name (Please Print)	Address
61.	Beth Walliser	45 Thomas St, Tiffin
62.	Richard Hughes	335 S. Monroe St #180 Box 1012, Tiffin
63.	~~[illegible]~~	~~[illegible]~~
64.	Bryan Stachlin	210 S main St Attica Oh
65.	~~Libby Bessler~~	~~2845 N SR 101 Tiffin~~
66.	~~Mark D Dagnet Deer~~	~~8720 W. Twp Rd 96 New Riegel~~
67.	Ed Clark	3671 S. St. Rte 231 Tiffin
68.	Joe Anderson	9444 E twp RD 124 Republic Oh
69.	~~Jessica Cornett~~	~~6730 N SR 101 Clyde OH~~
70.	~~Dustin Austin AUSTIN~~	~~14281 E CR 46 Bettsville Oh~~

DUSTIN AUSTIN

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Name (Please Print)	Address
71. ~~MARK ANDERSON~~	~~6667 S. Twp Rd 159, Tiffin~~
72. ~~Michael Eversole~~	~~102 Dorchester Sq Westerville~~
73. Chris Zemai	6868 E. Twp. Rd. 138, Republic, OH 44867
74. Tom Schelle	4686 N. Twp Rd 175 Republic OH 44867
75.	
76.	
77.	
78.	
79.	
80.	

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	Name (Please Print)	Address	
81.	Kurt Dunn	1500 E. Co. Rd. 50 Tiffin	
82.	Paula Dunn	1500 E CR 50 Tiffin	
83.			
84.			
85.			
86.			
87.			
88.			
89.			
90.			

Trench is no wider than 15 feet

Edward Clark - Exhibit 1

OSHA FactSheet

4' for egress

5' for shoring

Trenching and Excavation Safety

Trench collapses, or cave-ins, pose the greatest risk to workers' lives. When done safely, trenching operations can reduce worker exposure to other potential hazards include falls, falling loads, hazardous atmospheres, and incidents involving mobile equipment.

OSHA standards require that employers provide workplaces free of recognized hazards. The employer must comply with the trenching and excavation requirements of 29 CFR 1926.651 and 1926.652 or comparable OSHA-approved state plan requirements.

Slope shall not ½ Horz. to 1 Vertical

Trench Safety Measures

Trenches 5 feet (1.5 meters) deep or greater require a protective system unless the excavation is made entirely in stable rock. If less than 5 feet deep, a competent person may determine that a protective system is not required.

Trenches 20 feet (6.1 meters) deep or greater require that the protective system be designed by a registered professional engineer or be based on tabulated data prepared and/or approved by a registered professional engineer in accordance with 1926.652(b) and (c).

Competent Person

OSHA standards require, before any worker entry, that employers have a competent person inspect trenches daily and as conditions change to ensure elimination of excavation hazards. A competent person is an individual who is capable of identifying existing and predictable hazards or working conditions that are hazardous, unsanitary, or dangerous to workers, soil types and protective systems required, and who is authorized to take prompt corrective measures to eliminate these hazards and conditions.

Access and Egress

- Keep heavy equipment away from trench edges.
- Identify other sources that might affect trench stability.
- Keep excavated soil (spoils) and other materials at least 2 feet (0.6 meters) from trench edges.
- Know where underground utilities are located before digging.
- Test for atmospheric hazards such as low oxygen, hazardous fumes and toxic gases when > 4 feet deep.
- Inspect trenches at the start of each shift.
- Inspect trenches following a rainstorm or other water intrusion.
- Do not work under suspended or raised loads and materials.
- Inspect trenches after any occurrence that could have changed conditions in the trench.
- Ensure that personnel wear high visibility or other suitable clothing when exposed to vehicular traffic.

Protective Systems

There are different types of protective systems.

Benching means a method of protecting workers from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels. *Benching cannot be done in Type C soil.*

Sloping involves cutting back the trench wall at an angle inclined away from the excavation.

Shoring requires installing aluminum hydraulic or other types of supports to prevent soil movement and cave-ins.

Shielding protects workers by using trench boxes or other types of supports to prevent soil cave-ins. Designing a protective system can be complex because you must consider many factors: soil classification, depth of cut, water

content of soil, changes caused by weather or climate, surcharge loads (e.g., spoil, other materials to be used in the trench) and other operations in the vicinity.

Additional Information

Visit OSHA's Safety and Health Topics webpage on trenching and excavation at www.osha.gov/trenching.

Workers' Rights

Workers have the right to:

- Working conditions that do not pose a risk of serious harm.
  Receive information and training (in a language and vocabulary the worker understands) about workplace hazards, methods to prevent them, and the OSHA standards that apply to their workplace.
- Review records of work-related injuries and illnesses.
- File a complaint asking OSHA to inspect their workplace if they believe there is a serious hazard or that their employer is not following OSHA's rules. OSHA will keep all identities confidential.
- Exercise their rights under the law without retaliation, including reporting an injury or raising health and safety concerns with their employer or OSHA. If a worker has been retaliated against for using their rights, they must file a complaint with OSHA as soon as possible, but no later than 30 days.

For additional information, see OSHA's Workers page (www.osha.gov/workers).

How to Contact OSHA

Under the Occupational Safety and Health Act of 1970, employers are responsible for providing safe and healthful workplaces for their employees. OSHA's role is to help ensure these conditions for America's working men and women by setting and enforcing standards, and providing training, education and assistance. For more information, visit www.osha.gov or call OSHA at 1-800-321-OSHA (6742), TTY 1-877-889-5627.

This is one in a series of informational fact sheets highlighting OSHA programs, policies or standards. It does not impose any new compliance requirements. For a comprehensive list of compliance requirements of OSHA standards or regulations, refer to Title 29 of the Code of Federal Regulations. This information will be made available to sensory-impaired individuals upon request. The voice phone is (202) 693-1999; teletypewriter (TTY) number: (877) 889-5627.

U.S. Department of Labor

OSHA® Occupational Safety and Health Administration

DOC FS-3476 09/2011

T&D WORLD MAGAZINE

INTELLIGENT UNDERGROUNDING

Underground Cables Need a Proper Burial

Deepak Parmar and Jan Steinmanis, Geotherm Inc. | Apr 01, 2003

Overhead systems are out in the open, so it is easy to detect and fix design and installation problems. Underground problems, however, are out of sight and out of

Here's a brief example. A wind-generating farm was installed with underground cables tied directly to a main feeder cable. Unfortunately, the cables were simply placed in a trench using native soil backfill with minimal soil compaction. Ampacity calculations were performed using typical soil values, but thermal properties were not measured. Since wind turbines operate almost continuously, the feeder cable often ran at maximum capacity. The heat generated from the feeder cable dried out the surrounding soil completely. Because the native soil was poorly compacted fine silt, it acted like an insulating blanket and the cable failed prematurely.

A significant source of potential problems with underground circuits is the improper selection and installation of thermal backfill materials. To prevent premature failures, you must ensure you place cable systems in a hospitable environment.

Too few utilities have stringent specifications or quality-assurance programs for installing cable-trench backfill; this often leaves the decision up to the civil contractor. The effects of poorly installed thermal backfills and soils may not be evident for many years, until cable loads increase and temperatures rise beyond allowable levels, resulting in cable failures. The remedial cost of removing and replacing poor backfills is high, especially under paved roads. The loss of revenues from derating a system may be even higher. Installing a new circuit may be the only, albeit expensive, option.

Importance of Soil and Backfill

All the heat generated by an underground power cable must be dissipated through the soil. This is quantified by the soil thermal resistivity (or thermal rho, °C-cm/W), which can vary from 30 to 500°C-cm/W. Electrical engineers understand the performance of the cable quite well, but to most, the soil behavior is a mystery, usually handled by using a thermal backfill with a supposedly "safe" thermal rho.

The ability of the surrounding soil to transfer the heat determines whether an operating cable remains cool or overheats. Improving the external thermal environment and accurately defining the soil and backfill thermal rho commonly results in a 10% to 15% increase in cable ampacity, with 30% improvements noted in some cases.

You can address potential problems by measuring the native soil's thermal properties and by using properly designed and installed corrective thermal backfills in the cable trench. In recent years, we've learned that using thermal probes connected to a Thermal Property Analyzer (EPRI EL-2128) can accurately measure the thermal rho in the field and laboratory.

The use of a soil thermal rho of 90°C-cm/W has become ingrained in cable engineering practices. Soil studies performed in the 1950s found this was a "safe" value for most moist soils. This value is commonly used for distribution cables, where cable loads are usually low and the native soil is used as the backfill. For transmission cables, it is assumed that the "thermal backfill" placed around the cables will be much better than the native soil and that it will have a thermal rho of less than 90°C-cm/W.

Thermal Backfills

Most moist soils (with the exception of organic clays and silts, volcanic soils, peat and fills with ash and slag) have a rho of less than 90°C-cm/W. Moist sands, which are commonly placed around transmission cables, may even have a rho of less than 50°C-cm/W.

The critical word is "moist." Many soils, especially uniform sands, can dry substantially when subjected to heat from the cables. The thermal rho of a dry soil would exceed 150°C-cm/W, and possibly approach 300°C-cm/W for a dry uniform sand. (The dry thermal rho of a properly designed and installed thermal backfill should be less than 100°C-cm/W and possibly as low as 75°C-cm/W).

In fact, a contractor, if left to his or her own devices, most likely would use readily available fine sand or concrete sand as the backfill. From a construction viewpoint, this sand makes an inexpensive and excellent bedding material, but thermally, it is very poor because it dries out easily under high cable loads.

Unfortunately, over the years utilities have used many unsuitable sands or "thermal backfills" because of ease of installation and availability. Several route thermal surveys of existing circuits installed before 1980 confirm this practice. Almost any sand, when moist, will give a reasonably low thermal rho. The crucial aspect is how easily it dries when subjected to cable heat loads.

Soils in semi-arid climates are naturally quite dry, so the assumption of a moist soil is not valid. It doesn't take much to dry these soils completely. In many parts of the

higher ambient temperatures, and if in the vicinity of other cables, will experience mutual heating and run hotter.

The thermal rho is important not only for transmission cables but also in any situation resulting in high heat generation. The assumption of a soil and backfill thermal rho of 90°C-cm/W may be erroneous, possibly leading to long-term problems when the cable is heavily loaded.

Poorly compacted trench backfill is a major problem. Not only is the thermal rho of uncompacted soil significantly higher, but the loose soil will dry more easily, which increases the possibility of thermal runaway.

Corrective Thermal Backfills

Generally, native soils do not make good thermal backfills because their thermal rho values are poor, or they are difficult to properly re-compact in a cable trench. There are also problems associated with stockpiling, screening of debris, and contamination of good soil with organic topsoil. In the long run, the operational reliability gained by placing a classified thermal backfill around the cable has

to fine gravel can be a good thermal backfill when compacted to its maximum density as determined by a laboratory standard Proctor test (ASTM D698). The total cost of a compacted backfill must include material and transportation costs, as well as installation labor and quality-assurance costs.

The one often-neglected factor about compacted backfills is the need for quality assurance during installation. If the gradation of the backfill is not correct (sieve analysis ASTM D422), or it is not at the optimum moisture content (ASTM D698), or not enough compaction effort is applied, or the backfill lifts are too thick, then the maximum density will not be achieved and the thermal capability degraded.

Cement stabilized sand frequently has been used as a cable trench backfill in many countries. A typical mix design consists of 14 parts sand to one part cement, mixed with about 8% water. If the correct sand is used and properly installed, this material can have acceptable thermal performance. However, this backfill is quite strong and thus would be difficult to excavate. Quality control is required during mixing and installation, otherwise the thermal performance cannot be assured.

Many North American utilities have been using stone dust or crushed stone screenings as thermal backfill. If well graded and of the right mineral type, it provides a low and stable thermal resistivity when compacted at optimum moisture content and density. It does require thorough testing to establish density, moisture and thermal performance, and a good quality-control program to ensure proper installation.

With compacted soils, maximum soil density is needed in the restricted trench areas near cables or around cable pipe groups where proper compaction is difficult. Yet, it is precisely in these zones adjacent to the cables, where the heat flux is highest, that suitable compaction is most important to ensure maximum heat

backfills (FTB), which are formulated to meet thermal resistivity, thermal stability, strength and flow criteria. This free-flowing, controlled-density fill is ideal for hard-to-access areas, such as narrow trenches, small diameter tunnels or areas congested with many underground services — basically where mechanical compaction is not feasible or practical. While the material cost of FTB may be higher, it should be considered for general usage because of its assured quality and quick installation, thus speeding up construction and decreasing overall costs, which are important factors when working in busy city streets.

FTB is a slurry backfill consisting of medium aggregate, sand, a small amount of cement, water and a fluidizing agent. FTBs can be formulated using locally available aggregates. The component proportions are chosen by laboratory testing of trial mixes to minimize thermal resistivity and maximize flow without segregating the components.

Be wary of commonly available "controlled density fills," "flowable fills" or "slurry backfills," which use large volumes of fly ash or sand. These may meet the mechanical and flow requirements for trench backfilling, but too often they provide totally unsuitable thermal performance. Fluidized thermal backfills should be formulated and tested only by soil thermal specialists who understand the tricks of the trade in making thermal measurements.

Fluidized thermal backfills do not have to be compacted; they flow in a fashion similar to concrete. In fact, FTB is typically supplied from concrete trucks, and may be poured or pumped, and seldom requires any special shoring or bulkheading. It solidifies to a uniform density by consolidation, with excess water seeping to the top. Regular FTB can be pumped up to 150 m (500 ft) using conventional concrete pumping equipment and greater distances with special modifications. It hardens quickly so that the ground surface may be reinstated the next day, but the low

Future settlements are negligible. It also affords mechanical protection for the cables or cable pipes and provides support for underground and surface facilities (road pavement). FTB has good heat dissipation properties even when totally dry. Depending on the mix design, typical thermal rhos are 35 to 40°C-cm/W wet, and 70 to 100°C-cm/W dry, with excellent thermal stability. The FTB can be formulated for use in both flat and hilly terrain. Thicker, slower flowing mixes can be formulated when addressing an area with a significant slope.

Backfills ... The Right Way

The use of a well-designed thermal backfill can enhance the heat dissipation and increase the allowable ampacity of an underground power cable, as well as alleviating thermal instability concerns. The corrective backfill will reduce the heat flux experienced by the native soil so that it will not dry out; therefore, the stability of the native soil is no longer a concern. A good backfill should be better able to resist total drying and also have a low dry thermal rho if it is completely dried. It should be available at a reasonable cost, and be easy to install and easy to remove if required. The thermal backfill must be laboratory evaluated and include specifications for mineral quality, gradation (sieve analysis), thermal dryout curve and optimum density. Typically, the entire trench width is filled with thermal backfill to a minimum height of 300 mm (12 inches) above the cables. For poor native soil conditions or heavily loaded cables, the thickness of the backfill can be increased to maintain a low composite thermal rho. A fluidized thermal backfill is the ideal way of providing a high-quality cable backfill.

Dennis Parman is president of Geotherm Inc. From 1968 to 1978, he worked on

He is a member of the Engineering Institute of Canada, Canadian Society for Civil Engineers, Canadian Geotechnical Society, Canadian Society for Electrical and Computer Engineers, Tunneling Association of Canada, IEEE/PES/ICC, Canadian Electrical Association and CIGR....

Jan Steinmanis is vice president of Geotherm Inc. He received a B.A.Sc. degree in civil engineering from the University of Toronto, Canada, in 1975. From 1976 to 1982, Steinmanis worked as a research engineer with Ontario Hydro, where he worked on several civil engineering projects and on the Electric Power Research Institute (EPRI)-funded projects for the Development of Thermal Property Analyzer. He also conducted several research projects, including the soil geotechnical-thermal properties database for Canada (a Canadian government-funded project). He is a registered professional engineer.

Elements of a Cable Route Thermal Survey

- Perform in-situ thermal rho testing and sampling of the native soils. This may be done in conjunction with any required geotechnical testing, such as for manholes. Review any available soils information so test locations cover all the soil types.
- In the laboratory, perform thermal dryout tests (thermal rho vs. soil moisture) on select samples. This will define the thermal rho for drier soil conditions.
- Source and design the fluidized thermal backfill (or compacted granular backfill) based on locally available materials. This also will include a thermal dryout curve.
- Choose the design thermal rho values for the native soil and thermal backfill based on the lowest expected soil moistures.
- Use a computer cable design program to optimize configuration of cables,

Soil Components	
Description	**Thermal Resistivity Dry (°C-cm/W)**
Soil Grains	
Quartz	12
Granite	30
Limestone	40
Sandstone	50
Shale (sound)	60
Shale (highly friable)	200
Mica	170
Others	
Ice	45
Water	165
Organics	500
Oil (petroleum)	800
Air	4500

Thermal Stability

Thermal stability describes the ability of a moist soil to maintain a relatively constant thermal rho when subjected to a cable heat load, thus preventing a power cable from exceeding its safe operating temperature. Thermal instability (or "thermal runaway") occurs when a soil is unable to sustain the heat from a cable. The soil progressively dries, resulting in a substantial increase in the thermal rho and attendant increase in the cable-operating temperature. If soil moisture is not replenished or current reduced, the ultimate result may be a totally dry thermal rho and cable failure caused by overheating.

Visually, thermal runaway can be described on a thermal dryout curve. At high moistures, the curve is relatively flat, so any minor drying of the soil will not change the thermal rho very much (thermally stable). Excessive cable heat will dry the soil below the knee of the curve (critical moisture), and the thermal rho will increase significantly. This will cause the cable to get hotter, thus drying the soil

backfill around the cable. The thermal dryout curve of a good backfill has a sharp knee at a low critical moisture content and the totally dry thermal rho is quite low. For these backfills the thermal stability may be treated as a binary concept, that is, if the lowest expected moisture is above the critical moisture content then the backfill is stable for normal heat rates and the moist thermal rho may be used in ampacity calculations. If the lowest expected moisture is below the critical moisture then the backfill is unstable and the totally dry thermal rho must be used for the design. For FTB, the totally dry thermal rho is usually less than 90°C-cm/W, so it is still quite acceptable. By using a sufficiently large thermal backfill envelope, the heat flux through the native soil will be quite low; therefore, the native soil will not dry out, and the stability of the native soil is not a concern.

1 COMMENT

RELATED

Manhole Safety
JUL 18, 2019

LADWP Announces Year-Long Power Upgrade Project
JUN 25, 2019

It's Time for Utilities to Reconsider Undergrounding Power Lines
JUN 11, 2019

As Paradise Rebuild Begins, PG&E Commits to Underground Power Lines
MAY 29, 2019

Directives / Inspection Procedures for Enforcing the Excavation Standard, 29 CFR 1926, Subpart P

- **Record Type:** OSHA Instruction
  Current Directive
- **Number:** CPL 02-00-087
  Old Directive
- **Number:** CPL 2.87
- **Title:** Inspection Procedures for Enforcing the Excavation Standard, 29 CFR 1926, Subpart P
- **Information Date:** 02/20/1990
- **Standard Number:** 1926 Subpart P ; 1926.650 ; 1926.651 ; 1926.652

OSHA Instruction CPL 2.87 FEB 20, 1990 Directorate of Compliance Programs

SUBJECT: Inspection Procedures for Enforcing the Excavation Standards - 29 CFR 1926, Subpart P.

A. Purpose. This instruction establishes inspection procedures and provides clarification to ensure uniform enforcement of the Excavation Standards.

B. Scope. This instruction applies OSHA-wide.

C. References.

1. Construction Safety and Health Standards, Subpart P., 29 CFR 1926.650, 651, and 652.

2. OSHA Instruction CPL 2.45B, June 15, 1989, the Revised Field Operations Manual (FOM).

3. OSHA Instruction CPL 2.34, September 1, 1979, the Construction SAVEs Manual.

D. Cancellation. OSHA Instruction STD 3-14.1, October 30, 1978, Citation Policy - Specific Trenching Requirements, is canceled.

E. Action. Regional Administrators and Area Directors shall ensure that the guidelines in this instruction are followed and that compliance officers are familiar with the contents of the standard.

F. Federal Program Change. This instruction describes a Federal program change which affects State programs. Each Regional Administrator shall:

1. Ensure that this change is forwarded to each State designee.

2. Explain the technical content of the change to the State designee as requested.

3. Ensure that State designees acknowledge receipt of this Federal program change in writing, within 30 days of notification, to the Regional Administrator. This acknowledgment should include the State's intention to follow the inspection guidelines described in this instruction, or a description of the State's alternate guidelines which are "at least as effective as" the Federal guidelines.

a. If a State intends to follow the revised inspection guidelines described in this instruction, the State must submit either a revised version of this instruction, adapted as appropriate to reference State law, regulations and administrative structure, or a cover sheet describing how references in this instruction correspond to the State's structure. The State's acknowledgment letter may fulfill the plan supplement requirement if the appropriate documentation is provided.

b. Any alternative State inspection guidelines must be submitted as a State plan supplement within 60 days. If the State adopts an alternative to Federal inspection guidelines, the State's submission must identify and provide a rationale for all substantial differences from Federal guidelines in order for OSHA to judge whether a different State guideline is as effective as a comparable Federal guideline.

4. After Regional review of the State plan supplement and resolution of any comments thereon, forward the State submission to the National Office in accordance with established procedures. The Regional Administrator shall provide a judgment on the relative effectiveness of each substantial difference in the State plan change and an overall assessment thereon with a recommendation for approval or disapproval by the Assistant Secretary.

5. Review policies, instructions and guidelines issued by the State to determine that this change has been communicated to State personnel.

G. Background. The Occupational Safety and Health Administration after 15 years of experience involving the adopted Federal standards for covered employees in the construction industry (36 CFR 25232 December 30, 1971) issued revised rules for Subpart P. to 29 CFR 1926 (54 CFR 45894 October 31, 1989).

1. These rules have been reviewed by the Advisory Committee on Construction Safety and Health (ACCOSH) and many of the changes reflect their recommendations and those of other interested parties.

2. On April 15, 1987, OSHA issued a notice of proposed rulemaking on excavations (52 FR 12288). After an extensive comment period and public hearings, the hearing transcript and related submissions were certified and closed on December 15, 1988

3. The final rule resolves many issues raised in earlier attempts to regulate this activity within the construction industry. Many of these issues involved previous decisions under the existing standard.

a. It is the intent of this rule to establish one set of requirements which are applicable to all excavations, including trenches.

b. Where compliance requirements are intended to be applicable only to trenches, the final rule makes it clear that these requirements apply only to those excavations which are also trenches.

4. So that ongoing guidance may be provided, enforcement problems, including misinterpretations or other difficulties being experienced by employers and apparent efforts by employers to circumvent the standard, shall be promptly reported to the Office of Construction and Maritime Compliance Assistance.

H. Inspection Guidelines (Compliance Procedures).

1. Excavation Protection Programs. This standard provides requirements which allow employers flexibility in developing programs that provide effective protection for employees working in excavations. In addition to the standard itself, the preamble provides further guidance and rationale for changes in the existing standard.

2. Program Compliance. During all inspections at construction sites, where excavation standards are or will be applicable, compliance personnel shall ensure that compliance with 29 CFR 1926, Subpart P, Excavations, is in accordance with the FOM, Chapter III, D.7 and D.8.

a. This review shall include any documentation by employers of the methodology and background information used to determine whether shoring systems are required and the type of systems used.

b. The compliance safety and health officer (CSHO) shall evaluate the employer's compliance with the specific requirements of the standard.

3. CSHO Responsibilities. The following procedural guidance provides a general framework that is designed to assist the CSHO with all inspections:

a. Ask the employer for the basis on which the employee excavation protection program related to the standard was developed.

b. Interview a representative cross-section of affected employees to verify the employer's program. This shall include an evaluation of the training of affected employees and the effectiveness of the employer's enforcement of its program. (See 29 CFR 1926.20(b)(1) and 1926.21(b)(2) .)

c. Evaluate compliance with requirements for periodic inspection of excavations. (See 29 CFR 1926.651 (k) (1).)

d. Identify all persons (competent person, registered professional engineer, etc.) responsible for excavation activities and/or operations.

e. Evaluate compliance with training requirements identified by periodic inspections or changes in equipment and/or procedures. This shall include an evaluation of the effectiveness of the employer's inspection procedures and training program for assessment and correction of situations resulting in near misses and/or injuries or circumstances indicating that modifications are necessary. (See 29 CFR 1926.20(b)(1) and 1926.21(b) (2).)

4. Specific Excavation Requirements.

a. Scope and Application. This subpart applies to all open excavations made in the earth's surface. Excavations are defined to include trenches. All trenches are excavations; all excavations are not trenches. (See 29 CFR 1926.650(a).)

NOTE: If installed form work or other similar obstructions reduce the depth-to-width dimensions for a particular excavation, it may become a trench as defined later in the specific requirements of this instruction.

b. Definitions. The definitions contained in the excavation standard shall be relied upon to interpret and apply the standard properly. In some cases terms within a definition are themselves defined within the same section.

(1) Accepted Engineering Practices. CSHOs shall verify with the employer which aspects of the employee protection system have been designed or approved by a registered professional engineer. The name of such individual or, if a firm, the firm's name, the name of the engineer of record that approved the work for the firm, and the registration number shall be recorded.

(a) Field offices may review any work which must be certified as to the status of such certification with the State Board of Certification and Registration for Professional Engineers and Land Surveyors in their respective States.

(b) Verification shall also be made for all other aspects of the onsite excavation conditions which the employer indicates are under the direct supervision of a registered professional engineer.

1 All inquiries relating to the adequacy of the engineering design shall be referred to the Regional Office of Technical Support (ARA-TS).

2 In appropriate cases, the Regional Office may refer deficient or inadequate engineering designs of protective systems to the State Board of Certification and Registration for professional Engineers.

(c) Any equipment, shoring devices, shields or other special aspects of an employer's excavation program in which the compliance investigation reveals the use of a Registered Professional Engineer shall be so noted on OSHA 1-B during the onsite investigation. If such devices, shields or other special aspects of the employer's program do not comply with the requirements of the standard, appropriate citations shall be issued.

(2) Competent Person. CSHOs shall pay particular attention to the investigation and documentation of data to establish that any person serving in this capacity possesses the capability of identifying existing and potential hazards for workers.

(a) To be a "competent person" under this standard, a person must have had training in, and be knowledgeable about, soils analysis, the use of protective systems and the requirements of this standard.

(b) The competent person having such training and knowledge must be capable of identifying existing and predictable hazards in excavation work and have the authority to take prompt measures to abate these hazards. Thus, a backhoe operator who would otherwise meet the requirements of the definition is not a competent person if the person lacks the authority to take prompt corrective

measures to eliminate existing or potential hazards.

(3) Hazardous Atmospheres. The CSHO shall check for hazardous or oxygen deficient atmospheres. For example, these include irritating atmospheres which could be encountered in areas close to a landfill, where it is not uncommon to encounter hydrogen sulfide H(2)S.

(4) Registered Professional Engineer. The CSHO shall determine that the Registered Professional Engineer of record is in fact working within a discipline applicable to the excavation work; i.e., it would be inappropriate for an electrical engineer to approve shoring design for an excavation. See also the definition for acceptable engineering practices in this instruction.

(5) Tabulated Data. The CSHO shall examine and ensure that all tabulated data for protective systems are approved by a Registered Professional Engineer.

NOTE: The use of tabulated data appearing in the appendices to this standard is excluded from this requirement.

c. General Requirements.

(1) Surface Encumbrances. The standard requires that all surface encumbrances that are located so as to create a hazard to employees shall have been removed or supported, as necessary, to safeguard employees. The requirement is the same as the existing 1926.651(b) and applies to all employees at the construction worksite. (See 29 CFR 1926.651 (a).)

(2) Underground Installations. The estimated location of utility installations, such as sewer, telephone, fuel, electric, and water lines, or any other underground installations that reasonably may be expected to be encountered during excavation work, shall have been determined prior to opening an excavation.

(a) Utility companies or owners shall have been contacted, advised of the proposed work, and asked to establish the location of the utility underground installations prior to the start of actual excavation.

1 An employer need not contact utility companies where the excavation work is to be performed in a remote location where no underground installations are likely to be encountered and there are no features which would indicate the presence of underground installations.

2 When utility companies or owners cannot respond to a request to locate underground utility installations within 24 hours (unless a longer period is required by State or local law) or cannot establish the exact location of these installations, the employer may proceed, provided the employer does so with caution, and detection equipment or other acceptable means of locating utility installations are used.

3 The employer is required, while the excavation is open, to ensure that underground installations are protected, supported, or removed to safeguard employees from hazards. (See 29 CFR 1926.651 (b) (2) and (3).)

(b) The CSHO shall ascertain whether the employer has contacted the appropriate utility companies to establish the location of underground installations that may be encountered.

NOTE: Many States require the "one call system" prior to the start of excavation work. (See 29 CFR 1926.651(b)(2).)

(c) When excavation operations approach the estimated location of underground installations, the exact location of the underground installation shall be determined by means that are safe to employees. (See 29 CFR 1926.651 (b)(3).)

(d) The CSHO shall determine that underground installations have been protected, supported or removed as necessary to protect employees. (See 29 CFR 1926.651 (b)(4).)

(e) The sloped end of a trench, e.g., an earth ramp, may be considered a safe means of egress on

1 The CSHO shall consider such factors as the degree of the slope, depth of the excavation, soil and environmental conditions, and the presence of any obstructions in determining whether or not the earth ramp can be used for safe egress.

2 An employer may not use knotted rope lines to assist employees using sloped areas as access to trenches.

3 OSHA does not consider lifting equipment as "an other safe means of egress." For example, employees riding in a backhoe bucket to either enter or exit trench excavations, is not "other safe means of egress" for purposes of the standard. (See 29 CFR 1926 651(c)(2) and 54 FR 45918 (Oct. 31, 1989)).

(f) The prohibition against employees being under loads handled by lifting or digging equipment includes both excavated materials and slung loads (pipe, etc.). (See 29 CFR 1926.651(e).)

(g) The CSHO shall ensure that an adequate warning system has been provided for mobile equipment operating adjacent to or without a clear view of the edge of excavations.

NOTE: This requirement does not apply to equipment used to push spoil back into the excavation for backfilling. (See 29 CFR 1926.651(f).)

(3) Hazardous Atmospheres. In addition to the requirements set forth in Subparts D and E of this part (29 CFR 1926.50 -- 1926.107), to prevent exposure to harmful levels of atmospheric contaminants and to ensure acceptable atmospheric conditions, the following additional requirements apply: (See 29 CFR 1926.651(g).)

(a) Air quality tests shall be taken before employees enter excavations more than 4 feet in depth when a hazardous atmosphere exists or could be expected to exist.

(b) Tests shall be conducted as often as necessary to ensure the quality and quantity of the atmosphere. This includes checks for flammable gases and oxygen O(2) deficiency.

(c) Where hazardous atmospheres exist or may reasonably be expected to exist, emergency rescue equipment must be on the worksite and readily accessible to employees. (See 29 CFR 1926.651(g)(2)(i)).

(d) Daily inspections must be conducted by a competent person. Evidence of the lack of such

inspections may include indication of failure of protective systems or employees exposed to hazardous atmospheres. (See 29 CFR 1926.651(k)(1) and (2).)

d. Requirements for Protective Systems.

(1) When the employer has elected to protect employees by sloping, 1926.652 (b)(1) requires that the slope be not steeper than 1.5H:1V "unless the employer uses one of the other options ..."

(a) In a contested case proceeding once OSHA shows that no support system was used and that the sides of the excavation were steeper than 1.5H:1V, the employer has the burden of showing its compliance with one of the other sloping options.

(b) The CSHO, however, shall document all relevant facts to evaluate the hazard to obtain information which may be necessary for rebuttal of the employer's case.

(2) If the CSHO observes that a protective system appears inadequate or in danger of failure, the employer's representative or competent person shall be notified immediately so as to remove any employees in the excavation until such danger of failure has been abated. (See 29 CFR 1926.652 (a)(2).)

(3) In evaluating the design of sloping and benching systems, the CSHO shall refer to the decision chart found in Figure 2 of Appendix F, Selection of Protective System. (See 1926.652(b)(1) through (b)(4).)

(4) In evaluating the design of support systems, shield systems and their protective systems, the CSHO shall refer to the decision chart found in Figure 3 of Appendix F, Selection of Protection Systems. (See 29 CFR 1926.652(c)(1) through (c)(4).)

(5) The CSHO shall examine appropriate structural members of any protective system for damage or defects. (See 29 CFR 1926.652(d)(1).)

(6) Observation by CSHOs of excavations beneath the protective system requires confirmation that the support system was designed to resist forces calculated for the full depth of the trench. (See 29 CFR 1926.652 (e)(2)(i) and (g)(2).)

e. Appendices in the Standard.

(1) The following compliance guidelines apply whenever CSHOs encounter, excavation operations where employers have elected to provide protective systems using the appendices in this standard. CSHOs shall provide documentation, including soil tests where applicable, to support or reject the employer's decisions on protective systems.

(2) When the employer elects to use sloping option 2 or support option 1, the soils classification procedures are mandatory. Employer guesses or other shortcuts taken in classifying soils do not meet the intent of the standard.

(a) Thus, citations shall be issued where one or more provisions of Appendix A have been violated even if the degree of sloping turns out to be appropriate.

(b) Example: A backhoe operator slopes an excavation at what turns out to be an appropriate slope, but the operator is not a competent person within the meaning of the standard, and his determination was not based on both one visual and one manual test. 1926.652(a) will be cited, but the gravity of the violation will be reduced. (See 29 CFR 1926.652(a) (1) .)

f. Appendix A to Subpart P - Soil Classification. This appendix describes a method of classifying soil and rock deposits based on site and environmental conditions and on the structure and compaction of earth deposits. Appendix A contains further definition directly related to soil classification.

(1) The classification of soil and rock deposits shall be made based on the results of at least one visual and one manual test.

(a) Such analysis shall be conducted by a competent person using the tests described in paragraph (d) of this appendix.

(b) The specific soil tests referenced in this Appendix are given as examples for an employer to use in making a soil classification. However, other recognized methods of soil classification and testing, such or those adopted by the American Society for Testing Materials (ASTM) , are acceptable for purposes of compliance with the standard.

(c) The competent person conducting the soil classification may not base a classification by "feeling" the strength or composition of the soil through the use of heavy equipment.

1 This method is not an acceptable "other recognized method" of soil classification and testing" contemplated by Appendix A, (c) (2).

2 OSHA believes this is too indirect a method to classify properly the qualitative as well as the quantitative properties of soil.

3 For example, an employer may not classify the soil as Type A solely because its backhoe experienced difficulty digging the excavation.

(2) Each soil and rock deposit shall have been classified by a competent person as either stable rock, Type A, Type B, or Type C in accordance with the definitions set forth in paragraph (b) of Appendix A.

(3) In a layered system, the system shall have been classified in accordance with its weakest layer. However, each layer may be classified individually where a more stable layer lies under a less stable layer.

(4) If, after classifying soils and rock deposits, the properties, factors, or conditions affecting its classification change in any manner, such as after a rainstorm, such changes shall have been evaluated by the competent person on site. The soil and rock deposits shall have been reclassified as necessary to reflect any changed circumstances.

g. Appendix B to Subpart P - Sloping and Benching. Under section (c)(3)(ii) of this Appendix, whenever surcharge loads from stored material or equipment, operating equipment, or traffic are to be present, the competent person's determination of the degree to which the actual slope must be reduced below the maximum allowable slope shall have been based on the requirements set forth in (c) (3) (ii). The requirement to slope back in accordance with (c) (3) (ii) shall be triggered in situations

where the surcharge loads cause signs of distress.

h. Appendix C to Subpart P - Tables. The compliance officer should note that Tables C-1.1-1.3 are actual size measurements based on mixed oak or equivalent with a bending strength not less than 850 psi. On the other hand, Tables C-2.1, 2.2 and 2.3 are nominal (S4S-Surface 4 Sides) measurements based on Douglas fir or equivalent with a bending strength not less than 1500 psi.

i. Appendix D to Subpart P - Aluminum Hydraulic Shoring for Trenches. This appendix contains criteria that can be used when aluminum hydraulic shoring is to be used as a method of protection in trenches not exceeding 20 feet in depth, in the absence of manufacturer's tabulated data. The appendix is provided for those situations where manufacturers' data, permitted under paragraph 1926.652(c) (2), has been lost or is otherwise not available. When referenced, Appendix D must be used in conjunction with Appendix A, Soil Classification.

I. Training. Field inspection procedures must be modified to reflect the more technical nature of soils classification and protection systems requirements of the new standard. To classify soils properly, visual and manual tests must now be performed. It is imperative that CSHOs be trained in the techniques used in these tests. The training program will consist of detailed instructions on the new standard and the compliance directive.

1. Train-the-trainer sessions on the new standard will be conducted at the OSHA Training Institute. These trainers will then conduct sessions for their respective Regional and Area Offices.

2. This program will supplement OSHA Training Institute Course 301, Excavation, Trenching and Soils. Additional training will be developed and presented as needed to maintain currency of the new excavation standard for CSHOs.

J. SAVEs. Existing SAVEs for 29 CFR 1926.651 and 1926.652 as found in the existing Construction SAVEs Manual, OSHA Instruction CPL 2.34, shall not be used for citation of excavation or trenching violations after March 5, 1990. The attached draft SAVEs are provided for interim use and may be modified, as deemed appropriate, at the discretion of the Regional Administrator, to accommodate local circumstances, until the final SAVEs are published and distributed.

Gerard F. Scannell Assistant Secretary

Distribution: National, Regional, and Area offices, All Compliance Officers, State Plan Designees, Consultation Project Managers NIOSH Regional Program Directors

DRAFT SAVEs

1 29 CFR 1926.651(a): All surface encumbrances that were located so as to create a hazard to employees were not removed or supported, as necessary, to safeguard employees:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY)

2 29 CFR 1926.651(b)(1): The estimated location of underground utility installations, such as sewer, telephone,

fuel, electric, water lines, or any other underground installations that reasonably may be expected to be encountered during excavation work, were not determined prior to opening an excavation:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY AND WHAT UTILITY WAS ENCOUNTERED DURING EXCAVATING OPERATIONS)

3 29 CFR 1926,651(b)(2): Utility companies or owners were not contacted within established or customary local response times, advised of the proposed work, and asked to establish the location of the utility underground installations prior to the start of an actual excavation:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY)

4 29 CFR 1926 651(b)(3): When excavation operations approached the estimated location of underground installations, the exact location of the installations was not determined by safe and acceptable means:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY AND WHAT SHOULD HAVE BEEN A SAFE AND ACCEPTABLE MEANS TO FIND THE UNDERGROUND UTILITY)

A-1

1 29 CFR 1926.651(b) (4): While the excavation was opened, underground installations were not protected, supported or removed as necessary to safeguard employees:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY AND WHAT SHOULD HAVE BEEN PROVIDED TO SAFEGUARD THE EMPLOYEES)

OPTION 1

2 29 CFR 1926.651(c)(1)(i): Structural ramps that were used solely by employees as a means of access or egress from excavations were not designed by a competent person:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY AND WHAT THE RAMP(S) WERE BEING USED FOR BY THE EMPLOYEES)

OPTION 2

3 29 CFR 1926.651(c)(1)(i): Structural ramps used for access or egress of equipment were not designed by a competent person qualified in structural design:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY AND THE COMPETENT PERSON'S LACK OF QUALIFICATIONS IN STRUCTURAL DESIGNS)

OPTION 3

4 29 CFR 1926.651(c)(1)(i): Structural ramps used for access or egress by employees were not constructed in accordance with the design:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY AND WHY THE RAMPS DID NOT MEET THE DESIGN)

A-2

1 29 CFR 1926.651(c)(1)(ii): Ramps and runways constructed of two or more structural members did not have the structural members connected together to prevent displacement:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY)

2 29 CFR 1926.651(c)(1)(iii) Structural members used for ramps and runways were not of uniform thickness:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY)

OPTION 1

3 29 CFR 1926.651(c)(1)(iv): Cleats or other appropriate means used to connect runway structural members were not attached to the bottom of the runway:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY AND WHAT MEANS WAS USED TO CONNECT THE MEMBERS TOGETHER)

OPTION 2

4 29 CFR 1926.651(c)(1)(iv): Cleats or other appropriate means used to connect runway structural members were not attached in such a manner to prevent tripping:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY AND HOW STRUCTURAL MEMBERS WERE CONNECTED TO CAUSE A TRIPPING HAZARD)

A-3

1 29 CFR 1926.651(c)(1)(v): Structural ramps used in lieu of steps were not provided with cleats or other surface treatments on the top surface to prevent slipping:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY AND WHAT IF ANYTHING WAS PROVIDED ON THE RAMP SURFACE)

2 29 CFR 1926.651(c)(2): A stairway, ladder, ramp or other safe means of egress was not located in trench excavations that were 4 feet (1.22m) or more in depth so as to require no more than 25 feet (7.62m) of lateral travel for employees:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY, MEASUREMENTS AS NEEDED, AND WHAT IF ANYTHING WAS PROVIDED)

OPTION 1

3 29 CFR 1926.651(d): Employees exposed to public vehicular traffic were not provided with a warning vest or other suitable garments marked with or made of reflectorized or high-visibility material:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY)

OPTION 2

4 29 CFR 1926.651(d): Employees exposed to public vehicular traffic were not required to wear warning vest provided by the employer:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE WHAT IF ANYTHING THE EMPLOYEE(S) WERE WEARING TO WARN THE TRAFFIC IN THE AREA)

OPTION 1

5 29 CFR 1926.651(e): Employee was not prohibited to be underneath loads handled by lifting or digging equipment:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE EQUIPMENT BEING USED)

A-4

OPTION 2

1 29 CFR 1926.651(e): Employees were not required to stand away from any vehicles being loaded or unloaded to avoid being struck by any spillage or falling materials:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE EQUIPMENT, WHETHER LOADING OR UNLOADING, AND TYPE OF MATERIAL BEING HANDLED BY THE EQUIPMENT)

2 29 CFR 1926.651(f): A warning system was not utilized such as barricades, hand or mechanical signals, or stop logs when mobile equipment was operated adjacent to an excavation, when such equipment was required to approach the edge of an excavation, and the operator did not have a clear and direct view of the edge of the excavation:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE WHAT IF ANYTHING WAS WRONG WITH THE WARNING SYSTEM PROVIDED, AND WHAT OBSTRUCTED THE OPERATOR'S VIEW)

3 29 CFR 1926.651(g)(1)(i): Where oxygen deficiency atmosphere containing less than 19.5 percent oxygen or a hazardous atmosphere existed or could reasonably be expected to exist, such as in excavations in landfill areas or excavations in areas where hazardous substances are stored nearby, the atmospheres in the excavation were not tested before employees entered excavations greater than 4 feet (1.22m) in depth:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE TYPE OF HAZARD(S) WHERE NECESSARY, WHAT THE OXYGEN PERCENT LEVEL TAKEN WAS, AND DEPTH OF EXCAVATION MEASUREMENT OBTAINED)

4 29 CFR 1926.651(g)(1)(ii): Adequate precautions were not taken to prevent employee exposure to atmospheres containing less than 19.5 percent oxygen and other hazardous atmospheres:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY AND WHAT WAS LACKING IN PRECAUTIONS TAKEN)

A-5

1 29 CFR 1926.651(g)(1)(iii): Adequate precautions were not taken such as providing ventilation, to prevent employee exposure to an atmosphere containing a concentration of a flammable gas in excess of 20 percent of the lower flammable limit of the gas:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY, TYPE OF GAS ENCOUNTERED, AND PERCENT OF GAS OVER THE LOWER LIMIT)

2 29 CFR 1926.651(g)(1)(iv): When controls were used that were intended to reduce the level of atmospheric contaminants to acceptable levels, testing was not conducted as often as necessary to ensure that the atmosphere remains safe:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY, TYPE OF CONTROLS BEING USED, AND ATMOSPHERIC CONTAMINANTS)

OPTION 1

3 29 CFR 1926.651(g)(2)(i): Emergency rescue equipment, such as breathing apparatus, a safety harness and line, or a basket stretcher, was not readily available where hazardous atmosphere conditions existed or could reasonably be expected to develop during work in an excavation:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY, THE NEED FOR ANY OR ALL OF THIS EQUIPMENT, AND LOCATION OF EQUIPMENT PROVIDED)

OPTION 2

4 29 CFR 1926.651(g)(2)(i): Emergency rescue equipment listed in this section was not attended when in use:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY AND WHY THE EQUIPMENT WAS NOT ATTENDED)

A-6

OPTION 1

1 29 CFR 1926.651(g)(2)(ii): Employees entering bell-bottom pier holes, or other similar deep and confined footing excavations, did not wear a harness with a lifeline securely attached to it:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY AND WHAT THE EMPLOYEES WERE ENTERING)

OPTION 2

2 29 CFR 1926.651(g)(2)(ii): The lifeline provided for employee protection was not separate from any line used to handle materials:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY, AND TO WHAT THE EMPLOYEE LIFELINE WAS ATTACHED)

OPTION 3

3 29 CFR 1926.651(g)(2)(ii): The employee lifeline was not individually attended at all times while the employee wearing the lifeline was in the excavation:

(A) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY AND DETERMINE AS TO WHY THE LIFELINE WAS NOT ATTENDED)

4 29 CFR 1926.651(h)(1): Employees were permitted to work in excavations in which there was accumulated water, or excavations in which water was accumulating, and adequate precautions had not been taken to protect employees against the hazards posed by water accumulation:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY, WHAT PRECAUTIONS THE EMPLOYER WAS LACKING, AND WHERE WAS THE WATER COMING FROM)

A-7

1 29 CFR 1926.651(h)(2): Where water was controlled or prevented from accumulating by use of water removal equipment, the water removal equipment and operations were not monitored by a competent person to ensure proper operation:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE AND IDENTIFY WATER REMOVAL EQUIPMENT BEING USED, AND HAZARDS INVOLVED)

OPTION 1

2 29 CFR 1926.651 (h)(3): Where excavation work interrupted the natural drainage of surface water such as streams, diversion ditches, dikes, or other suitable means were not used to prevent surface water from entering the excavation and to provide adequate drainage of the area adjacent to the excavation:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE EXCAVATION WORK BEING ACCOMPLISHED, AND HAZARDS WHERE NECESSARY)

OPTION 2

3 29 CFR 1926.651(h)(3): Excavations subject to run-off from heavy rains were not inspected by a competent person to ensure compliance with paragraphs (h)(1) and (h)(2) of this section:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE

NECESSARY, PROVIDE DATE OF LAST INSPECTION AND LAST HEAVY RAIN)

4 29 CFR 1926.651(i)(1): Where the stability of adjoining buildings, walls, or other structures was endangered by excavation operations, support systems such as shoring, bracing or underpinning was not provided to ensure the stability of such structures for the protection of employees:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE WHAT WAS ENDANGERED RESULTING FROM EXCAVATION OPERATIONS, AND WHAT IF ANY TYPE OF SUPPORT SYSTEM WAS PROVIDED)

A-8

1 29 CFR 1926.651(i)(2): Excavation below the level of the base or footing of any foundation or retaining wall that could be reasonably expected to pose a hazard to the employees was not prohibited:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY, WHAT THE EXCAVATION WAS EXCAVATED BELOW OF)

NOTE: See exceptions listed in paragraphs (i)-(iv) of this section

2 29 CFR 1926.651(i)(3): A support system or another method of protection was not provided beneath sidewalks, pavements, and appurtenant structures to protect employees from the possible collapse of such structures:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE TYPE OF STRUCTURE NEEDING SUPPORT AND ANY INADEQUATE SUPPORT SYSTEM PROVIDED)

OPTION 1

3 29 CFR 1926.651(j)(1): Adequate protection was not provided to protect employees from loose rock or soil that could pose a hazard by falling or rolling from an excavation face:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHAT IF ANYTHING WAS PROVIDED)

OPTION 2

4 29 CFR 1926.651(j)(1): Equivalent protection to protect employees such as scaling to remove loose materials; installation of protective barricades at intervals as necessary on the face to stop and contain falling material was not provided to protect employees:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHAT TYPE OF PROTECTION SHOULD HAVE BEEN PROVIDED TO PROTECT THE EMPLOYEES)

A-9

OPTION 1

1 29 CFR 1926.651(j)(2): Employees were not protected from excavated or other materials or equipment that

could pose a hazard by falling or rolling into excavations:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, MATERIAL OR EQUIPMENT, AND WHAT PROTECTION SHOULD HAVE BEEN PROVIDED)

Option 2

2 29 CFR 1926.651(j)(2): Protection was not provided by placing and keeping such materials or equipment at least 2 feet (.61m) from the edge of excavations, or by the use of retaining devices that were sufficient to prevent materials or equipment from falling or rolling into excavations, or by a combination of both if necessary:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS.) (DESCRIBE HAZARDS WHERE NECESSARY, MATERIALS OR EQUIPMENT, AND WHAT PROTECTION SHOULD HAVE BEEN PROVIDED)

OPTION 1

3 29 CFR 1926.651(k)(1): Daily inspections of excavations, the adjacent areas, and protective systems were not made by a competent person for evidence of a situation that could have resulted in possible cave-ins, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHEN THE LAST DAILY INSPECTION WAS CONDUCTED)

OPTION 2

4 29 CFR 1926.651(k)(1): An inspection was not conducted by the competent person prior to the start of work and as needed throughout the shift:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY, AND WHAT INDICATED THAT INSPECTION WAS NOT CONDUCTED BEFORE AND AFTER WORK HAS STARTED)

OPTION 3

1 29 CFR 1926.651(k)(1): Inspections were not made after every rainstorm or other hazard increasing occurrence:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHAT INDICATED AN INSPECTION WAS NEEDED)

2 29 CFR 1926.651(k)(2): Where the competent person found evidence of a situation that could result in a possible cave-in, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions, exposed employees were not removed from the hazardous area until the necessary precautions had been taken to ensure their safety:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, WHAT WAS UNSAFE AND WHAT PRECAUTIONS SHOULD HAVE BEEN TAKEN)

3 29 CFR 1926.651(l)(1): Where employees or equipment are required or permitted to cross over excavations, walkways or bridges with standard guardrails were not provided:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, WHAT WAS LACKING GUARDRAILS, AND PROVIDE OVERALL MEASUREMENTS INCLUDING THE FALLING DISTANCE)

OPTION 1

4 29 CFR 1926.651(l)(2): Adequate barrier physical protection was not provided at all remotely located excavations:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHAT TYPE OF PHYSICAL BARRIER SHOULD HAVE BEEN PROVIDED)

A-11

OPTION 2

1 29 CFR 1926.651(l)(2): All wells, pits, shafts, etc., were not barricaded or covered:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHAT SHOULD HAVE BEEN PROVIDED)

OPTION 3

2 29 CFR 1926.651(l)(2): Upon completion of exploration and similar operations, temporary wells, pits, shafts, etc., were not backfilled:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHEN OPERATIONS WERE COMPLETED)

3 29 CFR 1926.652(a)(1): Each employee in an excavation was not protected from cave-ins by an adequate protective system designed in accordance with paragraph (b) or (c) of this section:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHAT WAS LACKING IN PROTECTIVE SYSTEM DESIGN)

NOTE: See exception in (i) and (ii) of this section

4 29 CFR 1926.652(a)(2): Protective systems did not have the capacity to resist without failure all loads that were intended or could reasonably be expected to be applied or transmitted to the system:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHAT WAS LACKING IN THE PROTECTIVE SYSTEM TO CAUSE A FAILURE)

A-12

OPTION 1

1 29 CFR 1926.652(b): The slopes and configurations of slope and benching systems were not selected and constructed by the employer or his designee:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHO MADE THE SELECTION OF THE SYSTEM TO BE USED)

OPTION 2

2 29 CFR 1926.652(b): The slopes and configurations of sloping and benching systems selected to be used were not constructed in accordance with the requirements of paragraph (b)(1):

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, WHAT WAS LACKING IN THE SYSTEM THE EMPLOYER SELECTED TO USE)

OPTION 1

3 29 CFR 1926.652(c): Designs of support systems shield systems, and other protective systems were not selected and constructed by the employer or his designee:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHO SELECTED THE PROTECTIVE SYSTEM, OR SHIELD SYSTEM BEING USED)

OPTION 2

4 29 CFR 1926.652(c): Designs of support systems shield systems being used were not designed and constructed in accordance with the requirements of paragraph (c)(1); or, in the alternative, paragraph (c)(2); or, in the alternative, paragraph (c)3); or, in the alternative, paragraph (c)(4):

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, WHAT WAS LACKING IN THE DESIGN AND CONSTRUCTION OF THE SUPPORT SYSTEMS, OR SHIELD SYSTEM BEING USED)

A-13

1 29 CFR 1926.652(d)(1): Materials and equipment used for protective systems were not free from damage or defects that might impair their proper function:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, WHAT WAS DAMAGE OR DEFECT IN THE MATERIALS OR EQUIPMENT BEING USED IN THE PROTECTIVE SYSTEM)

OPTION 1

2 29 CFR 1926.652(d)(2): Manufactured materials and equipment used for protective systems were not maintained in a manner that was consistent with the recommendations of the manufacturer:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, WHAT WAS WRONG WITH THE MATERIALS OR EQUIPMENT BEING USED THAT IT WAS NOT

CONSISTENT WITH THE MANUFACTURER'S RECOMMENDATIONS)

OPTION 2

3 29 CFR 1926.652(d)(2): Manufactured materials and equipment used for protective systems were not used in a manner that was consistent with the recommendations, and in a manner that would have prevented employee exposure to hazards:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHAT WAS WRONG WITH THE MATERIALS OR EQUIPMENT THAT PRESENTED A HAZARD TO THE EMPLOYEES)

OPTION 1

4 29 CFR 1926.652(d)(3): When material or equipment that was used for protective systems was damaged, a competent person did not examine the material or equipment and evaluate its suitability for continued use:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, WHAT WAS DAMAGED IN THE PROTECTIVE SYSTEM BEING USED AND ITS SUITABILITY FOR CONTINUED USE)

OPTION 2

1 29 CFR 1926.652(d)(3): When the competent person could not ensure that the material or equipment was able to support the intended loads or was otherwise suitable for safe use, then such material or equipment was not removed from service:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHAT WAS DEFECTIVE WITH THE MATERIAL OR EQUIPMENT THAT NEEDED TO BE REMOVED FROM SERVICE)

OPTION 3

2 29 CFR 1926.652(d)(3): Material or equipment used for protective systems that was found to be damaged and had been removed from service was not evaluated and approved by a registered professional engineer before being returned to service:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHAT WAS DEFECTIVE IN THE PROTECTIVE SYSTEM BEING USED, WHO APPROVED THE MATERIAL OR EQUIPMENT TO BE PUT BACK INTO SERVICE)

3 29 CFR 1926.652(e)(1)(i): Members of support systems were not securely connected together to prevent sliding, falling, kickouts, or other predictable failure:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND HOW THE MEMBERS OF THE SUPPORT SYSTEMS WERE CONNECTED TOGETHER)

4 29 CFR 1926.652(e)(1)(ii): Support systems were not installed and removed in a manner that protected employees from cave-ins, structural collapses, or from being struck by members of the support system:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHAT WAS WRONG WITH THE SUPPORT SYSTEM THAT IT PRESENTED HAZARD TO EMPLOYEES WHILE BEING INSTALLED OR REMOVED)

A-15

1 29 CFR 1926.652(e)(1)(iii): Individual members of support systems were subjected to loads exceeding those which those members were designed to withstand:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, WHAT THE LOADS WERE THAT EXCEEDED THOSE THE MEMBERS OF SUPPORT SYSTEMS WERE DESIGNED TO WITHSTAND)

2 29 CFR 1926.652(e)(1)(iv): Before temporary removal of individual members was begun, additional precautions were not taken to ensure the safety of employees, such as installing other structural members to carry the loads imposed on the support system:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHAT PRECAUTIONS SHOULD HAVE BEEN TAKEN BY THE EMPLOYER PRIOR TO TEMPORARY REMOVAL OF SUPPORT SYSTEM MEMBERS)

OPTION 1

3 29 CFR 1926.652(e)(1)(v): Removal of members from support system did not begin at, and progress from, the bottom of the excavation:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARD(S) WHERE NECESSARY, AND WHERE DID REMOVAL OF MEMBERS OF SUPPORT SYSTEM BEGIN)

OPTION 2

4 29 CFR 1926.652(e)(1)(v): Members were not released slowly so as to note any indication of possible failure of the remaining members of the structure or possible cave-in of the sides of the excavation:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND AREA WHERE MEMBERS WERE RELEASED TOO FAST INDICATING A FAILURE OR CAVE-IN WAS EVIDENT)

A-16

1 29 CFR 1926.652(e)(1)(vi): Backfilling did not progress together with removal of support systems from excavations:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHEN DID BACKFILLING START AS THE SUPPORT SYSTEM WAS REMOVED)

OPTION 1

2 29 CFR 1926.652(e)(2)(i): Excavation of material to a level no greater than 2 feet (.61m) below the bottom of the members of a support system was permitted where the system was not designed to resist the forces calculated for the full depth of the trench, and there were indications while the trench was open of a possible loss of soil behind or below the bottom of the support system:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND HOW FAR BELOW SUPPORT SYSTEM EXCAVATING WAS ACCOMPLISHED)

OPTION 2

3 29 CFR 1926.652(e)(2)(i): Excavation of material to a level no greater than 2 feet (.61m) below the bottom of the members of the support system was allowed when there were indications while the trench is open of a possible loss of soil from behind or below the bottom of the support system:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHERE LOSS OF SOIL WAS OCCURRING)

4 29 CFR 1926.652(e)(2)(ii): Installation of a support system was not closely coordinated with the excavation of trenches:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, WHEN WAS THE INSTALLATION OF THE SUPPORT SYSTEM STARTED RELATIVE TO THE EXCAVATING OPERATION)

A-17

1 29 CFR 1926.652(f): Employees were permitted to work on the faces of sloped or benched excavations at levels above other employees when employees at the lower levels were not adequately protected from the hazard of falling, rolling, or sliding material or equipment:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, WHAT WERE THE EMPLOYEES WORKING ON THE FACE DOING, AND WHAT WERE THEY WORKING WITH THAT CREATED A HAZARD)

2 29 CFR 1926.652(g)(1)(i): Shield systems were subjected to loads exceeding those which the system was designed to withstand:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, WHAT WERE THE LOADS THE SHIELD SYSTEMS WERE SUBJECTED TO THAT EXCEEDED THOSE THE SYSTEM WAS DESIGNED TO WITHSTAND)

3 29 CFR 1926.652(g)(1)(ii): Shields were not installed in a manner to restrict lateral or other hazardous movement of the shield in the event of the application of sudden lateral loads:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND HOW THE SHIELD WAS INSTALLED TO ALLOW LATERAL AND OTHER HAZARDOUS MOVEMENT)

4 29 CFR 1926.652(g)(1)(iii): Employees were not protected from the hazard of cave-ins when entering or exiting the area protected by shields:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHAT WAS DIRECTION OF TRAVEL BY THE EMPLOYEES)

A-18

1 29 CFR 1926.652(g)(1)(iv): Employees were allowed in shields when shields were being installed, removed, or moved vertically:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, WHAT WAS BEING DONE WITH THE SHIELD WHILE EMPLOYEES WERE IN SHIELD)

OPTION 1

2 29 CFR 1926.652(g)(2): Excavations of earth material to a level no greater than 2 feet (.61m) below the bottom of a shield was permitted, when the shield was not designed to resist the forces calculated for the full depth of the trench, and there were indications while the trench was open of a possible loss of soil from behind or below the bottom of the shield:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, WHAT INDICATED THAT SHIELD FAILED TO RESIST THE FORCES CALCULATED AND POSSIBLE LOSS OF SOIL FROM BEHIND THE SHIELD)

OPTION 2 3 29 CFR 1926.652 (g)(2): Excavation of material to a level no greater than 2 feet (.61m) below the bottom of a shield system was allowed when there were indications while the trench was open of a possible loss of soil from behind or below the bottom of the shield system:

(a) (LOCATION) (IDENTIFY SPECIFIC OPERATIONS AND/OR CONDITIONS) (DESCRIBE HAZARDS WHERE NECESSARY, AND WHERE LOSS OF SOIL WAS OCCURRING)

A-19

UNITED STATES
DEPARTMENT OF LABOR

Occupational Safety & Health Administration
200 Constitution Ave NW
Washington, DC 20210
800-321-6742 (OSHA)
TTY

EXECUTIVE ORDERS

Executive Order on Maximizing Use of American-Made Goods, Products, and Materials

— ECONOMY & JOBS

Issued on: **July 15, 2019**

★ ★ ★

By the authority vested in me as President by the Constitution and the laws of the United States of America, and to promote the principles underlying the Buy American Act of 1933 (41 U.S.C. 8301-8305), it is hereby ordered as follows:

Section 1. Policy. (a) As expressed in Executive Order 13788 of April 18, 2017 (Buy American and Hire American), and in Executive Order 13858 of January 31, 2019 (Strengthening Buy-American Preferences for Infrastructure Projects), it is the policy of the United States to buy American and to maximize, consistent with law, the use of goods, products, and materials produced in the United States. To those ends, my Administration shall enforce the Buy American Act to the greatest extent permitted by law.

(b) In Executive Order 10582 of December 17, 1954 (Prescribing Uniform Procedures for Certain Determinations Under the Buy-American Act), President Eisenhower established that materials shall be, for purposes of the Buy American Act, considered of foreign origin if the cost of the foreign products used in such materials constitutes 50 percent or more of the cost of all the products used in such materials. He also established that, in determining whether the bid or offered price of materials of domestic origin is unreasonable or inconsistent with the public interest, the executive agencies shall either (1) add 6 percent to the total bid or offered price of materials of foreign origin, or (2) add 10 percent to the total bid or offered price of materials of foreign origin less certain specified costs as follows. Where the foreign bid or offer is less than $25,000, applicable duty is

excluded from the calculation. Where the foreign bid or offer is more than $25,000, both applicable duty, and all costs incurred after arrival in the United States, are excluded from the calculation.

(c) The policies described in section 1(b) of this order were adopted by the Federal Acquisition Regulatory Council (FAR Council) in the Federal Acquisition Regulation (FAR), title 48, Code of Federal Regulations. The FAR should be reviewed and revised, as appropriate, to most effectively carry out the goals of the Buy American Act and my Administration's policy of enforcing the Buy American Act to its maximum lawful extent. I therefore direct the members of the FAR Council to consider measures that may better effectuate this policy.

Sec. 2. Proposed Rules. (a) Within 180 days of the date of this order, the FAR Council shall consider proposing for notice and public comment:

(i) an amendment to the applicable provisions in the FAR that would provide that materials shall be considered to be of foreign origin if:

(A) for iron and steel end products, the cost of foreign iron and steel used in such iron and steel end products constitutes 5 percent or more of the cost of all the products used in such iron and steel end products; or

(B) for all other end products, the cost of the foreign products used in such end products constitutes 45 percent or more of the cost of all the products used in such end products; and

(ii) an amendment to the applicable provisions in the FAR that would provide that the executive agency concerned shall in each instance conduct the reasonableness and public interest determination referred to in sections 8302 and 8303 of title 41, United States Code, on the basis of the following-described differential formula, subject to the terms thereof: the sum determined by computing 20 percent (for other than small businesses), or 30 percent (for small businesses), of the offer or offered price of materials of foreign origin.

(b) The FAR Council shall consider and evaluate public comments on any regulations proposed pursuant to section 2(a) of this order and shall promptly issue a final rule, if appropriate and consistent with applicable law and the national security interests of the United States. The head of each executive agency shall issue such regulations as may be necessary to ensure that agency procurement practices conform to the provisions of any final rule issued pursuant to this order.

Sec. 3. Effect on Executive Order 10582. Executive Order 10582 is superseded to the extent that it is inconsistent with this order. Upon the issuance of a final rule pursuant to section 2 of this order, subsections 2(a) and 2(c) of Executive Order 10582 are revoked.

Sec. 4. Additional Actions. Within 180 days of the date of this order, the Secretary of Commerce and the Director of the Office of Management and Budget shall, in consultation with the FAR Council, the Chairman of the Council of Economic Advisers, the Assistant to the President for Economic Policy, and the Assistant to the President for Trade and Manufacturing Policy, submit to the President a report on any other changes to the FAR that the FAR Council should consider in order to better enforce the Buy American Act and to otherwise act consistent with the policy described in section 1 of this order, including whether and when to further decrease, including incrementally, the threshold percentage in subsection 2(a)(i)(B) of this order from the proposed 45 percent to 25 percent. The report shall include recommendations based on the feasibility and desirability of any decreases, including the timing of such decreases.

Sec. 5. General Provisions. (a) Nothing in this order shall be construed to impair or otherwise affect:

(i) the authority granted by law to an executive department or agency, or the head thereof, including, for example, the authority to utilize non-availability and public interest exceptions as delineated in section 8303 of title 41, United States Code, and 48 CFR 25.103; or

(ii) the functions of the Director of the Office of Management and Budget relating to budgetary, administrative, or legislative proposals.

(b) This order shall be implemented consistent with applicable law and subject to the availability of appropriations.

(c) This order is not intended to, and does not, create any right or benefit, substantive or procedural, enforceable at law or in equity by any party against the United States, its departments, agencies, or entities, its officers, employees, or agents, or any other person.

DONALD J. TRUMP

THE WHITE HOUSE,

July 15, 2019.

Belker Exhibit 1

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Opinion

5/15/19

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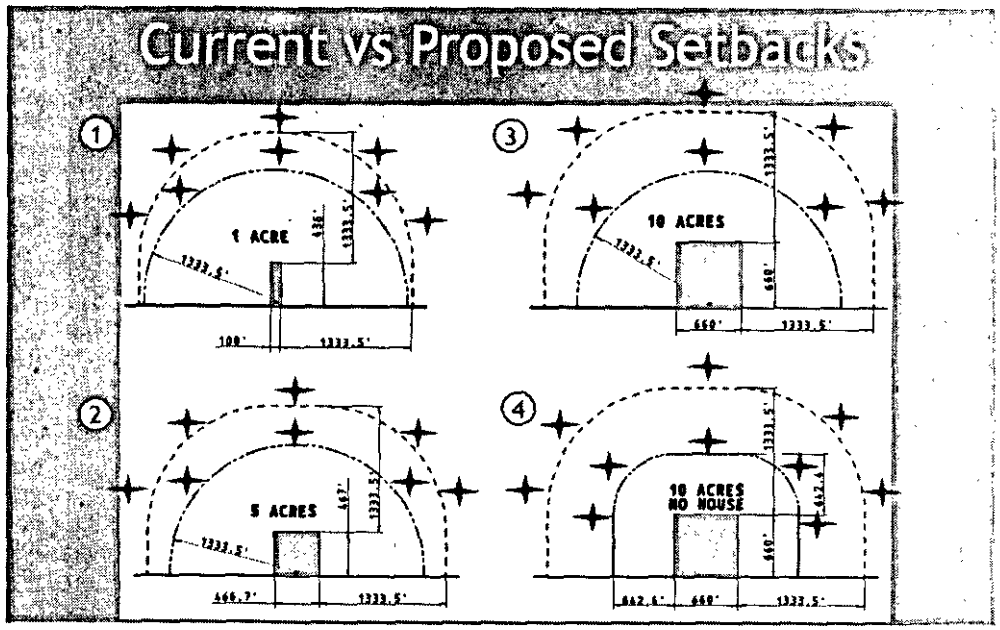
The Advertiser-Tribune

Wind turbine setbacks not 'burdensome'

Chris Aichholz
of Bloomville is a guest columnist.

Industrial wind turbine setbacks have been a hot topic for several years. Developers have uttered words like "overly burdensome," "effective moratorium" and "unreasonable" when describing Ohio's current setbacks. We even have seen on at least two accounts in the last year where our very own Seneca County Commissioner Holly Stacy has submitted testimony requesting that any new energy bill should include "the restoration of reasonable wind siting regulations so that developers are no longer hindered by the current, unreasonable setbacks."

Here is the reality: My family's home lies within the proposed Seneca Wind project and the yard where my children play will have 20 600-plus-feet-tall industrial wind turbines placed within a 1.5-mile radius. The pro-wind lobby and Stacy would have you believe this is impossible with Ohio's current setbacks. But the truth is they are merely pushing their own agendas.



Turbine Model: GE 2.8-127 turbine; 584' tall; 208.5' rotor radius
Current Setback From Property Line = (1125' + rotor radius) = 1333.5' ———
Proposed Setback:
Exterior of Home = 1125' + 208.5' = 1333.5' — · · —
Property Line = 1.1x turbine height = 1.1 x 584' = 642.4'

Under the current Ohio law, landowners and developers are afforded an opportunity to negotiate and sign a "setback easement," aka "Good Neighbor Agreement," allowing developers to place industrial wind turbines closer to people's properties than the law specifies. During this process, landowners have a chance to weigh the cost versus benefit to them. Typically, these agreements pay landowners $500-$2,000 per year. To date, the Seneca Wind and Republic Wind projects in Seneca County have acquired nearly 90% of the necessary setback waivers to build their projects under current setback law.

The real issue here is that the wind industry does not want to work with people who must live less than 1,125ft from a 600-plus-foot industrial wind turbine, but would rather convince our elected officials in Columbus to grant them uncompensated easements and take away our right to live peaceably on our own property. Such a use of force would give more rights to the outsider wind industry than their own Ohio residents.

Shame on you, Stacy, and shame on these politicians from urban areas that are far removed from this controversial issue. HB 223 (current bill aiming to reduce setbacks) is one of the most ill-conceived bills I have ever seen. I encourage anyone who thinks its just wrong to cram industrial wind turbines closer to homes, schools and parks to write your elected officials telling them how you feel. For more information on the topic, you can visit the Seneca Anti-Wind Union's Facebook page.

www.legislature.ohio.gov/legislation/legislation-summary?id=GA133-HB-223

ATTIC 5/30/19
HUB

State Representative Bill Reineke Seeks to give Local Constituents the Right to Vote on Wind Turbines

Richard Stegman Staff Reporter richard@atticahub.com

In a bold move Rep. Reineke is staking out a significant position that allows the local voters to decide if they want wind turbines in their community. There has been considerable outcry from many in north central Ohio because they do not have that opportunity.

According to Rep. Reineke "in my sincere attempt to represent the constituents of the 88th House District, I have submitted an amendment to House Bill 6 that would allow local electors to hold a referendum regarding the approval or rejection of any certificates issued by the Ohio Power Siting Board." Only if the Siting Board grants a particular wind turbine project its "build" certificate would the proposed legislation apply. Presently Ohio law provides final approval authority to the Ohio Power Siting Board. Further, Reineke's amendment stipulates the local referendum would only be for wind farms that are "economically significant" or a "large wind farm", as defined by the Ohio Revised Code.

Reineke stated in a press release "a great frustration of mine is when those outside of the community are trying to tell us how to run our counties." The state representative continued with "Constituent emails and calls that come into my office repeatedly express local control. Amended HB6 addresses this issue."

Reinike's amendment was well received by the Seneca Anti-Wind Union (SAWU), who are opposed to Apex Clean Energy installation of over 80 turbines in Seneca and Sandusky counties. Chris Aicholtz, a leader in SAWU, on behalf of the group stated, "We are happy...that Representative Bill Reineke has created a proposal that establishes a path for a local referendum (vote) in the siting of industrial wind turbine projects." A SAWU press release offered "We are continually impressed with most of our elected officials recognizing the overwhelming number of people that are against these projects..." The press release goes on to state "This is truly Democracy in action."

Aicholtz personally commented "this (Reineke's amendment) is a game changer." And local community leader and opponent of the area's potential large wind turbines, Kenn Rospert, stated to *The Hub* about Reineke's action "Great! Some elected officials are listening to letting the residents effected decide if they want them (wind turbines) or not."

Apex Clean Energy was contacted by *The Hub* for comment. They were unable to provide any information prior to this week's issue going to print.

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Opinion

The Advertiser-Tribune

Rob Weaver, editor rweaver@advertiser-tribune.com

5/9/19

LETTER

letter also states, "I also ask you to consider no new energy bill without the restoration of reasonable wind siting regulations so that developers are no longer hindered by the current, unreasonable setbacks."

Current, unreasonable setbacks! The current setback law is defined as 1,125 feet plus the rotor radius of the turbine measured from the nearest property line of a non-participating landowner. For the 584-foot-tall turbines that are proposed in the Seneca Wind project (208.5-foot rotor radius), the setback distance would be 1,333.5 feet from the property line.

The pre-2014 setback law was defined as 1,125 feet plus rotor radius from the exterior of an inhabitable residence of the nearest non-participating property owner and a minimum of 1.1 times the total height of the turbine measured from the property line. So this means the turbine would be located 1,333.5 feet from the exterior of a home and a minimum of 642.4 feet from the property line. The turbine manufacturer's safety guidelines for their own employees recommend they stay a minimum distance of 1,640 feet away from the turbine in the event of an emergency. But Stacy and other pro-wind advocates are pushing for setbacks of 642.4 feet from our property lines.

Per a 2018 WindPower Engineering & Development article, there are 3,800 turbine blade failures every year globally. That is an average of over 10 failures every day. If the wind projects are built in Seneca County, it is not a question of if we will have a turbine blade failure but instead is just a matter of when. There have been three blade failures so far in Ohio and debris has been thrown as far as 1,561 feet for turbines that are only 476 feet tall. But Stacy and other pro-wind advocates are pushing for setbacks of 642.4 feet from our property lines.

April 29, HB 223 was introduced by District 39 Rep. Fred Strahorn, D-Dayton, and District 13 Rep. Michael Skindell, D-Lakewood). The bill was co-sponsored by a group of eight other big-city Democrats who want to dictate how we should live our lives in Seneca County. This bill, as proposed, would reinstate the pre-2014 setbacks. Please call or write as many of your state representatives and senators as possible stating your objections to this proposed bill.

The bottom line is that this group of big-city representatives along with Stacy want the setbacks reduced so more turbines can be installed in Seneca County, consuming more taxpayer funded subsidies, while ignoring the increased safety risks and quality of life of rural residents. If Stacy truly cared about the well being of Ohio and county residents, she and the other pro-wind advocates would be lengthening the setbacks instead of trying to shorten them. This is exactly what is happening in other states.

Greg Smith,
Bloom Township

. Researched + well respected person in ANW.

Economic impact
Benefits vs. costs of wind turbines

By Vicki Johnson
Staff Writer
vjohnson@advertiser-tribune.com

The economic impact of wind farms on Seneca County can be seen as beneficial or not, depending on individual perspective.

Two proposed wind farm projects are in the works in Seneca County - Seneca Wind Farm and Republic Wind Farm. A third wind farm, Emerson Creek, is proposed for Huron and Erie counties along the eastern edge of Seneca County.

Some people look at it as a business coming into the community that would provide tax revenue to the county, schools and other taxing districts through payments in lieu of taxes — or PILOT payments — while others say wind farms should pay the same rate of taxes as other businesses.

Among individuals, people who own land where turbines would be placed would see a direct financial gain, while some other people living in the area say the quality of life issues they would have to deal with would not be worth the cost.

This is the fifth story in a series about proposed wind farms and how they affect Seneca County.

"It's an extremely complicated issue," said David Zak, president and CEO of Tiffin-Seneca Economic Partnership. "We are not taking a position. We are strictly looking at tax revenue."

"A lot of people are saying it's not good for the county," he said.

Zak said TSEP provides services to any legal business that is working toward establishing itself in Seneca County.

To that end, Zak wrote a report requested by the Seneca County commissioners summarizing the economic impact wind farms would have on the county.

"There's a lot of tax revenue and some jobs," he said.

Company reports

In a Statement on the Economic Development Benefits of Wind Projects provided recently to the county commissioners, Zak reviewed the key project numbers for the Seneca and Republic wind projects.

In numbers reported on the Republic Wind website, Apex Clean Energy expects its investment in Republic Wind to be $400 million, although Zak notes the investment figure is kept confidential in applications submitted to OPSB.

In its December 2018 filing with OPSB, Republic Wind said it's planning 50 turbines, not to exceed 200 megawatts on a 24,000-acre project area. The company is making a 30-year commitment, and 10 long-term operations jobs are expected to be created.

The OPSB application, started by Apex in August 2010, was amended in December 2018.

If approved, the company is planning to begin construction in October.

According to numbers from sPower's OPSB application and the Seneca Wind website, the investment in the Seneca Wind project is expected to be $280 million — $175 million in turbines, $60 million in construction and electrical materials, $30 million in labor and $15 million in project development costs.

The application filed with OPSB in July 2018 proposes 85 turbines (which later was changed to 77 turbines) to be placed within a 56,900-acre area, which are expected to 212 MW of electricity.

Seneca Wind reports it is making a 30-year commitment, and is expected to create eight (6-10 long-term operations jobs.

In the report, Zak said sPower acquired the Seneca Wind project from Exelon in 2017, who had purchased it from John Deere previously.

Zak reported summaries from economic impact studies done on behalf of each project.

He said Republic Wind's analysis was completed in December 2018 by EDR Environmental Services, of Syracuse, New York, using the National Renewable Energy Laboratory's Jobs and Economic Development Impact Land-based Wind model.

As quoted from Zak's written statement, the report concluded:

The socioeconomic effects of the Republic Wind Farm, when assessed in light of regional and local economic trends, will have a positive impact on the communities within the Study Area and across the State of Ohio. Lease payments, short- and long-term job creation, and PILOT revenues will benefit private landowners, businesses and taxing jurisdictions. The Facility is not expected to generate significant expenditures on behalf of these beneficiaries; therefore, it will have a positive impact on the social and economic conditions of these communities and across Ohio.

In subpoints, the report said:

Total Statewide Economic Benefit: The construction of the Republic Wind Farm is expected to produce $41.1 million in employment earnings and $112.2 million in total economic output.

Subsequently, each year the Facility is operational it is expected to generate approximately $2.3 million in earnings and $5.9 million in total economic output.

Statewide Employment Benefits: During the construction period, the Facility is expected to support demand for a total of 753 onsite, supply chain, and induced employment positions. It is expected to support a total of 41 positions during each year of its operation.

Land Lease Revenue: The development of the Facility will result in $[Redacted] in annual lease payments made to participating landowners. (Redacted means the company requested the numbers not be made public.)

Property Tax Revenues: Construction of the proposed Republic Wind Farm will increase local government revenues through payments in lieu of taxes (PILOTs). Though the agreements outlining these payments are not yet finalized, it is estimated that annual PILOT revenues could amount to approximately $1.2 million to $1.8 million to be distributed to local taxing jurisdictions.

In a similar report completed for Seneca Wind by Tetra Tech, of Pasadena, California, using NREL's Jobs and Economic Development Impact Land-based Wind model, the conclusion in the OPSB application said, *"The results of this analysis indicate that construction and operation of the Project would provide direct employment for residents in Seneca County and elsewhere in-state, as well as support economic activity elsewhere in the local and state economies."*

Subpoints included:

Overall, construction of the Project is estimated to support 795 total (Project Development and On-Site, Turbine and Supply Chain, and Induced) jobs in the State of Ohio, and approximately $46.7 million in labor income, with total economic output of approximately $132.6 million. In Seneca County, Project construction is estimated to support approximately 49 total jobs and approximately $2.4 million in labor income, with total economic output of approximately $7.6 million. Construction impacts would be onetime impacts that would occur only during construction.

Operation of the Project is estimated to support approximately 59 total (direct, indirect, and induced) jobs in the State of Ohio and approximately $2.4 million in labor income, with total economic output of approximately $7.8 million. In Seneca County, Project operation is estimated to support approximately 27 full-time jobs and approximately $1.2 million in labor income, with total economic output of approximately $4.6 million. These annual average impacts are expected to occur over the life of Project operation.

Seneca Wind anticipates that it will make payments in lieu of real and personal property taxes in accordance with the applicable statute (ORC 5727.75 and the Board of Seneca County Commissioners' Office 2011), with the Project estimated to generate $1.91 million in PILOT payments during its first year of operation, and each year thereafter. Seneca Wind also estimates that lease payments to landowners will total more than $20 million over the life of the Project."

Tax revenue

Zak said the Seneca County auditor did an analysis in May 2018 with information provided from John Moran, then project manager for sPower, and Dalton Carr of Apex Clean Energy.

"The totals, even though the project information may have changed, line up with the estimates in the OSPB application," Zak said in his report. "It is worth noting that according to the Ohio Department of Education via the Seneca County auditor, the PILOT payments below do not impact any of the schools' funding formula."

Also, Zak said he spoke with two economic development organizations which verified that anticipated revenue came in. (See the accompanying grid with taxing districts and estimated amounts.)

In conclusion, Zak said, "The two projects under consideration would potentially generate a significant amount of tax (PILOT) revenue — $108 million over 30 years — and they would create almost 20 new, full-time jobs paying almost $60,000 per year."

He also noted that "caveats and qualifiers" are described throughout his report.

Zak said TSEP has been assisting with the facilitation of the wind projects since at least 2015.

"It has been involved with the Comprehensive Economic Development Strategy and used it as a strategic foundational document since the fall of 2015, along with many others, that targeted wind energy and assisted in the creation of the alternative energy zone in October of 2011," he said.

The AEZ has attracted wind development and has resulted in the current two — and potentially more — projects, he said.

"It is our view that without the AEZ, those projects would not have come to Seneca County," he said.

Anti-wind perspective

Local opponents to the wind projects point out hidden financial costs to be considered in addition to expected tax revenue.

"Although the two proposed wind projects in Seneca County could have brought substantially more revenue to the county if the commissioners had not let them have the large PILOT tax break, the projects are currently proposed to bring $1.8 million each per year to the county/school coffers," said Jim Feasel, who said he has been working with Seneca Anti-Wind Union to get information out to the public. "But this money cannot be considered in isolation. The costs to the county and its residents per year must also be taken into account."

Feasel's mention of "the large PILOT tax break" refers to the alternative energy zone.

Opponents say the wind project would not be cost effective for the companies without the tax break.

County Commissioner Mike Kerschner has been vocal in his opposition to the wind farms and twice has made motions to rescind the AEZ. Both motions died for lack of a second.

Kerschner said the AEZ amounts to a 50-percent tax break for the companies. If the wind companies were taxed at normal rates, he said, they would pay about $4 million the first year, and then depreciation would reduce that amount in subsequent years. If the companies updated the equipment in the future, the tax rate would be affected.

"I would rather have the $4 million the first year," he said. "I would like to have that money to invest for the county."

He said the AEZ prevents the county from negotiating the best deal financially and in other areas such as fire and safety training, which he said is important if residents are going to be forced to deal with the potential health risks.

"I think it's just bad for the county and bad for the citizens," he said. "The bottom line is when you are a government official representing folks and there are all these uncertainties, it is your responsibility to protect those folks you represent. You are obligated to do what's right for those you represent."

"That lack of local control is why we want the AEZ rescinded," said Greg Smith, of Seneca Anti-Wind Union.

Smith said PILOT payments are based on 2011 dollars and has no adjustment.

"If they were paying standard real estate taxes, Seneca Wind would pay $80 million instead of $57 million over 30 years.

"The politicians and the companies only talk about money," Smith said. "But is it worth the costs? At the end of the day is there going to be a net gain or loss?"

Smith said there are other financial considerations also.

"I think there is very high risk of lack of tax levy support for schools and other taxpayer-funded programs if the wind projects are built," he said. "If the projects are built, I fully expect people who are forced to sacrifice their property values and quality of lives will be extremely bitter when the schools come back to them for levy support in the future.

"If the revenue generated by the PILOT funding is so beneficial for the schools, people living with the turbines will tell the schools to go ask the wind companies for money versus asking the taxpayer for their further support," Smith said. "I don't think people are considering the unintended consequences of these projects that could result in a net loss versus a net gain for the schools."

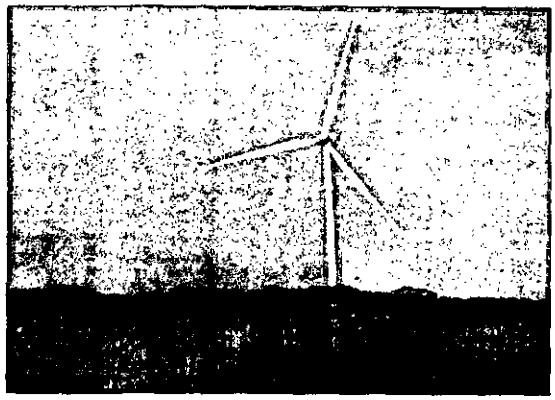
Feasel said the largest direct cost will be the impact on the bat population. He cited research done by Science Magazine that estimates the value of bats to Seneca County agriculture as a minimum of $2.75 million per year, but he said could be higher.

"Approximately 100 farmers will receive payments to host a turbine, some more than one, but the damage due to loss of bats will affect thousands of farmers," he said. "Each extra application of insecticide by county farmers (to kill insects that the bats used to kill) will cost over $1 million and will still not control many of the crop-eating insect populations that bats would decrease.

"Between the increased insecticide requirements, and resulting loss of yields that would still result, the costs to the area because of the decrease in bat population could easily be more than the expected income from the projects," Feasel said. "Those few farmers hosting turbines would still come out ahead. But lease payments to participating farmers without turbines are small and most would not come out ahead. They and the thousands of other non-participating farmers would suffer very substantial damages.

"Bats are a big deal and many wind projects in agricultural areas have been stopped or curtailed because of their importance."

please see IMPACT, 8C

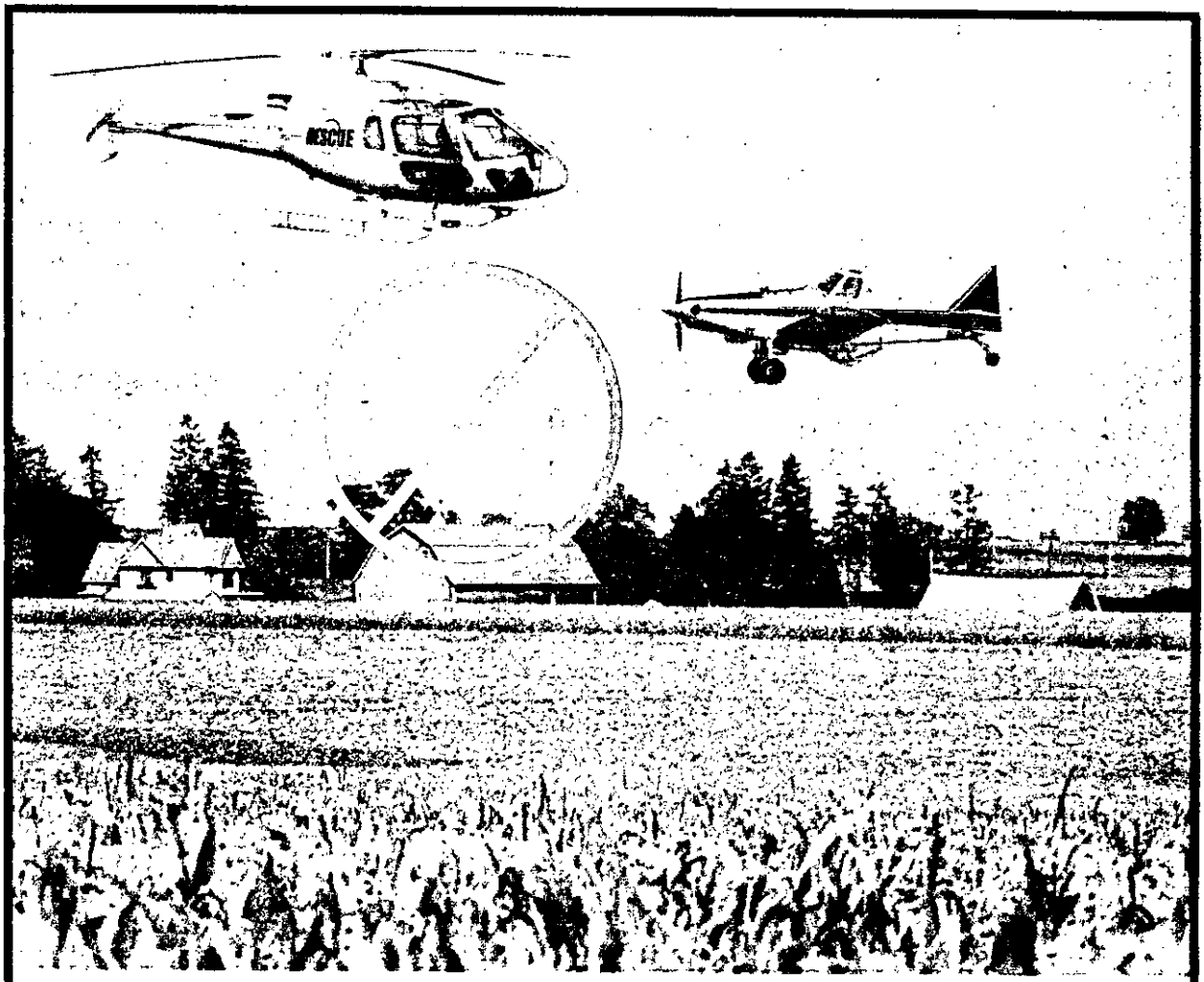


MARCOS GORRESEN HAWAII COOPERATIVE STUDIES UNIT

A public domain photo of a wind turbine in Hawaii.

INSIDE

What's cooking?: Trade shows offer peeks at kitchens of the future, 7C



With the support of the Seneca County Commissioners and the surrounding community since 1968, we have been seeking and receiving federal and state grants to remove houses and obstacles in the object free area around the Seneca County Airport. Removing these obstacles was in compliance with FAA guidelines to make the airport safer for private and commercial air traffic. It is very troubling that we now have local officials that support the construction of industrial wind turbines in Seneca County. These turbines would definitely be a safety hazard to air traffic. They will directly affect the landing approach to the airport. If turbines are built, it will change the landing minimums and thus the safety factor at the local airport. This could deter airplanes (including small jets) from landing and in return, deter business within Seneca County. They will also affect a medical helicopter's ability to land at the scene of a nearby accident. Seneca County is a rural community with substantial agriculture. The National Aerial Applicators Association (crop sprayers) are against the wind turbines in an agricultural community for safety reasons. They will obviously be unable to spray or seed fields in the vicinity of these turbines. From an aviation perspective, wind turbines are not desirable in Seneca County.

Tiffin Aire Inc.
by: Brad & Kim Newman

IT's not money IT's Health

all are Estimates

Taxing District	Republic Wind Annual	Republic Wind 30 Years	Seneca Wind Annual	Seneca Wind 30 Years	Both Projects Annual
$1K to GRF	196,020	5,880,600	205,310	6,159,300	401,330
County General Fund	48,331	1,449,930	50,367	1,511,010	98,698
Opportunity Center	221,303	6,639,090	230,628	6,918,840	451,931
Bellevue Schools	325,001	9,750,030	-	-	325,001
Buckeye Central LSD	-	-	301,119	9,033,570	301,119
Clyde EVSD	60,588	1,817,640	-	-	60,588
Mohawk LSD	-	-	273,828	8,214,840	273,828
Old Fort LSD	81,178	2,435,340	-	-	81,178
Seneca East LSD	511,470	15,344,100	475,237	14,257,110	986,707
SHOVE Career Center	34,765	1,042,950	-	-	34,765
Pioneer JVSD	-		22,508	675,240	22,508
Vanguard JVSD	28,199	845,970	32,680	980,400	60,879
Adams Twp	46,112	1,383,360	-	-	46,112
Bloom Twp	-	-	38,933	1,167,990	38,933
Eden Twp	-	-	30,463	913,890	30,463
Pleasant Twp	6,133	183,990	-	-	6,133
Reed Twp	16,393	491,790	27,037	811,110	43,430
Scipio Twp	32,777	983,310	6,230	186,900	39,007
Thompson Twp	56,998	1,709,940	-	-	56,998
Venice Twp	-	-	14,865	445,950	14,865
Health District	7,632	228,960	7,952	238,560	15,584
Bellevue Library	7,813	234,390	-	-	7,813
Birchard Library	1,202	36,060	-	-	1,202
Mohawk Library	-	-	5,415	162,450	5,415
Seneca East Library	11,023	330,690	10,243	307,290	21,266
T-S Public Library	1,725	51,750	-	-	1,725
Commission on Aging	7,632	228,960	7,952	238,560	15,584
Mental Health & Recovery	17,807	534,210	18,556	556,680	36,363
County Park District	12,719	381,570	13,255	397,650	25,974
Attica Venice Cemetery	-	-	4,054	121,620	4,054
AVR Fire District	16,145	484,350	41,267	1,238,010	57,412
AVR Jt Ambulance District	7,452	223,560	19,047	571,410	26,499
Bloom-Scipio Amb District	7,766	232,980	10,844	325,320	18,610
Tax District Totals	1,568,164	47,044,920	1,642,480	49,274,400	3,210,644
Revenue Totals	1,764,180	52,925,400	1,847,789	55,433,670	3,611,969

Impact

■ *from page 1C*

Pro-wind perspective

Farmer Gary Baldosser has a different view of the economics of wind turbines.

"This goes back to 2007, when we started looking at our losses when our property taxes were going up," Baldosser said.

He explained that values are adjusted periodically in CAUV - current agricultural use value — calculations.

"In 2007-08, our taxes went from $7 an acre to $19 an acre," he said. "Three years later, when the state updated the CAUV, they went from $19 to $47 an acre."

He said the rate was for bare farm ground with no buildings or woods.

"It became extremely apparent to myself and my dad that we needed to do something not only for ourselves but for our landlords to generate some revenue that wasn't specifically tied to production agriculture," Baldosser said.

A short time later, he said, he led an agricultural trip to Eastern Europe.

"I stood on the border of Poland and saw a line of turbines dotting the landscape," he said. "And I thought to myself, why can't we do that?"

When he returned, Baldosser said he looked into the idea and hosted a meeting of landowners that represented about 10,000 acres in Adams Township where they learned about wind possibilities.

He and others continued investigating for a few years.

"It became very apparent what the benefit was to the community beyond the landowner," he said. "There was tax revenue for schools and libraries. It was non-discretionary, non-tax-based revenue coming into the county. And nobody had to give up farm ground."

Between 2008 and 2011, he said more and more people showed interest.

"As the conversation grew from that, we really gained a lot of steam and people were just always calling and wanting to get involved," he said. "That's why we have multiple projects being [illegible] here in Seneca County."

In 2010, Baldosser said there were six different developers signing leases with landowners for wind projects.

"Truly, the discussion was serious right from the get go," he said. "That's the history of how we got to 18 months ago. And then 18 months ago, a group of individuals started to vocally oppose the wind projects."

Commissioner Shayne Thomas, who supports leaving the AEZ in place, said the wind farms are an agreement between private parties.

"Our job is to stay out of the way of economic development," Thomas said.

"There's a significant number of acres that have been signed up in leases and paid for almost a decade," he said. "Those leases are between a private individual and a private company. The county isn't building them. The state isn't building them. A private company is building them and a private individual has agreed to lease their land."

Thomas said the wind projects will bring extra money to the county it wouldn't otherwise receive.

"I look at how government funds have been cut from villages and schools," he said. "There's just no place else to get this money other than to generate it locally."

If there were other economic development possibilities, Thomas said local officials would pursue them.

"It's not like we're not trying to identify those opportunities," he said. "The fact is this is what's available in the rural areas."

Also, he said wind power is compatible with agriculture, the county's largest industry.

"That's why farmers and landowners sought this opportunity out," he said. "They didn't have to stop farming and helps diversify the farm income."

Next: The two sides of property rights.

Points of view

Wind turbines — among tallest structures in Ohio — would be visible from most of county

By Vicki Johnson
Staff Writer
vjohnson@advertiser-tribune.com

Opinions vary widely on whether wind farms are a good fit for Seneca County.

No matter which side an individual chooses — or no side at all — if wind turbines are erected in the county, some would be 652 feet tall and others would be 500-plus feet tall, making the local wind turbines the tallest in Ohio and the second-tallest in the United States.

This is the third story in a series about proposed wind farms and how they affect Seneca County.

Two proposed wind farm projects are in the works in Seneca County — Seneca Wind Farm and Republic Wind Farm. Plans have changed for a third wind farm, Emerson Creek, which no longer plans turbines in Seneca County but is proposed for Huron and Erie counties along the eastern edge of Seneca.

If approved, the proposed projects would place wind turbines in the eastern part of the county designed to generate electricity using wind power. Each of them is in a different stage of requesting a certificate from the Ohio Power Siting Board that would allow construction to begin.

To put turbine height in perspective, consider these comparisons.

The well-known Perry's Victory and International Peace Memorial on Put-in-Bay is 352 feet tall, a little more than height a turbine.

Davis Besse Nuclear Power Plant on Lake Erie is 493 feet tall.

The tallest building in Columbus is 624 feet tall.

Turbines would be 5.2 times taller than the Seneca County Justice Center and 3.6 times taller than the steeple at St. Joseph Church.

Turbines in Van Wert and the western part of Ohio are 400-some feet tall.

Because of the height of the turbines, the "viewshed" — or the area from which the turbines could be seen — would include most of the county and parts of other counties (see map).

The accompanying map from APEX has a color-coded legend that shows the numbers of turbines that would be seen from a 10-mile area around the wind farm sites.

One example of large numbers of turbines being see is at Sorrowful Mother Shrine, 4106 SR 269, Bellevue, where it's estimate people would be able to see turbines from both projects totaling more than 200, said Greg Smith, a Bloom Township resident and spokesman for Seneca Anti-Wind Union

As another example, Smith said people in Bascom would be able to see between 136 and 180.

Numbers of turbines that may be seen depend on the flatness of the ground and objects that might limit visibility.

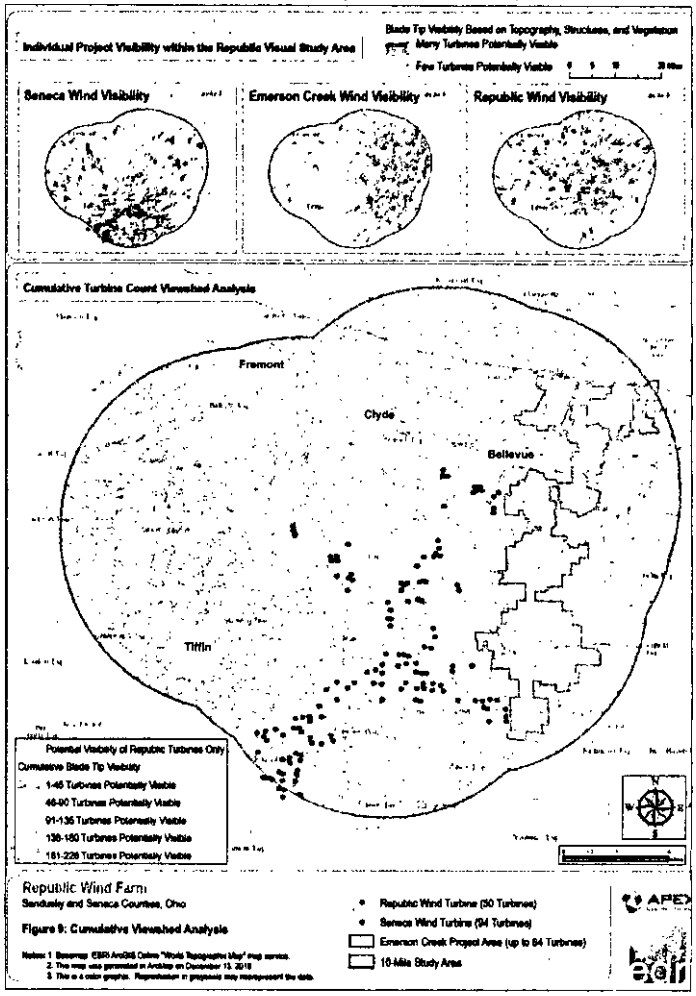
Energy needs

Whether it's seen as positive or negative, the viewshed is one aspect that makes the wind farms a countywide issue.

Other countywide wind-related issues are economic development and financial considerations (discussed in an upcoming story).

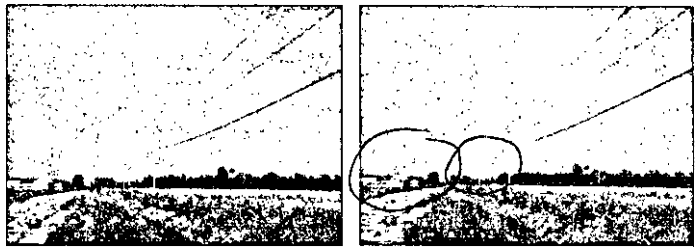
And a third viewpoint is a positive one in which people envision turbines blades turning and adding electricity to the country's power grid.

No matter how individuals see them, the look of rural Seneca County would change, particularly on the eastern side.

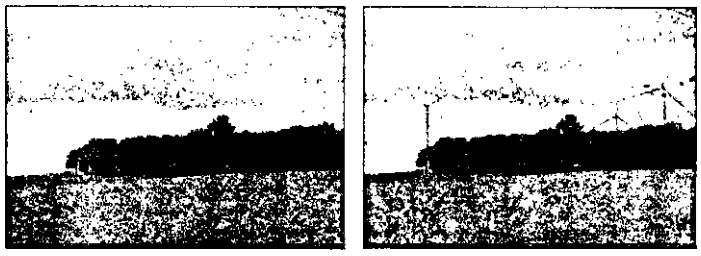


IMAGES BY APEX ENERGY

This map indicates how many turbines from the proposed Republic Wind, Seneca Wind and Emerson Creek projects would be visible from within 10 miles of wind farm sites. The cities of Tiffin, Fremont, Clyde and Bellevue have been labeled for clarity.



These images show the existing view from East TR 44 east of TR 75 in Pleasant Township (left) and a simulation of how wind turbines would be visible from that vantage point (right). Turbines barely are seen above the barn and between utility poles in the image at right.



These images show the existing view from CR 113 and CR 29 in Sandusky County's York Township (left) and a simulation of how wind turbines would be visible from that vantage point (right). The turbines are obvious in the image at right.

From the wind company perspective, Natasha Montague, public engagement manager for Apex Clean Energy, said there are positives.

"Some people complain about the way turbines look, while others find them beautiful," she said. "Ultimately, both are subjective claims, but communities that host wind farms have experienced increases in tourism because of the renewable facilities."

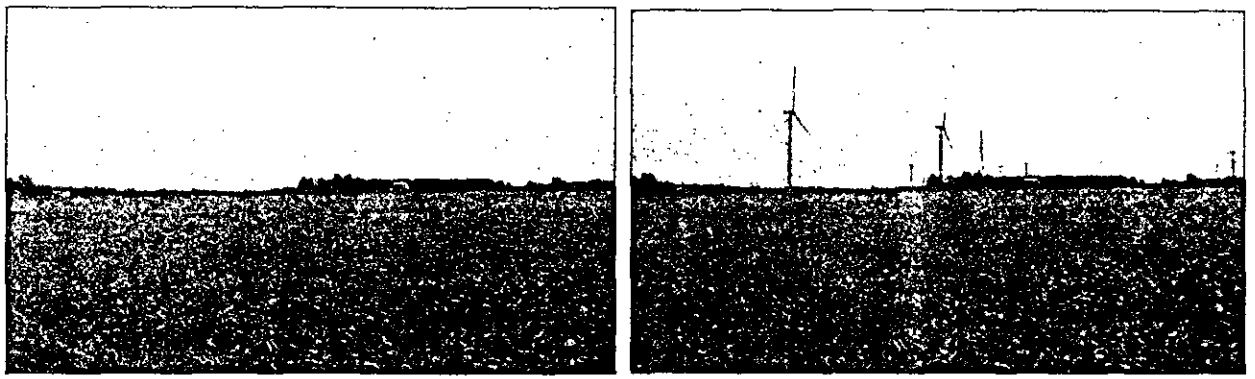
She said there is a form of tourism based around looking at wind turbines, and some people travel to wind farms around the country to enjoy the view and take scenic pictures.

Dan Williamson, spokesperson for Seneca Wind, said wind farms represent change.

"Some people have said they do not like the look of the turbines," he said. "For some, the project represents change, which takes getting used to for any community However, wind farms are a common sight in rural areas throughout the world and people live happily and healthily among them."

Seneca County Commissioner Holly Stacy said there's a need for diverse types of energy resources to be added to Ohio's portfolio.

■ *please see* VIEWSHED, 8C



These images show the existing view from East TR 148 east of North CR 43 in Adams Township (left) and a simulation of how wind turbines would be visible from that vantage point (right).

Viewshed

■ *from page 1C*

"We all have one thing in common," she said. "We want that light switch to work when we turn it on and that outlet to work when we plug something in.

"We want to make sure you and I and future generations have that power," she said. "This is one way Ohio is addressing that."

Stacy said she looks at wind farms as Seneca County doing its part to meet that goal.

"There might be more than one reason (landowners) chose to sign lease agreements," she said.

One of the landowners and farmers with a lease is Gary Baldosser, who sees wind turbines as a need for producing electricity everyone needs.

"Nuclear plants are not receiving their operation license renewals," he said. "Davis Besse is closing down. Where is that deficit going to be made up?"

He said the entire country needs more power-generation options.

"Our society is more and more dependent on electricity," Baldosser said. "Where are we going to generate the power for that need? The need is greater is highly populated areas than it is in areas with low population density."

Baldosser said electricity can be moved only so far without losing effiiciency.

"The further its moved, the more loss there is and the greater the cost," he said.

For example, he said running a 300-foot extension cord to the end of a driveway to plug in Christmas lights means the electricity at the end of that cord is less efficient that plugging directly into an outlet.

"You have a loss with moving that electricity 300 feet from the source to where you need it," he said.

On a larger scale, he said, that's how the nation's electric grid system works.

Baldosser said he uses an analogy to help understand the grid system. He said he gathered his information from electric companies as he researched the wind farm idea.

"We have 55-gallon drums of electricity sitting in various parts of the county that communities use to get their power from," he said.

In his example, if Chicago has a heat wave and everybody turns up their air conditioners, Toledo and Cleveland send some of their power to Chicago to make up the greater need.

In turn, Cleveland gets some power from New York so everybody continues to have a reliable supply of power.

However, the farther the electricity is moved, the less efficient it is.

Baldosser said that's where the wind turbines strength comes in. Electricity generated would go into the eastern grid and local power needs are drawn from that grid, "but we're not going to plug into the bottom of the grid."

While nuclear plants are either operating or not, Baldosser said wind turbines can be shut down and started much more easily.

"The operators can bring turbines online or take them offline," he said. "If we get to the point where they're not needed, the drums are full, they can be shut down for maintenance. Their efficiency is they are able to go quickly on and off line."

If Toledo has a heat wave and more power is needed, electricity from the turbines can help fill that need.

"If all of a sudden the demand is greater, it's harder to ramp up a coal or gas-fired plant than it is to put more turbines online," he said. "If the drum's running over, it's wasted. If it runs dry, somebody has a brown out."

Viewpoints

On the other hand, turbines would change the view.

"We're setting ourselves up to ruin our scenic landscapes in the county," Smith said. "Some people think they're sleek and cool. I, personally, don't see anything appealing about them at all."

Steve Shuff, an Eden Township resident, said the blades are "as long as a football field, or close to it."

Speaking as a private citizen and not as a common pleas court judge, Shuff said "the viewshed will be unbelievable all over our rural landscape. You're not going to see the rural landscape anymore unless you like to see 652-foot turbines."

He said he's working for the best interests of the county.

"It would be easier for me to not do anything," Shuff said. "But I think these will ruin the rural landscape of our county.

"I believe in the future of Seneca County and I believe this is one of the worst things that can happen to Seneca County," Shuff said. "Industrial wind turbines are not what we need in our county and I think in the long run they will be very detrimental to our county.

"My vested interest is not money," Shuff said. "I'm in this for my children and grandchildren. And for my neighbors. I don't want to sit on my patio and see wind turbines instead of God's beautiful earth."

County Commissioner Mike Kerschner said he's concerned about putting wind farms in an area where 56,000 people live.

"Nobody is against alternative energy, right," Kerschner said. "What it needs to be is in much less densely populated areas than Seneca County."

He said Seneca County is one of the most populated areas that has been proposed for wind farms.

Smith said Seneca Wind is proposing a wind farm of 56,000 acres, but have leases on only 25,000 acres.

"Those are islands within the 56,000 acres," he said. "The rest of the people are unwilling and unknowing and didn't sign leases."

Within that area, Smith said, several turbines in the Seneca Wind plans do not meet state-required setbacks of 1,330 feet from neighboring property lines. He said a proposal would change the setback requirements so they would be measured from a house instead of from a property line, and SAWU is against the change.

Smith said Seneca Wind is requesting waivers from property owners who have not signed easements, offering $500 a year to owners who allow turbines to be placed within the setback area.

Overall, several opponents were concerned there would be more wind projects in the future, while people in favor of wind projects look forward to their expansion and the economic benefits they bring with them.

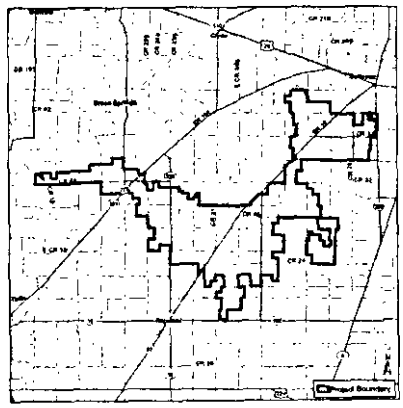
Notice of Proposed Major Utility Facility (Wind Farm)

FACILITY DESCRIPTION

Republic Wind, LLC filed an application on February 2, 2018 for authority to construct, own, and operate the Republic Wind Farm, a 200 megawatt (MW) wind-powered electric generation facility, Republic Wind Farm to be located in a rural portion of Seneca and Sandusky Counties, Ohio. On December 26 and December 27, 2018, Republic Wind filed an amendment to its application, which reduces the project area from approximately 35,000 acres to 24,000 acres of leased private land in Adams, Pleasant, Reed, Scipio, and Thompson Townships (Seneca County) and York Township (Sandusky County). The wind farm will consist of up to 50 wind turbine generators, along with access roads, electric collection cables, a substation, a laydown yard for construction staging, an operations and maintenance facility, and up to two meteorological towers. The nameplate capacity rating of these wind turbine generators ranges from 4.2 to 4.5 megawatts, depending on the final turbine model selected. The total generating capacity of the wind farm will not exceed 200 megawatts. Construction of the project is projected to begin in 2020, with projected commercial operation beginning in 2020.

LOCATION AND GENERAL LAYOUT

The general location and planned project layout of Republic Wind Farm is shown on the map below:



APPLICATION NOW PENDING

Republic's Application as amended is pending before the Ohio Power Siting Board. The assigned docket number for the Application is Case No. 17-2295-EL-BGN, and copies of all filings in the case can be located at the Ohio Power Siting Board website at (http://www.opsb.ohio.gov) by scrolling down to "Pending Cases" and selecting the case by name or docket number. To view the filings, click the case number for the case record.

PUBLIC OFFICIALS SERVED WITH COPIES OF THE APPLICATION

The following public officials were served with a copy of the Amended Application: Dave Carrothers, Bret Cleveland, Bill Frankart, Adams Township Trustees; Douglas Stacy, William Biller, David Kingsborough, Pleasant Township Trustees; Charles Miller, Gerald Miller, David Wright, Reed Township Trustees; Brad Bowerman, Jason Burkholder, Rodney Miller, Scipio Township Trustees; David Ziegler, Steven Swartz, Troy Warner, Thompson Township Trustees; Holly Stacy, Mike Kerschner, Shayne Thomas, Seneca County Commissioners; Mark Zimmerman, Seneca County Engineer; Joe Steyer, President of the Seneca Soil & Water Conservation District; Holly Stacy, Board President of Seneca Regional Planning Commission; Douglas Keegan, Norman Patten, Howard Watson, York Township Trustees; Sandusky County Commissioners in c/o Theresa Garcia, County Administrator; James R. Moyer, Sandusky County Engineer; and Chairman Dave Warner, Sandusky County Soil & Water. A copy of the Amended Application is also available for public inspection at the Tiffin-Seneca Public Library, 77 Jefferson Street, Tiffin, Ohio 44883 and the Birchard Public Library of Sandusky County, 423 Croghan Street, Fremont, Ohio 43420.

OHIO POWER SITING BOARD APPLICATION REVIEW CRITERIA

Pursuant to Ohio Revised Code Section 4906.10(A) the Ohio Power Siting Board shall not grant a certificate for the construction, operation, and maintenance of a major utility facility, either as proposed or as modified by the Board, unless it finds and determines all of the following: (1) The basis of the need for the facility if the facility is an electric transmission line or gas pipeline; (2) The nature of the probable environmental impact; (3) That the facility represents the minimum adverse environmental impact, considering the state of available technology and the nature and economics of the various alternatives, and other pertinent considerations; (4) In the case of an electric transmission line, that the facility is consistent with regional plans for expansion of the electric power grid of the electric systems serving this state and interconnected utility systems and that the facility will serve the interests of electric system economy and reliability; (5) That the facility will comply with Chapters 3704., 3734., and 6111. of the Revised Code and all rules and standards adopted under those chapters and under Sections 1501.33, 1501.34, and 4561.32 of the Revised Code. In determining whether the facility will comply with all rules and standards adopted under Section 4561.32 of the Revised Code, the Board shall consult with the office of aviation of the division of multi-modal planning and programs of the department of transportation under Section 4561.341 of the Revised Code; (6) That the facility will serve the public interest, convenience, and necessity; (7) In addition to the provisions contained in divisions (A)(1) to (6) of this section and rules adopted under those divisions, what its impact will be on the viability as agricultural land of any land in an existing agricultural district established under Chapter 929 of the Revised Code that is located within the site and alternative site of the proposed major utility facility; rules adopted to evaluate impact under Division (A)(7) of this section shall not require the compilation, creation, submission, or production of any information, document, or other data pertaining to land not located within the site and alternative site; and (8) That the facility incorporates maximum feasible water conservation practices as determined by the Board, considering available technology and the nature and economics of the various alternatives.

STATEMENT PURSUANT TO OHIO REVISED CODE SECTION 4906.07

Upon the receipt of an application complying with Section 4906.06 of the Revised Code, the Ohio Power Siting Board shall promptly fix a date for a public hearing thereon, not less than sixty nor more than ninety days after such receipt, and shall conclude the proceeding as expeditiously as practicable. The public hearing for this case shall consist of two parts:

(1) A local public hearing, pursuant to Section 4906.08(C), Revised Code, where the Board shall accept written or oral testimony from any person. The local public hearing date is **Tuesday, May 14, 2019 starting at 5:00 p.m.** and continuing until **9:30 p.m.**, at Bellevue High School, 200 Oakland Avenue, Bellevue, Ohio 44811.; and,

(2) **The date for the adjudicatory hearing has been scheduled for Monday, June 3, 2019 at 10:00 a.m.**, at the offices of the Public Utilities Commission of Ohio, 11th Floor Hearing Room 11-A, 180 East Broad Street, Columbus, Ohio 43215-3793.

The chairman of the Ohio Power Siting Board shall cause each application filed with the Board to be investigated and shall, not less than fifteen days prior to the date any application is set for hearing, submit a written report to the Board and to the applicant. A copy of such report shall be made available to any person upon request. Such report shall set forth the nature of the investigation, and the report shall contain recommended findings with regard to division (A) of Section 4906.10 of the Revised Code and shall become part of the record and served upon all parties to the proceeding.

STATEMENT OF OHIO REVISED CODE SECTION 4906.08(C)

The Board shall accept written or oral testimony from any person at the public hearing, but the right to call and examine witnesses shall be reserved for parties. However, the Board may adopt rules to exclude repetitive, immaterial, or irrelevant testimony.

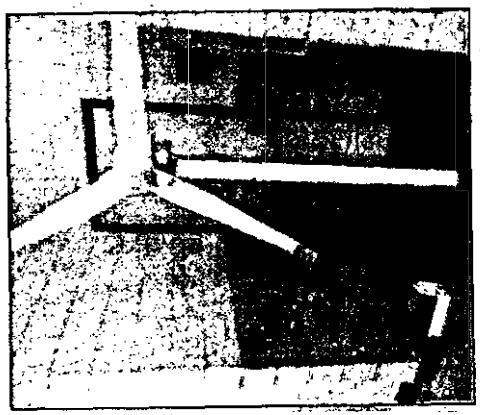
The Erie County commissioners at the Emerson Creek wind turbine project, L. to R., Pat Sheaiga, Matthew Old, Stephen Shoffner.

On Tuesday, February 26 over 325 people assembled at the Bellevue Elementary School to meet with the three Erie County Commissioners. The meeting was held to discuss the pending Apex Clean Energy's Emerson Creek Wind Project. Specifically, all were present to discuss whether the commissioner's should give approval to the PILOT program that Apex was requesting.

The PILOT program would allow for Apex to provide payment in lieu of property taxes. The commissioners made clear that their only authority regarding the wind turbines was the ability to vote on this one issue. The decision on approving the Emerson Creek Wind Project is not the purview of local official, or voters, and will be decided later by the Ohio Siting Board.

Nate Pedder, Project Developer for Apex, was the first guest to speak. He spoke in favor of granting the Pilot program for the proposed Emerson Creek Wind Project in Erie and Huron counties. The project could have up to 71 wind turbines. Nate did acknowledge that financially the PILOT would be a "wash" regarding tax collection but discussed other possible benefits of the program.

See Wind Turbines / Page 86



1/64 scale to 591 foot wind turbine comparison to the scale barn. Do you see the cows?

Wind Turbines from Page A1

Of the next 19 speakers, 18 were opposed to granting the PILOT program with one supporting it. The speakers were composed, some with numerous studies and facts, others spoke of the emotional toll the wind turbine project was taking on themselves, their neighbors and their community. The county commissioners throughout the evening were clearly diligent in listening carefully to all the speakers. The speakers were politely received by the large crowd. Some with big applause, some with good humor, and others with a hint of sadness regarding their experiences.

One of the most applauded speakers was Lori Riedy, who owns Russell's Garden Center on State Route 269 N. Lori addressed the Karst issue. Karst is characterized as an underground drainage systems with sinkholes and caves, according to Wikipedia. According to Riedy her business is located directly on a Karst shelf. She stated, "it has been documented that Bellevue has the largest sinkholes in the state of Ohio by perimeter, area and volume."

Lori went on to mention the serious flooding that has occurred recently in the southern area of Erie County. She claims, "I believe that with the amount of excavation that is required for these 655' turbines, the size, the weight and drilling could collapse all these natural drainage areas...with high possibility of contaminating our wells..." Reidy concluded her presentation to the commissioners with "...our neighbors and friends are depending on you to protect the integrity of this very unique area that we call home."

Other speakers spoke of "a forest of wind turbines", "schools have withdrawn their support", "residents have just found out recently the full details (of the wind turbine projects)", "only .37 miles of road work will be paid by Apex", "we don't know what will happen", "our landscape will change forever", "we have to follow the zoning rules; Apex doesn't." These comments are a sampling of the many that were addressed to the commissioners.

A couple comments that were strongly supported by the crowd included "no turbines of this height are in existence in the United States" and Apex does "threats and fear mongering." The lone speaker for the turbines stated, "we have to start doing better with our environment...and the anti-wind group is not presenting alternatives."

The commissioners had up to 30 days to vote on the PILOT request by Apex. But it was evident by their comments after hearing their constituent's thoughts and

Large crowd at the Bellevue Elementary School to dicuss with Erie County Commissioners the Emerson Ceesk wind turbine project

according to Commissioner Old "there is no advantage to the PILOT program" that they were ready to vote. That evening, too much applause, the three commissioners, two Republicans and one Democrat, unanimously voted to not provide approval.

According to Dalton Carr, Apex Development Manager, "it is not what we expected". However, Carr also stated "we will continue to move the project forward." Chris Aicholz, a leader in the local anti-wind turbine movement stated, "we are pleased to see the outcome of the special Erie County Commissioner's meeting tonight." Chris continued with "Since Erie County did not have an Alternative Energy Zone in place, the decision to grant or decline the PILOT was made locally..." According to Aicholz "The Anti-Wind opposition continues to gain momentum throughout the state."

ATTIC Hab 5/7/19

Letter to The Editor

Seneca Wind Project

Attica Residents – While the S Power Seneca Wind project seems to be "on hold" for a couple months, the Apex Republic Wind project for our neighbors in Adams, Pleasant, Reed, Scipio and Thompson Townships (Seneca County) and in York Township (Sandusky County) is coming to a head. This project will consist of between 44 and 47 turbines depending on which turbine model is used. Their maximum total height will be anywhere from 591 feet to 602 feet - rotor diameter from 476 feet to 492 feet (split that in half for each one of the three blades). The tentative delivery route is listed as "either from the northwest by way of Interstate-80/90 (I-80/90;Ohio Turnpike) to State Route 53, then U.S. Route 20 (primary route) or from the northeast by way of I-80/90 to State Route 4 then State Route 269 (alternate route)." While Route 224 may not be directly affected, if this project is approved, we will still have multi-axel trucks carrying turbine components, cement trucks, gravel trucks, etc. all causing traffic congestion in our area. The Ohio Power Siting Board Republic Wind public meeting is scheduled for May 14th from 5 p.m. to 9:30 p.m. at the Bellevue High School, Cafeteria, 200 Oakland Avenue, Bellevue, Ohio. This meeting gives residents who live in the footprint of the project a chance to voice their concerns. The adjudicatory hearing will be held in Columbus on June 3, 2019. The Board's decision will be released sometime after that.

Our county and the surrounding counties are being besieged by these wind power companies – Apex has submitted an application for another project, Emerson Creek, which is projected for portions of Erie & Huron counties. Do we want our rural farmland converted into miles of Industrial Wind Turbines?? Who would want to purchase a property with red flickering lights on over one hundred 570 to 602-foot wind turbines lighting up the local sky at night? To learn more or to voice your comments on these projects "Google" the Ohio Power Siting Board website. The case number for Republic Wind Project is: 17-2295-EL-BGN.

The case number for the Seneca Wind Project is: 18-0488-EL-BGN. Check the wind power companies' applications – they make for time consuming, but interesting reading!

Richard & Gail Miller, Attica, Ohio

LETTERS

Adver. 1 x 16 – 5/7/19

TIME TO TALK WIND TURBINE SETBACKS

Per Ohio law, industrial turbines in wind projects must be set back a certain distance from neighbors who are not part of the project. Each year, turbines used in new projects are getting bigger and bigger, from 250 feet tall a dozen years ago to about 600 to 650 feet today. That is as tall as the tallest building in Columbus.

In 2014, Ohio's Legislature increased the setbacks by a marginal amount because of the increasing size of turbines. This caused a stir in the wind energy industry and it since has said repeatedly the change has shut down all wind development in Ohio. That is an odd thing to say considering there are currently three wind projects under development in our area alone.

Nevertheless, the wind industry has convinced a few Ohio representatives to introduce House Bill 223, a bill to reduce setbacks to pre-2014 standards in the name of increasing economic development in Ohio. This despite the fact that new turbines are much taller now than 2014. Again I mention, there are three projects in the Seneca County area moving along nicely under current setback rules.

But, even more importantly, the setback issue has very recently taken on an entirely new meaning. April 30, the Ohio Power Siting Board, the branch of the PUCO that oversees energy projects, held a hearing on wind turbine blade failure incidents which heretofore were not required to be reported to regulators. At the hearing, testimony was given documenting several actual blade failure incidents in which fragments weighing several pounds were thrown distances of several hundred feet *farther* than the new, shorter setback from occupied homes proposed in HB 223, and over *twice* as far as current setbacks from the neighbor's property line. A June 2018 Windpower Engineering and Development article states there are an average of 3,800 blade failures globally per year. That is over 10 per day. Wind turbine blade failures have happened and will continue to happen in Ohio.

The wind turbine setback issue addressed by HB 223 is no longer about economic development, it is about public safety. It is good that we are talking about setbacks now because, in the interest of public safety, these wind turbine setbacks need to be *increased*, not decreased. It would be unconscionable for any lawmaker to support HB 223 as it is currently written, or any other legislation shortening setbacks, because it is a documented fact current setbacks already are too short. Economic development that so blatantly puts public safety in jeopardy is not development at all, it is regression. Lawmakers who choose that path would do so at their political peril.

Jim Feasel,
Tiffin

www.advertiser-tribune.com

Opinion

The Advertiser-Tribune

Chris Dixon, publisher cdixon@advertiser-tribune.com
Rob Weaver, editor rweaver@advertiser-tribune.com

LETTER

THE RISKS OF RIPPING OUT THE ROOTS

I reside in central Virginia, where I'm raising three sons with firm Ohio roots. I've had my eye and ear on the wind turbine projects for some time and was actually, initially, for the idea! In fact, the company trying to move their skyscrapers into Seneca County is based out of the town we currently call home. What a kick in the gut.

If I live so far away, why do I care? Why is this important to me? Why does the idea of this coming to fruition pain me to the marrow of my bones? Roots.

The only home I ever knew my dad built with his own hands at the age of 24. He worked hard, saved his money and bought the most beautiful farm down the road from "The Homestead," where my grandparents raised their four children. Under the paint on the red barn, which he also built by hand, lives his writing "J + S = ??" ... the young dreaming of the little feet that would soon chase and play and learn on the fruits of his labor.

My family landed in Ohio after coming to the U..S for a better life and bigger promises six generations ago. We have always been farmers, artists of the land, stubborn and determined. Craving the sight of wheat blowing in the wind while the golden sun sets on its dancing whiskers is in my DNA, and my sons beam with delight and a quiet comfort at the foot of a large green field. They, like their ancestors, are their best selves with their hands in the dirt. My hope is that our jobs will lead us back. My hope is that at least one of my sons will return to our farm for good one day. My hope is to spend my retirement in a rocking chair on the front porch with my own grandbabies to enjoy the crisp fields and perfect view without shadow flicker and spinning metal forcing us inside.

Eden Township is my home and long before these projects were ever known to be a possibility, I would regularly say, "I will let NYC build up around that farm before I'd ever let anything happen to it." And here we are. I never thought the landscape that is burned into my memory could be at risk. The soil, the water, the ecosystem, those among us battling mental health or epilepsy are all under attack. My family collectively refused to sign on the dotted line when the opportunity presented itself because we love this land, this community and our neighbors too much. This will not be a problem that will go away or that we can ignore. Only one building in Columbus is taller than these will be; they will literally be standing and spinning over us 24/7.

Those opposed to the turbines are your farmers, your neighbors, your friends and our hearts are bleeding..I am incredibly for clean/green energy but when you dive into the documents outlining the proposed projects, they are extremely flawed with dubious fine print. We have begged commissioners Holly Stacy and Shayne Thomas to review tireless research and go back to the drawing board to preserve our community, but it's fallen on deaf ears.

I work for a major worldwide company on their field sales team. During our quarterly meetings, we are often challenged to spontaneously "sell" our favorite vacation to the others in the room without revealing the location until the audience votes at the end. To no surprise to those who know me well, I choose Tiffin, Ohio, and begin my pitch. I choose my hometown and sell it not only for the local pizza, ice cream and potato chips, but mostly for the warmth of the people and beauty of the landscape. I often tell people that going home is "like putting a sponge back in water."

I didn't see it until I stepped outside and took my blinders off. Tiffin, Ohio, isn't the norm. Small schools, historic buildings at every turn, flat sprawling landscape, authentic amazing people with long, storied tradition rooted firmly in this space. Rarely will you ever find another town who gives a police escort to the band and cheerleaders on the way to their home football game (go, Senecas). This place is unique and special and I'm so fearful that people aren't going to see it for what it is until the industrial wind turbine train runs us all over.

We are at a fork in the road. We will either see the people of Seneca County be heard and we will continue to benefit from future generations taking over the work of their elders or we will see impossible conditions, decreased land values, and hostility brew and take over like poison.

Warmly and worriedly,

Anna (Feasel) Brooks,
Zion Crossroads, Virginia

VOCAL OPPOSITION CAN DROWN OUT MONEY

Recently, there have been several letters published here emphasizing potential revenue the wind industry could provide local school districts, particularly Seneca East. I appreciate the intent expressed in those letters. But in response, I would like to make clear that opposition to the wind industry does not equal opposition to local education. Indeed, many people who have yellow No Wind Turbine signs in their front yards are the same people who helped Seneca East pass its last levy by an almost 70-percent margin.

Any discussion of the wind industry's potential impact on education locally must acknowledge that in November, the Seneca East Board of Education voted unanimously to intervene before the Ohio Power Siting Board in the Seneca Wind project, siting its "interest in protecting its students and staff from potentially adverse impacts on their health, safety and welfare while at school or participating in school services or programs." The intervention also expresses concern about Seneca Wind's "potential impacts on residential, commercial and industrial development and property values within the District." More recently, Bellevue City Schools withdrew its support of the Apex-owned Republic Wind and Emerson Creek Wind projects.

At the June 5 Seneca County commissioners meeting, I read a letter by Jane Harper, a former commissioner from Tipton County, Indiana, who now regrets her role in allowing the wind industry to enter her county. "You can't lose something you never had," Harper points out, "so you are not 'losing' the supposed 'windfall' of money that the project purportedly brings in. What you *will* lose however, cannot be measured in dollars. You will lose the rural landscape as you know it and you will lose the closeness of 'community spirit' because people will hate each other over this and the presence of the towers will always be a constant reminder of the rift ... thus, the wounds will never heal." These are words from someone who has first-hand experience of the wind industry's impact on her community.

Funding for education is a worthwhile cause, but for schools, there is one thing even more critical than money — and that is students. Six weeks after I read the letter mentioned above to our county commissioners, the Kokomo Tribune ran an article with the headline "Slumping enrollment threatens funding at Tipton schools." This is not an isolated occurrence. In fact, according to a non-profit group from Clinton County, Indiana, every school district in that state where wind farms were constructed has had a decrease in school population. While school enrollment in rural districts is obviously affected by many factors beyond the presence (or absence) of industrial wind turbines, I think these statistics show the Seneca East Board of Education is wise to be concerned about Seneca Wind's potential impact on the district.

Although many local wind leases were signed years before the rest of the community was made aware of the Seneca Wind project, it is now apparent the vast majority of residents who would live within Seneca Wind are opposed to its construction. Even the youngest of children cannot fail to notice the sea of yellow signs that cover so much of this county. If the wind industry continues using school funding to justify overriding the community's vehement objections (including the local board of education's unanimous opposition) I fear the message to our youth is that it is OK to ignore your neighbors' concerns as long as you receive enough money while you are doing it.

It is my hope our children instead will learn other lessons from the wind industry's foray into Seneca County. Rather than holding up money as the "end all, be all," I hope the current debate teaches that neighbors and friends can share good intentions even when they find themselves on opposite sides of an issue. And when the wind industry finally leaves Seneca County, I pray our children will look back on this chapter and recognize there is value in each individual voice. Joined together, I am confident those voices will ultimately prove that neighbors who are smart, engaging and passionate in their advocacy of their families and their community can create a chorus more powerful than any amount of money.

Charles Groth,
Bloomville

Sources:

Seneca County Board of Elections data, accessible online at seneca.ohioboe.com

"Memorandum in Support of Petition for Leave to Intervene of the Board of Education of Seneca East Local School District," filed with the Ohio Power Siting Board Nov. 15, 2018, in Case No. 18-0488-EL—BGN

Full text of Harper's letter is available at edgarcountywatchdogs.com/2015/03/meet-jane-harper-board-member-who-regrets-voting-pro-wind/

"Slumping Enrollment Threatens Funding at Tipton Schools" July 28, 2018, accessible online at www.kokomotribune.com

"The Truth About Education and Industrial Wind" by Responsible Harvest of Clinton County Inc., accessible online at www.responsibleharvest.com

WIND FARMS AND STINKY FARMS

On the west side of Seneca County there is a huge landfill, run by a company called Sunny Farms, only as it turns out, it has become "stinky farms." This started as a local landfill that has now changed hands several times. It now takes out-of-county and out-of-state waste, including building materials which when decomposing, produces out-gassing that smells like rotten eggs. What does this do to the quality of life, health and property values to nearby residents? Did the landfill owners tell people in the vicinity what effects this would produce, before they took on this project? The answer would be, of course not.

Are the out-of-state people pushing for wind farms, or are they only telling them about a way to make more money from their land? Only by attending area meetings, getting information from research gathered from places already having gone through this experience, and reading scientific information have we come to the conclusion that wind farms are not the right answer for rural Seneca and surrounding counties. In fact, they may not be the solution to the energy question at all. Remember the "flavor of the week" when it was all about nuclear power plants for energy?

The subjects seem somewhat unrelated, but in the cases mentioned above, big corporations are trying to "dump" on areas far away from where they are headquartered. Let's learn a lesson from "stinky farms" and not create another problem with "windy farms" without a lot more research.

One opinion we read lately suggests that you should be able to do with your land what you want. We agree wholeheartily with this concept, *except* when what you do on your land has an adverse effect on the rest of us. We would imagine, that is why there are agencies, zoning laws and EPA regulations that tell us we have to do certain things and are not allowed to do others on *our land*, because it might have negative results on the lives of others or our world environment in general.

Let's learn from the problems that have resulted from the landfill site. Let's use a lot more discretion now and in the future about what we allow to happen that could or would harm the health and welfare of others. Let's look into solar power and goethermal energy, if we are looking for renewable energy sources. Let's not be sold a bill of goods. We need to be sure we are always vigilant and get all the facts *before we jump in to a "quick fix!"* If it sounds to good to be true, it probably is.

Caring grandparents,

Fred and Kay Zirger,
Tiffin

WALK YOUR DOG

January is National Walk Your Dog Month, and if you haven't already, it's a great time to start a healthy new habit with your canine companion.

Daily dog walks are part of being a responsible guardian, and they're vital to dogs' health and happiness. They're a great bonding opportunity for you and your canine companion—and they provide exercise and stress relief for the one holding the leash, too!

Walks not only help dogs stay in shape, they also provide much-needed mental stimulation and social interaction from investigating new smells, sights and sounds, and meeting other people and dogs along the way.

Be sure to use a comfortable harness (never a painful choke or prong collar) and keep young, elderly and small dogs warm on winter walks by bundling them in sweaters and booties. Afterward, clean off dogs' feet, legs and stomachs to remove salt and other chemicals that can sicken them. And remember, it's their walk, so give your pup plenty of time to stop and sniff the "news" on the trees and fire hydrants.

For more tips on caring for canine companions, visit www.PETA.org.

Sincerely,

Lindsay Pollard-Post,
The PETA Foundation

How to submit a letter:

Mail it to:
The Advertiser-Tribune
PO Box 778
Tiffin, Ohio 44883

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Letter policies:

Letters should be limited to 400 words. A letter must include the writer's name, address and telephone number. Phone numbers are not published, but are used for verification. Letters may be edited for length, grammar and newspaper style.

DECIDING CORRECTLY ON SENECA WIND PROJECT

Others have said the Seneca Wind project should not be built for a variety of reasons, among these being the heavy financial cost to agriculture and the environmental toll that will occur by the killing off of bat populations that are a proven result of wind turbines; the dangers to underground aquifers shown to be at risk by Ohio EPA maps; the hazards to the American eagles that are attempting to re-establish in the area; and, due to the large and dispersed population of Seneca County, the proven and possible negative effects on the health of a great number of people who must live close to the turbines.

Let me state that I agree with those arguments, but the reason I would like to bring forth for the project's approval to be withheld has to do with the particular company that has applied to build it and the tactics that have been used in developing it. This project has been through three different companies so far in its development, first John Deere Renewables, then Exelon and now sPower. This project has a history of strong-armed and intimidating tactics. In my particular case, I was mislead and intimidated into signing a setback waiver. The only reason I considered signing such a contract was to enable my brother to have a turbine on his property adjacent to mine, even though I objected to it. I felt it my duty to end the brother-against-brother conflict that Exelon had initiated. The reps from Exelon mislead me into signing a contract that was more extensive than was needed to help my brother and which allows a turbine to be sited on another neighbor just a few feet from my property line and very close to my house. When sPower bought out the project, I informed them of how I was treated, but they refused to allow the contract to be modified. On top of that, they withheld payment to me that was specified in the agreement. I had to threaten them with a lawsuit before they decided to pay.

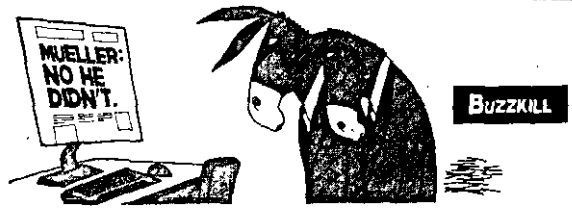
In conversations on the subject, I have learned many other leaseholders wish they had never become involved with sPower. I would estimate a full one-third of those holding agreements with sPower would rather not be a part of the project now that they know the size and scope will be far larger than they were ever lead to believe by land agents. About one-fourth of the sPower contracts have expired, according to the terms of the leases, and a majority of these leaseholders (many whose property would host turbines) have publicly stated they would not be renewing. sPower has used gray-area legal tactics to keep the legals in force against the wishes of these landowners, most of whom do not have the resources to hire attorneys to fight a multi-million dollar corporation such as sPower.

This is the kind of company that the Ohio Power Siting Board is considering to grant a construction certificate based on the story that sPower is putting forth and the promises it is making. sPower has demonstrated in many ways to many people in Seneca County the kind of tactics they are willing to employ. The fact that they are buying full-page ads in the newspaper, cozying up to local officials, and belong to organizations that lobby state officials for their purpose is a thinly veiled attempt to hide how they treat people in the course of their business. With the larger-than-normal (for a wind project) population that will live near their larger-than-ever turbines, the experiences in other projects says many people will have issues after the project is built. Given the proven negative history of sPower in dealing with the local people, there is little doubt that ignoring and intimidating followed by the purchase of positive PR spin will be their method of dealing with such issues.

If wind energy is really to be the savior of our climate that its proponents claim, then the negativity caused building of a project in a highly populated area by a company that has demonstrated its willingness to abuse surrounding people will only serve to work against that goal. The combination of a heavy and dispersed local population and a company with a history of thuggish tactics will work against any lofty stated goals that the state of Ohio may embrace in its energy policy.

I would certainly hope the OPSB considers this part of the big picture when making its important decision.

Jim Hoffert,
Bloom Township



JOURNALISM IS DEAD

Saturday, The Advertiser-Tribune ran a front-page article telling readers that the discredited website, BuzzFeed, had anonymous sources alleging President Donald Trump obstructed justice. But special counsel Robert Mueller issued a statement at 7:30 p.m. Friday that said BuzzFeed's story was not accurate.

Surely you must know that every time The A-T prints inaccurate or unverified stories, you damage your reputation and that of the entire press. Or perhaps the ends justify the means?

Thursday, we found out (but not from The A-T) that before it was used by the FBI as a basis to spy on the Trump campaign, Mueller's hit men knew the Steele dossier was unverified and funded by the Clinton campaign. Did BuzzFeed release its story Friday to distract from that damaging fact?

But the already disgraced Mueller team had to refute BuzzFeed to try and say what little of its stature remains and avoid a leak investigation (where Mueller's team would be subjected to lie-detector tests).

The A-T's reporting on matters regarding Trump continues to be one-sided and shoddy at best. To wit: Who murdered Seth Rich? Where is Josef Mifsud? Who is Stefan Halper? Who is Elizabeth Dibble? Who is Felix Sater?

Why were the DNC email servers not examined by the FBI when they were supposedly hacked? Why the kid-glove treatment when investigating Hilary Clinton's illegal email server? Why was Gen. Michael Flynn set up by the FBI? Who authorized operation Crossfire Hurricane? Why was U.N. Ambassador Samantha Power abusively unmasking the identities of US citizens? Why is Zanab Ahmed on Mueller's team?

Why did Alexander Downer deliver intelligence to the U.S. embassy rather than his own Australian embassy? Why did the perjurous DNI James Clapper try to fire NSA Chief Michael Rogers? Why did Susan Rice write her inauguration day memo? Why did Mueller personally deliver 10 grams of highly enriched uranium to Russia? Why is the press conspiring in the coup d'etat against Trump?

The answers to these questions apparently don't comport with the agenda of your press cabal. Thus, neither The A-T nor The Associated Press will solve them. Americans deserve better. Journalism is dead.

Bruce Guzowski,
Tiffin

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LETTER

IS BIG WIND JUST ANOTHER FACE OF BIG OIL?

Much is said and repeated about wind turbines being necessary because of the evil effects of Big Oil on the environment from drilling, fracking, pollution, supplies running out, etc. But are wind turbines being touted to relieve our dependence on Big Oil or to get us further addicted?

Until recently, almost all electrical generation was being fueled by coal and nuclear, with a small amount of natural gas for peaking during the time of day when load is the greatest. So even though Big Oil produces all the natural gas, it was a bit player when it comes to electrical generation.

But then two things happened over a relatively short period of time. One was the wind turbine fad catching hold and the second was fracking, which greatly increased the available supply of natural gas. Since it is difficult to export, the huge supply of gas sent prices for it plummeting. Big Oil was not going to capitalize on its new *treasure unless it* could find a new market, and it had to be a big one.

Few people realize the output from wind turbines is very inconsistent; sometimes they produce a lot, sometimes a little, sometimes none. This effect is not completely overcome even if turbines over a large area are viewed as a single source, because there is a limit on how far you can send electricity and weather systems tend to be very large. The output can vary rapidly, and another form of generation has to be ready to fill in the gaps immediately. Coal and nuclear generators cannot adjust their outputs quickly enough to do the job, but single-cycle natural gas generators are well suited for this. So the net effect of installing more and more wind turbines on the grid is to require more and more of the remaining generators to be converted to gas (and away from coal and nuclear) so they are ready to back up the intermittency of wind turbines.

Wind turbines produce electricity on average about one third of what they would if *they ran* continuously at full power. If Big Wind is successful in covering the planet with turbines as it proposes, then it will necessitate natural gas filling in the dips in output. The net effect is the defacto takeover of two-thirds of our electrical generation by Big Oil, which produces the gas.

What could possibly go wrong at that point? Well, because fracking causes problems and natural gas is a limited resource, Big Oil could decide to decrease production and *let the price rise dramatically.* Economical batteries with only a few hours of capacity at grid scale are decades in the future. Since no other source exists to back up wind turbines then the price of electricity would go *through the roof if the price* of natural gas rises significantly. We could end up with affordable electricity only being available intermittently, with very high surcharges if you want power at times when the wind isn't blowing sufficiently.

It is not uncommon these days to see news articles about how Big Oil is finally acknowledging how great renewable energy is and making big investments in it. Perhaps the real reason for them to promote intermittent output renewables is so they can take over two-thirds of a market that they previously had little participation in.

So, when you hear someone saying we have to build more wind turbines to get away from evil Big Oil, remember what is really happening. Big Oil's marketing genius has co-opted the Big Wind movement for their own expansion and profit.

If wind energy was consistent and reliable as some believe then this would not have been possible. Whether you realize it or not, to be pro-wind is to be pro-Big Oil. It's time to recognize which side of this the Koch Brothers are really on.

Jim Feasel,
rural Tiffin

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LETTER

WIND TURBINE MISCONCEPTIONS

In a recent A-T article about wind turbines, Gary Baldosser was quoted at some length describing how turbines work to provide power. Unfortunately, his description left some hefty misconceptions in the minds of readers who are unfamiliar with the subject.

When Baldosser states that wind turbines' "efficiency is that they are quickly able to go on and off line" and if we need extra power it is easy to "put more turbines online," it leaves the impression that wind turbines are turned on and off with a switch and that the wind is always there to use at a moment's notice. This is just not the case.

In real life, the variable wind only blows enough for the turbines to generate one third of the electricity they could if they ran full power all the time. And, as every reader knows, the wind blows when it wants to, not when you want it to. In real *life, the turbines* are seldom if ever "switched off" if they happen to be turning. The wind companies are loathe to do so because they do not want to lower their average output to even less than one third.

The intermittent output of turbines is one of their big downfalls. Some people like to say that it's not a problem because they are connected to the grid and some other generating source will fill in the gaps. Currently, the only reliable source of power that is always ready to ramp up at a moment's notice is certain kinds of natural gas generators. In the end, they will generate the two-thirds of the electricity that the turbines were suppose to provide but can't because of variable winds. If you like the fracking that enables the supply of natural gas, then you will love having more turbines. And, because of the physics involved in using gas as a backup, the inefficiencies cause as much or more gas to be used in backing up wind turbines as would be used in more efficient full-time gas generators making all the electricity and not building any turbines in the first place. That is why wind turbines do not save on CO2 emissions. And remember, whenever you read that "wind energy is *now the cheapest form of electricity" the* cost of backing it up when the wind slows is not included in that price. Intermittent electricity has little value to you as the end user.

But what about batteries, you say? Baldosser's 55-gallon drums sound like batteries! Giant batteries that could soak up power when the wind blows and then disperse it when the wind slows would be wonderful. But the many stories we read about batteries for such purposes are talking about sometime in the future, if ever. While there are a few installed in California and Australia, they are only capable of storing a few seconds' or minutes' worth of power, and they do so at a very high cost. While there are many storage ideas being researched, there is nothing even close to being developed or deployed that can store the massive amount of electricity needed at an affordable price. Maybe someday, but certainly not anytime soon. If we were to ramp up current battery technology to the required scale, besides being extremely expensive, it would involve many environmental impacts and require moving mountains of earth on a scale even greater than mining coal to acquire the necessary *natural elements like lithium, etc.*

In the end, there is no perfect way to generate electricity without causing some issue. If we think CO2 is the immediate biggest problem, then we should be installing more nuclear plants, as they are the only thing that can generate massive amounts of stable electricity with no CO2. But then people worry about the waste lasting thousands of years. If, as we see in the news, the world is going to end in 10-20 years if we don't stop emitting CO2, then which should be our top priority, the 10-year problem or the 1,000-year problem? It is too bad that we have to let politicians and politician-appointed state agencies sort this all out. Their focus will always be on doing whatever the current fad is to gain votes and collect money. Eventually, they will realize that large number of voters being forced to live near wind turbines will not be happy with their current politicians. At that point, the wind fad will be over, but we will be left to live among the huge flailing armed-machines for decades into the future, while things like solar panels would have had very few effects on surrounding residents.

Some will make lots of money on wind *power and they will be happy. They are the* ones so busily promoting it now. Every fad in history was pushed to its maximum by those making money on it.

Jim Feasel,
Tiffin

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THE ANSWER ISN'T BLOWING IN THE WIND

The new Budweiser commercial shown during the Super Bowl claimed it is powered by 100-percent renewables, which is a fallacy. Did you notice there weren't any homes shown near the turbines? The reality is much different for us here in Seneca County.

We have said numerous times previously that we will have 18 turbines within 1 1/2 miles of our home. We recently found out our situation is even worse. Our home is "receptor" 77 on Seneca Wind's noise and shadow flicker map. Our home ranks No. 5 on the list of homes in the footprint with the most shadow flicker exposure and No. 1 for non-participants at 62-plus hours per year. The allowable standard per the Ohio Power Siting Board is 30 hours for non-participating landowners.

Other people will be making money on these projects, yet we will be bearing the brunt of the negative effects and suffering the consequences. When we bought our 35 acres in 2002 and built our home and dedicated our acreage to nature and wildlife, we never would have dreamed that it would potentially be scarred forever. How can our elected officials ignore this and not help?

The Budweiser commercial included audio from Bob Dylan's song "Blowing In the Wind." The situation with our elected officials is ironic when you listen to the lyrics of the song:

Yes, 'n' how many times can a man turn his head
And pretend that he just doesn't see?
The answer, my friend, is blowin' in the wind
The answer is blowin' in the wind

Yes, 'n' how many times must a man look up
Before he can see the sky?
Yes, 'n' how many ears must one man have
Before he can hear people cry?
The answer, my friend, is blowin' in the wind
The answer is blowin' in the wind

Greg and Janeen Smith
Bloomville

Public hearing set for proposed Seneca Wind Farm

COLUMBUS — The Ohio Power Siting Board has set a hearing for 3-9 p.m. Feb. 19 to allow the public to express views about Seneca Wind LLC's proposal to construct a wind-powered electric generation facility in parts of Seneca County.

The meeting is to take place at Tiffin University's Marion Center, 235 Miami St., according to an OPSB news release.

The proposed Seneca Wind Farm would be constructed on about 56,900 acres of leased private land in Scipio, Reed, Venice, Eden and Bloom townships. The facility would consist of up to 86 wind turbines with a total generating capacity of up to 212 megawatts.

An adjudicatory hearing in this proceeding is to begin at 10 a.m. March 6 at the offices of the Public Utilities Commission of Ohio, Hearing Room 11-A, 180 E. Broad St., Columbus. The purpose of the adjudicatory hearing is to allow formal parties to the case to present testimony and evidence and cross examine other parties' witnesses.

The OPSB has not scheduled a date for a final decision in this case.

For additional information, visit the OPSB website at www.OPSB.ohio.gov and find case number 18-0488-EL-BGN.

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Flicker

from page 1A

studies that talk about infrasound causing physiological problems in the organs," Kerschner said.

"Google the term 'infrasound' to learn more about serious health issues that affect some people including headaches, nausea, dizziness and sleep disorders," Smith said.

Also, there are safety issues when turbines malfunction.

As an example, Aichholz said there is a woman near a wind farm in Van Wert County who had to deal daily with a turbine that wasn't working properly.

"She basically was driven from her home," he said. "A turbine had an issue and it made a sound like a siren."

Another example cited by Smith was debris from a failed blade traveling 1,837 feet, "while our setbacks are 1,338 feet."

Shuff said he found a related concern about ice being thrown from blades, causing danger to residents on the ground.

Another potential issue is ground water contamination, Shuff said, because well water is fairly close to the surface and the depth underground construction crews must go to anchor turbines in the ground.

"Why would you put anybody in harm's way?" Kerschner said. "For the

Quality of life

Homeowners concerned about turbine flicker, noise

This is the fourth story in a series about proposed wind farms and how they affect Seneca County.

By Vicki Johnson
Staff Writer
vjohnson@advertiser-tribune.com

Living with visible shadow flicker in their homes as well as noise — audible and inaudible — are two quality-of-life concerns of residents in eastern Seneca County who would have wind turbines near their property if two proposed wind farm projects are constructed.

Two proposed wind farm projects are in the works in Seneca County — Seneca Wind Farm and Republic Wind Farm. A third wind farm, Emerson Creek, is proposed for Huron and Erie counties along the eastern edge of Seneca County.

"Evidence continues to increase regarding the potential health risks," said Seneca County Commissioner Mike Kerschner.

Shadow flicker is caused by turbine blades passing through sunlight as they rotate high above the landscape, each turbine casting shadows causing a strobe effect from different angles as the sun changes position.

Related to light, each turbine would have a flashing light at the top to make it visible to aircraft.

"At night these are all going to have blinking lights," said Chris Aichholz, a Bloom Township resident and spokesman for Seneca Anti-Wind Union. "It's just very worrisome. There's a lot of things we're really concerned about."

On the list is turbine noise.

Greg Smith, a Bloom Township resident and

for wind turbine noise.

"They recommend that noise levels should be below 45 decibels to avoid adverse health effects such as hearing loss, tinnitus, heart problems and high blood pressure when subjected to extended exposure," he said. On a map, he showed areas where 45-50 decibels are expected and other areas where 50-55 decibels are expected. Some of those areas are around Seneca East school.

Steve Shuff, of Eden Township, said he lives in a corner of the proposed wind farm, and he's concerned about the impact wind farms would have on residents.

Speaking as a private citizen and not as a common pleas court judge, Shuff said he researched noise levels as listed in the application of Seneca Wind to OPSB and found them to exceed the 40-decibel threshold recommendation of the World Health Organization.

Property owners also are concerned about the health effects of infrasound, an inaudible "noise" below the level of human hearing.

"It's low-level sound the human ear doesn't pick up but it's still there," Kerschner said. "It's especially

Attica Village Council

Residents voice concerns about impact of wind projects on roads during installation

By Bonnie Daniel
Correspondent

ATTICA — Venice Township residents Gail and Richard Miller addressed Attica Village Council during its Thursday night meeting. Mrs. Miller recited a letter of opposition to the proposed wind turbines in the vicinity but voiced her concern for another related problem not getting much attention.

After accessing the Ohio Power Siting Board website, she learned the sPower and Republic Wind applications list the roads that will be affected. Final delivery routes have not been determined, but Republic Wind proposes to access I-80/90 from the northeast to SR 4 and I-80/90 from the northwest to SR 53 and US 20. sPower proposes I-80/90 from the northeast to SR 4 and I-75 to US 224 from the northwest. Secondary access roads include SR 162, SR 19 and SR 67 while tertiary roads may be CR 36, CR 16, CR 43, CR 6 and CR 58. Township roads mentioned include 197, 12, 104, 81, 8, 79, 77, 106, 173 and 44.

Both companies' routes may involve road widening, upgrading or replacing bridges or culverts, profile modifications at railroad crossings, raising electric lines across roads, utility pole relocation and tree trimming.

Both companies' routes may involve road widening, upgrading or replacing bridges or culverts, profile modifications at railroad crossings, raising electric lines across roads, utility pole relocation and tree trimming.

She believes that moving large track-mounted cranes, terrain cranes, boom trucks and heavy turbine components will break down local roads and cause delays and detours for local residents. Local contractors would haul gravel and cement over those roads, too. She said she hopes the county engineer has a firm road utilities maintenance agreement with the companies to repair the roads following construction.

The Millers invited the public to participate in Venice Township's meeting about the turbines at 7 p.m. Monday at the Attica Fairgrounds.

Village Administrator Greg Martin announced that a hazardous eyesore has been removed from the village. The abandoned Eagles facility was demolished, leaving a cleared-off lot. The village has received a query from the American Legion about creating a Veterans' Memorial in the area, and another party questioned placing a gazebo there, also.

Martin reported the completion of the water line to Sunrise and the addition of its taps.

Police Chief Keith Turner informed council members he has applied for a grant to secure five bulletproof vests for his department. The grant has a 25-percent matching fund obligation from the village.

He said 45 Kid IDs were created for youngsters during Attica Independent Fair week, while gun safety literature was distributed to young people. He noted bike helmets were provided by Mercy Health - Willard Hospital and information on the Project Lifesaver program was shared.

Councilman Louis Sanders noted the fire association has scheduled a gun raffle during September. Any questions may be directed to Fire Chief Lonnie James.

Councilman Nate Frisch thanked former councilman Jeff Painter for the years he headed up the effort to procure American flags for the community and display them along US 224 and SR 4 through the village. The Legion Riders and Sons of the Legion plan to continue the project.

Sons of the Legion are sponsoring Party in the Park again this year. The event is scheduled for Sept. 21-22. Activities include softball tournaments, corn hole, a poker run, gun raffles and food vendors. Those interested in participating may call Tim Heibertshausen, (419) 271-0180; Dillon Thornton, (419) 706-8157; or Mike Reisinger, (567) 224-7750.

In other matters, the council:

- Has an open seat.
- Discussed tree planting.
- Approved hiring Angela Depinet as fiscal officer. Mayor Bryan Shock introduced her to those present.
- Heard the third reading of the ordinance created by Councilman Kirk Stanfield to eliminate the flat-rate sewer charge for customers. Councilman Ed Treft moved for approval, with Stanfield offering the second. The ordinance failed by a 3-2 vote.

Council is scheduled to

Ohio Power Siting Board Application Review Criteria

The criteria the Board must use to review the application are as follows:

(1) the basis of the need for the facility if the facility is an electric transmission line or gas pipeline:

✓ (2) the nature of the probable environmental impact;

(3) that the facility represents the minimum adverse environmental impact, considering the state of available technology and the nature and economics of the various alternatives. and other pertinent considerations:

(4) in the case of an electric transmission line, that the facility is consistent with regional plans for expansion of the electric power grid of the electric systems serving this state and interconnected utility systems and that the facility will serve the interests of electric system economy and reliability;

(5) that the facility will comply with Chapters 3704, 3734, and 6111 of the Revised Code and all rules and standards adopted under those chapters and under Sections 1501.33, 1501.34 and 1501.35 of the Revised Code;

✓ (6) that the facility will serve the public interest, convenience, and necessity;

(7) the impact on the viability as agricultural land of any land in an existing agricultural district established under Chapter 929 of the Revised Code that is located within the site and alternative site of the proposed major utility facility;

✓ (8) that the facility incorporates maximum feasible water conservation practices as determined by the Board, considering available technology and the nature and economics of the various alternatives.

Revised Code Section 4906.07

Upon the receipt of an application
promptly fix a date for a public

Christina Popa

POPA EX. 1 see back also

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Robert Berg
Exhibit 1

Presentation to the

Ohio Power Siting Board

Case No. 18-488-EL-BGN

From Robert Berg

800 East Township road 58

Tiffin, OH 44883

Eden Township

Topic:

Infrasound Produced by Wind Turbines Presents Hazards To Human Health

Presentation to the Ohio Power Siting Board

July 23, 2019

OPSB Case No. 18-488-EL-BGN

My name is Robert Berg. I live at 800 East Township Road 58, Tiffin, OH 44883. That is in Eden Township. I am an Emeritus Professor of German at Heidelberg University, Tiffin, Ohio, and I am now a part-time archivist there.

I would like to offer evidence that infrasound produced by wind turbines is harmful to our health.

What is infrasound? This is sometimes referred to as low frequency sound. It is sound lower than 20 Hz or cycles, below the "normal" limit of human hearing.

My primary source of information is a broadcast from November 1, 2018 by ZDF, German Television, entitled "Unerhörter Lärm" (Unheard and Unheard of Noise). It contains interviews with several German and American physicians and scientists. Their conclusion: Infrasound has negative effects on the strength of heart tissue, on the brain and on the auditory system. I was able to view the broadcast online several times, to translate or summarize parts of it. Here are some of the main points.

The principal focus of the broadcast is the research of Dr. Christian-Friedrich Vahl, a cardiac surgeon at the University Clinics in Mainz, Germany. His team has exposed various sized pieces of live human heart tissue, as well as single heart cells, to infrasound in laboratory conditions. His results have been replicated and show in measurable terms that in all experiments there is a proven reduction of strength of the tissues of the human heart when they are exposed to infrasound signals.

When asked whether other scientists are doing related research, Dr. Vahl cited the work of a team of researchers at the Institute for Physiology at the University of Hamburg, Germany which has shown similar results when working with live rat subjects. He also cites the findings of research on the vessels of the heart by a team of scientists at the University of Rostock, Germany which shows similar results.

Asked about his stance on wind energy, he said he thinks we need to continue to support wind energy production, but that wind installations must be kept at great enough distances from human habitation and gathering places to assure that we do not endanger people's health.

Other researchers presented in the same broadcast indicate negative effects of infrasound. Several are summarized here.

One of them, Prof. Simone Kühn of the University Clinic of Hamburg-Eppendorf, Germany has conducted research on the effects of infrasound on the brain. Her team found that sounds below the human limit

of hearing activate areas in the brain that deal with stress and conflict. Kühn's team has developed the hypothesis that annoying sounds we can hear we can perhaps better block out or deal with, for example by moving away from the source of the sound or by using protective devices over our ears. But sounds which we can't hear we don't recognize. We are not aware of them, so we can't dismiss them. That may cause stress. The team has also begun studying the exposure to infrasound as a cause of sleep disturbances reported by people who live close to wind parks.

Around the world, various countries have conducted research on the use of infrasound as a non-lethal weapon, especially during the Cold War era. Col. John B. Alexander, US Army Retired, said that research on infrasound as a weapon has been given up in most places due to technical issues and inconsistent test results. The US military now has little interest in research in the area of sonic attack except in determining the causes of the baffling complaints of employees in the US Embassy in Cuba in 2017 and in the US Embassy in Moscow in the 1980's. Both instances are still puzzling. Perhaps microwaves were at work, not infrasound.

Dr. Lars Ceranna of the BGR, the German Federal Bureau for Geoscience and Raw Materials, was also interviewed. His team has been monitoring vibrations and infrasound for many years, originally as part of a program to ensure compliance with the Comprehensive Nuclear Test Ban Treaty. He reports that they have found that there is no measurement norm for frequencies below 20 Hz for wind energy installations, indeed those sounds have been left out of traditional measurements, and those below 8 Hz totally neglected, left unmeasured. His team is correcting these measurement inadequacies and has now recorded clear infrasound signals from wind turbines at various distances. In order to get an accurate measurement, the BGR maintains that there must be a distance of 15 kilometers (9 miles) between the measuring site and a wind park.

Dr. Alex Salt of the medical school at Washington University in St. Louis is an expert on maladies of the inner ear. His research team has shown that the inner ear reacts to infrasound signals, even very low signals of 5 Hz and lower. The reason is due to the anatomy of the inner ear which has two types of hair cells that react to sound. Infrasound stimulates only the outer cells, not the inner cells, but it does produce an electric reaction in the ear which is not audible. This may be related to symptoms such as headaches, nausea, sleep interruptions and lack of ability to concentrate. His team has had complaints from wind energy companies denying his results, but he insists that they have been repeated in laboratory conditions and suggests that the wind energy companies are motivated by bias and money.

Since viewing this broadcast and discussing it with others, colleagues have sent me additional documentation of scientific evidence of the dangers to health of infrasound.

Vahl, Ghazy and Chaban. *Are There Harmful Effects Caused by the Silent Noise of Infrasound Produced by Windparks?* An Experimental Approach. 22 January 2018 online.

Conclusion: Infrasound can have direct negative effects on the human myocardium in experimental settings. This needs additional investigation as the number of wind turbines increases and exposes more people to the potential harm from infrasound.

Louisinha, Ana et.al. Infrasound induces coronary perivascular fibrosis in rats. Accepted for publication October 3, 2018. Center for Interdisciplinary Research Egas Moniz (CHEM), Health Sciences Institute, Monte de Caprica, Portugal; Department of Anatomy and UMBID, Abel Salazar Institute of Biomedical Sciences (ICBAS), University of Porto, Portugal; Faculty of engineering (FEUP), University of Porto, Portugal; Faculty of Engineering (FEUP), University of Porto, Portugal.

Conclusion: The cardio vascular system is sensitive to infrasound. Infrasound exposure induces coronary perivascular fibrosis in experiments with rats.

Aleksieyev, A.V. Glinchikov, V.V., and Usenko, V.R. *Reaction of Liver Cells to the Impact of Infrasound.* 1985. Sanitary and Hygienic Medical Institute, Leningrad. Translated from Russian.

Conclusion: The study showed that infrasound has a damaging impact over liver cells at a frequency of 8 Hz and an intensity of 120 dB, causing changes of both the nucleus and the cytoplasm. The greatest damaging effect of infrasound is observed at a frequency of 8 and 16 Hz and an intensity of q40 dB. Such damage can lead to the death of cells.

Gordeladze, A.S., Glinchikov, V.V., Usenko, V.R. *Experimental Myocardial Ischemia Caused by Infrasound.* 1985. Sanitary and Hygienic Medical Institute, Leningrad. Translated from Russian.

Conclusion: Infrasound with the frequency of 8 Hz and an intensity of 120 dB has a damaging effect on the structure of the myocardium, associated primarily with damage to cardio myocytes. The size of the damage increases with increasing duration of impact. These damaging effects can mask the clinical symptoms and thus impede timely diagnosis. Timely detection of this harmful factor and control of it is important to preserving the health of those exposed to the effect.

Karpova, N.I., Alekseyev, S.V., Yerokhin, V.N., Kadyskina, E.N., and Reutov, O.W. *Early Reaction of the Organism to the Low-Frequency Acoustic Oscillations.* 1978. Sanitary and Hygienic Medical Institute, Leningrad. Translated from Russian.

Conclusion: Infrasonic oscillations have adverse effects over the entire human organism. The central nervous, cardiovascular and respiratory systems, as well as the auditory analyzer, react already in the first minutes of infrasound impact. The experiments detected changes in the functional state of the

cardiovascular and respiratory systems, violation of protein synthesis and metabolic process in the organism.

Dr. Jerry Punch, Professor Emeritus of Michigan State University and a retired, certified audiologist with 50 years of clinical, research, teaching and administrative experience has submitted a detailed brief on behalf of a resident of Scipio Township who has been diagnosed with chronic vertigo. In Dr. Punch's opinion, this man can be expected to experience worsened health symptoms if forced to live in close proximity to one or more turbines. Dr. Punch includes important information as well as a bibliography of recent research on the subject of symptoms caused by infrasound. These include headaches, dizziness, nausea and motion sickness. These symptoms had been observed even before the more recent research of Dr. Vahl and others cited above.

I have brought with me documents to support all of the research I have summarized and wish to have them included in the records of today's hearing. I sincerely hope that the Ohio Power Siting Board will give them serious consideration and will take action to protect the well-being of residents of our area in northwest Ohio.

Glossary

dB - decibel, unit of sound used to measure degree of loudness. Whispering is about 30 dB, normal conversation about 50-60 dB, a dishwasher about 75 dB, a lawn mower about 90 dB.

Fibrosis – the thickening and scarring of connective tissue

Hz – hertz, is a unit of frequency in the International System of Units (SI) and is defined as one cycle per second. Frequency is how often something happens in one second. The note middle C on the piano is 262 Hz., i.e. there are 262 vibrations every second when that key is played. Humans are able to hear sounds between 20 and 20,000 Hz.

Infrasound – very low level sound, 20 Hz or below, not audible to the human ear

Ischemia – an inadequate blood supply to an organ or part of the body, especially the heart muscles

Myocardium – the muscular tissue of the heart

Myocyte – a type of long tubular cell that develops to form muscles

Perivascular – situated or occurring around a blood vessel

Vascular – relating to, or consisting of a vessel or vessels, especially those which carry blood

Vertigo – a chronic condition in which the individual has the sensation of rotating or spinning or in which objects in the environment appear to be in motion or spinning

November 2018 ZDF German Television Documentary

Oral Presentations
Tuesday, February 20, 2018
DGTHG: Basic Science: Various
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ZDF.de → Suche (search) → enter → Vahl → Weitere laden → Documentary "Infraschall-Unerhörter Lärm

Are There Harmful Effects Caused by the Silent Noise of Infrasound Produced by Windparks? An Experimental Approach

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Germany
Oral Presentation
- ongoing research -
Feb 2018

Effect:
up to 25% reduction
in Heart Tissue
Contraction Ability

Publication History

Publication Date:
22 January 2018 (online)

- Congress Abstract
- Full Text

Introduction: The increased number of wind parks raised the question, whether infrasound waves produced by wind turbines are harmful on human-beings, or not. Infrasound is a low frequency sound (< 20 Hz), undetectable with human ears. However, some people live near windparks describe unspecific symptoms i.e., palpitations, dizziness, headache, etc. This study analyses the infrasound effects on isolated atrial human myocardium and measures the contractile performance in human trabeculae using different frequencies and amplitudes of infrasound generated by a loudspeaker.

Methods: Human atrial trabeculae were resected from 8 patients undergoing aorto coronary bypass surgery, then demembranized using Triton X 100 and small fibers were generated with diameter < 0.3 mm and length 4–6 mm. The fibers were attached between force transducer and loudspeaker while

activated at optimal length and room temperature in an organ bath using supramaximal calcium concentrations. Then infrasound was imposed using frequencies of 10 Hz or 20 Hz. Sound amplitudes (SA) were either 5% or 10% of tissue length (TL). Sound was applied for 1 minute. Force was measured before and after 1 minute of infrasound.

Results: Imposed infrasound on isolated human myocardium caused a direct force inhibition of the completely activated myocardial preparation. At 10 Hz and 5% TL (SA) force inhibition was 18.8+2% while at 10% TL (SA) up to 23.3+2% ($p < 0.05$). At 20 Hz; force inhibition was 23+2% at 5% TL and 32+4% at 10% TL ($p < 0.01$). After stopping infrasound; force was recovered but not to the initial value. No sound was heard during the experiments. Passive resting force was minimally affected (n.s.).

Conclusion: Infrasound can induce direct effects on human myocardium in the given experimental setting. Although mono-frequency sounds are not present in nature, our experimental data indicates, that direct effects on myocardial tissue are present. The infrasound influence on human tissue requires further investigation because the increasing number of a) wind turbines and b) human beings exposed by the neighborhood of windparks. Humans have no chance to protect themselves from the silent noise of infrasound, as long as no scientific data presents.

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S.V. ALEKSEYEV, V. V. GLINCHIKOV, V. R. USENKO

REACTION OF LIVER CELLS TO THE IMPACT OF INFRASOUND

Sanitary and Hygienic Medical Institute, Leningrad

Intensive development of modern industry led to the creation of the machines and the mechanism of high power, which are the source of acoustic oscillations of various spectral range. The researchers pay special attention to infrasound as an integral part of production noises.

Scientific studies of recent years showed that infrasound in certain parameters has a harmful effect over the human body [1, 3, 7]. At the same time, the effect of infrasound is studied not only on the whole organism, but also on separate organs and tissues, as well as cellular structures [2,5]. Among the experimental works there are ones that show the harmful impact of infrasound over liver cells [4, 6]. However, many of the details of this process remained not researched and are the subject of this study.

The infrasound installation described in our previous work [3] was used at the experiment. The experiments were performed on sexually matured white rats-males weighing up to 250 g, which were exposed to infrasound frequency at 2, 4, 8, 16 Hz and with an intensity of 90–140 dB during 40 days with a daily exposure of 3 hours. The material was taken on the 5th, 10th, 15th, 20th, 40th day. The animals were decapitated. The material was fixed in 20% formalin, the cuttings were colored with hematoxylin-eosin, by Van-Gieson method, methyl green with pyronin, by Brache method and halo-cyanin, by Einarson method for nucleic acids

For electronic - microscopic research the pieces of liver were fixed by 2.5% glugraldehyde with additional fixation by 1% osmium and poured into araldide. Ultrathin cuttings were made on the ultratome LKB-III, contrasted by citrate of lead and studied in the electronic microscope JEM-7A.

It was established that infrasound has a damaging impact over hepatocytes of the liver at the frequency of 8 Hz and the intensity of 120 dB. In the glandular parenchyma of the liver there are diffuse changes which have the nature of reactive

processes and are found in separate hepatocytes or in the whole group of cells. In addition, changes from the side of the sinusoid cells of the liver were observed.

The reaction of hepatocytes to the impact of infrasound was mosaic by nature and was expressed in the fact that the damaged cells lost contact with each other and were rounded. The phenomena of dissociation increased along with the effect of the infrasound and were characterized by changes from the side of both the nucleus and the cytoplasm. First of all, there was a deformation of the nuclei with the redistribution of chromatin and its concentration in the form of dense layer under the nucleus membrane. In the cytoplasm, the RNA content increased, it became sharply basophilic. Hepatocyte changes were more pronounced at the increase of the infrasound intensity up to 140 dB.

Electronic microscopic studies showed that mitochondrial swelling in reactively altered hepatocytes initially took place, the density of the matrix sharply increased, and deformation of the cristae was observed. The endoplasmic reticulum canaliculi expanded, and vacuoles of irregular shape and of various sizes were formed in them.

At long time exposure to infrasound, myelin-like bodies and lipid granules appeared in a number of hepatocytes on the 25th and 40th day.

In the granular cytoplasmic reticulum, the number of ribosomes sharply decreased and lysis areas appeared, especially around the nuclei (Fig. 1). The amount of glycogen decreased sharply compared with the norm. Around the lysis areas there were relatively small mitochondria with the dense matrix.

Next to sharply damaged hepatocytes there were cells in which nuclei chromatin was unevenly distributed, and in the endoplasmic reticulum there was a moderately pronounced vacuolization and the number of ribosomes decreased. Ultimately, in such reactively altered hepatocytes, the chromatin predominantly accumulates around the nuclear envelope, having the view of large clumps of irregular form. Vacuolization increased in the cytoplasm, but the swollen mitochondria contained shortened and fragmented cristae. Such hepatocytes remain viable after the termination of the infrasound action as well, gradually acquiring the normal structure.

The subject of degenerative changes are only those hepatocytes in which nuclear deformation takes place, but in the cytoplasm there are lysis areas with the ultimate formation of large vacuoles and the presence of small mitochondria with a dense matrix and destroyed cristae (Fig. 2). Polyblasts accumulate around dystrophic-

altered hepatocytes and infiltrates gradually form. Proliferative processes are accompanied with the appearance of a large number of Kupffer cells, which are divided by mitosis and are accumulated in areas of the damaged parenchyma. In some cases, hepatocyte mitosis can be observed, which undoubtedly indicates the presence of regeneration processes.

The study showed that infrasound has a damaging impact over liver cells at a frequency of 8 Hz and an intensity of 120 dB, causing changes of both the nucleus and the cytoplasm. The initial form of the reaction of hepatocytes to the infrasound is the deformation of the nucleus with the redistribution of chromatin and the concentration of its clumps under the nuclear envelope with the disintegration of the nucleoli and the increase of the pernuclear spaces size. As a rule, such changes in hepatocytes are observed during the first day after irradiation with infrasound and are observed in those cells that are the subject of dissociation. At the same time, changes in the cytoplasm also take place in such hepatocytes, where mitochondria swelling with cristae fragmentation is observed.

Along with infrasound action, the number of reactively modified hepatocytes increases as well, especially on the 10-15th day, with the appearance of degenerative forms among them.

The greatest damaging effect of infrasound is observed at a frequency of 8 and 16 Hz and an intensity of 140 dB. At the same time, the number of dissociated hepatocytes increased, they formed whole groups. The nuclei of such cells were sharply deformed, and in the cytoplasm there were lysis areas of the endoplasmic reticulum, with ultimate formation of large vacuoles. In the preserved areas of the granular cytoplasmic reticulum, the canaliculi were enlarged and formed vacuoles of various dimensions and sizes. At the same time, lipid granules containing osmiophil inclusions appeared in the cytoplasm, and the structure of mitochondria changed.

The mitochondria that were located closest to the lysis area and were reduced in size, with a dense matrix and mild cristae, were altered most of all. In those areas of the cytoplasm in which the canaliculi of the granule network were preserved, though expanded, the mitochondria were enlarged in size, the fragmentation of the cristae was observed. The changes described above indicate that infrasound damages not only intracellular membranes and mitochondria, but also the nuclear apparatus, that can lead to the death of cells, if these changes have pathological nature and are

accompanied by lysis of cytoplasmic areas with ultimate formation of large vacuoles.

Such hepatocytes ultimately die, and polyblasts and profiling Kupffer cells are accumulated around them.

Less damaged hepatocytes, in which lysis of the cytoplasmic membranes is not detected, are gradually restored, though the extended canaliculi of the endoplasmic reticulum and the increased density of mitochondria with moderate vacuolization remain in them for a long time.

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Рис. 1. Электронограмма гепатоцита через 5 сут после воздействия инфразвука.
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[иза]куолизация с постепенным уменьшением рибо[со]м, появлением липидных гранул и уменьшением [кол]ичества зерен гликогена, которые теряют [чет]кость своих контуров и становятся менее [эл]ектронно-плотными, чем в нормальных гепатоцитах. Наряду с изменением со стороны гепато[ци]тов отмечаются изменения и в сосудах. Просветы последних переполняются кровью, а в некото[-]рых участках имеются и очаги кровоизлияния. Клетки синусоидов печени становятся базофи[-]

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A. S. GORDELADZE, V. V. GLINCHIKOV, V. R. USENKO

EXPERIMENTAL MYOCARDIAL ISCHEMIA CAUSED BY INFRASOUND

Sanitary and Hygienic Medical Institute, Leningrad

Modern scientific and technological progress has led to the creation of large-sized machines and units capable to generate infrasonic vibrations, which are an integral part of production noise. At certain parameters, infrasound can have a harmful effect on the body [4]. Currently, an intensive study of the effect of infrasound over both the whole organism, and on various organs and tissues is being conducted [3).

There are works in the literature showing the effect of infrasound over the myocardium [1, 2, 5, 6). These studies stated that infrasound damages firstly the vessels of the myocardium. At the same time, the pathogenesis of the effect of infrasound over the myocardium remains unclear in many details, the effect of infrasound over the structures of cardiomyocytes has not been studied, which is the goal of the present study.

For holding experiments, a specially constructed acoustic installation was used, allowing to create the infrasonic field in the range of 0.5–50 Hz with a pressure intensity of 90–140 dB.

The experiments were performed on white rats and guinea pigs, which were irradiated with infrasound at a frequency of 8 Hz, intensity of 120 dB during 1, 5, 10, 15, 25, 40 days with daily exposure of 3 hours. In all groups of experiments 10 animals were used, 3 of which served as a control. Animals were slaughtered by decapitation. Fixation was performed by Carnoy method and in 20% formalin.

The preparations were stained with hematoxylin-eosin, by Van Gieson method, halo-cyanin, by Einarson method, to detect nucleic acids, methyl green with pyronin, by Brache method (control with ribonuclease). The SCHIFF- reaction with amylase control was used, the activity of succinate dehydrogenase (LDH), lactate dehydrogenase (LDH), and glucose-6-phosphate dehydrogenase (G-6-FDG) were also investigated. To detect the activity of redox enzymes, cooled myocardium was cut in the cryostat at a temperature of —5 ° C. Cuttings were processed according to E. Pierce's prescriptions. Evaluation of histochemical reactions and the activity of redox enzymes was performed by a semi-quantitative method, comparing the obtained data with the control.

For electron microscopic examination, fixation was performed with 2.5% glutaraldehyde for 2 hours with additional fixation with 1% osmium and with

subsequent dehydration with alcohol. Ultrathin cuttings were made on the LKB-III ultratome, contrasted with lead citrate and examined with electron microscope JEM-7A.

In acute experiments after 3-hour single exposure to infrasound with a frequency of 7 Hz and an intensity of 120 dV, when examining the heart, barely perceptible pallor and swelling of the left and right ventricular walls and small-point hemorrhage in the pericardium structure were noted.

Histological examination showed mild edema and in some cardiomyocytes - moderate grit and even vacuolar dystrophy of myofibrils with the disappearance of ransverse striation. SCHIFF -reaction was unevenly expressed, weakened after treatment of cuttings with amylase. Pironnofilia was of diffuse nature and decreased after exposure to nuclease. The activity of the LDH was increased, the precipitated grains of diformazan differed in polymorphism. Capillary lumens are filled with red blood cells, but endothelial cells look swollen.

During electron microscopic examination, reactively altered cardiomyocytes show mitochondrial swelling and destruction of outer membranes with loss of dual contour, enlightenment and homogenization of the matrix with fragmentation of the cristae. In myofibrils there are areas of re-coloring, and sometimes tears of myofilaments in the area of the disks. The canals of the T-system are dilated. An increase in the amount of chromatin is noted in the nuclei. Nuclear pores are enlarged.

With continued impact of infrasound, a day after the start of the experiment, the activity of redox enzymes falls in the ischemic zone, but at the same time there are areas in which myofibrils are painted over with aggregation of diformazan grains. Reactively modified cardiomyocytes give a weak SCHIFF -positive reaction, weakening when treating medicines with amylase. Pironnofilia has a diffuse character. The activity of SDH varies, at first decreasing sharply compared to the control one, then increasing. The activity of LDH in some myofibrils is increased. The activity of G-6-FDG and NAD-diaphorase is expressed weak. In the foci of ischemia, the capillaries are sharply narrowed as a result of the swelling of the endothelium cells. The sarcoplasm of cardiomyocytes is edematous, the sarcolemma is damaged in a number of areas, there are homogenization zones and a re-dyeing band in the myofibrils. The mitochondria are swollen, with a vague outer membrane, devoid of matrix, the cristae are fragmented to varying degrees. The contours of the nuclei are strengthened, the nucleoli disappear, the amount of chromatin is increased, the nuclear pores are enlarged. In the T-system there are vacuoles of various sizes, the sarcoplasmic reticulum canaliculi are enlarged.

In the intact zones, single modified cardiomyocytes appear with the presence of re-dyeing bands and even with damage of myofilaments.

At the 5^{th}, 10^{th}, and 15^{th} day, in the zones of myocardial ischemia located mosaically in the region of the left ventricle, there are perivaecular hemorrhages around the small vessels, and there are separate leukocytes in the surrounding connective tissue. Damaged infrasound cardiomyomatics changed, they have all the signs of granular dystrophy. The SCHIFF reaction is poorly expressed, does not change after treatment with amylase, pyronnophilia is focal in nature and disappears after treatment with ribonuclease. The a/ctivity of redox enzymes is reduced, the myofibrils are diffusely stained, the diformazan grains form polymorphic clusters. Sarcoplasma of cardiomyocytes is edematous, in some places myofibrils are fragmented in the area of the discs, there are foci of homogenization of myofilaments (see figure); discs are mixed and expanded. Many mitochondria are swollen, with a spotty-coated matrix, the cristae are finely fragmented, the outer membrane in a number of structures is devoid of dual contour. The contours of the nuclei are deformed, nucleoplasm is cleared in some places, chromatin forms clusters of irregular shape. Sarco-plasma reticulum canaliculi dilated. The erythrocytes accumulate in the lumens of the dilated capillaries, and in the swollen endothelial cells there are destroyed mitochondria

After 25 and 40 days of infrasound impact in the area of myocardial ischemia, the SCHIC-reaction of cardiomyocytes is weak. Pironnofilia of cells has a focal character and decreases after treatment with ribonuclease. The activity of redox enzymes increases, there are areas with myofibrils stained in color, the diformazan grains form focal accumulations. The activity of G-6-FDG increases.

At the 25^{th} day in reactively altered cardiomyocytes, sarcoplasm edema decreases. Sarcolemma is sharply contoured, the number of ribosomes increases, however, myofilaments are homogenized in some places. Mitochondria have an oval shape, in the matrix there are sometimes foci of enlightenment, the crista are in most cases parallel to each other, fragmentation is poorly noticeable. The nuclei of cells have rugged but clear contours, chromatin is located in the form of clumps of various sizes, the pores of the nuclear membrane are enlarged. The lamellar complex is little changed, the tubules of the sarco-plasma reticulum and the T-system are moderately dilated. There are single lipid inclusions, sometimes primary and secondary lysosomes are found. Capillary openings are enlarged, the amount of chromatin in the nuclei is increased, the mitochondria are homogenized, the number of glycogen granules is reduced.

Full restoration of damaged cardiac cells occurs as a result of intracellular regeneration and occurs after the termination of infrasound impact.

Conclusions. 1. Infrasound with a frequency of 8 Hz and an intensity of 120 dB has a damaging effect on the structure of the myocardium, which is associated primarily with damage to cardiomyocytes, as well as with damages related to microcirculation process. In this case, the size of the damage increases with increasing of duration of impact.

2. Having a damaging effect on the myocardium, infrasound in parallel causes the development of compensatory and supportive processes, which can mask the clinical symptoms and thus impede the correct and timely diagnosis.

3. The concealment of the action of infrasound on the myocardium requires the timely detection of this harmful factor in production and the control of it for the sake of preserving the health of those who are exposed to its constant effect.

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EARLY REACTION OF THE ORGANISM TO THE LOW-FREQUENCY ACOUSTIC OSCILLATIONS

Sanitary and Hygienic Medical Institute

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The causes of the appearance of the artificial infrasound are operating mechanisms with large radiating surfaces, as well as moving gas flows. According to a number of authors (V.I. Zinchenko and F.E. Grigoryan; E.N. Malyshev; Tempest; Hood and Leventhall, etc.) and the results of our researches, the sources of infrasound can be diesel engines, turbines, piston pumps, compressors, fans, large air blowing machines. Infrasound appears in tunnels for motor transport, in chimneys of high furnaces and in burners of open-hearth furnaces. The infrasound fields created by the work of the mentioned equipment have the intensity from 110 to 132 dB at the main frequencies 1,5, 2, 4, 8, 12 Hz.

Infrasound intensity often has a higher level than the level of audible sound. The distribution of infrasound, the degree of absorption by the atmosphere, the ability to disperse, etc. are somewhat different from the corresponding indicators of audible sounds. Infrasound can cause resonance of large objects due to the commensurability of the wavelength with these objects. All this causes some features of the impact of the infrasonic vibrations over the live organism and creates certain difficulties in combating them.

The Chair of Labor Hygiene of the Leningrad Sanitary and Hygienic Medical Institute performs the determination of the production sources of infrasound, clarifying the nature of its action over the organism, the determination of the changing mechanism observed in the organism under the influence of infrasonic vibrations. However, the disclosure of this mechanism is impossible without establishing the earliest reactions of the organism to the impact of the studying factor. This was the purpose of the present work.

The studies were conducted under the conditions of modeling the infrasound production parameters at the experimental acoustic complex specially equipped at the Chair. Recognized healthy men at the age from 19 to 29 years who passed preliminary medical examination took part at the research. In addition, the impact

over the organism of infrasonic oscillations with the frequency of 5 and 10 Hz, with a sound pressure level of 100 and 135 dB was studied at rats, rabbits and guinea pigs. The time of factor action is 15 minutes Already in the first minutes of exposure, infrasound causes mental stress, vegetative reactions, unpleasant auditory sensations. The most common complaints caused by the infrasound action of the studied frequencies are feelings of general fatigue, lethargy and pressure in the ears. A small number of people (average 15–20%) had such symptoms as headache, dizziness, which were observed in a short time at the end and after the finalization of the experiment. More than half of the researched people complained for distraction, drowsiness, and feeling of depression. During the entire period of infrasound impact, some of the researched people noted the vibration of the internal organs, that mainly causes the sensation of vibrations at the chest, abdominal wall and stomach. These data allow to expect functional changes in the central nervous, cardiovascular systems, from the side of the hearing analyzer, respiratory system and vestibular apparatus under the influence of infrasound.

The functional state of the central nervous system was studied by electroencephalography method.

After a 15-minutes impact of infrasound, an increase in synchronization phenomena, most often in the left hemisphere, was observed at the electroencephalographic curves. In some cases, the hypsynchronized α-rhythm and the appearance of Θ-waves were observed in the left fronto-temporal region.

The obtained results allow us to make an assumption about the general reconstructions of the biopotentials, apparently caused by the impact of infrasound over the brain stem formations. These changes should be attributed to non-specific reactions associated with the weakening of the activating influences of the reticular formation of the trunk over the cerebral cortex (P. K. Anokhin; Moruzzi and Magoun, and others).

After the infrasound action with the frequency of 10 Hz, the intensity of 135 dB, the lengthening of the absolute values of the visual-motor reaction to the strong and weak stimuli and the decrease of the strength of the effector response were also observed.

At the action of infrasound with the frequency of 5 and 10 Hz and the intensity level of 135 dB, peculiar changes in the heart rhythm were noted. In the first minutes of exposure, the number of heartbeats tends to increase, expressed at the same level for both influencing frequencies. In 5–10 minutes, the heart rhythm slows down,

returning to the initial, but after turning off the generator, the number of heartbeats becomes even more rare compared to the background values. Some studied people had an arrhythmia. These phenomena are most pronounced in the first minutes of the action of low frequencies, gradually disappearing with increasing of the time spent in the camera by studied people. A decrease in peripheral vascular tone was found, manifesting in the increase of skin temperature and in the decrease of maximum arterial pressure.

The study of cerebral hemodynamics was performed by rheoencephalography method. Analysis of rheoencephalogram showed that the action of infrasound is accompanied with the signs of inhibition of cerebral hemodynamics, manifested in the difficulty of venous outflow from the cranial cavity. The infrasound with frequency of 10 Hz, the intensity of 135 dB, caused deeper and more stable changes in the cerebral blood circulation, which consisted in a greater increase of the amplitude of the rheographic wave, in an increase of the duration of its anacrotic phase and in a decrease of the tonic voltage indicator compared to the impact of infrasonic vibrations with frequency 5 Hz of the same intensity. Under the influence of infrasound, the most noticeable and authentic changes in cerebral hemodynamics appear from about 7-10th minute of being in the infrasound field.

For registration of mechanical movements of the heart during contraction, the method of seismic cardiography developed by V. M. Baevsky and M. A. Kazaryan was used. The obtained results allowed to conclude that the infrasonic oscillations with intensity of 135dB cause disturbances in the mechanical movements of the heart, reducing the force of contraction of the heart muscle. This is manifested in a decrease in both the amplitude of the 1st oscillatory cycle, reflecting the magnitude of the cardiac forces acting during the systole, and the amplitude of the 2nd (diastolic) oscillatory cycle. The most pronounced changes in the contractile activity of the heart take place under the influence of infrasound frequency of 10 Hz.

Analysis of pneumograms registered during the action of infrasonic oscillations with a frequency of 5 and 10 Hz, an intensity of 135 dB shows changes in the respiratory function, manifested in the stable decrease of respiration frequency, starting from the 1st minute of the infrasound impact.

The state of the auditory analyzer was investigated with the help of tone audiometer AP-02. Researches of the infrasound impact with the frequency of 10 Hz and the intensity of 135 dB showed in most cases a slight exacerbation of hearing sensitivity - within 10 dB at the frequencies of 125, 250, 500 and 300 Hz.

The applying of the electron-syntagmography method did not reveal any disturbances in the vestibular apparatus under the influence of low-frequency oscillations of the studied intensity.

At experimental studies over the laboratory animals exposed to infrasound of the same parameters, changes in the bioelectrical activity of some cortical and subcortical structures of the brain, disturbances of redox processes in skeletal muscles, changes in the volume of nuclei of receptor cells in the helical body of the guinea pig snail were revealed that is a morphological expression of excitation caused by the infrasound action. Changes in the content of nucleic acids were found in these cells.

The results of the conducted researches allow us to conclude that infrasonic oscillations are not indifferent for biological objects, have the adverse effect over the entire organism and make many important functional systems react. The central nervous, cardiovascular, and respiratory systems, as well as the auditory analyzer are the most interested, reacting already in the first minutes of the infrasound impact. Among all studied parameters of infrasound, the deeper changes in the indicated systems of the studied people were caused by the oscillations with the frequency of 10 Hz and the intensity of 135 dB. The infrasound with the frequency of 5 Hz at the same intensity caused much smaller effect. Studies conducted at a lower infrasound intensity of 100 dB practically did not lead to the changes in the studied systems.

The analysis of the received data witnesses about the fact that the impact of infrasonic oscillations is manifested, primarily, in the violation of the mechanisms of central regulation of the body vital systems, the manifestation of which are the detected changes in the functional state of the cardiovascular and respiratory systems, violation of proteins synthesis and metabolic processes in the organism.

Thus, the study of the early reactions of the organism to the impact of infrasonic oscillations allows to reveal certain aspects of the mechanism of its biological action and contributes to the scientific argumentation of the production infrasound levels acceptable to the humans.

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Original Article

Infrasound induces coronary perivascular fibrosis in rats

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ABSTRACT

Background: Chronic exposure to industrial noise is known to affect biological systems, namely, by inducing fibrosis in the absence of inflammatory cells. In rat hearts exposed to this environmental hazard, we have previously found myocardial and perivascular fibrosis. The acoustic spectrum of industrial environments is particularly rich in high-intensity infrasound (<20 Hz), whose effects on the heart are unknown. We evaluated the morphological changes induced by IFS in rat coronaries in the presence and absence of dexamethasone.
Methods: Adult Wistar rats were divided into three groups: group A (GA)—IFS (<20 Hz, 120 dB)-exposed rats for 28 days treated with dexamethasone; group B (GB)—IFS-exposed rats; group C (GC)—age-matched controls. The midventricle was prepared for observation with an optical microscope using 100× magnification. Thirty-one arterial vessels were selected (GA 8, GB 10, GC 13). The vessel caliber, thickness of the wall, and perivascular dimensions were quantified using *image J* software. Mann–Whitney and Kruskal–Wallis tests were used to compare the groups for lumen-to-vessel wall (L/W) and vessel wall-to-perivascular tissue (W/P) ratios.
Results: IFS-exposed rats exhibited a prominent perivascular tissue. The median L/W and median W/P ratios were 0.54 and 0.48, 0.66 and 0.49, and 0.71 and 0.68, respectively, in GA, GB, and GC. The W/P ratio was significantly higher in GC compared with IFS-exposed animals ($P=.001$). The difference was significant between GC and GB ($P=.008$) but not between GC and GA.
Conclusion: IFS induces coronary perivascular fibrosis that differs under treatment with corticosteroid.

1. Introduction

Noise represents a major environmental factor and is among the stressors with the highest impact on public health [1]. Noise and sound are physically the same, but the reaction to perception varies between people, depending on the cognitive environment in which detection takes place and ultimately leads to a definition of noise as an undesired sound [2,3]. Low-frequency noise (LFN) and infrasound (IFS) are conventionally defined as sound below 200 and 20 Hz, respectively. The lower limit of the audio frequency range of human hearing is usually given as 16 or 20 Hz, but humans can perceive infrasound if the sound pressure level (dB) is sufficiently high [4]. In the range of IFS, comparative studies have shown that the auditory sensitivity of different species can vary widely. For instance, rats have poorer infrasonic hearing than humans, considering different sound pressure levels [5], but high-intensity (110 dB) IFS vibrations on experimental rats can be perceived, as they elicit active avoidance reactions [6]. Beside its auditory health effects, noise can cause nonauditory effects—such as annoyance, sleep disturbance, and psychological stress—that experimental and epidemiological evidence links to cardiovascular disease, including ischemic heart disease, heart failure, arterial hypertension, arrhythmia, and stroke [7–12].

In recent years, scientists have directed their attention towards the relatively understudied noise range of below 200 Hz. LFN and IFS are present everywhere, from natural occurrences to industrial installations and low-speed machinery. The characteristics of strong penetration and less attenuation in long distance propagation have been proposed to explain several adverse biological effects in experimental and epidemiological studies [13]. Low-frequency sounds have higher energy than the sounds at mid and higher frequencies and cannot be correctly evaluated using the conventional A-filters, which are most often used in environmental studies [14]. It is also possible that there are subtle effects of LFN on the body that we do not yet understand. High sound pressure levels (> ≈ 90 dB) of LFN can induce resonance responses in body cavities [13]. The overall range of human body resonant frequencies was

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found to be from 2 to 16 Hz [15], which is nearly the exact range of IFS. It may be assumed that animals also possess inherent specific sound frequencies in certain tissues and organs [16], and for that reason, it is important to document, using animal models, the morphological and biological effects induced by a wide spectrum of wavelengths, from industrial to LFN and IFS.

The cardiovascular system of rodents is sensitive to LFN [17–19]. We previously documented the development of perivascular fibrosis around the coronary arteries (from small to large caliber) of rats exposed to industrial noise [20,21]. We also found a significant fibrotic development in ventricular myocardium among rats submitted to LFN [22,23]. These morphological changes were found in the absence of inflammatory cells, which could suggest a noninflammatory process. However, the fibrotic proliferation mechanism remains unclear.

The effects of IFS on the coronary artery morphology under the influence of an anti-inflammatory agent are unknown. In order to fill this gap, we sought to evaluate the morphological changes induced by IFS in rat coronary arteries in the presence and absence of dexamethasone.

2. Material and methods

Fourteen adult female Wistar rats 10 months old were used in this study. They were purchased from a Spanish breeder (Charles River Laboratories España, S.A., Spain). All the handling and care of the experimental animals were performed by authorized researchers (accredited by the Federation of European Laboratory Animal Science Associations, Category C) and were done in accordance with the EU Commission on Animal Protection for Experimental and Scientific Purposes (2010/63/EU) and with the Portuguese legislation for the same purpose (Decree-Law No. 197/96). The rats were housed in 42×27×16-cm polypropylene cages with a steel lid and had unrestricted access to food (commercial chow) and water. The same standard house conditions were used throughout the experiment for all the animals, and they involved keeping a maximum of two rats in a single cage.

In the beginning of the study, the 14 rats were randomly distributed into three groups. Nine of the rats were continuously exposed to high-intensity and very LFN (2–20 Hz/Lp=114 dB) during a period of 28 days. In four of the noise-treated rats, two tablets of dexamethasone 0.5 mg (Decadron 0.5 mg, Medinfar) were introduced subcutaneously in the dorsal region at two time points of the noise exposure, day one and day 12, and these were designated as group A, while the dexamethasone-free rats were included in group B. The remaining five rats were used as age-matched controls (group C) and sacrificed when all of the rats reached 11 months of age.

2.1. Short description of electroacoustic experiment

With the objective of creating a strong subsonic acoustic field in the *vivarium* chamber, a slightly trapezoidal room with 23.7 m^3 (3.55×3.31×2.02, average length×width×height, respectively, in meters), a pseudo-random waveform in the 2-Hz to 20-Hz decade band was designed with Matlab based on a bandpass-filtered 30-s maximum length sequence segment. The waveform was used to excite an array of two infinite baffles mounted 18-in. 300-W-rated magnetodynamic subwoofers, by means of a 2×600-W heavy-duty quasi-dc voltage output audio power amplifier. Subsequently, with the aim of exploiting as much as possible the available subwoofers dynamic range at this frequency range with an acceptable amplitude distortion, the waveform was iteratively nonlinearly treated with moderate compression-expansion and further filtering (in order to reduce the crest factor to approximately 2.0 times). The total sound pressure level and the spectral characteristics of the resulting acoustic pressure waveform were monitored, and the results were an average sound pressure level of 120 dB with a tolerance of ±3 dB in the 30-s time window. As to the spectral boundedness of the produced sound field, the result was 80 dB total out-of-band average sound pressure level (−40 dB lower).

2.2. Light microscopy

All rats were sacrificed by an intravenous injection of 0.6 ml of a 5:4 mixture containing ketamine (Imalgene 1000, Bayer, Portugal) and xylazine (Rompun, Bayer, Portugal). The vascular system was perfused with a saline solution followed by paraformaldehyde fixation. The heart was excised, sectioned transversely from the ventricular apex to the atria, and routinely processed for light microscopy. The midventricular fragment from each heart was selected for the study. Five-micrometer paraffin-embedded slices of the tissue samples were made and dyed according to Sirius red techniques. The histological images were acquired with an optical microscope using 100× magnification.

2.3. Histomorphometric data

Thirty-one arterial vessels were selected (8 in GA, 10 in GB, and 13 in GC) (Fig. 1). At least one vessel from each rat was included. The researchers, including data collectors and data analysts, were blinded to which group the animals belonged to. Data were analyzed using the *image J* software (National Institutes of Health, Bethesda, MD, USA). The caliber of the arterial vessels, the thickness of the walls, and the perivascular tissue dimension were measured, and for each rat, the mean lumen-to-vessel wall (L/W) and mean vessel wall-to-perivascular tissue (W/P) ratios were calculated (Fig. 2). (See Table 1.)

2.4. Statistical analysis

Mann–Whitney test has been applied in the comparison of IFS-exposed animals (including animals treated with dexamethasone and nontreated animals) and a control group for two parameters: L/W and W/P ratios. Kruskal–Wallis and Mann–Whitney tests were used in the comparison of the three groups for the same parameters. A P value <.05 was considered statistically significant.

3. Results

3.1. IFS-exposed animals vs. control animals

The Mann–Whitney test has been used to compare the two groups for L/W ratio and W/P ratio variables, with the Bonferroni correction $\alpha^* = 0.05/2 = 0.025$. The analysis shows that the W/P ratio is significantly lower in the IFS-exposed group (P=.001). In contrast, the L/W ratio did not differ between the two groups (P=.060). It should be mentioned that the extreme observation for W/P ratio values in the control group does not influence these conclusions, as differences between the groups were still detected by the Mann–Whitney test after removal of that observation (P=.003), as expected in view of the robustness of this nonparametric test against such extreme values (Fig. 3).

3.2. Comparison between IFS-exposed dexamethasone-treated animals, IFS-exposed animals, and control animals

In the comparison between the three groups, the Kruskal–Wallis test has been applied with the same Bonferroni correction to the significance level, $\alpha^* = 0.025$. The analysis has shown that there are differences between the groups for W/P ratio (P=.011) but not for L/W ratio (P=.104). *Post hoc* comparisons between the groups were conducted for W/P ratio, using the Mann–Whitney test, at the 0.025/3= 0.0083 significance level to control for inflation of type 1 error. In this case, differences were detected between control and IFS-exposed animals not treated with dexamethasone (P=.008). It should be mentioned that the extreme observation of W/P ratio values does not seem to influence the main conclusion of the Kruskal–Wallis test, as expressed by a significance of .021 of the test result after removal of that observation, but it does change the conclusions of the Mann–Whitney test in the comparison between groups B and C, which is now

Fig. 1. (A, B, and C) Coronary artery vessels in fragments taken from the left midventricle from (A) group A, infrasound-exposed dexamethasone-treated rats; (B) group B, infrasound-exposed rats; and (C) control group. Note the prominent perivascular tissue in infrasound-exposed animals [Sirius red, 100×].

nonsignificant (P=.021) under the Bonferroni correction (* = 0.0083) (Fig. 4).

4. Discussion

The present study evaluated the coronary morphological changes in rat heart induced by pure IFS, created in a laboratory controlled electro-acoustic experiment, and is the first study assessing the possible influence of an anti-inflammatory agent on these changes.

In this investigation, we found an increase in the perivascular tissue around the coronaries in rats exposed to IFS. There were significant differences between IFS-exposed rats and controls concerning the mean W/P ratio, higher among the control group (P<.001). But such differences did not reach statistical significance in the comparison between the animals treated with dexamethasone and the control group, pointing to a possible influence of this potent anti-inflammatory agent.

Previous work from our group, in Wistar rats, investigated the histomorphometric changes in the large and small coronary arteries induced by high-intensity industrial noise within a wide spectrum of wavelengths that included LFN, this last characterized by large sound pressure amplitude ≥90 dB and low-frequency bands of ≤500 Hz [20, 21]. The exposure time ranged from 1 to 7 months. In both studies, we found the development of perivascular fibrosis in the absence of inflammatory cells, regardless of exposure time. In another study, we have documented a significant fibrotic development in ventricular myocardium of rats exposed to LFN during a period of 3 months [22]. These investigations confirmed the abnormal proliferation of connective tissue as the main morphological change induced by LFN.

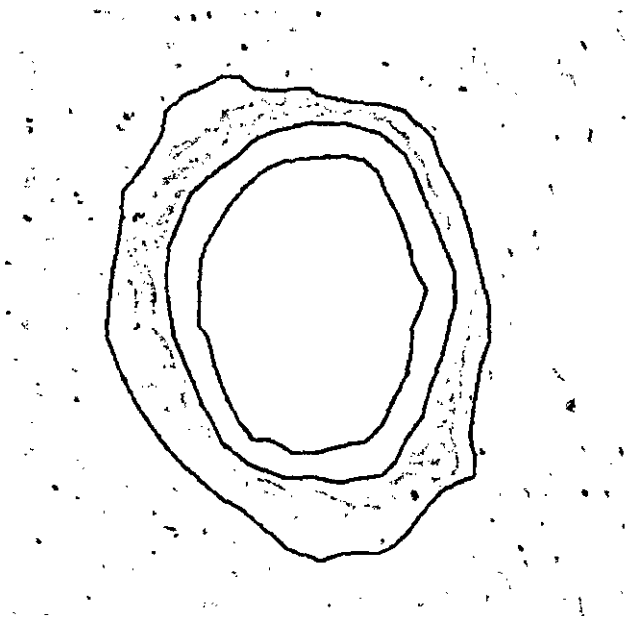

Fig. 2. Example of a coronary artery in a fragment taken from the left midventricle of an infrasound exposed rat [Sirius red, 100×]. The black lines represent the measurements performed using *Image j* software and correspond to vessel caliber, thickness of the wall, and perivascular dimension. These were used to calculate the L/W and W/P ratios.

With increasing urbanization, noise is rising as one of the most important environmental risk factors in modern societies. The importance of the characteristics of the noise stimulus, such as frequency content, intensity, mean and peak dB level, pattern, and exposure time, is not well understood. In the quantitative risk assessment of environmental noise, the World Health Organization (WHO) Regional Office for Europe is concerned with sound pressure level limits, not frequencies [1]. Nonetheless, WHO also acknowledges the special place of LFN as an environmental problem, recognizing that the evidence is sufficiently strong to warrant immediate concern.

Sources of LFN include natural occurrences, industrial installations, and low-speed machinery, ranging from very low-frequency atmospheric fluctuations up to lower audio frequencies. Due to the characteristics of strong penetration and less attenuation in long distance propagation, it has been implicated in several adverse biological effects in experimental and epidemiological studies [13].

One effect of high pressure levels of LFN is excitation of body vibrations [13,19,24]. At high sound levels, typically above 80 dB, the occurrence of resonance responses in body cavities was described [24]. The overall range of human body resonant frequencies was found to be from 2 to 16 Hz [15], which is almost the exact range of infrasound. The displacement between the organ and the skeletal structure places biodynamic strain on the body tissue involved, and it is known to reach its maximum under exposure to vibration close to the body's resonant frequency. Despite the practical impossibility of stimulating the natural frequency of one organ alone without exciting the whole-body resonances, measurements of vibration transmissibility from the point of excitation to a specific organ reveal frequencies of maximum transmissibility that can be attributed to the resonance of the organ. Considering that animals also possess inherent specific sound frequencies in certain tissues and organs [16], it is important to assess the morphological and biological effects induced by noise with different wavelengths in distinct animal models. So far, we have focused our investigation on the effects of large pressure amplitude noise within a wide spectrum of wavelengths, from the industrial to LFN and IFS, and with different exposure times, from 1 to several months [20–23]. The common finding was an abnormal deposition of collagen in the extracellular matrix (ECM), regardless of the characteristics of the noise stimulus other than pressure amplitude.

Table 1
Median (interquartile range) of the two measured outcomes in the three groups

	Ratio L/W Median (interquartile range)	Ratio W/P Median (interquartile range)
Group A	0.54 (0.17)	0.48 (0.15)
Group B	0.66 (0.09)	0.49 (0.08)
Group C	0.71 (0.10)	0.68 (0.08)

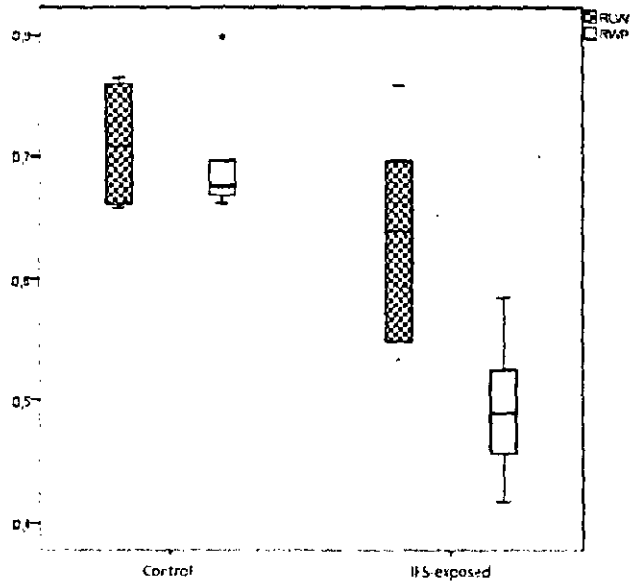

Fig. 3. Lumen-to-vessel wall and vessel wall-to-perivascular tissue ratios in IFS-exposed and control animals. The W/P ratio was significantly reduced in IFS-exposed animals ($P=.001$). RLW, lumen-to-vessel wall ratio; RWP, vessel wall-to-perivascular tissue ratio.

Interest in the potential adverse health effects of IFS has increased over time. High-level IFS below 20 Hz was historically thought to be of much less significance than LFN in the 20–200 Hz range at the same pressure level [25]. Research on the impact of IFS on the environment established that, for levels above 120 dB, it is dangerous to the human body [13].

Infrasound exposure studies in laboratory animals are scarce and report adverse effects in the ear and auditory system [26], brain and central nervous system [27,28], liver [29,30], and lung [31]. Specifically, the cardiovascular system is sensitive to IFS, as shown by the first studies conducted more than 25 years ago. In these studies, rats were exposed to infrasound (4, 8, and/or 16 Hz at 90 to 145 dB) for up to 45 days, which ultimately led to myocardial ischemia and morphofunctional changes in the myocardium cells [32–34]. More recently, Pei et al. reported IFS-induced hemodynamics, cardiac ultrastructure damage, and cardiac cell apoptosis in the rat myocardium [35,36]. The same group found that IFS dysregulates the L-type calcium currents in rat ventricular myocytes [16] and also that acute exposure to IFS induces oxidative damage of cardiomyocytes that affects a series of oxidative damage-related proteins and genes, suggesting a complex signaling network that is evoked by this stressor [37].

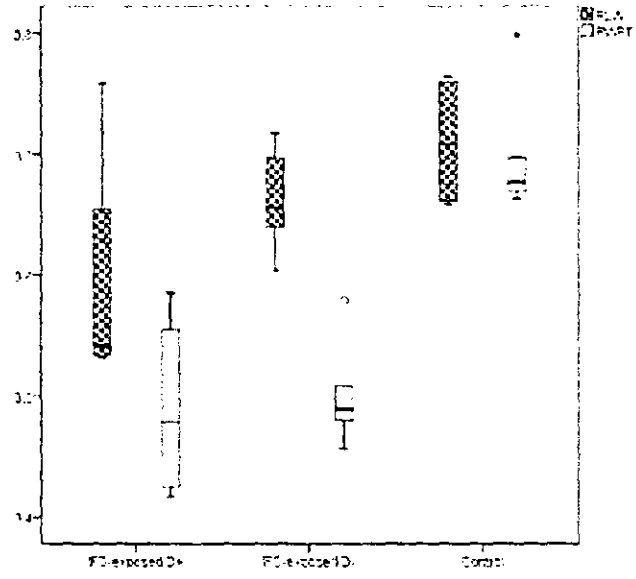

Fig. 4. Lumen-to-vessel wall and vessel wall-to-perivascular tissue ratios in infrasound-exposed dexamethasone-treated rats (group A), infrasound-exposed rats (group B), and control group (group C). For W/P ratio, there are differences between the groups ($P=.011$) and between groups B and C ($P=.008$), but not between groups A and C. RLW, lumen-to-vessel wall ratio; RWP, vessel wall-to-perivascular tissue ratio. D+ and D−, dexamethasone-treated and not treated, respectively.

There is no agreement about the biological activity of LFN and IFS and the possible underlying mechanisms. The biological effects of noise on living bodies may not be the same due to different parameters such as biological species, frequency, level of sound pressure, or time of exposure. Over the last years, an increased focus from investigators towards the elucidation of these questions has been observed. Increased release of stress hormones, activation of sympathetic nervous system, increased reactive oxygen species production, endothelial dysfunction, peripheral vasoconstriction, increased peripheral vascular resistance, and increased blood viscosity are among the proposed mechanisms elicited by acute or chronic noise stress leading to detrimental outcomes on the cardiovascular system [7,9,38]. Following this line of investigation, Said and El-Gohary studied the effect of noise in the 80–100-dB range on heart rate and mean systemic arterial blood pressure in adult male albino rats and explored possible underlying mechanisms [39]. They concluded that noise stress has many adverse effects on cardiovascular system through increasing plasma levels of stress hormones, oxidative stress, and endothelial dysfunction.

Until recently, it was presumed that LFN required greater sound pressure in order to elicit toxicological effects on humans and animals. High sound pressure levels can be harmful to the cochlea and cause hearing loss, raising the question of other noise effects being secondary, at least partially, to direct auditory damage. Since animal models in previous studies employed mainly high dBA levels (>100–120 dBA), some investigators started exploring the effects of low decibel noise. Jin et al. [17] used isolated and cultured cardiac fibroblasts from rats to study the effects of low decibel IFS. They reported that noise below 90 dB at 4–20 Hz inhibits angiotensin-II-stimulated cardiac fibroblasts by reactivating miR-29a targeting the TGF- /Smad3 pathway, possibly eliciting cardiac protective effects. Munzel et al. [18] developed a novel noise exposure model in mice with lower peak sound levels (<85 dBA), lower mean sound pressure levels (72 dBA), and shorter exposure times (1–4 days), thought to cause mainly nonauditory effects to animals such as stress reactions. Exposure to noise resulted in elevated blood pressure and heart rate and was associated with detrimental changes in vascular endothelial function, vascular production of reactive oxygen species, and increased blood stress hormones and biomarkers of inflammation. Notably, they describe an invasion of the vasculature with inflammatory cells. The same group demonstrated that nighttime aircraft noise in healthy volunteers causes endothelial dysfunction, which was partially corrected by the acute administration of vitamin C, pointing to increased oxidative stress as a key mechanism [40].

There are currently limited data on the hypothetical noise-induced pathway involving inflammation [11]. In humans, sleep disturbance is associated with a proinflammatory state [41]. As previously mentioned, the common finding in the noise experiments conducted by our group was the perivascular and myocardial fibrotic development in the absence of inflammatory cells [20–23]. In the present study, we included a group of IFS-exposed animals treated with dexamethasone, a synthetic glucocorticoid member with immunosuppressive potency of about 20–30 times that of hydrocortisone and 4–5 times of prednisone [42,43]. Subcutaneous application of dexamethasone, in contrast to intraperitoneal, is highly effective in inhibiting inflammation in mouse models even at low doses [44]. Interestingly, we found differences in

the comparison of control group with IFS-exposed animals with and without dexamethasone treatment, as the treated animals did not show significant differences when compared to controls. This is the first time that such differences are documented, and despite the absence of inflammatory cells previously described by our group, we have to consider a potential underlying inflammatory mechanism.

The mechanism behind the fibrotic proliferation induced by noise in rat heart is not yet understood. In general, the differentiation of cardiac fibroblasts into more active myofibroblasts is the hallmark of cardiac fibrosis, leading to an abnormal accumulation of the ECM components, such as collagen, around damaged heart tissues [45,46].

Myofibroblast differentiation is a complex and highly regulated process, where biochemical and mechanical factors are interdependent [47]. From a biochemical aspect, the differentiation of cardiac fibroblasts into myofibroblasts is well studied, while the role of mechanical factors remains elusive [48]. When exposed to abnormal mechanical conditions such as strain and ECM stiffness, cardiac fibroblasts can undergo myofibroblast differentiation [49,50]. A fact worth mentioning within the scope of our investigation is that, during the cellular response to heart injury, myofibroblasts actively secrete ECM proteins, such as collagen I and III, to replace the damaged myocardium [51]. We previously performed an immunohistochemical and electron microscopy study in order to evaluate the effects of LFN on cardiac collagen and cardiomyocyte ultrastructure [23]. A significant increase of collagens I and III in the ECM was observed. The ultrastructural observation denoted high concentration of collagen in the ECM next to fibroblasts, confirming the pronounced effect of LFN on the connective tissue.

Comparable to the traditional cardiovascular risk factors, experimental and epidemiological evidence substantiates the concept that noise, through auditory and nonauditory effects, may induce activation of different pathways (oxidative stress, vascular dysfunction, autonomic imbalance) that ultimately lead to cardiac fibrosis, adverse ventricular remodeling, and arrhythmogenesis [7–12]. It is important to note that nonauditory noise effects (annoyance, sleep disturbance, and psychological stress) do not follow the toxicological principle of dosage [7]. Consequently, not simply the accumulated sound energy that causes the adverse effect but also the cognitive perception of the sound, the subsequent cortical activation, and the emotional response need to be taken into account. More epidemiological research on LFN and health effects is needed since the available research is scarce and suffers from methodological shortcomings. A systematic review of observational studies suggests an association between everyday life LFN and IFS components (up to 250 Hz) and health effects in the general population, such as annoyance, sleep-related problems, concentration difficulties, and headache [52]. However, they underline the inconsistency across studies and the small number of existing observational investigations, precluding a direct comparison with experimental evidence.

This study has some limitations. The number of animals per group was limited; therefore, the results should be interpreted cautiously. The significant correlation between the two dependent variables considered in this study, ratio L/W and ratio W/P, as expressed by a Spearman correlation coefficient of 0.705 (P=.005), would recommend a multivariate approach to the data in order to account for the effect of the association between variables on type I error. However, given the reduced dimensions of the groups, it is not recommended to assess the multivariate normality and homogeneity of variance–covariance assumptions in view of the reduced power of the corresponding tests. In these conditions, the Mann–Whitney test has been used to compare the two groups for ratio L/W and ratio W/P variables, with the Bonferroni correction * = 0.05/2=0.025. For the reasons mentioned above regarding the correlation between the dependent variables and group dimension, a nonparametric approach to the data was implemented in the comparison between three groups. The Kruskal–Wallis test has been applied with the same Bonferroni correction to the significance level, * = 0.025, and post hoc comparisons between the groups were conducted for ratio W/P using the Mann–Whitney test, at the 0.025/3=0.0083 significance level, to control for inflation of type 1 error. Also, experimental noise stress models are scarce, and at the present time, a well-defined morphological cardiac model to study the consequences of IFS exposure does not exist. There is a lack of consensus regarding the cardiac cell composition, including fibroblasts, in mammals, with potential variations between species that also depend on the age [53]. Concerning the characteristics of noise, public health research uses A-weighting method to measure noise and focus on sound pressure level, disregarding frequencies. We believe that both sound frequency and intensity are key factors. So far, we investigated the structural modifications in the rat myocardium induced by high sound pressure noise of different wavelengths, from industrial to IFS. Addressing these important questions at the mechanistic level in animals may help provide directions for studies in humans, as more epidemiological research is imperative.

5. Conclusions

Infrasound exposure induces coronary perivascular fibrosis that differs under corticosteroid administration, which raises the possibility of an underlying inflammatory mechanism. The importance of noise in perturbation of inflammatory factors needs to be further investigated.

Con icts of interest

None.

Acknowledgments

The authors would like to address a posthumous thanks to Professor José Martins dos Santos for contributing to the works related to low frequency noise and infrasound.

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MICHIGAN STATE
UNIVERSITY

January 15, 2019

To Whom It May Concern:

At the request of Mr. James Dillingham of Scipio Township, I write this letter to express concern for his health as it relates to sPower's proposed Seneca Wind Project. The emphasis of my concern is the low-frequency noise and infrasound emitted by industrial wind turbines, which is known to lead to, or exaberate, a variety of adverse health effects. Mr. Dillingham is a U.S. Army veteran who has been diagnosed by the Department of Veterans Affairs with chronic vertigo, among other service-connected disabilities. Vertigo can be either *objective*, in which stationary objects in the environment appear to be in motion or spinning, or *subjective*, in which the individual has a sensation of rotating or spinning. During severe episodes, vertigo is an aggressively debilitating condition during which an individual is in a state of dysfunction and must remain motionless until the episode passes.

As a retired, certified audiologist with 50 years of clinical, research, teaching, and administrative experience in my profession, I am intervening on Mr. Dillingham's behalf because of my understanding of the anatomy and physiology of the human ear, and how sound is produced, propogated, measured, and perceived by humans. I have almost 10 years experience as a consulting expert witness in various legal cases on behalf of citizen intervenors who are concerned with the potential adverse health effects of wind turbine noise. I am not a physician, but given that Mr. Dillingham has already been medically diagnosed with vertigo and other chronic health conditions, he is not requesting that I diagnose his personal health status, but instead is requesting an evaluation of whether exposure to the proposed wind project has the potential to worsen his vertigo and possibly cause additional health issues. This type of evaluation is known as *causation assessment*, as opposed to *differential diagnosis*.

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The World Health Organization states that individuals who are most vulnerable to the detrimental effects of environmental noise are the very young, the elderly, and those with chronic health conditions. Certainly, Mr. Dillingham falls into the latter category, and his concerns deserve special consideration. The WHO has established guidelines for limiting community and environmental low-frequency noise in documents published in 1999[1] and 2009.[2] In the 2009 guidelines, the WHO recommended that average, A-weighted noise levels outside a residence, designated as *LAeq,outside*, not exceed 40 dB to avoid substantial annoyance, sleep disturbance, and other adverse health effects. It established limits specifically for wind turbine noise for the first time in its most recent guidelines,[3] recommending that noise emissions from turbines not exceed 45 dB Lden. The Lden metric penalizes evening and nighttime noise levels by 5 and 10 dB, respectively, relative to daytime levels, and a level of 45 dB Lden is equivalent to an Leq of 38.3 dB. Levels

between 38-40 dB Leq are in agreement with those recommended by Dr. Paul Schomer, a prominent acoustician who is the former Director of the Standards Division of the Acoustical Society of America.

It is important to understand that all of these metrics for reporting decibel levels are based on A-weighting, which is used for its convenience in expressing noise levels across a range of frequencies as a single number. A-weighting, however, effectively excludes infrasound and substantial amounts of low-frequency noise and is regarded by most independent acousticians as inadequate either to predict the level of outdoor or indoor infrasound or to reveal a definitive relationship with adverse health impacts. The effects of infrasound are best assessed by using narrow-band frequency analysis at frequencies below 20 Hz or by comparing A-weighted levels to C-weighted levels, the latter of which encompass more low-frequency information. The 1999 WHO community noise guidelines discuss in detail the fact that averaged levels do not adequately account for any momentary peaks of low-frequency noise and infrasound (such as those emitted by wind turbines). The amplitude modulation in wind turbine noise is believed to lead to extreme annoyance, sleep disturbance, negative sensations, and adverse health effects.

In 2016, I co-authored with acoustician Richard James an article titled *Wind turbine noise and human health: A four-decade history of evidence that wind turbines pose risks.*[4] In it, we reviewed the scientific literature that largely disputes many of the major postions taken by the wind industry with regard to the causative relationship between wind turbine noise and adverse health effects. Because of that article's length—55 pages of text and 17 pages of references—most people are likely to skim through it or ignore it completely, so I would like to summarize below our major conclusions, with special emphasis on those aspects that relate to Mr. Dillingham's health concerns.

While audible noise from wind turbines is known to disturb sleep, be extremely annoying, and substantially reduce quality of life, health symptoms such as headaches, dizziness, nausea, and motion sickness seem to be explained best by exposure to infrasound. Paller et al.,[5] in Canada, found a statistically significant association between wind turbine noise and vertigo, although few studies have established a direct causative relationship. Schomer and colleagues[6] have explained that the types of vestibular symptoms reported by individuals living near wind turbines, including vertigo, are similar to motion sickness, which is known to be induced by very low-frequency sources below 1 Hz—which modern wind turbines are known to produce. Their study indicates that the vestibular components of the inner ear appear to be central to motion sickness and other balance disorders reported by persons living near wind turbines. Dr. Nina Pierpont[7] has explicitly described the relationship between complaints associated with wind turbine noise exposure and migraines, motion sickness, vertigo, gastrointestinal sensitivity to noise and visual stimulation, and anxiety. Despite the wind industry's vigorous denials, recent research is largely consistent with Dr. Nina Pierpont's original description of symptoms resulting from exposure to wind turbines, which she termed *Wind Turbine Syndrome.*

Wind turbine noise has unique acoustic characteristics when compared to other environmental noises. Those characteristics include amplitude modulation with intermittent occurrences of tones that mirror the peak energy of the blade-pass frequency and the first several harmonics. Infrasound emissions from wind turbines can also resonate air inside closed rooms, effectively amplifying any acoustic energy that is present, and can resonate, or vibrate, organs and tissues of the human body.[8] The wind industry often states that infrasound from turbines is less intense than infrasound generated by other environmental sources or within the human body itself. Based on its anatomical characteristics, however, the inner ear

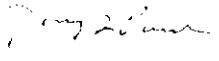
is capable of preventing internally generated sound, but not externally generated sound, from being perceived, which means that perception of wind turbine infrasound may be far more disturbing than any infrasound generated within the body. Also, infrasound is more perceptible when higher frequencies are absent, meaning that conditions are likely to be at their worst in a quiet bedroom at night, when higher frequencies are relatively attenuated by the surrounding structures of a residence.

Advocates of wind energy also take the position that levels of infrasound and low-frequency noise generated by modern wind projects are well below those that adversely affect health, and that there is no accepted physiological mechanism that explains how sub-audible infrasound can affect health. Wind advocates superficially reject the work of Dr. Alec Salt and colleagues, who have explained in detail the physiological mechanisms by which the cochlear and vestibular mechanisms of the inner ear process infrasound and how infrasound stimulates various regions of the brain to result in unpleasant sensations. Dr. Salt is a highly reputable scientist who is known as a preeminent investigator of the inner ear, and is a recipient of numerous grants from the National Institutes of Health. In laboratory studies of lower animals that have similar ears to humans, Salt and his colleagues have shown that low-frequency tones presented at moderate to moderately intense levels for no more than three minutes can induce endolymphatic hydrops, commonly known as Menière's disease, in which vertigo is a major symptom.

Noise reports conducted by wind industry acousticians frequently indicate that no scientifically valid studies have shown a causative or direct relationship between modeled or measured levels of wind turbine noise and adverse health effects. Such a conclusion reflects an overly narrow and self-serving understanding of causation, and ignores the role of mediators between noise and health, which include annoyance, stress, anxiety, and sleep disturbance. The Bradford Hill criteria[9] consist of rules by which evidence of causative relationships between diseases and environmental exposures should be established. Those rules include the notion that while epidemiologic research is helpful in that regard, evidence from other sources must also be considered. In addition to numerous anecdotal reports, researchers have provided a large body of scientific evidence in peer-reviewed journals, government documents, print and web-based media, and in scientific papers presented at professional meetings that indicates a general causal link between a variety of adverse health effects and noise emitted by industrial wind turbines. For detailed information regarding that evidence, readers can refer to the review article by Punch and James.[4]

In my professional opinion, Mr. Dillingham can be expected to experience worsened health symptoms if forced to live in close proximity to one or more wind turbines. If the proposed Seneca Wind Project is approved, I would urge that the approval process take extraordinary precautions to avoid exposing him to potentially devastating consequences to his health. The same concern should be applied to any other residents within the vicinity of the project who exhibit similar health conditions.

Respectfully submitted,



Jerry Punch, Ph.D.
Professor Emeritus

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POFFENBAUGH
EX. 1

EXHIBIT 1
WALT POFFENBAUGH

Wind Energy

Seaman Ex1

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RESEARCH ARTICLE

Analysis of throw distances of detached objects from horizontal-axis wind turbines

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ABSTRACT

This paper aims at predicting trajectories of the detached fragments from wind turbines, in order to better quantify consequences of wind turbine failures. The trajectories of thrown objects are attained using the solution to equations of motion and rotation, with the external loads and moments obtained using blade element approach. We have extended an earlier work by taking into account dynamic stall and wind variations due to shear, and investigated different scenarios of throw including throw of the entire or a part of blade, as well as throw of accumulated ice on the blade. Trajectories are simulated for modern wind turbines ranging in size from 2 to 20 MW using upscaling laws. Extensive parametric analyses are performed against initial release angle, tip speed ratio, detachment geometry, and blade pitch setting. It is found that, while at tip speeds of about 70 m/s (normal operating conditions), pieces of blade (with weights in the range of approximately 7-16 ton) would be thrown out less than 700 m for the entire range of wind turbines, and turbines operating at the extreme tip speed of 150 m/s may be subject to blade throw of up to 2 km from the turbine. For the ice throw cases, maximum distances of approximately 100 and 600 m are obtained for standstill and normal operating conditions of the wind turbine, respectively, with the ice pieces weighting from 0.4 to 6.5 kg. The simulations can be useful for revision of wind turbine setback standards, especially when combined with risk assessment studies.

KEYWORDS

wind turbine accidents; blade element theory; blade detachment; ice throw; aerodynamic model; HAWT

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1. INTRODUCTION

The ever-growing number of wind turbines installed near inhabited areas, buildings and community facilities, such as bridges, power installations or highways, has resulted in an increasing concern by authorities to determine risk levels associated with wind turbine blade failure. From a safety point of view, the most serious failure is associated with splintering of rotor blades and detachment of debris, which could be thrown over long distances and damage people or property. Ice-throw from wind turbines installed in cold climate is also of high concern, especially for wind turbines erected near highways where the ice pieces thrown from a wind turbine may strike a passing car, which in the worst case may cause a fatal accident.

Various types of hazards regarding operation of wind turbines have recently been reported by Durstwitz and the Caithness Windfarm Information Forum.[2,3] According to a recent survey by the Caithness Windfarm Information Forum, blade failures resulting in either whole blades or pieces of blades being thrown from the turbine are the most important causes of turbine accidents.[3] A comparative graph showing the growth of wind turbine accidents over the past four decades is shown in Figure 1, where the share of blade accidents and accidents due to fire, which may eventually cause throw of fire patches, are also presented. Due to such accident data, energy authorities all over the world have tried to enforce safety distances around wind turbines and wind farms. The safety distance is a distance within which it is not allowed to build human structures such as buildings and roads. Shown in Table I is an example of the safety distance standards defined by different authorities. It can be seen from the table the values of offset safety distances fall within an extensive range of

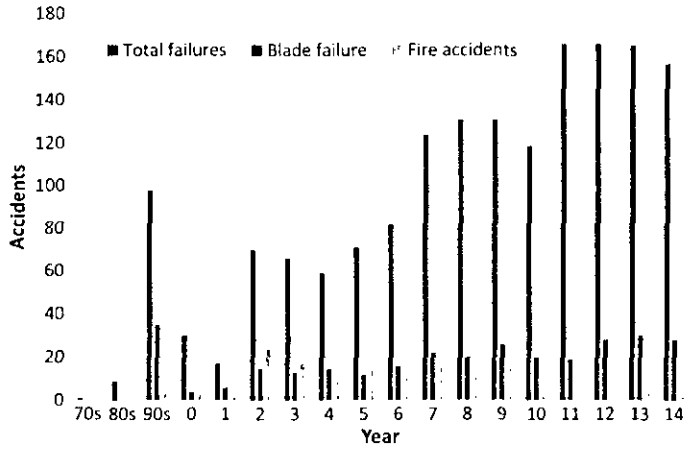

Figure 1. *Comparison of wind turbine accidents and particularly blade failure data in a period from 1970s until 2014 (data taken from* Caithness Windfarms[3]).

Table I. Safety distances of wind turbines from human *structures as practiced in different regions of the world.*[17]

Authority/source	Safety distance (m) (ft)
France	1609 (5280)
Germany	1609 (5280)
Rural Manitoba, Canada (1981)	(6500)
US National Research Council	762 (2500)
IL, USA	457 (1500)
Riverside County, CA, USA	**3218 (10560)**
MI, USA	**304 (1000)**

scales between 3.2km and 300m, and that the setback standards are not even similar in different regions of the same country. To standardize such safety guidelines, it is useful to employ mathematical models of the throw in various conditions and risk assessment tools to associate the probability of failure in each particular setting.

Motions of solid particles in fluids were first addressed analytically by Kirchhoff.[4] He showed that the equations of motion for a solid body in an ideal fluid reduce to a set of ordinary differential equations (ODE) based on Euler's equations. Further experimental investigations on falling objects revealed, despite originating from Euler's equations, various states of chaotic motion. It was also mathematically shown that Kirchhoff's equations had been prone to yield chaotic solutions [5]. Tanabe *et al.*[6] developed a set of two-dimensional equations of motion (including rotation) based on simple mechanics in which plates of zero thickness were subject to lift, friction and gravity forces. Based on those assumptions, they found five different falling patterns, ranging from a periodic movement to chaotic random motions depending on the density ratio between the solid and the surrounding fluid and on the length of the object. Pesavento and Wang[7] and Andersen *et al.*[8] performed more detailed studies to determine the motion of a falling two-dimensional elliptic object using direct numerical simulation of the Navier–Stokes equations. They took added mass and added moment of inertia into account and analyzed the transient motion and local jumps of the falling object thoroughly.

Due to complications in a real-life blade accidents (erratic motions, high Reynolds numbers, complex geometries etc.), the fundamental studies mentioned above could only partially help understanding the physics of wind turbine blade throw patterns. To cope with the wind turbine problems, simplified approaches were used. Macqueen *et al.*,[9] for instance, studied the problem of blade-throw from wind turbines, using classical ballistics and also assumption of constant lift and drag. A lift coefficient of Cl = 0.8 and a drag coefficient of Cd = 0.4 were used for the gliding simulations, with Cl = 0.0 and Cd = 1.0 for the tumbling motion. However, the probability that gliding would occur was deemed very small. Their maximum throw studies using simple ballistic analysis, that is, by neglecting aerodynamic forces, showed that in the extreme throw velocity of approximately 310m/s, the maximum throw length reaches 10km.

One of the first detailed studies on the aerodynamics of a detached wind turbine blade was performed by Sørensen[1] using a blade element approach. In this approach, the detached blade is divided into a number of sections and the aerodynamic loads are determined for each section. The total external aerodynamic load on the whole blade would then be determined as the summation of the individual forces on each section.

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Recently, Rogers *et al.*[10] used a dynamic model employing quaternions instead of Euler angles and rotation vectors to form the orientation matrix and performed Monte Carlo simulations of a large set of initial conditions in order to obtain a range of the throw distances.

Ice throw has also been investigated, especially for the turbines erected in the cold climate. Seifert *et al.* measured ice-throw accidents together with a simple aerodynamic model and performed risk analysis of the ice fragments thrown from the blades.[11] Recently, a model of ice throw for a wind turbine in operation was presented by Biswas *et al.*,[12] in which calculations were carried out for ice pieces by neglecting lift and using a fixed drag coefficient of $C_d = 1.0$. It was also estimated that including the highest possible, lift increases the throw distance by approximately a factor of two.

The problem of blade/ice throw has also been investigated through the window of probabilistic methods. Such methods deal with risk levels and probabilities that a certain throw distance will occur. Such studies are typically performed together with a dynamic model for calculating the throw distances. Macqueen *et al.*,[9] Morgan,[13] Morgan and Bossanyi[14] and Rogers *et al.*[10] carried out risk analyses of ice throw to determine safety guidelines for wind developments in ice-prone areas. Sørensen[15] proposed a statistical model that determines risk levels of debris hitting people. Similarly, Carbone and Afferrante[16] performed a combined probabilistic and dynamic analyses to quantify hazards due to the blade throw.

In the present work, detailed aerodynamic analysis are performed for simulating flying debris. The cases include blade throw in which the blade together with its components is thrown, a case in which only a shell laminate is thrown and a case involving detachment of ice fragments. The governing equations of motion form a set of 18 ODEs responsible for the six degree-of-freedom motion. The resulting system of discretized equations are solved using an ordinary time integration method. Throw distances for four different turbine sizes ranging from 2.3 to 20 MW are compared, by employing simple upscaling rules. The computations are carried out for different wind and tip speeds.

2. MATHEMATICAL MODELING

The equations of motion for a detached blade include equations of translation and equations of rotation. These are obtained using Newton's second law and Euler's equations of motion, with the aerodynamic forces obtained from tabulated airfoil data. To be able to quantify the rotational motion of the detached blade, the moments of inertia around the rotation axes are calculated. This, however, cannot be calculated in a fixed coordinate system (i.e., an inertial system) since both the moments of inertia and the rotational speeds are varying and a solution would become very complicated. Instead, the equations are computed around the body-fixed principal axis, and the obtained values are subsequently transformed to the global (inertial) coordinate system to represent the absolute location and orientations. Two coordinate systems are defined here: a global coordinate system $\mathbf{x} = (x, y, z)$ with the origin on the tower basement and orthonormal right-handed unit vectors $(\vec{i}, \vec{j}, \vec{k})$, with the y-axis in the wind direction and the z-axis in the upward direction. A body-fixed coordinate system $\mathbf{b} = (x_b, y_b, z_b)$ is defined by an orthonormal right-handed unit vector $(\vec{r}_1, \vec{r}_2, \vec{r}_3)$, with the origin located at the center of gravity of the detached blade fragment and the third axis parallel to the length axis of the blade (Figure 2).

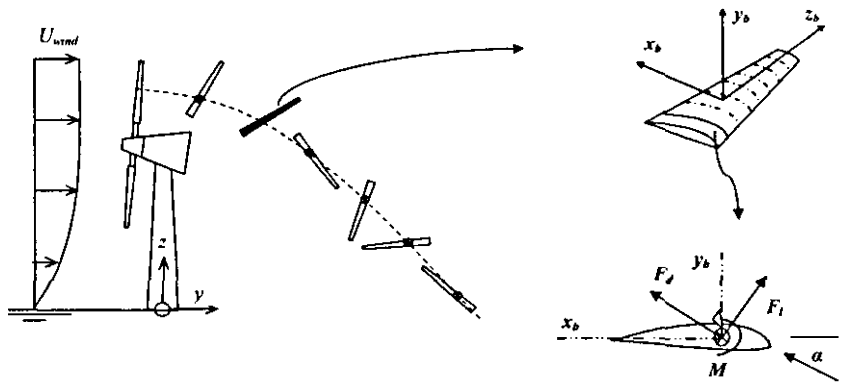

Figure 2. Sketch of the problem and definition of coordinate systems.

The orientation of the detached part is determined through a matrix **R**, which gives the transformation from global coordinates to the body-fixed coordinates

$$\begin{bmatrix}\vec{r}_1\\ \vec{r}_2\\ \vec{r}_3\end{bmatrix} = [\mathbf{R}]\begin{bmatrix}\vec{i}\\ \vec{j}\\ \vec{k}\end{bmatrix} = \begin{bmatrix}r_{11} & r_{12} & r_{13}\\ r_{21} & r_{22} & r_{23}\\ r_{31} & r_{32} & r_{33}\end{bmatrix}\begin{bmatrix}\vec{i}\\ \vec{j}\\ \vec{k}\end{bmatrix} \quad \text{and similarly,} \quad \begin{bmatrix}\vec{i}\\ \vec{j}\\ \vec{k}\end{bmatrix} = [\mathbf{R}^{-1}]\begin{bmatrix}\vec{r}_1\\ \vec{r}_2\\ \vec{r}_3\end{bmatrix} \tag{1}$$

Equation (1) holds for transformation of any variable between the two coordinate systems. This way of defining a vectorized rotation matrix (as opposed to Euler's scalar angles) ensures uniqueness of orientation angles and avoids the problem known as gimbal lock.

The full six degree-of-freedom motion is governed by Newton's second law of motion and Euler's equations of motion:

$$m\underline{\ddot{x}_g} = \underline{F} + m\underline{g} \tag{2}$$

$$\underline{\underline{I}}.\underline{\dot{\omega}_b} = \underline{\omega_b} \times (\underline{\underline{I}}.\underline{\omega_b}) = \underline{M} \tag{3}$$

where m is the mass of the blade, $\underline{x_g}$ is the position vector of the center of gravity, $\underline{F}$ is the aerodynamic force acting on the center of gravity, g is the gravitational acceleration, $\underline{\underline{I}}$ is the moment of inertia tensor, $\underline{\omega}$ is the angular velocity in the rotating frame of reference, $\underline{M}$ is the aerodynamic force acting along the principal axis of the moment of inertia tensor and (.) denotes differentiation with respect to time. To close the system, the following relationship between the motion of the unit vectors of the body (the blade fragment) and the angular velocity is used:

$$\dot{\underline{r}} = \underline{\omega} \times \underline{r} \tag{4}$$

where $\underline{\omega}$ is the angular velocity of the blade fragment in the inertial coordinate system, which by equation (1) is transformed into the local body-fixed coordinate system. The total set of equations are solved using a fourth-order Runge–Kutta–Nystrom or a third-order Adams–Bashforth method. For more information about the mathematical and numerical treatment of the equations, readers are referred to the early work of Sørensen.[1]

2.1. Aerodynamic modeling

For the solution of the system of ODEs, a blade element approach is employed in which each blade is divided into n sections along the span. In each section, the external forces and moments are calculated from airfoil data based on the local wind speed and relative velocities.

The three-dimensional edge effects are to some extent considered through the finite aspect ratio assumption of the blade, and the aerodynamic coefficients of lift and drag are calculated for all angles of attack based on flat-plate theory. The induced velocities are, however, neglected, and the Reynolds-number dependence of the airfoil data is disregarded. Once the aerodynamic coefficients are found, the lift, drag and moments on the blade fragment are computed as

$$L_i = \frac{1}{2}\rho v_i^2 A_i C_{Li}, \quad D_i = \frac{1}{2}\rho v_i^2 A_i C_{Di} \tag{5}$$

where L_i and D_i are lift and drag forces on the i-th section, ρ is the air density, v_i is the local relative airspeed, $A_i = c_i \Delta r_i$ is the local planform area where c_i and Δr_i are the local chord and the section lengths, and C_{Li} and C_{Di} are the sectional lift and drag coefficients at the desired angle of attack.

The static forces aerodynamic coefficients of the airfoil only depend on the angle of attack. Unsteady effects at high angles of attack are included by using the dynamic stall model of Øye.[18] In this model, the dynamic lift coefficient is obtained by interpolating between the lift coefficient of an airfoil in a fully attached flow and a lift coefficient of the airfoil when the flow around the airfoil is fully separated, i.e.,

$$C_{l,dyn} = f_s C_{l,inv}(\alpha) + (1 - f_s) C_{l,fs}(\alpha) \tag{6}$$

where $C_{l,inv}$ is the lift coefficient for a fully attached flow (i.e., inviscid flow assumption) and $C_{l,fs}$ is the lift coefficient for fully separated flow. The stall-changing rate is defined as

$$\frac{df_s}{dt} = \frac{f_s^{st} - f_s}{\tau} \tag{7}$$

where f_s is the time-dependent separation function, which can be thought of as the unsteady weighting function between the fully attached and the fully separated flow. f_s^{st} is a function of airfoil section,

$$f_s^{st}(\alpha) = \frac{C_{l,st}(\alpha) - C_{l,fs}(\alpha)}{C_{l,inv}(\alpha) - C_{l,fs}(\alpha)} \tag{8}$$

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and τ is an empirically determined time constant giving the time lag between the dynamic value of f_s and its static value. It follows from equation (7) that

$$f_s(t+\Delta t) = f_s^{st} + \left(f_s(t) - f_s^{st}\right)\exp\left(\frac{-\Delta t}{\tau}\right) \tag{9}$$

2.2. The atmospheric boundary layer effects

The inlet wind is included as a velocity profile corresponding to the Atmospheric Boundary Layer (ABL). As a result, in addition to simulating uniform inflow,[1] it is possible to simulate throw distances for blades thrown in wind fields following a power or logarithmic law, depending on the specific site information. The ABL wind profile as a function of height and atmospheric conditions reads

$$u_z = \frac{u_*}{\kappa}\left[\ln\left(\frac{z}{z_0}\right) + \psi(z, z_0, L)\right] \tag{10}$$

where u_* is the friction velocity, κ is the von Karman constant (~ 0.41), z_0 is the roughness length, ψ is a function of atmospheric stability and L is the Monin–Obukhov stability parameter (see Wyngaard[19] for more details).

If no data are available in a specific site, and neutral ABL is assumed, a power law $u(z) = u_{hub}(z/z_{hub})^{\alpha}$, $\alpha \sim 0.14$ will be used for the wind velocity at different heights having the wind velocity at hub height as an input. The power-law method is used for the parametric studies in this paper.

Using the mentioned wind profile and denoting the local position vector of a point p on the wing as $\vec{r}_{pb}$, the local relative wind velocity $\vec{u}_{pb}$, as seen by the blade fragment, is given as

$$\vec{u}_{pb} = \left[\mathbf{R}\right].(\vec{u}_{wind} - \vec{u}_g) - \vec{\omega}_b \times \vec{r}_{pb} \tag{11}$$

where the wind vector is assumed to be $\vec{u}_{wind} = (0, u_y, 0)$, neglecting the vertical and lateral components.

3. SIMULATION RESULTS

Simulations of both blade-throw and ice-throw distances are performed by solving the equations derived in the previous sections using the in-house aerodynamic code *Savbal**. The overall procedure for the solution consists of three stages, comprising coordinate transformation, aerodynamics load assessment and time integration. The initial position, orientation and velocities of the detached part are first evaluated at their local coordinates. Based on these values, an iterative procedure starts where the local velocities are evaluated, according to exerted aerodynamic loads, and integrated to give the location and orientation of the fragment in global coordinates until the fragment reaches the ground level.

For the blade-throw analysis, cases with different detached lengths and tip speeds are compared in two sub-cases: (1) the whole blade together with its sandwich structure is thrown and (2) only the shell layer of the blade is thrown. For ice-throw analysis, it turns out that the drag to mass ratio plays an important role for the magnitude of the throw distance. As a result, a few cases with different C_dA/m ratios (as discussed by Biswas *et al.*[12]) with both standstill and running turbine conditions are simulated. The analyses are performed for different wind turbine sizes.

3.1. Turbine upscaling laws

The throw distance analysis was initially performed for a 2.3 MW turbine using publicly available data. A series of empirical relations was then used to upscale the data for the larger turbines, and the analyses were performed for four different wind turbine sizes, i.e., 2.3, 5, 10 and 20 MW. The scale-up factors are first obtained for the blade length, which scales as the square root of the power ratio. Therefore, denoting the blade length, mass (applicable to both total sandwich structure and the shell laminate masses) and mass moment of inertia for the reference turbine with index a, i.e., r_a, m_a and $\mathbf{I}_a$, respectively, the corresponding values for the upscaled turbine, index b, can be obtained as

$$r_b = r_a\left(\frac{P_b}{P_a}\right)^{S_l},\quad m_b = m_a\left(\frac{r_b}{r_a}\right)^{S_m},\quad \mathbf{I}_b = \mathbf{I}_a\left(\frac{m_b}{m_a}\right)\left(\frac{r_b}{r_a}\right)^2 = \mathbf{I}_a\left(\frac{r_b}{r_a}\right)^{S_m+2} \tag{12}$$

*The computing code *Savbal* will be available upon request for further studies on this field.

Table II. Characteristics of different turbine sizes considered in the throw analyses.

Size	$L^* = \frac{L}{R}$	L (m)	m (kg)	I_x (kg·m^2)	I_y (kg·m^2)	I_z (kg·m^2)
2.3 MW $R = 45$ m, $H = 100$ m	1.0	45	7.3E+3	0.1E+7	0.1E+7	0.3E+04
	0.5	22.5	2.4E+3	0.1E+6	0.1E+6	0.40E+03
	0.2	10	4.1E+2	0.4E+04	0.4E+04	0.2E+02
5 MW $R = 66$ m, $H = 147$ m	1.0	66	2.6E+04	0.9E+07	0.9E+07	0.2E+05
	0.5	33	8.2E+03	0.1E+07	0.1E+07	0.3E+04
	0.2	14	1.7E+3	0.3E+05	0.3E+05	0.2E+03
10 MW $R = 93$ m, $H = 208$ m	1.0	93	8.2E+04	0.5E+08	0.5E+08	0.1E+06
	0.5	46.5	2.7E+04	0.6E+07	0.6E+07	0.2E+05
	0.2	20	5.3E+3	0.2E+06	0.2E+06	0.1E+04
20 MW $R = 132$ m, $H = 294$ m	1.0	132	2.6E+05	0.3E+09	0.3E+09	0.9E+06
	0.5	66	8.7E+04	0.4E+08	0.4E+08	0.1E+06
	0.2	29	1.6E+04	0.1E+07	0.1E+07	0.8E+04

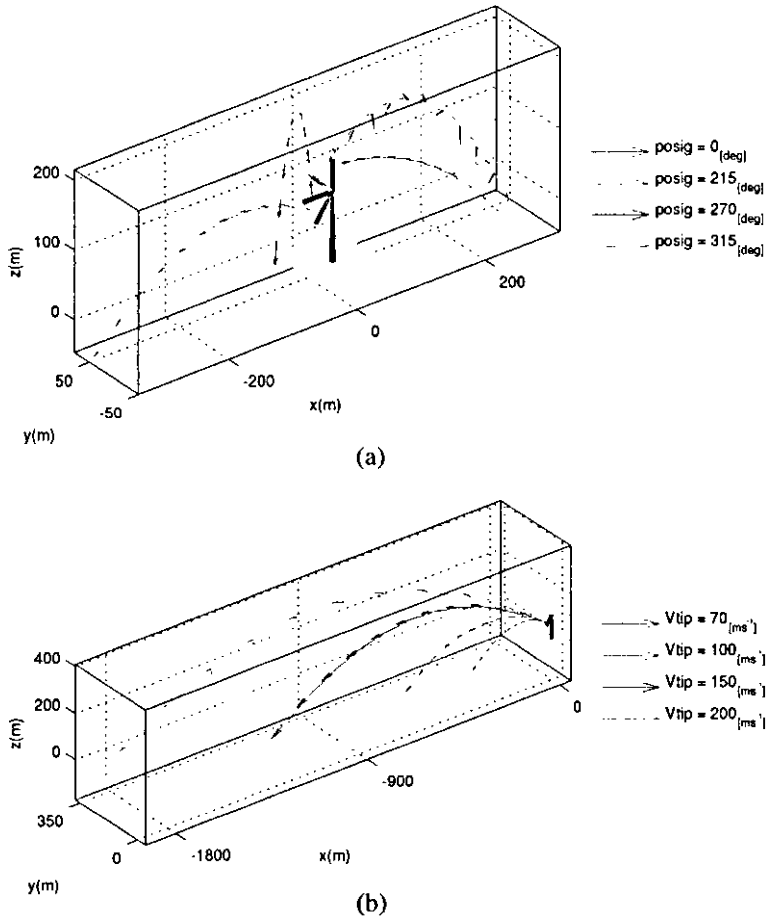

Figure 3. Schematic graphs of the throw distances for half-blade detachment changing (a) the initial release angles (upward-clockwise reference) and (b) the tip speed velocities for the 2.3 MW reference turbine.

where $\mathbf{I} = (I_x, I_y, I_z)$. In the previous relations, $S_l = 1/2$ and S_m depends on actual scaling laws when increasing the size of the rotor. From simple upscaling rules, S_m would be equal to 3 , but because of more elaborate rotor designs, this parameter is usually found to be somewhat smaller. In the present work, we employ $S_m = 2.3$ (see UpWind[20] and TPI Composites[21] for more information on turbine scaling).

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3.2. Full-blade throw analysis

In this section, the throw distance analyses are performed for four different turbine sizes based on the upscaling rules presented previously. Here, the term full blade refers to the case of blade shell including stiffening members (upper and lower shells, spar, etc.). The dimensions and other characteristics of each turbine size are reported in Table II. In accordance with the copyright policies of the turbine manufacturers, the data for the reference turbine (2.3 MW) do not correspond to an existing turbine but are chosen to mimic a real turbine.

The analysis included a parametric study, where the effects of the length of the detached parts, incoming wind speeds, blade tip speeds and wind turbine size on the blade-throw distances were investigated. The height of the tower is in all considered cases assumed to be equal to the rotor diameter. Figure 3 shows three-dimensional visualizations of the throw distances of a half-blade piece thrown of the 2.3 MW machine for different initial conditions. The small colored patches in the figure shows the instantaneous orientation of the detached part. For the sake of clarity, only some selected curves are shown in the figure. Figure 3(a) shows the effect of release angle on the throw distance, and Figure 3(b) shows the effect

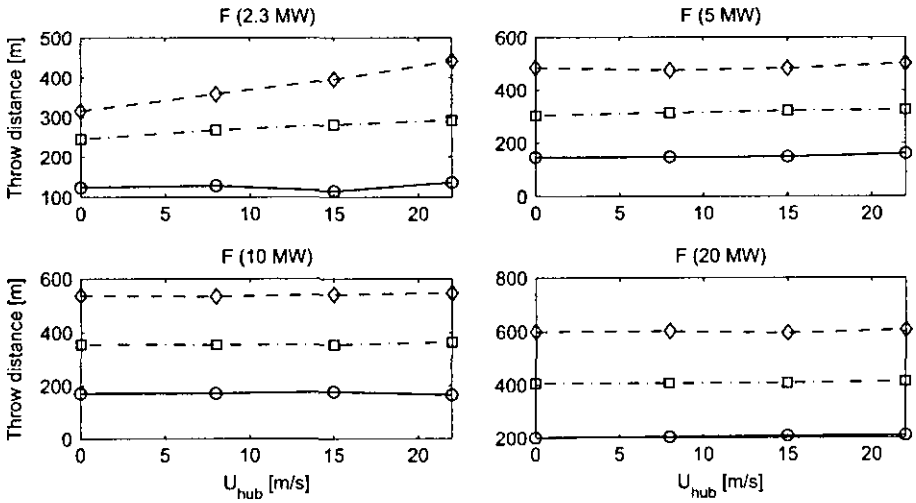

Figure 4. Throw distance calculations of full blade with three different detached lengths for 2.3, 5, 10 and 20 MW turbines at the normal operating condition of V_{tip} = 70 m/s. The horizontal axis shows the wind speed at the hub height and the vertical axis represents the throw distance. ◇ ◇ ◇: $L^* = 0.2$; □ □ □: $L^* = 0.5$; and o o o: $L^* = 1$.

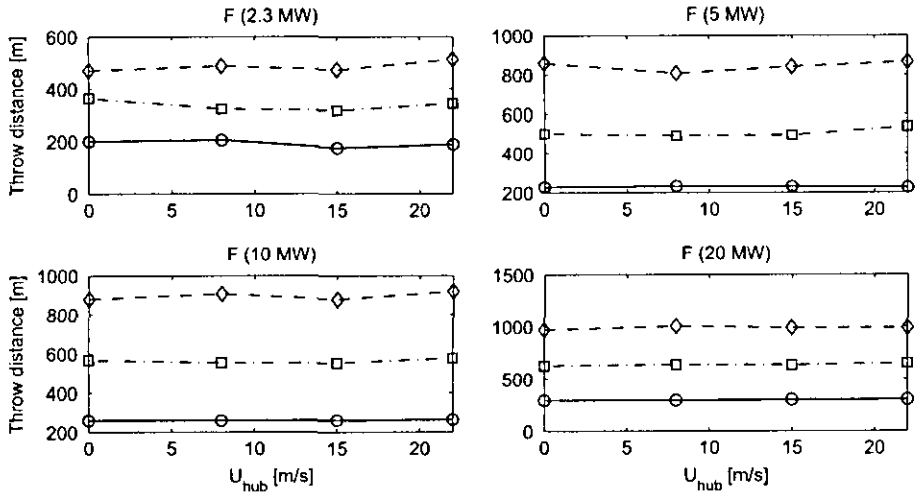

Figure 5. Throw distance calculations of full blade with three different detached lengths at a high tip speed of V_{tip} = 100 m/s. Legends are similar to those in Figure 4.

of release tip velocity. As can be seen, the release tip speed is a very important factor influencing the maximum throw distances. Normal operating conditions with $V_{tip} = 70$ m/s result in throw distances of about 500 m long, whereas a tip speed of $V_{tip} = 150$ m/s may lead to throw distances up to 2 km.

For the quantitative analysis performed in the next section, the fragments are thrown at a release angle of 45° from the horizon (225° measured upward-clockwise) in all calculations. The full-blade and blade-shell throw calculations are performed using flat-plate assumption for the aerodynamic coefficients.

Figures 4, 5 and 6 show the throw distances for three different fragments of the full blade for a combination of three blade tip speeds ($v_{tip} = 70$, 100 150 m/s) and four different incoming wind velocities (with power-law profiles) ranging between 0 and 22 m/s at hub height.

The figures are divided into three groups, the first group (Figure 4) shows the throw distances, relative to the tower position, for different incoming wind speeds (shown on the horizontal axis) and different detachment lengths at a tip speed of $V_{tip} = 70$ m/s. The detachment length L^*, shown with markers, is the length of the detached piece, measured from the blade tip and normalized by the blade length. The throw distances are calculated and plotted for the four considered wind turbine sizes ranging from 2.3 to 20 MW. As can be seen, except for the 2.3 MW machine, the effect of the incoming wind on the throw distance is almost negligible. Similarly, the effect of turbine size on the throw distance is minimal and the main

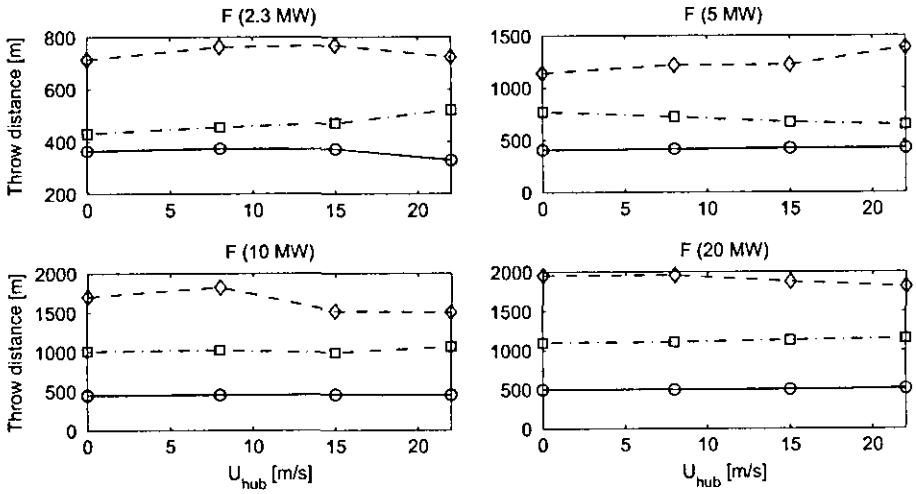

Figure 6. Throw distance calculations of full blade with three different detached lengths at an extreme tip speed of $V_{tip} = 150$ m/s. Legends are similar to those in Figure 4.

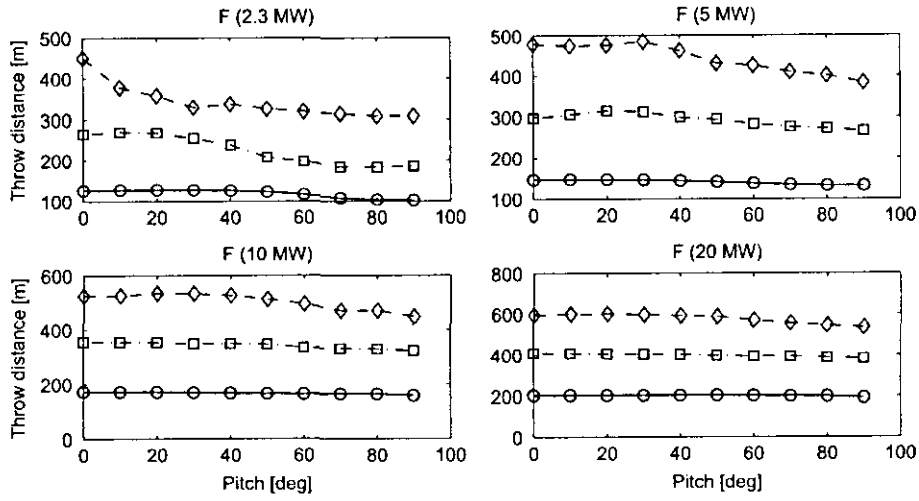

Figure 7. Sensitivity of throw distances of full blade to the initial pitch setting for 2.3, 5, 10 and 20 MW turbines operating at $V_{tip} = 70$ m/s. ◇ ◇ ◇: $L^* = 0.2$; □ □ □: $L^* = 0.5$; and o o o: $L^* = 1$.

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parameter governing the throw distance is the detachment length. The minimum throw distance is obtained for the heaviest fragment ($L^* = 0.2$) thrown from the 2.3 MW turbine, while the maximum throw distance of all cases at $V_{tip} = 70$ m/s is around 600 m for the lightest fragment ($L^* = 0.2$).

Figure 5 shows the same graphs for the higher tip speed of $V_{tip} = 100$ m/s, where the maximum throw distances for the smallest and largest turbines are about 500 and 1000 m, respectively, while the minimum throw distance is reached for a full-blade throw ($L^* = 1$) of a 2.3 MW turbine. Also, it is clear that the effect of the hub-height wind velocity is still very small. Figure 6 shows the same plots for the most extreme case considered, i.e., using a tip speed of $V_{tip} = 150$ m/s. Here, the thrown pieces reach throw distances ranging from approximately 350 m for the full-blade throw for a 2.3 MW turbine to about 2000 m for the lightest fragment thrown from the 20 MW turbine.

As can be seen from the red curve in Figure 6 for the 10 MW turbine (bottom-left), the throw distance has unexpectedly decreased when increasing the wind speed from 10 to 15 m/s. This behavior is somehow repeated to a smaller extent in other cases, especially at higher tip velocities. The unexpected results can happen because of the fact that a small change in the initial conditions can change the force/moment distributions on the fragments, thereby changing the trajectory drastically. To investigate the erratic motion further, the effect of initial pitch setting on the trajectory is analyzed in the next section.

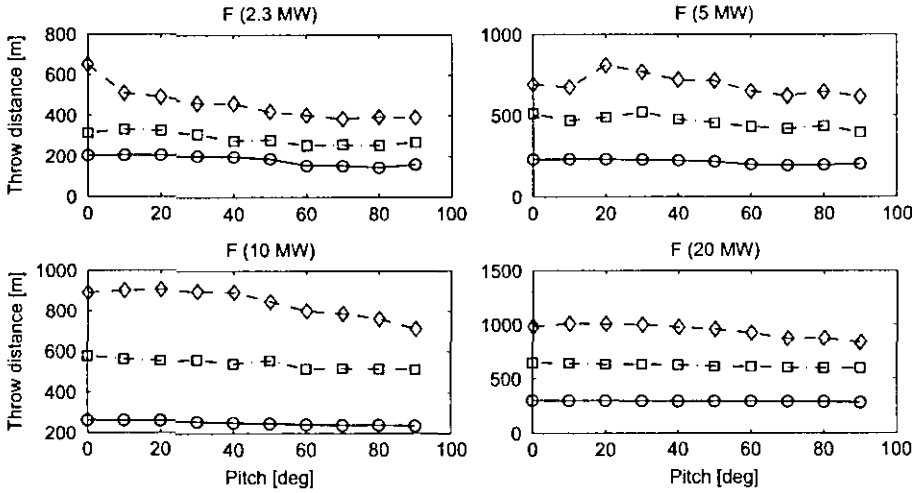

Figure 8. Sensitivity of throw distances of full blade to the initial pitch setting at $V_{tip} = 100$ m/s. Legends are similar to those in Figure 7.

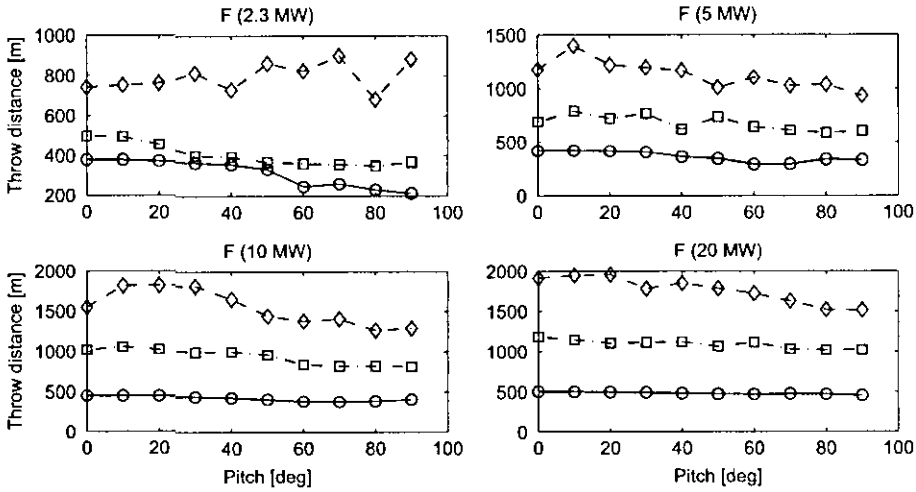

Figure 9. Sensitivity of throw distances of full blade to the initial pitch setting at $V_{tip} = 150$ m/s. Legends are similar to those in Figure 7.

3.2.1. Effect of initial pitch settings.

As explained earlier, analyses of the throw trajectories show that the throw distance for a particular wind turbine sometimes exhibits an erratic behavior going from one dominant solution to another with only a slight change in the initial conditions.

Table III. Aspect ratios, reference chord length C_{ref} and detached mass m of the blade shells (ρ_{shell} = 1700 kg/m^3) used for throw simulation from turbines of different sizes.

	2.3 MW		5 MW		10 MW		20 MW	
Cases – AR	C_{ref} (m)	m (kg)	C_{ref} (m)	m (kg)	C_{ref} (m)	m (kg)	C_{ref} (m)	m (kg)
AR = 1		34		83		184		408
AR = 5	1	170	1.5	415	2.1	920	3	2040
AR = 10		340		830		1840		4080

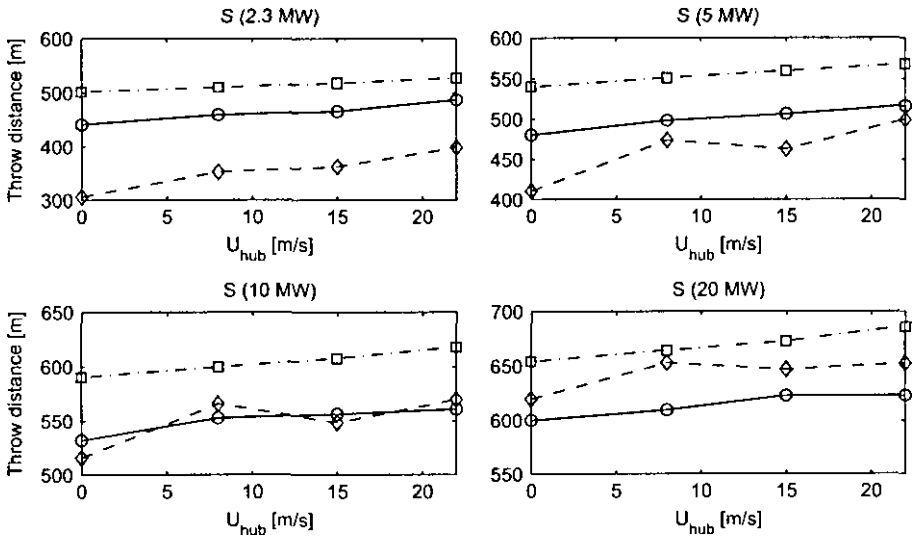

Figure 10. Throw distance calculations of blade shell with three different aspect ratios (invariant chord length for each turbine) for 2.3, 5, 10 and 20 MW turbines at a normal operating condition of V_{tip} = 70 m/s. ◇ ◇ ◇: AR = 1; □ □ □: AR = 5; and o o o: AR = 10.

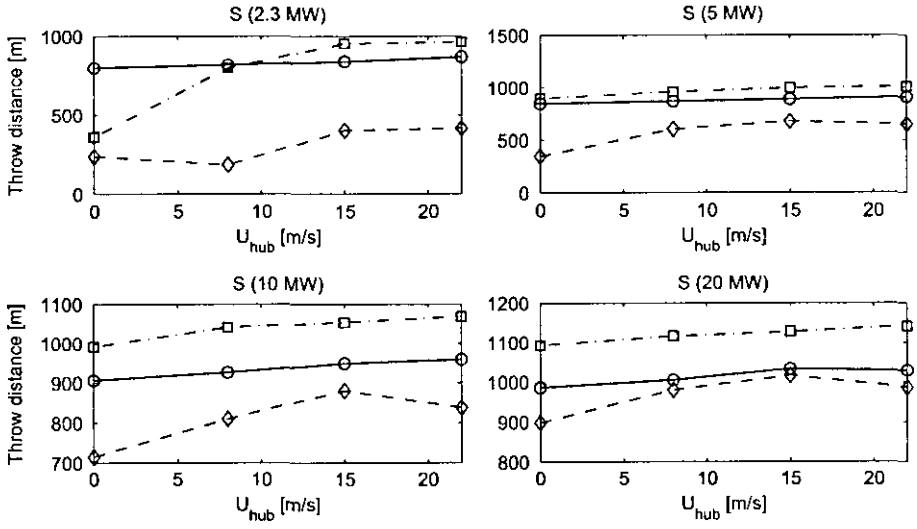

Figure 11. Throw distance calculations of blade shell at high tip speed of V_{tip} = 100 m/s. Legends are similar to those in Figure 10.

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To understand this behavior, a sensitivity study is performed to investigate the effects of the initial pitch settings on the trajectory. Figures 7–9 demonstrate the pitch angle dependence of the full-blade throw distances for different turbine sizes and tip speeds, where the throw distances are obtained for release pitch angles ranging from 0° to 90°. As can be seen, the pitch setting has a substantial impact especially for the lighter parts. In general, higher throw distances are achieved using fragments thrown at lower pitch angles, which are due to the reduced drag. The effect of pitch angle on the heavier pieces (green and blue curves) is, however, smaller. The reason for this is that the aerodynamics plays a less significant role for the heavy parts in the throw distance calculation and the distance is mainly governed by the inertial forces. For the extreme tip velocity, and especially for the 2.3 MW turbine, increasing the pitch angle produces erratic throw distances for the lightest fragments. The exact reason for such erratic behavior has not been yet understood, but it is most likely explained by the physics of the problem, as explained earlier.

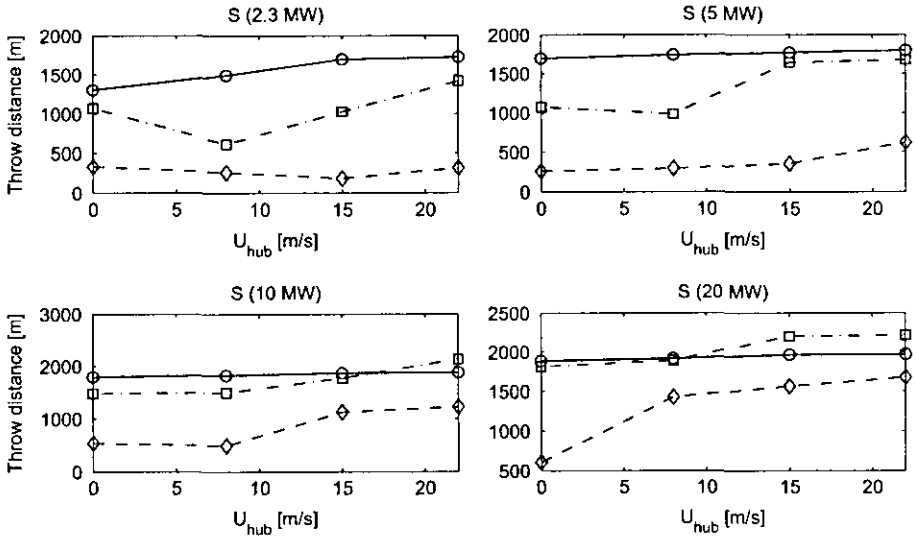

Figure 12. Throw distance calculations of blade shell at an extreme tip speed of V_{tip} = 150 m/s. Legends are similar to those in Figure 10.

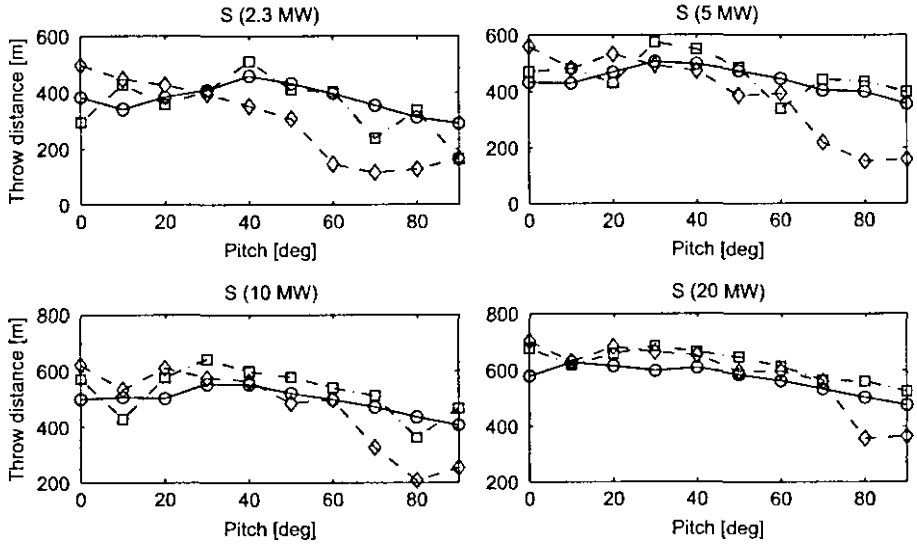

Figure 13. Sensitivity of throw distances of blade shell to the initial pitch setting at V_{tip} = 70 m/s. Legends are the same as in Figure 10.

3.3. Blade-shell throw analysis

An analysis of available data from blade failure accidents shows that depending on the manufacturing method and the structural integrity of the blade, it might first shatter into lighter parts, with the consequence that the shell layer is most likely to be thrown away. Three cases of different aspect ratios are considered for the shell throw analyses. For the reference case of 2.3 MW turbine, an average chord of 1 m and a shell thickness of 2 cm are chosen, and three aspect ratios (where AR is defined as the ratio of span to average chord) of 1, 5 and 10 are investigated. Then keeping the same AR, the analysis is repeated for each of the turbines introduced in the preceding sections. The density of the shell, consisting of fiber and glass, is assumed to be 1700 kg/m^3. Table III shows the test cases used for blade shell throw simulations.

Throw distances for the four different turbine sizes with the same working conditions as those for the full-blade case are plotted in Figures 10–12. Here, the non-dimensional length is replaced by the aspect ratio of the blade shell and three different aspect ratios are considered. As can be seen, increasing the hub-height wind speed and the turbine size generally results in larger throw distance. Nevertheless, an erratic behavior, as mentioned in the previous section, appears in the

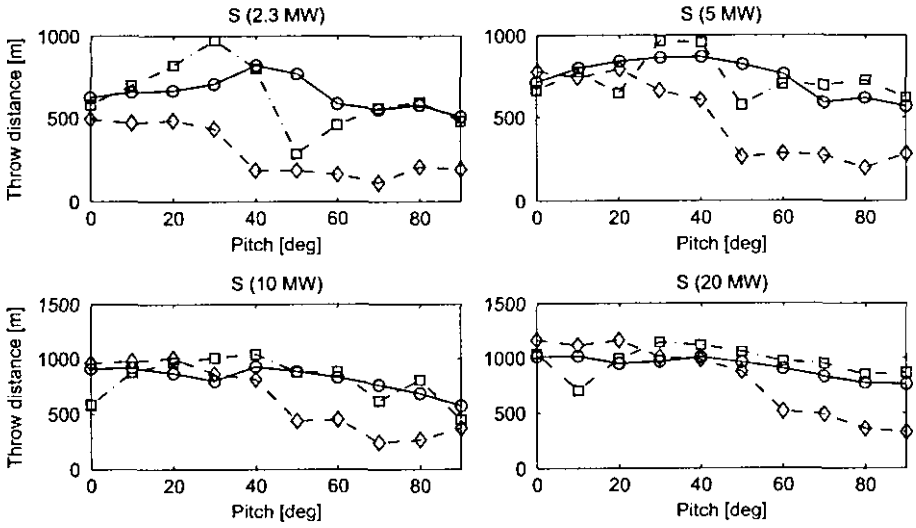

Figure 14. Sensitivity of throw distances of blade shell to the initial pitch setting at V_{tip} = 100 m/s. Legends are the same as in Figure 10.

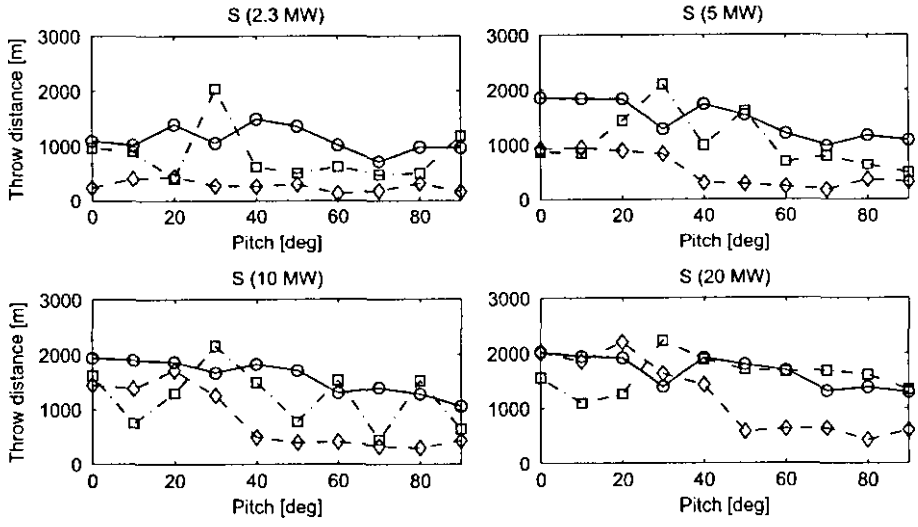

Figure 15. Sensitivity of throw distances of blade shell to the initial pitch setting at V_{tip} = 150 m/s. Legends are the same as in Figure 10.

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simulation results. By comparing the shell-throw graphs with the corresponding figures from the full-blade analysis, the throwing range of the blade shells and that of the full-blade structure are seen to be of the same order of magnitude. That is, the range is between 300 m for the 2.3 MW turbine operating at $V_{tip} = 70$ m/s and a maximum of 2200 m obtained for the 20 MW turbine in the extreme case of $V_{tip} = 150$ m/s. However, unlike the full-blade throw cases, the case with the smallest length ($AR = 1$) reaches the least throw distance, whereas for the full blade, the smallest fragment reaches the highest distance. This is most probably due to the fact that the small shell object is lighter and the corresponding inertial force is relatively small as compared with the drag forces.

As a comparison, the throw distances obtained for the ballistic motion of an equivalent particle in vacuum was also performed (results not shown), in which case there is no aerodynamic forcing on the objects. The results revealed that the ballistic throw distances are the most extreme cases in terms of throw distance.

3.3.1. Effect of initial pitch settings.

Similar to Section 3.2.1, the role of initial pitch setting on the trajectory of thrown blade-shell debris is assessed. Figures 13–15 show the pitch angle dependence of the throw distances for different turbine sizes and tip speeds for the blade-shell cases. Similar to the full-blade throw cases, the pitch setting has a substantial impact on the throw distance of thrown blade-shell structures. One major difference with the full-blade cases is, however, that the effect of the shell aspect ratios on the throw distance is much less significant and all of the cases show similar behavior with AR = 1 cases (red diamonds), predicting smaller throw distances in general.

3.4. Ice throw

For the analysis of the ice throw, the same procedure as for the blade throw is applied except that the throw analysis is not performed for the extreme tip speed conditions but only for the standstill where the tip speed is zero, and the running conditions, where the turbine is assumed to rotate in its normal operational mode at a tip speed of 70 m/s. For the icing case,

Table IV. Aspect ratios, reference chord length C_{ref} and detached mass m of the ice fragments ($\rho_{ice} = 0.7$ kg/m^3) used for throw simulation of turbines of different sizes.

	2.3 MW		5 MW		10 MW		20 MW	
Cases – AR	C_{ref} (m)	m (kg)	C_{ref} (m)	m (kg)	C_{ref} (m)	m (kg)	C_{ref} (m)	m (kg)
$AR = 1$		0.18		0.43		0.97		2.16
$AR = 2$	0.1	0.36	0.15	0.87	0.2	1.95	0.3	4.33
$AR = 3$		0.54		1.31		2.94		6.49

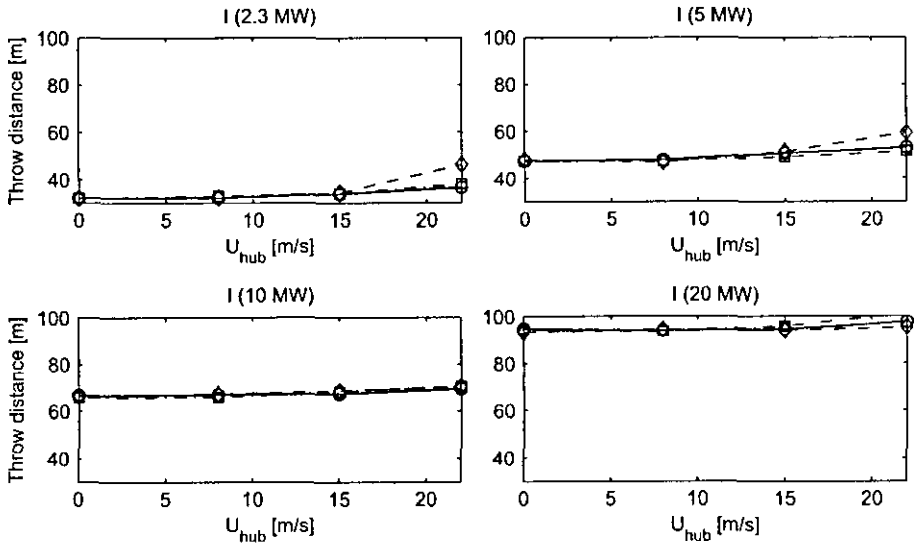

Figure 16. Throw distance calculations of ice fragments for three different aspect ratios for 2.3, 5, 10 and 20 MW turbines in standstill operation ($V_{tip} = 0$ m/s). ◇ ◇ ◇: $AR = 1$; □ □ □: $AR = 2$; and o o o: $AR = 3$.

a density of 700 kg/m^3 is used (see also Seifert *et al.*[11]). The dimensions of the tested ice fragments and corresponding turbine sizes are shown in Table IV. According to field studies performed by, e.g., Cattin *et al.*,[22] most of the ice fragments thrown away from turbine are broken into objects that typically are smaller than 1 kg. However, fragments as heavy as up to 1.8 kg have also been observed. Because the pieces are so light, the throw distance of an ice piece is mainly governed by the drag forces applied on it (which are only functions of mass–area ratio) and the incoming wind.

Similar to the previous section, studies of the effects of different parameters on throw distances are performed and plotted in Figures 16 and 17 with the graphs structured in the same way as in the previous sections.

For the simulations, no lift is considered and the drag coefficient according to the flat-plate assumption is used. Figure 16 shows that the throw distances of the standstill case range from 30 to 100 m for different turbine sizes and incoming wind speeds. For the running conditions however, the fragments can reach distances up to 600 m. It is also clear from the figure that in many cases the aspect ratio does not play a significant role in the determination of throw distances.

3.5. Maximum throw distances

This section presents a summary of the previous results in terms of maximum throw distances. The maximum throw distances are obtained from the entire set of previous simulations regardless of the size and upcoming wind speed and plotted in Figure 18 for the full-blade and blade-shell cases and in Figure 19 for the ice-throw cases, respectively. In all

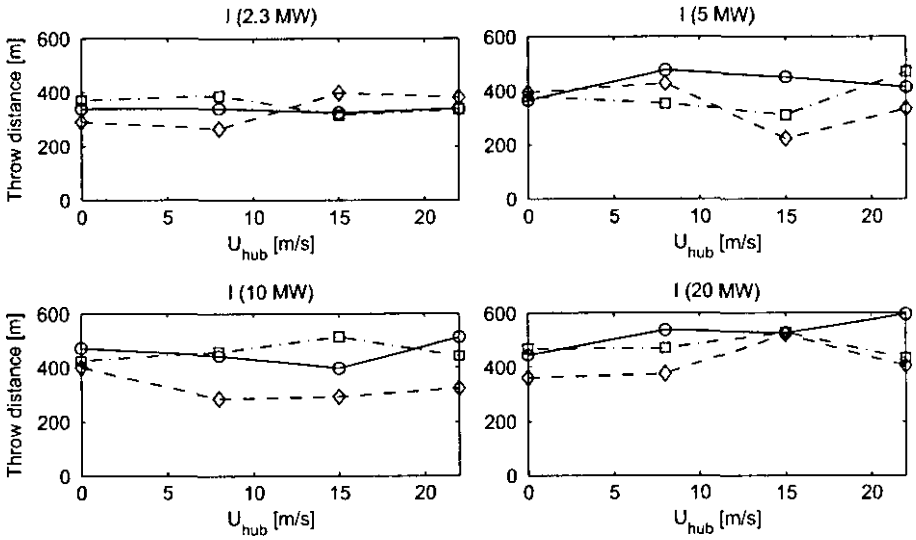

Figure 17. Throw distance calculations of ice fragments for three different aspect ratios for turbines in normal operation (V_{tip} = 70 m/s). Legends are the same as in Figure 16.

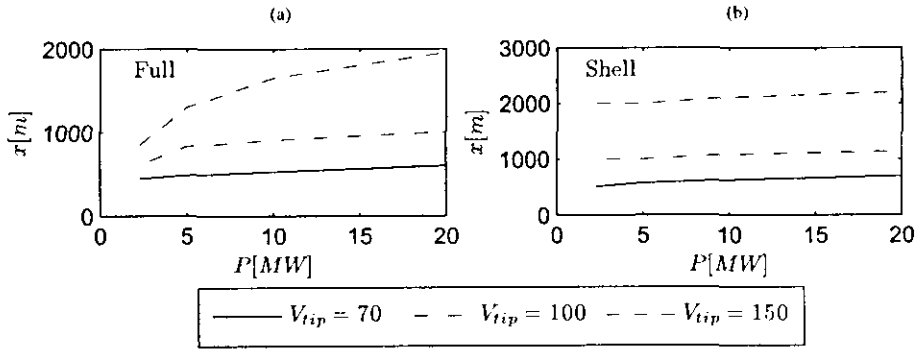

Figure 18. Maximum throw distances obtained for (a) full blade and (b) blade shell in different operating conditions. Blue line: V_{tip} = 70 m/s as a function of turbines power.

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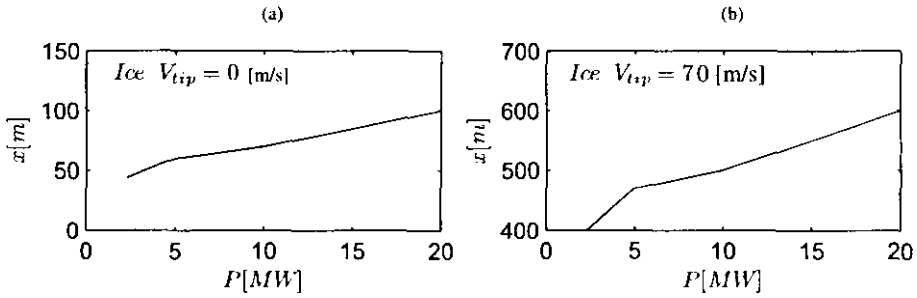

Figure 19. Maximum throw distances obtained for the ice throw in (a) standstill operation, i.e., $V_{tip} = 0$ m/s and (b) normal operating condition, i.e., $V_{tip} = 70$ m/s as a function of turbines power.

figures, the horizontal axis shows the turbine capacity and the vertical axis represents the maximum throw distance. It can be concluded that, in general, the tip speed has a large impact on the throw distances. From Figure 18(a), the turbine size does not affect the throw distances drastically for the lower tip speeds, whereas throw distances at high tip speeds experience a significant growth with increasing turbine size. Figure 18(b), on the other hand, shows that the effect of turbine size on the throw distance for the shell parts is almost negligible.

4. CONCLUDING REMARKS

Trajectory analysis of detached parts of blades and ice fragments thrown from horizontal-axis wind turbines was studied extensively using Newton's and Euler's equations of motion and rotation, employing a blade element approach for the aerodynamics. Full-blade and blade-shell analyses were performed for turbines running under different tip velocities. Turbine upscaling laws were derived, and simulations of throw distances were performed for four different turbine sizes, ranging from existing 2.3 MW machines to future 20 MW turbines.

In some cases, erratic behavior was observed in the computations, where a small change in one parameter could influence throw distance drastically. The behavior was believed to depend highly on the initial conditions. A likely explanation is that a small change in positioning and velocity components in some cases alters the distribution of forces on the detached objects and causes significant changes in the trajectory.

Maximum throw distances obtained at different tip speeds and detachment sizes were analyzed, and it was shown that the tip speed plays the most important role in the throw distance. From the full-blade throw analysis, it was shown that, when released at extreme tip speeds, throw distance picks up more rapidly with the tip speed rather than throw at lower tip speeds (looking at the absolute throw distances). The considered [thrown] full-blade pieces reached approximately 700, 900 and 2000 m at tip speeds of 70, 100 and 150 m/s, respectively. For the blade shell, throw distances were found to be approximately constant as turbine size escalates, and of the same order of magnitude as in the full-blade throw. Throw calculations were also obtained at the tip speeds of $V_{tip} = 0$ and $V_{tip} = 70$ m/s for ice pieces of three different aspect ratios and it was seen that the maximum throw distances scaled almost linearly with the turbine size irrespective of the tip speed. The ice-throw distances reached about 100 and 600 m in standstill $V_{tip} = 0$ m/s and normal operating conditions $V_{tip} = 70$ m/s, respectively. The throw distances presented by this study were obtained with respect to a set of initial parameters without taking into account their probabilities of occurrence. The authors are extending the current study to include the risk levels associated with each of the cases.

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Gail Moyer Ex.

Excerpts from the Seneca County Comprehensive Plan

In order to promote positive economic growth countywide, there should be a cooperative understanding between all agencies, citizens, and public officials so all parties can be involved in new industry proposals.

Recognizing agriculture as integral to the economy and character of the County, prime farmland should be preserved. Methods of preservation included the use of restrictive wills, trusts, government programs, and keeping farms in the family.

Several problems related to the implementation of a farmland preservation plan were identified. Two of these were funding issues and the **buyout of development rights by private corporations** that may seek to prohibit farming. Other concerns were **lack of respect for private property rights** and lack of support for agriculture among the citizenry.

The group cited growth management as a means to plan ahead for growth and prevent the further environmental degradation of the land

However, given the citizenry's concern about loss of prime farmland and land conversion, growth management will be a valuable tool as the County faces development pressures in the future.

Goals, objectives, and policies for Seneca County were developed as a result of input from focus groups, interviews with local officials, and citizen surveys. **Three themes emerged as primary goals of the Plan: Quality of Life, Balanced Growth, and Efficient Services. A focus on these principles will permit Seneca County to accommodate growth while retaining the character and inherent attractiveness so important to the citizens of the County.**

The following major goal statements and objectives reflect these three themes. More specific policies and implementation strategies for each goal are detailed in Chapter 9.

1. Maintain and enhance the standard of living for all citizens of Seneca County.

1.1 Increase the economic development potential of the County.
1.2 Provide a range of housing choices for all residents.
1.3 Ensure all residents have access to quality open space and recreation opportunities.
1.4 Preserve and protect historic sites and structures in the context of their natural settings.
1.5 Maintain the rural character of the County

2. Encourage growth that focuses upon existing urban areas and respects the intrinsic values of the land.

2.1 **Encourage growth that builds upon existing municipalities, and support new residential, commercial, and industrial growth only within identified urban growth boundaries where public infrastructure is available.**
2.2 Utilize growth management principles.
2.3 **Preserve prime farmland recognizing agriculture as a viable economic resource.**
2.4 **Protect sensitive environmental areas such as woodlands, steep slopes, endangered species habitats, and native flora and fauna from the impacts of development.**
2.5 **Encourage intergovernmental cooperation and collaboration among political jurisdictions and between governmental agencies.**

ECONOMIC DEVELOPMENT AND FUTURE LAND USE

Economic development must be considered within a land use framework in order to have maximum benefit on the regional and local economies while having minimum negative impacts on the environment, service capacity, and character of the area. Therefore, it is this Plan's recommendation that economic development activities should be focused in identified urban service areas where infrastructure and services can be provided most efficiently.

Furthermore, the use of economic development agreements through intergovernmental coordination should be promoted, as growth is beneficial to the entire County wherever jobs are retained or created.

Cities, townships, and counties across the nation provide valuable open space and recreational opportunities for their citizens. **Seneca County provides an example of the value of open space and natural resources to its residents. Throughout the County's past, the natural environment has played an important role in defining Seneca's identity. Seneca County prides itself on its rural character and agricultural resources.**

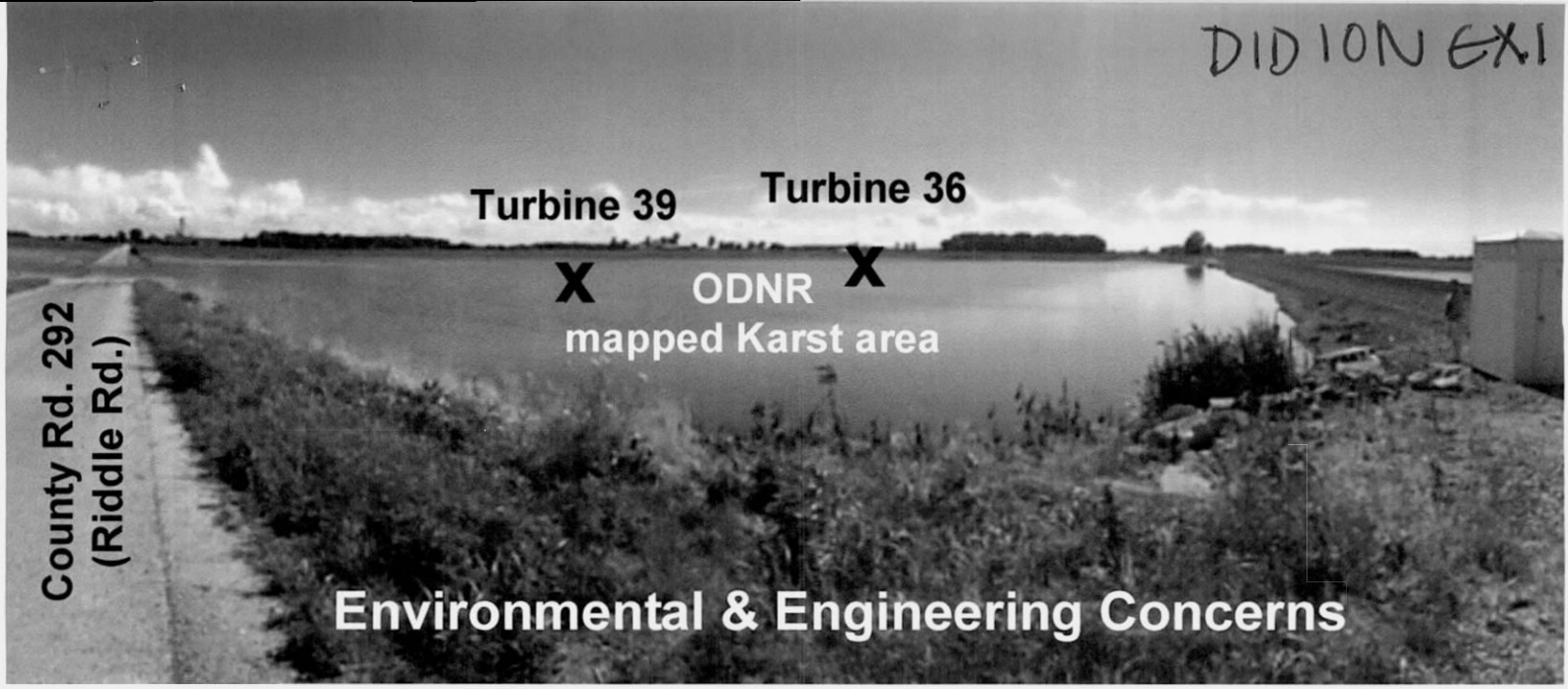
In the planning process, citizens were able to express their views on a number of issues, including open space. Citizens were concerned with preserving significant natural and historic features such as the Sandusky River corridor, County parks, and historic municipal downtowns. **Citizens also want to maintain the rural character of the County by preserving farmland and other natural features. To protect the County's rural character, citizens suggested implementing growth management techniques such as encouraging compact development in existing urban areas.**

2.3 Preserve prime farmland recognizing agriculture as a viable economic resource.

a. **Develop and implement an aggressive program to preserve agricultural uses in those areas identified for permanent agricultural preservation.**
b. **Preserve the top 70 percent of the County's prime farmland.**
c. Develop an incentive based land management system, utilizing the LESA model, which provides cluster (hamlet/conservation) alternatives for areas suitable for development.

2.4 Protect sensitive environmental areas such as wetlands, woodlands, native species habitats, and flora and fauna from the impacts of development.

a. Restrict development in karst terrain.
b. **Restrict development in critical resource areas such as in the 100-year flood plain and in perennial stream buffers.**
c. Evaluate and improve the County's current environmental protection practices.
d. Encourage developers to consider alternative land use designs that provide the best protection for existing natural features through density incentives.
e. Maintain and preserve natural open space corridors that are important to wildlife and plant life habitats.



Bellevue's known Karst pose major infrastructure complications. Facilities built in karst areas are at risk of subsidence and collapse.

To provide for future planning the Ohio Geological Survey produced a map book identifying the known Karst areas in the Bellevue and surrounding areas.

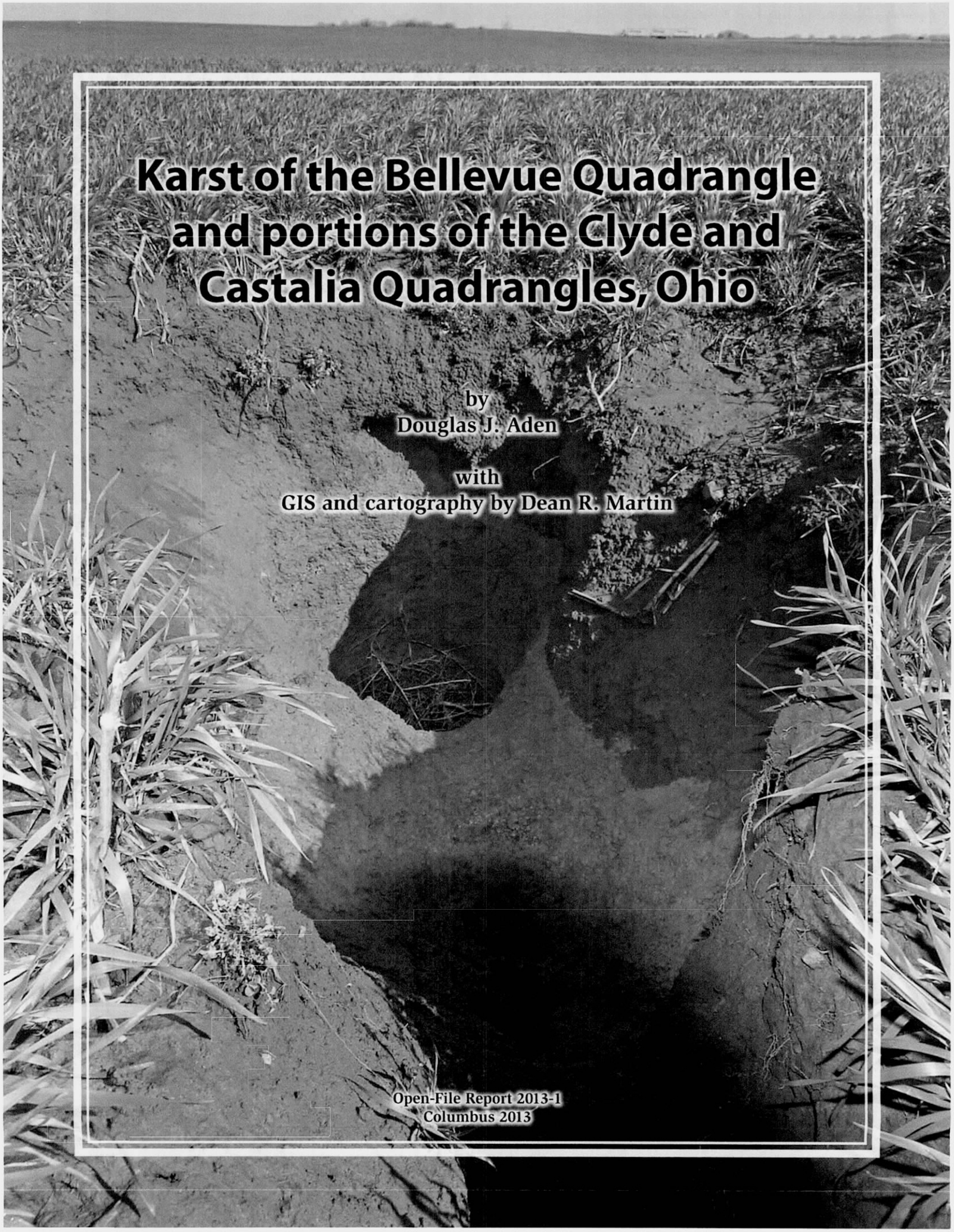
Karst mapped during the Fall of 2012 through 2013, confirmed numerous karst areas now projected to have wind turbines built on them.

The biggest and most feared Karst hazard is a sinkhole! These are when underlying bedrock that supports the soil becomes totally dissolved, thus causing the ground to collapse. A sinkhole can be as big as a town.

In contact with the OPSB, the reply stated," that the applicant must describe the suitability of the site geology and plans to remedy any inadequacies."

To avoid the potential for catastrophic collapse and protect our ground water.

Turbines should not be built anywhere near karst areas!



Karst of the Bellevue Quadrangle and portions of the Clyde and Castalia Quadrangles, Ohio

by
Douglas J. Aden

with
GIS and cartography by Dean R. Martin

Open-File Report 2013-1
Columbus 2013

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Cover image: At about 6 ft deep, this sink has formed since the winter wheat was planted eight months prior. Brown top soil is visible above the orange till and plant material has been washed in by rain and fills the sink throat. Photo faces north and a truck can be seen on Interstate 80 on the horizon. Eighty-five feet SW of this sink is an intermittent disappearing stream that aligns with the trend of the much larger depression containing these features. The overall depression is 10 ft deep (with the pictured sink another 6 ft deeper) about 1.25 mi long, 1000 ft wide, and bisected by the Interstate.

Recommended citation: Aden, D.J., 2013, Karst of the Bellevue Quadrangle and portions of the Clyde and Castalia Quadrangles, Ohio: Columbus, Ohio Department of Natural Resources, Division of Geological Survey Open-File Report 2013-1, 4 p., 59 maps.

Karst of the Bellevue Quadrangle and portions of the Clyde and Castalia Quadrangles, Ohio

by

Douglas J. Aden, with GIS and cartography by Dean R. Martin

Introduction

Karst terrain forms by dissolution of carbonate rocks, such as limestone or dolomite, or evaporites, such as gypsum or salt, and is characterized by features including sinkholes, disappearing streams, caves, and springs. *Sinkholes* (or *sinks*) are enclosed depressions that do not usually hold water; they often have a "throat" or opening at the bottom where they drain to the subsurface. When a stream flows into a sinkhole, it is known as a *disappearing stream* or *losing stream*. Water flowing into the ground can cause solution enlargement of natural fractures in the rock and eventually can grow into caves. In Ohio, a *cave* is defined as "...a naturally occurring void, cavity, recess, or system of interconnecting passages beneath the surface of the earth or within a cliff or ledge..." (State of Ohio, 1989).

The many passageways formed in karst terrain allow for high connectivity between the land surface and the water table. These passageways permit water to bypass soil and rock layers that filter out contaminants. Consequently, when compounds such as fertilizers, pesticides, and waste enter sinkholes, they are rapidly transported to the water table and quickly pollute water wells, streams, and rivers. When water exits these solutional features, a *spring* is formed. Such springs enable release of these contaminants at the surface.

The different types of karst features may pose infrastructure complications; roads, utilities, houses, and other facilities built in karst areas are at risk of subsidence, collapse, or other damage. In order to provide a reference for future planning on both the local and regional scale, the Ohio Geological Survey has produced this map book identifying the known and suspected karst areas in the vicinity of Bellevue, Ohio.

Previous Work

Karst areas have been studied in Ohio for many years. In the 1980s and 1990s, karst was researched for the proposed Superconducting Super Collider and was mapped statewide to determine areas suitable for storage of low-level nuclear byproducts. Ohio's preliminary map of karst features (Pavey and others, 1999) was completed in 1997 and released in 1999; it since has been updated with new data in 2003, 2005, and 2007 and will be updated again in the near future.

In the spring of 2008, severe karst-related flooding occurred in Bellevue and initiated increased concern regarding Ohio's geohazards (Raab and others, 2009; Pavey and others, 2012). From 2011 to 2012, karst was mapped in the Delaware County region (Aden and others, 2011) and in the Springfield and Donnelsville 7.5-minute quadrangles (Aden 2012). Finally, from fall 2012 to spring 2013 karst was mapped in the Bellevue 7.5-minute quadrangle and parts of the Clyde and Castalia quadrangles.

Methodology

A digital elevation map (DEM), generated from LiDAR (Light Detection and Ranging) data, was used to create a map layer that identified low, enclosed areas. To locate potential sinkholes, these low spots were cross referenced with known karst points, bedrock geology, aerial photography of multiple sources and ages, soil maps, glacial drift thickness maps, and water well logs. Suspect locations were then visited in the field, evaluated, and photographed. Through this process many of the LiDAR returns were found not to be sinkholes; features such as building foundations, broken field tiles, steep-walled streams, road culverts, and glacial features often produced enclosed areas

similar in shape to sinkholes. Many of these misleading features were eliminated remotely using both 6-inches-per-pixel aerial photography and experience from past field verification. However, many points remained that could not be distinguished remotely and these were visited in the field.

Results

The resulting karst feature data set was overlain on four different geologic data sets—the Land Surface, the Bedrock Geology, the Bedrock Topography, and the Drift Thickness maps—to show how the features are related to the local geology. The first of these is the Land Surface map (p. 5), which shows the 107 two-km^2 tiles and the 7.5-minute quadrangles that form the project area overlain on the DEM of the land surface. The Bellevue quad was the core project area. However, some adjacent points were mapped as time allowed, particularly in Clyde and Castalia; these areas will be completed as part of next year's project. The land surface map shows that in Bellevue sinks are concentrated to the south and east while springs are found down gradient north and west.

On the Land Surface map, tiles outlined in red contain the karst features identified through this project. No karst was identified in black-outline tiles. In total there are 997 karst features, including 29 springs, in 107 tiles. On the top left of each aerial imagery page (p. 9–68) is a Tile Number that references the corresponding numbered tile on the four overlay maps.

There are four types of karst features identified on each map:

- Red circles indicate field-verified features, i.e., those that have been visited in the field and confirmed as karst.
- Orange circles indicate sites that were visited but could not be verified at the time, for example a suspicious depression that is flooded or that lacks an active sink throat and cannot be clearly classified.
- Yellow circles represent areas with suspect characteristics, such as a distinct LiDAR depression, but where access to the property could not be gained or where there was not enough time to check the point.
- Blue squares represent springs, including "blue holes," where water was found flowing from the subsurface, primarily to the north.

The next overlay map is the Bedrock Geology map (p. 6). This map shows that the karst features are forming primarily by dissolution of the Columbus Limestone; however, it is thought that the Salina undifferentiated below is also affecting the sinks. The Salina contains beds of the mineral anhydrite, which alters to gypsum by hydration. This change causes swelling of about 40 percent (Boggs, 2006), which could help to fracture surrounding rocks; but more importantly, gypsum is easily dissolved by additional ground water, removing roof support and leading to collapse. In the Bellevue region there are two main ways that karst is expressed: one where catastrophic collapse forms a steep-walled, cone-shaped depression with active sinking and a second that is much more broad and shallow and may or may not have an active sink throat where water is draining into it.

Eight hundred and twenty three of the 997 karst features are within the Columbus Limestone (**Dc** on the Bedrock Geology map) with the majority of the remaining features in the Bass Islands Dolomite or Salina undifferentiated (within the **Sbi** or **Ssu**). These formations and the others on the Bedrock Geology map are buried in many places by surficial glacial materials. The elevation of the bedrock below the surficial materials is called Bedrock Topography and is shown on page 7. The elevations of the bedrock surface were subtracted from the DEM (p. 5) to create the Drift Thickness map (p. 8). Knowing the drift thickness is useful because where the drift is shallow—about 25 ft or less—sinkholes are commonly expressed. Other sinkholes may exist but were either buried beneath the glacial drift or prevented from forming by thick drift. The Drift Thickness map clearly shows that in the Bellevue area the sinkholes are concentrated along areas of thin glacial drift.

Conclusions

Of the 997 mapped karst features, 415 have photos and 838 appear on LiDAR. Of the 29 springs, nine have a LiDAR response while 20 do not. Springs do not typically show up as depressions unless a catch basin was built and subsequently failed or a build-up of material deposits from carbonate-rich spring waters forms a mound. The large number of sinks and springs found without LiDAR attests to the need for spending time in the field near known karst areas, looking for new features and talking to the public; many of the

springs in the Bellevue area were reported by a local resident, Jim Norrocky. Farmers and other land holders are still one of the best sources of local information, particularly for historical features, such as drained ponds, old mill races, and even sinkholes that have been periodically filled in.

In addition to this map book, a DVD containing the GIS data, metadata, LiDAR depressions, and photographs of many of the features is available. The GIS data contains details such as the location of each point and a brief description of what was found there. The metadata provides information on the sources and quality of the data used in this project. The LiDAR depressions layer records the depth and area for many of the sinkholes. In addition, the collection of photographs captured for many of these features can be used to monitor the growth of preexisting sinkholes and development of new karst features, as well as assisting in identification. Identification is important because karst regions are highly susceptible to pollution and structures built near them may subside. Furthermore, in the Bellevue region, low-lying karst features may be subject to flooding during periods of unusually high precipitation when the water table rises above the land surface. The maps in this report will allow areas of land development near karst features to be better planned and maintained.

Acknowledgments

The Bellevue project, the Delaware County region project, and the Springfield project were funded by the Great Lakes Geologic Mapping Coalition surficial mapping grant program.

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Aden, D.J., Powers, D.M., Pavey, R.R., Jones, D.M., Martin, D.R., Shrake, D.L., and Angle, M.P., 2011, Karst of the western Delaware County, Ohio, region: Ohio Department of Natural Resources, Division of Geological Survey Open-File Report 2011-4, 2 p., 35 maps, accessible at < http://geosurvey.ohiodnr.gov/portals/geosurvey/PDFs/OpenFileReports/OFR_2011-4.pdf > .

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Pavey, R.R., Angle, M.P., Powers, D.M., Swinford, E.M., 2012, Karst flooding in Bellevue, Ohio, and vicinity—2008: Ohio Department of Natural Resources, Division of Geological Survey Map EG-5, scale 1:24,000.

Pavey, R.R., Hull, D.N., Brockman, C.S., Schumacher, G.A., Stith, D.A., Swinford, E.M., Sole, T.L., Vorbau, K.E., Kallini, K.D., Evans, E.E., Slucher, E.R., and Van Horn, R.G., with GIS and cartography by Powers, D.M., and Vogt, K.L., 1999, Known and probable karst in Ohio: Ohio Department of Natural Resources, Division of Geological Survey Map EG-1, scale 1:500,000. [Revised 2002, 2004, 2007.]

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Further Reading

For more information on karst in Ohio, visit the Ohio Geological Survey website, **OhioGeology.com.** The following resources also provide additional information on karst and its effects in Ohio and beyond.

Ohio Department of Natural Resources

Ground Water Induced Flooding in the Bellevue Ohio Area Spring and Summer 2008, ODNR Division of Water Technical Report of Investigation 2009-1, 19 p.

Karst Flooding in Bellevue, Ohio, and Vicinity—2008, ODNR Division of Geological Survey Map EG-5, 2012, scale 1:24,000.

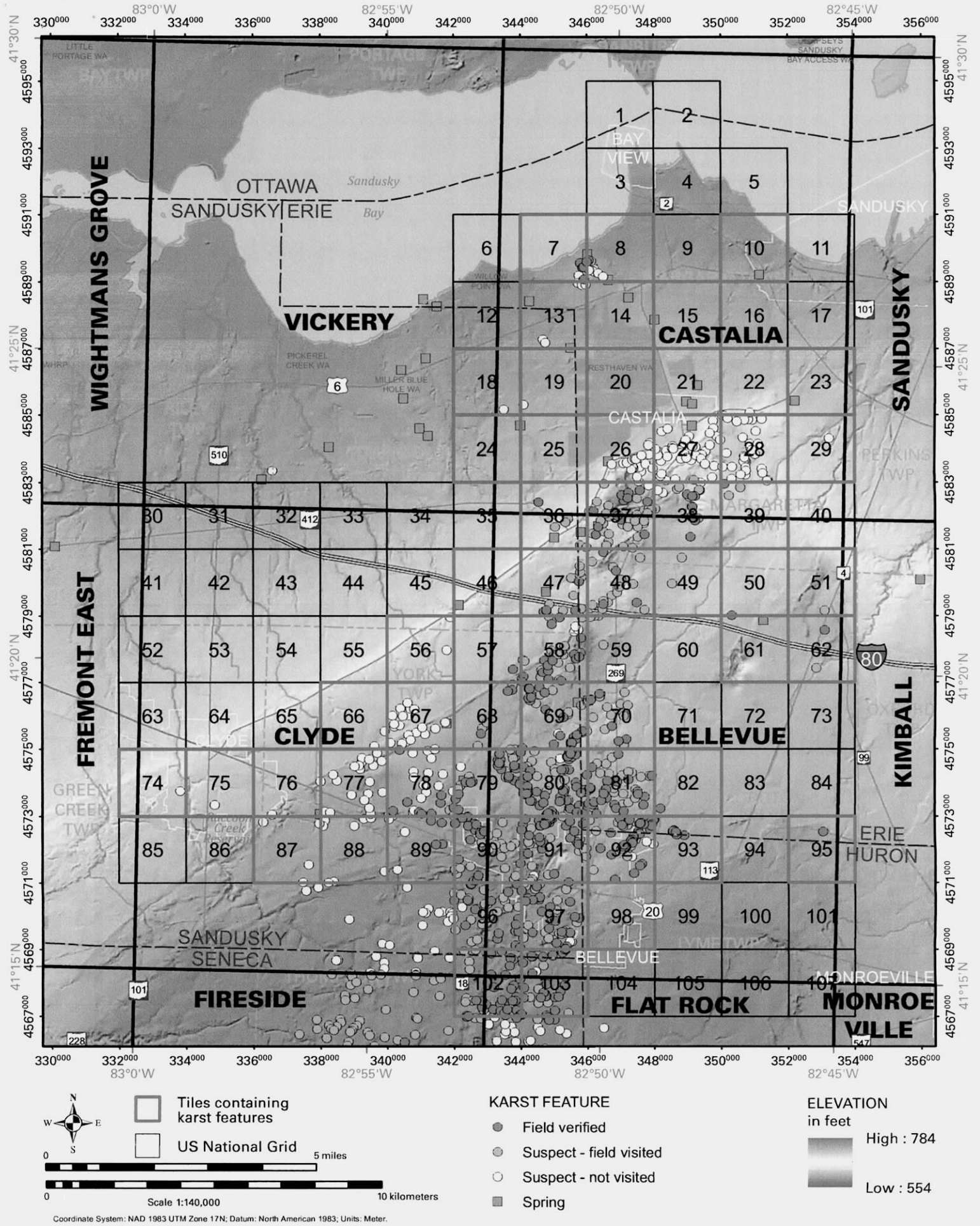
Known and Probable Karst in Ohio, ODNR Division of Geological Survey Map EG-1, generalized page-size version with text, 2 p., scale 1:2,000,000.

American Geological Institute

Living with Karst—A Fragile Foundation, AGI Environmental Awareness Series, no. 4, accessible at < http://www.agiweb.org/environment/publications/karst.pdf > .

U.S. Geological Survey

USGS Groundwater Information, Karst and the USGS, accessible at < http://water.usgs.gov/ogw/karst/ > .



Tiles containing karst features

US National Grid

0 5 miles

0 10 kilometers

Scale 1:140,000

Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

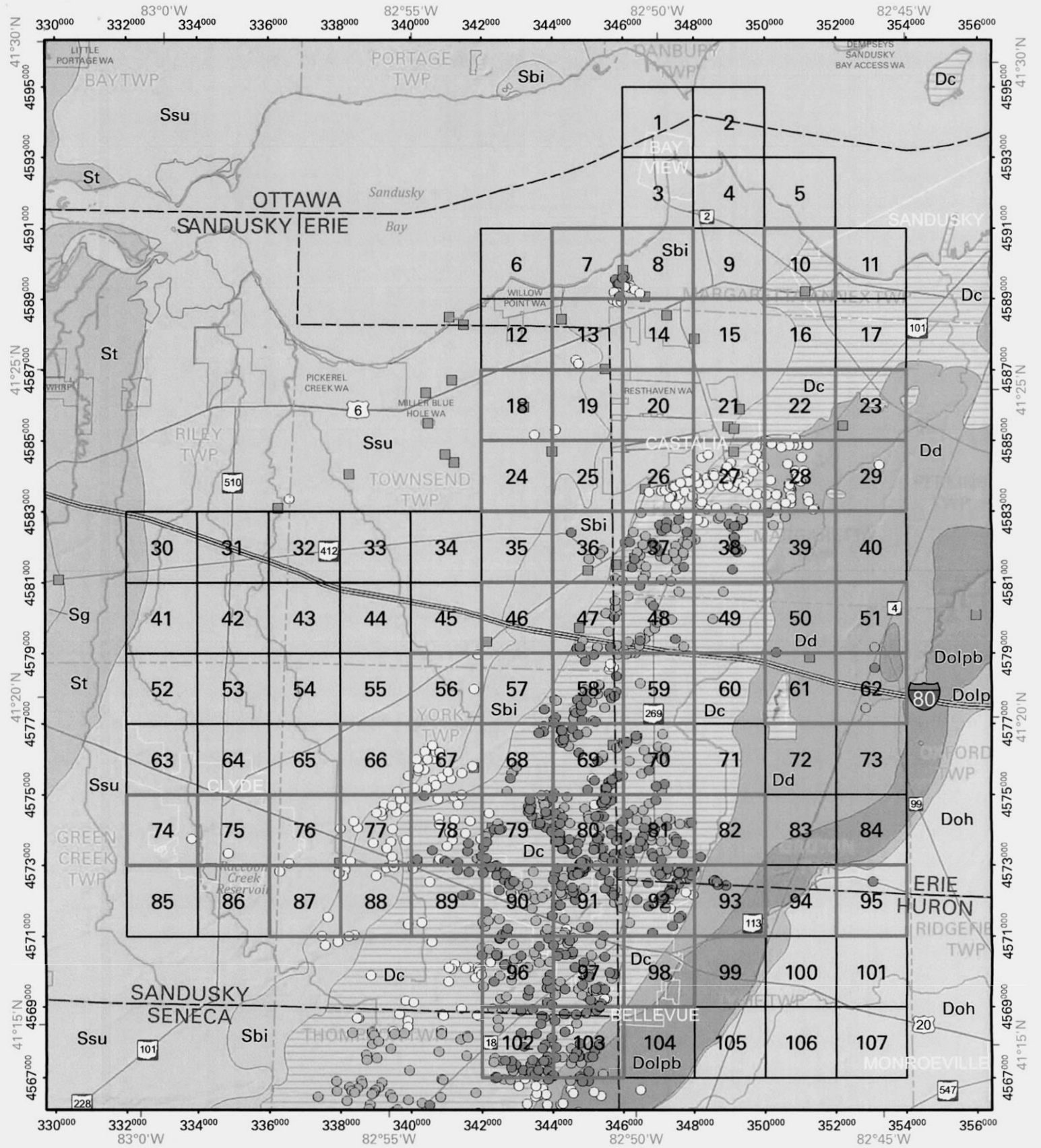
KARST FEATURE

- Field verified
- Suspect - field visited
- Suspect - not visited
- Spring

ELEVATION in feet

High : 784

Low : 554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41°20'N
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OTTAWA
SANDUSKY
ERIE
SANDUSKY
SENECA
HURON
Sandusky Bay
BAY TWP
PORTAGE TWP
DANBURY TWP
RIDGEFIELD TWP
RIDGEVILLE TWP
CLAY TWP
YORK TWP
CLYDE
GREEN CREEK TWP
RILEY TWP
TOWNSEND TWP
THOMPSON TWP
CASTALIA
RESTHAVEN WA
PICKEREL CREEK WA
MILLER BLUE HOLE WA
WILLOW POINT WA
DEMPSEYS SANDUSKY BAY ACCESS WA
BAY VIEW
BELLEVUE
MONROEVILLE
Raccoon Creek Reservoir
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Tiles containing karst features
US National Grid
0
5 miles
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Scale 1:140,000
10 kilometers
Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.
KARST FEATURE
Field verified
Suspect - field visited
Suspect - not visited
Spring
BEDROCK GEOLOGY
Doh Ohio Sh
Dolp Prout Ls
Dolpb Plum Brook Sh
Dd Delaware Ls
Dc Columbus Ls
Sbi Bass Islands Dol
Ssu Salina undiff
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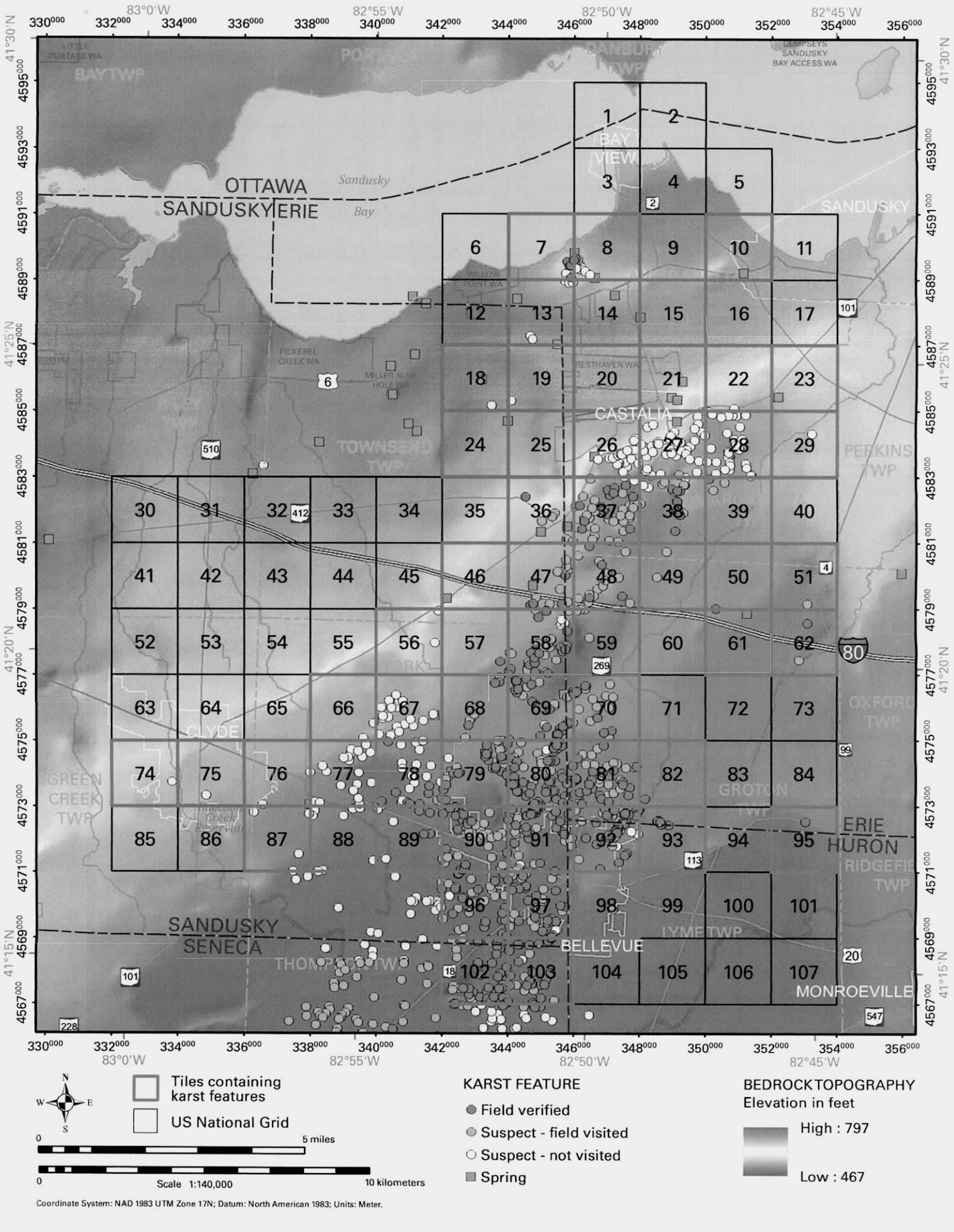
Sg Greenfield Dol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OTTAWA
SANDUSKY
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Sandusky Bay
BAY VIEW
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LYME TWP
GROTON TWP
OXFORD TWP
PERKINS TWP
HURON
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PICKEREL CREEK WA
MILLER BLUE HOLE WA
WILLOW POINT WA
WESTHAVEN WA
Tiles containing karst features
US National Grid
0
5 miles
0
Scale 1:140,000
10 kilometers
KARST FEATURE
Field verified
Suspect - field visited
Suspect - not visited
Spring
BEDROCK TOPOGRAPHY
Elevation in feet
High : 797
Low : 467
Coordinate System: NAD 1983 UTM Zone 17N; Datum: North American 1983; Units: Meter.

Riddle Road (Sandusky County)

Bellevue, Ohio 44811

Also, see Bellevue Birding Drive

Bar Charts by Season by Month											
All Months											
Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Spring			Summer		Fall				Winter		

eBird Hotspot

Sandusky County

Riddle Rd. (Sandusky Co.)

Coordinates: 41.2618206, -82.8967252
eBird links: Hotspot map – View details – Recent visits
My eBird links: Location life list – Submit data

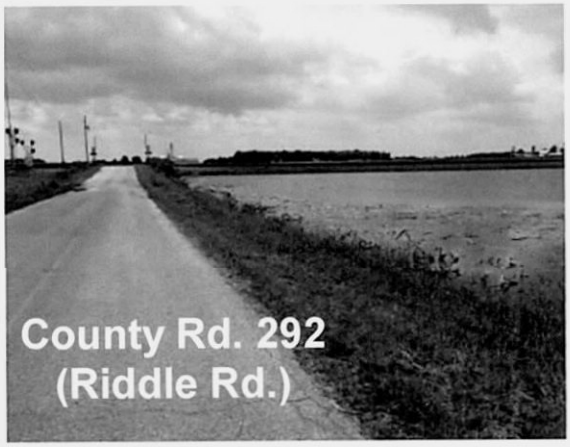


Photo by Ken Ostermiller

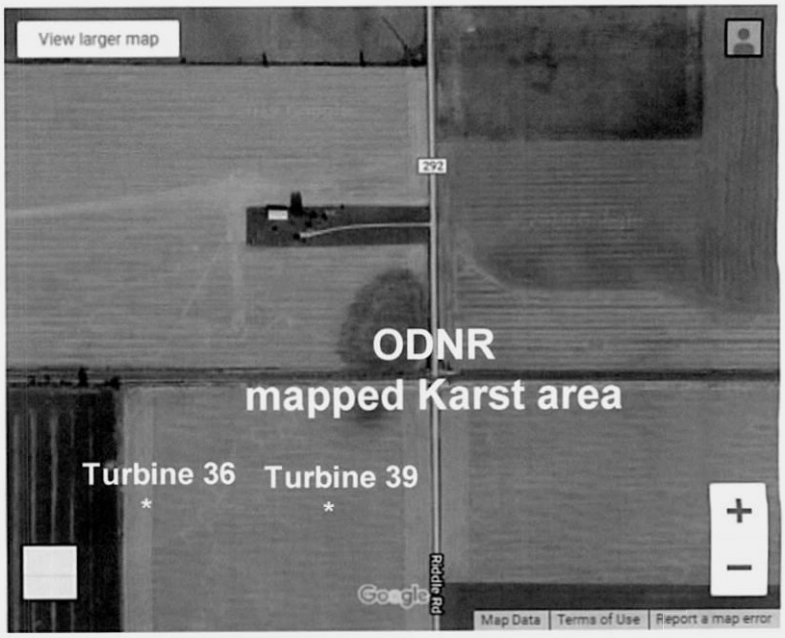
Tips for birding Riddle Road

The farm fields around Bellevue, Ohio, near the Seneca and Sandusky county line, flood during certain years, providing habitat for shorebirds, mostly in migration, but in some years there have been breeding records in this area.

When there is high water in the area, the agricultural fields on both sides of Riddle Road flood near the railroad crossing, so it is worth checking both sides of the tracks. Sometimes high water will cover the road in this area.

Riddle Road traverses privately owned properties. Please view birds from the roadside only.
From Ken Ostermiller

No restroom facilities.



eBird is a real-time, online checklist program which has revolutionized the way that the birding community reports and accesses information about birds. Jointly sponsored by the Laboratory of Ornithology at Cornell University and the National Audubon Society, eBird provides rich data sources for basic information on bird abundance and distribution.

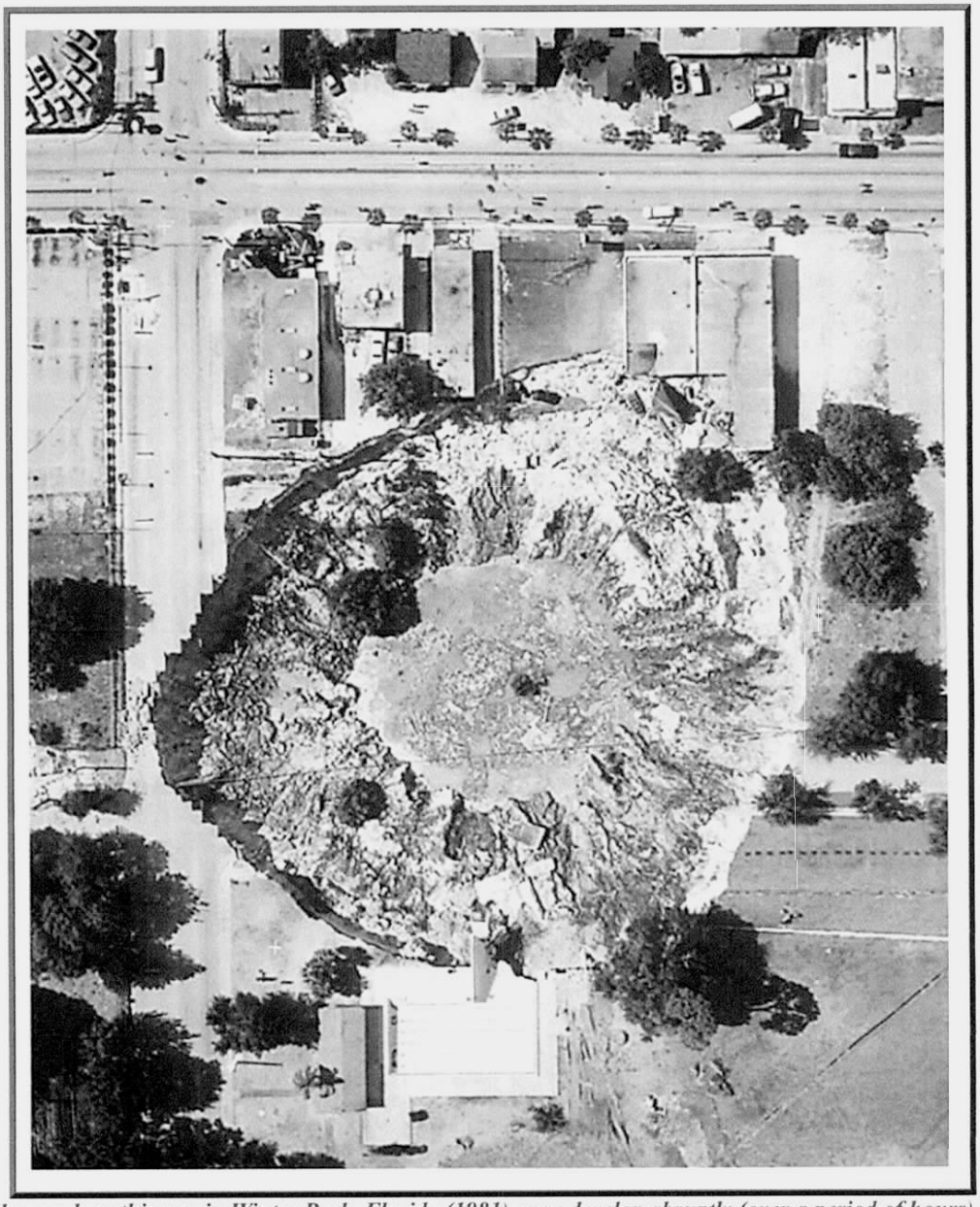
This website provides descriptions and maps of eBird Hotspots in Ohio. In eBird, Hotspots are shared locations where birders may report their bird sightings to eBird. Hotspots provide birders with information about birding locations where birds are being seen.

Endangered Earth

Sinkholes

Winter Park, Florida

May 9, 1981



Collapse sinkholes, such as this one in Winter Park, Florida (1981), may develop abruptly (over a period of hours) and cause catastrophic damage Credit USGS

The sudden and sometimes catastrophic subsidence associated with localized collapse of subsurface cavities (sinkholes) (fig. 8) is detailed in two case studies. This type of subsidence is commonly triggered by ground-water-level declines caused by pumping and by enhanced percolation of ground water. Collapse features tend to be associated with specific rock types, such as evaporites (salt, gypsum, and anhydrite) and carbonates (limestone and dolomite) (fig. 9). These rocks are susceptible to dissolution in water and the formation of cavities Salt and gypsum are much more soluble than limestone, the rock type most often associated with catastrophic sinkhole formation.

Evaporite rocks underlie about 35 to 40 percent of the United States, though in many areas they are buried at great depths (Martinez and others, 1998). Natural solution-related subsidence has occured in each of the major salt basins in the United States (Ege, 1984). The high solubilities of salt and gypsum permit cavities to form in days to years, whereas cavity formation in carbonate bedrock is a very slow process that generally occurs over centuries to millennia. Human activities can expedite

Corran Exhibit 1

136. Kongress der Deutschen Gesellschaft für Chirurgie

Abstract-ID: **410**, Poster-Nr.: DGCH - 13

JG|U UNIVERSITÄTSmedizin. MAINZ

Dept. of Cardiothoracic and Vascular Surgery

High level infrasound exposure reduces the contractility of human cardiac tissues in in-vitro model

Chaban R, Ghazy A, Brendel L, Buschmann K, Vahl C-F

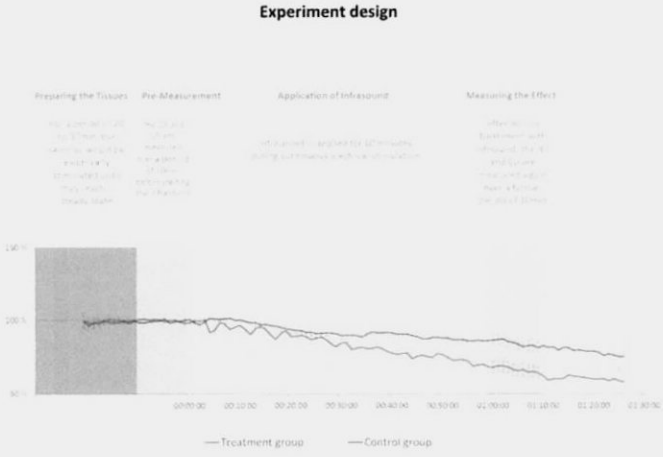
Background

Human exposure to infrasound is increasing due to man-made factors, like industrial installations, wind farms and transportation. A growing concern among the public regarding the safety of this exposure can be noticed. The aim of this work is to evaluate whether exposure to infrasound interferes directly with human cardiac function and hence attributes to any kind of pathological process.

Methods

Human myocardial tissues, obtained from patients undergoing cardiac surgery, were prepared in small muscle samples and then stimulated electrically with a frequency of 75 bpm for a period of almost 120 minutes under sustained perfusion with an oxygenated physiological solution. Two samples were obtained from each patient: one was subjected to infrasound at 16 Hz and the other served as a control. The exhibited isometric contraction force (CF) and contraction duration (CD) were measured before and after the treatment. The changes in these values ($CF_{\%}$ and $CD_{\%}$, corresponding to the ratios between the values after the exposure and before) were evaluated and analyzed as dependent variables in a multiple linear regression model, considering the ratios in the corresponding control samples and infrasound levels of exposure as explanatory variables.

Three infrasound levels of exposure were used in this study: 100, 110 and 120 dBz. No weighting system was used.

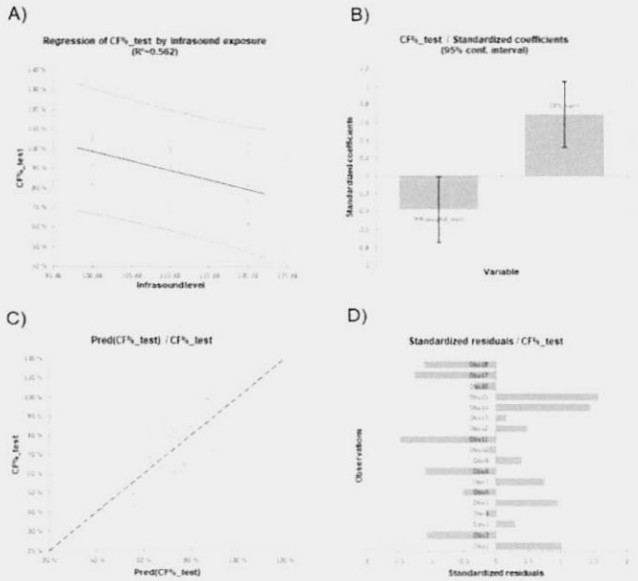


Experiment design: first the samples were stimulated for a period of 30 minutes until they reached a steady state. Then the CF and CD are measured (CF_1 & CD_1) over a period of 10 minutes. After that, infrasound was applied for a period of 60 minutes during continuous electrical stimulation. A second sample from every patient served as a control. At the end, the measurement was repeated (CF_2 & CD_2) again over a further period of 10 minutes. The Ratios between the values (CF_2 / CF_1 & CD_2 / CD_1) were calculated for each trial.

Results

The measured $CF_{\%}$ in the samples treated with infrasound were proportional to the measured $CF_{\%}$ in the corresponding control samples (p= 0.001) and corresponded negatively with the infrasound level of exposure measured in dBz (r^2=0.56; p= 0.044). The decrease in $CF_{\%}$ measured almost 7.5% for every 10 dBz above the 100 dBz limit, resulting in almost 15% decrease in contraction force at 120 dBz.

The $CD_{\%}$ remained unchanged after the treatment with infrasound.



Using multiple linear regression, we found the measured $CF_{\%}$ in the samples treated with infrasound to be proportional to the measured $CF_{\%}$ in the corresponding control samples (p= 0.001) and negatively corresponded with the infrasound level of exposure measured in dBz (r^2=0.56; p= 0.044). The decrease in $CF_{\%}$ measured almost 7.5% for every 10 dBz above the 100 dBz limit, resulting in almost 15% decrease in contraction force at 120 dBz.

Conclusion

Exposure to high levels of infrasound (more than 100 dBz) interferes harmfully with the cardiac contraction function, even as soon as after one hour of exposure. There are plenty of other works that support this conclusion. The effect of infrasound obviously goes beyond the direct mechanical effect in increasing the cross-bridge breakage and involve a wide range of process, like calcium metabolism und mitochondrial integrity.

These results should be considered when looking at environmental regulations. We recommend introducing a maximal tolerated infrasound level for long-term exposure as low as 80 dBz.

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N.I. KARPOVA, S.V. ALEKSEYEV, V.N. YEROKHIN, E.N. KADYSKINA, O.V. REUTOV (Leningrad)

EARLY REACTION OF THE ORGANISM TO THE LOW-FREQUENCY ACOUSTIC OSCILLATIONS

Sanitary and Hygienic Medical Institute

(Entered to the redaction on 14.02.1978)

The causes of the appearance of the artificial infrasound are operating mechanisms with large radiating surfaces, as well as moving gas flows. According to a number of authors (V.I. Zinchenko and F.E. Grigoryan; E.N. Malyshev; Tempest; Hood and Leventhall, etc.) and the results of our researches, the sources of infrasound can be diesel engines, turbines, piston pumps, compressors, fans, large air blowing machines. Infrasound appears in tunnels for motor transport, in chimneys of high furnaces and in burners of open-hearth furnaces. The infrasound fields created by the work of the mentioned equipment have the intensity from 110 to 132 dB at the main frequencies 1,5, 2, 4, 8, 12 Hz.

Infrasound intensity often has a higher level than the level of audible sound. The distribution of infrasound, the degree of absorption by the atmosphere, the ability to disperse, etc. are somewhat different from the corresponding indicators of audible sounds. Infrasound can cause resonance of large objects due to the commensurability of the wavelength with these objects. All this causes some features of the impact of the infrasonic vibrations over the live organism and creates certain difficulties in combating them.

The Chair of Labor Hygiene of the Leningrad Sanitary and Hygienic Medical Institute performs the determination of the production sources of infrasound, clarifying the nature of its action over the organism, the determination of the changing mechanism observed in the organism under the influence of infrasonic vibrations. However, the disclosure of this mechanism is impossible without establishing the earliest reactions of the organism to the impact of the studying factor. This was the purpose of the present work.

The studies were conducted under the conditions of modeling the infrasound production parameters at the experimental acoustic complex specially equipped at the Chair. Recognized healthy men at the age from 19 to 29 years who passed preliminary medical examination took part at the research. In addition, the impact

over the organism of infrasonic oscillations with the frequency of 5 and 10 Hz, with a sound pressure level of 100 and 135 dB was studied at rats, rabbits and guinea pigs. The time of factor action is 15 minutes Already in the first minutes of exposure, infrasound causes mental stress, vegetative reactions, unpleasant auditory sensations. The most common complaints caused by the infrasound action of the studied frequencies are feelings of general fatigue, lethargy and pressure in the ears. A small number of people (average 15–20%) had such symptoms as headache, dizziness, which were observed in a short time at the end and after the finalization of the experiment. More than half of the researched people complained for distraction, drowsiness, and feeling of depression. During the entire period of infrasound impact, some of the researched people noted the vibration of the internal organs, that mainly causes the sensation of vibrations at the chest, abdominal wall and stomach. These data allow to expect functional changes in the central nervous, cardiovascular systems, from the side of the hearing analyzer, respiratory system and vestibular apparatus under the influence of infrasound.

The functional state of the central nervous system was studied by electroencephalography method.

After a 15-minutes impact of infrasound, an increase in synchronization phenomena, most often in the left hemisphere, was observed at the electroencephalographic curves. In some cases, the hypsynchronized α-rhythm and the appearance of Θ-waves were observed in the left fronto-temporal region.

The obtained results allow us to make an assumption about the general reconstructions of the biopotentials, apparently caused by the impact of infrasound over the brain stem formations. These changes should be attributed to non-specific reactions associated with the weakening of the activating influences of the reticular formation of the trunk over the cerebral cortex (P. K. Anokhin; Moruzzi and Magoun, and others).

After the infrasound action with the frequency of 10 Hz, the intensity of 135 dB, the lengthening of the absolute values of the visual-motor reaction to the strong and weak stimuli and the decrease of the strength of the effector response were also observed.

At the action of infrasound with the frequency of 5 and 10 Hz and the intensity level of 135 dB, peculiar changes in the heart rhythm were noted. In the first minutes of exposure, the number of heartbeats tends to increase, expressed at the same level for both influencing frequencies. In 5–10 minutes, the heart rhythm slows down,

returning to the initial, but after turning off the generator, the number of heartbeats becomes even more rare compared to the background values. Some studied people had an arrhythmia. These phenomena are most pronounced in the first minutes of the action of low frequencies, gradually disappearing with increasing of the time spent in the camera by studied people. A decrease in peripheral vascular tone was found, manifesting in the increase of skin temperature and in the decrease of maximum arterial pressure.

The study of cerebral hemodynamics was performed by rheoencephalography method. Analysis of rheoencephalogram showed that the action of infrasound is accompanied with the signs of inhibition of cerebral hemodynamics, manifested in the difficulty of venous outflow from the cranial cavity. The infrasound with frequency of 10 Hz, the intensity of 135 dB, caused deeper and more stable changes in the cerebral blood circulation, which consisted in a greater increase of the amplitude of the rheographic wave, in an increase of the duration of its anacrotic phase and in a decrease of the tonic voltage indicator compared to the impact of infrasonic vibrations with frequency 5 Hz of the same intensity. Under the influence of infrasound, the most noticeable and authentic changes in cerebral hemodynamics appear from about 7-10th minute of being in the infrasound field.

For registration of mechanical movements of the heart during contraction, the method of seismic cardiography developed by V. M. Baevsky and M. A. Kazaryan was used. The obtained results allowed to conclude that the infrasonic oscillations with intensity of 135dB cause disturbances in the mechanical movements of the heart, reducing the force of contraction of the heart muscle. This is manifested in a decrease in both the amplitude of the 1st oscillatory cycle, reflecting the magnitude of the cardiac forces acting during the systole, and the amplitude of the 2nd (diastolic) oscillatory cycle. The most pronounced changes in the contractile activity of the heart take place under the influence of infrasound frequency of 10 Hz.

Analysis of pneumograms registered during the action of infrasonic oscillations with a frequency of 5 and 10 Hz, an intensity of 135 dB shows changes in the respiratory function, manifested in the stable decrease of respiration frequency, starting from the 1st minute of the infrasound impact.

The state of the auditory analyzer was investigated with the help of tone audiometer AP-02. Researches of the infrasound impact with the frequency of 10 Hz and the intensity of 135 dB showed in most cases a slight exacerbation of hearing sensitivity - within 10 dB at the frequencies of 125, 250, 500 and 300 Hz.

The applying of the electron-syntagmography method did not reveal any disturbances in the vestibular apparatus under the influence of low-frequency oscillations of the studied intensity.

At experimental studies over the laboratory animals exposed to infrasound of the same parameters, changes in the bioelectrical activity of some cortical and subcortical structures of the brain, disturbances of redox processes in skeletal muscles, changes in the volume of nuclei of receptor cells in the helical body of the guinea pig snail were revealed that is a morphological expression of excitation caused by the infrasound action. Changes in the content of nucleic acids were found in these cells.

The results of the conducted researches allow us to conclude that infrasonic oscillations are not indifferent for biological objects, have the adverse effect over the entire organism and make many important functional systems react. The central nervous, cardiovascular, and respiratory systems, as well as the auditory analyzer are the most interested, reacting already in the first minutes of the infrasound impact. Among all studied parameters of infrasound, the deeper changes in the indicated systems of the studied people were caused by the oscillations with the frequency of 10 Hz and the intensity of 135 dB. The infrasound with the frequency of 5 Hz at the same intensity caused much smaller effect. Studies conducted at a lower infrasound intensity of 100 dB practically did not lead to the changes in the studied systems.

The analysis of the received data witnesses about the fact that the impact of infrasonic oscillations is manifested, primarily, in the violation of the mechanisms of central regulation of the body vital systems, the manifestation of which are the detected changes in the functional state of the cardiovascular and respiratory systems, violation of proteins synthesis and metabolic processes in the organism.

Thus, the study of the early reactions of the organism to the impact of infrasonic oscillations allows to reveal certain aspects of the mechanism of its biological action and contributes to the scientific argumentation of the production infrasound levels acceptable to the humans.

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и профессиональные заболевания

10

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Москва

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О. В. РЕУТОВ (Ленинград)

РАННЯЯ РЕАКЦИЯ ОРГАНИЗМА НА НИЗКОЧАСТОТНЫЕ АКУСТИЧЕСКИЕ КОЛЕБАНИЯ

Санитарно-гигиенический медицинский институт

(Поступила в редакцию 14/II 1978 г.)

Причиной возникновения искусственного инфразвука являются работающие механизмы с большими излучающими поверхностями, а также движущиеся потоки газов. Источниками инфразвука, по данным ряда авторов (В. И. Зинченко и Ф. Е. Григорян; Э. И. Малышев; Tempest; Hood и Leventhall, и др.) и результатам наших исследований, могут являться дизельные двигатели, турбины, поршневые насосы, компрессоры, вентиляторы, большие воздуходувные машины. Инфразвук возникает в туннелях для автотранспорта, в дымоходах высоких печей и в горелках мартеновских печей. Инфразвуковые поля, создаваемые работой перечисленного оборудования, имеют на основных частотах 1, 5, 2, 4, 8, 12 Гц интенсивность от 110 до 132 дБ.

Интенсивность инфразвука часто имеет больший уровень, чем уровень слышимого звука. Распространение инфразвука, степень поглощения атмосферой, способность к дисперсии и др. несколько отличаются от соответствующих показателей слышимых звуков. Инфразвук способен вызывать резонанс крупных объектов в силу соизмеримости длины волны с этими объектами. Все это обусловливает некоторые особенности воздействия инфразвуковых колебаний на живой организм и создает определенные трудности в борьбе с ними.

На кафедре гигиены труда Ленинградского санитарно-гигиенического медицинского института проводятся определения производственных источников инфразвука, выяснение характера его действия на организм, определение механизма изменений, наблюдаемых в организме под влиянием инфразвуковых колебаний. Однако раскрытие этого механизма невозможно без установления самых ранних реакций организма на воздействие изучаемого фактора. Это и явилось целью настоящей работы.

Исследования проводили в условиях моделирования производственных параметров инфразвука в специально оборудованном на кафедре экспериментальном акустическом комплексе. В исследованиях принимали участие прошедшие предварительное медицинское освидетельствование и признанные здоровыми мужчины в возрасте от 19 до 29 лет. Кроме того, на крысах, кроликах, морских свинках изучали действие на организм инфразвуковых колебаний частотой 5 и 10 Гц, с уровнем звукового давления 100 и 135 дБ. Время действия фактора 15 мин. Уже в первые минуты воздействия инфразвук вызывает психическое напряжение, вегетативные реакции, неприятные слуховые ощущения. Наиболее общими жалобами, предъявляемыми при действии инфразвука исследуемых частот, являются ощущения общей усталости, вялости и давления в ушах. У небольшого количества лиц (в среднем у 15—20%) возникали такие симптомы, как головная боль, головокружение, которые отмечались непродолжительное время в конце и после окончания эксперимента. Более чем у половины исследуемых были зафиксированы жалобы на рассеянность, сонливость и ощущение депрессии. В течение всего периода воздействия инфразвука некоторые исследуемые отмечали вибрацию внутренних органов, которая сказывалась в основном в ощущении колебаний грудной клетки, брюшной стенки и желудка. Эти данные позволяют ожидать функциональных изменений в центральной нервной

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A. S. GORDELADZE, V. V. GLINCHIKOV, V. R. USENKO

EXPERIMENTAL MYOCARDIAL ISCHEMIA CAUSED BY INFRASOUND

Sanitary and Hygienic Medical Institute, Leningrad

Modern scientific and technological progress has led to the creation of large-sized machines and units capable to generate infrasonic vibrations, which are an integral part of production noise. At certain parameters, infrasound can have a harmful effect on the body [4]. Currently, an intensive study of the effect of infrasound over both the whole organism, and on various organs and tissues is being conducted [3].

There are works in the literature showing the effect of infrasound over the myocardium [1, 2, 5, 6). These studies stated that infrasound damages firstly the vessels of the myocardium. At the same time, the pathogenesis of the effect of infrasound over the myocardium remains unclear in many details, the effect of infrasound over the structures of cardiomyocytes has not been studied, which is the goal of the present study.

For holding experiments, a specially constructed acoustic installation was used, allowing to create the infrasonic field in the range of 0.5–50 Hz with a pressure intensity of 90–140 dB.

The experiments were performed on white rats and guinea pigs, which were irradiated with infrasound at a frequency of 8 Hz, intensity of 120 dB during 1, 5, 10, 15, 25, 40 days with daily exposure of 3 hours. In all groups of experiments 10 animals were used, 3 of which served as a control. Animals were slaughtered by decapitation. Fixation was performed by Carnoy method and in 20% formalin.

The preparations were stained with hematoxylin-eosin, by Van Gieson method, halo-cyanin, by Einarson method, to detect nucleic acids, methyl green with pyronin, by Brache method (control with ribonuclease). The SCHIFF- reaction with amylase control was used, the activity of succinate dehydrogenase (LDH), lactate dehydrogenase (LDH), and glucose-6-phosphate dehydrogenase (G-6-FDG) were also investigated. To detect the activity of redox enzymes, cooled myocardium was cut in the cryostat at a temperature of —5 ° C. Cuttings were processed according to E. Pierce's prescriptions. Evaluation of histochemical reactions and the activity of redox enzymes was performed by a semi-quantitative method, comparing the obtained data with the control.

For electron microscopic examination, fixation was performed with 2.5% glutaraldehyde for 2 hours with additional fixation with 1% osmium and with

subsequent dehydration with alcohol. Ultrathin cuttings were made on the LKB-III ultratome, contrasted with lead citrate and examined with electron microscope JEM-7A.

In acute experiments after 3-hour single exposure to infrasound with a frequency of 7 Hz and an intensity of 120 dV, when examining the heart, barely perceptible pallor and swelling of the left and right ventricular walls and small-point hemorrhage in the pericardium structure were noted.

Histological examination showed mild edema and in some cardiomyocytes - moderate grit and even vacuolar dystrophy of myofibrils with the disappearance of ransverse striation. SCHIFF -reaction was unevenly expressed, weakened after treatment of cuttings with amylase. Pironnofilia was of diffuse nature and decreased after exposure to nuclease. The activity of the LDH was increased, the precipitated grains of diformazan differed in polymorphism. Capillary lumens are filled with red blood cells, but endothelial cells look swollen.

During electron microscopic examination, reactively altered cardiomyocytes show mitochondrial swelling and destruction of outer membranes with loss of dual contour, enlightenment and homogenization of the matrix with fragmentation of the cristae. In myofibrils there are areas of re-coloring, and sometimes tears of myofilaments in the area of the disks. The canals of the T-system are dilated. An increase in the amount of chromatin is noted in the nuclei. Nuclear pores are enlarged.

With continued impact of infrasound, a day after the start of the experiment, the activity of redox enzymes falls in the ischemic zone, but at the same time there are areas in which myofibrils are painted over with aggregation of diformazan grains. Reactively modified cardiomyocytes give a weak SCHIFF -positive reaction, weakening when treating medicines with amylase. Pironnofilia has a diffuse character. The activity of SDH varies, at first decreasing sharply compared to the control one, then increasing. The activity of LDH in some myofibrils is increased. The activity of G-6-FDG and NAD-diaphorase is expressed weak. In the foci of ischemia, the capillaries are sharply narrowed as a result of the swelling of the endothelium cells. The sarcoplasm of cardiomyocytes is edematous, the sarcolemma is damaged in a number of areas, there are homogenization zones and a re-dyeing band in the myofibrils. The mitochondria are swollen, with a vague outer membrane, devoid of matrix, the cristae are fragmented to varying degrees. The contours of the nuclei are strengthened, the nucleoli disappear, the amount of chromatin is increased, the nuclear pores are enlarged. In the T-system there are vacuoles of various sizes, the sarcoplasmic reticulum canaliculi are enlarged.

In the intact zones, single modified cardiomyocytes appear with the presence of re-dyeing bands and even with damage of myofilaments.

At the 5th, 10th, and 15th day, in the zones of myocardial ischemia located mosaically in the region of the left ventricle, there are perivaecular hemorrhages around the small vessels, and there are separate leukocytes in the surrounding connective tissue. Damaged infrasound cardiomyomatics changed, they have all the signs of granular dystrophy. The SCHIFF reaction is poorly expressed, does not change after treatment with amylase, pyronnophilia is focal in nature and disappears after treatment with ribonuclease. The activity of redox enzymes is reduced, the myofibrils are diffusely stained, the diformazan grains form polymorphic clusters. Sarcoplasma of cardiomyocytes is edematous, in some places myofibrils are fragmented in the area of the discs, there are foci of homogenization of myofilaments (see figure); discs are mixed and expanded. Many mitochondria are swollen, with a spotty-coated matrix, the cristae are finely fragmented, the outer membrane in a number of structures is devoid of dual contour. The contours of the nuclei are deformed, nucleoplasm is cleared in some places, chromatin forms clusters of irregular shape. Sarco-plasma reticulum canaliculi dilated. The erythrocytes accumulate in the lumens of the dilated capillaries, and in the swollen endothelial cells there are destroyed mitochondria

After 25 and 40 days of infrasound impact in the area of myocardial ischemia, the SCHIC-reaction of cardiomyocytes is weak. Pironnofilia of cells has a focal character and decreases after treatment with ribonuclease. The activity of redox enzymes increases, there are areas with myofibrils stained in color, the diformazan grains form focal accumulations. The activity of G-6-FDG increases.

At the 25th day in reactively altered cardiomyocytes, sarcoplasm edema decreases. Sarcolemma is sharply contoured, the number of ribosomes increases, however, myofilaments are homogenized in some places. Mitochondria have an oval shape, in the matrix there are sometimes foci of enlightenment, the crista are in most cases parallel to each other, fragmentation is poorly noticeable. The nuclei of cells have rugged but clear contours, chromatin is located in the form of clumps of various sizes, the pores of the nuclear membrane are enlarged. The lamellar complex is little changed, the tubules of the sarco-plasma reticulum and the T-system are moderately dilated. There are single lipid inclusions, sometimes primary and secondary lysosomes are found. Capillary openings are enlarged, the amount of chromatin in the nuclei is increased, the mitochondria are homogenized, the number of glycogen granules is reduced.

Full restoration of damaged cardiac cells occurs as a result of intracellular regeneration and occurs after the termination of infrasound impact.

Conclusions. 1. Infrasound with a frequency of 8 Hz and an intensity of 120 dB has a damaging effect on the structure of the myocardium, which is associated primarily with damage to cardiomyocytes, as well as with damages related to microcirculation process. In this case, the size of the damage increases with increasing of duration of impact.

2. Having a damaging effect on the myocardium, infrasound in parallel causes the development of compensatory and supportive processes, which can mask the clinical symptoms and thus impede the correct and timely diagnosis.

3. The concealment of the action of infrasound on the myocardium requires the timely detection of this harmful factor in production and the control of it for the sake of preserving the health of those who are exposed to its constant effect.

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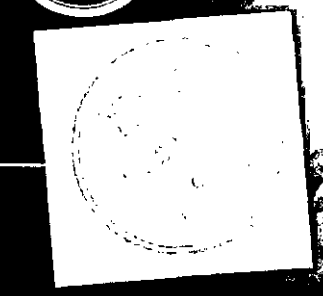

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ЭДЕЛАДЗЕ, В. В. ГЛИНЧИКОВ, В. Р. УСЕНКО

ИМЕНТАЛЬНАЯ ИШЕМИЯ МИОКАРДА, ВЫЗВАННАЯ ИНФРАЗВУКОМ

э-гигиенический медицинский институт, Ленинград

менный научно-технический
привел к созданию крупноага-
их машин и агрегатов, способ-
ерировать инфразвуковые коле-
которые являются составной
производственных шумов. При
енных параметрах инфразвук
оказывать вредное влияние
низм [4]. В настоящее время
интенсивное изучение воздей-
нфразвука как на целостный
м, так и на различные органы
[3].

ературе имеются работы, сви-
вующие о влиянии инфразвука
ард [1, 2, 5, 6]. Эти иссле-
констатировали, что инфразвук
ает прежде всего сосуды мио-
Вместе с тем патогенез воздей-
фразвука на миокард во многих
остается невыясненным, не изу-
яние нифразвука на структуры
иоцитов, что и является целью
его исследования.

роведения экспериментов была
вана специально сконструиро-
вкустическая установка, позво-
создавать инфразвуковое поле
зоне 0,5—50 Гц с интенсив-
давления 90—140 дБ.

были поставлены на белых
морских свинках, которых об-
нфразвуком частотой 8 Гц, ин-
стью 120 дБ на протяжении
15, 25, 40 сут с ежедневной
ией 3 ч. Во всех группах опы-

тов использовали по 10 животных,
которых служили контролем. Живот
забивали декапитацией. Фиксацию п
изводили по Карнуа и в 20 % фор
лине. Препараты окрашивали гем
ксилин-эозином, по Ван-Гизону, га
цианином по Эйнарсону для выявле
нуклеиновых кислот, метиловым з
ным с пиронином по Браше (контр
с рибонуклеазой). Использовали Ш
реакцию с контролем амилазой,
следбвали также активность сукци
дегидрогеназы (СДГ), лактатдеги
геназы (ЛДГ) и глюкозо-6-фосфа
гидрогеназы (Г-6-ФДГ). Для выя
ния активности окислительно-восст
вительных ферментов охлажден
миокард резали в криостате при те
ратуре —5 °С. Срезы обрабатывал
прописям Э. Пирса. Оценку гист
мических реакций и активности оки
тельно-восстановительных ферме
осуществляли полуколичествен
методом, сравнивая полученные да
с контролем.

Для электронно-микроскопичес
исследования фиксацию произво
2,5 % глутаральдегидом на протяж
2 ч с дофиксацией 1 % осмием
последующим обезвоживанием
том. Ультратонкие срезы делал
ультратоме LKB-III, контрастиро
цитратом свинца и изучали с помо
электронного микроскопа JEM-7A.

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S.V. ALEKSEYEV, V. V. GLINCHIKOV, V. R. USENKO

REACTION OF LIVER CELLS TO THE IMPACT OF INFRASOUND

Sanitary and Hygienic Medical Institute, Leningrad

Intensive development of modern industry led to the creation of the machines and the mechanism of high power, which are the source of acoustic oscillations of various spectral range. The researchers pay special attention to infrasound as an integral part of production noises.

Scientific studies of recent years showed that infrasound in certain parameters has a harmful effect over the human body [1, 3, 7]. At the same time, the effect of infrasound is studied not only on the whole organism, but also on separate organs and tissues, as well as cellular structures [2,5]. Among the experimental works there are ones that show the harmful impact of infrasound over liver cells [4, 6]. However, many of the details of this process remained not researched and are the subject of this study.

The infrasound installation described in our previous work [3] was used at the experiment. The experiments were performed on sexually matured white rats-males weighing up to 250 g, which were exposed to infrasound frequency at 2, 4, 8, 16 Hz and with an intensity of 90–140 dB during 40 days with a daily exposure of 3 hours. The material was taken on the 5th, 10th, 15th, 20th, 40th day. The animals were decapitated. The material was fixed in 20% formalin, the cuttings were colored with hematoxylin-eosin, by Van-Gieson method, methyl green with pyronin, by Brache method and halo-cyanin, by Einarson method for nucleic acids

For electronic - microscopic research the pieces of liver were fixed by 2.5% glugraldehyde with additional fixation by 1% osmium and poured into araldide. Ultrathin cuttings were made on the ultratome LKB-III, contrasted by citrate of lead and studied in the electronic microscope JEM-7A.

It was established that infrasound has a damaging impact over hepatocytes of the liver at the frequency of 8 Hz and the intensity of 120 dB. In the glandular parenchyma of the liver there are diffuse changes which have the nature of reactive

processes and are found in separate hepatocytes or in the whole group of cells. In addition, changes from the side of the sinusoid cells of the liver were observed.

The reaction of hepatocytes to the impact of infrasound was mosaic by nature and was expressed in the fact that the damaged cells lost contact with each other and were rounded. The phenomena of dissociation increased along with the effect of the infrasound and were characterized by changes from the side of both the nucleus and the cytoplasm. First of all, there was a deformation of the nuclei with the redistribution of chromatin and its concentration in the form of dense layer under the nucleus membrane. In the cytoplasm, the RNA content increased, it became sharply basophilic. Hepatocyte changes were more pronounced at the increase of the infrasound intensity up to 140 dB.

Electronic microscopic studies showed that mitochondrial swelling in reactively altered hepatocytes initially took place, the density of the matrix sharply increased, and deformation of the cristae was observed. The endoplasmic reticulum canaliculi expanded, and vacuoles of irregular shape and of various sizes were formed in them.

At long time exposure to infrasound, myelin-like bodies and lipid granules appeared in a number of hepatocytes on the 25th and 40th day.

In the granular cytoplasmic reticulum, the number of ribosomes sharply decreased and lysis areas appeared, especially around the nuclei (Fig. 1). The amount of glycogen decreased sharply compared with the norm. Around the lysis areas there were relatively small mitochondria with the dense matrix.

Next to sharply damaged hepatocytes there were cells in which nuclei chromatin was unevenly distributed, and in the endoplasmic reticulum there was a moderately pronounced vacuolization and the number of ribosomes decreased. Ultimately, in such reactively altered hepatocytes, the chromatin predominantly accumulates around the nuclear envelope, having the view of large clumps of irregular form. Vacuolization increased in the cytoplasm, but the swollen mitochondria contained shortened and fragmented cristae. Such hepatocytes remain viable after the termination of the infrasound action as well, gradually acquiring the normal structure.

The subject of degenerative changes are only those hepatocytes in which nuclear deformation takes place, but in the cytoplasm there are lysis areas with the ultimate formation of large vacuoles and the presence of small mitochondria with a dense matrix and destroyed cristae (Fig. 2). Polyblasts accumulate around dystrophic-

altered hepatocytes and infiltrates gradually form. Proliferative processes are accompanied with the appearance of a large number of Kupffer cells, which are divided by mitosis and are accumulated in areas of the damaged parenchyma. In some cases, hepatocyte mitosis can be observed, which undoubtedly indicates the presence of regeneration processes.

The study showed that infrasound has a damaging impact over liver cells at a frequency of 8 Hz and an intensity of 120 dB, causing changes of both the nucleus and the cytoplasm. The initial form of the reaction of hepatocytes to the infrasound is the deformation of the nucleus with the redistribution of chromatin and the concentration of its clumps under the nuclear envelope with the disintegration of the nucleoli and the increase of the pernuclear spaces size. As a rule, such changes in hepatocytes are observed during the first day after irradiation with infrasound and are observed in those cells that are the subject of dissociation. At the same time, changes in the cytoplasm also take place in such hepatocytes, where mitochondria swelling with cristae fragmentation is observed.

Along with infrasound action, the number of reactively modified hepatocytes increases as well, especially on the 10-15th day, with the appearance of degenerative forms among them.

The greatest damaging effect of infrasound is observed at a frequency of 8 and 16 Hz and an intensity of 140 dB. At the same time, the number of dissociated hepatocytes increased, they formed whole groups. The nuclei of such cells were sharply deformed, and in the cytoplasm there were lysis areas of the endoplasmic reticulum, with ultimate formation of large vacuoles. In the preserved areas of the granular cytoplasmic reticulum, the canaliculi were enlarged and formed vacuoles of various dimensions and sizes. At the same time, lipid granules containing osmiophil inclusions appeared in the cytoplasm, and the structure of mitochondria changed.

The mitochondria that were located closest to the lysis area and were reduced in size, with a dense matrix and mild cristae, were altered most of all. In those areas of the cytoplasm in which the canaliculi of the granule network were preserved, though expanded, the mitochondria were enlarged in size, the fragmentation of the cristae was observed. The changes described above indicate that infrasound damages not only intracellular membranes and mitochondria, but also the nuclear apparatus, that can lead to the death of cells, if these changes have pathological nature and are

accompanied by lysis of cytoplasmic areas with ultimate formation of large vacuoles.

Such hepatocytes ultimately die, and polyblasts and profiling Kupffer cells are accumulated around them.

Less damaged hepatocytes, in which lysis of the cytoplasmic membranes is not detected, are gradually restored, though the extended canaliculi of the endoplasmic reticulum and the increased density of mitochondria with moderate vacuolization remain in them for a long time.

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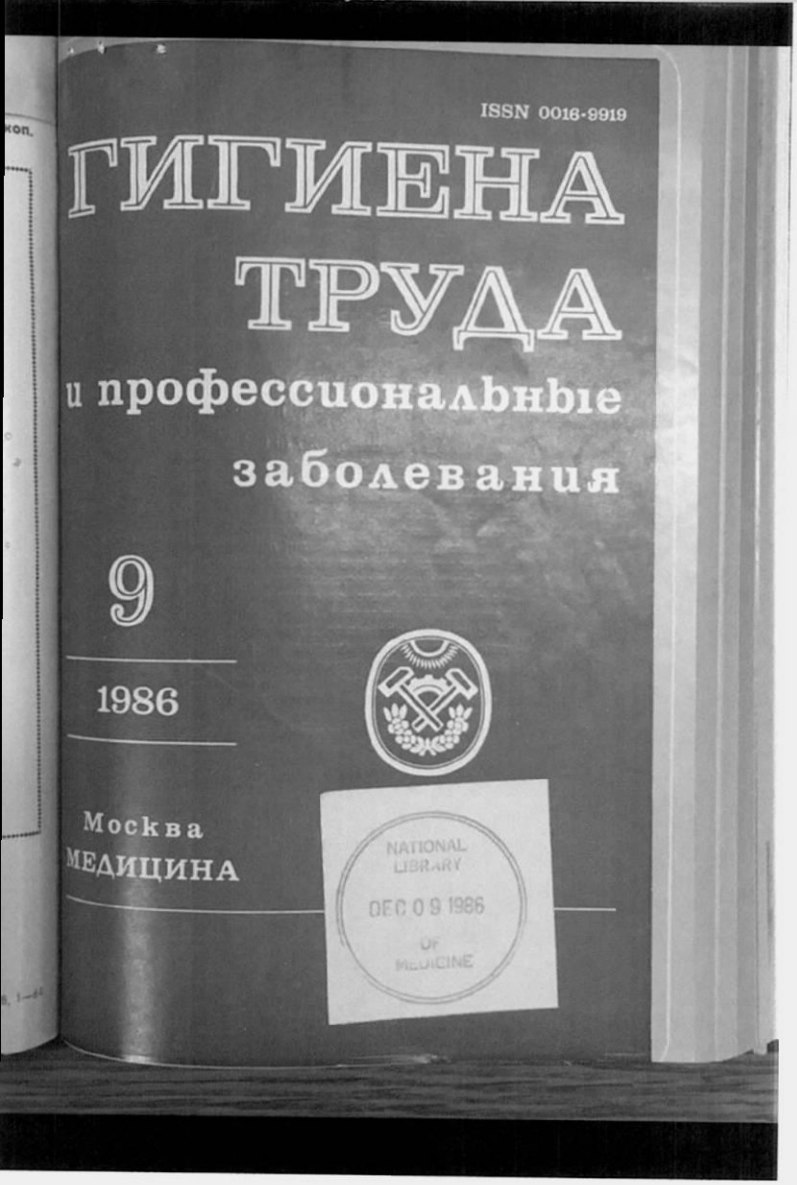
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РЕАКЦИЯ КЛЕТОК ПЕЧЕНИ НА ВОЗДЕЙСТВИЕ ИНФРАЗВУКА

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Интенсивное развитие современной промышленности привело к созданию машин и механизмов большой мощности, которые являются источником акустических колебаний различного спектрального диапазона. Особое внимание исследователей обращают на инфразвук как составную часть производственных шумов.

Научные исследования последних лет показали, что инфразвук в определенных параметрах оказывает вредное влияние на организм человека [1, 3, 7]. При этом изучается воздействие инфразвука не только на целостный организм, но и на отдельные органы и ткани, а также клеточные структуры [2, 5]. Среди экспериментальных имеются работы, в которых показано вредное воздействие инфразвука на клетки печени [4, 6]. Однако многие детали этого процесса остались неизученными и явились предметом настоящего исследования.

В эксперименте была использована инфразвуковая установка, описанная в предыдущей нашей работе [3]. Опыты поставлены на половозрелых белых крысах-самцах массой до 250 г, которые подвергались воздействию инфразвука частотой 2, 4, 8, 16 Гц и интенсивностью 90—120 дБ на протяжении 40 сут при ежедневной экспозиции 3 ч. Материал брали на 5, 10, 15, 25, 40 сутки. Животных декапитировали. Материал фиксировали в 20 % формалине, срезы окрашивали гематоксилин-эозином, по Ван-Гизону, метиленовым синим по Браше и галлоцианином по Эйкарсону на нуклеиновые кислоты.

Для электронно-микроскопического исследования кусочки печени фиксировали 2,5 % глутаральдегидом с дофиксацией 1 % осмием и заливали в аралдид. Ультратонкие срезы делали на ультратоме LKB-III, контрастировали цитратом свинца и изучали в электронном микроскопе JEM-7A.

Установлено, что инфразвук оказывает повреждающее действие на гепатоциты печени при частоте 8 Гц и интенсивности 120 дБ. В железистой паренхиме печени имеются диффузные изменения, которые носит характер реактивных процессов и встречаются в отдельных гепатоцитах или в целой группе клеток. Наблюдались изменения и со стороны клеток синусоидов печени.

Реакция гепатоцитов на воздействие инфразвука носила мозаичный характер и выражалась в том, что поврежденные клетки теряли связь друг с другом и округлялись. Явления дистрофии нарастали по мере действия инфразвука и характеризовались изменением со стороны как ядер, так и цитоплазмы. Прежде всего наблюдалась деформация ядер с перераспределением хроматина и концентрацией его в виде плотных слоя под ядерной мембраной. В цитоплазме увеличивалось содержание РНК, она становилась резко базофильной. Более выраженными были изменения со стороны гепатоцитов при увеличении интенсивности инфразвука до 140 дБ. Электронно-микроскопические исследования показали, что в реактивно-измененных гепатоцитах вначале происходило набухание митохондрий, резко увеличивалась плотность матрикса, а также наблюдалась деформация крист. Канальцы эндоплазматического ретикулума расширялись, и в них формировались вакуоли неправильной формы и различных размеров.

При длительном воздействии инфразвука на 25-е и 40-е сутки в ряде гепатоцитов возникали миелиноподобные тельца и липидные гранулы.

В гранулярной цитоплазматической сети количество рибосом резко уменьшалось и появлялись зоны лизиса, особенно вокруг ядер (рис. 1). Количество гликогена резко уменьшалось по сравнению с нормой. Вокруг зон лизиса находились сравнительно мелкие митохондрии с плотным матриксом.

Рядом с резко поврежденными гепатоцитами располагались клетки, в ядрах которых хроматин был распределен неравномерно, а в эндоплазматическом ретикулуме имелась умеренно выраженная вакуолизация и уменьшалось количество рибосом. В дальнейшем в подобных реактивно-измененных гепатоцитах хроматин преимущественно скапливается около ядерной оболочки, имея вид крупных, неправильной формы глыбок. В цитоплазме нарастала вакуолизация, а набухшие митохондрии содержали укороченные и фрагментированные кристы. Подобные гепатоциты остаются жизнеспособными и после прекращения действия инфразвука постепенно приобретают нормальное строение.

Дегенеративным изменениям подвергаются лишь те гепатоциты, в которых происходит деформация ядер, а в цитоплазме имеются участки лизиса с последующим образованием крупных вакуолей и наличием мелких митохондрий с плотным матриксом и разрушенными кристами (рис. 2). Вокруг дистрофически-измененных гепатоцитов скапливаются полибласты и постепенно формируются инфильтраты. Пролиферативные процессы сопровождаются появлением большого количества купферовских клеток, которые делятся митозом и скапливаются в участках поврежденной паренхимы. В ряде случаев можно наблюдать и митоз гепатоцитов, что, несомненно, свидетельствует о наличии процессов регенерации.

Исследование показало, что инфразвук оказывает повреждающее действие на клетки печени при частоте 8 Гц и интенсивности 120 дБ, вызывая изменения как ядер, так и цитоплазмы. Начальной формой реакции гепатоцитов на инфразвук является деформация ядер с перераспределением хроматина и концентрацией его глыбок под ядерной оболочкой с распадом ядрышек и увеличением размеров перинуклеарных пространств. Как правило, подобные изменения в гепатоцитах наблюдаются на протяжении первых суток после облучения инфразвуком и отмечаются в тех клетках, которые подвергаются диссоциации. Одновременно в подобных гепатоцитах происходят изменения и в цитоплазме, где наблюдается набухание митохондрий с фрагментацией крист.

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Original Article

Infrasound induces coronary perivascular fibrosis in rats

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ABSTRACT

Background: Chronic exposure to industrial noise is known to affect biological systems, namely, by inducing fibrosis in the absence of inflammatory cells. In rat hearts exposed to this environmental hazard, we have previously found myocardial and perivascular fibrosis. The acoustic spectrum of industrial environments is particularly rich in high-intensity infrasound (<20 Hz), whose effects on the heart are unknown. We evaluated the morphological changes induced by IFS in rat coronaries in the presence and absence of dexamethasone.
Methods: Adult Wistar rats were divided into three groups: group A (GA)—IFS (<20 Hz, 120 dB)-exposed rats for 28 days treated with dexamethasone; group B (GB)—IFS-exposed rats; group C (GC)—age-matched controls. The midventricle was prepared for observation with an optical microscope using 100× magnification. Thirty-one arterial vessels were selected (GA 8, GB 10, GC 13). The vessel caliber, thickness of the wall, and perivascular dimensions were quantified using *image J* software. Mann–Whitney and Kruskal–Wallis tests were used to compare the groups for lumen-to-vessel wall (L/W) and vessel wall-to-perivascular tissue (W/P) ratios.
Results: IFS-exposed rats exhibited a prominent perivascular tissue. The median L/W and median W/P ratios were 0.54 and 0.48, 0.66 and 0.49, and 0.71 and 0.68, respectively, in GA, GB, and GC. The W/P ratio was significantly higher in GC compared with IFS-exposed animals (P=.001). The difference was significant between GC and GB (P=.008) but not between GC and GA.
Conclusion: IFS induces coronary perivascular fibrosis that differs under treatment with corticosteroid.

1. Introduction

Noise represents a major environmental factor and is among the stressors with the highest impact on public health [1]. Noise and sound are physically the same, but the reaction to perception varies between people, depending on the cognitive environment in which detection takes place and ultimately leads to a definition of noise as an undesired sound [2,3]. Low-frequency noise (LFN) and infrasound (IFS) are conventionally defined as sound below 200 and 20 Hz, respectively. The lower limit of the audio frequency range of human hearing is usually given as 16 or 20 Hz, but humans can perceive infrasound if the sound pressure level (dB) is sufficiently high [4]. In the range of IFS, comparative studies have shown that the auditory sensitivity of different species can vary widely. For instance, rats have poorer infrasonic hearing than humans, considering different sound pressure levels [5], but high-intensity (110 dB) IFS vibrations on experimental rats can be perceived, as they elicit active avoidance reactions [6]. Beside its auditory health effects, noise can cause nonauditory effects—such as annoyance, sleep disturbance, and psychological stress—that experimental and epidemiological evidence links to cardiovascular disease, including ischemic heart disease, heart failure, arterial hypertension, arrhythmia, and stroke [7–12].

In recent years, scientists have directed their attention towards the relatively understudied noise range of below 200 Hz. LFN and IFS are present everywhere, from natural occurrences to industrial installations and low-speed machinery. The characteristics of strong penetration and less attenuation in long distance propagation have been proposed to explain several adverse biological effects in experimental and epidemiological studies [13]. Low-frequency sounds have higher energy than the sounds at mid and higher frequencies and cannot be correctly evaluated using the conventional A-filters, which are most often used in environmental studies [14]. It is also possible that there are subtle effects of LFN on the body that we do not yet understand. High sound pressure levels (> = 90 dB) of LFN can induce resonance responses in body cavities [13]. The overall range of human body resonant frequencies was

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found to be from 2 to 16 Hz [15], which is nearly the exact range of IFS. It may be assumed that animals also possess inherent specific sound frequencies in certain tissues and organs [16], and for that reason, it is important to document, using animal models, the morphological and biological effects induced by a wide spectrum of wavelengths, from industrial to LFN and IFS.

The cardiovascular system of rodents is sensitive to LFN [17–19]. We previously documented the development of perivascular fibrosis around the coronary arteries (from small to large caliber) of rats exposed to industrial noise [20,21]. We also found a significant fibrotic development in ventricular myocardium among rats submitted to LFN [22,23]. These morphological changes were found in the absence of inflammatory cells, which could suggest a noninflammatory process. However, the fibrotic proliferation mechanism remains unclear.

The effects of IFS on the coronary artery morphology under the influence of an anti-inflammatory agent are unknown. In order to fill this gap, we sought to evaluate the morphological changes induced by IFS in rat coronary arteries in the presence and absence of dexamethasone.

2. Material and methods

Fourteen adult female Wistar rats 10 months old were used in this study. They were purchased from a Spanish breeder (Charles River Laboratories España, S.A., Spain). All the handling and care of the experimental animals were performed by authorized researchers (accredited by the Federation of European Laboratory Animal Science Associations, Category C) and were done in accordance with the EU Commission on Animal Protection for Experimental and Scientific Purposes (2010/63/EU) and with the Portuguese legislation for the same purpose (Decree-Law No. 197/96). The rats were housed in 42×27×16-cm polypropylene cages with a steel lid and had unrestricted access to food (commercial chow) and water. The same standard house conditions were used throughout the experiment for all the animals, and they involved keeping a maximum of two rats in a single cage.

In the beginning of the study, the 14 rats were randomly distributed into three groups. Nine of the rats were continuously exposed to high-intensity and very LFN (2–20 Hz/Lp=114 dB) during a period of 28 days. In four of the noise-treated rats, two tablets of dexamethasone 0.5 mg (Decadron 0.5 mg, Medinfar) were introduced subcutaneously in the dorsal region at two time points of the noise exposure, day one and day 12, and these were designated as group A, while the dexamethasone-free rats were included in group B. The remaining five rats were used as age-matched controls (group C) and sacrificed when all of the rats reached 11 months of age.

2.1. Short description of electroacoustic experiment

With the objective of creating a strong subsonic acoustic field in the *vivarium* chamber, a slightly trapezoidal room with 23.7 m^3 (3.55×3.31×2.02, average length×width×height, respectively, in meters), a pseudo-random waveform in the 2-Hz to 20-Hz decade band was designed with Matlab based on a bandpass-filtered 30-s maximum length sequence segment. The waveform was used to excite an array of two infinite baffles mounted 18-in. 300-W-rated magnetodynamic subwoofers, by means of a 2×600-W heavy-duty quasi-dc voltage output audio power amplifier. Subsequently, with the aim of exploiting as much as possible the available subwoofers dynamic range at this frequency range with an acceptable amplitude distortion, the waveform was iteratively nonlinearly treated with moderate compression-expansion and further filtering (in order to reduce the crest factor to approximately 2.0 times). The total sound pressure level and the spectral characteristics of the resulting acoustic pressure waveform were monitored, and the results were an average sound pressure level of 120 dB with a tolerance of ±3 dB in the 30-s time window. As to the spectral boundedness of the produced sound field, the result was 80 dB total out-of-band average sound pressure level (−40 dB lower).

2.2. Light microscopy

All rats were sacrificed by an intravenous injection of 0.6 ml of a 5:4 mixture containing ketamine (Imalgene 1000, Bayer, Portugal) and xylazine (Rompun, Bayer, Portugal). The vascular system was perfused with a saline solution followed by paraformaldehyde fixation. The heart was excised, sectioned transversely from the ventricular apex to the atria, and routinely processed for light microscopy. The midventricular fragment from each heart was selected for the study. Five-micrometer paraffin-embedded slices of the tissue samples were made and dyed according to Sirius red techniques. The histological images were acquired with an optical microscope using 100× magnification.

2.3. Histomorphometric data

Thirty-one arterial vessels were selected (8 in GA, 10 in GB, and 13 in GC) (Fig. 1). At least one vessel from each rat was included. The researchers, including data collectors and data analysts, were blinded to which group the animals belonged to. Data were analyzed using the *image J* software (National Institutes of Health, Bethesda, MD, USA). The caliber of the arterial vessels, the thickness of the walls, and the perivascular tissue dimension were measured, and for each rat, the mean lumen-to-vessel wall (L/W) and mean vessel wall-to-perivascular tissue (W/P) ratios were calculated (Fig. 2). (See Table 1.)

2.4. Statistical analysis

Mann–Whitney test has been applied in the comparison of IFS-exposed animals (including animals treated with dexamethasone and nontreated animals) and a control group for two parameters: L/W and W/P ratios. Kruskal–Wallis and Mann–Whitney tests were used in the comparison of the three groups for the same parameters. A P value <.05 was considered statistically significant.

3. Results

3.1. IFS-exposed animals vs. control animals

The Mann–Whitney test has been used to compare the two groups for L/W ratio and W/P ratio variables, with the Bonferroni correction $\alpha^* = 0.05/2 = 0.025$. The analysis shows that the W/P ratio is significantly lower in the IFS-exposed group ($P=.001$). In contrast, the L/W ratio did not differ between the two groups ($P=.060$). It should be mentioned that the extreme observation for W/P ratio values in the control group does not influence these conclusions, as differences between the groups were still detected by the Mann–Whitney test after removal of that observation ($P=.003$), as expected in view of the robustness of this nonparametric test against such extreme values (Fig. 3).

3.2. Comparison between IFS-exposed dexamethasone-treated animals, IFS-exposed animals, and control animals

In the comparison between the three groups, the Kruskal–Wallis test has been applied with the same Bonferroni correction to the significance level, $\alpha^* = 0.025$. The analysis has shown that there are differences between the groups for W/P ratio ($P=.011$) but not for L/W ratio ($P=.104$). *Post hoc* comparisons between the groups were conducted for W/P ratio, using the Mann–Whitney test, at the 0.025/3= 0.0083 significance level to control for inflation of type 1 error. In this case, differences were detected between control and IFS-exposed animals not treated with dexamethasone ($P=.008$). It should be mentioned that the extreme observation of W/P ratio values does not seem to influence the main conclusion of the Kruskal–Wallis test, as expressed by a significance of .021 of the test result after removal of that observation, but it does change the conclusions of the Mann–Whitney test in the comparison between groups B and C, which is now

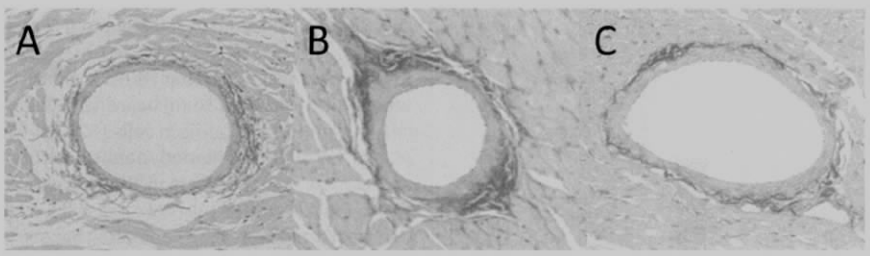

Fig. 1. (A, B, and C) Coronary artery vessels in fragments taken from the left midventricle from (A) group A, infrasound-exposed dexamethasone-treated rats; (B) group B, infrasound-exposed rats; and (C) control group. Note the prominent perivascular tissue in infrasound-exposed animals [Sirius red, 100×].

nonsignificant (P=.021) under the Bonferroni correction ($^{*} = 0.0083$) (Fig. 4).

4. Discussion

The present study evaluated the coronary morphological changes in rat heart induced by pure IFS, created in a laboratory controlled electro-acoustic experiment, and is the first study assessing the possible influence of an anti-inflammatory agent on these changes.

In this investigation, we found an increase in the perivascular tissue around the coronaries in rats exposed to IFS. There were significant differences between IFS-exposed rats and controls concerning the mean W/P ratio, higher among the control group (P<.001). But such differences did not reach statistical significance in the comparison between the animals treated with dexamethasone and the control group, pointing to a possible influence of this potent anti-inflammatory agent.

Previous work from our group, in Wistar rats, investigated the histomorphometric changes in the large and small coronary arteries induced by high-intensity industrial noise within a wide spectrum of wavelengths that included LFN, this last characterized by large sound pressure amplitude ≥90 dB and low-frequency bands of ≤500 Hz [20,21]. The exposure time ranged from 1 to 7 months. In both studies, we found the development of perivascular fibrosis in the absence of inflammatory cells, regardless of exposure time. In another study, we have documented a significant fibrotic development in ventricular myocardium of rats exposed to LFN during a period of 3 months [22]. These investigations confirmed the abnormal proliferation of connective tissue as the main morphological change induced by LFN.

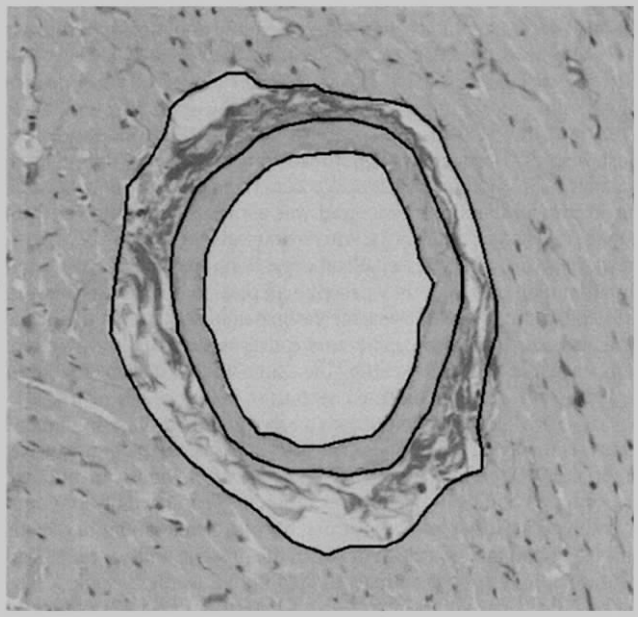

Fig. 2. Example of a coronary artery in a fragment taken from the left midventricle of an infrasound exposed rat [Sirius red, 100×]. The black lines represent the measurements performed using *Image j* software and correspond to vessel caliber, thickness of the wall, and perivascular dimension. These were used to calculate the L/W and W/P ratios.

With increasing urbanization, noise is rising as one of the most important environmental risk factors in modern societies. The importance of the characteristics of the noise stimulus, such as frequency content, intensity, mean and peak dB level, pattern, and exposure time, is not well understood. In the quantitative risk assessment of environmental noise, the World Health Organization (WHO) Regional Office for Europe is concerned with sound pressure level limits, not frequencies [1]. Nonetheless, WHO also acknowledges the special place of LFN as an environmental problem, recognizing that the evidence is sufficiently strong to warrant immediate concern.

Sources of LFN include natural occurrences, industrial installations, and low-speed machinery, ranging from very low-frequency atmospheric fluctuations up to lower audio frequencies. Due to the characteristics of strong penetration and less attenuation in long distance propagation, it has been implicated in several adverse biological effects in experimental and epidemiological studies [13].

One effect of high pressure levels of LFN is excitation of body vibrations [13,19,24]. At high sound levels, typically above 80 dB, the occurrence of resonance responses in body cavities was described [24]. The overall range of human body resonant frequencies was found to be from 2 to 16 Hz [15], which is almost the exact range of infrasound. The displacement between the organ and the skeletal structure places biodynamic strain on the body tissue involved, and it is known to reach its maximum under exposure to vibration close to the body's resonant frequency. Despite the practical impossibility of stimulating the natural frequency of one organ alone without exciting the whole-body resonances, measurements of vibration transmissibility from the point of excitation to a specific organ reveal frequencies of maximum transmissibility that can be attributed to the resonance of the organ. Considering that animals also possess inherent specific sound frequencies in certain tissues and organs [16], it is important to assess the morphological and biological effects induced by noise with different wavelengths in distinct animal models. So far, we have focused our investigation on the effects of large pressure amplitude noise within a wide spectrum of wavelengths, from the industrial to LFN and IFS, and with different exposure times, from 1 to several months [20–23]. The common finding was an abnormal deposition of collagen in the extracellular matrix (ECM), regardless of the characteristics of the noise stimulus other than pressure amplitude.

Table 1
Median (interquartile range) of the two measured outcomes in the three groups

	Ratio L/W Median (interquartile range)	Ratio W/P Median (interquartile range)
Group A	0.54 (0.17)	0.48 (0.15)
Group B	0.66 (0.09)	0.49 (0.08)
Group C	0.71 (0.10)	0.68 (0.08)

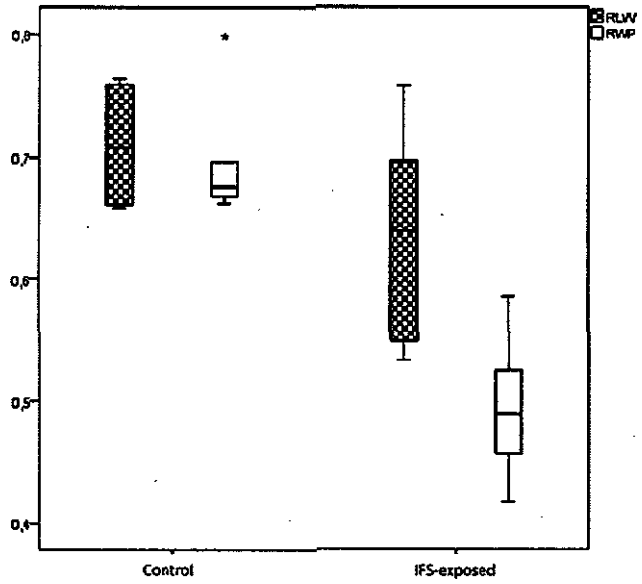

Fig. 3. Lumen-to-vessel wall and vessel wall-to-perivascular tissue ratios in IFS-exposed and control animals. The W/P ratio was significantly reduced in IFS-exposed animals (P=.001). RLW, lumen-to-vessel wall ratio; RWP, vessel wall-to-perivascular tissue ratio.

Interest in the potential adverse health effects of IFS has increased over time. High-level IFS below 20 Hz was historically thought to be of much less significance than LFN in the 20–200 Hz range at the same pressure level [25]. Research on the impact of IFS on the environment established that, for levels above 120 dB, it is dangerous to the human body [13].

Infrasound exposure studies in laboratory animals are scarce and report adverse effects in the ear and auditory system [26], brain and central nervous system [27,28], liver [29,30], and lung [31]. Specifically, the

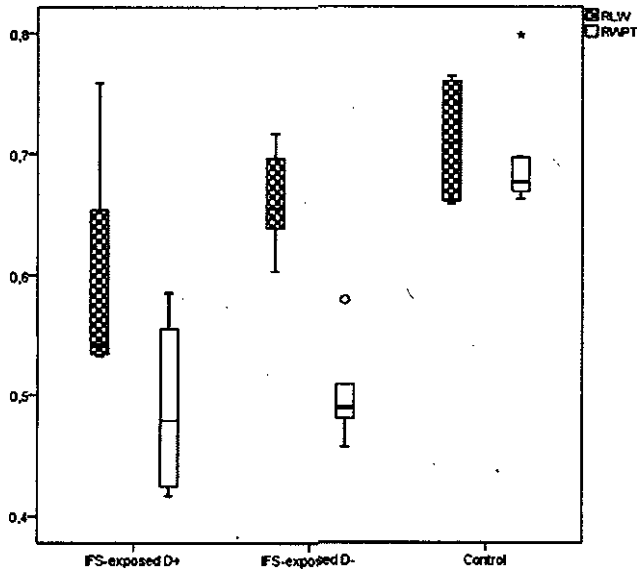

Fig. 4. Lumen-to-vessel wall and vessel wall-to-perivascular tissue ratios in infrasound-exposed dexamethasone-treated rats (group A), infrasound-exposed rats (group B), and control group (group C). For W/P ratio, there are differences between the groups (P=.011) and between groups B and C (P=.008), but not between groups A and C. RLW, lumen-to-vessel wall ratio; RWP, vessel wall-to-perivascular tissue ratio, D+ and D−, dexamethasone-treated and not treated, respectively.

cardiovascular system is sensitive to IFS, as shown by the first studies conducted more than 25 years ago. In these studies, rats were exposed to infrasound (4, 8, and/or 16 Hz at 90 to 145 dB) for up to 45 days, which ultimately led to myocardial ischemia and morphofunctional changes in the myocardium cells [32–34]. More recently, Pei et al. reported IFS-induced hemodynamics, cardiac ultrastructure damage, and cardiac cell apoptosis in the rat myocardium [35,36]. The same group found that IFS dysregulates the L-type calcium currents in rat ventricular myocytes [16] and also that acute exposure to IFS induces oxidative damage of cardiomyocytes that affects a series of oxidative damage-related proteins and genes, suggesting a complex signaling network that is evoked by this stressor [37].

There is no agreement about the biological activity of LFN and IFS and the possible underlying mechanisms. The biological effects of noise on living bodies may not be the same due to different parameters such as biological species, frequency, level of sound pressure, or time of exposure. Over the last years, an increased focus from investigators towards the elucidation of these questions has been observed. Increased release of stress hormones, activation of sympathetic nervous system, increased reactive oxygen species production, endothelial dysfunction, peripheral vasoconstriction, increased peripheral vascular resistance, and increased blood viscosity are among the proposed mechanisms elicited by acute or chronic noise stress leading to detrimental outcomes on the cardiovascular system [7,9,38]. Following this line of investigation, Said and El-Gohary studied the effect of noise in the 80–100-dB range on heart rate and mean systemic arterial blood pressure in adult male albino rats and explored possible underlying mechanisms [39]. They concluded that noise stress has many adverse effects on cardiovascular system through increasing plasma levels of stress hormones, oxidative stress, and endothelial dysfunction.

Until recently, it was presumed that LFN required greater sound pressure in order to elicit toxicological effects on humans and animals. High sound pressure levels can be harmful to the cochlea and cause hearing loss, raising the question of other noise effects being secondary, at least partially, to direct auditory damage. Since animal models in previous studies employed mainly high dBA levels (>100–120 dBA), some investigators started exploring the effects of low decibel noise. Jin et al. [17] used isolated and cultured cardiac fibroblasts from rats to study the effects of low decibel IFS. They reported that noise below 90 dB at 4–20 Hz inhibits angiotensin-II-stimulated cardiac fibroblasts by reactivating miR-29a targeting the TGF- /Smad3 pathway, possibly eliciting cardiac protective effects. Munzel et al. [18] developed a novel noise exposure model in mice with lower peak sound levels (<85 dBA), lower mean sound pressure levels (72 dBA), and shorter exposure times (1–4 days), thought to cause mainly nonauditory effects to animals such as stress reactions. Exposure to noise resulted in elevated blood pressure and heart rate and was associated with detrimental changes in vascular endothelial function, vascular production of reactive oxygen species, and increased blood stress hormones and biomarkers of inflammation. Notably, they describe an invasion of the vasculature with inflammatory cells. The same group demonstrated that nighttime aircraft noise in healthy volunteers causes endothelial dysfunction, which was partially corrected by the acute administration of vitamin C, pointing to increased oxidative stress as a key mechanism [40].

There are currently limited data on the hypothetical noise-induced pathway involving inflammation [11]. In humans, sleep disturbance is associated with a proinflammatory state [41]. As previously mentioned, the common finding in the noise experiments conducted by our group was the perivascular and myocardial fibrotic development in the absence of inflammatory cells [20–23]. In the present study, we included a group of IFS-exposed animals treated with dexamethasone, a synthetic glucocorticoid member with immunosuppressive potency of about 20–30 times that of hydrocortisone and 4–5 times of prednisone [42,43]. Subcutaneous application of dexamethasone, in contrast to intraperitoneal, is highly effective in inhibiting inflammation in mouse models even at low doses [44]. Interestingly, we found differences in

the comparison of control group with IFS-exposed animals with and without dexamethasone treatment, as the treated animals did not show significant differences when compared to controls. This is the first time that such differences are documented, and despite the absence of inflammatory cells previously described by our group, we have to consider a potential underlying inflammatory mechanism.

The mechanism behind the fibrotic proliferation induced by noise in rat heart is not yet understood. In general, the differentiation of cardiac fibroblasts into more active myofibroblasts is the hallmark of cardiac fibrosis, leading to an abnormal accumulation of the ECM components, such as collagen, around damaged heart tissues [45,46].

Myofibroblast differentiation is a complex and highly regulated process, where biochemical and mechanical factors are interdependent [47]. From a biochemical aspect, the differentiation of cardiac fibroblasts into myofibroblasts is well studied, while the role of mechanical factors remains elusive [48]. When exposed to abnormal mechanical conditions such as strain and ECM stiffness, cardiac fibroblasts can undergo myofibroblast differentiation [49,50]. A fact worth mentioning within the scope of our investigation is that, during the cellular response to heart injury, myofibroblasts actively secrete ECM proteins, such as collagen I and III, to replace the damaged myocardium [51]. We previously performed an immunohistochemical and electron microscopy study in order to evaluate the effects of LFN on cardiac collagen and cardiomyocyte ultrastructure [23]. A significant increase of collagens I and III in the ECM was observed. The ultrastructural observation denoted high concentration of collagen in the ECM next to fibroblasts, confirming the pronounced effect of LFN on the connective tissue.

Comparable to the traditional cardiovascular risk factors, experimental and epidemiological evidence substantiates the concept that noise, through auditory and nonauditory effects, may induce activation of different pathways (oxidative stress, vascular dysfunction, autonomic imbalance) that ultimately lead to cardiac fibrosis, adverse ventricular remodeling, and arrhythmogenesis [7–12]. It is important to note that nonauditory noise effects (annoyance, sleep disturbance, and psychological stress) do not follow the toxicological principle of dosage [7]. Consequently, not simply the accumulated sound energy that causes the adverse effect but also the cognitive perception of the sound, the subsequent cortical activation, and the emotional response need to be taken into account. More epidemiological research on LFN and health effects is needed since the available research is scarce and suffers from methodological shortcomings. A systematic review of observational studies suggests an association between everyday life LFN and IFS components (up to 250 Hz) and health effects in the general population, such as annoyance, sleep-related problems, concentration difficulties, and headache [52]. However, they underline the inconsistency across studies and the small number of existing observational investigations, precluding a direct comparison with experimental evidence.

This study has some limitations. The number of animals per group was limited; therefore, the results should be interpreted cautiously. The significant correlation between the two dependent variables considered in this study, ratio L/W and ratio W/P, as expressed by a Spearman correlation coefficient of 0.705 ($P=.005$), would recommend a multivariate approach to the data in order to account for the effect of the association between variables on type I error. However, given the reduced dimensions of the groups, it is not recommended to assess the multivariate normality and homogeneity of variance–covariance assumptions in view of the reduced power of the corresponding tests. In these conditions, the Mann–Whitney test has been used to compare the two groups for ratio L/W and ratio W/P variables, with the Bonferroni correction $^{*} = 0.05/2=0.025$. For the reasons mentioned above regarding the correlation between the dependent variables and group dimension, a nonparametric approach to the data was implemented in the comparison between three groups. The Kruskal–Wallis test has been applied with the same Bonferroni correction to the significance level, $^{*} = 0.025$, and post hoc comparisons between the groups were conducted for ratio W/P using the Mann–Whitney test, at the $0.025/3=0.0083$ significance level, to control for inflation of type 1 error. Also, experimental noise stress models are scarce, and at the present time, a well-defined morphological cardiac model to study the consequences of IFS exposure does not exist. There is a lack of consensus regarding the cardiac cell composition, including fibroblasts, in mammals, with potential variations between species that also depend on the age [53]. Concerning the characteristics of noise, public health research uses A-weighting method to measure noise and focus on sound pressure level, disregarding frequencies. We believe that both sound frequency and intensity are key factors. So far, we investigated the structural modifications in the rat myocardium induced by high sound pressure noise of different wavelengths, from industrial to IFS. Addressing these important questions at the mechanistic level in animals may help provide directions for studies in humans, as more epidemiological research is imperative.

5. Conclusions

Infrasound exposure induces coronary perivascular fibrosis that differs under corticosteroid administration, which raises the possibility of an underlying inflammatory mechanism. The importance of noise in perturbation of inflammatory factors needs to be further investigated.

Con icts of interest

None.

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