Department of
Local Government, Sport
and Cultural Industries

GOVERNMENT OF WESTERN AUSTRALIA

Natural Grass vs Synthetic Turf Study Report

The use of synthetic turf playing surfaces is becoming more popular in Australia and internationally.
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Tags

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An organisation's (sport club, association, local or State Government) decision to have a natural grass or synthetic turf comes down to their specific objectives for environmental, social, health and financial outcomes.

In addition to the **Decision Making Guide** (/sport-and-recreation/facility-management/natural-grass-vs-synthetic-turf-decision-making-guide), the following is a detailed report on natural grass vs synthetic turf for bowls, tennis, hockey, soccer/rugby, ovals (football/cricket) and/or any relevant multi-purpose facilities, that the department and other key stakeholders can use to assist with decision making, policy and planning. The report will consider the factors that contribute to the choice of playing surface, in terms of performance, safety and playing facility requirements for the above sports.

In addition to details on the specific sports, the current knowledge on environmental, social, health and financial implications of synthetic turf compared to natural turf will be presented in detail.

Disclaimer

The information in this guide was published in 2011 and cannot be relied upon as professional advice concerning the decision as to natural grass v synthetic turf. No assurance is given as to the accuracy of any information contained in this guide and readers should seek more up to date information prior to making a decision. Readers should obtain their own independent and professional advice in relation to their project.

Background and glossary

Natural grass

Traditionally sport has been played on natural grass surfaces. As towns and cities were established natural grass sports surfaces were developed on open space sites set aside for recreation. The nature of the sporting activity determined the requirements for the sports ground, in relation to size and surface characteristics.

The construction of natural grass sports surfaces has varied according to the site, and in many cases, sports grounds have been developed either, on original soil, fill sites with poor quality imported soil or in some cases old landfill or drainage sites

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which can be prone to sinkage. As a result, the quality of natural grass sports grounds is variable, particularly in winter months or following high rain fall events.

In the last 20 years as the profile of sport has increased, particularly at an elite level, the expectation and standards for sports ground quality have also increased. The main drivers for higher standard of sports grounds are;

- Increased professionalism with significant financial benefit available for elite athletes
- Increased exposure through media coverage
- Increased sponsorship
- Continued technological advancements; and
- Increased awareness of player safety.

First class and international sports venues must comply with stringent standards in relation to the quality of the sports ground surface. These standards can be accessed on the various state, national and international sporting governing body's websites (refer to acknowledgments and further information for further details).

The impact of this on local sports grounds is the increased expectation of sporting clubs and associations, in relation to the quality of sports grounds across the sector. Ground management authorities, including local government, schools, clubs and associations, are under increased pressure to provide high quality sports grounds in an environment where participation rates are increasing for some sports and access to open space is decreasing. Whilst it is not always possible to provide elite standard facilities, sports grounds must be 'fit for purpose' for the designated activity.

Whilst specific requirements for individual sporting codes will be discussed later in this report, a general discussion on the major considerations in relation to natural grass sports surfaces follows.

Construction (soil profile)

The aim of natural grass sports ground construction is to produce a turf surface that is 'fit for purpose' for the designated activity. Construction standards for elite and premier surfaces are higher than those for local sports grounds.

Elite sports grounds

Elite sports grounds are constructed using an imported sand profile over a drainage layer with sub-surface drainage installed. Such construction is limited to elite venues, which are used for national and international grade sport or smaller areas such as golf or bowling greens.

Premier sports grounds

Premier sports grounds are constructed using an imported sand profile over a natural sub-base with sub-surface drainage installed. Such construction is used for high grade and state level sporting venues.

Local sports grounds

Local sports grounds are constructed using natural soils, where possible, with amendments incorporated if necessary. Generally surface slope is used for surface drainage. Where drainage becomes a problem sand slit drains can be incorporated to improve drainage.

For further information refer to sport specific requirements.

Natural grass species

The desirable characteristics of grass species for sports grounds are drought tolerance, wear tolerance, a consistent leaf density and good recovery rates.

Natural grass species can be divided into two types;

- Warm season (Kikuyu – Pennisetum clandestinum/Couch – Cynodon sp.)
- Cool season (Rye – Lolium sp./Fescue – Festuca sp.)

The warm season grasses have a creeping growth habit with horizontal stems growing above the ground (stolons) and below the ground (rhizomes) which provide good recovery characteristics. Warm season grasses can be established using seed, vegetative cuttings (stolons) or sods. Seed or stolons require several months and up to a year respectively to establish prior to use. Laying of sods, whilst more expensive, is quicker to establish and can be used within weeks of laying given the right conditions. The growing season is spring, summer and autumn with peak growth stages in the hotter summer months. Both Kikuyu and Couch provide a consistent leaf density, they are drought tolerant and have good wear tolerance. However, winter dormancy results in limited recovery from damage or wear during the cooler months, which is the period when grounds are subject to most wear.

Cool season grasses (Rye/Fescue) have an upright tufted growth habit relying on tillering from individual plants for growth and recovery. Cool season grass can be established using seed or sods. Seeded sports grounds require several months and up to a year to establish prior to use. Laying of sods, whilst more expensive, is quicker to establish and can be used within weeks of laying given the right conditions. The peak growth season is spring and autumn with reduced growth in winter. Whilst rye and fescue grass does not actually have a dormant period, they require significantly more water to sustain healthy growth in summer and are not drought tolerant. Where turf has declined due to wear, recovery requires over sowing as the individual grass plants must be replaced.

Kikuyu or Couch sports grounds can be over sown with rye grass to provide improved winter wear tolerance. However, it is necessary to eradicate the rye in spring. This practice is costly and is usually done only on premier sports grounds.

At a 'local' sports ground level the desired grass species are either Kikuyu or Couch grass. It is important that the grass quality is maintained to a high level with a consistent dense coverage going into winter dormancy so the grass can withstand winter wear. Whilst recovery from excessive wear in winter may be slow, the grass will recover during spring and summer. Where natural grass quality deteriorates this has an impact on surface quality with the development unstable, loose or uneven areas leading to divots and pot-holes resulting in twisting or trip hazards.

Natural grass turf maintenance

In order to maintain the grass turf to provide an acceptable, 'fit for purpose' facility, a sound turf maintenance program should be implemented aimed at maintaining turf health, soil structure, and surface levels. A turf maintenance program includes the following:

Mowing

Turf should be cut with a cylinder mower weekly during spring and summer and fortnightly during the colder months when grass growth is slower. Height of cut should generally be between 15-25 mm for warm season grasses and 25-40mm for cool season grasses.

De-compaction

To maintain soil structure, de-compaction works using a mix of deep coring with hollow tynes in spring (verti-drain) and deep slicing (earthquake) in Autumn. Varying the de-compaction methods will ensure that a hard pan is not created within the profile.

Sodding

Areas that suffer excessive wear may require sodding in order to maintain acceptable turf and surface quality. Areas such as goal squares and cricket pitch run-ups are particularly susceptible. Maxi-sods which are 600mm wide are preferred. Unless sods are grown on a sandy soil they will require coring with the addition of sand top-dressing to ensure drainage through any imported clay loam soil.

Top-dressing

To maintain surface levels, sports turf should be top-dressed, concentrating on heavy wear areas such as the centre corridor and goals, in early spring following the winter competition season. Top-dressing material should be of high medium to coarse sand with hydraulic conductivity of > 100mm/hr and pH of between 6.0–7.0. Top-dressing rates are between 100–150 tonnes per hectare concentrating on the centre corridor and high wear areas. Top-dressing should follow sodding and coring to ensure the sand is incorporated into the root zone of the soil profile.

Weed/pest/disease control

It is generally not necessary to implement a proactive weed, pest and disease control program for local sports grounds. Rather where weeds, pests or disease are identified specific action will be required.

Irrigation

Irrigation schedules over the summer months should replace soil moisture lost through evapotranspiration. A base irrigation schedule is developed using average climatic conditions and irrigation system application rates to ensure adequate irrigation is applied without wastage. The schedule needs to be adjusted for weather variations. As a guide the irrigation requirement for warm season turf using average climatic conditions in Perth is between 5,500kL-6,800kL per hectare.

Thatch control

Excessive thatch can be detrimental to turf health and should be minimised. The usage schedules will thin turf and thatch can be controlled with close mowing and sound irrigation programming. Where thatch levels become a problem dethatching or scarifying is required.

Fertiliser

Healthy natural grass requires correct nutrition to provide the necessary food for the plant to grow. Laboratory soil tests should be done annually to determine soil nutrient status and enable amendment fertiliser program to ensure chemical balance within the soil. This is coupled with an ongoing maintenance fertiliser program providing the major nutrients of Nitrogen, Phosphorus and Potassium.

A natural grass sports surface provides an asset to a community which is alive and self-renewing given sound management. Being a natural surface it is subject to many variables and the quality of the surface is impacted by the quality of construction, maintenance regimes, weather and usage rates. Full lifecycle costings for specific

natural grass sports surfaces for individual sporting codes are provided later in this report. [1] For further information on Natural Grass Surfaces Management refer to acknowledgments and further information.

Synthetic turf

History of synthetic turf

Synthetic turf was first invented in the mid 1960's in America. It originally came into existence in the market place to replace natural grass that had difficulty growing in indoor stadiums. The Houston Astrodome was the world's first fully enclosed stadium with a synthetic turf field. This field was not much more than green plastic indoor-outdoor carpet, however, it was praised for its visual appeal and playability and as a result, synthetic turf fields were soon under construction across America.

Despite a growing number of complaints from teams and players about various injuries occurring on the fields for most of the next decade, little change was made to the original turf design. Many of the USA stadiums that tried synthetic turf around this time, including the Houston Astrodome, all eventually returned to natural grass.[2]

However by the mid-1970s these first generation synthetic turf pitches (low-pile height, high-density of fibres) had improved to the point where a synthetic turf pitch was successfully used for the hockey tournament at the 1976 Olympic Games in Montreal. Made of nylon (polyamide) yarns, first generation pitches were coarse and capable of causing friction burns and wounds unless they were played on when they were wet - as per the hockey model. This model did not suit a number of sports including soccer, baseball and American football[3] so the uptake of synthetic surfaces in these sports was slow.

Improvements in synthetic turf technologies continued over the next decade but it wasn't until the early 1990's that significant changes were seen, with the introduction of the third generation turfs. New, revolutionary improvements were happening. Various mixtures of silica sand and/or recycled tires (granulated crumb rubber) were now being incorporated into extremely well-drained synthetic turf fields. The overall playability of the fields was becoming more and more similar to natural grass surfaces.[2]

The use of a softer polyethylene based fibre and the ability of the surface to take a normal stud has resulted in it becoming an acceptable surface for sports such as soccer and rugby. The rubber infill, sometimes with a shock pad for added safety, have made third generation synthetic turf more acceptable for most of the sports where a player might occasionally slide, fall to the ground, or land from height. These third generation pitches are now becoming popular in Australia, and will increasingly be seen in the future being used for Australian Rules football and cricket (outfields), and for multi-sport usage.[3]

Types of synthetic turf

Type according to infill content:

Unfilled

Unfilled pitches were the first type of system implemented for sport. They had short pile height, were dense in quantity and had no infill material. They were often made of nylon, which meant the prototypes were often tough and abrasive. Partly due to the abrasiveness, watered unfilled surfaces were developed and have since been popular for elite levels of hockey.

Filled

With filled synthetic turf systems, the synthetic turf fibres or blades are fully supported or stabilised by the addition of a filling material, such as sand, clay and rubber granules, or a mix of sand and rubber granules. The sand and fibres combine to form the characteristics of the playing surface. Synthetic turf surfaces which are filled with sand only are generally suitable for hockey, tennis, lawn bowls, touch rugby, lacrosse, and soccer (training) and multifunction use.

Dressed

Dressed systems are a derivative of the sand-filled system, and intermediate in their properties and playing characteristics between the traditional filled and unfilled carpets. They can have either:

- a shorter, denser pile than the standard filled system which are considered suitable for hockey, soccer (training), touch rugby, lacrosse and cricket (fielding practice).
- a longer pile which is suitable for soccer, rugby, Australian Rules football and cricket.

Types according to pile height:

Short-pile turf

Short-pile turf is made up of high-density short fibres (between 8-12mm in length) and is used predominantly for cricket pitches or for elite level hockey pitches. The unfilled hockey pitches have, until now, had to be kept wet to improve foot traction, ball speed and heat suppression.

Medium-pile turf

Medium-pile turf (between 20-35mm in length) has traditionally been the hard-wearing sand-filled carpets used for hockey, tennis, lawn bowls and for training level activities in a variety of other sports.

Long-pile turf

Long-pile turf has long blades of fibre similar in height to some natural grass playing surfaces. The long fibres (between 40-65mm in length) provide cushioning and allow for a great amount of infill to be integrated into the pitch adding to the shock absorbency and force reduction characteristics of the ground, and plays more like grass. These fibres can be single fibre or multi-ended yarns (brush-like at the tip), and are proving to be popular for soccer, rugby, Australian Rules football/cricket and golf. The latest development with long-pile turf is the development of even longer fibre carpet (80-85mm, with approximately 60mm of infill material). This is being hailed as the first suitable synthetic turf system for athletics field events including hammer, shot put, discus and javelin.[4]

Maintenance practices for synthetic turf

It is often widely believed that synthetic turf fields require less ongoing maintenance than natural grass. Even though they do not require watering and mowing they do have an extensive maintenance protocol, particularly if used regularly for a multitude of sports events or for elite level sport.

Such maintenance is critical if the surface is to achieve its optimum performance, and full lifespan. Usually the installer's guarantee or warranty will usually be conditional on the recommended maintenance requirements being carried out.

Maintenance practices differ depending on the type of synthetic turf surface installed and it is important to follow the manufacturer's instructions and guidelines. Below is a list of common maintenance practices that are undertaken for synthetic turf.

Cleaning

Sweeping of leaves and other debris from the surface generally needs to be done weekly. If leaves, tree flowers, pine needles and other debris are left on the surface for any length of time they rapidly rot down and form a drainage-inhibiting skin within the surface which can encourage the growth of algae and moss.

Grooming

Grooming the surface is a crucial operation aimed at keeping the mat and texture of the synthetic turf as even and uniform as possible, so as to prevent the deterioration of play characteristics, appearance and drainage properties. Grooming the surface through brushing and/or drag matting lifts the fibres at the surface. It redistributes evenly any sand or rubber that has been disturbed, and counteracts any compaction of the sand and any tendency to form an impervious surface skin which might impair drainage (filled surfaces only).

Moss and algae

In certain situations and in some seasons, algae or moss can become established on the surface. This only becomes a serious problem if it is allowed to become established. Prevention is more effective than cure, therefore, an annual application of moss-killer and/or algaecide is recommended. It is important to check the surface regularly for any signs of moss or algae growth and imperative that affected areas are treated as soon as they become present.

Weed removal

Weeds are not as prevalent in synthetic turf as they are with natural grass but, they do still appear from time to time. It is important to remove weeds as soon as they are noticed to prevent them from spreading. They can either be removed by hand or local areas of infestation can usually be treated with domestic weed killer, however, always check with the manufacturer before using any chemical sprays on the surface.

Stain removal

Most stains can be removed easily with a solution of warm (not boiling) water and a household detergent such as dishwashing liquid. Before attempting to remove heavy soiling and stubborn stains it is important to seek the surface supplier's advice.

Joints and Seams

It is important to check all joints and seams on a regular basis and repair any failures promptly, before loss of any synthetic surface pile or risk to users.

Check and top-up infill levels (filled surfaces only)

High traffic areas such as penalty spots and short corners should be checked daily or weekly, but other areas of the ground infill levels should be checked monthly.

Power brushing

Many (but not all) manufacturers of third generation rubber-filled surfaces now recommend the use of powered brushing machines to ensure that the rubber particles remain mobile and the carpet fibres upright. This operation is

recommended at least every 6 months.

Deep cleaning

Both sand filled, dressed and rubber filled surfaces may in time require a degree of deep cleaning. This will depend largely on the environment and usage levels and should only be performed if surface contamination is suspected, and then only by specialist contractors.[5]

Glossary

Clegg Hammer
Simple to use device consisting of two basic components: a flat-ended cylindrical mass and a guide tube. The mass, i.e. the hammer, is manually dropped from a predetermined height to measure the "stiffness" of natural or constructed soil conditions.

Crumb rubber
Granules of new or recycled rubber materials used for infill or for top dressing on synthetic grass materials.

Dressed pitches
Pitches using a carpet of woven, tufted or knitted synthetic yarn partly supported or stabilised by the addition of filling material (eg. sand and/or rubber granules – generally filled to around 60% of the pile height and therefore sometimes referred to as a sand-dressed pitch).

Evapotranspiration
Loss of water from a land area through evaporation from the soil and through plant transpiration.

Filled pitches
Pitches using a carpet of woven, tufted or knitted synthetic yarn fully supported or stabilised by the addition of filling material (e.g. sand and/or rubber granules). Generally loose laid, not stuck to the layers below (except at the seams).

Impermeable surfaces
Surface that does not allow water to soak through.

Impervious surfaces
Artificial structures such as pavements, roads, sidewalks, driveways and parking lots that are covered by impenetrable materials such as asphalt, concrete, brick, and stone and rooftops.

In-fill
Generally silica sand, rubber granules, or a combination of both, and its function is to support the pile of the carpet, help the pile to remain vertical and contribute to the playing and cushioning qualities of the surface (ball rebound, shock absorption and vertical deformation).

Natural Grass
Natural turf species used for sports ground construction i.e. Kikuyu, Couch and Rye grass.

Pile
The full depth of tufts or loops of yarn which form the carpet.

Pile length
The length of the extended tufts measured from the primary backing top surface to their tips. Pile tuft should be gently extended but not stretched during this measurement.

Polyethylene
Softer type of plastic used for the new generation synthetic turf yarn. It is durable, resistant to staining, can be U.V. stabilised and is currently the most suitable material for synthetic turf yarns.

Polypropylene
Type of plastic predominately used for synthetic turf backing and can also be used for synthetic turf yarn.

Seams
The line formed where two pieces of turf are joined. The action of setting the turf and seaming using one or more methods; adhesives, sewing or tacks.

Shock pad
If required, a shock-absorbing layer is placed over the base, directly under the carpet. It is used to provide a degree of comfort to players underfoot, but also to reduce peak forces for head impacts, and to create defined playing characteristics for specific sports.

Surface run-off
The water flow that occurs when soil is infiltrated to full capacity and excess water from rain or other sources flows over the surface.

Synthetic Turf
Refers to any artificial turf surface used in sports ground construction including unfilled, filled and water-based surfaces.

Third Generation (3G) turf
Introduced in the late 1990s – comprising a longer pile (35-65mm), lower density of fibres infilled with sand/rubber granules or both. Generally loose laid, not stuck to the layers below (except at the seams).

Unfilled pitches
Pitches using a carpet of woven, tufted or knitted synthetic yarn in which the density of the pile is sufficient to maintain yarn vertically without support or stabilisation by other materials, usually needs to be wet to achieve playability.

Volatile organic compounds
Organic chemicals that have a high vapor pressure at ordinary, room-temperature conditions. Their high vapor pressure results from a low boiling point, which causes large numbers of molecules to evaporate from the liquid or solid form of the compound and enter the surrounding air. Many VOCs are dangerous to human health or cause harm to the environment.

Water-based pitches
An unfilled pitch (generally low-pile height, high-density of fibres) most often used for hockey, that is played on 'wet' to help keep the ball on the carpet surface, provide some controlled foot-slide when players need to stop/turn, and to allow players to fall on the surface without risking friction burns.

Yarn
A continuous strand of twisted fibres.

Demand and capacity

Sport participation trends and demand

A key component of determining whether to use natural grass or synthetic turf is the demand for the use of the surface. The seven sports included are either main stream sports in Western Australia or are an emerging sport i.e. rugby union. The

Commonwealth Government, in conjunction with the State and Territory Governments, prepare participation data for a range of sport and active recreation pursuits on an annual basis. This is known as the Exercise, Recreation and Sport Survey (ERASS). ERASS provides participation numbers and rates for a range of sporting activities at national and state levels. Table 1 below highlights the participation levels and rates for each sport in Western Australia from 2006-2010.

Participation in cricket declined in 2007, increased in 2008 before declining again in 2009 and 2010. Australian Rules football tends to be cyclical decreasing in 2007 and 2009 but increasing in 2008 and 2010. Hockey has been increasing in popularity up until 2010 when it dropped off significantly. Lawn bowls has been increasing in popularity from 2006-2010. Rugby union participation like Australian Rules is cyclical. Soccer has increased significantly in popularity from 2007-2010. Tennis declined initially and then increased in 2008-2009 followed by a decrease again in 2010.

This highlights the dynamic nature of sports participation and the need to understand the fluctuations that can occur within individual sports. In addition to statewide trends local factors such as facility provision, club management, availability of volunteer resources, local demographics and marketing techniques all impact on participation rates, and need to be considered when determining the preferred surface type.

Table 1: ERASS Participation Data for WA 2006-2010

Sport played	**2006**		**2007**		**2008**		**2009**		**2010**	
	'000	**%**	**'000**	**%**	**'000**	**%**	**'000**	**%**	**'000**	**%**
Cricket	50.3	3.1	36.3	2.2	58.6	3.5	49.4	2.8	39.0	2.2
Football - Australian Rules	82.3	5.0	48.8	3.0	73.0	4.4	68.4	3.9	96.8	5.4
Hockey	25.2	1.5	28.2	1.7	37.2	2.3	41.7	2.4	24.3	1.4
Lawn Bowls	33.5	2.1	33.2	2.1	33.7	2.0	39.9	2.3	41.4	2.3
Rugby Union	7.2*	0.4*	12.8*	0.8*	10.6*	0.6*	15.1*	0.9*	5.9*	0.3*
Soccer	59.3	3.6	48.8	3.0	73.0	4.4	70.7	4.1	82.6	4.6
Tennis	97.4	6.0	72.0	4.5	90.5	5.5	94.6	5.4	87.1	4.9

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Natural Grass Sports Ground Capacity

The capacity of a natural grass sports ground is the maximum level of traffic/usage that the site can sustain without resulting in a major decline in the turf and surface condition that renders the site 'unfit for use'.

When assessing the capacity of a sports ground two principal considerations are asset management and player safety.

- Asset management refers to the condition of the asset or the sports ground, and in particular, the condition of the turf and surface in relation to the desired condition and intended use.
- Player safety refers to the standard or quality of the turf and surface that is required to safely undertake a specific activity on the site.

Given sports grounds are used for diverse activities and levels of sport, the asset management and player safety standards will vary depending on the activity. It is not necessary for elite sports standards to apply to local level sports grounds. All sports grounds should be maintained to a 'fit for use' standard to minimise the risk to users.

The factors that directly impact on the capacity of a sports ground include;

- Sports Ground Condition
  - Grass species and quality
  - Surface quality
- Weather Conditions
  - Temperature
  - Rainfall
- Type of Usage/Sporting code
  - High Impact (e.g. Football/Rugby)
  - Lower Impact (e.g. Cricket/Athletics)
- Level of Usage
  - Number of registered teams
  - Competition games
  - Training schedule
  - The level or age range of users

Natural grass sports ground condition

When sports grounds are under stress from either, poor nutrition, weed or disease infestation, or compacted soil, turf health and density will be poor. When this is the case the surface will become unstable and unable to withstand ongoing wear from usage.

Weather conditions

The weather has a significant impact on the natural grass quality and its ability to recover from wear. Temperature affects the growth of natural grass with warm season species actively growing in the summer months and cool season species peak growth in spring and autumn. All grasses have reduced growth in the colder winter months with lower recovery rates.

Rainfall also impacts on the wear of natural grass. High rainfall events, in conjunction with high usage, result in deterioration of the soil structure and excessive wear on the natural grass. This is particularly the case in heavy soils during the winter months,

when the natural grass growth and recovery is minimal. Where sports grounds are constructed with either natural or imported sand profiles with high drainage rates and/or subsurface drainage the ability to remove excessive water is increased with a corresponding reduction in natural grass wear.

Rainfall occurring in the colder winter months has a potential high impact on the capacity of the ground particularly where high impact sporting activities such as football (AFL and soccer) are in season.

Type of usage

Different activities have a varying impact on the natural grass surface. Football (soccer) and Australian Rules football are high impact sports with high wear on the centre corridor of the ground. Rugby and hockey, whilst being high impact sports, are spread across the ground and therefore have less impact. Cricket is a lower impact sport with less intensive wear across the ground with the exception of the centre wicket, which has high wear due to the intensity of activity in this area.

Level of usage

The level of usage is one of the main factors which impact on the condition of the natural grass surface of a sports ground and the subsequent capacity of the ground to provide a safe, 'fit for purpose' facility for community sporting activities.

The number of registered teams, competition games and training schedules will impact on the natural grass and surface condition of a sports ground. Issues such as significant deterioration of natural grass quality lead to bare areas and a reduction in surface quality that may, in extreme cases, render the ground 'unfit for use' and result in ground closures or restricted usage.

The number of participants and the number of games held on the site impact on the level of wear of the natural grass. Training also has a significant impact on natural grass wear, particularly where it is concentrated in localised areas of the ground. The level or age range of users also has a varying impact on natural grass wear. For the same activity senior teams tend to have a greater impact than junior teams.

Work has been done in developing benchmarks for sports ground usage using the 'IPOS – Sports Ground Usage Model'. Using data in relation to the number of competition games and training schedules, usage rates are determined on the basis of "person hours per week".

Different sporting codes and venues have different playing field sizes which result in varying wear impacts. The same number of person hours usage will have a higher impact on a smaller playing field. In order to standardise information so that comparison can be made for different sporting codes and venues the measure or 'Sports Ground Usage Index' used to assess sports ground usage is 'metre square per person hour per week' (m^2/phr/wk).

This criteria has been developed as it reflects the number of hours the ground is used, the number of persons using the ground per week and the size of the field. It also provides a standard measure or 'Sports Ground Usage Index' that can be compared across sporting codes and for various sized sports grounds.

Benchmarks have been developed for football (AFL and Soccer) as follows.

Table 2: Sports Ground Usage Rate Benchmarks - Football (AFL)

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No of Teams	Sports Ground Usage Rates (Adj Person Hr/week) (AFL - 16,000 m2)	Sports Ground Usage Index (m2/Person/hr/week) (AFL – 16,000 m2)	Usage Comment
> 5 Jnr / 5 Snr	>750	<20	**Extremely High**
5 Jnr / 5 Snr	450 - 750	21 - 35	**High**
4 Jnr / 4 Snr	300 - 450	36 - 50	**Moderate**
3 Jnr / 3 Snr	200 - 300	50 - 70	**Moderate - Low**
2 Jnr / 2 Snr	< 200	> 70	**Low**

Table 3: Sports Ground Usage Rate Benchmarks - Football (Soccer)

No of Teams	Sports Ground Usage Rates (Adj Person Hr/week) (Soccer - 7,000 m2)	Sports Ground Usage Index (m2/ Person/hr/week) (Soccer - 7,000 m2)	Usage Comment
> 5 Jnr / 5 Snr	> 350	<20	**Extremely High**
5 Jnr / 5 Snr	200 - 350	21 - 35	**High**
4 Jnr / 4 Snr	140 - 200	36 - 50	**Moderate**
3 Jnr / 3 Snr	100 - 140	50 - 70	**Moderate - Low**

2 Jnr / 2 Snr	< 100	> 70	**Low**

Sports ground usage and capacity measures are indicative only and can be used to compare usage levels and capacity between sports grounds or to determine management strategies for a given venue.

There are many variables that may further impact on capacity that may be unknown or not measured. These include the impact of:

- unstructured community use;
- unauthorised structured use;
- intensive localised training under lights and near the club rooms; and
- intense rainfall events.

There will always be a need to inspect, monitor the performance of the sports ground and liaise with the sports club or association to ensure that it is 'fit for use' for the designated activity.

Further information regarding Sports Ground Usage and Capacity Measures is available at **www.ipos.net.au** (http://www.ipos.net.au/)

Local climatic and environmental considerations

An additional key component of the decision making process is the local climatic and environmental factors which affect the local region. In particular the water supply, rainfall events and other weather conditions. Western Australia has been experiencing a period of drought conditions and in some areas access to a reliable water supply for irrigating sports grounds has been limited. These considerations are elaborated on below.

Water supply

There are two principle water supplies available for irrigating natural grass sports facilities in Perth. Water Corporation is responsible for "Scheme" water and The Department of Water is responsible for bore water. Reclaimed water, storm water and other alternatives are available for irrigation in varying capacity across the state. Local waste water treatment schemes may be available in regional areas. In some regional areas it is understood that potable water is currently being transported in to maintain sports grounds due to a shortage of water from usual sources.

The majority of natural grass sports surfaces are watered using ground water bores managed by the Department of Water. Licences are issued to users, generally through Local Government. The licence conditions state the quota and conditions of usage. Generally bore water used for irrigating sports fields is allowed on 3 days per week between the hours of 6.00 pm and 9.00 am with further irrigation subject to exemption permit. There is no charge for bore water other than an annual licence fee and pumping costs (as at December 2011). Ground water areas are at their sustainable limit and it is understood that it is unlikely that bore licences will be granted for new users or increased for existing users.

Water Corporation 'scheme water' is available for use for irrigating sports grounds subject to water wise measures similar to the use of bore water. Irrigation is permitted on 3 days per week between the hours of 6.00 pm and 9.00 am with further

irrigation subject to exemption permit. The cost of scheme water for 2011/12 is $1.72 kL with additional charges depending on the size of the water supply metre.

Further and current information on water supply costs, watering times options is available from **Water Corporation (http://www.watercorporation.com.au/)** and **Department of Water (http://www.water.wa.gov.au/)**

Irrigation requirement

The irrigation requirement for both warm and cool season's natural grass, for varying quality of natural sports turf, has been calculated using the models developed as part of the 'Code of Practice – Irrigated Public Open Space'[1].

The 'Turf Quality Visual Standard' (TQVS) classification system was developed in the Code of Practice. The TQVS system has 4 classifications of natural turf and is shown in the table below.

Table 1: Turf Quality Visual Standard Classification System

TQVS Classification	Description	Comment
1	Elite Sports Turf	International/National Level Sport: e.g. WACA, Subiaco Oval, Perth Oval
2	Premier Sports Turf	State/Regional/District Level Sport: e.g. Leederville Oval, Baseball Park, Fremantle Oval
3	Local Sports Turf	Local Level Sports: e.g. local based sports grounds'
4	Passive Recreational Turf	Non-Sports Turf: e.g. Community parks/Passive reserves

The irrigation requirement for elite sports turf is higher than that for premier or local sports turf. Likewise the irrigation requirement for cool season grasses is higher than that for warm season grasses.

High irrigation requirement occurs in conditions where there is least rainfall and high evapotranspiration (Etc). For Perth this is in the warmer months from September to March as illustrated in Figure 1 below.

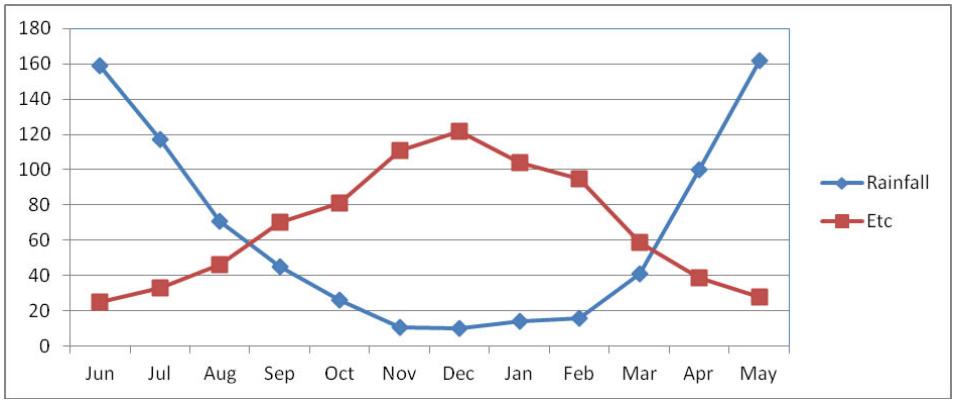

Figure 1: Relationship between Rainfall and Turf Water Requirement

Using climatic data for the Bureau of Meteorology weather station located at Perth Airport, the irrigation requirement for the 4 TQVS classifications of natural grass using cool and warm season natural grass has been calculated and can be seen in Table 2 below.

Table 2: Irrigation Requirements for the 4 TQVS Classification of Natural Grass

TQVS Classification	**Description**	**Irrigation Requirement Cool Season Turf kL / ha**	**Irrigation requirement Warm season Turf kL / ha**
1	Elite Sports Turf	15,840	11,830
2	Premier Sports Turf	9,040	6,780
3	Local Sports Turf	7,520	5,520
4	Passive Recreational Turf	5,990	4,260

Warm season natural grass uses between 35 – 40% less water than cool season natural grass and irrigation requirements for local natural sports turf is approximately 50% less than elite natural sports turf.

Footnotes

1. Handreck, K. A. and Black, N. D. (2001) Growing Media for Ornamental Plants and Turf, 3rd Edition, NSW University Press, Kensington, Australia 2001
2. Target Technologies, 2011. A Brief History of Artificial Turf, **http://www.ttiionline.com/turf_industry_history.htm** (http://www.ttiionline.com/turf_industry_history.htm) viewed August 2011.
3. State Government Victoria, 2011. Artificial Grass for Sport, Sport and Recreation Victoria

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Department of Planning and Community Development, Melbourne, Victoria.
4. State Government Victoria, 2011. Artificial Grass for Sport, Sport and Recreation Victoria
   Department of Planning and Community Development, Melbourne, Victoria.
5. State Government Victoria, 2011. Artificial Grass for Sport, Sport and Recreation Victoria
   Department of Planning and Community Development, Melbourne, Victoria

Sport specific requirements

Different sports have different requirements when it comes to installing a synthetic option. Synthetic turf surface types vary significantly from sport to sport in terms of factors such as pile height, playability, construction methods and material use (infill, shock pads etc).

The study has included analysis of seven sports, with each sport's specific requirement's detailed in the relevant section:

Cricket

History of natural grass vs synthetic turf

Pitch

Synthetic turf pitches have become the preferred playing surface for middle and lower grade cricket competitions over the past two decades.

The preparation of a high standard natural grass cricket pitch requires highly-skilled staff and requires large levels of maintenance in order to obtain the correct speed, bounce, consistency and durability. Many factors are involved in creating high class natural turf cricket pitches and as a result these types of pitches are generally used for higher levels of cricket. It's important for junior development that young players have exposure to natural grass pitches if they are to improve their skills and enhance their chances of progressing through to high levels of cricket.

Outfield

Whilst natural grass is the preferred surface for cricket outfields, there has been advancement in synthetic turf technology and a prototype surface has been approved as meeting the detailed Australian Rules football/cricket outfield specification. Cricket Australia (CA) is satisfied that the potential problem of surface temperature during hot weather is one that is manageable (through their existing heat policies), as is the general all-round performance of the product specification for cricket at all levels. CA believes the new specification is as close as is practical to the performance of natural grass, with excellent rebound and rolling ability of the ball across the surface area.

The Australian Football Leagues's (AFL) and CA's recommendations can be found in the document titled Development of Standards for the Use of Artificial Surfaces for Australian Football and Cricket' written by University of Ballarat in 2008.

Surface type

Synthetic turf

Pitch

Synthetic turf pitches are generally single strips of high-density carpet (9–11mm pile height) without infill glued to a concrete base. During the winter season, if the ground is used for Australian Rules football the pitch is covered with loam or a second sheet of synthetic turf (often a longer pile with much less density of fibres) is laid over the pitch, and the upper layer is filled with rubber granules to provide a cushioning level to counteract the pitch's concrete base.

Outfield

Since the development of the AFL/CA standards for the use of synthetic turf, several new products are being developed to meet those specifications. These products are typically sand-dressed polyethylene carpets normally 40mm high, sitting on a 20mm preformed shock pad. They are dressed with rounded sand grains or crumbed rubber infill to approximately 20mm, leaving approximately 20mm of the fibre blades exposed.

Natural grass

Pitch

Natural grass cricket pitches are constructed using heavy reactive clay which can be worked into a hard surface providing a consistent speed and bounce over multiple days of competition. The grass species is couch grass (Cynodon sp.) cut to between 2–4 mm height. The pitch is rolled using a heavy roller. All the practices used to prepare a turf cricket pitch for play are contrary to good quality grass health. The grass is cut short with minimal leaf remaining and the pitch is rolled, when moist, to provide the required level of compaction. The pitch is then subject to moisture stress during play and provides a concrete like surface which is subject to cracking as it dries over a two to five day period.

The centre pitch table contains a number of pitches which are alternated during the season to enable used pitches to recover over a period of six to eight weeks. Management of natural grass cricket pitches and practice pitches requires a high level of skill, expertise and time.

Outfield

The cricket ground outfield requires a consistent even grass coverage and density. Desirable natural grass species is couch grass (Cynodon sp.) or Kikuyu (Pennisetum clandestinum). Grass should be cut at between 15–25mm and thatch should be kept to a minimum to produce an even true ball roll. The surface must be even and stable, free from pot holes, divots, loose or saturated areas. Surface hardness should be within the desired range of 4–15 CIV (Clegg Impact Value) when tested using a Clegg Impact Hammer.

Competition level

Synthetic turf outfields that adhere to strict CA specifications have been approved for use for all levels below the national and state level leagues around Australia. However, due to the current lack of accredited fields, all games at all levels in Western Australia are currently played on natural grass.

Playing seasons, times and usage patterns

Cricket is a summer sport and is played predominantly on Saturday mornings and afternoons and Sunday afternoons. Training typically occurs during the weekday evenings or during the afternoons for junior players.

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Facility capacity

Synthetic turf cricket pitches are able to sustain significantly more use than natural grass pitches. As the advent of synthetic turf cricket outfields is in its infancy, it can only be assumed that synthetic turf grounds will be able to withstand additional usage in comparison to natural grass, similar to sports such as soccer and hockey. However, cricket is a low impact sporting activity (in relation to the outfield) as it is played when the natural grass is in its peak growth phase and has good wear recovery.

Cricket is a game that is played over a long duration (typically from a few hours up to several days). The capacity of the outfield is limited only by the length of the game and not by the activity itself. The major activity areas are at the bowling run-ups at each end of the pitch. In the case of natural grass cricket pitches the run-ups are rested according to the pitch rotation, this enables natural grass recovery. In the case of hard (concrete) pitches with synthetic turf covering, the run-ups do not get rested. They are often impacted by intensive use and require adequate management to avoid the deterioration of grass and development of pot holes or an uneven surface.

Compatible sports

Natural grass cricket grounds are also used for many other sports including Australian Rules football, rugby and soccer. Synthetic turf cricket grounds are primarily going to be suitable for Australian Rules football and possibly soccer.

Resources

- **Western Australian Cricket Association** (http://www.waca.com.au/)
- **Cricket Australia** (http://www.cricket.com.au/)
- **Development of Standards for the Use of Artificial Surfaces for Australian Football and Cricket.** (http://www.aflcommunityclub.com.au/index.php?id=891) University of Ballarat, Victoria, Australia.

Footnotes

1. State Government Victoria, 2011. Artificial Grass for Sport, Sport and Recreation Victoria
   Department of Planning and Community Development, Melbourne, Victoria.

Football (Australian Rules)

History of natural grass vs synthetic turf

Traditionally Australian Rules football has been played on a natural grass surface. At the National and State League level it is anticipated that the game will continue to be played on natural grass for many years to come. However, in 2008 the AFL in partnership with CA released the criteria for synthetic turf to be used at the community level (community level is described as all football and cricket played below the respective National and State league competitions).

The AFL's and CA's recommendations can be found in the document titled 'Development of Standards for the Use of Artificial Surfaces for Australian Football and Cricket' written by University of Ballarat in 2008.

In February 2011, the first full-sized AFL (and Cricket) oval following the development of these specifications, commenced construction at Point Cook on the outskirts of Melbourne in Victoria. It is anticipated to be completed by the end of 2011. To date, many schools in Victoria have installed 3G synthetic turf fields to replace their natural

grass ovals and have trained on the fields. Additionally, in drought or flood affected areas local junior football clubs have use of the school synthetic turf fields for training when they are unable to use their own natural grass grounds.

Surface type

Synthetic turf

After the standards for the use of synthetic turf were developed for the AFL and CA, several new products were and are still being developed to meet those specifications. These products are typically sand dressed polyethylene carpets normally 40mm high, sitting on a 20mm preformed shock pad. They are dressed with rounded sand grains to approximately 20mm, leaving approximately 20mm of the fibre blades exposed.[1] Due to the inclusion of a critical fall height requirement, the use of a shockpad is essential to satisfy the AFL/CA criteria. The synthetic turf manufacturing industry is endeavouring to balance the thickness of the shockpad with the level of infill to ensure the most suitable surface performance.

Natural grass

Natural grass is the preferred surface for Australian Rules football. Australian Rules football requires a consistent even grass coverage and density. Desirable natural grass species are either warm season (couch grass or kikuyu) or cool season (Rye grass). Natural grass should be cut at between 15 – 25 mm and thatch should be kept to a minimum. The surface must be even and stable, free from pot holes, divots, loose or saturated areas. The surface should be firm but no excessively hard. Surface hardness should be within the desired range of 4 – 15 CIV for local competition and between 4 – 12 CIV for premier and elite levels when tested using a Clegg Impact Hammer.

Competition level

Synthetic turf fields have been approved for use for all levels below the national and state leagues around Australia (including approval for the elite Under 18 TAC Cup). However, due to the current lack of accredited fields, all games, at all levels are currently played on natural grass.

Playing seasons, times and usage patterns

Australian Rules football is a winter sport. Competitions are typically played on Saturday afternoons with some Friday night and Sunday afternoon fixtures. Training occurs throughout the week. Junior games are usually played on Saturday or Sunday mornings.

Facility capacity

As the advent of synthetic turf Australian Rules football grounds is in its infancy it can only be assumed that synthetic turf grounds will be able to withstand additional usage in comparison to natural grass, similar to sports such as soccer and hockey.

As discussed above natural grass surfaces cannot sustain the high levels of use that synthetic turf surfaces are able to and need to be 'rested' from use to enable the natural grass to recover. Current research around natural grass sports ground capacity is being conducted based on the level of use. Indicative results show that more than 10 teams per football oval, is deemed to be high use and may have detrimental impact on the playability of grass, depending upon the season and amount of rainfall. Football is played in winter when wet weather conditions, slow growth rates and recovery of natural grass may reduce capacity. Due to the nature of

the game, it is unlikely that it will be played all year round, particularly in the heat of summer. However, with pre-season training and additional fixtures the football season is extending into late summer and autumn months when grass recovery and capacity is increased.

Compatible sports

At a local competition level natural grass football grounds can be shared with other codes such as cricket, soccer, rugby, hockey, lacrosse, and athletics.

As mentioned previously, the AFL has partnered up with CA to develop joint guidelines for synthetic turf, with the intention that the grounds be developed and shared between the sports. Given that they are traditionally in opposite seasons this partnership should be successful.

There is a significant difference between the carpet system for AFL/Cricket approved grounds and the specification for football (soccer) pitches. The Australian Rules football/cricket version requires a shock pad (a key performance criteria for Australian Rules football is the critical fall height for players), while the FIFA approved surfaces may have rubber granule infill rather than a shock pad. This may limit the capacity of the surface to be used for all three sports.

There are other factors to consider when looking into multi-purpose facilities of a synthetic nature, a major one being the permanence of line markings on the surface. The AFL (at a community level) acknowledges the benefits of multi-purpose fields and is comfortable for the fields to include permanent lines for other sporting codes. It is however important to check with other peak bodies to determine limitations that they may place on multi-use/multi-lined fields. Other factors that need to be considered include fixturing and insurance. [2]

Resources

- " **Development of Standards for the Use of Artificial Surfaces for Australian Football and Cricket (http://www.aflcommunityclub.com.au/index.php?id=891)**". University of Ballarat, Victoria, Australia.

Footnotes

1. State Government Victoria, 2011. Artificial Grass for Sport, Sport and Recreation Victoria
   Department of Planning and Community Development, Melbourne, Victoria.\
2. State Government Victoria, 2011. Artificial Grass for Sport, Sport and Recreation Victoria
   Department of Planning and Community Development, Melbourne, Victoria.

Hockey

History of natural grass vs synthetic turf

Hockey was traditionally regarded as a natural grass field winter game, however there is a strong and accelerating demand for access to synthetic turf facilities for both training and competition at all levels. Hockey was an early adapter of synthetic turf and was the first sport in Australia to start using synthetic turf at the elite level. Synthetic turf has made rapid progress since being first used in the sport and whilst all Elite Premier League games in Western Australia are still played on water based synthetic turf, there is a move toward 'hybrid' and dry synthetic turf at the community

and regional level. Natural grass pitches are still used for a significant proportion of games at both senior and junior levels around the state, with Hockey WA estimating a 50/50 ratio of natural grass v synthetic turf across all levels of competition.

At present 44% of clubs in WA have access to a synthetic turf pitch and where they do have access there is a move to two seasons of competition (summer and winter), allowing hockey to be accessible on synthetic turf pitches all year round. All of the major regional population centres in Western Australia (those of more than 25,000 people) already have a synthetic turf installation, albeit a mixture of sand dressed and wet surfaces. Collectively in WA there are eight synthetic turf installations in the regions and eight in metropolitan Perth. There are two additional synthetic turf pitches scheduled for installation in Perth in the near future, both of them in private schools. This will see only two of the ten metropolitan synthetic turf pitches located on council reserves, whilst all of the country synthetic turf pitches are on council reserves.[1]

Surface type

Hockey prefers shorter length turf in comparison to sports such as soccer, Australian Rules football and rugby union, regardless of whether it is played on natural grass or synthetic turf.

Synthetic turf

There are various types of synthetic turf surfaces available including filled, dressed and water-based surfaces. Synthetic turf yarns are usually made of nylon, polypropylene or polyethylene. The turf carpet can be made in various ways but must meet the International Hockey Federation (FIH) requirements. Three of the more common synthetic turf types used for Hockey are Sand-filled, Hybrid (part sand-filled and part water based, and water based. FIH requirements also include a shock-pad under the synthetic turf carpet. The shock-pad can be constructed in various ways, but an in-situ pad is generally preferred (a hot mix of rubber shreds/crumbs bound with polyurethane and laid using a small highway type paving machine).

FIH's 'standard'[2] category synthetic turf is usually sand-filled or sand-dressed while the 'global'[10]category is water-based un-filled. In a water-based un-filled surface the water is applied through an irrigation system to the surface immediately before play, it reduces the player-to-surface friction, modifies the speed of the hockey ball and cools the surface in hot weather. In order to maintain adequate playing and training conditions, large amounts of water are often required. Due to the significant cost of the high-density unfilled carpet, required irrigation systems, and high water usage, unfilled carpet suppliers are now responding to the call from FIH to develop a dry unfilled carpet that can perform to elite level standard. Recent technology is now focused on producing non-watered, unfilled carpet that can replicate the playing characteristics of watered fields. The major difference is a move from abrasive nylon fibre to softer polyethylene yarn. Several such polyethylene-based installations are being trialled in Australia.[3]


Figure 1: Water-based un-filled synthetic hockey pitch surface and irrigation point

The FIH 'Handbook of Performance Requirements for Synthetic Hockey Pitches – Outdoor'sets out the specifications for approved synthetic turf pitches and certified fields. The typical length for synthetic turf hockey pitches is short pile (8-13mm) for wet dressed and the newly developed hybrid pitches and medium pile (20-35mm) for the conventional sand dressed pitches. Synthetic turf of a pile length of 40mm or greater is unlikely to be suitable for higher level competition hockey although it may be suitable for junior, school and social level hockey.

Natural grass

Hockey requires a consistent even turf coverage and density. Desirable natural grass species is couch grass (Cynodon sp.) or Kikuyu (Pennisetum clandestinum) Natural turf surfaces should be cut at between 15 – 25mm and thatch should be kept to a minimum to produce an even true ball roll. The surface must be even and stable, free from pot holes, divots, loose or saturated areas. Surface hardness should be within the desired range of 4 – 15 CIV when tested using a Clegg Impact Hammer.

Competition level

The 'Hockey WA Fact Sheet for Competition' outlines the structure of the hockey competition in WA and provides information on which games are played on natural grass and on synthetic turf, in summary they are as follows:

- Premier League Elite Turf – This is the highest level of club Hockey in WA and all games are played on synthetic turf with preferential days and times (such as Saturday/Sunday afternoons).
- Provisional League Turf – This is for non-elite players and teams who prefer synthetic turf to natural grass surfaces and all games are played on synthetic turf generally on less favoured days and times (such as Saturday evening).
- Metropolitan League Grass – This is for players that prefer grass hockey and all games are played on grass on regular days and times (such as Saturday afternoons). [4]
- Masters Grade –Midweek competition is played on synthetic turf and the weekend competition is played on natural grass.

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- Regional Competitions – associations with synthetic turf pitches tend to play games throughout the weekend starting on Friday nights and associations with natural grass tend to play traditional times such as Saturday afternoons.
- Juniors – Hockey WA has a 'Junior Turf Policy' that states the percentage of games each year group and grade should ideally play on synthetic turf. [5]

Playing seasons, times and usage patterns

Hockey is historically a winter sport, with the increase of the provision of synthetic turf pitches around the state, there is a shift to two seasons of competition, leading to hockey becoming a year round sport in many areas of Western Australia.

Facility capacity

Synthetic turf pitches are capable of sustaining greater use than natural turf pitches. Essentially, synthetic turf pitches can be programmed to be used 7 days a week. Intensive sustained use of synthetic turf will reduce its overall lifespan. High traffic areas around the goals and the centre corridor will tend to deteriorate more quickly for both natural grass and synthetic turf pitches. Natural grass pitches cannot sustain the high levels of use that synthetic turf pitches can and need to be 'rested' from use. Research around natural grass sports ground capacity is being conducted

and based on the level of use indicative results show that 10 teams per hockey pitch is deemed to be high use and may have detrimental impact on the playability of grass depending upon the season and amount of rainfall.

Hockey is traditionally played in winter when wet weather conditions and slow growth rates and recovery of natural grass may reduce capacity. If played in summer the capacity of natural grass surfaces would be improved.

Compatible sports

Synthetic turf used for hockey is suitable for a number of other sports, the most common use is for tennis and this is predominantly on sand dressed synthetic turf. Depending on the type and fibre length of the synthetic turf surface other sports that can use the pitch include junior cricket (development level), lacrosse, soccer, gridiron and touch football. However, it is normally at a social or community level as the surface often does not meet the specifications for higher level competition for these sports. Natural turf hockey pitches can also be shared with other sports such as junior cricket (development level), lacrosse, soccer, gridiron and touch football.

Further information

- **Hockey WA** (http://www.hockeywa.org.au/)
  Hockey WA, 2009. State Sporting Strategic Facilities Plan 2009-2025
- **Hockey Australia** (http://www.hockey.org.au/)
  FIH, 2008. International Hockey Federation Pitch Facilities Guide, Hockey Australia
- **International Hockey Federation** (http://www.fih.ch/en/home)

Footnotes

1. Hockey WA, 2009. State Sporting Strategic Facilities Plan 2009-2025, CCS Strategic Management in Association with Geografia
2. FIH Standard category pitches are satisfactory for international matches and/or tournaments other than Olympic Games, World Cup, Champions Trophies and their respective qualifying tournaments.
   FIH Global category pitches are mandatory for all FIH world-level competitions and qualifying tournaments such as Olympic Games, World Cup and Champions Trophies.
3. State Government Victoria, 2011. Artificial Grass for Sport, Sport and Recreation Victoria Department of Planning and Community Development, Melbourne, Victoria.
4. Hockey WA, 2008. Fact Sheet 4 - Competition Structure
5. Hockey WA, 2009. Policy 9.18 Junior Turf Allocation

Lawn Bowls

History of natural grass vs synthetic turf

Due to the high costs of maintaining natural grass greens, lawn bowls was one of the sports to investigate the use of synthetic turf surfaces over 30 years ago. Since then there has been rapid development in the quality of synthetic turf available for the sport and the use of synthetic turf greens has increased dramatically. In Western Australia both natural grass and synthetic turf greens are used at all levels of competition, approximately half of the greens are natural grass and the other half synthetic turf. Bowls WA 'Greens Policy' does not stipulate which type of surface is to

be used for competition but is more concerned that it adheres to the green specifications which include: length of the green, level playing surface, quality of the surface, and green speed.[1]

Bowls WA have seen a shift over the past few years towards synthetic turf, especially for the smaller country and social clubs. Although the upfront cost is generally higher, the ongoing maintenance cost is much lower and it is difficult to find experienced green keepers in some areas to maintain natural grass greens.

Surface type

Synthetic turf

Lawn bowls synthetic turfs can be either tufted woven or needle-punched products. The characteristics of these products are:

- Sand-filled products
    - Tufted products are generally 13-15mm high, and usually made with a Knit-de-Knit fibre yarn which crimps down to 12-13mm, sometimes coming with a cushioned backing. They generally have approximately 8mm of sand infill.
- Non sand-filled products
    - Woven carpets are much lower (generally about 4mm high, but sitting on an underlay to help control both comfort and green speed levels). These carpets are tensioned to achieve a consistent playing surface.
    - Needle-punched products are created by a process of converting batts or webs of loose fibres into a coherent nonwoven fabric on a needle loom. The product is generally 6-9mm high, and also has a 3-9mm underlay. The combined carpet and underlay will usually be in the 9-18mm range.[2]

Bowls WA doesn't stipulate which type of synthetic turf must be used but its greens policy states that the surface must be of uniform colour and is free of tears or other surface irregularities.

Natural grass

Lawn bowls requires a consistent even grass coverage and density. Desirable natural grass species is either hybrid couch (Tift dwarf / Santa Anna) in warm climates or creeping bent grass (Agrostis sp.) in cooler climates. Grass should be of creeping habit and cut closely between 4 – 6 mm. Thatch should be kept to a minimum. The surface must be even and stable, free from pot holes, divots, loose or saturated areas. The surface should be firm but no excessively hard to create a consistent ball roll. Bowls WA greens policy does not stipulate which type of grass should be used, but states there must be good grass cover over all (especially around the mat line) and the grass is of uniform colour and free of weeds. [3]

Competition level

All levels of bowls are played on both natural grass and synthetic turf surfaces depending on which surfaces are available. State and International competitions will have a preference for high quality natural grass, but if this is unavailable then high quality synthetic turf will be used.

Playing seasons, times and usage patterns

Bowls competitions are played throughout the week. Synthetic turf greens allow for play throughout the year. Natural grass greens constructed with high drainage capacity can be used all year round. Couch grass greens do however have a dormant period during winter, when turf recovery rates are slower.

Facility capacity

Synthetic turf bowling greens are able to sustain more usage than natural grass greens. One issue with synthetic turf is the 'heat island' effect in which the high summer temperatures can be more of an issue than natural turf, current research is being conducted by the University of Ballarat on behalf of the City of Melbourne in relation to this issue on a soccer field and it is anticipated that the outcomes will be transferrable to other sports using 3G synthetic turf surfaces.

Compatible sports

Both natural grass and synthetic turf bowling greens, primarily due to their dimensions and relatively small size, are typically not compatible with other sports, at the moment.

Resources

- **Bowls WA** (http://www.bowlswa.com.au/)

Footnotes

1. Bowls WA, 2010. Policy Statement: Greens Self Assessment (Metropolitan Pennants)
2. State Government Victoria, 2011. Artificial Grass for Sport, Sport and Recreation Victoria
   Department of Planning and Community Development, Melbourne, Victoria.
3. Bowls WA, 2010. Policy Statement: Greens Self Assessment (Metropolitan Pennants)

Rugby Union

History of natural grass vs synthetic turf

Rugby Union has historically been played on natural grass and throughout WA rugby games at all levels are played on natural grass surfaces. There is recognition by the International Rugby Board (IRB) that it is necessary in some parts of the world for rugby to be played on synthetic turf , for example, in Europe, climatic conditions often result in natural grass surfaces becoming badly worn and unsuitable in winter. As a result the IRB has produced the IRB 'Artificial Rugby Turf Performance Specification' to set a minimum standard for synthetic turf playing surfaces which may be used in rugby, offering a solution to those parts of the world where climate or resources make good quality natural grass pitches difficult or impossible to achieve.[1]

It is important to note that this specification for the use of synthetic turf surfaces is a developmental or temporary standard and is currently under review. Rugby authorities are clearly monitoring ongoing developments with synthetic turf and are still seeking to satisfy themselves regarding suitability for the specific demands of their sport.[2]

Surface type

Synthetic turf

The IRB 'Artificial Rugby Turf Performance Specification' stipulates the testing and approval procedures which manufacturers and other entities involved in the installation of synthetic turf playing surfaces must comply with, in order for their products to be approved for use in rugby. This document specifies the use of 3G synthetic turf with pile height 65mm (give or take 2mm) with adequate shock pads installed.16

Natural grass

Natural grass is the preferred surface for rugby. Rugby requires a consistent even grass coverage and density. Desirable natural grass species is either warm season (couch grass or kikuyu) or cool season (Rye grass). Grass should be cut at between 15 – 25 mm and thatch should be kept to a minimum. The surface must be even and stable, free from pot holes, divots, loose or saturated areas. The surface should be firm but no excessively hard. Surface hardness should be within the desired range of 4 – 15 CIV for local competition and between 4 – 12 CIV for premier and elite levels, when tested using a Clegg Impact Hammer.

Competition level

At this point in time all levels of rugby in WA are played on natural grass.

Playing seasons, times and usage patterns

Rugby is a winter sport that is traditionally played on weekends, with training and social competitions typically conducted throughout the weekday evenings.

Facility capacity

As the advent of synthetic turf rugby fields is in its infancy, it can only be assumed that synthetic turf grounds will be able to withstand additional usage than natural grass, similar to sports such as soccer and hockey.

Natural grass rugby fields cannot sustain the high levels of use that synthetic turf fields are able to and need to be 'rested' from use to enable the grass to recover. Current industry research around natural grass sports ground capacity is being conducted based on the level of use. Indicative results show that more than 10 teams per rugby field is deemed to be high use and may have detrimental impact on the playability of grass depending upon the season and amount of rainfall. Rugby is played in winter when wet weather conditions and slow growth rates and recovery of natural grass may reduce capacity. Due to the nature of the game it is unlikely that it will be played all year round, particularly in the heat of summer.

Compatible sports

At a local competition level natural grass rugby fields can be shared with other codes such as junior cricket, soccer, hockey, and lacrosse.

Similar to Australian Rules football grounds, if a synthetic turf surface satisfies the criteria for rugby union, it also satisfies the criteria for soccer. The compatibility of rugby league may be possible although the line markings may be an issue. It has not been found at this point in time that rugby league has any standards on synthetic turf sports surfaces.

Resources

- International Rugby Board (http://www.irb.com/)
- Artificial Rugby Turf Performance Specification - Technical Document (https://playerwelfare.worldrugby.org/?documentid=68) (viewed June 2011)

Footnotes

1. IRB, 2011. IRB Regulation 22 Performance Specification – Technical Document - Artificial Rugby Turf Performance Specification , https://playerwelfare.worldrugby.org/?documentid=68 (https://playerwelfare.worldrugby.org/?documentid=68), (viewed June 2011) (#)

2. State Government Victoria, 2011. Artificial Grass for Sport, Sport and Recreation Victoria
Department of Planning and Community Development, Melbourne, Victoria.

Soccer

History of grass vs synthetic

Traditionally soccer has been played on natural grass and will continue to be played on natural grass at the elite level in Australia for many years to come. The interest in the use of synthetic turf for community level use is growing in Australia and around the world. With changing climatic conditions and an increased demand for high quality pitches Football West recognises the increased interest in synthetic playing surfaces at the community level, and will encourage clubs to look at this as a viable option.

In the 1980's soccer experimented with short piled synthetic turf and found it to be unsuccessful, as the earlier versions were not specifically designed for soccer. The turf was too short and tightly packed and changed the game dramatically.[1] In recent years, soccer has had success with 3G long pile carpet (usually 35-65mm) for their synthetic turf pitches. This new generation of synthetic turf has similar characteristics to natural grass, it has longer more thinly spaced tufts and is usually filled with a combination of sand/and or rubber granules to give bounce. [2]

Surface type

Synthetic turf

Football West has adopted Federation Internationale de Football Association (FIFA) requirements as the basis for approval of synthetic turf pitches for competition matches. Synthetic turf requirements are driven by FIFA recommendations and must be installed by FIFA approved nominated suppliers.

The aim of FIFA's synthetic turf standards is to replicate as closely as possible the playing characteristics of high-quality natural grass.

There are two FIFA recommended quality star levels:

- 1 Star for recreational, community and municipal use; and
- 2 Star for professional use.

The FIFA recommended star levels are only awarded to those synthetic turf pitches which have passed a series of stringent laboratory and field tests. Natural grass in ideal condition is the benchmark for these FIFA test criteria in order to insure highest playing comfort and to constantly improve the quality of synthetic turf soccer pitches.

Every product must first pass laboratory tests to determine its composition and then must be tested for durability, joint strength, climatic resistance, player-to-surface interaction and ball-to-surface interaction. Every installed pitch must then be tested on site.

If the synthetic turf pitch passes all the laboratory tests and all the field tests then it will qualify for one of the two FIFA recommended star levels. The marks will only be given to an installed pitch and not simply to the turf carpet. This is because the underlying base surface is just as important to the playability of the pitch as the turf itself. [3]

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FIFA approved suppliers should know and carry out all of the specific requirements, detailed information can be found in FIFA's handbook of test methods and requirements.

Natural grass

Natural grass is the preferred surface for soccer. Soccer requires a consistent even turf coverage and density. Desirable natural grass species is either warm season (couch grass or kikuyu) or cool season (Rye grass). Natural grass should be cut at between 15–25 mm and thatch should be kept to a minimum. The surface must be even and stable, free from pot holes, divots, loose or saturated areas. The surface should be firm but no excessively hard. Surface hardness should be within the desired range of 4–15 CIV when tested using a Clegg Impact Hammer.

Competition level

All elite level games are currently played on natural grass in Western Australia. A League and International games can only be played on a FIFA approved 2 Star surface, Western Australia does not currently have any 2 Star surfaces.

At the community level the majority of games are currently played on natural grass. Competitions that are affiliated with Football West, at any level, may be played on synthetic turf but they must be to FIFA 1 Star standard. The City of Swan council is currently constructing the first 1 Star synthetic turf soccer pitch in Western Australia which will be available for recreation, community and municipal use.

Competitions that are not affiliated with Football West can be played on any surface. Nationally, there have been W-League (Women's National League) and National Youth League matches sanctioned by Football Federation Australia played on synthetic turf pitches. A-League matches are yet to be played on synthetic turf pitches.

Playing seasons, times and usage patterns

Soccer is a winter sport. Generally competition games are played on weekends, social competition and training occurs throughout the week.

Facility capacity

As discussed above in relation to synthetic turf hockey pitches, synthetic soccer turf is capable of sustaining greater use than natural grass pitches. Essentially synthetic turf pitches can be programmed to be used 7 days a week. Intensive sustained use of synthetic turf will reduce its overall lifespan. High traffic areas around the goals and the centre corridor will tend to deteriorate more quickly for both natural grass and synthetic turf pitches. Natural grass pitches cannot sustain the high levels of use that synthetic turf pitches are able to and need to be 'rested' from use, current industry research around natural grass sports ground capacity is being conducted based on the level of use. Indicative results show that more than 10 teams per soccer pitch is deemed to be high use and may have detrimental impact on the playability of grass depending upon the season and amount of rainfall. Soccer is traditionally played in winter when wet weather conditions, slow growth rates and recovery of natural grass may reduce capacity. If played in summer the capacity of natural grass surfaces would be improved.

Compatible sports

Compatible sports for both synthetic turf and natural grass pitches include community and social level cricket, and Australian Rules football training providing a shock pad is included under the carpet (refer Australian Rules football section

below). Soccer pitches are often incorporated within athletics tracks as Figure 4 below highlights. Hockey, lacrosse, and touch football can also be used on soccer pitches at a local competitive and social level.

Figure 1: Synthetic soccer pitch and community/school level athletics track.

Resources

- **Football West** (http://www.footballwest.com.au/)
- **FIFA** (http://www.fifa.com/)
- Handbook of Test Methods and Requirements
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Footnotes

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Tennis

History of natural grass vs synthetic turf

Tennis is one of the few international elite level sports that is played on a variety of surfaces. The International Tennis Federation recognises the use of several surfaces, including natural grass and synthetic turf. Tennis Australia's court surface policy only

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recognises three surfaces as player development surfaces. These are based on the Grand Slam surfaces and include porous/clay, natural grass and hard court (including cushioned and non-cushioned acrylic variations).[1] Despite synthetic turf not being a supported player development surface by Tennis Australia, it is still widely used and promoted for community and club use throughout Western Australia and nationally. From a state perspective, Tennis WA follow Tennis Australia's surface guidelines for the elite levels of competition but at the community level there are limited restrictions on the type of surface used.

Surface type

The Tennis Australia Court Rebate funding scheme has provided rebates for resurfacing courts in one of the four Tennis Australia approved surfaces (cushioned acrylic, hard court, natural clay or natural grass). The highest rebate is available for resurfacing the courts in the same acrylic surface used at the Australian Open; this has resulted in a high number of courts throughout Australia being resurfaced with this type of surface, since the rebate has been available. It is important to note that rebates are available for natural grass surfaces but no rebate is available for resurfacing a court in synthetic turf or carpet.[2]

Synthetic turf

Sand filled synthetic turf is the most commonly used synthetic turf for tennis, a sand filled surface is a tufted synthetic carpet laid on a base usually constructed of concrete, asphalt or crushed rock. The carpet is filled with sand to occupy the space between the carpet fibres to within about 2mm of the top of the pile. The pile length needs to be a playable length for tennis (generally not longer than 19mm). The use of shock pads underneath synthetic turf (used for various other sports) is not ideal for tennis ball bounce, therefore if the surface needs to be shared with other sports then a compromise using a thinner shock pad has to be reached.

Natural grass

Tennis requires a consistent even turf coverage and density. Desirable natural grass species is couch grass (Cynodon sp.) Grass should be cut at between 6 – 10mm and thatch should be kept to a minimum. The surface must be even and stable, free from pot holes, divots, loose or saturated areas. The surface should be firm to produce an even bounce. Generally tennis is constructed using loam soil type to enable consolidation of the surface and create even bounce characteristics.

Competition level

There are no restrictions on the type of surface used for club competitions and community level tennis in WA. Unlike natural grass courts, synthetic turf courts are not an accredited surface within Tennis Australia's court surface policy and as a result are not to be used for Australian ranking point's tournaments (at senior or junior level).

Playing seasons, times and usage patterns

Tennis is historically a summer sport, however, synthetic turf and hard court surfaces permit tennis to be played all year round. Tennis is played mid week and weekends, traditionally on a Saturday, but as with many sports, competitions are held throughout the week.

Facility capacity

Synthetic turf courts are capable of sustaining greater use than lawn courts. Synthetic courts can be programmed to be used 7 days a week. Intensive sustained use of synthetic courts will reduce their overall lifespan. Lawn courts cannot sustain the high levels of use that synthetic courts are able to and need to be 'rested' from use to enable recovery of the turf. Principal wear areas are baselines and centre lines where activity is most intensive. Lawn courts are often unavailable, or have limited use, during the winter season as the grass remains dormant in the cooler conditions. The clubs that do use lawn courts during winter need to manage them carefully and the courts require recovery time after use.

Compatible sports

Natural grass or 'lawn' tennis courts and clay courts are generally not compatible with any other sport. Synthetic turf courts can be used for other sports primarily hockey (see Figure 5) if a suitable shock pad has been installed and sufficient space is provided. Acrylic hard courts at a community level can be line marked for multiple sports such as netball and basketball although multiple court line markings may not be suitable or permitted for competitive tennis use.

Broader environmental considerations

There are many environmental issues that need to be considered when making a decision on a preferred surface. Many factors come into consideration and rather providing advice on which is the more environmentally sustainable choice the information below, is provided as a initial starting point and to help initiate thinking and discussion.

If it is an area that is important in the decision making process then it is advisable to conduct and seek further research and information in this area, as there are many helpful resources available. These are referenced but not fully expanded on within this report.

Synthetic turf is often promoted as being a 'green' alternative to natural grass. The main ecological benefits of synthetic turf that are promoted are:

- Conserves water (research in the US has shown that each full-sized rectangular field saves between 1.8 million to 3.7 million litres of water each year);
- No mowing (mowing, especially large areas of natural grass, use fossil fuels and contribute carbon dioxide into the atmosphere);
- No pesticides or herbicides for pest and disease management are required (reducing harmful chemical inputs)
- Recycled materials are often used (rubber granules are often used in the base of synthetic turf as infill, these rubber granules are usually made from recycled tyres, keeping them out of landfill and reused sandshoe cushioning can be used for the shock pad).[1]

There are other environmental considerations such as water issues, carbon emissions, materials manufacture, maintenance and disposal and the impact on local environments. These need to be taken into account when considering the full environmental impact of each surface. They are elaborated on in the following.

Water issues

Water usage

With many states of Australia experiencing extreme drought and water shortages over the past decade, the heavy irrigation needs of maintaining natural grass sports grounds has been questioned and alternatives have been sought. These include better management and use of water by harvesting rainwater for re-use, or using recycled waste water for irrigation. Another alternative is to install a synthetic turf surface, which, from a water perspective has a major advantage over natural grass for most sports. Irrigation is a key component in maintaining good quality natural grass, whereas, synthetic turf does not require irrigation in most situations. There are some types of synthetic turf that do perform better when watered, as it helps to decrease static cling, helps to wash away bacteria and fluids on fields, improves playability in some sports, such as hockey and helps to cool (at least temporarily) the often high temperatures of synthetic turf. This water usage is generally significantly less than that needed to irrigate and maintain natural grass.[2]

Table 1: Typical grass water use per year

Sport	Area (ha)	Water Use ML/yr
AFL	1.60	9.6
Soccer	0.80	4.8
Rugby	1.00	6.0
Hockey	0.70	4.2
Bowls	0.16	1.0
Tennis	0.06	0.4
Athletics	0.70	4.2

For example, elite level hockey pitches are water based synthetic turf and require large amounts of water, this is something that the sport is conducting further research on and alternatives are currently being developed, which reduce the level of water required to 'wet down' a pitch. Estimates are that a single hockey pitch requires 12,000 to 18,000 litres to take the pitch from a dry condition to a playable condition.

Irrigation not only requires the resource of water, but also needs energy to deliver it to the end user.

Stormwater and runoff

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In addition to irrigation demands for water, a field's ability to take in storm water is another environmental consideration. There are several environmental problems associated with storm water runoff. In general, natural habitats absorb storm water better than impermeable surfaces.

There is little groundwater retention when the soil surface is bare or when there are impervious surfaces such as streets, driveways, parking lots, rooves and synthetic turf. However, synthetic turfs can include drainage systems that compensate for their inability to take in water. A thick, healthy area of natural grass reduces rainwater runoff to practically nothing. The natural grass areas and the soil beneath create a good quality medium to purify water as it leaches through the root zone and the soil into underground aquifers.[3]

Studies in relation to the water quality of the runoff from synthetic turf compared to natural grass are conflicting and depend on the type of synthetic turf used. There are reports available that show the run-off into waterways from natural grass (that contain pesticides and fertilisers) compares poorly with the quality of runoff from synthetic turf.[4] However, other studies show that leaching of zinc and other metals from rubber infill can be found in runoff from synthetic turf which may affect water quality and aquatic organisms.[5] The lack of consistency in the reported literature makes it difficult to draw conclusions, but it seems that the synthetic turf manufacturers are addressing the issues of contamination as the need for water harvesting becomes more important.

Capturing rainwater

Unlike natural grass, synthetic turf does not absorb rainwater—it simply drains through the surface or along the ground into storm sewers. The harvesting of this water runoff, for re-use on site or locally, is an area that has been investigated and there are several reports available on this topic. The general consensus is that whilst the idea has merit and can been seen as being environmentally responsible the practicalities of setting up the infrastructure and ongoing management require significant capital investment, often making it economically unviable.[6] However, this has been achieved and there are a number of cases in Australia where hockey fields have been designed to incorporate stormwater runoff and reuse technology, in which much of the water is recycled and re-used for watering the field.

Case study - State Netball Hockey Centre, Victoria

Victoria's State Netball Hockey Centre in Parkville is a world-class sporting venue catering to a variety of sports at a local, state and international level. Maintaining the centre's two synthetic wet hockey pitches to international standards required around 24 megalitres of drinking quality water every year. This significant use of water resources was a concern shared by the players, the wider community and the Centre's management. In response, the State Netball Hockey Centre took up the challenge to find an alternative source of water.

The Centre was awarded a government grant to research and introduce a recycled water harvesting scheme allowing for the irrigation of pitches with recycled water from a range of sources. Instead of using mains water, the scheme allows rainwater collected from pitch areas and roofing to be stored in four 45 kilolitre underground tanks. The stored water is treated before use. Overflow from the tanks irrigates the centre's native plants, while the bulk of the water irrigates the hockey pitches.

The new recycled water system will save 19 of the 24 megalitres the State Netball Hockey Centre uses each year on the pitches, reducing its use of drinking quality water by 80 per cent. The initiative will not only result in significant water savings but

will also deliver financial savings for the Centre. (Content supplied by Hockey Victoria).

Carbon dioxide

Carbon footprint

When comparing the carbon footprint of natural grass and synthetic turf the whole life cycle of the product, not just the maintenance component needs to be investigated. The carbon footprint for natural grass tends to come from the installation and maintenance stage (fertiliser production, mowing and lawn management), whereas for synthetic turf it is derived from production, transportation and disposal of materials. Synthetic turf is a petro-chemical product which requires the use of virgin materials, high levels of processing and production, transportation and disposal at end of life. When considering the entire life cycle, these material impacts of synthetic turf significantly increase the total emission of this product and far outweigh the emissions that occur from maintaining natural grass.[7]

In 2007, a Canadian study set out to estimate the greenhouse gases emitted during the life cycle of the synthetic turf system as opposed to a natural grass surface. The study also determined the number of trees to be planted to achieve a 10-year carbon neutral synthetic turf installation. This was a very complicated process and many assumptions were made, but the findings give an indication of the greenhouse gas emissions related to the life cycle (from raw material acquisition through manufacturing, transportation, use and maintenance, and end-of-life disposal) of the synthetic turf field. In conclusion, the study found for a 9,000 square metre facility over a 10-year period, a total CO^2 emission of 55.6 tons plus additional greenhouse gases. The tree planting offset requirements to achieve a 10-year carbon neutral synthetic turf installation for the same sized facility was estimated to be 1861 trees (based on a medium growth coniferous tree, planted in an urban setting allowed to grow for 10 years).[8]

Carbon sink

Natural grass helps remove carbon dioxide from the atmosphere through photosynthesis and stores it as organic carbon in soil, making them important "carbon sinks." A typical lawn (2,500 sq. ft./232 m^2) converts enough carbon dioxide from the atmosphere to provide adequate oxygen for a family of four. [9] There is some recent research from the United States that suggests greenhouse gas emissions from fertiliser production (mowing, leaf blowing and other lawn management practices) are greater than, the amount of carbon that can be stored in them, suggesting that natural grass may contribute to global warming rather than reduce it. This study also found that athletic sports fields do not store as much carbon as ornamental grass due to soil disruption by tilling and resodding. [10] However, it was later discovered that there were several computation errors in this research and when the computations were corrected, it was found that natural grass actually is a net sequesterer of carbon dioxide, reversing the conclusions of the original report.[11] This is backed up by another recent US study that concludes "After reviewing the direct carbon sequestration of grasses and their root systems, we found that managed lawns sequester, or store, significant amounts of carbon, capturing four times more carbon from the air than is produced by the engine of today's typical lawnmower. The study also finds that well-managed turfgrasses (natural) that are cut regularly and at the appropriate height, fed with nutrients left by grass clippings, watered in a responsible way, and not disturbed at the root zone actively pull pollutants from the air, creating a greater carbon benefit."[12]

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It must also be noted that whilst synthetic turf does not require mowing, it still does require ongoing maintenance, often using fuel powered machinery to help keep it clean and performing well. Ride on mowers with brushes rather than mowing blades are used to brush the surface and leaf blowers are also used to remove leaves from fields. This maintenance equipment produces greenhouse gas emissions but unlike natural grass there is no carbon sink to counter balance it.

Figure 2: Ride on grooming and cleaning machine with petrol engine used to maintain synthetic turf.

Often artificial turf replaces a natural grass surface, so another contribution synthetic turf makes to global warming is the removal of a natural grass surface that reduces carbon dioxide, by converting it into oxygen. [13]

Materials

Some of the key environmental issues related to synthetic turf revolve around the production, transportation and disposal of materials.

Recycled content

The crumb rubber used as infill in synthetic turf fields is often made from recycled tyres. Products made from recycled content are generally preferable to those made from virgin material in two respects, firstly, they do not draw on resources that may be limited, and secondly they address issues of waste.[14] It is estimated that a large synthetic soccer pitch uses approximately 27,000 tyres.[15] Many see the use of recycled waste products for field infill as one of the primary environmental benefits of synthetic turf and whilst this is an environmental positive, synthetic turf also requires the use of many virgin materials in its production.[34]

The shockpad used underneath the synthetic turf can also be made from reused materials. The shockpad underneath the new facility at Point Cook in Victoria is made from reused running shoe soles. Figure 2: Shock pad made from recycled sports shoe soles being incorporated into the Australian Rules football and Cricket ground at Point Cooke, Victoria.

Material safety

There has been some concern over the use of recycled car tyres as rubber infill. Whilst it is considered sustainable to use recycled tyres, it has been suggested, but not yet proven, that tyres have the ability to leach out volatile organic hydrocarbons and other toxic materials causing concern for human health (if ingested or absorbed) and also concern over leaching toxic chemicals into soil and groundwater.

A review of existing literature points to the relative safety of crumb rubber fill playground and athletic field surfaces. Generally, these surfaces, though containing numerous elements potentially toxic to humans, do not provide the opportunity in ordinary circumstances for exposure at levels that are actually dangerous. Numerous studies have been carried out on this material and have addressed numerous different aspects of the issue. For the most part, the studies have identified it as a safe, cost-effective, and responsible use for tyre rubber[40].

There remain a few objects of concern, though. First, the allergen potential of latex in tyres used for athletic (sports) fields remains obscure. Though there has not been experimental confirmation of the risk of crumb rubber triggering a latex allergy, the possibility cannot be ruled out and needs to be investigated more thoroughly.

Additionally, lead exposure remains an object of some concern. The results of experimental evaluation of lead in these fields have been thus far inconclusive. Most studies have cleared the fields as safe in terms of lead risk, but others have noted an elevated presence of lead.[16] Given the fact that lead levels in tyres varies significantly, according to production processes, it is advisable, as part of the tender process to insist upon suppliers that all materials are lead-free.

Finally, and most significantly, repeated testing has shown that the presence of zinc in leachate from crumb rubber fields remains problematically high. It would appear that levels of zinc leaching into groundwater from crumb rubber fields are significant. Further research needs to be conducted into this question to determine whether it is a real issue, and if it is, greater innovation needs to be carried out at the level of product development to eliminate this issue.[40]

Given these continual questions and concerns, alternatives to crumbed rubber infill are being sought, the new facility at Point Cook in Victoria has chosen to use round sand sourced from the Middle East as the infill for its facility (Figure 3). The roundness of the sand means that it is not as abrasive on the player's skin as other sand particles and it removes any of the concerns outlined above about using rubber infill.

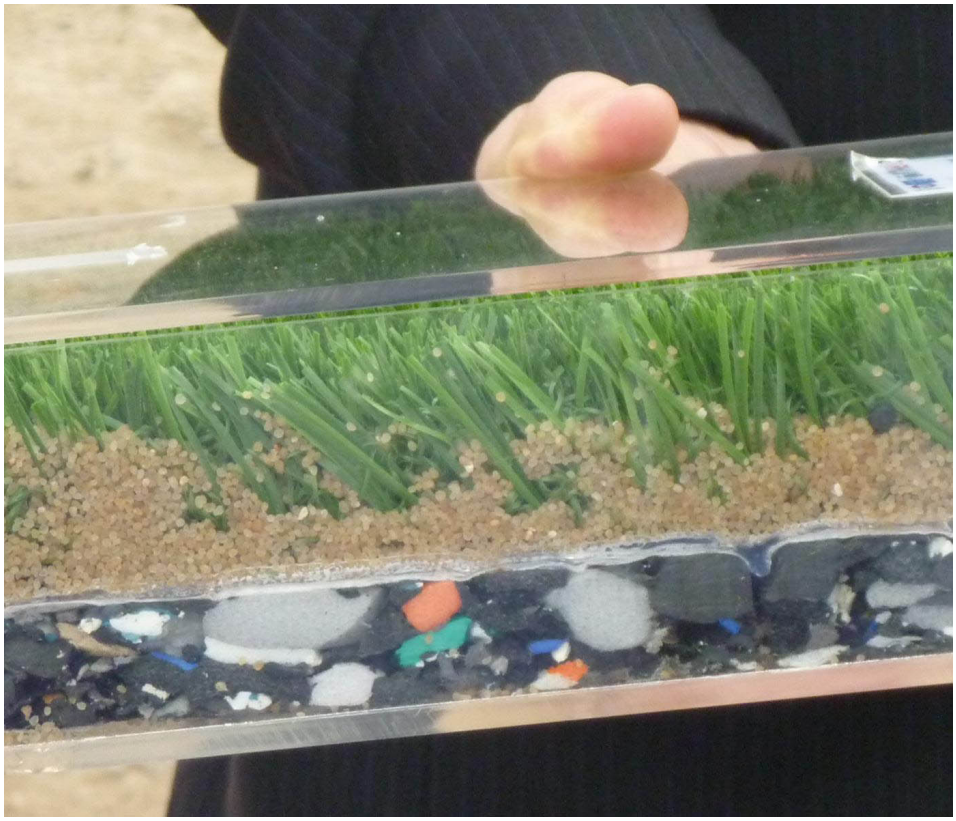

Figure 4: Rounded sand being used as the turf infill in place of rubber granules

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Transportation

Generally speaking, synthetic turf is transported long distances (usually all or part of the product is made overseas), whereas 'instant' natural grass fields have short shelf lives and can only be transported shorter distances, or are planted from seeds which have minimal transportation costs and the associated reduced carbon footprint.

End of life disposal

Synthetic turf

An additional environmental (and financial) challenge associated with synthetic turf comes in its disposal. Synthetic turf is not designed to breakdown quickly (that is one of its advantages) which means that when the surface has passed its useful life it has the potential to stay in landfill for long periods of time.

Figure 4: Disused sand filled synthetic turf waiting for transport to landfill

End of life disposal involves costs associated with removal, transportation and landfill charges (which are generally based on weight, and synthetic turf is a relatively weighty product), making the disposal of a disused surface a significant expense. It is beneficial to try and re-sell or recycle parts of the synthetic turf wherever possible, for example often community groups can utilise different aspects of an elite playing surface that is being replaced. Whilst this enables the surface to achieve a greater life span it is important to note that this option does not remove the disposal issue, it just delays it, and at some point in time the surface will need to be disposed of. Currently, in Western Australia, if the surface cannot be reused in any way it ends up in landfill. There is ongoing research into better ways in which synthetic turf can be removed, cleaned and re-used, or components of it recycled. Currently in the United States and the United Kingdom, there are cement plants that turn disused synthetic turf surfaces into a clean burning energy source by using it to fuel kilns and furnaces in the production of their products.[17] With the increase in the number of fields being installed, this is a technology that may make its way into Australia in the future.

Natural grass surfaces have no end of life costs as it is naturally renewing and regenerating.

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Other environmental considerations

Soil regeneration and dust stabilisation qualities

Topsoil takes thousands of years to develop. It is lost quickly by wind and water erosion. Natural grass sends many fine rootlets into crevices of the soil where they grow and, as they decay, add organic matter to the soil. Natural grass is the most effective plant in conditioning the soil. Natural grass roots are continually developing, dying, decomposing and redeveloping. By leaving clippings on the lawn and by allowing them to decay, the equivalent of three applications of lawn fertiliser is made. This process builds humus, keeps soils microbiologically active and, over time, improves soils both physically and chemically. Natural grass improves the soil by stimulating biological life and by creating a more favourable soil structure.

On the other hand, before installing synthetic turf it is recommended that all soil be heavily compacted. This damages soil structure, soil microbes and soil life. It can also significantly damage any tree roots in the vicinity.[18]

Healthy, well maintained natural grass helps with dust stabilisation and soil erosion control. Healthy grass surfaces capture dirt and dust from the atmosphere.[38] During severe drought periods and tight water restrictions, natural grass can deteriorate and loss of natural grass can create 'dust bowls'. During prolonged periods of drought synthetic turf has an advantage in this area.

Heat dissipation

Most synthetic turf surfaces absorb rather than reflect sunlight, causing the emission of heat. These high temperatures not only impact the surrounding environment, but they can also affect the health and safety of athletes and children who use the synthetic turf grounds. They can become an uncomfortable playing surface very quickly, especially for summer sports like cricket, tennis and lawn bowls. (Refer to section 9 for more information on the health impacts of heat related issues).

Recent local research for the AFL and CA, suggests that in hot conditions, an artificial grass sporting area can be up to 40% hotter than a natural field, although this increased heat dissipates quickly on a windy day.[19]

Natural grass plays an important role in controlling climate. Natural grass is one of the best exterior solar radiation control ground covers, because it absorbs radiation and converts it to food for growth through photosynthesis. Natural grass surfaces reduce temperature extremes by absorbing the sun's heat during the day and releasing it slowly in the evening.[44]

The replacement of natural grass with synthetic turf has the opposite effect and can contribute to rising temperatures in urban settings, known as the urban heat island effect. Urban heat islands are created when natural grass and trees are replaced by impervious surfaces which absorb heat. Urban heat islands increase demand for energy (particularly air conditioning), intensify air pollution, and increase heat-related health problems. Not only does removing natural grass exacerbate the urban heat island effect – most synthetic turf fields absorb rather than reflect sunlight, causing them to emit heat.[20]

Noise and glare reduction

Natural grass provides greater noise abatement and glare reduction when compared with synthetic turf. Natural grass plants have the ability to absorb sound. Noise levels are affected by the softness or hardness of the surface over which sound travels. Because grassed areas present such an irregular soft surface, they are very effective at reducing noise levels.[21] To help reduce glare from synthetic turf fields it

is important in the design stage, that the pitch is orientated correctly to avoid high sun glare during peak playing times, it is also important to place lights in the correct position to avoid glare.

Figure 6: Sun glare arising from a recently installed synthetic turf soccer pitch in Melton, Victoria

Biodiversity and habitat

Natural grass offers habitats for insects, plants, and other organisms, and provides food for birds. Natural grass and the topsoil are home to zillions of beneficial organisms that break down and recycle organic and inorganic products that fall into the grass. Plants absorb gaseous pollutants into their leaves and assimilate them, helping to clean the air and create oxygen. Synthetic turf does nothing to enhance biodiversity, though most synthetic turf fields have drainage systems, they do not contain microorganisms that can break down pollutants.[22]

In conclusion, detailed consideration of a variety of environmental factors needs to be taken into account when planning the installation of a synthetic turf or natural grass surface. It is advisable to conduct and seek further research and information in this area, as there are many helpful resources available that are referenced but not fully expanded on within this report.

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Social impact

User demand, perceptions and preferences

Cricket

The use of synthetic turf outfields for cricket is a new frontier. In 2008 the AFL and CA released the criteria for synthetic turf to be used at the community level and the first certified field following these specifications is currently being developed at Point Cook, Victoria on the outskirts of Melbourne. This ground will be used for training, and community competitions for both cricket and Australian Rules football.

As with other sports a major benefit of a synthetic turf oval will be the ability to schedule activity at any time and have consistent playing surface conditions. There may also be a use in remote areas where water and maintenance is an issue, as it may be the only means of providing a quality playing ground.

The Western Australian Cricket Association sees the benefit for outfielding in terms of consistency of roll and the opportunity to program modified small games on a synthetic turf ground as they don't require a cricket pitch.

Football (Australian Rules)

The use of synthetic turf for Australian Rules football is also a new frontier. Synthetic turf ovals are not currently used in Australian Rules football and the AFL see the long term future of the game, at the elite level (State and National), being played on natural grass.

However, as discussed previously in this study, in 2008 the AFL and CA released the criteria for synthetic turf to be used at the community level and the first certified field following these specifications is currently being developed at Point Cooke, Victoria on the outskirts of Melbourne (Figure 1). This ground will be used for training, and competitions for various levels of football and cricket.

Figure 1: Construction of the first AFL and CA endorsed synthetic turf oval in Australia at Point Cooke, Melbourne.

As with other sports, a major benefit of synthetic turf grounds will be the ability to schedule activity at any time and the consistent playing surface conditions. As more games are scheduled, there is the likelihood of an increase in participation which also has a positive social impact.

There may also be a use in remote areas where water and maintenance is an issue, as it may be the only means of providing a quality playing ground.

Hockey

As stated previously in this report hockey is well advanced in the provision of synthetic turf surfaces and these surfaces have been used for over three decades.

Hockey West have advised that natural grass is still preferred by the majority of veteran players, particularly given the recent rule changes that have increased the speed of the game. They have seen a significant increase in the number of older in hockey teams (30+) that are moving from playing on synthetic turf to playing on natural grass.

Wet surfaces are still preferred by higher level players and juniors, and most grades are played on this type of surface in the Perth metropolitan area.

Wet dressed pitches can generally not be used for other sports although some junior sports have used the surface for modified games. Sand dressed/filled pitches can be used for other sports such as tennis and lacrosse.

The international body for hockey the FIH has been instigating innovation in terms of providing a surface that has similar levels of playability of a wet dressed synthetic turf but requires significantly less water to use. A number of 'hybrid' or wet/dry products have been released to the market in recent years and this type of pitch has been installed at Aquinis College in Perth.

Figure 2: WA Hockey Stadium which has two wet dressed hockey pitches

Lawn Bowls

The bowls community, particularly at the elite level, has a preference in general for the use of natural grass greens. Natural grass is dormant between April and August and therefore is generally not used during this period. Synthetic turf provides the opportunity for bowls to be played all year round.

In addition the following perceptions were provided by Bowls WA:

- Of the 69 clubs in WA, 45 have at least one synthetic turf green and 10 clubs have all synthetic turf greens. Country regions have a higher demand for synthetic turf primarily due to the green keeper skill shortage.
- Synthetic turf has the benefit of all year round use and Bowls WA has found that it is mostly suitable to accommodate the social and corporate bowling markets.
- Issues with synthetic turf include inconsistent role particularly as a surface ages or if the original base is not well constructed.

- Greens tend to last between 6-7 years however the roll tends to be affected after five years.
- Heat is a major issue and a number of clubs are installing or planning to install shade structures over their greens, therefore adding to the capital and ongoing maintenance costs.
- Bowls WA is currently developing a guideline document for the development of synthetic turf greens for clubs.
- Bowls Australia is developing a system which includes a list of specific contractors for base construction.

Figure 3: Synthetic turf lawn bowls green

Rugby Union

Rugby Union is a niche sport in WA, but there is a demand, as the sport has grown by over 65% in recent years. The growth has primarily been in the Perth metropolitan area. Clubs are often competing with other sports for green space to play competitions and train on, and the current facilities are accommodating the need, however, if the strong growth continues additional facilities/grounds will be required.

Synthetic turf surfaces are seen by Rugby WA as an option for training, however at this stage they could not see a need for access to synthetic turf fields for competition matches.

Other issues raised by Rugby WA included:

- Rugby clubs tend to operate with low budgets, therefore cost increases could be an issue;
- Traction is a key requirement for rugby particularly in scrum situations and this may be an issue on synthetic turf;
- Priorities such as clubroom upgrades and other basic amenities are seen as priorities for clubs rather than access to synthetic turf field;
- Concern was raised around multiple line markings for various sports and the compatibility of rugby and football (soccer);
- Opportunities may exist to install synthetic turf in high use physical training areas; and
- Risk management particularly in relation to player safety was raised as a potential issue.

Figure 4: Rugby being played overseas on a synthetic turf field

Soccer

Although soccer is well advanced in terms of synthetic turf pitch provision worldwide within Australia it is a relatively new development. Victoria is the state that is the most advanced, with over 40 synthetic turf pitches now in existence. WA does not currently have a synthetic turf soccer pitch suitable for senior level games.

Synthetic turf is supported by the Football Federation of Western Australia (FFWA) and it is understood a prominent club in Perth is currently investigating the installation of a synthetic turf pitch.

The following perceptions were raised by the FFWA

- Soccer has a strong demand for pitches across the state and sees that synthetic could assist with increasing capacity, particularly for training;
- State league matches could not be played on multiple line markings however, at the community level this is not seen as such an issue;
- Sees that the Council's would have to drive the development of synthetic turf pitches into the future as many clubs would not have the resources to do so;
- Perception that synthetic looks green all of the time so has aesthetic appeal; and
- Recognises the water issues may drive the development of synthetic turf pitches in WA in the future.

Figure 5: Synthetic Soccer Pitch at Cheltenham, Victoria

Tennis

Tennis, like hockey, has been exposed to synthetic turf surfaces for a number of decades. As stated previously, tennis is the only sport that has multiple surface types for their elite competitions, i.e.; lawn, hard court (acrylic) and clay. Synthetic turf is not endorsed for high level competitions but has proven to be a popular choice for clubs particularly in regional areas of WA.

The following perceptions and issues were raised by Tennis West

- There is a demand for more casual use at non-traditional times such as week nights and week days;
- WA and Perth in particular, has a high proportion of lawn courts compared with other states and this may not be sustainable into the future;
- Tennis Australia financially supports the development of the Grand Slam surfaces (Acrylic, Lawn and Natural Clay). Note: Under the current program, the Australian Open Surface (cushioned acrylic hard court) and natural clay courts are given the highest level of subsidies by Tennis Australia (up to $18,000 per court). Other acrylic surfaces and lawn courts are also supported financially to a lesser degree, however synthetic turf court surfaces are ineligible for subsidy with the exception of the lighting and fencing components;
- The majority of country areas prefer synthetic turf over acrylic if lawn courts are unavailable/not sustainable primarily due to the heat issues associated with hard courts;
- Tennis West sees a mix of surface types being provided in metropolitan Perth and an increase in the number of hard courts in the future;
- Tennis Australia cites that acrylic surfaces are preferred as they facilitate improved skill development due to consistent bounce etc. Also acrylic is less expensive than synthetic turf from a lifecycle cost perspective;
- There is no standard for synthetic turf provided by Tennis Australia although they are currently in the process of developing some guidelines. Synthetic turf courts tend to be a slower court with variable bounce;
- The preferred surface which is a cushioned acrylic the same surface used for the Australian Open is in the higher cost range. This may make it unaffordable for many local clubs; and

- Only 15% of tennis participants are club members and Tennis West is looking at capturing the 'casual' market.

Aesthetic, wellbeing and mental health qualities

There are many variables when assessing people's perceptions and personal views and benefits derived by the type of surface they prefer to play their sport on. Some sports such as hockey and tennis, which have been using synthetic turf surfaces for many years, have participants that now prefer synthetic turf surfaces to traditional natural grass playing surfaces. In other sports, where the technology is very new, and hasn't had the time to advance and develop, many people may yet be unaware that endorsed synthetic turf options are available.

The following points are subjective and based on discussions with players, officials, researchers, product suppliers and visual inspections of a range of sites by the consulting team, but do offer some insight into the various qualities both surfaces offer.

Natural grass

- Cooler feel, particularly in summer;
- Softer and more forgiving;
- Variable quality depending on the soil type and maintenance regime;
- Traditional and served the various sports well for many years;
- Natural and calming feel;
- Pleasant smells e.g. freshly cut grass;
- Visually appealing if well maintained; and
- Provides environmental benefits in terms of carbon absorption and contribution to biodiversity.

Synthetic turf

- Consistent surface;
- Warmer and subject to glare when sunlight is present;
- Consistent quality and set maintenance regime;
- Modern and innovative product;
- Artificial and unnatural feel;
- Strong odour, particularly for synthetic turf with rubber granule infill;
- Visually appealing as it looks 'green' all of the time;
- Suitable in many types of weather conditions;
- Durable and low maintenance; and
- Provides environmental benefits in terms of water savings and reduced maintenance.

General issues

In addition to the many issues raised in the previous sections of this report, there are some general social elements and impacts that need to be considered when investigating synthetic turf surfaces.

The effect on traditional club environments, including programming and scheduling needs to be considered. For example, hockey was a traditional Saturday afternoon sport prior to the advent of synthetic turf. As the number of synthetic turf pitches increased additional games were programmed at the new facilities. Hockey is now played from Friday evenings to Sunday evenings with training on every other night of the week.

This is good from a facility usage perspective, however, it does interfere with the traditional after games social events and dinners that were previously scheduled on a Saturday evening. This aspect does need to be considered for sports that are beginning to embrace synthetic turf surfaces as a district/regional level facility which will cater for a number of clubs. They will have to address this issue as it goes to the core of many sporting club operations.

The benefit of this is having multiple clubs and users utilising the one facility. In some cases, the facilities may be used for multiple sports and will assist in ensuring the ongoing viability of the facilities which have synthetic turf surfaces, as the initial cost of construction of synthetic surfaces, in many cases is higher than traditional natural grass surfaces.

Health impact

Synthetic turf has changed considerably since its inception in the 1960's, however, concerns still exist around the potential negative health impacts of the surface. The perceived increase in injury risk on synthetic turf, compared to natural grass, has been debated for many years. Recently, the potential harm from heat-related exposure and toxicity have become a major focus of attention. This section will present the current knowledge and evidence on the differences between natural grass and synthetic turf in terms of injury risk, and heat-related issues.

Injury risk

There has been a considerable lack of consensus on whether there is a higher risk of injury on natural grass or synthetic turf playing fields in the literature to date. This may be a consequence of inconsistencies in injury definitions, the lack of evaluating surface–related injuries only, or even the inherent variations between different synthetic products or different natural grass types. The surface properties of first and second generation synthetic turf were very different, in many respects, to the current third generation (3G) turf. The lack of impact absorption and the high friction/traction on the earlier surfaces were associated with an increased risk of injury.

In a review of the effects of synthetic turf and natural grass on surface –related injuries in soccer by Ekstrand & Nigg in 1989[1], they reported that there were more abrasion injuries sustained on the synthetic turf than the natural grass but no difference in the number of traumatic injury incidences between the two surfaces. Many subsequent studies, primarily in soccer and American football, reported an increase in injury risk on synthetic turf compared to natural grass.[2][3][4] While abrasions and lower extremity sprains were the most common injuries to have a higher rates on synthetic turf, an important study by Naunheim et al in 2002[5] examined the risk of head injuries between natural grass and synthetic turf. They found a difference in impact attenuation (i.e., the ability of the surface to absorb the force) between three surfaces; two indoor synthetic Astroturf (synthetic turf) and one outdoor natural grass playing surface. They suggested that a surface with low impact attenuation may contribute to a higher incidence of concussion injuries in American football players.

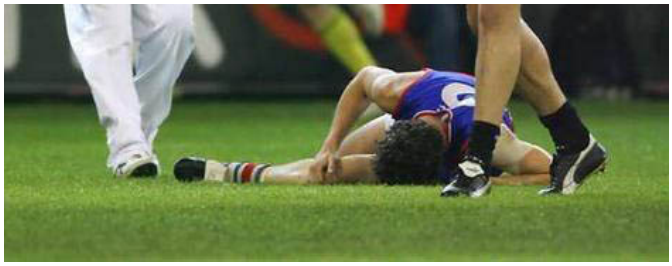

Figure 1: Injury photos on natural grass.

The negative experiences and perceptions that ensued were to some extent responsible for the improvements to synthetic turf surfaces to replicate the characteristics of natural grass more closely. It is notable that one study on first/second generation turf reported an increase in injuries on natural grass.[6] That particular study was an analysis of injuries in the National Football League (NFL) in the United States from 1989 to 1993 and showed that anterior cruciate ligament (ACL) injuries were five times more likely on natural grass than synthetic turf. This was an important finding as ACL injuries are both debilitating for the athlete and a high cost burden on the health care system. However, training injuries revealed the exact opposite result, with a higher risk of ACL injuries on the synthetic turf surface.[48] Overall, injury rates appeared to be higher on first/second generations of synthetic turf compared to natural grass but despite all the research it remains uncertain whether footwear, environmental conditions or the surface itself was predominantly responsible.

Despite the fact that third generation or 3G turf playing fields began to appear in the late 1990s, the first study of injuries on these fields was not published until 2006. That study by Ekstrand et al (2006)[7] compared injuries on natural grass and 3G synthetic turf across 10 Swedish elite level male soccer clubs over three seasons and found no significant differences in injury rates and hence no greater risk on either surface. However, there was a higher incidence of ankle injuries on the 3G synthetic turf and a lower incidence of muscle strains. The authors acknowledged that the differences in injury patterns must be interpreted with caution as the numbers for specific injury subgroups were small. Notably, abrasion and friction burn injuries, which had been commonly reported on the previous generations of synthetic turf, were not identified as a problem in this study. However, the injury definition used by Ekstrand et al.[49] only included those injuries that resulted in time loss from full training or matches and hence may have underestimated the abrasion type injuries.

Following this, Fuller et al (2007)[8] [9] compared injuries on natural grass and synthetic turf in the 2005 and 2006 American college soccer playing seasons, across genders and all games and training, and found no significant differences in the overall incidence, severity, nature or mechanism of injury. Although there was a significantly higher incidence of head/neck injuries in the male cohort on synthetic turf, none of those injuries were as a result of player-surface contact. The incidences of dermal injuries were also higher for the men on the synthetic turf and interestingly, the women recorded less ankle sprains on the synthetic turf. In training, the men had more incidences of ankle, foot and joint injuries and the women had less joint injuries on the synthetic turf. Similar results were reported in another study of 14-16 year old Norwegian female soccer players for the 2005 playing season. They also reported no significant difference in the overall risk of acute injuries between the surfaces but found a higher incidence of severe match injuries on the synthetic turf.[10]


Figure 2: Broken leg injury

In the past 18 months, there has been a significant increase in the number of studies on injury risk on the latest 3G synthetic turf. Bjorneboe et al (2010)[11] published the first study on Federation Internationale de Football Association (FIFA) certified 3G synthetic turf. The significance of the certification is that the product would have undergone rigorous testing to satisfied a number of surface property standards before being played on.[12] These standards are based on durability and performance /safety and therefore the expectation is that the synthetic turf closely replicates natural grass. They studied the injuries of Norwegian male professional soccer players over four playing seasons and found no significant difference between injury location, type or severity between turf types for both training and match injuries. The injury definition used was time-loss based, i.e. an injury was registered if a player was unable to take part fully in soccer related activity for at least 1 day after the day of injury. Consequently, the study was limited to reporting acute injuries only.

In support of Bjorneboe et al's work, a recent study published by Ekstrand et al (2010) [13] comparing the incidences and patterns of injury for female and male elite soccer players when playing on 3G turf and natural grass, found no differences in injury risk between the two surfaces. Their analysis of injury type revealed no significant differences but there were indications of a lower injury risk of quadriceps strains and a higher risk of ankle sprains on the synthetic turf during matches. Interestingly, they also indicated that men were more likely to sustain a calf strain on natural grass, but the number of injuries was small and therefore the differences didn't reach a significant level. Similar to previous studies on 3G turf, they found a low number (0.4% of all injuries) of wounds, burns and friction injuries were sustained. This result is somewhat expected as the standards set by the governing bodies of the sports are demanding that the 3G surfaces satisfy friction standards before play. However, it is important to note that in their study they only included time-loss injuries and may have underestimated these types of injuries.

The results of a study undertaken over four consecutive Norway Cup tournaments, [14] which is a youth soccer tournament played over 6 consecutive days, comparing injuries on 3G synthetic turf compared to natural grass further supported the findings of Ekstrand et al[55]. They found that minor abrasions and friction burns associated with synthetic turf in early studies was not the case on 3G synthetic turf.[56] The occurrence of abrasions and lacerations was low on both surfaces. A strength of this study was that it spanned 4 years and therefore included a wide range of conditions of the natural grass. Similar to all previous 3G studies, there was no difference in the overall risk of injury between the two surfaces.

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In recognition of the limitations of previous studies to include chronic /overuse injuries Aoki et al (2010)[15] undertook a study comparing the incidence of injury, especially chronic injuries of adolescent soccer players, between natural grass and FIFA certified 3G synthetic turf. They monitored six teams of 12-17 year old males and again found no significant difference between the turf types but there was an association between chronic back pain and training on synthetic turf. However, they did postulate that it could be due to physical maturity or training hours as this differed between the natural grass and synthetic turf group. In light of this, they undertook further analysis and found that longer training hours on synthetic turf was a risk factor for younger, less mature adolescents. Although these results are interesting, the challenge with reporting and interpreting overuse injuries is controlling for confounding factors such as adaptation, event identification and other physical activity undertaken.[16]

In contrast to all other studies, there has been one recent study that found a greater incidence of injuries on natural grass compared to synthetic turf.[17] The synthetic turf product in their study was Fieldturf, which was specifically developed to replicate the playing characteristics of natural grass. They evaluated injuries from 2006 – 2008 in American college level football players and found more injuries on natural grass than synthetic turf (53.4% compared to 46.6%). They did not observe any differences in the category of injury between the surfaces or in head, knee or shoulder traumas. The factors that influenced the overall difference between the Fieldturf and natural grass were injury time loss, injury situation, grade of injury, injuries under various field conditions, and temperature.[16] They suggested that the contrast in their results to previous studies were reflective of the advancements in synthetic materials.

As the use of synthetic turf is relatively new for rugby union, there has only been one study published to date comparing rugby union injuries on natural grass and 3G synthetic turf.[18] They found that there were no significant differences in the overall incidence or severity of injuries on synthetic turf compared to natural grass, although the incidence of minor injuries during training was significantly higher on synthetic turf. There was also a higher incidence (four times higher) of anterior cruciate ligament injuries during match play on synthetic turf but the sample size was too small to achieve a level of significance. It was also notable that in their study all concussion and skin lacerations were a result of player to player contact rather than player – surface contact. Although, the sample size in their study was small, the findings present some preliminary evidence to suggest that rugby union can continue to be played on synthetic turf but needs close monitoring as new products are evolving.[60]

A recent addition to the standards for synthetic turf has been the inclusion of a critical fall height in sports such as rugby union, Australian Rules football and Gaelic football. Critical fall height is an approximation of the height below which an individual may fall and most likely not sustain a severe head injury.[19] [20]

Since there is little published work to date on injuries on synthetic turf for these sports, the risk of head injuries from impacts has not been well established. A study by Theobald et al (2010)[21] on a variety of third generation soccer surfaces found that shockpads and infill were important in maximising the impact attenuation properties of the surface. Also they reported that moisture content did not influence the critical fall height and so safety remained consistent between arid and extremely wet conditions. They also found that impact attenuation of natural grass was dependent on its use and for players on poorly attended natural grass fields, the risk of a mild traumatic brain injury may be increased. Of the six 3G surfaces they tested, the fall heights ranged from 0.46 - 0.77 m for a 10% risk of sustaining a mild

traumatic brain injury. With the increasing use of 3G synthetic turf for rugby union, and the impending use for Australian Rules football and Gaelic football, empirical evidence on the risk of head injuries on synthetic turf will hopefully be addressed in the near future.

A limitation of the work thus far is that it has focussed solely on the epidemiology of injuries or on the mechanistic nature of shoe-surface interactions but there is an immense need to develop an understanding of the underlying causes of injury on the different surfaces. As mentioned by Naunheim et al (2002)[22] in their work on head injuries on various surfaces, reporting the condition of the surface is critical to the correct interpretation of the results as the condition of all outdoor surfaces will vary according to environmental and maintenance conditions. A good description of the condition of the synthetic turf has not been included in most studies to date. An unmaintained field or moisture content could influence injury rates. Similarly, substandard natural grass fields or well worn areas on natural grass fields have been associated with a higher injury risk. Future studies investigating the mechanistic nature of injuries in the real-world context combined with details of the surface and footwear properties at the location of the injury will make a significant contribution to this area.

In summary, there were more injuries recorded on first and second generation synthetic turf compared to natural grass but currently there is insufficient evidence on third generation turf to draw the same conclusions. There appears to be a difference in injury patterns but not overall injury rates on third generation turf compared to natural grass. The multi-factorial nature of injuries makes it difficult to determine the exact contribution of the surface to the injury sustained. Future studies that include data on footwear, surface properties and detailed mechanistic information are undeniably needed.

Heat issues – natural grass and synthetic surfaces

In addition to an increased injury risk on synthetic turf, heat has become a factor of growing interest and concern. The lack of a natural cooling effect in synthetic turf compared to natural grass seems to have formed the basis for the unease. We know that the surface temperature increases with solar radiation load and is poorly related to air temperature[23] but to date the issue of the surface temperature of synthetic surfaces for outdoor sports has been poorly researched.[24] Not only has the research been limited, but in some cases this potential problem has been ignored. Despite the increased use of synthetic turf, little thought has been given to the inherent qualities of the surface and the amount of heat radiated or reflected in Australian climatic conditions. Nonetheless, there is evidence to suggest that there is a difference between the effect of a synthetic surface versus natural grass on the heat load experienced by those exercising on outdoor grounds e.g., football, soccer, cricket.

Some early work on surface temperature on first /second generation synthetic turf identified increases in temperature on the synthetic compared to the natural grass, particularly when exposed to sunlight.[25] For example, a study by Buskirk et al. (1971)[26] reported differences in maximum temperature ranging from 35-60°C between the natural grass and synthetic turf. Similarly, Kandelin (1976)[27] found that over a 21 day period the maximum temperature reached by the natural grass was 45 degrees and 59 degrees by the synthetic turf. In general, heat-related research on the earlier generations of synthetic turf concluded that the physiological stress from the increased heat could be problematic.

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Although there have been relatively few studies to date on 3G synthetic turf, the results have elicited the same findings. A study of heat on synthetic turf at Brigham Young University in the USA in 2009[28] reported temperatures as high as 93°C on the synthetic turf. They watered the synthetic turf in an attempt to reduce the temperature and found that the immediate effect was remarkable, a reduction from approximately 73.9°C to 29.4°C in the first few minutes. However, this effect was not sustained with the temperature rose to 73.3°C within twenty minutes. Watering has regularly been suggested to reduce the surface temperatures of the synthetic turf fields, but despite the fact that it is not always possible in drought-stricken regions, it is very temporary, unless large volumes of water are administered.[29]

Another study that examined the differences between a synthetic outdoor futsal field and a natural grass field in Japan reported a difference of 16.4 degrees between the surfaces in September but that difference was reduced to 4.5 degrees in December.[30] These results highlight the effect of direct sunlight compared to days of cloud cover. Data was also published on the differences between natural grass, synthetic turf, tennis courts and a running track.[31] The results have been summarised in Table 8 below and demonstrate that the temperatures on natural grass are lower than the other surfaces.

Table 1: A synthesis of surface and air temperature results of three studies on surface temperatures of different outdoor surfaces

Study	**Air temperature**	**Natural grass**	**Green synthetic turf**	**White synthetic turf**	**Soil**	**Asphalt**	**Artificial track**	**Clay track**	**Artificial turf tennis**
Williams & Pulley (2009)#	27.5	25.7	47.2		36.8	43.1			
Aoki (2005)	11am summer	42.2	67				63.9	45.1	59.3
Aoki (2005)	11am winter	11.5	19.6				21.8	10.8	11.8
Devitt et al (2007)	44.5max	38*	76	66.4	59*	60.9			

These data were reported as average temperatures for a period between 7am and 7pm and the temperatures have been converted from Fahrenheit to Celsius. * estimated from graph as exact temperature was not reported.

During the development of guidelines for synthetic turf for Australian Rules football and cricket, some pilot data was collected on the temperatures on a synthetic turf field in Australia.[32] Despite the limited data, it provides some indication of the temperatures that can be expected in the Australian climate refer to Table 2 .

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Table 2: A summary of all field testing sites and temperatures recorded at each site (adapted

Ground type	Weather	Air temp (^{0}C)	Surface temp(^{0}C)	Ratio Surface - Air
Grass	Sunny	28.7	39.6	1.38
Grass	Sunny	25.0	36.1	1.44
Grass	Overcast	16.4	16.8	1.02
Synthetic	Sunny	26.6	34.5	1.3
Synthetic	Sunny	38.6	63	1.63
Synthetic	Overcast	20.9	22.2	1.06
Synthetic	Sunny (3pm)No wind	42.1	72.7	1.73
Synthetic	Sunny (4.30pm) Windy		58.6	1.65
Synthetic	Sunny		54.7(Max-63)	1.81

Table 2: A summary of all field testing sites and temperatures recorded at each site (adapted with permission from Twomey et al[29]).

The information above shows that on all occasions, the surface temperature of synthetic turf was greater than natural grass. The effect of these temperature differences on sports participants is unknown and untested in Australian conditions. Currently guidelines for safe exercising in the heat have been developed by Sports Medicine Australia. This peak organisation have produced three resources which cover hot weather guidelines and tips for preventing heat related illnesses and strategies for sporting organisations and these can be found at the following address: **http://sma.org.au/resources/policies/hot-weather/ (http://sma.org.au/resources/policies/hot-weather/)**. They provide general guidelines and deal only with ambient temperatures and relative humidity and are not related to surface temperatures of the grounds. It is known that children and adolescents do not adapt as well to heat stress as an adult when exercising and therefore are more vulnerable to heat illnesses and extra precautions need to be taken.

In conclusion, the evidence to date suggests that there is an increase in peak temperatures on 3G synthetic turf. The composition of the 3G turf makes it difficult to ascertain what component(s) of the product are responsible for the increased

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temperatures. In addition, factors such as wind, humidity and cloud cover may all contribute to the surface temperature and have not yet been tested simultaneously. Recently, there has been a move in the synthetic turf industry to produce 'heat-resistant' products but currently they have not been sufficiently tested in the natural environment to compare them to natural grass. Future research is needed to quantify temperatures on the latest products and where necessary develop heat safety policies for synthetic turf on surface temperatures and not solely based on air temperatures.

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Life cycle cost

Life cycle cost principles

Life cycle costing is a key asset management tool that takes into account the whole life implications of planning, acquiring, operating, maintaining and disposing of an asset.

The process is an evaluation method that considers all ownership and management costs. These include;

- Concept and definition;
- Design and development;
- Manufacturing and installation;
- Maintenance and replacement;
- Support services; and
- Retirement, remediation and disposal costs.

There are four primary principles to consider when assessing life cycle costs.[1] They are:

1. Recognise that a facility development project begins at the concept and preplanning stage and is complete when the asset is sold or the site returned to its original condition;
2. Examine the full cost of each project component across the life of a project rather than choose the cheapest option. This may mean a higher initial outlay but lead to reduced ongoing operational, maintenance and disposal costs and a net lower total ownership cost;
3. Lifecycle costings consider all of the economic and financial costs associated with constructing, procuring and operating a facility at a level for which it was originally planned; and
4. Developing a life cycle cost analysis is an intrinsic part of your overall asset management strategy.

Life cycle costing will help you to get the most out of your facility by making sure construction, redevelopment, or asset replacement is achieved at the lowest "whole of life" cycle cost. Life cycle cost analysis may mean you trade higher initial construction or plant costs for lower future operating costs. The department has a comprehensive resource tool that enables facility developers to develop life cycle cost reports and understand the full cost impact of owning and managing a facility. This can be accessed on the department's website and should be followed when assessing the life cycle costs of natural grass and synthetic turf options.

Capital cost

To assess the life cycle cost of a proposed surface the initial capital cost, the operational costs and the replacement costs need to be determined. The initial capital cost would include items such as:

- Design;
- Project management services;
- Quantity surveyor services;
- Engineering services;
- Site assessment, base construction, drainage and other civil engineering considerations;
- Environmental consultants;
- Turf and infill materials (synthetic) or Turf/grass seeds (natural);
- Shockpads (synthetic turf only);
- Installation and labour costs;
- Irrigation systems;

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- Ancillary facilities such as floodlighting, perimeter and security fencing;
- Sporting items such as goals, nets and safety fencing;
- Maintenance machinery: line marker, mower, blower etc; and
- Disposal and remediation costs

For the purposes of this decision making guideline, a series of capital, operating and replacement costs have been prepared for each of the sports included in the scope of this study namely:

- AFL/Cricket
- Bowls
- Hockey
- Rugby
- Soccer
- Tennis

In terms of construction costs a comparison was made between various standards of natural grass and synthetic turf suitable for community and elite level sporting activity. Comprehensive cost estimate calculations have been prepared and these are included in a series of spreadsheets (refer Appendix 2).

As an example of the difference between the capital costs to establish a natural grass versus synthetic turf, a summary of the costs to develop a community level natural grass and a community level synthetic turf facility are provided in Table 1. As can be seen the costs to construct synthetic turf facilities are significantly higher in all sports studied and in some cases are more than five times the cost.

Table 1: Comparison of Natural Grass and Synthetic Turf Sports Surfaces for Select Sports

	Construction Cost*	
Sport		
	Natural Grass	**Synthetic Turf**
AFL/Cricket	$358,000	$1,565,000
Hockey	$186,750	$550,000**
Lawn Bowls	$133,000	$198,500
Rugby	$244,500	$1,050,000
Soccer	$212,000	$705,000
Tennis	$27,500	$69,000

Table 1: Comparison of Natural Grass and Synthetic Turf Sports Surfaces for Select Sports

* Supporting facilities i.e. clubrooms, lights, fencing, goals & accessories not included in construction costs. Costs exclude professional fees and contingencies.

** Sand filled pitch

Note: Escalation has not been factored into any of these calculations all costs are in 2011 dollars and include GST.

Operating Costs

Operating costs are the recurring expenses which are related to the operation of a business, or to the operation of a device, component, piece of equipment or facility.

Although the common perception is that synthetic turf requires limited maintenance and hence lower operating costs, this is not necessarily the case. Many synthetic turf surfaces require significant levels of maintenance and in some cases higher levels of maintenance compared to natural grass alternatives. The cost of the maintenance equipment is a substantial contributor to the operating cost. Table 2 outlines the typical maintenance requirements for both types of surfaces. These have been described in further detail in section 3.2.3 of the report.

Table 2: Maintenance requirements for Natural Grass and Synthetic Turf

Natural grass	Synthetic turf
• Mowing and edging • Fertiliser, spraying and growth regulator • Top soil dressing, de-compaction and aeration • Over-seeding and thatch control • Watering and irrigation system operation • Line marking • Sodding replacement/replanting (sections and whole)	• Cleaning, stain and debris removal • Grooming and drag/power brushing • Moss and algae prevention and removal • Line marking • Check and top up infill levels (filled surfaces only) • Joints and seam inspections • Irrigation – some surfaces still require water to maintain a consistent moisture level in the sub base material and to prevent movement and to improve playability

Table 2: Maintenance requirements for Natural Grass and Synthetic Turf

Similar to construction costs a comparison was made between various standards of natural grass and synthetic turf suitable for community and elite level sporting activity in relation to operating costs. Comprehensive cost estimate calculations have been prepared and these are included in a series of spreadsheets (refer Appendix 2).

As an example of the difference between the operating costs to maintain a natural grass versus synthetic turf playing surface a summary of the costs to operate a community level natural grass and a community level synthetic turf facility are provided in the tables below. The costs to maintain synthetic turf are of a similar magnitude to that of natural grass if the surface is to be used at a community level.

Table 3: Comparison of Annual Operating Costs to Maintain Natural Grass (community level) versus Synthetic Turf

	Operating Cost (Annual)	
Sport		
	Natural Grass (Community)	**Synthetic Turf**
AFL/Cricket	$43,700	$50,000
Hockey	$22,350	$10,000 (Sand filled)
Lawn Bowls	$17,500	$10,000
Rugby	$32,100	$38,000
Soccer	$27,250	$25,000
Tennis	$9,500	$4,000

Table 3: Comparison of Annual Operating Costs to Maintain Natural Grass (community level) versus Synthetic Turf

When a comparison is made between a natural grass surface maintained at a level for elite level sport maintenance costs are lower for synthetic turf than natural grass for all sports with the exception of hockey which are very similar.

Table 4: Comparison of Annual Operating Costs to Maintain Natural Grass (elite level) versus Synthetic Turf

	Operating Cost*	
Sport		
	Natural Grass (Elite)	**Synthetic Turf**
AFL/Cricket	$55,250	$50,000
Hockey	$22,350	$24,000 (Water Based)

Sport	Operating Cost*	
	Natural Grass (Elite)	**Synthetic Turf**
Lawn Bowls	$17,500	$14,000
Rugby	$39,650	$38,000
Soccer	$34,400	$25,000
Tennis	$9,500	NA

Table 4: Comparison of Annual Operating Costs to Maintain Natural Grass (elite level) versus Synthetic Turf

Replacement Costs

Unlike natural grass, synthetic turf must be replaced at the end of its useful life. This varies from sport to sport and the timeframe in which it is replaced is dependent on a number of factors. These include the level of usage, level and type of maintenance undertaken on the surface and the performance requirements expected from the surface. For example the need to replace a synthetic turf hockey field surface used for elite level training and competition may be every four – five years where a similar surface used for club based hockey could last 8-10 years.

Generally natural grass has an indefinite lifespan if properly maintained but to maintain optimum performance it may be resurfaced anywhere between 10 to 20 years. For the purpose of the lifecycle cost analysis it has been assumed that resurfacing of natural grass occurs every 15 years. The shockpad required for some sports typically will last much longer than one cycle of synthetic turf resurfacing, it may however require minor maintenance during the resurfacing process.

Life cycle cost

To determine full lifecycle costing a comparison has been made between natural grass and synthetic turf over a 25 and 50 year period. This has been conducted for all sports and includes the capital (construction), operating (maintenance) and replacement costs. The lifecycle costing spreadsheets contained within Appendix 2 outline these total lifecycle costs for each sport. An example where this analysis has been performed for lawn bowling greens is included in Table 13 below. In both the 25 and 50 year scenarios the synthetic turf has a higher lifecycle cost.

Table 5: Total Cost of Ownership over 25 years for various Lawn Bowls Surfaces

Cost of Ownership	**Natural Grass**	**Sand filled**	**Non sand filled**

Cost of Ownership	Natural Grass	Sand filled	Non sand filled
Construction	$133,000	$228,500	$198,500
Maintenance	$475,000	$250,000	$350,000
Surface Replacement	$48,611	$313,125	$235,625
Total Cost of Ownership	**$656,611**	**$791,625**	**$784,125**

Table 5: Total Cost of Ownership over 50 years for various Lawn Bowls Surfaces

Cost of Ownership	Natural Grass	Sand filled	Non sand filled
Construction	$133,000	$228,500	$198,500
Maintenance	$950,000	$500,000	$700,000
Surface Replacement	$97,222	$626,250	$471,250
Total Cost of Ownership	**$1,180,222**	**$1,354,750**	**$1,369,750**

Table 5: Total Cost of Ownership over 25 years and 50 years for various Lawn Bowls Surfaces

Across all of the sports synthetic turf over a 25 year and 50 year lifecycle synthetic turf had a higher life cycle cost than natural grass as displayed in Table 6.

Table 6: Total Cost of Natural Grass and Synthetic Turf over a 25 and 50 Year Period

Sport	Natural Grass (community)		Synthetic Turf	
25 Years	**50 Years**	**25 Years**	**50 Years**	
AFL/Cricket	$1,622,167	$2,886,333	$4,090,000	$7,725,000

Sport	Natural Grass (community)		Synthetic Turf	
Hockey	$787,167	$1,387,583	$1,013,300	$1,753,575
Lawn Bowls	$619,111	$1,105,222	$784,125	$1,369,750
Rugby	$1,185,333	$2,126,167	$2,847,500	$5,397,500
Soccer	$1,004,917	$1,797,833	$2,517,500	$4,330,000
Tennis	$266,000	$552,500	$246,500	$424,000

* The costings prepared are indicative and are based on a series of assumptions which are contained in the lifecycle spreadsheet included as an Appendix to this report.

Table 6: Total Cost of Natural Grass and Synthetic Turf over a 25 and 50 Year Period

It is important to note that it would be too simplistic to state that due to the fact that natural grass has a lower life cycle cost then this is the best option. As discussed elsewhere in this report there are many other factors that need to be considered when determining which surface is going to best meet the needs of a particular sport or club. For example, one of the major benefits of synthetic turf is that it can be programmed non-stop with little impact on the playing surface (but influences its longevity), whereas natural grass has only a finite capacity before the condition of the surface effects playability and in some cases player safety. All factors need to be considered when making a choice as to the preferred surface and this cost modelling also dispels the myth that synthetic turf has a lower cost in the long term.

Footnotes

1. Department of Sport and Recreation WA Government, May 2005, Life Cycle Cost Guidelines Sport and Recreation Facilities; A guide for sport and recreation facilities owners and managers.

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- Hockey WA
- Rugby WA
- Shire of Melton
- Tennis Australia
- Tennis West
- Victorian Department of Planning and Community Development
- Western Australian Cricket Association
- Western Australian Football Commission
- Western Australian Sports Foundation
- Western Australian Department of Sport and Recreation

Further Information

Sports

Sports dimensions (https://www.dsr.wa.gov.au/support-and-advice/facility-management/developing-facilities/dimensions-guide) information and diagrams have been sourced from The Government of Western Australia, Department of Sport and Recreation.

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