COMMONWEALTH OF MASSACHUSETTS
TRIAL DEPARTMENT

ESSEX, SS

LAND COURT
NO. 19 MISC 000187 (RBF)

MICHAEL SILVERIO,

Plaintiff,

V.

TOWN OF NORTH ANDOVER, ET AL.,

Defendants.

EXPERT AFFIDAVIT OF THOMAS SCIACCA

I, Thomas Sciacca, a resident of the Town of Wayland, Massachusetts, do hereby depose and say:

1. I have expert knowledge and information about what I am stating in this affidavit.

2. I am an electrical engineer with expertise in thermal engineering. I received my undergraduate degree in Electrical Engineering from the Massachusetts Institute of Technology in 1968. I hold a certificate in Management of Technology from the Sloan School of Management (MIT).

3. My professional work has included design of computerized data acquisition systems used for precision temperature measurements, using thermal physics extensively in circuit and systems design work. I hold a patent for a residential heating system, which utilizes cogeneration to produce electricity while heating the house. I served as a member of Wayland's Conservation Commission from 1973-1986. Since 2009 I have been a member of Wayland's Energy and Climate Committee. My resume is attached to this affidavit. Exhibit 1.

4. I have studied the pertinent documents appertaining to the development of the recreation complex at 495 Main Street, North Andover, Massachusetts - namely the following: Special Permit – Site Plan review Application (Dec. 20, 2018); Special Permit Decision (April 2, 2019); Permitting Plans (Dec. 20, 2018 – Waterfield Design Group); Town of North Andover Middle School Athletic Fields Redevelopment – Conceptual Layout – Preliminary Budget (March 26, 2018) (Whole Project).

5. From a reading of the foregoing documents, it is my understanding that the site is primarily lawn/grass fields with the exception of the skinned infields and the paved parking area. Special Permit – Site Plan Review Application ("Special Permit Application"), page 1. Presently, the site has on it a baseball field, two little league fields, a soccer field and a parking area. Special Permit Application, page 1. Located within the site there is an area designated as Hayes Stadium, containing a football field; the field is natural grass and the track is bituminous. All fields are natural grass.

6. From a reading of the foregoing documents and other considerations, it is my understanding that the project entails the creation of the following amenities with materials as indicated:

1. Baseball & Multipurpose Field - Artificial turf surface (with crumb rubber)
2. West Softball Field & Rec Field- Artificial turf surface (with crumb rubber)
3. Half basketball court (not given - likely cement, asphalt or rubber)
4. Multipurpose courts (not given – likely cement, asphalt or rubber)
5. 5-12 age playground- fibar mulch surface (poured-in rubber)
6. 2-5 age playground- fibar mulch surface (poured-in rubber)
7. Exercise course (not given – likely cement, asphalt or rubber)
8. Bocce courts (stone dust)
9. Shuffleboard courts (not given – likely cement, asphalt or rubber)
10. Parking, driveways, & curbing (asphalt with curbing stones)
11. Walking paths (bituminous concrete)
12. Stairways (concrete)
13. Restroom building (not given – likely metal, asphalt or rubber roofing)
14. Concession building (not given – likely metal, asphalt or rubber roofing)
15. Storage building (asphalt shingle roofing)
16. Gazebo/shade pavilion, plaza (metal roofing)
17. Parking lot (Middle School) (asphalt with curbing stones)
18. Parking lot-other (asphalt with curbing stones)
19. Stairs and stairways (cement)
20. Walkways (bituminous concrete)
21. Field storage sheds (asphalt shingle roofing)
22. Batting cages (artificial turf surface with crumb rubber)
23. Perimeter and field fences (metal black vinyl)
24. Electric/light poles (die-cast aluminum)
25. Trash receptacles (metal)
26. Bleachers (aluminum)
27. Dugouts (metal roofing)

7. Solar energy is the fundamental input causing temperature elevation in surfaces. Light energy is absorbed by the surface of the field which is made of plastic carpet blades (filaments made from polyethylene or polypropylene) usually in dark green, and infill consisting of crumb rubber or other material such as sand and thermoplastics.

8. Solar energy is composed of ultraviolet (UV) rays, visible light, and infrared energy, each reaching the Earth in different percentages: 5 percent of solar energy is in

the UV spectrum, including the type of rays responsible for sunburn; 43 percent of solar energy is visible light, in colors ranging from violet to red; and the remaining 52 percent of solar energy is infrared. U.S. Environmental Protection Agency, "Cool Roofs," in Reducing Urban heat Islands: Compendium of Strategies, 2008, page 2. https://www.epa.gov/sites/production/files/2017-05/documents/reducing_urban_heat_islands_ch_4.pdf . Relevant excerpts from this publication are attached to this affidavit. Exhibit 2.

9. Solar reflectance, or albedo, is the percentage of solar energy reflected by a surface. The "cool" materials have a high solar reflectance – meaning they absorb and transfer less of the energy that reaches them. Albedo alone can significantly influence surface temperature, with the white stripe on the brick wall about 5 to 10°F (3-5°C) cooler than the surrounding, darker areas. U.S. Environmental Protection Agency, "Cool Roofs," in Reducing Urban heat Islands: Compendium of Strategies, 2008, page 3. https://www.epa.gov/sites/production/files/2017-05/documents/reducing_urban_heat_islands_ch_4.pdf . Relevant excerpts from this publication are attached to this affidavit. Exhibit 2.

10. Although solar reflectance is the most important property in determining a material's contribution to urban heat islands, thermal emittance is also a part of the equation. Any surface exposed to radiant energy will get hotter until it reaches thermal equilibrium (i.e., it gives off as much heat as it receives). A material's thermal emittance determines how much heat it will radiate per unit area at a given temperature, that is, how readily a surface gives up heat. When exposed to sunlight, a surface with high emittance will reach thermal equilibrium at a lower temperature than a surface with low emittance, because the high-emittance surface gives off its heat more readily.

11. It has long been understood that surfaces made of concrete, brick, stone, tar, and asphalt used in buildings, sidewalks and roads, parking lots, other pavements and rooftops are among materials that absorb heat, retain it and then release it during radiation cooling (night) time thus contributing to the heat island effect.

12. One of the factors exacerbating the current climate crisis is the impact of heat islands, particularly urban heat islands, on the warming of the air around us (atmospheric warming). This leads to increased energy consumption (for cooling/air conditioning), elevated emissions of air pollutants and greenhouse gases, compromised human health and comfort, and impaired water quality. According to an estimate by the United States Environmental Protection Agency, on a hot, sunny summer day, insolated roof and pavement surface temperatures can be 50-90° F hotter than air, while shaded or moist surfaces – often in more rural surroundings – remain close to air temperature. Elevated summertime temperatures increase energy demand for cooling. Research shows that electricity demand for cooling increases 1.5-2.0% for every 1° F increase in air temperatures, starting from 68 to 77° F. EPA, Heat Island Impacts, accessed 9/3/2019 – at https://www.epa.gov/heat-islands/heat-island-impacts . I attach the EPA document to this affidavit. Exhibit 3.

13. The heat island effect occurs in areas with higher concentration of surfaces such as buildings, parking lots, and roadways. These surfaces absorb solar radiation during the hottest part of the day which increases the nearby air temperature in the daytime and keeps nighttime temperatures higher as the heat is released from the materials. MAGIC Climate Change Resiliency Plan (Vulnerability Assessment, Pt. 1) prepared for MAGIC Regional Council - http://www.mapc.org/magic - by Metropolitan Area Planning Council (Boston, Massachusetts) www.mapc.org - Working Document 2.0 (July 2017). Relevant excerpts (pages 24-26, 80) from this publication are attached to this affidavit. Exhibit 4.

14. It is my informed expert conclusion that synthetic turf fields (with plastic carpets and crumb rubber/sand infill) and rubberized playground surfaces (poured-in rubber) are in the same category of heat island material as concrete, asphalt and other surfaces associated with heat island effect.

15. In 2007, as the result in part of my examination of the heating of synthetic turf fields, The Boston Globe noted that "At 11 a.m. on an August morning, for example, the fake grass at Veterans Memorial Field in Waltham measured 126 degrees. Hotter than a patch of natural grass. Hotter than a nearby strip of concrete, too." Megan Woodhouse, "Grass-Roots Uprising," in The Boston Globe (Globe West) W1 (September 13, 2007). http://archive.boston.com/news/local/articles/2007/09/13/grass_roots_uprising .

16. It has long been noted that artificial turf fields can get very hot. However, until 2008, no one had written on the thermal mechanisms involved in this phenomenon. My paper on the subject, entitled "The Thermal Physics of Artificial Turf" was published on-line at www.SynTurf.org in January 2008. (http://www.synturf.org/sciaccaheatstudy.html) ("Sciacca Heat Study"). Copy of the investigative research study is attached to this affidavit. Exhibit 5.

17. The Sciacca Heat Study reported on numerous measurements taken in August-September 2007 at artificial turf fields around the Boston area. As examples, my Fluke Model 87 Digital Voltmeter (with 80 TK Thermocouple Module) measured the various surface temperatures at Lincoln-Sudbury Regional High School - 390 Lincoln Road Sudbury, Massachusetts, as follows (in degrees Fahrenheit):

August 3, 2007, 2 PM (hazy sun conditions)
Ambient air (shade, 3 feet off ground): 91
Clover patch (green, two inches high): 93
Grass athletic field (grass - brown and dry): 109
Asphalt (black): 135
Old synthetic turf field: 143
New synthetic turf field 156

August 14, 2007, 2:15 PM (mostly cloudy)
Ambient air (shade, 3 feet off ground): 78
Grass field: 98
Asphalt: 131
Old synthetic turf field: 127
New synthetic turf field 136

September 13, 2007, 2:10 PM (few clouds)
Ambient: 70
Grass (green): 88
Asphalt: 116
Old synthetic turf field: 145
New synthetic turf field: 136

18. The measurements above were taken well past the summer solstice, close to the autumnal equinox. Higher (and much higher) surface temperatures would have been registered had the measurements been taken at the time when the thermal energy source (the sun) would have been closer and more vertical to the surface. In July of 2008, I measured a surface temperature of 163° F at the then newly constructed Wayland High School synthetic turf field.

19. In the foregoing examples, the reason for the temperature variations between the ambient air and the various surfaces – controlling for all other factors - is that different materials absorb and retain thermal energy at different rates.

20. Most crumb rubber infill (made from used tires) is black, which we know from high school physics means they are excellent thermal radiation absorbers. Indeed, ground up tires, commonly called "crumb rubber", contain large quantities of carbon black, which is the blackest substance known and absorbs radiation throughout the solar spectrum with high efficiency. We know from elementary physics that black surfaces will be efficient radiators of infrared energy just as they are efficient absorbers, and that the magnitude of energy radiated will be proportional to the temperature. In addition, crumb rubber infill contain great quantities of air space and rubber itself is a poor thermal conductor, making the layer of rubber infill an excellent thermal conduction insulator.

21. Therefore, thermal energy is absorbed on the surface of the field but will not be dissipated into the mass of the field material. This allows temperatures to rise far higher than on other nearby black surfaces, such as asphalt. The asphalt mass absorbs the thermal energy and thus integrates the temperature rise over time, reducing it during the day but allowing it to remain high after the radiation input is removed at night. Temperatures on the rubber field surface, on the other hand, will drop almost immediately as solar input drops.

22. In keeping with the requirements of the law of conservation of energy heat is obviously dissipated from the fields or the temperature would increase without bound. And just as obviously, all three thermal transport mechanisms – radiation, conduction, and convection – are involved in the cooling of synthetic turf fields.

23. Conduction of thermal energy (heat) from the field occurs to the material beneath the surface, to the air immediately above it, and to whatever is in direct contact with the surface (in the case of playing fields, to the footwear and shoes of players). A major factor in allowing the surfaces of synthetic turf fields to reach temperature extremes is the much lower significance of conduction of energy to the material beneath the surface. Because conduction of heat from the fields to the air above it is a major cooling mechanism for the fields, conduction and convection are therefore also a major factor in warming of the air above and vicinity of the field.

24. The transfer of thermal energy (heat) from the surface of the synthetic turf field to the nearby environment is largely by radiation, which does not rely upon any contact between the heat source and the heated object. The heat is transmitted – let us say to a nearby building - through empty space by thermal radiation, in the same way as light from a brightly lit surface is transmitted to nearby structures. Maximum transfer will occur when the field surface is in close proximity to the surrounding buildings, as with the field built within a few feet of the abutter's property line. The field will serve as a powerful flat plate light source operating at infrared frequencies illuminating the neighboring property.

25. As evidenced by my measurements set forth in the Sciacca Heat Study, it is my informed expert opinion that synthetic turf fields (plastic carpet with crumb rubber/sand infill) – as well as rubberized playground surfaces - are surfaces that contribute to the heat island effect and thus directly and indirectly to the climate crisis by radiating heat and also by their carbon footprint (sum total of carbon emissions attendant upon the production, manufacturing, transportation, installation, maintenance, and disposal of the product and of use-related car trips due to greater use of the field). Air conditioning loads in nearby structures will be increased, leading to increased electric usage with attendant carbon emissions, and conversion of solar energy into carbon-storing plant material (grass) will be reduced.

26. As shown in the Sciacca Heat Study, the natural grass temperatures are significantly lower than the synthetic turf surface in the same location. By contrast to synthetic surfaces, all plants – like natural grass - take in carbon dioxide from the air (carbon sequestration). Photosynthesis produces oxygen and water (moisture). When heated by the sun, grass cools itself through transpiration, which lowers grass temperatures through evaporation, thereby having a cooling effect on the surrounding area as well.

27. While it is not as yet practicable to provide measurements of the cumulative effect of the development of the recreational complex on the micro-climate of the site and the surrounding neighborhood, it is however reasonably certain that the site and the surrounding neighborhood will experience a significant increase in the air temperature and radiative heat load due to the conversion of a mostly natural grass environment into surfaces that are contributory to the heat island effect. It is also reasonably certain that the air conditioning load for the structures/buildings located at or near the site will increase.

28. To measure and better assess the heat island effect of the proposed project's synthetic turf fields it is essential that access be had to the fields at the High School and the fields at the project site (Middle School) at a given day in the timeframe of June 21 and July 31 between the hours 12 Noon and 2:30 PM.

Commonwealth of Massachusetts

Middlesex, ss January 27, 2020

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COMES NOW, Thomas Sciacca, being first duly sworn, under oath, and states that the contents of the foregoing are within his personal knowledge and belief and that they are true and based on facts.

Signature: Thomas Sciacca

Address: 31 Rolling Lane, Wayland, MA 01778

SUBSCRIBED AND SWORN TO before me this 27th day of January 2020, by

Caroline Parrinello

Notary Public

My Commission Expires: 12-12-2025

CAROLINE PARRINELLO
Notary Public
COMMONWEALTH OF MASSACHUSETTS
My Commission Expires
December 12, 2025

EXH 1

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Thomas Sciacca

31 Rolling Lane
Wayland, MA 01778

Areas of Expertise - Thermal Engineering, Analog Instrumentation, Computerized Process Control, Industrial Control Systems, Acoustic Engineering, Management of Technology

Education

- Massachusetts Institute of Technology, Bachelor of Science in Electrical Engineering, 1968

- MIT Sloan School of Management, Certificate in Management of Technology, 1986

Employment

- Intelligen Energy Systems, Inc, Co-Founder, President and CEO, 1990-1998

- Digital Equipment Corporation, Senior Engineering Manager, 1977-1990

- Hybrid Systems, Inc, Principal Engineer 1973-1977

- Intronics, Inc, Principal Engineer, 1972-1973

- Analog Devices, Inc, Principal Engineer, 1968-1972

Volunteer Positions

- Wayland Energy and Climate Committee, member, 2009-present

- Sudbury, Assabet, and Concord Wild and Scenic River Stewardship Council, Wayland Representative, 1999-present

- Wayland Wellhead Protection Committee, member, 2007-2011

- Conservation Commission, Wayland, MA, member and Chairman, 1973-1986

Projects Related to Thermal Engineering

- At Analog Devices, designed semiconductor circuits to precisely compensate for temperature coefficient variations of both bipolar and Field Effect transistors.

- At Intronics, designed military instrumentation components to operate under extreme military temperature conditions.

• At Hybrid Systems, discovered the differential temperature coefficient of expansion phenomenon underlying the unacceptable failure rate of company's major product.

• At DEC, designed computer systems to operate under temperature and humidity conditions ranging from tropical to arctic. Designed computer instrumentation to more precisely control fiber optic manufacturing temperatures than any then in existence, leading to first widespread deployment of fiber optics worldwide. Both personally designed and led groups designing systems to control industrial facilities such as chemical plants, oil refineries, nuclear power plants, and steel mills, all of which involved numerous temperature measurements as the most fundamental function.

• At Intelligen, co-invented, designed, and manufactured a novel and patented home heating system which became the subject of a front-page article in the Wall Street Journal and won the 1993 Product of the Year award from Popular Science magazine. The system cut a home's energy usage approximately in half, addressing the issue of climate change at a time when it was just beginning to become public knowledge.

Artificial Turf Temperature Investigations

• In 2007, I was the first person to document elevated temperatures of Artificial Turf in New England. I used both thermocouple and infrared surface temperature instruments to prove, contrary to earlier claims, AT fields could reach hazardous temperatures, as high as 163° F, in the latitude and climate of Massachusetts. I formulated a model to explain how the unique combination of the infill properties of radiative absorption and conductive insulation leads to the highest outdoor surface temperatures encountered in the environment, far higher than familiar surfaces like asphalt.