Chemicals in Artificial turf SBR infill

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Prepared for the ETRA Committee on SBR :

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The presence of harmful chemicals in artificial turf, especially in SBR infill is one of the main arguments against the construction of sports fields with artificial turf.

Indisputably, rubber used to manufacture tires, just like the vast majority of plastic products around us, includes numerous chemical compounds. They come from the raw materials, acting in their undesirable impurity (eg. heavy metals or PAH) or are added to the rubber to ensure the required properties.

The mere fact of their occurrence in the rubber does not constitute a direct threat. It is important if the hazardous chemicals may be released from rubber under operating conditions and how they can affect our body.

Rubber with tire tread wears off during the use of tires, creating a noticeable dust floating in significant quantities in the air every major city. This way our bodies get the chemicals present in the rubber. We accept this state of affairs as a matter of course.

In the case of using the same rubber for artificial turf,it is important to note that the turf contains much larger particles and is not subject to such intense abrasion during use as tyres on the road. Nonetheless, people have voiced serious doubts. During exploitation the artificial turf generates far less of the small particles that can get into the body's respiratory system. Another way of contact with the SBR infill can be a skin or ingestion.

Adverse effects of chemicals contained in rubber, on the human body and the environment, depends on the possibility of its release from the pellet under the conditions of use. Artificial turf is certainly not in contact with organic solvents which elute harmful organic chemical compounds, e.g. PAH, or with acids that can rinse other harmful substances. In the study of exposure it is also important to determine a viable path of exposure and testing relevant to the actual conditions of use. Therefore, in recent years, more attention has been paid not to specify the content of harmful substances in the rubber infill, but the content of these substances in the resulting operating conditions in an aqueous filtrate, in the liquid simulating human sweat and saliva, in the air over the artificial turf sports fields.

Since 1 January 2010, European law has called for only the new PAH-low extender oils to be used in vehicle tires. As a result of the requirement in entry 50, paragraphs 1 & 2 of Annex XVII of Regulation 1907/2006 / EC of the PAH content of vehicle tires has been demonstrably reduced.

For this reason, the table below includes the results of studies by European and American researchers published after 2010. This is to account for the changes in the composition of the rubber used in tyres as well as the changes of the potential assessment threat posed by SBR infill to the human body and the environment

Based on the results of the research, we should consider producing infill material for artificial turf pitches exclusively from tires manufactured in Europe since 2010, when the PAH in the rubber was radically reduced. Tires producedoutside of Europe, or those that do not comply with current requirements, or those previously produced in Europe in this regard, are much worse.

Producers of SBR infill are required to provide reports of testing the rubber granulate in order to show the content of potentially hazardous substances .

The results of the twelve studies included herein for review cover a broad range of issues raised concerning SBR infill. A review of the results indicate that while there are numerous potentially hazardous chemicals found in the SBR infill, they are in minimal trace quantities that do not pose athreat either to the environment or to human health.

Analysis of the results of 12 recent studies on artificial turf : 2010 - 2016

	SOURCE	SUBJECT	OPINION
1.	May 26, 2015 Evaluation of Human Health Risks for Synthetic Field Turf for George Kosovich Assistant Superintendent, Programs & Community Investments Verdant Health Commission Public Hospital District No. 2, Snohomish County 4710 196th St. S.W. Lynnwood, WA 98036 Re: Evaluation of Human Health Risks for Synthetic Field Turf by Michael K. Peterson, MEM, DABT Senior Toxicologist Thomas A. Lewandowski, Ph.D., DABT, ERT, ATS Principal Scientist/Member www. gradientcorp.com	risk of health effects from chemical exposure contains “Introduction to Toxicology”	***Based on the data publically available for this analysis, the chemical levels found in FieldTurf SBR andGeoTurf infill do not present a risk to people playing on or using the fields with these products***. Theseconclusions are consistent with those of multiple regulatory agencies that have evaluated the risk from artificial turf products in general (e.g., CalOEHHA, 2007; New York City Department of Health andMental Hygiene, 2009; US EPA, 2009; Connecticut Dept. of Public Health, 2010; CalOEHHA, 2010),including evaluations that are more complex than this screening level asessment. Although there arelimitations with a screening level risk assessment such as this one, the consistent conclusion that the datado not indicate an increased risk of health effects from chemical exposure lends additional support to ourconclusion.
2.	CHARACTERIZATION OF RUBBER RECYCLED FROM ELTs AND ASSESSMENT OF THE RISKS ASSOCIATED WITH DERMAL AND INHALATION EXPOSURE Daniele Fornai Version 03- 2016 This document summarizes the results of a project begun in 2014 by Ecopneus Scpa to ensure the healthiness of rubber recycled from end-of-life tyres.	PAH, Comparison of rubber crumb produced from EU tires before and after 2010-01-01 and from non-European countries	The progressive elimination of tyres produced with aromatic oils (i.e. until 2010) will lead to the further reduction of PAH content in rubber in the upcoming years; nevertheless, the presence of these substances in trace amounts in carbon black precludes its complete disappearance. The bioavailability of these substances contained in the rubber is in any case extremely limited, as confirmed by the migration coefficients measured in artificial sweat and pulmonary surfactant on 25 rubber samples. A monitoring plan performed during the installation of four artificial turf fields and during a football match played on one of these has allowed the quantification of the dermal and inhalation exposure to PAHs deriving from the use of rubber recycled from ELTs as a performance infill. ***The analysis of the data obtained from this monitoring has allowed the calculation of an incremental carcinogenic risk less than the de minimis value of 1x 10-6 for both the workers and athletes exposed frequently to the rubber***. This value is in line with what has already been calculated by other authors and confirms the

			absence of risks deriving from exposure to rubber recycled from tyres.
3.	Environmental and Health Impacts of Artificial Turf: A Review Cheng H., Hu Y., Reinhard M. (2014). EnvironSciTechnol. 48(4):2114-29.	Environmental and health impacts	With significant water savings and low maintenance requirements, artificial turf is increasingly promoted as a replacement for natural grass on athletic fields and lawns. However, there remains the question of whether it is an environmentally friendly alternative to natural grass. The major concerns stem from the infill material that is typically derived from scrap tires. Tire rubber crumb contains a range of organic contaminants and heavy metals that can volatilize into the air and/or leach into the percolating rainwater, thereby posing a potential risk to the environment and human health. A limited number of studies have shown that the concentrations of volatile and semivolatile organic compounds in the air above artificial turf fields were typically not higher than the local background, while the concentrations of heavy metals and organic contaminants in the field drainages were generally below the respective regulatory limits. ***Health risk assessment studies suggested that users of artificial turf fields, even professional athletes, were not exposed to elevated risks. Preliminary life cycle assessment suggested that the environmental impacts of artificial turf fields were lower than equivalent grass fields.*** Areas that need further research to better understand and mitigate the potential negative environmental impacts of artificial turf are identified.
4.	Environmental Sanitary Risk Analysis Procedure Applied to Artificial Turf Sports Fields Ruffino et al. (2013). Environ SciPollut Res Int.	environmental-sanitary risk	In this paper, the authors performed a Tier 2 environmental-sanitary risk analysis on five artificial turf sports fields located in the city of Turin (Italy) with the aid of RISC4 software. Two receptors (adult player and child player) and three routes of exposure (direct contact with crumb rubber, contact with rainwater soaking the rubber mat, inhalation of dusts and gases from the artificial turf fields) were considered in the conceptual model. For all the fields and for all the routes, the cumulative carcinogenic risk proved to be lower than 10(-6) and the cumulative non-carcinogenic risk lower than 1. The outdoor inhalation of dusts and gases was the main route of exposure for both carcinogenic and non-carcinogenic substances. The results given by the inhalation pathway were compared with those of a risk assessment carried out on citizens breathing gases and dusts from traffic emissions every day in Turin. ***For both classes of substances and for both receptors, the inhalation of atmospheric dusts and gases from vehicular traffic gave risk values of one order of magnitude higher than those due to playing soccer on an artificial field.***
5.	Leaching of DOC, DN and Inorganic Constituents from Scrap Tires Selbes M., Yilmaz O., Khan A.A., Karanfil T. (2015). Chemosphere. 139:617-23.	potential harmful impacts in environment.	One concern for recycle and reuse of scrap tires is the leaching of tire constituents (organic and inorganic) with time, and their subsequent potential harmful impacts in environment. The main objective of this study was to examine the leaching of dissolved organic carbon (DOC), dissolved nitrogen (DN), and selected inorganic constituents from scrap tires. Different sizes of tire chips and crumb rubber were exposed to leaching solutions with pH's ranging from 3.0 to 10.0 for 28days. The leaching of DOC and DN were found to be higher for smaller size tire chips; however, the leaching of inorganic constituents was independent of the size. In general, basic pH conditions increased the leaching of DOC and DN, whereas acidic pH conditions led to elevated concentrations of metals. ***Leaching was minimal around the neutral pH values for all the monitored parameters***. Analysis of the leaching rates showed that components associated with the rubbery portion of the tires (DOC, DN, zinc, calcium, magnesium, etc.) exhibited an initial rapid followed by a slow release. On the other hand, a constant rate of leaching was observed for iron and manganese, which are attributed to the metal wires present inside the tires. Although the total amounts that leached varied, the observed leaching rates were similar for all tire chip sizes and leaching solutions. Operation

			under neutral pH conditions, use of larger size tire chips, prewashing of tires, and removal of metal wires prior to application will reduce the impact of tire recycle and reuse.
6.	Artificial Turf Football Fields: Environmental and Mutagenicity Assessment Schilirò T., Traversi D., Degan R., Pignata C., Alessandria L., Scozia D., Bono R., Gilli G. (2013). ArchEnvironContamToxicol. 64(1):1-11.	comparison between artificial turf football fields and urban areas relative to concentrations of particles (PM10 and PM2.5) and related polycyclic aromatic hydrocarbons (PAHs), aromatic hydrocarbons (BTXs), and mutagenicity of organic extracts from PM10 and PM2.5.	The public has recently raised concerns regarding potential human health and environmental risks associated with tire crumb constituents in the artificial turf of football fields. The aim of the present study was to develop an environmental analysis drawing a comparison between artificial turf football fields and urban areas relative to concentrations of particles (PM10 and PM2.5) and related polycyclic aromatic hydrocarbons (PAHs), aromatic hydrocarbons (BTXs), and mutagenicity of organic extracts from PM10 and PM2.5. ***No significant differences were found between PM10 concentrations at an urban site and on a turf football field, both during warm and in cold seasons, either with or without on-field activity. PM2.5 concentrations were significantly greater at the urban site in the cold season as was the ratio of PM2.5 to PM10.*** BTXs were significantly greater at urban sites than on turf football fields on both on warm and cold days. The ratio of toluene to benzene (T/B ratio) was always comparable with that of normal urban conditions. The concentration of PAHs on the monitored football fields was comparable with urban levels during the two different sampling periods, and the contribution of PAHs released from the granular material was negligible. PM10 organic extract mutagenicity for artificial turf football fields was greater, whereas PM2.5 organic extract mutagenicity was lower, compared with the urban site studied. However, both organic extract mutagenicity values were comparable with the organic extract mutagenicity reported in the literature for urban sites. ***On the basis of environmental monitoring, artificial turf football fields present no more exposure risks than the rest of the city.***
7.	Review of the Human Health & Ecological Safety of Exposure to Recycled Tire Rubber Found at Playgrounds and Synthetic Turf Fields CardnoChem Risk. (2013). Prepared for: Rubber Manufacturers Association, Washington, DC.	risks to trace metals, semi-volatile organic compounds (SVOCs), and polycyclic aromatic hydrocarbons (PAHs)	The goal of this study was to evaluate potential exposures from playing on artificial turf fields and associated risks to trace metals, semi-volatile organic compounds (SVOCs), and polycyclic aromatic hydrocarbons (PAHs) by examining typical artificial turf fibers (n = 8), different types of infill (n = 8), and samples from actual fields (n = 7). Three artificial biofluids were prepared, which included: lung, sweat, and digestive fluids. Artificial biofluids were hypothesized to yield a more representative estimation of dose than the levels obtained from total extraction methods. PAHs were routinely below the limit of detection across all three biofluids, precluding completion of a meaningful risk assessment. No SVOCs were identified at quantifiable levels in any extracts based on a match of their mass spectrum to compounds that are regulated in soil. The metals were measurable but at concentrations for which human health risk was estimated to be low. ***The study demonstrated that for the products and fields we tested, exposure to infill and artificial turf was generally considered de minimus, with the possible exception of lead for some fields and materials***.
8.	Dutch study says synthetic turfs "safe" European Rubber Journal report December 21, 2016	Human health	Synthetic turf fields with crumb rubber as an infill are safe for the public and for sport according to the new research by the Dutch National Institute for Public Health and the Environment (RIVM). According to the studys result published on the 20thof December, substances such as polycyclic aromatic hydrocarbons (PAHs), plasticisers, metals, (phthalates) and bisphenol A (BPA) released from rubberpose no harm as they are invery low quantities". "This is because the substances are more or less ' enclosed' in the granulate, which means that the effect of these substances on human health is virtually negligible,"the study added.Reportedly, the study covers all fields with SBR rubber granulates inThe Netherlands, as there is little variation in the concentrations of substances between fields and between the measurement points per field. The study found there is no link between playing sports on synthetic turfs and leukaemia or lymph node cancer.

9.	Human Health Risk Assessment of Synthetic Turf Fields Based Upon Investigation of Five Fields in Connecticut Ginsberg et al. (2011). J Toxicol Environ Health A. 74(17):1150-74.	Human Health Risk Assessment of Synthetic Turf Fields	Questions have been raised regarding possible exposures when playing sports on synthetic turf fields cushioned with crumb rubber. Rubber is a complex mixture with some components possessing toxic and carcinogenic properties. Exposure is possible via inhalation, given that chemicals emitted from rubber might end up in the breathing zone of players and these players have high ventilation rates. Previous studies provide useful data but are limited with respect to the variety of fields and scenarios evaluated. The State of Connecticut investigated emissions associated with four outdoor and one indoor synthetic turf field under summer conditions. On-field and background locations were sampled using a variety of stationary and personal samplers. More than 20 chemicals of potential concern (COPC) were found to be above background and possibly field-related on both indoor and outdoor fields. These COPC were entered into separate risk assessments (1) for outdoor and indoor fields and (2) for children and adults. Exposure concentrations were prorated for time spent away from the fields and inhalation rates were adjusted for play activity and for children's greater ventilation than adults. Cancer and noncancer risk levels were at or below de minimis levels of concern. The scenario with the highest exposure was children playing on the indoor field. The acute hazard index (HI) for this scenario approached unity, suggesting a potential concern, although there was great uncertainty with this estimate. The main contributor was benzothiazole, a rubber-related semivolatile organic chemical (SVOC) that was 14-fold higher indoors than outdoors. ***Based upon these findings, outdoor and indoor synthetic turf fields are not associated with elevated adverse health risks. However, it would be prudent for building operators to provide adequate ventilation to prevent a buildup of rubber-related volatile organic chemicals (VOC) and SVOC at indoor fields.*** The current results are generally consistent with the findings from studies conducted by New York City, New York State, the U.S. Environmental Protection Agency (EPA), and Norway, which tested different kinds of fields and under a variety of weather conditions.
10.	Toxicological Assessment of Coated Versus Uncoated Rubber Granulates Obtained from Used Tires for Use in Sport Facilities Gomes et al. (2010). J Air Waste Manag Assoc. 60(6):741-6.	Coated and uncoated rubber granulates	Reuse of tire crumb in sport facilities is currently a very cost-effective waste management measure. Considering that incorporation of the waste materials in artificial turf would be facilitated if the rubber materials were already colored green, coatings were specifically developed for this purpose. This paper presents an experimental toxicological and environmental assessment aimed at comparing the obtained emissions to the environment in terms of polycyclic aromatic hydrocarbons (PAHs), heavy metals, and ecotoxicity for coated and noncoated rubber granulates. This study is a comprehensive evaluation of the major potential critical factors related with the release of all of these classes of pollutants because previous studies were not systematically performed. ***It was concluded that between the two types of coatings tested, one is particularly effective in reducing emissions to the environment, simultaneously meeting the requirements of adherence and color stability.***
11.	Safety Study of Artificial Turf Containing Crumb Rubber Infill Made from Recycled Tires: Measurements of Chemicals and Particulates in the Air, Bacteria in the Turf, and Skin Abrasions Caused by Contact with the Surface	Chemicals, particulates in the air, bacteria in the turf	… tire rubber is a complex material, containing many naturally-occurring and man-made chemicals. Crumb rubber made from recycled tires has the potential to release a variety of chemicals and particles into the air. It also represents a potential site of bacterial growth and transmission to athletes using the fields (including methicillin-resistant Staphylococcus aureus, MRSA). Therefore, OEHHA has evaluated the following aspects of artificial turf safety for fields constructed with

	California Office of Environmental Health Hazard Assessment. (2010). Prepared for the California Department of Resources Recycling and Recovery.		recycled crumb rubber infill. 1. Inhalation hazard a. PM2.5 and associated elements (including lead and other heavy metals) were either below the level of detection or at similar concentrations above artificial turf athletic fields and upwind of the fields. *No public health concern was identified.* b. The large majority of air samples collected from above artificial turf had VOC concentrations that were below the limit of detection. Those VOCs that were detected were usually present in only one or two samples out of the eight samples collected per field. There was also little consistency among the four artificial turf fields with regards to the VOCs detected. Nevertheless, seven VOCs detected above artificial turf were evaluated in a screening-level estimate of health risks for both chronic and acute inhalation exposure scenarios***. All exposures were below health-based screening levels, suggesting that adverse health effects were unlikely to occur in persons using artificial turf.*** c. There was no correlation between the concentrations or types of VOCs detected above artificial turf and the surface temperature. 2. Skin infection hazard a. Fewer bacteria were detected on artificial turf compared to natural turf. This was true for MRSA and other Staphylococci capable of infecting humans. ***This would tend to decrease the risk of skin infection in athletes using artificial turf relative to athletes using natural turf.*** b. The rate of skin abrasions due to contact with the turf was two- to three-fold higher for college soccer players competing on artificial turf compared to natural turf. This was observed for both female and male teams. Skin abrasion seriousness was similar on the two surfaces. ***The higher skin abrasion rate would tend to increase the risk of skin infection in athletes using artificial turf relative to* athletes using natural turf.** c. The sum of these effects on the skin infection rate for artificial turf relative to natural turf cannot be predicted from these data alone. Measuring the skin infection rates in athletes competing on artificial and natural turf might determine if there is a significant difference.
12.	Design of a New Test Chamber for Evaluation of the Toxicity of Rubber Infill Gomes JF, Mota HI, Bordado JC, Baião M, Sarmento GM, Fernandes J, Pampulim VM, Custódio ML, Veloso I. (2011). Toxicol Mech Methods. 21(8):622-7		A test chamber was projected and built (according to ISO 16000-9 Standard) to simulate atmospheric conditions experienced by rubber infill (when applied in synthetic turf pitches) and measure accurately the airborne emissions of pollutants such as dusts and volatile organic compounds (VOC), as well as pollutants present in leachates. It should be pointed out that standard ISO 16000-9 is only concerned with the determination of the emission of VOC from building products and furnishing (not specific of synthetic turf materials), whereas other standards are concerned with the emission of leachates only. **This procedure is to be considered as a technical option to the lysimeter "global turf system evaluation" when the rubber infill alone is to be evaluated. The advantage of the proposed option considering this "test chamber" is its simplicity and economy. This test chamber is actually installed and being used for tests in LAIST**.

Brief Presentation

More than 3,000,000 tonnes of vehicle tyres are discarded each year and defined as waste within the European Union. Approximately half of the tyres collected annually in the Member States are valorised using some form of material recycling. Today, the largest market for recycled tyre material is the sports and leisure sector, i.e., playing surfaces and other products, although primarily for artificial turf.

Beginning 1 January, 2010, tyres manufactured in the European Union are required to use only new low-PAH extender oils. As a result, the PAH content has been measurably reduced. As explained by the WDK, PAH is a vital element in the carbon black used in vehicle tyres. It remains firmly bonded in the carbon black and can only be extracted using organic solvents.

Tyres produced outside of the EU do not necessarily comply with the same requirements. It is important to note that since the new requirements were implanted, the quantities of imported tyres within the EU have increased to approximately

1. Tyre recycling is a predominant means of valorising a large quantity of valuable, very sophisticated and much needed 'secondary raw materials' each year. In the EU alone, over 3,000,000 tonnes of tyres become waste annually – of which almost half are materially recycled into new materials and applications and enter into the economic stream in substitution of virgin resources in a broad array manufactured products.

2. Tyre recycling contributes to the Circular Economy by developing and producing sustainable, cost-effective materials, products and applications for use in critical industries including : transport, infrastructure, civil engineering, const-ruction, consumer and industrial products, sports and leisure, among others.

3. Throughout the past twenty years, SBR infill has grown into the largest market for recycled tyre materials. It is used throughout the world and supported by the UN as a means of providing socialisation opportunities to children and adults in wartorn areas.

4. During the 20 year period, there have been few reported health concerns involving these materials from contact, inges-tion, inhalation, overall health or carcinogenic issues. In fact, over 200 scientific studies undertaken in the EU, the US and Canada[1] do not support these concerns or indicate problematic levels of health issues.

5. **Research into the health & safety implications of using of rubber crumb infill in 3rd Generation sports surfaces (Issued February 2016) by** The Football Association, The Football Foundation, Rugby Football Union, England Hockey

   At present the preponderance of evidence very clearly shows no negative health effects associated with crumb rubber infill used in synthetic turf and the NGB`s believe that they have taken all reasonable measures to ensure that the pitches they use and fund in England are safe and present no known hazard to health.

6. **Review Of The Impacts Of Crumb Rubber In Artificial Turf Applications (February 2010)**

   University of California, Berkeley and the Corporation for Manufacturing Excellence (Manex)

[1] Norway France, Netherlands, New York, New Jersey, Toronto, Massechusetts, Connecticut, California, EPA, among others

"The uptake of PAH by athletes who have contact with crumb rubber synthetic turf is negligible. As far as dermal contact is concerned, the Norwegian Institute of Public Health and Radium Hospital (2006) carried out an extensive analysis of possible health concerns. The study found that there was no evidence to suggest that allergic reactions were caused by exposure to crumb rubber and speculated that latex in car tires was either - less available for uptake or was - deactivated as an allergen."

7. Three 2010 long-term studies undertaken by researchers from Norway and Sweden compared acute injuries on synthetic turf with those on natural grass. The studies examined the type, location and severity of injuries sustained by hundreds of players during thousands of hours of matches and training over a four to five year period. Many types of acute injuries to men and women soccer players were assessed. Knee injuries, ankle sprains, muscle strains, concussions, MCL tears, and fractures were evaluated. They concluded that the injury risk of playing on artificial turf is no greater than playing on natural grass.

8. Following are summaries of 14 studies focused on health issues

Fourteen Studies on Health Risks from SBR

Ingestion, Inhalation, Dermal Contact *"Eleven different risk assessments applied various available concentrations of COPCs [chemical of potential concern] and none identified an increased risk for human health effects as a result of ingestion, dermal or inhalation exposure to crumb rubber." A Review of the Potential Health and Safety Risks from Synthetic Turf Fields Containing Crumbs Rubber Infill,* New York City Department of Health and Mental Hygiene, May 2008

Ingestion, Inhalation, Dermal Contact *"Based on the available literature on exposure to rubber crumb swallowing, inhalation and skin contact...we conclude that there is not a significant health risk due to the presence of rubber infill for football players (for) an artificial turf pitch with rubber infill from used car tires."* Hofstra University, *Environmental and Health Risks of Rubber Infill: Rubber Crumb from Car Tires as Infill on Artificial Turf,* 2007

Ingestion *"OEHHA then compared the levels of released chemicals to their health-based screening values, assuming a young child ingested ten grams of tire shreds; all exposures were at or below the screening values* ***suggesting a low risk of noncancer acute health effects****."* California Integrated Waste Management Board, 2007, Integrated Waste Management Board: Sacramento, CA

*"Based upon the current evidence****, a public health risk appears unlikely****. DPH does not believe there is a unique or significant exposure from chemicals that can be inhaled or ingested at these fields."* Connecticut Department of Public Health, *Health Questions about Artificial Turf Fields*, Oct 2007

Ingestion *"In the event of ingestion of crumb rubber particles, although it is highly improbable, the particles do not present any toxicity, as the digestive system is not powerful enough to extract the chemical components from the rubber."* Laboratoire de Rechercheset de Controle du Caoutchouc et des Plastiques, *End of Life Tire Crumb Rubber in Sports Floors – Environmental Consequences,* Updated 2006

Inhalation *"A screening-level assessment of health risks was performed by comparing the estimated exposures to health-based screening levels****. All exposures were lower than the screening levels, indicating that adverse health effects were unlikely in athletes using these fields****."* Office of Environmental Health and Hazard Assessment, *Safety Study of Artificial Turf Containing Crumb Rubber Infill Made from Recycled Tires: Measurements of Chemicals and Particulates in the Air, Bacteria in the Turf, and Skin Abrasions Caused by Contact with the Surface*, Department of Resources Recycling and Recovery, Editor. 2010, State of California

Inhalation *"In summary, an analysis of the air in the breathing zones of children above synthetic turf fields do not show appreciable impacts from COPCs [Chemicals of Potential Concern] contained in the crumb rubber. Therefore, a risk assessment was not warranted from the inhalation route of exposure." Air Quality Survey of Synthetic Turf Fields Containing Crumb Rubber Infill,* New York City Department of Health and Mental Hygiene, March 2009

Dermal Contact *"The chances that substances in the rubber cause skin irritation to non-sensitized persons is estimated to be low."* Hofstra, U., *Environmental and Health Risks of Rubber Infill: Rubber crumb from car tyres as infill on artificial turf,* 2007

"This study provides evidence that uptake of PAH of football players active on artificial grass fields with rubber crumb infill is minimal. ***If there is any exposure, then the uptake is very limited and within the range of uptake of PAH from environmental sources and/or diet."*** Joost G. M. van Rooij Æ Frans J. Jongeneelen, *Hydroxypyrene in urine of football players after playing on artificial sports field with tire crumb infill,* International Arch Occup Environ Health (2010) 83:105–110

Dermal Contact *"As is apparent from Table 10, exposure to PCBs , PAHs, phthalates and alkyl phenols via the skin is extremely low and is measured in ng/kg body weight/day. It is therefore concluded* ***that skin exposure to recycled rubber granulate will not cause any increased health risk."*** Norwegian Institute of Public Health and the Radium Hospital, *Artificial turf pitches – an assessment of the health risks for football players*, 2006, Norwegian Institute of Public Health and the Radium Hospital: Oslo. p. 1-34

Risk of Cancer *"Ingestion of a significant quantity of tire shred* ***did not elevate a child's risk of developing cancer,*** *relative to the overall cancer rate of the population."* Rachel Simon, University of California, Berkeley, Review of the Impacts of Crumb Rubber in Artificial Turf Applications, February 2010

"Genotoxicity testing of tire crumb samples ... suggests that ingestion of small amounts of tire crumb by small children ***will not result in an unacceptable hazard of contracting cancer."*** Detlef A. Birkholz, Kathy L. Belton, Tee L. Guidotti, *Toxicological Evaluation for the Hazard Assessment of Tire Crumb for Use in Public Playgrounds,* J. Air & Waste Management Association, 53:903–907, July 2003

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All are on the web-site of the

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