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.

AFFIDAVIT OF CAMILO PEREZ ARRAU

I, Camilo Perez Arrau, a resident of Beaconsfield, Quebec, Canada, do hereby depose and say:

A. I am a Geographic Information Systems (GIS) consultant at AustralGIS, a Canadian enterprise, with a business address at 187 Acres Road, Beaconsfield, Québec, H9W 1Y5, Canada. Among the range of services that I provides is land surface temperature (LST) satellite data extraction for urban heat island analysis and urban planning. For more information about what I do, please refer to https://www.australgis.com . A representative sample of my work in the area of heat island – urban heat islands (UHI) - can be found at the website www.UrbanHeatIslands.com . This website contains a page dedicated to various LST readings, including data related to synthetic turf fields.

CPA

B. I have a Master of Science degree in Urban Planning and GIS from the University of Québec, Montreal, Canada. I received my Bachelor of Science degree in Geography from the Universidad Católica, Santiago, Chile. I have a certificate in Geological Risks from the University of Geneva, Switzerland.

C. Heat islands (or hot spots) are locations where, due to the nature of the surface and materials, solar thermal energy is absorbed and then released through radiation into the air, increasing the ambient air temperature in the surrounding area. The most commonly known heat island phenomenon is the urban heat island effect. The heat island effect, however, is not limited to urban areas; they can occur anywhere.

D. In 2007, I prepared a presentation entitled, "Five Synthetic soccer fields and their surface temperature derived from Landsat 5 (27th June 2005 at ~ 10:32 a.m.), which

showed the surface temperature of a number of synthetic turf fields around Montreal, as compared to natural grass fields. The presentation was an important factor in the decision of Montreal City Council to keep Westmount Park synthetic-free. The Westmount Park proceedings, as well as my presentation, are preserved at http://www.synturf.org/westmountbrief.html .

E. As a continuing joint effort by the U.S. Department of the Interior, U.S. Department of Agriculture, and the National Aeronautics and Space Administration (NASA) to develop and launch civilian Earth observation satellites, Landsat 8 was launched in February 2013. The satellite carries the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS). The stated goal of the Landsat missions is to provide the opportunity to collect valuable resource data and use it to improve the quality of the environment.

F. It is my expert opinion that synthetic turf playing fields are a big matter of concern: They appear among the hottest places in the city, on the same scale as parking lots, supermarket structures and big factories.

G. I have been retained by the Plaintiff in the above-captioned action to provide geographical and satellite thermal views of the open spaces (fields) in North Andover, Massachusetts, in the general area of North Andover High School and North Andover Middle School. The purpose of this exercise is to provide an analytical tool by which one can assess the potential heat island impact of the proposed development of the North Andover Middle School fields from predominantly natural grass to surfaces that are associated with heat island effect, such as asphalt, cement, rubber surfaces, metal roofs and synthetic turf fields.

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H. I now explain the information on each of the slides/panels in the attached power-point presentation (cover sheet and 11 slides), dated March 1, 2020, entitled **Surface temperature of synthetic and natural grass fields in North Andover Massachusetts (USA) as seen by the satellite Landsat 8 (August 19th, 2018 at 10:25am).**

I. The Landsat 8 satellite orbits the Earth in a sun-synchronous, near-polar orbit, at an altitude of 705 km (438 mi), inclined at 98.2 degrees, and circles the Earth every 99 minutes. The satellite has a 16-day repeat cycle with an equatorial crossing time: 10:00 a.m. +/- 15 minutes. Landsat 8 aquires about 740 scenes a day on the Worldwide Reference System-2 (WRS-2) path/row system [https://landsat.gsfc.nasa.gov/the-worldwide-reference-system/], with a swath overlap (or sidelap) varying from 7 percent at the Equator to a maximum of approximately 85 percent at extreme latitudes. The scene size is 185 km x 180 km (114 mi x 112 mi).

J. The data products created from over 1.6 million Landsat 8 OLI/TIRS scenes are available to download from EarthExplorer [https://earthexplorer.usgs.gov/], GloVis [https://glovis.usgs.gov/], andLandsatLook Viewer [https://landsatlook.usgs.gov/]. For more about Landsat 8, go to the U.S. Geological Survey website at

https://www.usgs.gov/land-resources/nli/landsat/landsat-8?qt-science_support_page_related_con=0#qt-science_support_page_related_con .

K. Following the cover sheet of the presentation are the following numbered slides:

1. Land Surface Temperature (°F). This slide is a standard color code for the purposes of associating a color with the range of observed temperatures – the hottest being, naturally, red hot. In Science, we do this work by measuring temperatures in Celsius (°C). My terms of reference required that the temperatures be given in Fahrenheit (°F).

The color scheme of the thermal images gives the viewer a visual sensation of the difference between surface temperatures associated with different surfaces of the subject area.

According to https://www.timeanddate.com/weather/@4832272/historic : The weather conditions in North Andover on August 19, 2018 at 10:25 AM, were as follows: Scattered clouds, no precipitation, with the temperature falling between the low of 66° F at 6 AM and the high of 75° F at Noon.

2. Overview of the Town of North Andover, Massachusetts (USA). This slide provides a satellite image of natural landscape of the subject – North Andover – with temperatures readings for select locations.

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3. Thermal image of the Town of North Andover, Massachusetts (USA). This slide shows the thermal information of Slide 2 in a color-coded fashion, with the hot spots shown in various shades of red depending on the temperature range, as compared with cooler surface temperatures in the other areas of North Andover.

4. North Andover High School Fields, 430 Osgood St, North Andover, MA 01845. This slide provides a satellite image of natural landscape the subject – North Andover High School Fields - two adjacent fields, one synthetic the other natural grass.

5. North Andover High School Fields, 430 Osgood St, North Andover, MA 01845. This slide shows Landsat 8's surface temperature recording for the area corresponding to the synthetic turf and natural grass fields at the High School. The observable contemporaneous temperature difference between the two surfaces is shown to be 13.95 hotter on the synthetic field. The synthetic field at 98.37° F at 10:25 AM measured 23.37 degrees hotter than the would-be ambient air temperature of 75° at noontime.

6. North Andover High School Fields, 430 Osgood St, North Andover, MA 01845. This slide translates the thermal information in Slide 5 as recorded by

Landsat 8 - with the hot spots shown in various shades of orange-to-red depending on the temperature range, as compared with cooler surface temperatures in the other areas of North Andover along the cooler side of the color spectrum.

7. North Andover Middle School Fields (A and B) and North Andover Middle School Fields (C) 495 Main St., N. Andover, MA 01845. This slide provides a satellite image of the fields at North Andover High School (fields A and B) and the fields at North Andover Middle School area (C), with areas designated as B and C being natural grass.

8. North Andover Middle School Fields (A and B) and North Andover Middle School Fields. This slide shows Landsat 8's surface temperature recording for the areas designated as fields A, B, C on Slide 7. The surface temperature of the grass fields registered in the 84 to 87 degree range, whereas the reading for the synthetic field at North Andover High School registered at 98.37 degrees.

9. North Andover Middle School Fields and North Andover Middle School Fields. This slide shows the thermal image for slides 7 and 8, with the synthetic field appearing in red hot, in contrast to the surface temperature of adjacent areas – such as grass fields - that fell on the cooler side of the color spectrum.

10. 34 Hemlock Street in North Andover (Middle School fields). This slide isolates Plaintiff's property at 34 Hemlock Street in North Andover, represented by a faint blue dot (the color of this dot does not have a thermal significance). The slide shows the property in relation to the North Andover Middle School fields, bounded by Parker Street, Hemlock Street, and Beacon Hill Blvd. The slide includes the surface temperatures information as recorded by Landsat 8. The surface temperature associated with the area of 34 Hemlock Street is shown to be in the 84 to 84 degree range, with a degree or two cooler than the abutting field showing the temperature of 86.78° F.

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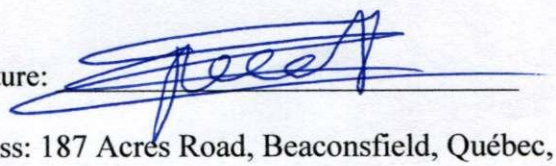
11. 34 Hemlock Street in North Andover (& Middle School fields). This slide provides the thermal image of the area occupied by 34 Hemlock Street and the Middle School fields, with surface temperatures in the range of 84 to 87 degrees at 10: 25 AM of August 19, 2018, in contrast with locations depicted by other shades on the color spectrum.

L. It is my expert opinion that on August 19, 2018 at 10: 25 AM and - if synthetic and in the same condition as the synthetic field at North Andover High School – one playing field in the area designated as C (Middles School fields) would have shown a surface temperature similar to that of the synthetic field at the North Andover High School (98.37° F), more or less. It is more likely than not that other adjacent or nearby installations like more synthetic fields, buildings, parking lots, and cement, asphalt or rubber surfaces in the area designated as C on these slides will increase the cumulative

value of the surface temperature for the larger area and also result in higher ambient air temperatures associated with the locale.

Declaration

I, Camilo Perez Arrau, being first duly sworn, under oath, state that the contents of the foregoing are within my personal knowledge and belief and that they are true and based on facts.

Signature: 

Address: 187 Acres Road, Beaconsfield, Québec, H9W 1Y5, Canada

SUBSCRIBED AND SWORN TO before me this 22 day of APRIL, 2020,

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Notary Public
My Commission Expires:

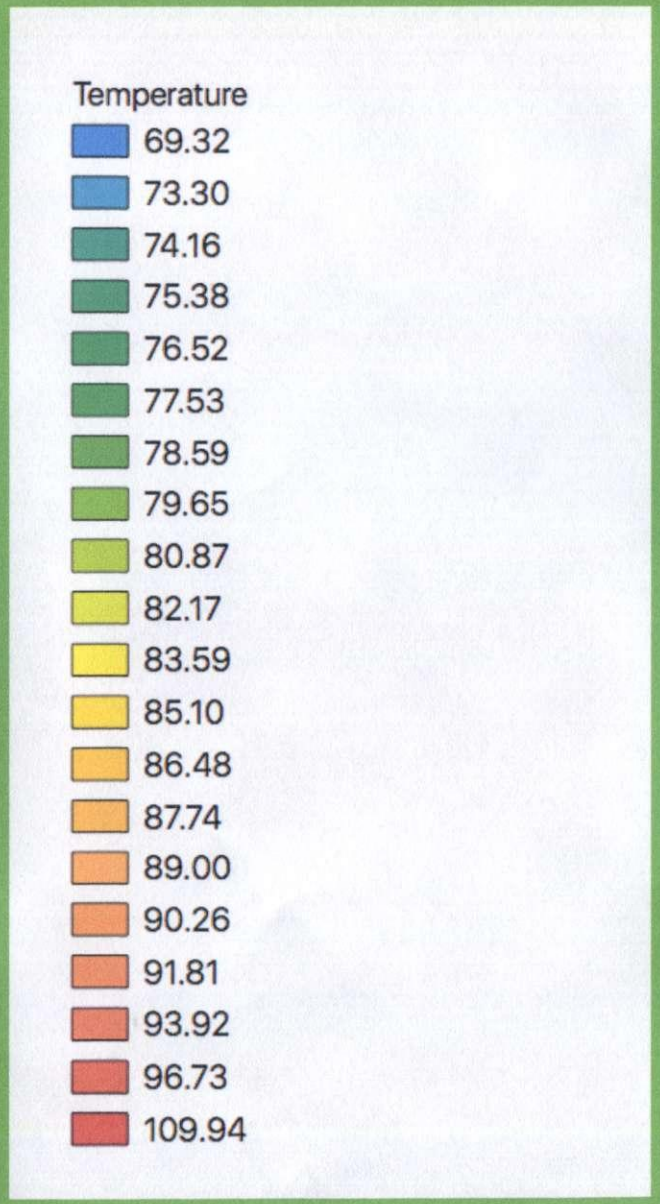
Surface temperature of synthetic and natural grass fields in North Andover Massachusetts (USA) as seen by the satellite Landsat 8 (August 19th, 2018 at 10:25am)

Camilo Perez Arrau

MS degree in Urban Planning and GIS at Université de Québec à Montréal (UQAM) Canada

March 1st, 2020

1.Land Surface Temperature (^{0}F)*



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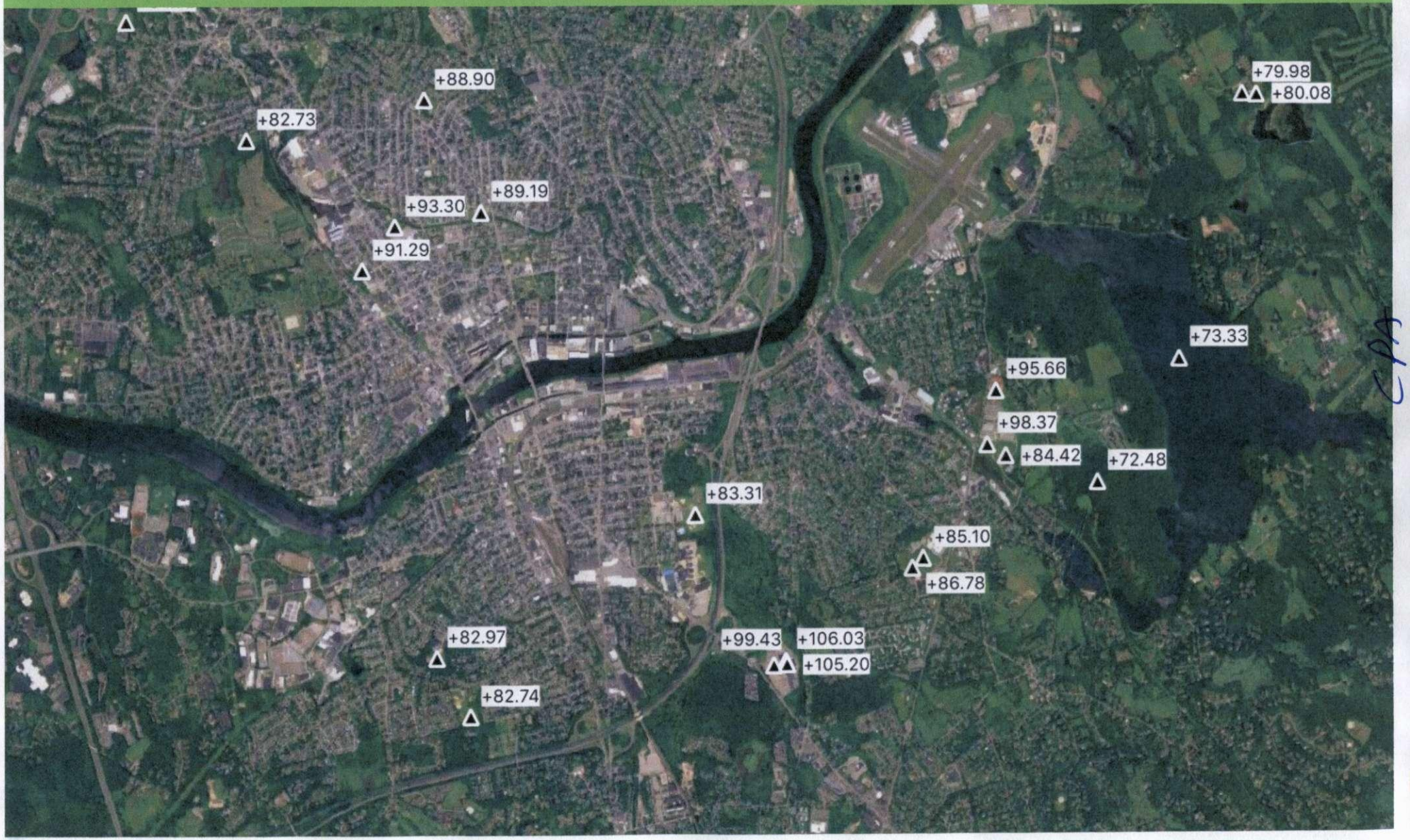
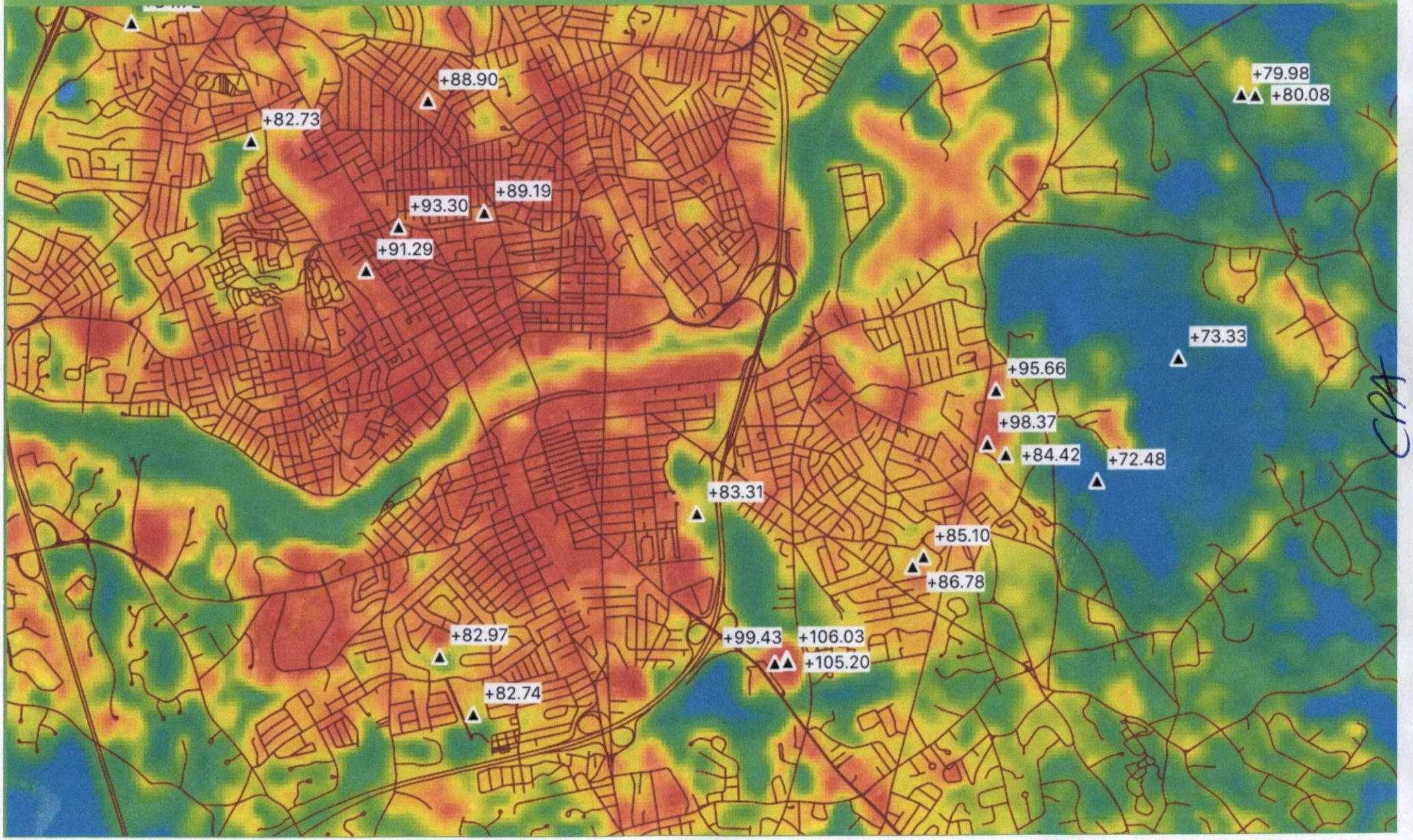
*No atmospheric correction has been applied on these images

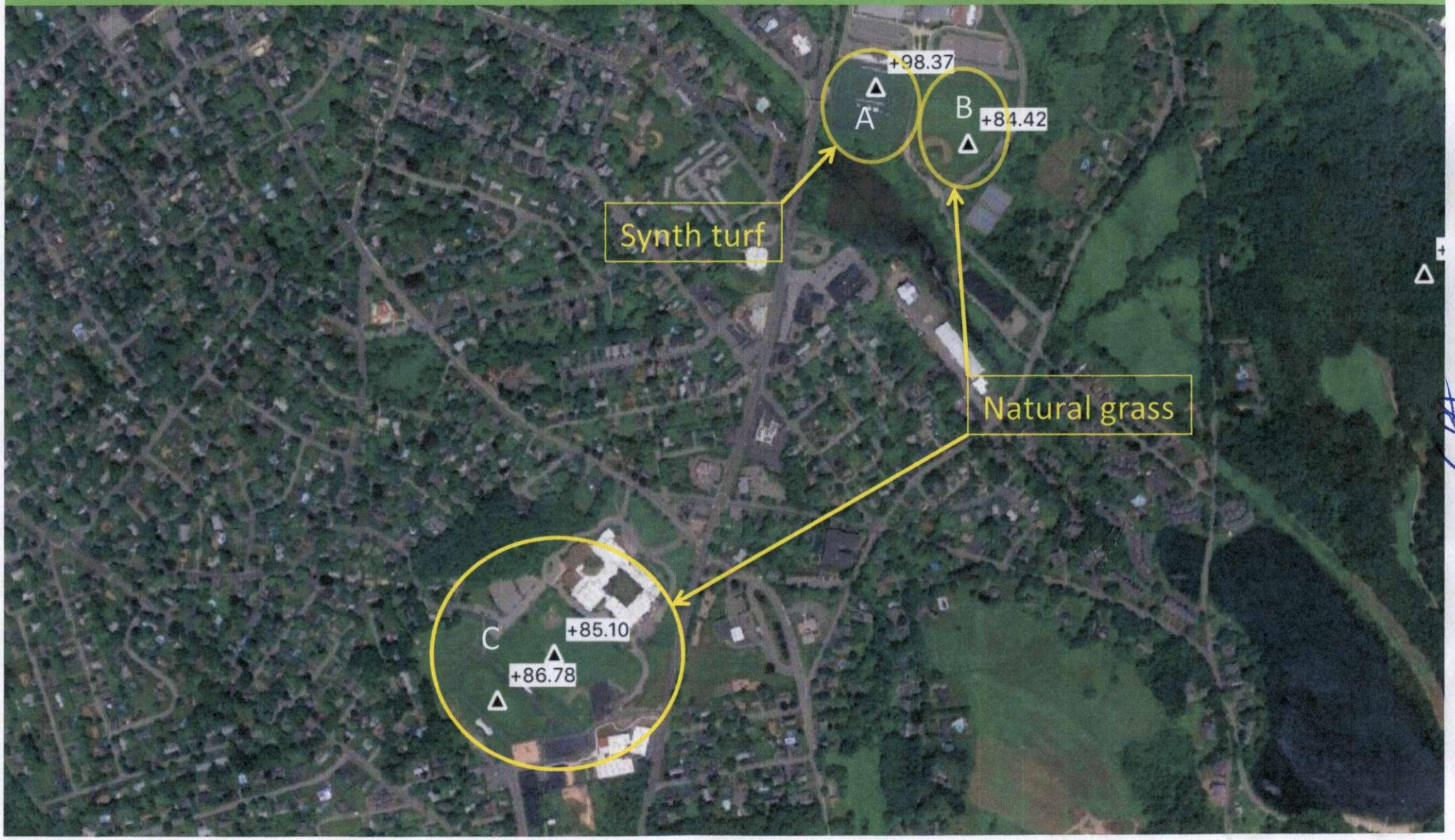
2. Overview of the Town of North Andover, Massachusetts (USA)



3. Thermal image of the Town of North Andover, Massachusetts (USA)



8. North Andover High School Fields and North Andover Middle School Fields



9. North Andover High School Fields and North Andover Middle School Fields