APPENDIX B

Sport Field Strategy

VANCOUVER
BOARD OF PARKS AND RECREATION

ENVIRONMENTAL AND HUMAN HEALTH REPORT

APRIL 2024

ACKNOWLEDGEMENTS

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Land Acknowledgement

Vancouver is located on the unceded traditional territories of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish) and səl̓ilwətaʔɬ (Tsleil-Waututh) Peoples. Musqueam, Squamish, and Tsleil-Waututh peoples have been and are stewards of these lands and have deep knowledge and connection to the plants and the land that have sustained their people for time immemorial.

The Vancouver Board of Parks and Recreation is committed to working with First Nations to advance decolonization and reconciliation across its network of facilities and spaces.

Statement of Limitations

This report was prepared on behalf of the Vancouver Park Board by planning, design, and engineering professionals using current best practices in their respective fields. The information presented in this report is valid as of the date the study was performed. New information may become available with time; consequently, the findings presented herein are subject to change.

This report was prepared for the sole use of the Vancouver Park Board. Any use which a third party makes of the Report, is the sole responsibility of such third party.

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1. OVERVIEW

1.1. PROJECT CONTEXT

The Vancouver Board of Parks and Recreation (Park Board) is developing a Sport Field Strategy to guide how it manages and invests in sport fields in the city. More specifically, the Strategy will:

- Undertake comprehensive community and stakeholder engagement to better understand city-wide sport field needs, trends and perspectives.
- Review the condition and performance of existing sport fields.
- Identify optimum city-wide service levels, project future needs and explore and recommend innovative directions.
- Propose priorities and phasing for replacing and renewing existing sport field facilities and identify new facility needs.
- Assess surfacing options for sports fields, including environmental and human health impacts.
- Develop a field use allocation policy.

WHAT TYPES OF SPORTS FIELDS ARE INCLUDED IN THE STRATEGY?

Sport fields include rectangular fields (for soccer, football, rugby, etc.), ball diamonds, and cricket pitches. They can have natural turf or synthetic turf; they can also be all-weather (gravel) surfaces. Vancouver sports fields are located at school sites and parks of various sizes. The project study area includes all Vancouver owned and managed parks as well as some VSB sites.

OVERVIEW OF THE 4 STRATEGY BACKGROUND DOCUMENTS

- **"What We Heard" Report #1 (findings from the initial round of engagement)**
- **Environmental and Human Health Considerations Report**
- **"Current State" Research Findings Report**
- **"What We Heard" Report #2 (findings from a second round of engagement)**

Research, engagement and analysis is a critical aspect of developing the Strategy and will help ensure that the sport field system in the city is understood as well as explore key topics that need to influence future decision making. **The research, engagement and analysis undertaken to inform the Strategy is being compiled into four background documents – this Environmental and Human Health Considerations Report is one of those four documents.**

The purpose of this document is to identify key considerations related to the environmental and human health impacts of different sport field surfacing typologies. The information contained in this report has been developed by the project team's subject matter experts and contains findings from a number of sources (as cited throughout). **It is important to note that this background report is not intended to be used as the sole basis for making decisions on turf typologies but rather present an unbiased point of reference that can ensure future conversations are adequately informed.**

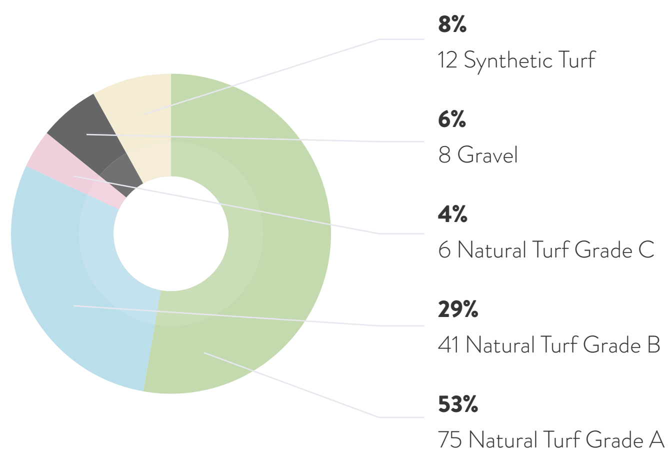
1.2. PURPOSE OF SYNTHETIC TURF ENVIRONMENTAL AND HEALTH REVIEW REPORT

The purpose of this report is to provide an objective review of the environmental and human health impacts of natural turf and synthetic turf. The findings in this report are intended be used as a component of the overall Sport Field Strategy and will form part of a decision making framework for the planning and implementation of new synthetic turf fields in the City.

1.3. EXISTING PARK BOARD FIELD TYPES

The Park Board's field inventory includes both natural turf and synthetic turf. With respect to synthetic turf, the majority of the Park Board's fields contain crumb rubber infill, with one baseball diamond infield containing coated sand and one field containing Thermoplastic Elastomer (TPE) infill materials. The Park Board has paused construction on synthetic fields containing crumb rubber infill based on the 2019 decision to install a TPE infill at Kerrisdale Park. As the Park Board's existing synthetic fields are replaced, it is anticipated that infills other than crumb rubber will be used.

QUANTITY OF RECTANGULAR SPORTS FIELD TYPES IN VANCOUVER



The Park Board's natural turf sports field inventory includes irrigated sand-based fields, irrigated and non-irrigated soil-based natural turf fields. The Park Board also has gravel fields, which are used primarily for softball and some baseball diamonds. Eight gravel fields are used as practice fields, however, gravel is an undesirable playing surface for field sports including soccer. Gravel field surfaces are not part of this environmental review.

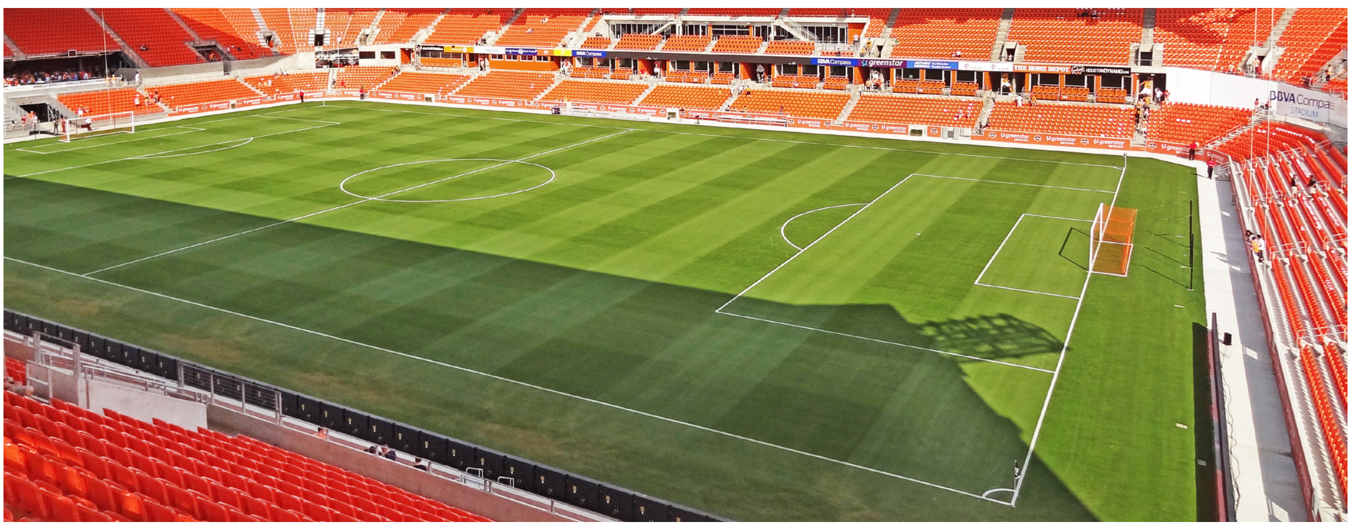
1.4. MUNICIPAL SPORTS FIELDS CONSIDERATIONS

While synthetic turf offers a number of benefits over natural turf, particularly for high intensity municipally operated athletic parks, it is important to recognize that a well maintained, optimally utilized natural turf field is considered by users and international sports governing bodies to be the preferred surface for soccer, field lacrosse, rugby, football and the majority of other sports and uses. Natural turf also provides a preferred surface for non-programmed community casual sport and non-sport uses. Field hockey is the only sport where users and the international sport governing body (FIH) require a synthetic turf surface for higher level play.

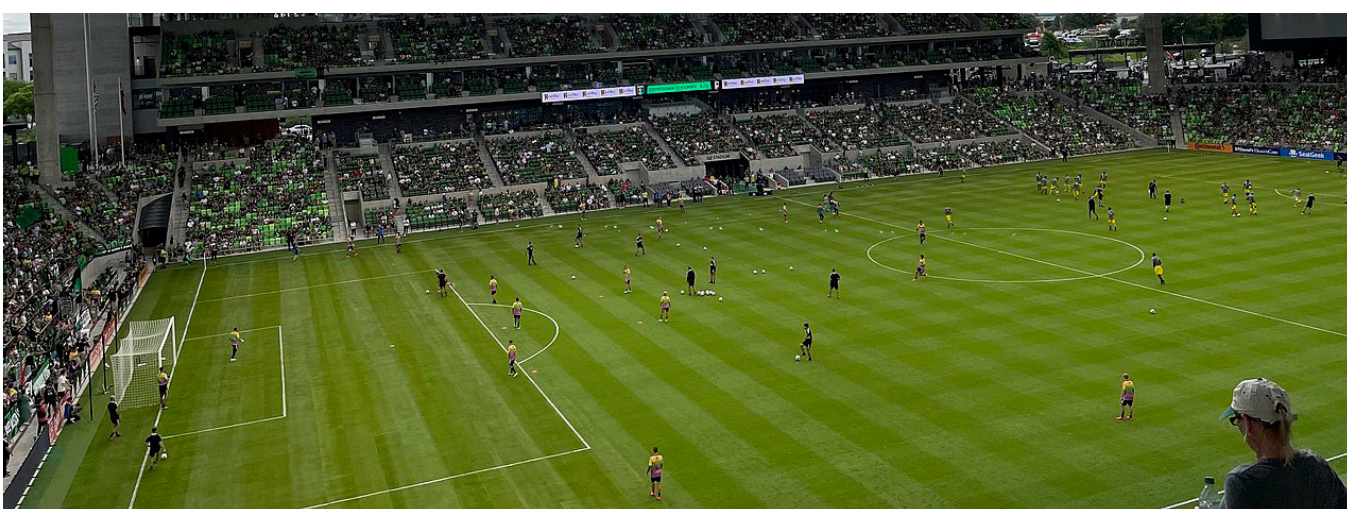
The challenge for many municipalities is that high performance natural turf fields are typically operated by professional organizations or universities, with funding for full time field managers, used by a single field user group, and have restricted public access. Under these conditions, a natural turf field would be superior to synthetic turf. From a practical perspective, municipalities do not have adequate resources to construct and maintain high performance natural turf fields. Due to pressures for field bookings and lack of resources for maintenance, municipalities rarely have the ability to significantly restrict and monitor field use, particularly with changing weather patterns (ie. sudden rainfall). As such, natural turf fields are at risk of damage due to overuse (or improper use such as from dogs) and are typically not in an ideal condition throughout the sports season. Damages from overuse may lead to temporary field closures and cancellations are common.

Conversely, synthetic turf surfaces can be played on year-round under a variety of adverse weather conditions without risking damage to the surface. Due to the durability of synthetic surfaces as compared to natural turf, a synthetic field accommodates (on average) about four times the hours of play, with up to six times the amount of play for fields located on multi-use, highly utilized sites including shared municipal/school sites.

Wet, damaged natural turf field, Steve Hardwood, flickr.com



Professional soccer natural turf field, PNC Stadium, Houston, Texas. Natural Turf Field, Paul Duron, en.wikipedia.org



Professional soccer natural turf field, Austin FC Stadium, Austin, Texas. Natural Turf Field, Daniel Ziegler, en.wikipedia.org

As part of the research phase of the Sport Field Strategy, a study of sport field surfaces across other municipalities, along with the experience of the consultant team on previous work, it is determined that the need for synthetic turf is typically driven by the following factors:

- Provide an opportunity to relieve natural turf fields from overuse, by transferring bookable hours to synthetic surfaces where possible. This is particularly important for popular natural turf fields that show signs of excess wear.
- Allow for extension of use into the wet season, when natural turf is dormant (and incapable of recovering from damage) and ground conditions are saturated and occasionally frozen (ie. October to April). Due to generally mild winter conditions in Vancouver, fields are typically booked year-round. Field sports such as soccer are operating at peak seasonal capacity with high demand for sports fields. Increased pressure to keep natural turf fields open can result in extensive field damage arising from just a single day of sports such as football, rugby or adult soccer.
- Synthetic turf allows for natural turf fields to be closed when wet and play scheduled onto synthetic turf. This allows for natural turf fields to recover and minimizes costly field damage and further closures for growing-in periods.
- On tournament sites, inclusion of one or more synthetic turf fields can allow for maximum utilization of the amenity even during poor weather conditions. Tournament delays and cancellations are minimized, the playing surface is reliable, and concerns over potential field damage due to overuse are greatly reduced.
- Due to the high utilization of synthetic turf, the overall Park Board-wide development footprint allocated to sports fields could be reduced (ie. fewer sports related parking lots, washrooms, fields, etc.) allowing for additional opportunities for use of park land.

The primary goal for a synthetic turf surface for most municipalities is not to replace natural turf wherever possible, but rather to supplement and support natural turf fields within the municipalities overall inventory.

Vancouver is one of a small number of known jurisdictions in North America that has specifically undertaken a comprehensive literature review of human health and environmental impacts of natural turf and synthetic turf.

2. ABOUT SYNTHETIC TURF SPORT FIELD SURFACES

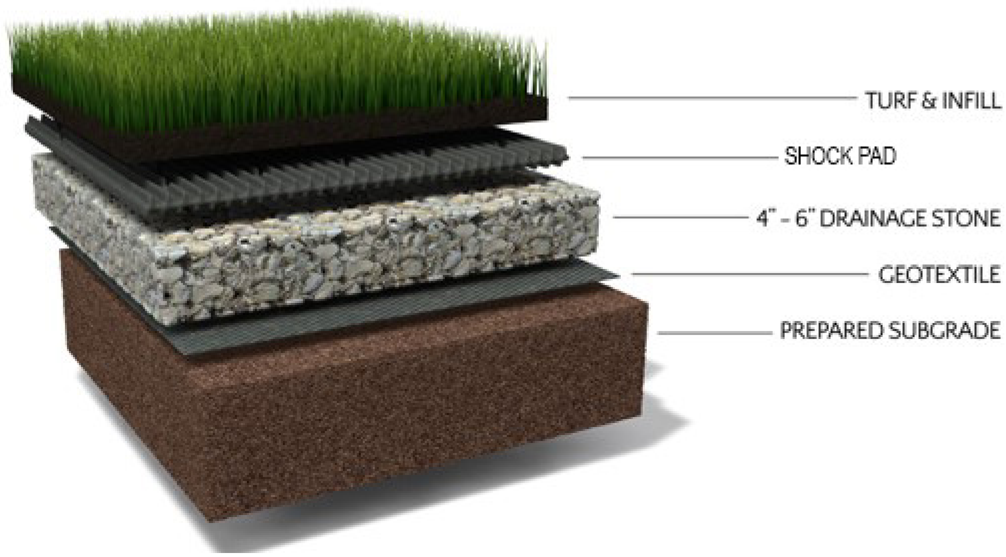
2.1 OVERVIEW

Synthetic turf is surface that is made of the synthetic fibers to look and simulate natural turf. The product is typically used in athletic fields, putting greens, runway aprons, playgrounds, dog parks and other applications. With the exception of field hockey, the vast majority of synthetic turf fields in use today are referred to as third generation systems, comprised of synthetic grass fibres tufted into a backing to resemble a carpet with infill material. Infill material is added during installation. The most common infills include:

- Recycled crumb rubber (recycled tires) – over 95% of synthetic fields use crumb rubber
- Thermoplastic Elastomer (TPE) and Ethylene Propylene Diene Monomer (EPDM)
- Organics (Cork, coconut shells, walnut shells, various other shredded or pelleted organic materials)
- Coated and uncoated mineral materials (sand, zeolite)

2.2 COMPONENTS OF A SYNTHETIC TURF SYSTEM

The diagram below, indicates the components of a synthetic turf sports field:



The four main components of a synthetic turf system that have health and environmental considerations are outlined below.

TURF FIBRE

Fibre used in synthetic turf is constructed of polypropylene, polyethylene, nylon, or other suitable synthetic extruded yarn resembling blades of grass. Occasionally a thatch layer may also be added using a textured yarn that is situated below the face yarn to enhance grass-pile recovery.

BACKING MATERIALS

A synthetic backing material (polypropylene, polyethylene) is used to support the yard fibres, and the fibre is either knitted or tufted into the backing material. Urethane or latex adhesives are applied to the backing to stabilize and secure the fibre tufts.

ENERGY ABSORBING SHOCK PAD

An energy absorbing shock attenuation pad is installed under the turf system for the purposes of minimizing the risk and severity of impact injury (especially brain injury) between the surface and player. Shock pads may be premanufactured in rolls or panels, or they may be constructed in situ using rubber, urethane and sometimes aggregates. The majority of shock pads incorporate recycled materials and many can be completely recycled after use.

The synthetic turf carpet (fibre and backing) and shock pad are extensively tested for compliance with current safety and environmental regulations.

INFILL

Infill materials are used to simulate the look and feel of natural turf stabilize the grass fibre and provide ballast for the turf carpet. Infill material, when used, also plays a critical role in the sport performance of the field and the interaction between the athlete and surface, as well as the ball and surface. There are a variety of infills that can be used, and the infill material has typically generated the most public concern over human health and environmental impact. There are four types of infill that are most commonly used and were researched as part of this report: Crumb Rubber, Thermoplastic Elastomer, Organic (coconut, cork, walnut), and silica sand. Table 4.2 below outlines the description, advantages and disadvantages of each type.

TABLE 1. ADVANTAGES AND DISADVANTAGES OF INFILL TYPES

Crumb Rubber (CRI)	
Product Description	• Crumb Rubber (CRI) is produced by grinding or shredding used passenger vehicle and truck tires and removing approximately 99% of the steel and fabric belting material. The CRI is then installed within the synthetic turf grass blades, blended with silica sand, or occasionally without sand. • Approximately 50% of crumb rubber from recycled tires is utilized in sports surfaces and playgrounds. The remaining uses include rubberized asphalt pavement, extruded rubber products, and automotive parts.
Advantages	• Highly resilient and durable • Excellent shock absorption • Widely used - over 95% of fields • Lowest cost compared to other infill materials • Post-consumer recycled product removes tires from waste stream • High UV resistance • Can be reused in multiple turf life cycles
Disadvantages	• Post-consumer recycled product—material source can be variable • Public perception of potential health impact • Due to its black colour, more heat is absorbed resulting in higher surface temperatures than some of the alternative infills • CRI can omit a somewhat unpleasant 'off-gassing' odor when first installed, particularly during very hot weather • Is a microplastic thus any migration off field requires management • Infill migration (splash and tracking off field) is a concern • Potentially harmful to aquatic life if installed close to a fish-bearing watercourse

Thermoplastic Elastomer (TPE), Ethylene Propylene Diene Monomer (EPDM)	
Product Description	• Thermoplastic Elastomer or Olefin (TPE or TPO) is made from raw materials for use as infill. It is not a recycled product. It is a ground crumb, formed particle or shredded material, about the same size as CRI. It is commonly green in colour but can be manufactured in a variety of colours. TPE is installed within the synthetic turf grass blades, blended with silica sand, or occasionally without sand.
Advantages	• Can have high resiliency– good shock absorption • Virgin material–raw materials can be controlled – contains no polycyclic aromatic hydrocarbons (PAH) or heavy metals • TPE is a food-safe material • Can be melted so they can be recycled after use • Potential reduction in turf surface temperature • Athletic Performance (elasticity) • Good particle size distribution due to its angular shape • Limited fine particles • Minimized infill migration (splash and tracking off field) • Can be reused in multiple turf life cycles
Disadvantages	• High cost; limited availability results in high transportation costs • Medium UV Resistance • Different qualities (various origin/recycling): A low polymer content can lead to premature ageing problems and agglomeration • As a manufactured, non-local material, TPE has a higher carbon footprint • Limited supply and manufacturers • Is a microplastic

Organics (Coconut Fiber, Cork, Walnut Shells, etc.)	
Product Description	• There are several organic infills available on the North American market, all utilizing different organic components, such as coconut shell, cork, walnut shells and other organic materials These products can be utilized in professional sports applications as well as for landscaping.
Advantages	• Natural product–not chemically produced • Light color absorbs less visible light to reduce surface temperature • Retains water for evaporative cooling • Not a microplastic • Can be composted at end of lifecycle
Disadvantages	• Higher costs • Requires more maintenance and refreshing than crumb rubber fields • Limited to no resilience–requires a pad • Some requires a watering system to maintain playability • Can be susceptible to freezing due to low water permeability • Low density can allow material to float/displace, cling to fibers with static • Limited availability • Limited Sport Performance Data • Additional Maintenance and top-dressing annually • Not enough data on multiple field life cycle reuse

Silica Sand	
Product Description	• Rounded Silica Sand is used as a ballast material for most infill systems. It is placed as a single layer at the bottom of the turf or occasionally blended with the infill. Silica sand (either natural or acrylic colour coated) is occasionally used on its own as infill (such as for baseball, field hockey or other short pile pitches). It is one of the original infilling materials utilized in synthetic turf. This product is a natural infill that is non-toxic, chemically stable, and fracture resistant.
Advantages	• Relatively low cost • Inorganic material–can be cleaned to have low impurities • Natural, non-toxic material • Not a microplastic • Can be colour coated for aesthetic or performance reasons • Can be reused on multiple turf life cycles
Disadvantages	• No resiliency–low shock absorption • Requires a shock pad • On its own does not meet sport performance standards for all sports

3. ENVIRONMENTAL CONSIDERATIONS

3.1. WATER CONSUMPTION

Water consumption is a consideration for municipalities based on the high cost, environmental policies around reducing water consumption and the need for water in parks for a variety of needs across the system. The following table summarizes the weekly and annual water consumption of both natural turf and synthetic turf:

TABLE 2. WATER USAGE BY FIELD TYPE

Field Type	Water Usage / Week	Water Usage / Year
Synthetic Turf Field – Multi Sport	0	0
Synthetic Turf Field – Field Hockey	37,000 gallons	1.1M gallons
Sand Based Natural Turf (Class A) – Irrigated	97,000 gallons	2.7M gallons
Sand / Soil Based Natural Turf (Class B) – Irrigated	50,000 gallons	1.4M gallons

Irrigated natural turf fields consume high amounts of water whereas synthetic turf fields typically do not. The only exception is for field hockey, which is a relatively uncommon single sport synthetic turf field that incorporates a wetdown sprinkler system to lubricate the turf and increase ball speed. The City currently operates one field hockey pitch with a wet down sprinkler system.

For reference and comparison an Olympic size swimming pool contains 660,000 gallons of water.

The following table compares various water usage needs for both natural turf and synthetic turf.

TABLE 3. WATER USAGE NEEDS

	Natural Turf Sand Based Soccer Field	Natural Turf Soil Based Soccer Field	Synthetic Turf Field (Field Hockey)
City Supply	Min. 50 gpm/100 psi	Min. 50 gpm/100 psi	Min. 184 gal/100 psi
Field Size	100m x 65m	100m x 65m	110.6m x 70.6m
Total Zones	13 (F/5, H/6, Q/2)	13 (F/5, H/6, Q/2)	8 (H/2, Q/6)
Rotor	Rain Bird 8005 @ 70 psi	Rain Bird 8005 @ 70 psi	Komet - Twin 101 Plus 22Noz. @ 70 psi
gpm/per Rotor	13.2 gpm (max. 3 rotors/stn)	13.2 gpm (max. 3 rotors/stn)	183.1 gpm (max. 1 rotors/stn)
Rotor Spacing	16m x 16m	16m x 16m	3-Q @ each end zone, 1-H @ each side line
Watering	7 days/wk	4 days/wk	10 Games/wk
Total Run Time/Full Cycle	356 min (5 hrs, 56 mins)	322 min (5 hrs, 22 mins)	10 mins prior to game/10 min @half time
(each station)	F/42 min, H/21 min, Q/11 min.	F/38 min, H/19 min, Q/9 min.	H/2 min, Q/1 min
Total Water/Full Cycle	13,886.4 gal	12,909.6 gal	3,662 gal
Total Water/Week	97,204.8 gal	51,638.4 gal	36,620 gal
Total Water/Year	2,721,734.4 gal	1,445,875.2 gal	1,171,840 gal

F = 360°, H = 180°, Q = 90°

Watering for soccer fields is between March to September (28 weeks). Watering schedule above is based on a week in Mid July.

Irrigation for soccer fields runs only at night.

ATF rotor layout is not head to head.

Watering for field hockey is from September to April (32 weeks). Watering schedule for above is based on a week.

3.2. MICROPLASTICS AND INFILL MIGRATION

There have been concerns raised in the past regarding the migration of microplastics from turf systems into watercourses. Microplastics consist of non-organic or non-sand infill as well as fibre loss. A microplastic is defined as any plastic derived material with a dimension of 5 mm or less.

MICROPLASTIC SOURCES

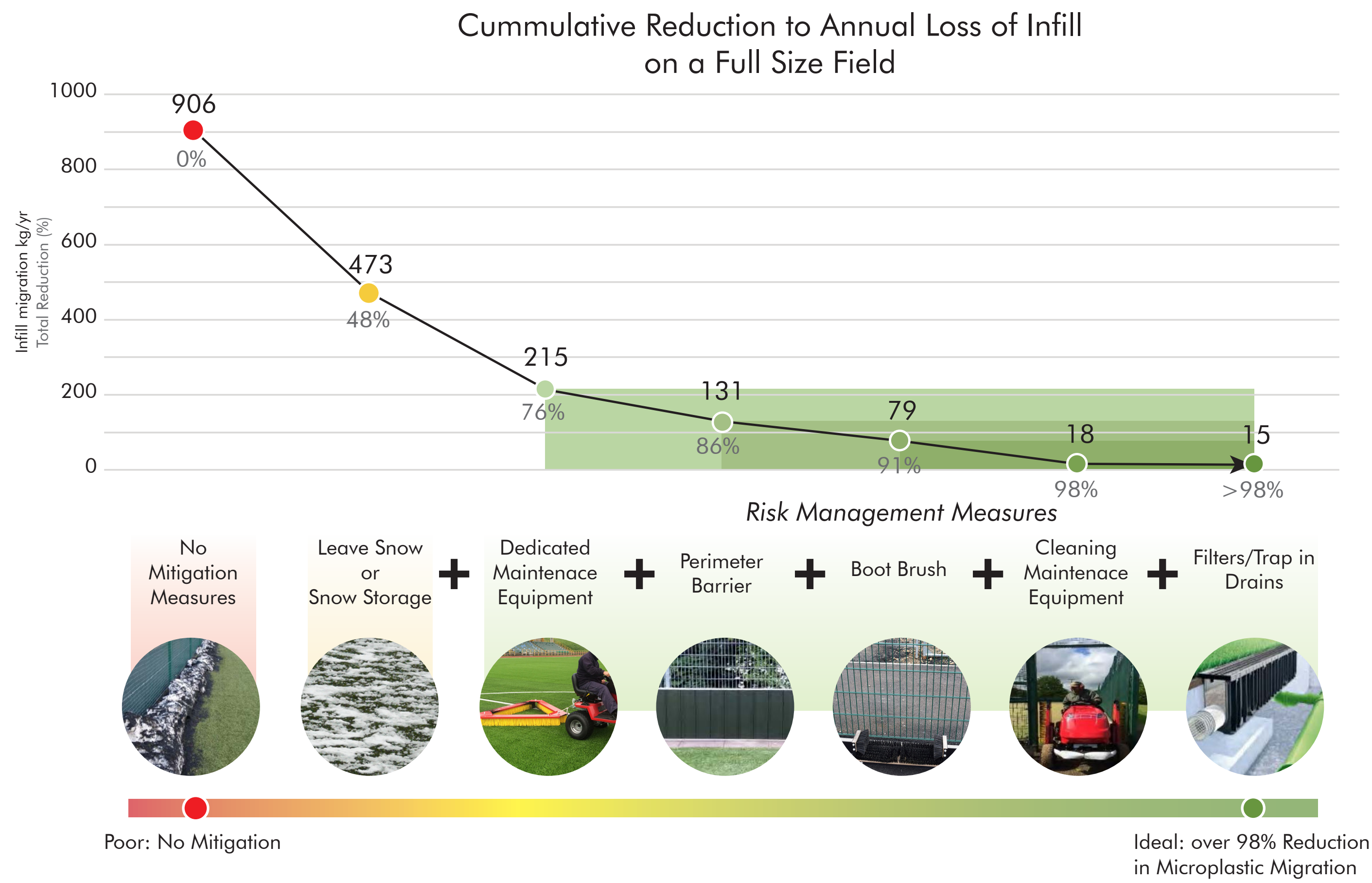
Sources of microplastics on synthetic turf fields include infill and turf fibre.

- Different infill products have different migration rates. Infill product migration is partially managed at the source through the choice of infill product.
- Turf fibres migrate significantly less than infill. Fibre migration increases when the turf has been severely damaged and not repaired or over worn. Turf wear is monitored by the extent of splitting of the fibre ends. Once splitting reaches a certain point, the turf loses its playable characteristics and should be replaced, before it is overworn.

MITIGATION MEASURES

- To contain infill and turf fibre migration for any future proposed field:
  - » Select an infill product with a low migration characteristic and stitched turf fibre system.
  - » Implement a raised perimeter edge to contain migration.
  - » Install weighted fabric screens (450 mm to 600 mm tall) on the field perimeter fences to contain infill splash.
  - » Install boot brushes and educational signage at all access and egress gates.
  - » Implement a site overland drainage system that directs all drainage to sump style catch basins possessing an inverted weir and filter.
  - » Minimize snow removal. If snow is removed, store it in an area away from drainage systems and in an area where fibre and infill can be captured during snow melt.
  - » Ensure fields are replaced at the end of their life cycles and before they're overworn.
  - » Additional water quality measures can be included within the overall stormwater management plan by adding a stormceptor (Oil Grit Separator) to outlet of catchment area for the synthetic turf field area.
- Collectively, these efforts will prevent migratory elements from entering the municipal storm water system and ultimately the natural environment, and allow for recovery and reuse of migrated infill products.

Refer to the following graphic for the cumulative effectiveness of measures that should be taken to reduce microplastic migration on synthetic turf fields:



Determining the effectiveness of Risk Management Measures to minimize infill migration from synthetic turf sports fields, EcoLoopAug. 2020
https://www.estc.info/wp-content/uploads/2020/09/Ecoloop-Report-Effectiveness-RMMs.pdf

3.3. SYNTHETIC TURF END OF LIFE & RECYCLING OPTIONS

Existing end of life and recycling options for synthetic turf systems are outlined below.

3.3.1 FIBER AND BACKING

It estimated that approximately 80,000 pounds of fiber, primary backing, and secondary backing will be used in the construction of a typical new synthetic turf athletic field. At the end-of-life of the field, these materials cannot be reused for the construction of a new synthetic turf field at the site. Although some manufacturers discuss options for diverting turf from landfills by reusing the turf into other applications such as landscaping, pet turf, and beautification projects, the demand for repurposing end-of-life fiber and backing into other applications remains uncertain. It is considered unlikely that these materials can be easily recycled due to the mixed-polymer composition of the fiber (nylon, polypropylene, or polyethylene), primary backing ("thermoformable performance polymer"), and secondary backing (polyurethane). If no other options are available, the fiber and backing can be disposed of as nonhazardous waste.

3.3.2 INFILL

It is estimated that approximately 240,000 pounds of organic infill and 1,300,000 pounds of sand would be used in the construction of a typical new synthetic turf athletic field. At the end-of-life, these materials could be reused for the construction of a new synthetic turf field at the site. If reuse for the construction of a new synthetic turf field is not specified, the sand can be separated from the organic infill and reused for other applications and the organic infill can be composted.

3.3.3 UNDERLAYMENT/SHOCK PAD

It is estimated that approximately 37,000 pounds of shock pad would be used in the construction of a typical new synthetic turf athletic field. This material can be reused for the construction of a second synthetic turf field at the site due to its 20-year warranty.

3.3.4 CONCLUSION

Most of the materials used for the proposed synthetic turf fields can be reused, recycled, or diverted from a landfill. Many pre-manufactured pads can be reused for a second synthetic turf field and then recycled into new polypropylene products at its end-of-life. Infill and sand can be reused for a second synthetic turf field or repurposed for other uses. The recycling and reuse options for the synthetic turf fiber and backing appear to be limited, but these components represent only 20% of the synthetic turf by weight.

To date, the Park Board has recycled old synthetic turf and infill from turf replacement projects by utilizing turf recycling facilities in the United States and Malaysia. Occasionally, the turf has been re-purposed (such as at Hillcrest Park). Turf recycling facilities are no longer operating so new alternatives to landfill disposal should be explored when future turf fields are resurfaced.

3.4. GREENHOUSE GAS EMISSIONS

Greenhouse gas emissions for manufactured products are defined as the emissions associated with the energy consumption needed to produce the inputs and manufacture the good itself. Greenhouse gas emissions of maintained landscapes are defined by the amount of carbon they sequester while growing plus the goods and services needed to maintain them.

Both synthetic and natural turf sport field are net emitters of greenhouse gases.

Depending on the type of synthetic turf, the carbon footprints for a typical field vary between 17 and 56 tons of carbon dioxide equivalents per year . The type of infill material plays a major role - organic infills such as wood and cork have lower carbon footprints compared to polymer-based infill materials. The greenhouse gas emissions associated with disposal are especially relevant for crumb rubber, EPDM, and TPE infills. The use of a polyethylene shock pad with organic, sand or no infill instead of crumb rubber, EPDM or TPE infill leads to significantly lower emissions of greenhouse gases both in the production phase and during disposal. High-quality recycling of the components and a longer useful life for infill materials and shock pad can also significantly reduce the carbon footprint of the synthetic turf playing field.

The grass (growing surface) of a natural turf field is considered a flux: growth and decay result in a roughly net zero contribution to climate change[1]. The maintenance (mostly mowing) and nitrogen-based fertilizer requirements, however, both produce greenhouse gases. Fertilizers, in particular, have a significant carbon footprint. Nitrogen in the fertilizers that is not used by grass is consumed by soil microbes that release nitrous oxide (N2O) as a waste product; N2O has 298 times the greenhouse forcing potential of carbon dioxide (CO2).

1 http://globecarboncycle.unh.edu/CarbonCycleBackground.pdf

Recent work suggests that a hectare of manicured "lawn" (as a proxy for a maintained natural turf playing surface) can be responsible for producing approximately 3 tons of CO2 per year[2].

Though difficult to calculate in terms that easily correlate, if one assumes a 20 year life of a synthetic turf field and compares that to the equivalent maintenance period of a natural turf field, synthetic fields are responsible for a greater relative contribution to climate change but the comparison is not as lop-sided as is generally believed:

TABLE 4. LIFECYCLE CO_{2e} EMISSIONS:

	Natural Turf Field	Synthetic Turf field
Carbon equivalent	60 tons[3]	300 – 1,100

The climate change comparison becomes closer when consideration is given to the high utilization of synthetic turf and the potential for synthetic turf to replace natural turf fields in terms of removing natural turf (and converting to carbon absorbing surfaces) or minimizing the construction of new natural turf fields.

TABLE 5. CO_{2e} EMISSIONS BASED ON HOURS OF SPORTS USE PER FIELD:

	Natural Turf Field	Synthetic Turf field
Carbon equivalent (per hour of play)	0.006 tons	0.0085 – 0.0312 tons

Carbon equivalent per hour of play = Annual emissions/annual hours of use

2 WEC279/UW324: What Types of Urban Greenspace are Better for Carbon Dioxide Sequestration? (ufl.edu)

3 Calculated as 30years x 3tons/year

3.5. 6PPD QUINONE REMOVAL

In 2020, 6PPD-quinone was identified as the stormwater chemical responsible for urban runoff mortality syndrome observed in coho salmon. 6PPD-q is also lethal to brook trout, rainbow trout and steelhead. 6PPD is used in the manufacture of and 6PPD-Quinone is created from the reaction of 6PPD and ozone. 6PPD-quinone is considered to enter the environment primarily through tire erosion on roadways where tire particles enter catch basins and ditches through surface runoff.

When tire derived crumb rubber is used as synthetic turf infill, the potential exists for 6PPD-quinone to enter fish-bearing watercourses through the following pathways:

- **Surface Runoff –** when synthetic turf fields are designed for storm water to runoff over the field, either due to heavy storm events or inadequate base drainage, the surrounding surface water collection systems will be exposed to 6PPD-quinone.
- **Infill Migration –** migration of infill off of the field can cause tire-based crumb rubber to be deposited directly into watercourses.

6PPD-quinone removal and mitigation measures include the following:

- Select infills from sources other than tire-derived crumb rubber, especially when synthetic fields are located in close proximity to a watercourse.
- Incorporate infill migration mitigation measures using the methods described in Section 3.2 of this report.
- Design synthetic fields to be vertically draining, with rainfall percolating through the turf and underlying porous aggregate base (rather than surface draining).
- Direct drainage systems that collect runoff from synthetic fields to a bioswale designed to remove a maximum amount of 6PPD-Quinone. Note that research is currently underway in Washington State and British Columbia to determine the optimal bioswale design for 6PPD-Quinone removal.

4. HUMAN HEALTH REVIEW

4.1. CRUMB RUBBER-RELATED HUMAN HEALTH ISSUES

For infill turf products, over 95% of fields incorporate crumb rubber from recycling passenger vehicle and truck tires, which performs well for the majority of sports and is readily available. In addition, use of crumb rubber diverts substantial waste from landfills making it a highly sustainable option. It is also the lowest cost option for synthetic turf infill, by a significant margin. While this product has been used for over 20 years in synthetic turf, in 2014 human health safety concerns were raised in regarding the use of crumb rubber in sports fields. The concerns, which were publicized internationally, originated from anecdotal reports by a Washington State soccer coach who perceived an increase in cancer occurring in female soccer players playing on synthetic turf. These claims were not supported by research conducted by the Washington State Department of Health.

It can be difficult for decision makers and professionals to navigate the large number of studies. Most of these studies have not been peer reviewed and make claims based on standards that are not adopted by the scientific community. The findings in this report are based on the current peer reviewed studies and findings conducted by government bodies including public health and environmental agencies, or studies that have been accepted by government bodies.

No peer-reviewed clinical studies have linked the use of crumb rubber infill (CRI) in recreation products to an increased risk of cancer in humans. Several limited studies have been conducted that are largely consistent in their conclusions regarding the low potential for chemical exposure causing human health impacts from CRI in synthetic turf fields. However, as no clinical studies have been conducted in humans, some uncertainty remains.

In response to public concern from this uncertainty in the United States, the US Environmental Protection Agency (EPA) is leading a study involving research/white paper review and CRI toxicity testing on 40 fields. Other US agencies partnering with the EPA include the Center for Disease Control and Prevention's National Center for Environmental Health/Agency for Toxic Substances and Disease Registry (CDC-NCEH/ATSDR), and the US Consumer Product Safety Commission (CPSC). To date, the EPA and their partners have released "Part 1 Report on Tire Crumb Rubber Characterization (July 2019)" summarizing their research. The report stated:

- In general, and not unexpected, the study found a range of chemicals (metals and organic compounds), and all fields tested positive for bacteria.
- Chemical concentrations are generally similar to those found in other studies where these exist
- Bacteria were found at levels similar to those previously reported on common household products.
- While a range of chemicals are present, air emissions of most organic chemicals, and bioaccessibility of metals are low.
- Human exposure to the chemicals in the tire crumb rubber appears to be limited based on what is released into air or simulated biological fluids

The final phase (Part 2) of the EPA's research has not yet been completed. Part 2 will include potential human exposures to the chemicals found in the tire crumb rubber and will be released along with results from a biomonitoring study being conducted by CDC to investigate potential exposure to crumb rubber.

The European Chemicals Agency (European Union Agency), evaluated the risk of synthetic turf on human health. The following are excerpts of their published findings (2017):

- Based on the information available, ECHA concludes that there is, at most, a very low level of concern from exposure to recycled rubber granules.
- The concern for lifetime cancer risk is very low given the concentrations of PAHs typically measured in European sports grounds
- The concern from metals is negligible given that the data indicated that the levels are below the limits allowed in the current toy safety production legislation
- No concerns were identified from the concentrations of phthalates, benzothiazole and methyl isobutyl ketone as these are below the concentrations that would lead to health problems
- It has been reported that volatile organic compounds emitted from rubber granules in indoor halls might cause irritation to the eyes and skin.

With regards to the European Union's recommendation for crumb rubber testing, it is recommended to conduct heavy metal testing of existing or new crumb rubber infill. The test protocol currently recommended is EN 71-3 (used throughout Europe), which measures the levels of heavy metals found in crumb rubber and compares the levels to maximum limit standards for children's toys. All fields constructed should include CRI testing under EN 71-3.

Provincial Health Authorities have been consulted by local Municipalities concerning potential public health concerns surrounding synthetic turf and crumb rubber infill. Vancouver Coastal Health's current position statement on synthetic turf is: *"Serious health risks, including cancer, are not increased from playing on synthetic turf fields with crumb rubber infill" and "there is no public health reason for discontinuing the use of synthetic turf"*

4.2. SYNTHETIC TURF HUMAN HEALTH CONTACT-RELATED RISKS

The following potential contact risks from synthetic turf have been evaluated: skin abrasion, skin infection, eye contact, inhalation, ingestion, and chronic health effects.

SKIN ABRASION

Dermal abrasion resulting from contact with the playing surface (i.e. turf burn) is a risk factor for athletes participating in contact sports. The first generation of synthetic turf (i.e. 'Astroturf') was a dense, non-infilled carpet-based system. Athlete skin contact with these first-generation playing surfaces often resulted in high rates of dermal abrasion (Dragoo and Braun, 2010). Current third-generation synthetic turf systems generally have longer fiber pile lengths, contain infill material and are much less abrasive than earlier generations of synthetic turf. In spite of advancements in synthetic turf, athlete contact with turf can result in increased dermal abrasion compared to contact with natural turf (OEHHA, 2010).

To quantify the abrasiveness of synthetic turf, American Society for Testing and Materials International (ASTM) developed the F1015-03(2009) Standard Test Method for Relative Abrasiveness of Synthetic Turf Playing Surfaces. This method determines the relative abrasive index of synthetic turf by pulling friable foam blocks attached to a weighted sled across a playing surface and measuring the resulting weight loss of the blocks. First generation synthetic turf systems have a relative abrasive index of 67, current third-generation synthetic turf systems using crumb rubber infill have relative abrasive indexes of 30-40, and natural turf grass has a relative abrasive index of approximately 20 (McNitt and Petrunik, 2013). It is possible that the substitution of an organic infill for crumb rubber may result in a lower relative abrasive index.

MITIGATION MEASURES

The increased rate of dermal abrasion from contact with synthetic turf can generally be mitigated using protective clothing and equipment (OEHHA, 2010). Furthermore, the abrasiveness of some synthetic surfaces can be reduced by the application of water (ie. sprinklers) which serves to lubricate and reduce friction between the athlete and surface.

SKIN INFECTION HAZARD

There has been concern that the increased dermal abrasion rate resulting from contact with synthetic turf may lead to a higher risk of skin infection, specifically, a risk of Methicillin-resistant Staphylococcus aureus (MRSA) infection. MRSA is an antibiotic-resistant bacterium that can cause serious soft-tissue infections. MRSA is significantly more prevalent among athletes who participate in contact sports than among the general population. MRSA has not been detected in studies analyzing the identity and quantity of bacteria present in synthetic turf athletic fields (McNitt and Petrunak, 2007; OEHHA, 2010; Serensits et al, 2011).

MITIGATION MEASURES

No mitigation measures are recommended due to the lack of detectable MRSA in synthetic turf athletic fields.

EYE CONTACT HAZARD

No information has been found regarding increased irritation or injury resulting from eye contact with synthetic turf fiber or infill. Although it is possible that eye irritation or corneal abrasions could result from contact with the sand component of infill systems, the specification for rounded, dust-free sand should aid in mitigating this risk.

CHRONIC EFFECTS FROM DERMAL CONTACT, INHALATION, AND INGESTION OF SYNTHETIC TURF INFILL

There has been considerable recent concern about potential human health impacts from exposure to heavy metals and carcinogenic polycyclic aromatic hydrocarbons (PAHs) in synthetic turf infill products. A simple and highly conservative method to estimate the potential chronic health effects is to compare the concentrations of total heavy metals and PAHs in infill to the Canadian Council of Ministers of the Environment (CCME) soil quality guidelines (SQG) for residential soil and parkland. These SQGs are highly conservative and are useful as a simple screening method.

The concentration of heavy metals and PAHs expressed as benzo(a)pyrene total equivalents (B(a)P-TEQs) for several infills are compared to their corresponding screening levels in Table 1. None of the organic infills have concentrations of heavy metals or PAHs approaching the screening levels. The concentrations of cobalt, zinc, and carcinogenic PAHs in synthetic butadiene rubber (crumb rubber) exceed the screening levels. The concentrations of antimony and total chromium in a confidential TPE infill also exceed their respective screening levels.

MITIGATION MEASURES

A simple mitigation method is to perform acceptance testing of all infills using the CCME SQGs as screening levels.

4.3. IMPACT ATTENUATION REQUIREMENTS FOR SYNTHETIC TURF

An essential performance characteristic of a synthetic turf athletic field is its ability to adequately absorb player impact with the surface. Impact attenuation is typically referred to as G-max and is defined as a ratio of the maximum acceleration of an impact event to the normal rate of acceleration due to gravity (the higher the G-max, the poorer the shock attenuation performance of the playing surface).

G-max values are measured using the ASTM F355-16e1 Standard Test Method for Impact Attenuation of Playing Surface Systems, Other Protective Sport Systems, and Materials Used for Athletics, Recreation, and Play. This method uses an accelerometer to measure the deceleration of a 20-pound missile dropped from a height of 2 feet onto the field surface. The ASTM F1936-10e1 Standard Specification for Impact Attenuation of Turf Playing Systems as Measured in the Field sets a maximum G-max value of 200 for each of the 10 test points measured on a playing field. The United States Consumer Products Safety Commission (CPSC) has determined that fields with a G-max greater than 200 are unsafe for athletic play, as impact events could lead to life threatening head injuries. The Synthetic Turf Council suggested guideline is that the average G-max value should remain below 165 for the life of the field (STC, 2021).

Typical design specifications for new synthetic turf athletic fields require that the G-max range shall remain between 95 and 130 for the life of the field. This specified range is like that of pristine grass, where the G-max value typically ranges from 90 to 115. The design specifications should require that G-max levels will be tested using ASTM F355 and ASTM F1936 at near substantial completion of the synthetic turf field, and at the completion of years two, four, six, and one-month prior to the completion of year eight. If the results of these tests do not fall within the required G-max range, the manufacturer shall be required to remedy the field to the satisfaction of the owner.

A proposed maximum G-max value between 95 and 130 for the lifetime of the field is protective of human health from impact events. Additionally, regular maintenance activities such as field brushing, and infill maintenance plays an essential role in keeping the surface hardness of the field within acceptable values.

4.4. SYNTHETIC TURF HEAT-RELATED HUMAN HEALTH ISSUES

Based on a review of available literature, the potential human health issues from exposure to extreme heat on synthetic turf have been evaluated and are outlined below. Synthetic turf with crumb rubber infill becomes hot when exposed to direct sunlight and strategies have been developed to mitigate heat-related human health effects (STC, 2013). Studies have shown that the use of organic infills are effective at keeping field temperatures up to 19 ºC cooler than a field with a crumb rubber infill.

High ambient temperatures are rare in the cool microclimate surrounding Vancouver. In the uncommon event of high ambient temperatures and strong sunlight, the option exists to water the field for both direct and evaporative cooling. If watering the field is not effective in lowering the temperature of the synthetic turf, the recommended option users could/should be made aware of the potential for heat-related injuries such as heat stroke, and if needed, to cease activities on the synthetic turf until the temperature is cooler.

5. ALTERNATIVES TO NATURAL TURF

This section has been provided to add context to the discussion comparing environmental and health impacts of natural and artificial turf types. It explores the question: if playing time could be accommodated and there was leftover ‘space’, what use would contribute to open space / recreational opportunities and yield environmental benefits?

As noted in the previous section, natural turf has environmental drawbacks.

“Lawns” (as a proxy for natural turf surfaces) are viewed as a social good, representing social status, prosperity, and organization. As a result, “urban greenspace” is currently dominated by short, mowed natural turf, maintained to prevent the return of natural flora that would return if left to its own devices (Engles, 2016).

Lawns cover approximately 30 million acres in the United States alone (Kaufman, 2002), at the expense of a number of other landscapes. The pros and cons of a maintained, natural turf lawn, which includes natural turf sports fields are indicated below:

TABLE 6. PROS AND CONS OF A MAINTAINED NATURAL TURF LAWN

Cons	Pros
• Not wildlife friendly • High maintenance (physical labour, significant potable water use) • Hard to grow in shade and in low water conditions • Water/soil contamination from lawn chemicals • Pollution and cost of gas powered lawn mowers	• Pleasant to play on • Looks nice – uniform colour/texture • Filters dust/pollen • Prevents soil erosion & reduces runoff

Alternatives to maintained lawns include:

- **Meadows/Prairies –** These contain a mix of native grasses and wildflowers. Meadows typically contain more "cool-season" species that grow in cooler spring and early summer; Prairies contain more "warm-season" species that grow when soil and weather are warm. However, many of the same species are found in both prairies and meadows. Perennial meadow grass usually takes 2-3 years to establish deep root systems, but is essentially maintenance free after 3 years.
- **Unmown Lawn –** Allowing existing grass to grow (with cutting up to once or twice per summer) can allow existing plant community to increase in height/flower cover but depends on diversity of existing flora (Norton, et al., 2019).
- **Verge garden –** Converting lawn space, between the sidewalk and the road, to a garden filled with native, low growing, water conscious plants (Ignatieva, et al., 2020).
- **"Woody meadows" –** Converting lawn space to low-growing native herbaceous and lower shrub species to create a naturalistic meadow. Requires little to no ongoing maintenance such as irrigation or mowing (Ignatieva, et al., 2020).

Meadow/Prairie - Hand Hills Ecological Res

Unmown Lawn

Verge garden

"Woody Meadow"

Compared to lawns, these communities:

- **Support Greater Biodiversity:** The above lawn alternatives provide food and cover with increases seen across all trophic levels (Plant, invertebrates, soil microbial communities, insects, pollinators, small mammals, birds etc.). This also helps prevent invasion of nonnative microbial and invertebrate species.
- **Improve Soil Quality:** Increasing the height and species diversity can alter the composition of soil microbial and invertebrate communities in abundance, richness, and biomass (Norton et al., 2019). Allowing plants to grow taller facilitates more nitrogen uptake which lowers soil nitrogen and increases the suitability for a wider range of vegetation (Norton et al, 2019).
- **Provide Habitat for Small Mammals:** Small native rodents, such as shrew and meadow mouse, are under pressure in urban environments and many are at risk. (Sullivan, K.L., 2005). Allowing the vegetation to grow taller, and/or providing a greater variety of plant species that have different growing seasons can increase habitat for these small mammals throughout the year.
- **Increase Pollinator Number and Health:** Plant species found in meadows / prairies may be selected and planted at specific times of the growing season to support a wider range of native pollinators. Native pollinators include insects such as butterflies, bees, and beetles, and animals such as birds, bats and other small mammals.
- **Require Less Water / Can Grow in a Wider Range of Conditions:** Lawn alternatives include more drought/flood tolerant species. According to the U.S Environmental Protection Agency 30-60% of urban fresh water is used on lawns. Studies from arid zones of the United States have revealed that lawn used up to 75% of the total annual household water consumption (Ignatieva, 2020). Turf requires two to three times the water of a sustainable mixed landscape (EPA 2021).
- **Better as a Flood-Protection Measure:** Meadows include plant species that are more effective at absorbing stormwater and aiding in flood prevention than natural turf lawns. Plant specifieds found in meadows often provide a more extensive root system and looser soils which allows increased rainwater infiltration. The benefits of increased rainwater infiltration include prevention of water loss through evapotranspiration and recharging groundwater supplies (Lotze, 2017).
- **Reduce Contributions to Climate Change:** A gasoline powered lawn mower produces as much pollution from CO_2 emissions in one hour, as a new car does in thirty hours (Kaufman, 2002). Opting to provide unmown lawns, meadows/prairies, and other alternatives therefore reduce CO_2 emissions.

6. SUMMARY

6.1. COMPARING SYNTHETIC TURF AND NATURAL TURF

As indicated previously, natural turf is generally considered a preferred sports surface, assuming natural turf fields are available, in suitable condition for play and are well maintained good quality natural turf. Due to high user demand, Vancouver's wet climate and current field inventory, synthetic turf surfacing is a key tool that enables the Park Board to meet user needs for sports fields and optimize natural turf field conditions by minimizing damage due to overuse and use during poor weather conditions.

The following table summarizes some of the major differences between natural turf and synthetic turf surfaces:

TABLE 7. DIFFERENCES BETWEEN NATURAL TURF AND SYNTHETIC TURF SURFACES

Considerations	Synthetic Turf	Natural Turf
Environmental	Urban heat source, hotter surface temperatures in summer Manufactured product Contains microplastics (turf/infill)	Not an urban heat source, cooler surface temperatures in summer Fertilizers required Pest and weed control measures required Natural product
Water Consumption	Low water consumption	High water consumption
Stormwater	Stormwater management measures needed to meet City requirements	Some reduction in runoff volume due to soil absorption (as compared to synthetic turf) Stormwater management measures needed to meet City requirements
User Safety	Safe surface if well maintained Consistent playing surface Can be hot for players in summer More abrasive than natural turf	Safe surface if well maintained Often inconsistent playing surface Subject to dogs digging
Maintenance	Lower maintenance	High maintenance

Considerations	Synthetic Turf	Natural Turf
Construction Cost	High capital cost	Medium capital cost
Life Cycle	Field infrastructure – 30 years Turf, Infill – 8 to 10 years Shock Pad – 25 years End of life disposal for turf. Shock pad can be recycled, infill re-used	Field infrastructure – 30 years Natural turf surface (rootzone) – 30 years
Utilization	High utilization (4 to 6 times > natural turf) More effective use of land, parking and amenities Annual Usage - 3,000 hours/field Year-Round Use	Low utilization Requires larger land space for same annual use as synthetic turf field Annual Usage – 200 to 600 hours/field 6-8 months/yr Periodic seasonal closure for resting and grass recovery
Public Perception	Concerns about human health impacts Considered ‘fake’ grass	Well perceived by public

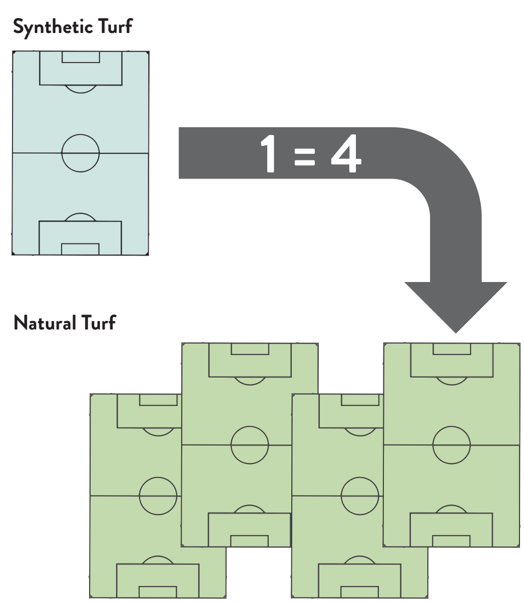
Considerations	Synthetic Turf	Natural Turf
User Group Perception	Well received by majority of users in all weather conditions High demand Very minimal interactions with dog owners due to off-leash activity on field	Well received in good weather conditions In demand but limited availability Negative interaction with dog owners allowing off leash activity on field
Community Access	Limited (Bookable/Allocations)	Available (Pending Field Classification)
Human Health Risks	Low	Low
Habitat Value	None	Low

The design and product development of synthetic turf is continually evolving, as manufacturers seek to better respond to user group, regulatory and owner/operator requirements. Accordingly, the information contained herein is based on current technology and industry standards, which are anticipated to change in the future.

Improved technology and maintenances practices for natural turf fields is also evolving and includes more water efficient irrigation, low emissions/electric maintenance vehicles and low impact pest and weed management practices.

The comparative components indicated above can be used to form an evaluation matrix to compare material needs and best use on a case by case basis.

1 SYNTHETIC TURF = 4+ NATURAL TURF FIELDS IN BOOKABLE HOURS OF PLAY



6.2 SUMMARY OF KEY FINDINGS AND RESEARCH THEMES

Key findings with respect to the environmental and human health aspects of synthetic turf and natural turf are summarized below.

- Natural turf consumes high amounts of water for irrigation – between 1.4 and 2.7 million gallons per year. Synthetic turf fields are not irrigated and therefore consume no water except in exceptional circumstances (ie. dedicated water-based field hockey pitches).
- Due to the high utilization of synthetic turf (at least 4 times annual hours of use as natural turf), the overall Park Board-wide development footprint allocated to sports fields could be reduced (ie. fewer sports related parking lots, washrooms, number of fields, etc.) allowing for additional opportunities for use of park land.
- Synthetic turf provides an opportunity to relieve natural turf fields from overuse and allows for extension of use into the wet season. This allows for increased opportunities for sport and physical activity.
- Natural turf sports fields are a highly maintained mono-culture providing relatively poor habitat value.
- Both natural turf and synthetic turf fields require stormwater management measures to meet Vancouver's runoff quantity and quality requirements.
- Both synthetic turf and natural turf sport fields are net producers of greenhouse gases.
    - » Synthetic turf produces on average between 17 and 56 tons of carbon emissions per year. The range is due to some synthetic turf systems having a lower carbon footprint than others.
    - » Natural turf produces approximately 3 tons of carbon dioxide per year.

- While natural turf itself is generally net neutral (it grows and dies back annually) carbon emissions associated with both mowing / maintenance machinery and fertilizers mean that natural turf fields are net contributors to climate change
- Well maintained and properly constructed natural turf and synthetic turf fields both provide safe surfaces for sport.
- To date, no peer reviewed clinical study has concluded synthetic turf fields cause an increase in cancer or other negative human health impacts.
- Vancouver Coastal Health's current position on synthetic turf is "Serious health risks, including cancer, are not increased from playing on synthetic turf fields with crumb rubber infill" and "there is no public health reason for discontinuing the use of synthetic turf"
- Synthetic turf generates microplastics that can be significantly mitigated through capture systems and maintenance best practices.

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VANCOUVER
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