**Comments on Chairperson Susan Chapnick's December 8, 2022 Statement to the Arlington MA Conservation Commission**

Laura C. Green, Ph.D., D.A.B.T.
Edmund A. C. Crouch, Ph.D.

Green Toxicology LLC

January 27, 2023

## Introduction & Summary

We have been asked to provide technical comments on Susan Chapnick's Statement, dated December 8, 2022, to the Arlington MA Conservation Commission, in which she writes, "**It is my opinion that the current weight-of-evidence points to adverse effects on wetland resource areas and resource area values from Artificial Turf Fields and negative climate resilience impacts."** [**bold face** in the original]

Ms. Chapnick is a highly trained, experienced, analytical chemist, and the Chair of the Arlington, MA Conservation Commission.

Testing by various analytical chemists — such as for other proposed synthetic turf field-systems in Massachusetts and elsewhere — using standard, U.S. EPA-approved methods, has revealed that these sports fields would not, and do not, threaten the quality of "wetland resource areas and resource area values," and would not adversely affect "climate resilience."

Synthetic turf is essentially an outdoor shag carpet (typically combined with an infill), engineered to provide a level, homogeneous surface for sports fields, putting greens, playground-areas, and the like. It is not a new product. Synthetic turf (then aka "Astroturf") was first marketed and installed in the mid-1960's. Currently, there are more than 10,000 such fields installed in the United States, more than 50,000 such fields in Europe, and thousands of others in Australia, Japan, and other Asian countries.

In what follows, we provide some technical details that we hope will prove useful to Arlington residents and others interested in this topic.

**Analysis**

Regarding "**Chemical Pollution**," the Statement cites to four references that may support the statement, "Known toxic chemicals including zinc, lead, polyaromatic hydrocarbons (PAHs), phthalates, and volatile organic compounds (VOCs), have been documented [in synthetic turf fields] (1, 2, 5, 6)."

As a general matter, essentially *any* chemical (including essential minerals, such as zinc, most essential vitamins, and essentially everything in what we eat, drink, and inhale) can be toxic *at some level of exposure.* So, pointing out the mere presence of such chemicals in synthetic turf is no more informative, than, for example, noting (correctly) that all topsoils (in Arlington as elsewhere) *also* contain zinc, lead, PAHs, and countless other contaminants, either naturally occurring from breakdown of the rocks whence the soils came, or deposited from outdoor air and other sources. Such topsoils are part of natural grass fields and playgrounds.

Despite the presence, for decades now, of tens of thousands of synthetic turf fields worldwide, we know of no evidence that synthetic fields have harmed environmental receptors, whether in wetlands or otherwise. Can the same be said of grass fields treated, whether naturally or otherwise, with fertilizer?

Citing to a study performed by researchers at the Connecticut DEP (in 2010), the Statement reads,

> *Direct toxicity to aquatic organisms has been documented from Artificial Turf Field surface runoff during rainstorms based on whole effluent toxicity (changes to runoff pH and hardness, as well as pollution from metals, semi/volatiles, and other contaminants), especially Zinc toxicity (3).*

Read that CT DEP (2010) report, however, and you will find that the authors reported that the small, part per billion concentrations of zinc that were detected in stormwater from crumb rubber-infilled synthetic turf fields in Connecticut were entirely within the range of zinc concentrations found in runoff from many other land uses, including residential, mixed residential, and commercial; and, of course, smaller than stormwater runoff from highways.

The Statement also asserts that synthetic turf fields contain "PFAS;" but there are *hundreds* (in theory, countless thousands) of different members of the PFAS-class of chemicals, each with its own physical, chemical, biological, and toxicological properties and environmental significance or lack thereof. In fact, the PFAS *of environmental concern* (such as the six, specific, PFAS regulated in groundwater by the Massachusetts Department of Environmental Protection, MassDEP; aka the PFAS6) are **not** detectable in manufactured turf, even as they **are** typically detectable in "background" topsoils throughout Massachusetts and elsewhere. This is

especially true of PFOS, and, to a somewhat lesser extent, PFOA. See, for example, work performed by researchers at the University of Vermont, available at https://anrweb.vt.gov/PubDocs/DEC/PFOA/Soil-Background/PFAS-Background-Vermont-Shallow-Soils-03-24-19.pdf.

To our knowledge, the only PFAS used, at small (part per million) concentrations, in the manufacturing of extruded polyethylene is the polymer processing aid, PVDF-HFP. This co-polymer, like most such plastic polymers, is not soluble in water, not volatile in air, and environmentally and biologically inert. It is of no concern with regard to environmental receptors, whether plants or animals, including humans.

Regarding "**Heat effects**", the Statement notes that "Temperatures of over 150 degrees F have been routinely recorded on Artificial Turf Fields during June and summer months, compared to natural grass fields with temperatures of < 90 degrees F (5)."

If you read citation #5, you will find no such statement as to "routine" temperature recordings: you will instead find citations to many studies in which various field-surface temperatures were measured; summarized by the authors, "Research indicates that all artificial turf reaches higher temperatures than natural grass,[62] although some infill materials may reach higher temperatures than others." This is quite correct: it is common knowledge that grass fields will stay cooler, under summertime conditions, than plastic surfaces (whether turf or playground equipment), non-grass-based tennis courts, basketball courts, poured in place rubber playground surfaces and running tracks, etc. We know of no data suggesting that elevated temperatures on the surface of synthetic turf fields, tennis courts, basketball courts, etc. result in adverse impacts to wetlands.

The Statement goes on to claim that, "The additional heat energy shed by an artificial turf field on a hot day is estimated at 10 to 20 gigawatts (10)."

Citation #10 is to an analysis by Dr. Les Golden, available at https://doi.org/10.1089/scc.2021.0038. Golden's paper does not conclude what the Statement suggests; and, more generally, the paper is an entirely speculative, misleading, and incomplete analysis.

First, the reference to the "modeled" 10 to 20 Gigawatt increase is for the *total* of an assumed 13,000 synthetic fields in the United States (all assumed to be 10,000 square meters in size), obviously not for a single field. So, the claim in the Statement must be an overestimate by at least a factor of 13,000.

Second, Dr. Golden's published analysis is based on a hypothetical, huge temperature difference (namely, 63 °F) between all assumed artificial turf fields in the U.S. and all assumed natural turf fields in the U.S., at an assumed ambient air temperature of 81°F.

There is zero basis for making any such assumptions either for the country as a whole, or for a proposed synthetic field in Arlington, Massachusetts in particular. Moreover, since the radiative heat loss mechanism "modeled" by Dr. Golden scales as the **fourth power** of absolute temperature, his extreme assumptions leads to an even more extreme conclusion.

Third, the modeling by Dr. Golden takes account only of the heat absorbed in air from infra-red re-radiation from the grass leaf surfaces for both synthetic and natural turf. His modeling fails to account for the other mechanisms that in fact release heat that is absorbed in air from either or both surfaces, including conduction, convection, and, for natural turf only, evapotranspiration.[1,2] Evapotranspiration is likely to be a major component of heat loss for natural turf, allowing the leaf to achieve temperatures lower than the air temperature.[3] For at least these reasons, Dr. Golden's comparison is thus entirely incorrect for evaluating total heat loss to the atmosphere.

Overall, then, the modeling by Dr. Golden is a failed attempt to compare absolute values of total heat loss to the atmosphere from either natural or synthetic turf. It cannot be relied upon to assess the potential effects on the local environment of any proposed, synthetic turf field in Arlington.

The Statement then claims that "Cooling of artificial turf fields for use by spraying water exacerbates chemical, plastic, and particulate pollution." It provides no evidence for such a

---

[1] Natural turf also stores a small fraction of the incident sunlight in energetic materials through photosynthesis (and also re-radiates some energy in a chlorophyll emission band), but the net effect of photosynthesis and respiration is a tiny fraction of the total incident energy that must be dissipated by other heat loss processes.

[2] Dr. Golden also discusses but then ignores the small difference in emissivity between natural and artificial grass, and its variation with wavelength; but when taking the difference between two relatively large numbers, as his calculation requires, such a small difference may be very important; and the change is in the direction opposite to that he calculates. Overall, the required calculations are much more complex than the simple model presented by Dr. Golden; or an alternative approach is needed.

[3] Dr. Golden trained as an astrophysicist. Treating radiation as the main energy transfer mechanism would be quite correct in most astrophysical situations, but it is not correct in most terrestrial situations. Instead, a full accounting using radiation transfer would require evaluation of absorption and reflection of incoming solar radiation combined with the re-radiation at infra-red wavelengths and the back radiation from the atmosphere, taking account of what transpires in both diurnal and annual cycles.

claim, nor do we know of any such evidence. In contrast, rainwater and irrigation of natural grass and soil fields might result in loading of nitrogen and phosphorous to local surface water and/or groundwater.

The Statement goes on claim: "Increased heat effects due to climate change will add 13 to 23 days of > 90 degrees F from the current 8 days per year (Table 26, reference 7)." But nothing presented demonstrates that installation of either synthetic turf or natural turf would have either a negative or positive overall effect on total net absorption of solar radiation compared with the current situation – and that factor, plus differential carbon dioxide emissions from grass-mowing and other activities needed to properly maintain natural grass and soil playing fields versus the maintenance requirements of synthetic fields, combined with the climate effects of production and installation of each system, are what might contribute to climate change.

Finally, regarding "**Plastic pollution**," and **"Particulate pollution,"** the Statement correctly notes that crumb rubber (and other plastic) infills can and do get kicked up by field players, and can migrate from infilled fields under various storm-conditions, depending on the field design, location, and maintenance or lack thereof. Proper design, siting, and maintenance are thus important for synthetic turf field systems, just as they are for grass and soil sports fields.

**Conclusions**

Overall, then, abundant information regarding both natural fields and synthetic turf fields indicates that each has their own advantages and disadvantages. With regard to wetlands protection and climate resiliency, however, neither field-type is either known or reasonably expected to pose significant risks.

**Acknowledgements**

This analysis was conducted by Green Toxicology LLC, and we take full responsibility for any errors or omissions. Our review, analysis, and input were requested and funded by the Town of Arlington (MA) Recreation Department, Arlington Youth Lacrosse, Arlington Youth Soccer, and Arlington Youth Baseball/Softball.