Appendix E.2
Supplemental Analysis of Artificial Turf Fields - Gradient

Memorandum

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Date: December 18, 2022

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Subject: Analysis of Artificial Turf Fields for Proposed Harvard-Westlake River Park Athletic Fields

1 Introduction

The River Park Project involves the redevelopment of the Weddington Golf & Tennis Site as an athletic and recreational facility for shared use by the Harvard Westlake School and the general public (ESA, 2021). The plans for the artificial turf fields include the use of FieldTurf Vertex Core grass mat, along with recycled rubber infill (Gensler Sports, 2022; Millennium Sports, 2022). The purpose of this document is to respond to stakeholder comments and add to the body of literature that evaluates the safety of artificial turf fields as part of the River Park Project.

2 General Background on Health Studies of Artificial Turf and Recycled Rubber Infill

There is often controversy surrounding the use of artificial turf fields, but almost all of that controversy is the result of studies that have only measured chemicals in recycled rubber – they have not evaluated potential exposure to the chemicals in recycled rubber or the risk of that exposure. The mere presence of chemicals is not indicative of potential risk; all consumer products we use daily are made up of chemicals that could be hazardous. The scientific and medical community agree that there is a significant difference between the presence of a chemical and risk from exposure to that chemical. In order to understand potential human health risk, we must understand exposure and dose.

Dozens of regulatory and peer-reviewed studies that have evaluated exposure and risk related to artificial turf and recycled rubber infill in the past decade have all found that there is no evidence that the levels of chemicals in recycled rubber infill present a public health concern. Many federal agencies within the United States are continuing to study these issues, with the United States Environmental Protection Agency (US EPA), the Agency for Toxic Substances and Disease Registry (ATSDR), and the National Toxicology Program (NTP) continuing to fund research on artificial turf and recycled tire crumb rubber infill (US EPA *et al.*, 2019a,b).

Several studies that have comprehensively evaluated the issues surrounding artificial turf fields have been published within the last 3 years, either in the peer-reviewed literature or by government public health agencies. On the federal level, within the United States, the US EPA (in partnership with the Centers for Disease Control and Prevention's [CDC] ATSDR) and the NTP released their findings from a comprehensive study of artificial turf fields in 2019 (US EPA *et al*., 2019a,b). In July 2019, US EPA and ATSDR released an evaluation of potential exposure to recycled tire crumb rubber on synthetic turf playing fields. US EPA (2022a) concluded that "while chemicals are present as expected in the tire crumb rubber, human exposure appears to be limited based on what is released into air or simulated biological fluids." NTP's conclusions from a series of four toxicological studies (Beckley *et al*., 2018; Pott *et al*., 1989; NTP, 2019a,b) were that no evidence of toxicity was found in mice from the ingestion of crumb rubber or exposure through bedding material, that animal studies show that "very low" levels of compounds from crumb rubber were identified in animals following exposure to crumb rubber, and that "[n]o health problems were observed" in these four studies (NTP, 2022a).[1]

More recently, the Japanese National Institute of Health Sciences conducted four studies of synthetic turf infill and published them in the peer-reviewed literature (Kawakami *et al*., 2022; Nishi *et al*., 2022; Kubota *et al*., 2022; Sakai *et al*., 2022). The Japanese National Institute of Health Sciences concluded that "risk related to the exposure to metals from synthetic turf rubber granule infill is considered low" (Kubota *et al*., 2022).

Past studies from other international public health agencies, such as the European Chemicals Agency (ECHA, 2017), the French Agency for Food, Environmental and Occupational Health and Safety (ANSES, 2018), and the Dutch National Institute of Public Health and the Environment (RIVM, 2018), found similar results, *i.e*., negligible risk for children and athletes playing on or near rubber surfaces.

Finally, in 2018, my colleagues and I published our own study in the peer-reviewed journal *Environmental Research* (Peterson *et al*., 2018). Our study found that risks from chemical exposures from recycled crumb rubber infill were below US EPA's health-protective screening levels for those chemicals and similar to health risks for children or athletes playing on natural grass surfaces.

Some stakeholders raised questions about the Draft Environmental Impact Report's (DEIR) reliance on this study. In general, the DEIR relied on the scientific literature and has sought assistance with integrating the information in the literature with the specifics of the proposed River Park Project. The consultants assembling the DEIR leaned on this publication, along with the many peer-reviewed and government agency studies, because of its applicability to the River Park Project. Since the publication of Peterson *et al*. (2018), no other peer-reviewed publication has contested the conclusions of the article. Peer-reviewed publications are preferred over materials produced through social media or common journalism, because the peer review process requires transparency and invites systematic scrutiny from other scientists. Other published materials have no such review mechanism.

The DEIR did not include the Graça *et al*. (2022) study, due to the authors' flawed calculations, which were contradicted elsewhere in the article and altered its conclusions. Graça *et al*. (2022) stated that "some metals present in crumb rubber may be above safe levels," and that "zinc accounted for 66%, on average, of the total metal concentrations in all samples." However, the zinc concentrations in Graça *et al*. (2022) ranged from 2,989 to 5,246 mg/kg, well below US EPA's Regional Screening Level (RSL) for zinc of 23,000 mg/kg, which is designed to be health-protective for even daily residential exposures (US EPA, 2022b). Additionally, based on their flawed cancer risk calculations, Graça *et al*. (2022) erroneously concluded that "[c]rumb rubber accidental ingestion could lead to chronic effects and cancer risks." Later in the same article, the authors contradict that conclusion, stating that "[r]egarding cancer risks from ingestion of crumb

[1] A summary of NTP's research is available at https://ntp.niehs.nih.gov/whatwestudy/topics/syntheticturf/index.html.

rubber, these are within the acceptable values for all receptors" (Graça *et al*., 2022). Based on these flaws, the Graça *et al*. (2022) study does not add to the body of evidence from past and recent studies that found no evidence of a public health concern from exposure to chemicals in recycled crumb rubber infill.

Taken together, the results of the recently published peer-reviewed and government health agency exposure and risk studies reaffirm the results of the dozens of previous studies that found no evidence of a public health concern for athletes playing on artificial turf and recycled crumb rubber infill (Peterson *et al*., 2018; the NTP studies [Beckley *et al*., 2018; Pott *et al*., 1989; NTP, 2019a,b]; US EPA *et al*., 2019a,b; Kawakami *et al*., 2022; Nishi *et al*., 2022; Kubota *et al*., 2022; Sakai *et al*., 2022; Schneider *et al*., 2020a-c).

3 General Background on Per- and Polyfluoroalkyl Substances (PFAS)

Per- and polyfluoroalkyl substances (PFAS) are a broad category of organic molecules containing fluorine and carbon that consists of thousands of distinct chemicals. A subset of these chemicals contains a chain of between 4 and 16 carbons that are fully bonded to fluorine atoms and another chemical group, such as a carboxylate or sulfonate group, that varies with different PFAS. In addition to fluorine, PFAS have functional groups that determine to which class of PFAS they belong (ATSDR, 2021; US EPA, 2020). For example, most of the PFAS related to artificial turf fields that commenters mentioned have either a sulfonate group or a carboxylate group attached to a terminal carbon. These compounds are also known as perfluoroalkyl acids (PFAAs). The structures of some of the more well-researched PFAS are depicted in Figure 1: perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), perfluorobutanoic acid (PFBA), perfluorobutane sulfonate (PFBS), perfluorohexane sulfonate (PFHxS), and perfluorononanoic acid (PFNA).

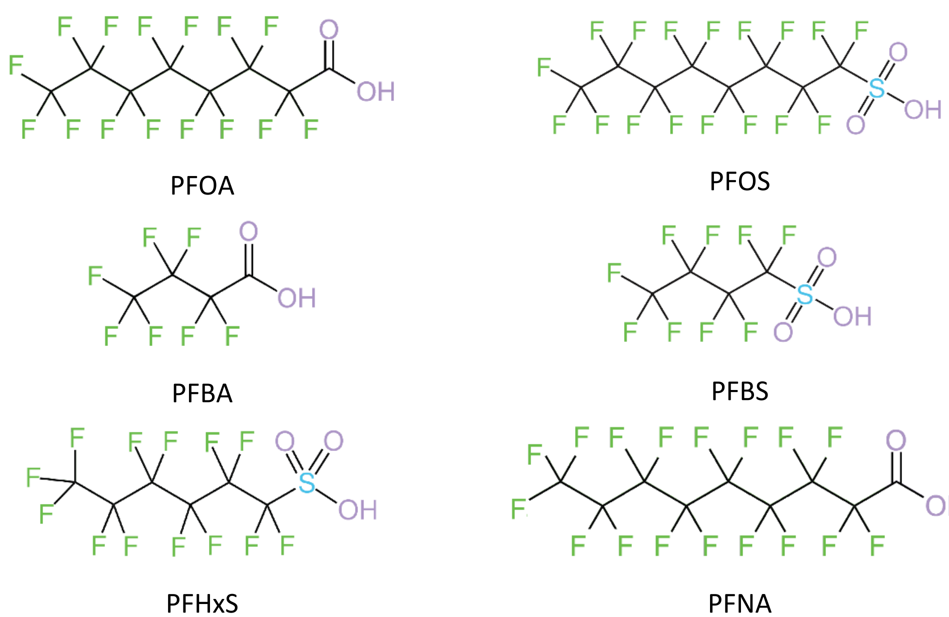

Figure 1 Chemical Structures of PFOA, PFOS, PFBA, PFBS, PFHxS, and PFNA. PFBA = Perfluorobutanoic Acid; PFBS = Perfluorobutane Sulfonate; PFHxS = Perfluorohexane Sulfonate; PFNA = Perfluorononanoic Acid; PFOA = Perfluorooctanoic Acid; PFOS = Perfluorooctane Sulfonate. Adapted from ATSDR (2021).

PFAS are produced by two major methods – telomerization and electrochemical fluorination (ATSDR, 2021; ITRC, 2020). Depending on the manufacturing process, many PFAS can occur as mixtures of linear and branched isomers in different proportions. The electrochemical fluorination process produces mixtures of linear and branched isomers, whereas the telomerization method produces mainly linear isomers. These structural differences may affect the biological properties of a particular PFAS (ATSDR, 2021).

In general, PFAS do not occur naturally and are the result of anthropogenic activities (ATSDR, 2021).[2] Globally, the background concentrations of PFOA and PFOS in remote soils (*i.e.*, those not directly influenced by anthropogenic activities) range up to 0.0034 and 0.0031 mg/kg, respectively (Rankin *et al*., 2016). Samples collected from three background locations (NA12, NA13, NA22) within California ranged from 0.0001 to 0.002 mg/kg for PFOA and from 0.00006 to 0.0007 mg/kg for PFOS (Rankin *et al*., 2016). Historically, some manufacturers used PFOA as a processing aid in the creation of fluoropolymers that have the ability to repel oil, stains, grease, and water, making these chemicals ideal for use in making protective coatings for non-stick cookware and clothing (Lau, 2015). PFOS possesses surfactant properties (*i.e.*, the ability to reduce the surface tension between liquids or between a liquid and solid). Because of these properties, PFOS or related chemicals have been used in numerous applications, such as fire-fighting foams, hydraulic fluids, carpet cleaners, and oil well surfactants.

It is important to consider how differences in the chemical and biological properties of individual PFAS impact receptors' potential exposure to, the toxicity of, and the environmental movement of each compound. Certain PFAS are resistant to degradation by water, sunlight, microbes, and animal metabolism. This resistance is attributable to the strong carbon-fluorine bond present in fully fluorinated PFAS, which makes these molecules very stable and non-reactive (ATSDR, 2021). Chain length does not affect these compounds' persistence in the environment; shorter PFAS are comparable to longer-chain PFAS in terms of their resistance to environmental degradation (Buck, 2015; ATSDR, 2021). Environmental persistence and bioaccumulation can vary significantly between different PFAS. One study detected PFOS in the tissues of fish, birds, and marine mammals in both urban and non-urban areas, with higher concentrations in predatory animals, suggesting that both transportation of PFOS far from its anthropogenic sources and biomagnification of PFOS up the food chain are possible (Giesy and Kannan, 2001). In the same study, all of the detected concentrations of PFHxS were lower than the limit of quantitation (LOQ) for this PFAS, and only a few samples contained PFOA at levels greater than the LOQ for this PFAS. This research indicates that there is variation in environmental movement across different PFAS.

The biological properties of a particular PFAS can depend on both its carbon chain length and the particular functional groups present in the chemical, as well as its isomer type (branched *vs*. linear). Certain PFAS with longer chain lengths (for example, those with eight carbons) have long biological half-lives in the body and can bioaccumulate under certain circumstances (Fujii *et al*., 2015; Lau, 2015; Buck, 2015; ATSDR, 2021). Bioaccumulation potential decreases at chain lengths greater than eight (ATSDR, 2021), likely due to a decreased capacity for absorption. In addition, certain sulfonate PFAS generally have longer half-lives than carboxylic acid PFAS with the same chain length (Lau, 2015; ATSDR, 2021). Variation in chain length and functional groups also produces different health effects in experimental animals (ATSDR, 2021).

4 Exposure Limits for PFAS

Many stakeholders, including the United States government, industry, academic researchers, and others, have been studying PFAS for decades to advance the government's and the broader scientific community's understanding of the toxicological properties of PFAS. For many chemicals, government agencies use

[2] Although it is commonly stated in the scientific literature that PFAS result only from anthropogenic activities, there is evidence that the PFAS trifluoroacetate occurs naturally in the environment (Von Sydow *et al*., 2000; Frank *et al*., 2002; Scott *et al*., 2005).

animal studies (typically rodent bioassays) for the purposes of risk assessment and regulatory decision making.[3] Animal studies are used to make up for the often limited information regarding the toxicity potential of chemicals available from human studies (NRC, 2004). PFOA and PFOS are two of the most well-studied PFAS. The United States Department of Health and Human Services's NTP continues to fund studies to improve knowledge of the toxicological properties of various chemicals and consumer products, including PFAS and artificial turf. NTP's ongoing research on PFAS is aimed at "studying the potential health effects of PFAS through a large research effort with multiple facets…. Taken together, these studies give insights into the potential adverse health outcomes of PFAS in the human body" (NTP, 2022b). While the ongoing NTP studies of PFAS are expected to add to the scientific knowledge base for assessing PFAS in the environment and may be used for refining toxicity values in the future, they do not include measurements of PFAS exposure or toxicity in artificial turf fields.

Using the information that has been developed on PFAS, the US EPA, ATSDR, several state agencies, and other international agencies have developed screening or guidance levels concerning acceptable human exposures to specific PFAS. In general, agencies may set limits for acceptable total daily or weekly intake of PFAS or acceptable concentrations of PFAS in soil, drinking water, other environmental media, and food. On the federal level, US EPA (and, more recently, ATSDR) have examined the animal studies available in the literature and have provided screening levels to help evaluate potential human exposures to various PFAS.

Screening levels are designed for public health purposes, *i.e.*, setting permissible regulatory limits. In setting these limits, public health agencies such as US EPA and ATSDR aim not to precisely define which effects are expected to occur at certain exposure levels, but to define the level at which health effects are unlikely to occur (US EPA, 1993; ATSDR, 2018). Comparisons of exposure levels and regulatory health-based screening levels (such as US EPA RSLs) are only useful as an exclusionary tool, meaning that if an exposure level is below a screening level, it can be confidently concluded that there is no reliable basis for concluding that health effects may occur as a result of exposure to that amount of a chemical. The converse is not true: if an exposure level exceeds a screening level, it means only that further analysis of that exposure is needed, not that adverse effects of any type can be expected to follow exposure to that amount of a chemical. US EPA has developed water and soil RSLs for the five PFAS (Table 1) for which the animal studies provide enough toxicological data to do so. US EPA's RSLs for soil are the appropriate values to evaluate potential exposures on athletic fields. The soil RSLs are intended to be health-protective for everyone, including sensitive populations such as children. In addition, these values are designed to be health-protective for residential exposures, meaning that US EPA calculated the soil RSLs using the assumption that a person is exposed to a chemical through ingestion, dermal (skin) contact, or inhalation (for volatile compounds) for 350 days per year for 26 years (6 years as a child and 20 years as an adult) (US EPA, 2022c). Thus, comparing PFAS concentrations in artificial turf to US EPA's soil RSLs for those PFAS would be very conservative, because children and adults are exposed to artificial turf for a much shorter amount of time than, and less frequently than, they would be exposed to sources of these chemicals in a residential setting.

[3] Such decisions might include, for example, setting permissible limits of chemicals in food or in environmental media, such as air.

Table 1 United States Environmental Protection Agency (US EPA) Regional Screening Levels (RSLs) for Per- and Polyfluoroalkyl Substances (PFAS)

Analyte	US EPA RSL for Residential Soil (mg/kg)
Perfluorooctanoic acid (PFOA)	0.19
Perfluorooctane sulfonate (PFOS)	0.13
Perfluorobutane sulfonate (PFBS)	19
Perfluorohexane sulfonate (PFHxS)	1.3
Perfluorononanoic acid (PFNA)	0.19

Source: US EPA (2022b).

5 Laboratory Testing of PFAS in FieldTurf Products

Several studies have been conducted to quantify the PFAS compounds present, if any, in the specific brand of turf planned for use in the River Park Project (TRC Companies, Inc., 2022; Teter, 2019; Eurofins Sacramento, 2022). The laboratory methods used to analyze artificial turf and recycled crumb rubber infill samples for PFAS are more harsh than typical conditions that artificial turf would be subject to in the outdoor environment.

Results from analytical sampling conducted on behalf of the City of Portsmouth, New Hampshire, indicated no detectable concentrations of PFAS in a sample of FieldTurf grass carpet analyzed using the standard method for analyzing PFAS (TRC Companies, Inc., 2022). The 2022 study conducted on behalf of the City of Portsmouth analyzed the FieldTurf grass carpet using two methods: (1) a modified US EPA Method 537, which is a standard method for analyzing PFAS, and (2) a total oxidizable precursor (TOP) assay, which is an additional step added to Method 537 that allows for testing for a broader range of complex PFAS that may not be measured by the original Method 537. These more complex PFAS can be broken down in the environment over time, due to microbial activity or other processes, into more commonly measured PFAS, like PFOA and PFOS. The TOP assay is meant to simulate this natural breakdown process on a shorter timescale, using a harsh oxidizer to convert more complex PFAS into simpler products like PFOS and PFOA. These simpler products are then measured in a way similar to Method 537. For the analysis, US EPA's Method 537 is modified by adapting the original method, which was meant for drinking water samples, to work with solid samples, such as samples of artificial turf carpet or recycled rubber infill. The grass carpet sample analyzed using modified US EPA Method 537 indicated no detectable concentrations of PFAS, while the same grass carpet sample analyzed using the additional TOP assay indicated "very low level, trace concentrations… of a limited number of PFAS" (TRC Companies, Inc., 2022). Because the extraction methods (both with and without the TOP assay) use a potassium hydroxide (KOH) and methanol mixture in an ultrasonic bath, the method used to extract PFAS in the laboratory is harsher than conditions that artificial turf would be subject to in the outdoor environment. Additionally, it is currently unclear if the homogenization step involved breaking the grass carpet samples into smaller pieces, which would expose a greater surface area of the artificial turf than would be exposed on a turf field. The TOP assay in particular is described by Eurofins as eliciting "worst-case scenario" concentrations of PFAAs (TRC Companies, Inc., 2022), because it also includes all pre-cursors to PFAAs, using a very strong oxidant. Notably, even though the TOP assay is likely to greatly overestimate PFAA concentrations in artificial turf or recycled rubber infill to which individuals could be exposed under environmental conditions, the concentration of PFOS (0.000135 mg/kg) detected by this method was orders of magnitude lower than health-protective screening levels (TRC Companies, Inc., 2022).

Similarly, no detectable concentrations of PFAS were found in analytical testing to evaluate PFAS concentrations in 1-square-foot samples from six types of FieldTurf grass carpet (Teter, 2019). Similar to the analysis conducted on behalf of the City of Portsmouth, the laboratory analyzing these six types of artificial turf used the modified US EPA Method 537, which is a standard method for analyzing PFAS.

Most recently, analytical testing was conducted on the artificial turf grass carpet and the recycled rubber infill that is planned to be used for the River Park Project (Teter, 2022; Eurofins Sacramento, 2022). Similar to previous analyses examining concentrations of PFAS in artificial turf products, the analytical report shows that no detectable concentrations of PFAS were found in analytical testing using the modified US EPA Method 537. The additional TOP assay post-treatment indicated trace concentrations of two PFAAs – PFBA and perfluoro-2-methoxypropianic acid (MTP) (Teter, 2022). While US EPA has not calculated exposure limits for either of these PFAAs, comparing these concentrations to the lowest PFAS exposure limit from Table 2 (0.13 mg/kg, for PFOS) indicates that the trace concentrations of PFAAs were well below existing PFAS exposure limits. Based on these analyses of PFAS in the artificial turf products planned to be used for the River Park Project, there are no or only very small detectable concentrations of PFAS in artificial turf, all of which were at least an order of magnitude lower than health-protective screening levels (see Table 2).

6 Comparison of Natural Soils and Artificial Turf

The chemicals that are often considered to be of concern in recycled rubber infill (*i.e.*, metals, PFAS, and PAHs) are also found in natural soils, and in some cases, these compounds are actually present at higher levels in soil than in artificial turf or recycled crumb rubber infill. For instance, nearly everyone is exposed to small amounts of metals every day, because many of them occur naturally in the Earth's crust. As a result, small amounts of metals are found in soil, air (dust), and water. Unlike metals that occur naturally in the Earth's crust, PFAS do not occur naturally and are the result of anthropogenic (human) activities (ATSDR, 2021). The general population is exposed to PFAS through food and water, but also through PFOA and PFOS present in soil, especially near commercial or industrial sites that may have used PFAS in the past. Because of human activities, PFAS have been detected across the globe, often at locations with no clear local source (Strynar *et al*., 2012; Rankin *et al*., 2016; ITRC PFAS Team, 2022). Background levels of PFAS in soils that are not near known PFAS sources are detailed in Table 2, below.

Of the substances that may be detected at higher concentrations in crumb rubber than in natural soil, cobalt and zinc have been studied in several exposure and risk assessments published in the peer-reviewed literature or by government public health agencies (ECHA, 2017; RIVM, 2017; ANSES, 2018; Peterson *et al*., 2018; Schneider *et al*., 2020c; Kubota *et al*., 2022). While cobalt is present in both natural soil and crumb rubber at levels similar to or above US EPA's RSL for cobalt (23 mg/kg; US EPA, 2022b), these levels have been evaluated using appropriate human health risk assessment methods in several studies of recycled crumb rubber infill, which have not indicated any likelihood for health effects or health risk for athletes using artificial turf fields (Schneider *et al*., 2020c; Peterson *et al*., 2018; ANSES, 2018; RIVM, 2017). Zinc is present in both natural soil and crumb rubber at concentrations that are well below US EPA's RSL for zinc (23,000 mg/kg; US EPA, 2022b). For additional discussion of the conservative assumptions used in US EPA's RSLs, see Section 4, above.

Additionally, cobalt and zinc, along with other metals present in recycled rubber infill or natural soils, were evaluated by US EPA *et al*. (2019a) to determine if these metals could be an exposure concern through ingestion (*i.e.*, gastric fluid or saliva) or dermal contact (*i.e.*, sweat) for athletes on artificial turf fields. US EPA *et al*. (2019a) determined that "only small fractions of metals were released" into saliva, stomach fluid, or sweat; that is, less than 1.2% of cobalt and less than 2.5% of zinc were available for absorption into the human body. This is much less than the typical assumption of 100% bioaccessibility that is assumed in most human health risk assessments. The reported low bioaccessibility of metals in recycled rubber infill indicates that exposure to compounds in recycled rubber infill is limited, and means that human health risk assessments that assume 100% of metals in recycled rubber infill are available for absorption will overestimate the exposures to metals.

Table 2 Comparison of Health-Protective Screening Levels to Concentrations of Metals, Polycyclic Aromatic Hydrocarbons (PAHs), and Per- and Polyfluoroalkyl Substances (PFAS) in Natural Soil and Crumb Rubber

Analyte	US EPA RSL for Residential Soil[1] (mg/kg)	Natural Soil Concentration (mg/kg)	Crumb Rubber Concentration (mg/kg)
Antimony[2]	31	1.5	2.5
Arsenic[2]	0.68	13.1 (Nationwide) 2.4 (Los Angeles County)	0.72
Cobalt[2]	23	21.2	114
Copper[2]	3,100	43.3	ND
Iron[2]	0	45,600	ND
Thallium[2]	0.78	0.8	0.66
Zinc[2]	23,000	125	12,782
Benzo(a)anthracene[3]	1.1	1.60	0.83
Benzo(a)pyrene[3]	0.11	1.77	1.7
Benzo(b)fluoranthene[3]	1.1	1.97	1.2
Benzo(k)fluoranthene[3]	11	1.37	1.2
Dibenz(a,h)anthracene[3]	0.11	0.39	0.70
Indeno(1,2,3-cd)pyrene[3]	1.1	1.12	0.56
Perfluorooctanoic acid (PFOA)[4]	0.19	ND-0.0034 (Global) 0.0009-0018 (California)	ND (Method 537) ND (TOP Assay)
Perfluorooctane sulfonate (PFOS)[4]	0.13	ND-0.0031 (Global) 0.00006-0.0007 (California)	ND (Method 537) 0.000135 (TOP Assay)
Perfluorobutane sulfonate (PFBS)[4]	19	Not available	ND (Method 537) ND (TOP Assay)
Perfluorohexane sulfonate (PFHxS)[4]	1.3	ND-0.00004 (North America) 0.000003-0.000006 (California)	ND (Method 537) ND (TOP Assay)
Perfluorononanoic acid (PFNA)[4]	0.19	0.00002-0.001 (North America) 0.00005-0.0004 (California)	ND (Method 537) 0.0002 (TOP Assay)

Notes:

ND = Not Detected; RSL = Regional Screening Level; UCL = Upper Confidence Limit; US EPA = United States Environmental Protection Agency.

(1) Source: US EPA (2022b).

(2) Soil metal concentrations were obtained from the United States Geological Survey (USGS, 2013), the California Department of Toxic Substances Control (CalDTSC, 2020). Crumb rubber metal concentrations are 95% UCLs reported in Peterson *et al*. (2018).

(3) Background PAH data were obtained by averaging the 95% UCL values from a variety of studies (BEM Systems, Inc., 1998; MADEP, 2002; Mauro *et al*., 2004; IEPA, 2013; Rabideau *et al*., 2007; ENVIRON Corp. *et al*., 2002). Crumb rubber PAH concentrations are 95% UCLs reported in Peterson *et al*. (2018).

(4) Background PFAS data are from ITRC PFAS Team (2022), Rankin *et al*. (2016, Table 17-2). Crumb rubber PFAS concentrations from Eurofins Sacramento (2022), Teter (2019), and TRC Companies, Inc. (2022).

Conclusions

Dozens of government public health agency and peer-reviewed studies that have evaluated exposure and risk related to artificial turf and recycled crumb rubber infill in the past decade have all found that there is no evidence that the levels of chemicals in these products present a public health concern. Although many of the studies did not specifically evaluate exposure and risk from PFAS compounds, several studies that evaluated the potential for humans to be exposed to the compounds present in artificial turf or recycled crumb rubber infill have determined that "while chemicals are present as expected in the tire crumb rubber, human exposure appears to be limited based on what is released into air or simulated biological fluids" (US EPA, 2022a). In addition to the studies indicating that users' exposure to any compounds in artificial turf or recycled crumb rubber will be limited, recent laboratory studies of the products proposed for use in the River Park Project have indicated that there are no or only very small detectable concentrations of PFAS in artificial turf (see Table 2). Based on the current body of evidence, PFAS and other compounds in artificial turf or recycled rubber infill do not present a public health concern.

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